经济与金融高级研究丛书

宏观经济研究

Studies on Macroeconomics

邹恒甫 著

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前　言

本书涉及到宏观经济和金融的许多理论和实际研究。它是继本人《财政、经济增长和动态经济分析》(北京大学出版社,2000年)之后我的合作者和我进一步探索的一个阶段性总结。我要把此书中的主要创新贡献归功于我的合作者龚六堂、Francesca Fornasari、金菁、李宏毅、Steven B. Webb、谢丹阳、徐立新和张涛。世界银行、武汉大学、北京大学和中国国家自然科学基金委给我们提供了良好的学术研究环境和必要的经济资助。

本书的第1章是献给邹至庄(Gregory Chow)先生的。该文试图把资本积累、产品创新、国际贸易和经济增长统一在一个简单的框架之中。邹至庄先生长期鼓励我在中国,特别是在中山大学岭南学院从事经济学教育。我把此文放在本书之首,也同时想表达我对众多世界著名经济学家的怀念和感激:Jean-Jacques Laffont (1947—2004)、董辅礽(1927—2004)、杨小凯(1949—2004)、Robert Barro、Richard Caves、Jacques Cremer、James Heckman、Edward Lazear、Robert Lucas、Eric Maskin、Paul Milgrom、Robert Mundell、Roger Myerson、Dwight Perkins、Jean Tirole、Stephen Turnovsky、Michael Woodford等等。这是个群星灿烂的世界。没有他们的帮助和贡献,我不可能在武汉大学、北京大学和中山大学从事经济学、金融学和管理学接近世界前沿的教育事业。

本书的第8章是献给中国著名统计学家张尧庭老师的。它表达了我对现在患有重病的张老师的感激。在此文和本书的第9、10和11章里,我们想建立多级政府条件下税收、转移支付、政府开支和经济增长的动态分析模型。我们相信这种对多级政府的动态研究是公共财政研究的重要方向之一。张尧庭老师、黄训腾老师、吴黎明、谢丹阳和我于1994年向武汉大学陶德麟校长、任心廉书记、侯杰昌常务副校长等提出成立武汉大学经济科学高级研究中心。此中心的倡议书是由张尧庭老师亲自执笔的。他多年来奔波于北京大学、武汉大学、上海财经大学、中国人民大学等多所高校讲课,是我学习的楷模。今天,借此前

言我一道感谢从1987年以来支持我进行中国经济学教育的众多其他同仁:阮志华、田国强、谭国富、陈小红、陈志武、舒元、姚先国、王则柯、方炳松、郎咸平、严加安、张五常、林毅夫、张维迎、朱晓冬、张敦穆、李楚霖、艾春荣、文一、周忠全和张建波等。同时,我要感谢长辈:刘道玉、曾启贤、汤在新、吴纪先、张培刚、刘涤源、谭崇台、成思危、胡兆森和厉以宁等。

本书的第2章证明,在资本主义精神模型里,货币超中性(superneutrality)不再成立。我现在庆幸自己在哈佛大学写作博士论文时(1986—1988)把马克思和韦伯关于资本主义本质和经济发展的学说引入新古典经济增长和内生经济增长模型。这种资本主义精神和资本主义本质的模型也帮助解释金融市场里资产风险溢金之迷(equity premium puzzle,见本书第3章)。在哈佛求学的日子里,我在学习宏观经济学、微观经济学、计量经济学之外,也有幸了解到数理马克思主义的学说在二十世纪的发展。对此我要感谢Robert Dorfman、Stephen Marglin、Murray Milgate和John E. Roemer在哈佛的授业。John E. Roemer关于剥削、阶级、公正、收入再分配和机会均等的理论不仅得到了非马克思主义经济学的承认,而且也成为世界银行2006年度《世界发展报告:公平与发展》的理论基础之一。1984年,我在巴黎蓬皮杜图书馆度过了一个痴心学习当代马克思主义的美好夏天。我狂热地阅读John E. Roemer的《马克思经济理论的分析基础》(Analytical Foundations of Marxian Economic Theory)、《剥削和阶级的一般理论》(A General Theory of Exploitation and Class)和Michio Morishima的《马克思的经济学》(Marx's Economics)。这些书把马克思主义带进了一个数理经济学的新天地。相当偶然,我居然于同一个夏天在巴黎拉丁区的一家书店里买到了董辅礽先生和刘国光先生分别发表的两本有关国民收入再生产的论文集(生活·读书·新知三联书店1980年出版)。我写了大量的笔记去评价两位先生修正和改造马克思再生产理论的算术和代数模型。当时我感到如果董辅礽先生和刘国光先生能初步了解投入—产出分析、哈罗德—多马尔经济增长模型、索洛经济增长模型和动态一般均衡理论该多好啊!若如是,他俩至少可以在青年和中年时代像Michio Morishima和John E. Roemer一样去发展当代马克思主义。从1987年开始,我多次同董辅礽先生聊起他和刘国光先生在二十世纪六十年代有关国民收入各部类平衡的模型所进行的学术争论。董辅礽先生总是要我不要再提那些幼稚的模型了。他说,他们这代人数学基础太差了,加上时代背景也不允许,不可能把马克思主义经济学带进一个新的时代。董辅礽先生谦虚而诚恳地鼓励我们后辈向Morishima、Jon Elster和John E. Roemer等学习,发展马克思的国民收入简单再生产、扩大再生产、资本主义积累和经济周期的理论。而我们这一代人也做得太差了,愧对董辅礽先生的在天之灵。我斗胆提

出，在当今中国没有一个人对当代数理马克思主义作出过基本贡献，而 John E. Roemer 或许能以马克思主义者的身份获得经济学诺贝尔纪念奖。

记得也是在 1984 年，年轻狂妄的我在哈佛第一次见到了在耶鲁大学进修的吴敬琏先生。他是代表中国政府来哈佛给中国留学生介绍国内当时的改革开放形势的。我在会上的发言一定给吴敬琏先生留下了深刻的印象。他在会上其实也没有多说话。据我后来的了解，他对 Janos Kornai 的短缺经济学和预算软约束倒是有兴趣。他的忘年交耶鲁硕士钱颖一于 1984 年秋季来到哈佛攻读经济学博士学位。恰巧 Janos Kornai 于 1985 年来到哈佛任教。钱颖一、许成钢、李稻葵和王一江四人都师从 Kornai 从事短缺经济学和预算软约束的研究。而樊纲正在 NBER 访问，他还蛮有干劲地同李稻葵和王一江等学习一年级研究生的课程。后来樊纲没有在哈佛得到博士入学通知书，大概是李稻葵、王一江和胡祖六三人同时得到哈佛的录取，把他给挤掉了。Dwight Perkins、Martin Feldstein 和我都为樊纲没有得到哈佛的录取通知书而深感遗憾。后来樊纲回国后很快拿到了中国社会科学院的博士学位，并写出了中国社会主义宏观经济学大纲的专著。我癫狂地同他们也讨论一些 Kornai 的学问，用动态优化的方法写了好几篇投资饥饿症、短缺、社会主义投资周期的文章（见邹恒甫：《财政、经济增长和动态经济分析》，北京大学出版社，2000 年）。Kornai 的一些思想也帮助我研究中央和地方的财政分权（见本书第 8、9、10、11 和 12 章），中央政府对地方政府的财政软约束给财政分权和政府规模带来的影响（见本书第 13 章），财政软约束与中央政府财政赤子和宏观经济不稳定（如通货膨胀）的关系（见本书第 14 章）。我也没想到这些问题至今还是财政理论和实践中最热门的课题。与此同时，我一直还关注着中央政府的军事开支和经济增长的关系（见本书第 15 章）以及政府开支的波动和经济增长的关系（见本书第 7 章）。

我对收入分配的研究一直有兴趣。本书中的第 4、5 和 6 章记录了我这一兴趣的连续。我们得到的收入分配不平等和经济增长之间正相关的经验结论一直为世界银行所不接受。但这一结论却在学术界还总是占有微小的一席地位。这使我同 R. Barro，W. Easterly，M. Ravallion 等众多经济学家继续争论。由于争论，我们反而走得更近一些了。对此问题有兴趣的同事，请参看他们的学术论文。

对发展中国家的援助一直是世界银行、国际货币基金组织、亚洲开发银行、联合国、美洲开发银行和许多著名的经济学家热衷的话题。龚六堂和我发表了一系列论文（见本书第 16 和 17 章），说明外国援助减少发展中国家的储蓄和投资，增加对国外贷款的依赖性，妨碍经济增长和资本积累。这些结论都不为世界银行所接受。但这些结论的生命力或许会越来越强——请容许我在此作出如此乐观的预测。比起 W. Easterly 对世界银行五十年的否定、R. Barro 对国际

货币基金组织项目的批判、Rahguram Rajan 对外援的怀疑，我们的结论或许更理论化一些、更一般化一些。

最令我高兴的是我能看到新的一代在国际学术界崭露头角的中国青年经济学家比我们这一代人在国际上发表了更高档次的文章。真的，长江后浪推前浪，前浪推到沙滩上。真的，生命是灰色的，理论之树常青。我都四十三岁过了，我在学术上还有作为吗？大概没有了吧。我不妨继续办经济学教育。中国似乎总不缺有名的新闻媒体经济学家，但中国的确缺少实实在在的经济学的教书匠。我希望我的学生都当经济学的教书匠。如果他们当中出了一批新闻媒体经济学家，那一定是我的噩梦。如果他们当中有人成为世界上知名的经济学家，那一定是我的美梦。

邹恒甫

2005 年 10 月 15 日早晨 5 点至 10 点

于北京王府饭店

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产品创新、资本积累与内生经济增长

Chapter 4

Product Innovation, Capital Accumulation, and Endogenous Growth

Heng–fu Zou

Introduction

This chapter integrates both product innovation and physical capital accumulation in a simple model of endogenous growth and examines the long–run relationship between product development and capital formation. It also studies the impact of international technology transfers and international trade on long–run capital accumulation.

This work can be regarded as a continuation of the line of research initiated by Romer (1990), Grossman and Helpman (1991), and Helpman (1992). In the Romer model, the innovative products are horizontally differentiated capital goods and are produced from the homogeneous final output. These differentiated capital goods are in turn employed to produce the final output. A different modeling strategy is adopted by Grossman and Helpman. In the Grossman–Helpman model, the innovative products are intermediate inputs into the production of a single, final good. But the final good can be either consumed by households or can be invested in the form of capital accumulation by firms. In both models, a similar, perhaps surprising, conclusion has been drawn: physical capital accumulation plays only a supporting role in the story of long–run growth because the primary sources of growth are a variety of factors such as the rate of time preference, the productivity of product innovation, and the elasticity of substitution across brands, 'while the investment rate adjusts so as to keep the rate of expansion of conventional capital in line with the growth rate of output' (Helpman, 1992). Some related approaches to the dynamics of innovation and long–run growth can be found in Stokey (1988, 1991a, 1991b), Aghion and Howitt (1992), Gort and Klepper (1992), and Stein (1997).

In this chapter, we intend to offer a different perspective on capital accumulation, product innovation, and output growth. In particular, we hope to distinguish the role of the marginal productivity of capital in determining the long–run rates of both product innovation and physical capital accumulation. In our model, all differentiated goods are produced using capital input, and can be consumed, or invested to increase capital stock, or used for product innovation. This modeling option has already been pointed out in Grossman and Helpman (1991), even though they choose to model capital as the homogeneous final good.

We should not argue about the plausibility of treating capital stock as the accumulated differentiated products, because in the real world capital does take many forms such as machinery, buildings, tools, and so on. In modeling capital as differentiated goods, our model agrees with the Romer (1990) model, but it differs from the Romer model in assuming that the final consumption in our model also consists of all differentiated goods instead of a single, homogeneous good as in the Romer model.

In this alternative framework, we will demonstrate how the long–run growth rates of capital accumulation and product innovation are determined. In particular we will show the roles of the productivity of the capital stock and the efficiency of product innovation process in determining the long–run rates. In addition, we extend the basic model to an open economy and show that trade in goods not only improves welfare, but also accelerates capital accumulation. Furthermore, for a developing country receiving technology transfers from a developed country such as in the North–South model, the rate of capital accumulation in the South is shown to be partly determined by the rate of product innovation in the North.

This chapter is organized as follows. The next section will set up the dynamic model with both capital accumulation and product innovation. The growth rates of different variables will be derived. Following this, we consider the effect of technology transfers from the developed country on product innovation and capital accumulation in the developing country. The next section extends the model to the case with international trade and shows the impact of trade on capital accumulation. We then conclude this chapter.

The model

The consumer preference is the standard Dixit–Stiglitz CES utility function, which has been used by Krugman (1979), Judd (1985), and Grossman and Helpman (1991) among many others in studying the dynamic process of product innovation:

$$(4.1)\quad U = \int_0^\infty e^{-\rho t}\left(\int_0^\infty c(n,t)^\theta\, dn\right)dt,$$

where $c(n, t)$ is the rate of consuming good n at time t, ρ is the time discount rate, and $0 < \theta < 1$. Here θ has the usual economic implication that the elasticity of substitution between any two goods is $(1 - \theta)^{-1}$.

At any time t, the available variety of goods in this economy is given by $[0, N(t)]$. New product can be obtained through costly product development:

$$(4.2)\quad \dot{N}(t) = R^\alpha,$$

where R is the spending on product development, and $0 < \alpha < 1$. Obviously, α measures the efficiency level of product innovation as a higher value of α yields more new variety with the same input R than a lower value of α.

The production functions for all goods are identical:

$$(4.3) \quad x(n,t) = \beta k(n,t),$$

where $x(n, t)$ is the output of good n at time t, $k(n, t)$ is the capital input to produce good n at time t, and β is the marginal productivity of capital at time t. In the context of endogenous growth, this constant return production function specified in (4.3) has been quite popular, see Barro (1990) and Rebelo (1991) for the arguments.

At time t, the total capital stock is given by $K(t)$:

$$(4.4) \quad K(t) = \int_0^{\infty} k(n,t)dn = \int_0^{N} k(n,t)dn .$$

In our model, both physical investment and product development utilize differentiated goods. For simplicity, we assume that all differentiated goods are perfect substitutes for these two purposes, even though they are imperfect substitutes in consumption. Since the utility function is symmetric in the variety of goods and since the marginal utility of each good is diminishing, the optimal consumption of each good at time t is the same: $c(n, t) = C(t)$ for all $n \subseteq [0, N]$. Thus we can write the discounted utility in (4.1) as

$$(4.1') \quad U = \int_0^{\infty} e^{-\rho t} N(t) C(t)^{\theta} dt .$$

Furthermore, due to identical consumption for each good and identical production function in (4.3), and due to the perfect substitutability across goods in physical investment and product development, the optimal output of each good at time t is also the same: $X(t) = x(n, t)$ for $n \subseteq [0, N]$ and

$$(4.3') \quad X(t) = \beta K(t) / N(t).$$

Therefore, all products that are not consumed can be either used for investment or for product development:

$$\dot{K}(t) = \int_0^{N} x(n,t)dn - \int_0^{N} c(n,t)dn - R - \delta K,$$

here δ is the rate of capital depreciation. Upon substituting $x(n, t) = X(t)$ and $c(n, t) = C(t)$ for all $n \subseteq [0, N]$

(4.5) $\dot{K}(t) = \beta K(t) - N(t)C(t) - R(t) - \delta K(t).$

Equation (4.5) says that the aggregate output is allocated among consumption, product innovation, the replacement of the depreciated capital, and new capital formation.

The optimization problem is to maximize (4.1') subject to the two dynamic constraints (4.5) and (4.2) with the initial values $K(0)$ and $N(0)$ given.

The current value Hamiltonian is:

$$(4.6)\quad \begin{aligned} &H(K,C,N,R,\lambda,\omega) \\ &= N(t)C(t)^{\theta} + \lambda[\beta K(t) - N(t)C(t) - R(t) - \delta K(t)] + \omega R(t)^{\alpha} \end{aligned}$$

where $\lambda(t)$ is the shadow price of capital, and $\omega(t)$ is the shadow price of product variety.

The first–order conditions necessary for optimization are:

(4.7) $\theta C(t)^{\theta-1} = \lambda(t),$

(4.8) $\alpha\omega(t)R(t)^{\alpha-1} = \lambda(t),$

(4.9) $(\beta - \delta - \rho) = -\dot{\lambda}(t)/\lambda(t),$

(4.10) $C(t)^{\theta} - \lambda(t)C(t) = \omega(t)\rho - \dot{\omega}(t),$

(4.11) $\dot{K}(t) = \beta K(t) - N(t)C(t) - R(t) - \delta K(t),$

(4.12) $\dot{N}(t) = R^{\alpha},$

and the transversality conditions:

$$\lim_{t\to\infty} \lambda(t)K(t)e^{-\rho t} = 0, \lim_{t\to\infty} \omega(t)N(t)e^{-\rho t} = 0.$$

Equation (4.7) implies that the marginal utility of consumption for every product and the shadow price of capital are equalized at all time. Equation (4.8) indicates that the allocation of resource for capital formation and product innovation is guided by the equality of their shadow price ratio to their marginal cost ratio: $\lambda(t)/\omega(t) = \alpha R^{1-\alpha}$. Equations (4.9) and (4.10) are the Euler conditions for the shadow prices of capital and innovation, respectively. Equation (4.11) restates the dynamic budget constraint (4.5), and equation (4.12) restates the technology generating new product variety, namely, equation (4.2).

Denote

$$g = -\dot{\lambda}(t)/\lambda(t).$$

From (4.9),

$$g = \beta - \delta - \rho.$$

For endogenous growth to be possible, g is assumed to be positive as usually done, e.g., Barro (1990) and Rebelo (1991). Then take log–differentiation in (4.7):

(4.13) $\dot{C}(t)/C(t) = g/(1-\theta).$

Or

(4.13') $C(t) = C(0)e^{gt/(1-\theta)},$

where $C(0)$ is the initial consumption of every product, which is discussed in the appendix. Expression (4.13) says that the growth rate is positively related to the marginal productivity of capital β, negatively related to the time preference ρ, and positively related to the elasticity of substitution $(1-\theta)^{-1}$.

Substituting (4.7) into (4.10):

$$(1-\theta)C(t)^{\theta}/\omega(t) = \rho - \dot{\omega}(t)/\omega(t).$$

If we focus on a constant growth rate for the shadow price of product variety, the right–hand side of the above equation is constant. Then take log–differentiation on both sides:

(4.14) $\dot{\omega}(t)/\omega(t) = \theta\dot{C}(t)/C(t) = \theta g/(1-\theta).$

Next, log–differentiate (4.8) and use (4.9) and (4.14):

(4.15) $\dot{R}(t)/R(t) = g/(1-\theta)(1-\alpha).$

Or

(4.15') $R(t) = R(0)e^{gt/(1-\theta)(1-\alpha)},$

and $R(0)$ is the initial spending on product innovation, and it is determined in the appendix together with the initial consumption $C(0)$. In equation (4.15), the growth rate of the product–development spending is an increasing function of the marginal

productivity of capital β, the elasticity of substitution in consumption $(1-\theta)^{-1}$, the efficiency of innovation technology α, but it is a decreasing function of the time preference ρ.

With (4.12) and (4.15'), we can solve the variety of products available at time t given the initial variety $N(0)$:

$$(4.16)\quad \begin{aligned} N(t) &= [R^{\alpha}(0)(1-\theta)(1-\alpha)/\alpha g[e^{\alpha g t/(1-\theta)(1-\alpha)}-1]+N(0) \\ &= R(t)^{\alpha}[(1-\theta)(1-\alpha)/\alpha g]+A(0), \end{aligned}$$

where $A(0) = [N(0) - R^{\alpha}(0)(1-\theta)(1-\alpha)/\alpha g]$. If $R(0)$ is known, $A(0)$ is just a constant because $N(0)$ is given.

The growth rate of the variety of products is given by:

$$\dot{N}(t)/N(t) = \{[(1-\theta)(1-\alpha)/\alpha g]+A(0)R(t)^{-\alpha}\}^{-1}$$

Since $R(t)$ approaches infinity as time t goes to infinity, the long-run growth rate of the variety is:

$$(4.17)\quad \lim_{t\to\infty}\dot{N}(t)/N(t) = \alpha g/(1-\theta)(1-\alpha),$$

which is the product of the efficiency of product innovation, α, and the growth rate of product-development spending,

$$\dot{R}(t)/R(t).$$

With the solutions of consumption and product variety, we can calculate the discounted utility:

$$\begin{aligned} U &= \int_0^{\infty} N(t)C(t)^{\theta}e^{-\rho t}dt \\ &= \int_0^{\infty} R(0)^{\alpha}C(0)^{\theta}[(1-\theta)(1-\alpha)/\alpha g]e^{[-\rho+\theta g/(1-\theta)+\alpha g/(1-\theta)(1-\alpha)]t}dt \\ &\quad + \int_0^{\infty} C(0)^{\theta}A(0)e^{[-\rho+\theta g/(1-\theta)]t}dt. \end{aligned}$$

For the above expression to be bounded, the following condition is required:

$$\theta g/(1-\theta)+\alpha g/(1-\theta)(1-\alpha) < \rho.$$

Since $g = \beta - \delta - \rho > 0$, the condition above is the same as

$$(4.18)\quad (\beta-\delta)(\alpha+\theta-\alpha\theta) < \rho.$$

Condition (18) also implies that

(4.19) $g/(1-\theta)(1-\alpha) < (\beta-\delta)$.

Now to find the optimal path of capital accumulation, we substitute (4.13'). (4.15'), and (4.16) into (4.11) and solve:

$$
\begin{aligned}
K(t) = &-[R(0)+C(0)R(0)^{\alpha}(1-\theta)(1-\alpha)/\alpha g] \\
&\cdot[g/(1-\theta)(1-\alpha)-(\beta-\delta)]^{-1}e^{gt/(1-\theta)(1-\alpha)} \\
&-A(0)C(0)[g/(1-\theta)-(\beta-\delta)]^{-1}e^{gt/(1-\theta)}+B(0)e^{(\beta-\delta)t}
\end{aligned} \tag{4.20}
$$

where

$$
\begin{aligned}
B(0) = K(0) &+ [R(0)+C(0)R(0)^{\alpha}(1-\theta)(1-\alpha)/\alpha g] \\
&\cdot[g/(1-\theta)(1-\alpha)-(\beta-\delta)]^{-1} \\
&+A(0)C(0)[g/(1-\theta)-(\beta-\delta)]^{-1}.
\end{aligned}
$$

For capital accumulation and product innovation, we want to make sure that the transversality conditions are satisfied. Using condition (4.19), we can easily show that

$$\lim_{t\to\infty}\omega(t)N(t)e^{-\rho t}=0.$$

But for the capital stock,

$$\lim_{t\to\infty}\lambda(t)K(t)e^{-\rho t}=\lim_{t\to\infty}\theta C(0)^{\theta-1}K(t)e^{-(\beta-\delta)t}=\theta C(0)^{\theta-1}B(0).$$

Hence the transversality condition requires that

(4.21) $B(0)=0$.

Substituting (4.21) into the capital–accumulation equation (4.20):

$$
\begin{aligned}
K(t) = &-[R(0)+C(0)R(0)^{\alpha}(1-\theta)(1-\alpha)/\alpha g] \\
&\cdot[g/(1-\theta)(1-\alpha)-(\beta-\delta)]^{-1}e^{gt/(1-\theta)(1-\alpha)} \\
&-A(0)C(0)[g/(1-\theta)-(\beta-\delta)]^{-1}e^{gt/(1-\theta)}.
\end{aligned} \tag{4.22}
$$

Since $g/(1-\theta)(1-\alpha) < (\beta-\delta)$ the first term on the right hand side of (22) is positive. Furthermore, since $g/(1-\theta)(1-\alpha) > g/(1-\theta)$ the first term will dominate

the second term as time t goes to infinity, and the long–run growth rate of the capital stock is:

(4.23) $\lim_{t\to\infty} \dot{K}(t)/K(t) = g/(1-\theta)(1-\alpha).$

Thus the long–run growth rate of capital is the same as the growth rate of product development spending. In particular, equation (23) implies that in the long run the preference, the innovation technology, and the productivity of capital jointly determine the growth rate of capital. This result is very different from the ones obtained by Romer (1990) and Helpman (1992) because the marginal productivity of capital plays no role in the determination of the long–run growth rate in their models.

In concluding this section, we make a general observation based on the expressions for the growth rates of the endogenous variables. Even though the growth rates for the endogenous variables are eventually constant, they differ in their magnitudes. In fact, the long–run growth rate of capital accumulation and the growth rate of product development spending are higher than the consumption growth rate:

(4.24) $g/(1-\theta)(1-\alpha) > g/(1-\theta)$

for $0 < \alpha < 1$. The long–run growth rate of product variety is smaller than the long–run growth rate of the capital stock, but it may be higher or lower than the rate of consumption growth depending on whether $\alpha/(1-\alpha)$ is larger or smaller than one.

Effects of technology transfers

Technology transfers have recently received considerable attention since Krugman (1979) has formally modeled them in a North–South product–cycle model; see Dollar (1986, 1987). Here we extend our model to the case of exogenous technology transfers from the North to the South. Think the country in our model as the South. As in Krugman (1979), the South receives technology transfers from the North in the following way: at any time t, it obtains part of the know–how about how to produce the product variety in the developed world without incurring any cost:

(4.25) $\dot{N}(t) = R(t)^{\alpha} + \pi N^{*}(t).$

In (4.25), $N^{*}(t)$ is the product variety known in the North, and $\pi(>0)$ is the rate of technology transfers.

With equation (4.25) replacing equation (4.2), the optimal conditions for consumption and product development spending are not altered. In particular, the growth rates are the same:

$$\dot{C}(t)/C(t) = g/(1-\theta),$$

and

$$\dot{R}(t)/R(t) = g/(1-\theta)(1-\alpha).$$

The important change is the dynamic equation for product innovation. Substitute $R(t)$ into $N(t)$ and solve for $N(t)$:

$$(4.26)\quad N(t) = A'(0) + [R^{\alpha}(0)(1-\theta)(1-\alpha)/\alpha g]e^{\alpha g t/(1-\theta)(1-\alpha)} + \int \pi N^{*}(t)dt.$$

If the growth rate of product variety in the North is given by an exogenous rate γ: $N^{*}/N^{*} = \gamma$, as in Krugman (1978), then

$$N(t) = A'(0) + [R^{\alpha}(0)(1-\theta)(1-\alpha)/\alpha g]e^{\alpha g t/(1-\theta)(1-\alpha)} + \pi N^{*}(0)e^{\gamma t}/\gamma.$$

where $A'(0) = N(0) - [R^{\alpha}(0)(1-\theta)(1-\alpha)] - \pi N^{*}(0)/\gamma$. If $\gamma > \alpha g/(1-\theta)(1-\alpha)$, then $N(t)$ will grow eventually at the rate of γ. If we imagine that over time the South can catch up with the efficiency levels of both capital and innovation in the North, then $\gamma > \alpha g/(1-\theta)(1-\alpha)$. In general the long-run growth rate is:

$$(4.27)\quad \lim_{t\to\infty} \dot{N}(t)/N(t) = \max[\alpha g/(1-\theta)(1-\alpha, \gamma].$$

Again we want to make sure that the discounted utility is bounded. Substitute $C(t)$ and $N(t)$ into the objective function:

$$\begin{aligned} U = &\int_0^{\infty} C(0)^{\theta} A'(0) e^{[-\rho+\theta g/(1-\theta)]t} dt \\ &+ \int_0^{\infty} R(0)^{\alpha} C(0)^{\theta} [(1-\theta)(1-\alpha)/\alpha g] e^{[-\rho+\theta g/(1-\theta)+\alpha g/(1-\theta)(1-\alpha)]t} dt \\ &+ \int_0^{\infty} [C(0)^{\theta} \pi/\gamma] e^{[-\rho+\theta g/(1-\theta)+\gamma]t} dt. \end{aligned}$$

For the expression above to be bounded, the following condition is required:

$$(4.28)\quad \rho > \max[\gamma + \theta g/(1-\theta), \alpha g/(1-\theta)(1-\alpha) + \theta g/(1-\theta)].$$

It is obvious that technology transfers can lead to more rapid product innovation in the developing country. But how do these transfers affect capital accumulation in the developing South? To answer this question, we solve for $K(t)$ in the budget constraint (11) with substitution for $C(t)$, $N(t)$, and $R(t)$:

$$
\begin{aligned}
K(t) = & -[R(0)+C(0)R(0)^{\alpha}(1-\theta)(1-\alpha)/\alpha g] \\
& \cdot[g/(1-\theta)(1-\alpha)-(\beta-\delta)]^{-1}e^{gt/(1-\theta)(1-\alpha)} \\
& -[C(0)N^{*}(0)\pi/\gamma][\gamma+g/(1-\theta)-(\beta-\delta)]^{-1}e^{[\gamma+g/(1-\theta)]t} \\
& -A^{*}(0)C(0)[g/(1-\theta)-(\beta-\delta)]^{-1}e^{gt/(1-\theta)}.
\end{aligned} \tag{4.29}
$$

As before, in deriving (4.29) we have used the transversality condition to impose the requirement:

$$
\begin{aligned}
B^{*}(0) = & K(0) \\
& +[R(0)+C(0)R(0)^{\alpha}(1-\theta)(1-\alpha)/\alpha g][g/(1-\theta)(1-\alpha)-(\beta-\delta)]^{-1} \\
& +[C(0)N^{*}(0)\pi/\gamma][\gamma+g/(1-\theta)-(\beta-\delta)]^{-1} \\
& +A^{*}(0)C(0)[g/(1-\theta)-(\beta-\delta)]^{-1}=0.
\end{aligned} \tag{4.30}
$$

In examining (4.29), we note that the coefficient for $e^{[\gamma+g/(1-\theta)]t}$ is always positive under the condition (28) because $[\gamma+g/(1-\theta)]<\rho<(\beta-\delta)$ (recall that $g=\beta-\delta-\rho>0$ or $\beta-\delta>\rho$). Therefore, the rate of product innovation in the developed North, γ, stimulates capital accumulation in the developing South. Not only this, the long run growth rate of capital also depends on the rate of product innovation in the developed North:

$$
\lim_{t\to\infty}\dot{K}(t)/K(t)=\max[\gamma+g/(1-\theta),g/(1-\theta)(1-\alpha)] \tag{4.31}
$$

that is to say, if $\gamma>\alpha g/(1-\theta)(1-\alpha)$, i.e., the rate of product innovation in the North is larger than the rate of product innovation in the South without technology transfers, then the long–run rate of capital accumulation in the South, not only the level of capital accumulation, is partly determined by the rate of product innovation in the North. In this case, the higher the rate of product innovation in the developed North, the higher the product innovation in the developing South, and the higher the long–run equilibrium growth rate of the capital stock in the developing South. Thus the link between capital accumulation in the developing country and technology transfers from the developed world is established in our model.

The economic intuition of this link is as follows. As technology transfers from the North accelerate product innovation in the South, more product variety will become available in the South, and more consumption demand for variety will be generated. To meet the rising consumption demand, the South will expand its capital stock and raise the production capacity. Thus technology transfers from the North lead to faster capital accumulation in the South.

Finally, to complete our solution, we need to determine the initial values $C(0)$ and $R(0)$. Schematically, we can just follow what we have done in the appendix and we omit this part here.

Effects of international trade

In this section, we want to show that foreign trade, even without technology transfers, can stimulate the rate of capital accumulation. This result applies to the developing country as well as to the developed country.

Assume that there are two countries in the world: the home country and the foreign country. The model we consider here is for, say, the home country. With foreign goods introduced into the model symmetrically as in Judd (1985), and Grossman and Helpman (1991), the objective function of the home country is modified to be:

$$(4.32)\quad \max U = \int_0^\infty e^{-\rho t}[N(t)+N^*(t)]C(t)^\theta dt,$$

subject to

$$(4.33)\quad \dot{K}(t) = \beta K(t) - [N(t)+N^*(t)]C(t) - R(t) - \delta K(t),$$

$$(4.34)\quad \dot{N}(t) = R(t)^\alpha,$$

where $N^*(t)$ is the number of product variety in the foreign country. In writing (4.32) and (4.33), we have assumed that all foreign goods prices are equal to one in terms of home goods. Since all goods are symmetric in the utility function, the consumption level of each good will be the same, namely, $C(t)$.

With these modifications, no change has been made on equations (4.7), (4.8), (4.9), and (4.12). Therefore, the growth rates for the consumption level of each good, the product–development spending, and the product variety remain the same as in section 2. Therefore we still have

$$(4.13)\quad \dot{C}(t)/C(t) = g/(1-\theta),$$

$$(4.15)\quad \dot{R}(t)/R(t) = g/(1-\theta)(1-\alpha),$$

$$(4.17)\quad \lim_{t\to\infty} \dot{N}(t)/N(t) = \alpha g/(1-\theta)(1-\alpha).$$

Thus, unlike the case of technology transfers, the growth rate of product variety is not affected by foreign trade even though the number of variety consumed in the home country increases by $N^*(t)$ at time t.

We still assume that the product variety in the foreign country grows at an exogenous rate ($\gamma = \dot{N}^*(t)/N^*(t)$) and the initial variety in the foreign country is $N^*(0)$. Then the discounted utility in the home country is

$$U = \int_0^\infty C(0)^\theta A(0) e^{[-\rho+\theta g/(1-\theta)]t} dt$$
$$+ \int_0^\infty R(0)^\alpha C(0)^\theta [(1-\theta)(1-\alpha)/\alpha g] e^{[-\rho+\theta g/(1-\theta)+\alpha g/(1-\theta)(1-\alpha)]t} dt$$
$$+ \int_0^\infty [C(0)^\theta N^*(0)] e^{[-\rho+\theta g/(1-\theta)+\gamma]t} dt.$$

The last term in this expression represents the welfare gain from consuming the foreign variety of products. Again, for this discounted utility to be bounded, the following condition is required:

(4.28) $\rho > \max[\gamma + \theta g/(1-\theta), \alpha g/(1-\theta)(1-\alpha) + \theta g/(1-\theta)].$

To see the impact of trade on capital accumulation in the home country, we solve (4.33):

$$\begin{aligned} K(t) = & -[R(0) + C(0)R(0)^\alpha (1-\theta)(1-\alpha)/\alpha g] \\ & \cdot [g/(1-\theta)(1-\alpha) - (\beta-\delta)]^{-1} e^{gt/(1-\theta)(1-\alpha)} \\ & -[C(0)N^*(0)][\gamma + g/(1-\theta) - (\beta-\delta)]^{-1} e^{[\gamma+g/(1-\theta)]t} \\ & - A(0)C(0)[g/(1-\theta) - (\beta-\delta)]^{-1} e^{gt/(1-\theta)}. \end{aligned} \tag{4.35}$$

The imposition of the transversality condition on the capital stock gives rise to:

$$\begin{aligned} B''(0) = & K(0) \\ & + [R(0) + C(0)R(0)^\alpha (1-\theta)(1-\alpha)/\alpha g][g/(1-\theta)(1-\alpha) - (\beta-\delta)]^{-1} \\ & + [C(0)N^*(0)][\gamma + g/(1-\theta) - (\beta-\delta)]^{-1} \\ & + A(0)C(0)[g/(1-\theta) - (\beta-\delta)]^{-1} = 0. \end{aligned} \tag{4.36}$$

In equation (4.35), we note that the coefficient for $e^{[\gamma + g/(1-\theta)]t}$ is again positive under the condition (4.28) because $[\gamma + g/(1-\theta)] < \rho < (\beta - \delta)$. Therefore, trade with the foreign country brings about more capital accumulation in the home country. Essentially, trade plays the role of technology transfers in stimulating capital accumulation in the home country. In the long run,

$$\begin{aligned} \lim_{t\to\infty} \dot{K}(t)/K(t) &= \max[\gamma + g/(1-\theta), g/(1-\theta)(1-\alpha)] \\ &= \max[(N^*/N^*) + g/(1-\theta), g/(1-\theta)(1-\alpha)]. \end{aligned} \tag{4.37}$$

Thus, the growth rate of the capital stock in the home country is increasing with the growth rate of product variety available from the foreign country. To provide the economic intuition for this result, we note that the availability of foreign goods is always welfare–enhancing for the home country given the Dixit–Stiglitz consumer

preference. But the rising consumption of the foreign goods needs to be financed through the exports of the home goods, which in turn call for the expansion of the capital stock in the home country in order to produce more home goods in exchange for more foreign goods.

Conclusion

This chapter has extended the Romer model and the Grossman–Helpman model to the case here in which consumption, investment, and product development use differentiated goods, while all goods are produced with capital. This simple framework has shown that the interaction among the productivity of capital, the efficiency in innovation and consumer preferences determine the long–run rates of both product innovation and capital accumulation. Thus the one–way causality from product innovation to capital accumulation in the Romer model and the Grossman–Helpman model has been revised to the two–way interaction in our model.

This simple framework has also been utilized to examine the effects of technology transfers and international trade on product innovation and capital accumulation in an open economy. Even though the stimulating impact of trade and technology transfers on capital accumulation and growth has observed empirically in many developing countries, our theoretical model has provided a strong argument in establishing the causality from technology transfers and trade to rapid capital accumulation and product innovation.

The simple model can also be extended to deal with other issues related to economic openness and growth in developing countries. In particular, we can consider how exports and technology imports in developing countries affect capital accumulation, consumption, and innovation in a two–gap model with both domestic technology (domestic capital) and foreign technology (foreign capital) (Zou, 1998a). In addition, in this model, we have assumed perfect competition in the world product market. If a developing country's exports have certain market power, intertemporal pricing of exports becomes an important issue for a developing country in determining the optimal paths of accumulation and innovation, and we have studied part of this issue in Zou (1998b).

Appendix: determination of the initial values

To complete our solutions to the dynamic paths of consumption, product development spending, innovation, and capital accumulation in section 2, we must determine the initial values of consumption $C(0)$ and product–development spending $R(0)$, given the initial values of two state variables $K(0)$ and $N(0)$. That can be done as follows.

We first note that condition (21), $B(0) = 0$, provides us a nonlinear relationship between $C(0)$ and $R(0)$ with $K(0)$ and $N(0)$ given.

Now differentiate the dynamic equation of capital accumulation (4.22) with respect to t and evaluate the derivative at $t = 0$:

$$\begin{aligned}\dot{K}(0) = &-[R(0)+C(0)R(0)^{\alpha}(1-\theta)(1-\alpha)/\alpha g]\\ &\cdot[g/(1-\theta)(1-\alpha)-(\beta-\delta)]^{-1}g/(1-\theta)(1-\alpha)\\ &-A(0)C(0)[g/(1-\theta)-(\beta-\delta)]^{-1}g/(1-\theta).\end{aligned}$$

Combining this initial investment equation with the dynamic budget constraint in (4.11) evaluated at $t = 0$:

$$\dot{K}(0) = \beta K(0) - N(0)C(0) - R(0) - \delta K(0),$$

we obtain another relationship between $C(0)$ and $R(0)$:

$$\begin{aligned}&-[R(0)+C(0)R(0)^{\alpha}(1-\theta)(1-\alpha)/\alpha g]\\ &\cdot[g/(1-\theta)(1-\alpha)-(\beta-\delta)]^{-1}g/(1-\theta)(1-\alpha)\\ &-A(0)C(0)[g/(1-\theta)-(\beta-\delta)]^{-1}g/(1-\theta)\\ &=\beta K(0)-N(0)C(0)-R(0)-\delta K(0).\end{aligned} \tag{4.38}$$

With $C(0)$ and $R(0)$ determined from equations (4.22) and (4.38), the optimal initial invest is given by the dynamic budget constraint (4.11) and the initial increase in product variety is given by

$$\dot{N}(0) = R(0)^{\alpha}.$$

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第 2 章

货币、社会地位与资本积累

LIUTANG GONG
HENG-FU ZOU

Money, Social Status, and Capital Accumulation in a Cash-in-Advance Model

This paper presents an infinite-horizon model of optimal capital accumulation with the social-status concern and the cash-in-advance constraint. When the cash-in-advance constraint applies to both consumption and investment, money is not superneutral. If only consumption is subject to the cash-in-advance constraint, inflation increases capital accumulation.

IN GROWTH AND ASSET-PRICING MODELS, wealth accumulation is often taken to be solely driven by one's desire to increase consumption rewards. The representative agent chooses his consumption path to maximize his discounted utility, which is defined only on consumption. Whereas this motive is important for wealth accumulation, it is, however, not the only motive. As social animals, people accumulate wealth also to gain prestige, social status, and power in the society. Possession of wealth is, to a considerable degree, a measure and standard of a person's success in a society. There is a recent literature that has paid attention to this motive[1] which cogently argues that concern for social status is instrumental in obtaining nonmarket goods. For example, Cole, Mailath, and Postlewaite (1992) have presented a model in which people care about relative wealth because relative wealth affects mating. When matching is positively assortative on wealth, individuals who are higher in the wealth distribution for their sex will end up with richer mates and higher consumption. In particular, they have shown that if wealth determines the pattern of marriage, the reduced-form preferences of individuals will take the structure as follows:

$$u(C_t, W_t) ,$$

where $u(.,.)$ is the utility function, C is consumption, and W is wealth. Another inter-

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1. See Frank (1985), Cole, Mailath, and Postlewaite (1992, 1995), Fershtman and Weiss (1993), Zou (1994, 1995, 1998), Bakshi and Chen (1996), and Fershtman, Murphy, and Weiss (1996), among others.

LIUTANG GONG *is associate professor and* HENG-FU ZOU *is professor of economics, Peking University and Wuhan University. E-mail:* ltgong@gsm.pku.edu.cn

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pretation of this model is in line with the spirit of capitalism in the sense of Weber (1958, p. 53): "Man is dominated by the making of money, by acquisition as the ultimate purpose of his life. Economic acquisition is no longer subordinated to man as the means for the satisfaction of this material need. This reversal of what we should call the natural relationship . . . is evidently a leading principle of capitalism."[2]

With the wealth-is-status or the-spirit-of-capitalism model, many studies have tried to offer new perspectives on economic growth, savings, and asset pricing. In this paper, we extend the wealth-is-status model from a real economy to a monetary economy and examine how inflation and monetary growth affect capital accumulation. The relationship between inflation and growth has been a controversial topic in macroeconomics since the 1960s. In an early contribution, Tobin (1965) demonstrates a positive effect of inflation on capital accumulation as a result of portfolio shift from non-interest-bearing real balances to the capital stock. Since then, many plausible models based on explicit optimization over an infinite horizon have been produced. The famous infinite-horizon model belongs to Sidrauski (1967). He shows that if the agent maximizes an additive, discounted lifetime utility defined on consumption and real balances, and if the marginal product of capital depends only on the capital-labor ratio, then the steady-state value of capital accumulation is independent of monetary growth or inflation. This result is known as the superneutrality of money.

However, in a significant contribution to the literature, Stockman (1981) imposes the cash-in-advance constraint on both consumption and investment, and obtains the surprising result that a permanent increase in the rate of monetary growth leads to a decrease in the steady-state value of the capital stock. Yet if the cash-in-advance constraint applies only to consumption, then money is still superneutral in the long run.[3] How does the inclusion of the wealth-is-status factor alter the conclusions in the Stockman model? This is our main task here.

The paper is organized as follows. Section 1 sets up an optimal growth model with both the social-status concern and the cash-in-advance constraint on consumption and investment. Section 2 analyzes the effects of monetary growth on the steady-state capital stock. It is shown that (1) with cash for consumption, inflation leads to more capital accumulation in the long run; and (2) with cash for both consumption and investment, inflation has an ambiguous effect on capital accumulation. Section 3 concludes.

1. THE MODEL

It is straightforward to extend the Stockman model to include the social-status concern.[4] For simplicity, we assume that the representative agent's instantaneous

2. See Zou (1994, 1995, 1998), and Bakshi and Chen (1996) for details.

3. See Abel (1985) for further development on the short-run effects of inflation on capital accumulation with cash for consumption and cash for both consumption and investment.

4. Our notations follow Abel (1985) closely.

utility is separable in consumption C and wealth W. Furthermore, let γ measure the agent's desire for social status. Then

$$U_1(C) + \gamma U_2(W) .$$

ASSUMPTION 1: $U_1(.): R^+ \to R, U_2(.): R^+ \to R$ *are twice continuously differentiable on* $(0,\infty)$.

ASSUMPTION 2: $U_1' > 0, U_2' > 0, U_1'' < 0, U_2'' < 0$ *on* $(0,\infty)$ *and*

$$\lim_{C\to 0} U_1'(C) = +\infty, \lim_{W\to 0} U_2'(W) = +\infty .$$

The time preference discount factor of the agent is given by β, and $0 < \beta < 1$. The objective of the representative agent is to maximize the present discounted value of the utility of consumption and wealth:

$$\sum_{t=0}^{\infty} \beta^t (U_1(C_t) + \gamma U_2(W_t)), \tag{1}$$

and

$$W_t = K_t + \frac{M_t + \tau_t}{P_t}, \tag{2}$$

where W_t is total real wealth at time t, which is the sum of the capital stock, K_t, and real balances, $\frac{M_t + \tau_t}{P_t}$; τ_t is the nominal money transfers received by the agent from the government at the beginning of time t; P_t is the money price of the homogeneous good at time t; $\gamma U_2(W_t)$ is the utility the representative agent derives directly from wealth accumulated at time t.

The production function, $f(K_t)$, is neoclassical with

$$f'(.) > 0. f''(.) < 0 . \tag{3}$$

Now, the budget constraint for the agent can be written as

$$C_t + K_{t+1} + \frac{M_{t+1}}{P_t} = f(K_t) + (1-\delta)K_t + \frac{M_t + \tau_t}{P_t}, \tag{4}$$

where δ is the rate of physical depreciation of capital.

As in Stockman (1981) and Abel (1985), the cash-in-advance constraint on consumption and investment is given in the general form

$$C_t + \mu K_{t+1} - \mu(1-\delta)K_t \le \frac{M_t + \tau_t}{P_t}, \tag{5}$$

where $\mu = 0$ or 1. When $\mu = 0$, equation (5) implies that the nominal value of consumption during period t must be less than or equal to the money on hand at the beginning of the period t. When $\mu = 1$, it says that the nominal value of consumption plus gross investment during a period cannot be greater than the money on hand at the beginning of the period.

Now, the representative agent chooses his consumption path, $\{C_t\}_{t=0}^{\infty}$, capital-accumulation path, $\{K_t\}_{t=0}^{\infty}$, and money-holdings path, $\{M_t\}_{t=0}^{\infty}$, to maximize his discounted utility

$$\max_{\{C_t\}_{t=0}^{\infty},\{K_t\}_{t=0}^{\infty},\{M_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t (U_1(C_t) + \gamma U_2(W_t)), \tag{6}$$

subject to the budget constraint (4) and the cash-in-advance constraint (5), with the given initial values of K_0 and M_0.

The Lagrangian function is defined by

$$\begin{aligned} L = B^t \Bigg\{ & U_1(C_t) + \gamma U_2\left(K_t + \frac{M_t + \tau_t}{P_t}\right) \\ & + \lambda_t \left(f(K_t) + (1-\delta)K_t + \frac{M_t + \tau_t}{P_t} - C_t - K_{t+1} - \frac{M_{t+1}}{P_t} \right) \\ & + \nu_t \left(\frac{M_t + \tau_t}{P_t} - C_t - \mu K_{t+1} + \mu(1-\delta)K_t \right) \Bigg\}, \end{aligned} \tag{7}$$

where λ_t is the Lagrangian multiplier associated with the budget constraint (4), and it represents the marginal utility of wealth. ν_t is the Lagrangian multiplier associated with the cash-in-advance constraint (5). The first-order conditions for optimization are

$$U_1'(C_t) = \lambda_t + \nu_t, \tag{8}$$

$$\begin{aligned} & \beta\lambda_{t+1}(f'(K_{t+1}) + (1-\delta)) + \beta\mu(1-\delta)\nu_{t+1} \\ & \qquad + \beta\gamma U_2'\left(K_{t+1} + \frac{M_{t+1} + \tau_{t+1}}{P_{t+1}}\right) = \lambda_t + \mu\nu_t, \end{aligned} \tag{9}$$

$$\frac{\beta\gamma}{P_{t+1}}U_2'\left(K_{t+1}+\frac{M_{t+1}+\tau_{t+1}}{P_{t+1}}\right)+\frac{\beta}{P_{t+1}}(\lambda_{t+1}+\nu_{t+1})=\frac{\lambda}{P_t}, \tag{10}$$

and the slackness condition:

$$\nu_t\left(\frac{M_t+\tau_t}{P_t}-C_t-\mu(K_{t+1}-(1-\delta)K_t)\right)=0, \nu_t\geq 0. \tag{11}$$

Equation (8) is just the familiar condition, which asserts that the marginal utility of current consumption equals the marginal cost of current consumption, that is, the marginal utility of having an additional unit of wealth. Equation (9) implies that the marginal utility of having an additional unit of capital equals the marginal cost of having an additional unit of capital. Equation (10) states that the discounted value of the marginal utility of having an additional unit of wealth at the beginning of time $t+1$ equals the deflated marginal cost of having an additional unit of wealth in this period.

In the steady state, we have a constant capital stock, K, a constant level of consumption, C, and a constant (gross) rate of inflation, $\pi_t=\frac{P_t}{P_{t-1}}$, which is equal to the constant (gross) rate of monetary growth, $\sigma=\frac{M_t}{M_{t-1}}$. Furthermore, from the definition we know that both λ_t and ν_t are constant. Then, in the steady state, we have[5]

$$C=f(K)-\delta K, \tag{12}$$

$$\beta(f'(K)+1-\delta)=1+\mu\left(\frac{\sigma}{\beta}-1\right)(1-\beta(1-\delta)) - \frac{\sigma\gamma U_2'(K+C+\mu\delta K)A}{\beta(U_2'(C)+\gamma U_2'(K+C+\mu\delta K))}, \tag{13}$$

where $A=\mu(1+\beta\delta)+(1-\mu)\beta$. We have also used the fact that $M_{t+1}=M_t+\tau_t$ in the budget constraint (4) in order to obtain the steady-state condition (12).

Equation (12) implies that the steady-state output is used for the agent's consumption and the replacement of depreciated capital stock. Equation (13) is the optimal rule of capital accumulation with the desire for social status. When $\mu=0$ and $\gamma=0$, it is reduced to

5. The formal proof of these steady-state conditions is available upon request. In addition, note that the necessary condition for the existence of a steady state is $\sigma\geq\beta+\beta\gamma\frac{U_2'(K+f(K)-(1-\mu)\delta K)}{U_1'(C)}$.

$$\beta(f'(K) + 1 - \delta) = 1,$$

which is the discrete version of the modified golden rule, and it implies that money is superneutral when consumption is subject to the cash-in-advance constraint. But, with the concern for social status, namely, $\gamma > 0$, even if the cash-in-advance constraint applies only to consumption, we still have

$$\beta(f'(K)+1-\delta)=1-\frac{\sigma\gamma U_2'(K+C)}{(U_1'(C)+\gamma U_2'(K+C))}, \tag{14}$$

Hence, capital accumulation is related to monetary growth, and money is not superneutral. We turn to a more detailed analysis of the effects of inflation in the next section.

2. EFFECTS OF INFLATION

Recall that Stockman (1981) has shown that (1) when the cash-in-advance constraint applies only to consumption, money is superneutral; and (2) if the cash-in-advance constraint applies to both consumption and investment, inflation always reduces capital accumulation in the long run. By including the wealth-induced social status in the model we can obtain a series of results that are very different.

2.1 Cash for Consumption

First let us consider the case where the cash-in-advance constraint applies only to consumption, that is, $\mu = 0$ in (5). As shown in the appendix, we have

$$\frac{dK}{d\sigma}=\frac{-\gamma U_2'(.)}{\Delta(\mu=0)\beta(U_1'(.)+\gamma U_2'(.))}, \tag{15}$$

$$\frac{dC}{d\sigma}=\frac{-\gamma U_2'(.)}{\Delta(\mu=0)\beta(U_1'(.)+\gamma U_2'(.))}(f'-\delta), \tag{16}$$

where

$$\Delta(\mu=0)=\frac{\sigma\gamma\beta(f'-\delta)(U_2''(.)U_1'(.)-U_2'(.)U_1''(.))}{\beta(U_1'(.)+\gamma U_2'(.))^2}$$

$$+\beta f''(K)+\frac{\sigma A U_1'(.)\gamma U_2''(.)}{\beta(U_1'(.)+\gamma U_2'(.))^2}. \tag{17}$$

For saddle-point stability of the system, $\Delta(\mu = 0)$ is negative.[6] Therefore,

$$\frac{dK}{d\sigma} \geq 0, \frac{dC}{d\sigma} \geq 0 . \tag{18}$$

PROPOSITION 1: *If the cash-in-advance constraint applies only to consumption, then, on the perfect-foresight path, inflation leads to more accumulation of capital and a higher level of consumption in the long run.*

In fact, if the growth rate of the money supply increases, it will be more costly for the status-seeking agent to hold real balances than capital in order to maintain the same wealth level and the same social status. Hence, the agent will decrease his money holdings and invest more in the capital stock. This portfolio-shift process results in more capital accumulation and higher consumption in the long run.

2.2. *Cash for Both Consumption and Investment*

If both consumption and investment are subject to the cash-in-advance constraint, we have, from the appendix,

$$\frac{dK}{d\sigma} = \frac{(1+\beta\delta)U_1' - \beta(U_1'(.) + \gamma U_2'(.))}{\Delta(\mu = 1)\beta(U_1'(.) + \gamma U_2'(.))}, \tag{19}$$

$$\frac{dC}{d\sigma} = \frac{(1+\beta\delta)U_1' - \beta(U_1'(.) + \gamma U_2'(.))}{\Delta(\mu = 1)\beta(U_1'(.) + \gamma U_2'(.))}(f' - \delta), \tag{20}$$

where

$$\Delta(\mu = 1) = \frac{\sigma\gamma(1+\beta\delta)(f' - \delta)(U_2''(.)U_1'(.) - U_2'(.)U_1''(.))}{\beta(U_1'(.) + \gamma U_2'(.))^2} + \beta f''(K)$$
$$+ \frac{\sigma(1+\beta\delta)U_1'(.)\gamma U_2''(.)(1+\mu\delta)}{\beta(U_1'(.) + \gamma U_2'(.))^2} \tag{21}$$

and $\Delta(\mu = 1)$ is still negative.

6. Unlike the stability analysis in Abel (1985), multiple equilibria may exist in our model. But, if $\frac{d\ln U_2'(W)}{d\ln U_1'(C)} \geq 1$, we know that one characteristic root is less than minus one, one root is between zero and one, and one is larger than one. The same condition will guarantee that $\Delta < 0$. In this case, since only one of the three characteristic roots has modulus less than one, the system is saddle-point stable. The whole proof is rather lengthy, and it is available from the authors upon request.

PROPOSITION 2: *With cash required for both consumption and investment, the steady-state capital stock and consumption level will increase (decrease) with inflation when* $\gamma U_2' > (<)(1 + \beta\delta - \beta)U_1'$. *If* $\gamma U_2' = (1 + \beta\delta - \beta)U_1'$, *money is still superneutral.*

Noticing that $\Delta(\mu = 1) < 0$, the proof of this proposition is immediate from equations (19), (20), and (21). The intuition for this proposition is as follows. When $\gamma U_2' > (1 + \beta\delta - \beta)U_1'$, the agent has a stronger desire for the wealth-induced social status. With a higher rate of inflation, the cost of investment rises. But the agent will still shift more of his asset holdings from real balances to capital investment because the social-status effect of capital investment dominates the cost effect of inflation. Therefore, in the long run, inflation leads to more capital accumulation, which in turn brings in more output and more consumption. On the other hand, when $\gamma U_2' < (1 + \beta\delta - \beta)U_1'$, the agent is less concerned with the wealth-induced social status. Then the inflation cost of investment dominates the wealth effect of investment. In this case, inflation reduces long-run capital accumulation. Finally, when $\gamma U_2' = (1 + \beta\delta - \beta)U_1'$, these two effects cancel each other, and inflation does not affect investment and capital formation.

2.3 Effects of the Desire for Social Status

Please note that the desire for social status itself can lead to more capital accumulation and more consumption in the long run. As shown in the Appendix,

$$\frac{dK}{d\gamma} = \frac{\sigma A U_1' U_2'}{\Delta(\mu)\beta(U_1'(.) + \gamma U_2'(.))^2}, \tag{22}$$

$$\frac{dC}{d\gamma} = \frac{\sigma A U_1' U_2'(f' - \delta)}{\Delta(\mu)\beta(U_1'(.) + \gamma U_2'(.))^2}, \tag{23}$$

where

$$\Delta(\mu) = \frac{\sigma\gamma A(f' - \delta)(U_2''(.)U_1'(.) - U_2'(.)U_1''(.))}{\beta(U_1'(.) + \gamma U_2'(.))^2} + \beta f''(K)$$

$$+ \frac{\sigma A U_1'(.)\gamma U_2''(.)U_1'(.)(1 + \mu\delta)}{\beta(U_1'(.) + \gamma U_2'(.))^2}, \tag{24}$$

and $\Delta(\mu) < 0$. From equations (22) and (23), we know

$$\frac{dK}{d\gamma} > 0, \frac{dC}{d\gamma} > 0:$$

PROPOSITION 3: *Under the assumption of perfect foresight, the stronger the desire for wealth-induced social status, the higher the steady-state capital stock and consumption.*

3. CONCLUSIONS

This paper has presented an infinite horizon model of optimal capital accumulation with the social-status concern and the cash-in-advance constraint. If only consumption is subject to the cash-in-advance constraint, inflation increases capital accumulation. If both consumption and investment are subject to the cash-in-advance constraint, the effect of inflation on capital accumulation is ambiguous. Specifically, when the agent has a stronger desire for the wealth-induced social status, he will shift more of his asset holdings from real balances to capital investment as a result of inflation because the social-status effect of capital investment dominates the cost effect of inflation. In this case, inflation leads to more capital accumulation. On the other hand, if the agent is less concerned with the wealth-induced social status, then inflation can reduce capital formation.

APPENDIX

Taking total differentiation in equations (12) and (13), we have

$$\left(\beta f''(K) + \frac{\sigma A U_1'(.)\gamma U_2''(.)(1+\mu\delta)}{\beta(U_1'(.)+\gamma U_2'(.))^2}\overset{f'-\delta}{} \frac{\sigma\gamma A(U_2''(.)U_1'(.) - U_2'(.)U_1''(.))}{\beta(U_1'(.)+\gamma U_2'(.))^2}\overset{-1}{}\right)\left(\frac{dK}{dC}\right)$$

$$= \left(\frac{\sigma \overset{0}{A} U_1' U_2'}{\beta(U_1'(.)+\gamma U_2'(.))^2}\right)d\gamma + \left(\frac{\overset{0}{A} U'}{\beta(U_1'(.)+\gamma U_2'(.))} - 1\right)d\sigma,$$

where $A = \mu(1 + \beta\delta) + (1 - \mu)\beta$.
Denote the determinant of the coefficient matrix as $\Delta(\mu)$. Then,

$$\Delta(\mu) = \frac{\sigma\gamma A(f' - \delta)(U_2''(.)U_1'(.) - U_2'(.)U_1''(.))}{\beta(U_1'(.)+\gamma U_2'(.))^2}$$

$$+ \beta f''(K)\frac{\sigma A U_1'(.)\gamma U_2''(.)U_1'(.)(1+\mu\delta)}{\beta(U_1'(.)+\gamma U_2'(.))^2},$$

and

$$\frac{dK}{d\gamma} = -\frac{\sigma A U_1' U_2'}{\Delta(\mu)\beta(U_1'(.) + \gamma U_2'(.))^2},$$

$$\frac{dC}{d\gamma} = -\frac{\sigma A U_1' U_2'(f' - \delta)}{\Delta(\mu)\beta(U_1'(.) + \gamma U_2'(.))^2},$$

$$\frac{dK}{d\sigma} = \frac{A U_1' - \beta(U_1'(.) + \gamma U_2'(.))}{\Delta(\mu)\beta(U_1'(.) + \gamma U_2'(.))},$$

$$\frac{dC}{d\sigma} = \frac{A U_1' - \beta(U_1'(.) + \gamma U_2'(.))}{\Delta(\mu)\beta(U_1'(.) + \gamma U_2'(.))}(f' - \delta).$$

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第 3 章

财富偏好与风险溢金之谜

Direct preferences for wealth, the risk premium puzzle, growth, and policy effectiveness☆

Liutang Gong[c], Heng-fu Zou[a,b,c,*]

[a]*Development Research Group, The World Bank, 1818 H Street, NW, Washington, DC 20433, USA*
[b]*Institute for Advanced Study, Wuhan University, China*
[c]*Guanghua School of Management, Peking University, China*

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Abstract

In this paper, we consider social status, the spirit of capitalism, fiscal policies, and asset pricing in a stochastic model of growth. With specific assumptions on the production technology, preferences, and stochastic shocks, we derive the explicit solutions to the growth rates of consumption and savings and equilibrium returns on all assets. We further demonstrate how fiscal policies, the spirit of capitalism, and stochastic shocks affect growth, asset pricing, and welfare.

JEL classification: E0; G1; H0; O0

Keywords: Social status; The spirit of capitalism; Fiscal policies; Asset pricing; Stochastic growth

1. Introduction

In neoclassical growth models wealth accumulation is often taken to be solely driven by one's desire to increase consumption rewards. The representative

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* Correspondence address. World Bank, MC2-611, 1818 H St. NW, Washington, DC 20433, USA.

agent chooses a consumption path to maximize his discounted utility, which is defined only on consumption. This motive is important for wealth accumulation. It is, however, not the only motive. Because man is a social animal, he also accumulates wealth to gain prestige, social status, and power in the society; see Frank (1985), Cole et al. (1992, 1995), Fershtman and Weiss (1993), Zou (1994, 1995), Bakshi and Chen (1996), and Fershtman et al. (1996). Earlier contributions include Duesenberry (1948), Kurz (1968), and Spence (1974). In these wealth-is-status models, the representative agent has direct preferences for wealth and accumulates wealth not only for consumption but also for wealth-induced status. Mathematically, in light of the new perspective, the utility function can be defined on both consumption, c, and wealth, W: $u(c_t, W_t)$. Another interpretation of these models is in line with the spirit of capitalism in the sense of Weber (1958) and Keynes (1971): capitalists accumulate wealth for the sake of wealth. To cite Weber (1958):

Man is dominated by making of money, by acquisition as the ultimate purpose of his life. Economic acquisition is no longer subordinated to man as the means for the satisfaction of his material needs. This reversal relationship, so irrational from a naive point of view, is evidently a leading principle of capitalism.

Using the wealth-is-status and the-spirit-of-capitalism models, many authors have tried to explain growth, savings, and asset pricing. Cole et al. (1992) have demonstrated how the presence of social status leads to multiple equilibria in long-run growth. Zou (1994, 1995) has studied the spirit of capitalism and long-run growth and showed that a strong capitalist spirit can lead to unbounded growth of consumption and capital even under the neoclassical assumption of production technology. Bakshi and Chen (1996) have explored empirically the relationship between the spirit of capitalism and stock market pricing and offered an attempt towards the resolution of the equity premium puzzle in Mehra and Prescott (1985). They have shown that when investors care about status they will be more conservative in risk taking and more frugal in consumption spending. Furthermore, stock prices tend to be more volatile with the presence of the spirit of capitalism.

On the other hand, Eaton (1981), Turnovsky (1993, 1995), Grinols and Turnovsky (1993, 1994), and Obstfeld (1994) have introduced stochastic tax and stochastic government expenditure into the continuous-time growth and asset-pricing models. Under specific assumptions on the production technology, preferences, and stochastic shocks, they have derived explicit solutions to the growth rates of consumption and savings and equilibrium returns on assets. But these continuous-time stochastic growth models have not explicitly considered the role of social status and the spirit of capitalism in capital accumulation, asset pricing, and growth.

In this paper, we integrate these two trends of growth and asset-pricing literature and consider social status, fiscal policies, and asset pricing in a stochastic model of growth. With specific assumptions on the production

technology, preferences, and stochastic shocks, we derive the explicit solutions to the growth rates of consumption and savings and equilibrium returns on all assets. We further demonstrate how fiscal policies, social status, the spirit of capitalism, and stochastic shocks affect economic growth and asset pricing.

The paper is organized as follows: in Section 2, we present a modified growth and asset-pricing framework as in Turnovsky (1995) and Bakshi and Chen (1996). In Section 3, we derive the optimal conditions for macroeconomic equilibrium. In Section 4, using a specific utility function, we present explicit solutions to the consumption–wealth ratio, the mean growth rate of the economy, and the expected real return on bonds and capital. In Section 5, we discuss the effects of stochastic shocks and fiscal policies on the economy. In Section 6, we discuss the effects of the concern for social status or the spirit of capitalism on asset pricing and growth. We conclude the paper in Section 7.

2. The model

Along with Eaton (1981) and Turnovsky (1995), we assume output Y and government expenditure G to be proportional to the mean-level output, i.e.

$$\mathrm{d}Y = \alpha K\,\mathrm{d}t + \alpha K\,\mathrm{d}y, \tag{1}$$

$$\mathrm{d}G = g\alpha K\,\mathrm{d}t + \alpha K\,\mathrm{d}z. \tag{2}$$

Eq. (1) asserts that the accumulated flow of output over the period $(t, t + \mathrm{d}t)$, given by the right-hand side of this equation, consists of two components. The deterministic component is described as the first term on the right hand, which is the firm's production technology and has been specified as a linear production function. The second part is the stochastic component, which can be viewed as the shock to the production and assumed to be temporally independent, normally distributed, and

$$E(\mathrm{d}y) = 0, \quad \mathrm{Var}(\mathrm{d}y) = \sigma_y^2\,\mathrm{d}t.$$

In Eq. (2), the deterministic part of government expenditure is expressed in terms of a fraction of mean output, and government expenditure has the stochastic shock $\mathrm{d}z$. It is further assumed that $\mathrm{d}z$ is temporally independent, normally distributed, and

$$E(\mathrm{d}z) = 0, \quad \mathrm{Var}(\mathrm{d}z) = \sigma_z^2\,\mathrm{d}t.$$

Following Turnovsky (1995), it is assumed that there are two assets in the economy: government bonds, B, and the capital stock, K. If the inflation rate is stochastic as in Fischer (1975), the return on government bonds B will also follow a stochastic process. Without providing much detail on the derivations, it

is postulated, as in Turnovsky (1995) that the stochastic real rate of return on bonds, dR_B, over a period dt, is given by

$$dR_B = r_B\,dt + du_B, \tag{3}$$

where r_B and du_B will be determined endogenously in the macroeconomic equilibrium.

Turning to the second asset, capital, and using the production technology in Eq. (1), the stochastic real rate of return on capital is

$$dR_K = \frac{dY}{K} = \alpha\,dt + \alpha\,dy = r_K\,dt + du_K. \tag{4}$$

Thus, wealth $W(t)$ is the sum of the holdings of $B(t)$ and $K(t)$, i.e.,

$$W(t) = B(t) + K(t).$$

Let n_B and n_K denote the fractions of wealth invested in bonds and capital, respectively, i.e.,

$$n_B = \frac{B(t)}{W(t)}, \qquad n_K = \frac{K(t)}{W(t)}$$

and $n_B + n_K = 1$.

We may assume that, without any loss of generality, taxes are levied on capital income and consumption, namely,

$$dT = (\tau r_K K + \tau_c c)\,dt + \tau' K\,du_K = (\tau\alpha K + \tau_c c_t)\,dt + \tau'\alpha K\,dy, \tag{5}$$

where τ,τ' are the tax rates on the deterministic component of capital income and the stochastic capital income, respectively, and τ_c is the tax rate on consumption. The introduction of a consumption tax into the model is new. As shown later, consumption tax impacts on economic growth in the wealth-is-status or the spirit-of-capitalism model. In the traditional setup with the utility defined only on consumption, a consumption tax has no long-run effect on growth and wealth accumulation, it only crowds out private consumption.

Now, the representative agent chooses the consumption–wealth ratio, c/W, and the portfolio shares, n_B and n_K, to maximize his expected utility subject to the budget constraint, i.e.,

$$\max E\int_0^\infty u(c_t, W_t)e^{-\beta t}\,dt$$

subject to

$$dW_t = (n_B W_t r_B + n_K W_t(1-\tau)r_K - (1+\tau_c)c_t)\,dt + W_t\,dw, \tag{6}$$

$$n_B + n_K = 1, \tag{7}$$

where β is the time discount rate. The initial stocks of bonds and capital are given by $B(0)$ and $K(0)$, respectively. In addition,

$$\mathrm{d}w = n_B\,\mathrm{d}u_B + n_K(1-\tau')\mathrm{d}u_K. \tag{8}$$

The inclusion of total wealth as an argument in the utility function has been done in many deterministic models mentioned in our introductory section, and its presence in a stochastic model appears only in Bakshi and Chen (1996) in the context of stock-market pricing. But recently Turnovsky (1995), Grinols (1996), and Grinols and Turnovsky (1996) have included real balances (or liquidity services), which are a component of wealth, in the utility function in their studies of fiscal and especially monetary policies in stochastic models. Since we will consider a real economy here, real balances are not in the picture. It is natural to extend the model to a monetary economy and take real balances as a part of total wealth. This is clearly a direction for further research. It will be interesting to compare the results obtained here with the ones with money.

3. Macroeconomic equilibrium

As in Turnovsky (1995), the economic system in equilibrium determines the rates of consumption and savings, the value of returns on all assets, and the economic growth rate.

The exogenous variables include the preference parameters, technology parameters, and government fiscal policies including government expenditure g, tax rates τ, τ', and τ_c. The exogenous stochastic processes consist of government expenditure, $\mathrm{d}z$, and productivity shocks, $\mathrm{d}y$, which are taken to be mutually uncorrelated. The remaining stochastic disturbances — real rates of returns on bonds, $\mathrm{d}u_B$, and total wealth, $\mathrm{d}w$, are both endogenous and will be determined by the economic system. The remaining endogenous variables include the following: the consumption–wealth ratio, c/W, the mean growth rate of the economy, the expected real returns on two assets, r_B, and r_K, respectively, and the corresponding portfolio shares n_B and n_K.

To solve the agent's optimization problem, we introduce the value function

$$V(W(t),t) = \max E_t \int_t^{\infty} u(c_s, W_s)\mathrm{e}^{-\beta s}\,\mathrm{d}s$$

subject to (6) and (7).

Define

$$V(W,t) = \mathrm{e}^{-\beta t}X(W,t).$$

Proposition 3.1. The first-order conditions for the optimization problem can be written as follows:

$$\frac{\partial u(c,W)}{\partial c} = (1+\tau_c)X_W, \tag{9}$$

$$(r_B X_W W - \eta)\,\mathrm{d}t + cov(\mathrm{d}w, \mathrm{d}u_B)X_{WW}W^2 = 0, \tag{10}$$

$$((1-\tau)r_K X_W W - \eta)\,\mathrm{d}t + cov(\mathrm{d}w, (1-\tau')\,\mathrm{d}u_K)X_{WW}W^2 = 0, \tag{11}$$

$$n_B + n_K = 1, \tag{12}$$

where η is the Lagrangian multiplier associated with the portfolio selection constraint (7). Furthermore, the optimal solutions of the problem must satisfy the Bellman equation

$$u(c,W) - \beta X(W,t) + X_t(W,t) + \left(\rho - (1+\tau_c)\frac{c}{W}\right)WX_W + \frac{1}{2}\sigma_w^2 W^2 X_{WW} = 0, \tag{13}$$

where $\rho = n_B r_B + n_K(1-\tau)r_K$, and it is the expected net-of-tax return on total asset holdings.

See the details of the proof in Appendix A.

Condition (9) asserts that in the equilibrium the marginal utility of consumption must equal the marginal utility of wealth; conditions (10) and (11) are the asset pricing relationships; condition (12) is the portfolio selection constraint; and Eq. (13) is the Bellman equation, from which we will solve the value function $X(W,t)$.

In order to determine the full equilibrium system, we follow Turnovsky (1995) in discussing government behavior. Eqs. (2) and (5) describe government expenditure policy and tax policies, both of which are proportional to current output. In the absence of lump-sum taxation, government budget constraint can be described as

$$\mathrm{d}B = B\,\mathrm{d}R_B + \mathrm{d}G - \mathrm{d}T. \tag{14}$$

From (2) and (5), this can be written in the form

$$\frac{\mathrm{d}B}{W} = \frac{B}{W}\mathrm{d}R_B + (g-\tau)\alpha\frac{K}{W}\mathrm{d}t - \tau_c\frac{c}{W}\mathrm{d}t + \alpha\frac{K}{W}\mathrm{d}z - \tau'\alpha\frac{K}{W}\mathrm{d}y,$$

i.e.,

$$n_B \frac{\mathrm{d}B}{B} = \left(r_B n_B - \tau_c \frac{c}{W} + \alpha(g - \tau) n_K \right) \mathrm{d}t + n_B \mathrm{d}u_B + \alpha n_K \mathrm{d}z - \tau' \alpha n_K \, \mathrm{d}y. \tag{15}$$

For the equilibrium in the product market, we have

$$\mathrm{d}K = \mathrm{d}Y - c\,\mathrm{d}t - \mathrm{d}G, \tag{16}$$

where G follows the stochastic process of Eq. (2). Now, we have

Proposition 3.2. The equilibrium system of the economy can be summarized as

$$\frac{\mathrm{d}K}{K} = \left[\alpha(1 - g) - \frac{c}{n_K W} \right] \mathrm{d}t + \alpha(\mathrm{d}y - \mathrm{d}z) = \phi\,\mathrm{d}t + \alpha(\mathrm{d}y - \mathrm{d}z), \tag{17}$$

$$\frac{\partial u(c, W)}{\partial c} = (1 + \tau_c) X_W, \tag{9}$$

$$(r_B X_W W - \eta)\,\mathrm{d}t + cov(\mathrm{d}w, \mathrm{d}u_B) X_{WW} W^2 = 0, \tag{10}$$

$$((1 - \tau) r_K X_W W - \eta)\,\mathrm{d}t + cov(\mathrm{d}w, (1 - \tau')\mathrm{d}u_K) X_{WW} W^2 = 0, \tag{11}$$

$$n_B + n_K = 1 \tag{12}$$

and the transversality condition (TVC) plus the initial conditions.

Furthermore,

Proposition 3.3. The stochastic component of real rate of return on bonds, $\mathrm{d}u_B$, *and total wealth,* $\mathrm{d}w$, *are determined by*

$$\mathrm{d}w = \alpha(\mathrm{d}y - \mathrm{d}z), \tag{18}$$

$$\mathrm{d}u_B = \frac{\alpha}{n_B} [(1 - n_K(1 - \tau'))\,\mathrm{d}y - \mathrm{d}z]. \tag{19}$$

Proof. Using the intertemporal constancy of portfolio shares we have

$$\frac{\mathrm{d}W}{W} = \frac{\mathrm{d}K}{K} = \frac{\mathrm{d}B}{B}, \tag{20}$$

i.e., all the real assets grow at a common stochastic rate. Combining with Eqs. (6), (15), (17), and (20), we get

$$\mathrm{d}w = n_B\,\mathrm{d}u_B + n_K(1-\tau')\alpha\,\mathrm{d}y = \alpha(\mathrm{d}y - \mathrm{d}z)$$

$$= \frac{1}{n_B}[n_B\,\mathrm{d}u_B + \alpha n_K(\mathrm{d}z - \tau'\,\mathrm{d}y)].$$

From the equations above, and noticing the fact $n_B + n_K = 1$, it is easy to get $\mathrm{d}w$ and $\mathrm{d}u_B$. □

These two equations enable us to compute all the necessary covariances and variances in the full equilibrium system. Eq. (19) implies that the stochastic shocks of government expenditure and production determine the stochastic rate of return on government bonds.

4. An explicit example

In order to find explicit solutions, we specify the utility function as in Bakshi and Chen (1996)

$$u(c, W) = \frac{c^{1-\gamma}}{1-\gamma}W^{-\lambda}, \tag{21}$$

where $\gamma > 0$, and $\lambda \geq 0$ when $\gamma \geq 1$, and $\lambda < 0$ otherwise; $|\lambda|$ measures the investor's concern with his social status or measures his spirit of capitalism. The larger the parameter $|\lambda|$, the stronger the agent's spirit of capitalism or concern for social status.

Under the form of the utility function in (21), we have

Proposition 4.1. The first-order optimal conditions are

$$\frac{c}{W} = \frac{\beta + \frac{1}{2}\sigma_w^2(1-\gamma-\lambda)(\gamma+\lambda) - \rho(1-\gamma-\lambda)}{(\gamma+\tau_c)/(1-\gamma)(1-\gamma-\lambda)}, \tag{9'}$$

$$\left(r_B - \frac{\eta}{\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}}\right)\mathrm{d}t = (\gamma+\lambda)\,cov(\mathrm{d}w, \mathrm{d}u_B), \tag{10'}$$

$$\left(r_K(1-\tau) - \frac{\eta}{\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}}\right)\mathrm{d}t = (\gamma+\lambda)(1-\tau')\,cov(\mathrm{d}w, \mathrm{d}u_K) \tag{11'}$$

where η is the Lagrangian multiplier associated with constraint (7),

$$\rho = n_B r_B + n_K(1-\tau)r_K, \tag{22}$$

$$\mathrm{d}w = n_B\,\mathrm{d}u_B + n_K(1-\tau')\,\mathrm{d}u_K, \tag{23}$$

$$\sigma_w^2 = n_B^2\sigma_B^2 + n_K^2(1-\tau')^2\sigma_K^2 + 2n_B n_K(1-\tau')\sigma_{BK}. \tag{24}$$

Eq. (9′) gives the consumption–wealth ratio. For a logarithmic utility function in consumption, i.e., $\gamma = 1$, we get $c/W = \beta$: the consumption–wealth ratio is equal to the time discount rate. If $\gamma \neq 1$, then the effect of an increase in the expected net-of-tax return on the consumption–wealth ratio will be

$$\frac{\mathrm{d}(c/W)}{\mathrm{d}\rho} = \frac{\gamma - 1}{\gamma + \tau_c}.$$

Therefore, an increase in the expected net-of-tax return ρ will raise the consumption–wealth ratio if $\gamma > 1$, and lower it otherwise. This can be explained as follows. When $\gamma > 1$, the elasticity of intertemporal substitution, $1/\gamma$, is relatively small. The representative agent will increase current consumption more than investment and wealth. On the other hand, when $\gamma < 1$, the elasticity of intertemporal substitution is relatively large, and the agent will increase wealth holding more than consumption.

Similar analysis holds for the effect of the variance of wealth, σ_w^2, on c/W:

$$\frac{\mathrm{d}(c/w)}{\mathrm{d}\sigma_w^2} = \frac{1-\gamma}{2(\gamma + \tau_c)(\gamma + \lambda)}.$$

Therefore, an increase in the variance of wealth reduces the consumption–wealth ratio when $\gamma < 1$, and increases the ratio when $\gamma > 1$.

Eqs. (10′) and (11′) illustrate the asset pricing relationships. The term of $\eta/\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}$ can be regarded as 'risk-free' return in this all risky world — both returns on bonds and capital are uncertain. Eq. (10′) implies that the return on bonds is equal to the 'risk-free' return plus a risk premium, which is proportional to the covariance between total wealth and risky bonds. Similarly, in Eq. (11′), for the net return on the risky capital, it is also equal to the 'risk-free' return plus a risk premium, which is proportional to the covariance between total wealth and risky capital.

Since ρ is still endogenous in terms of holding shares for the two assets, we now use the full equilibrium system to derive explicit solutions to c/W, n_B, n_K, r_B, and ϕ. With Proposition 3.3, and from the optimal conditions (10′) and (11′)

plus Eq. (15), we have

$$\sigma_w^2 = \alpha^2(\sigma_y^2 + \sigma_z^2)\,\mathrm{d}t,$$

$$\mathrm{cov}(\mathrm{d}w, \mathrm{d}u_B) = \frac{\alpha^2}{n_B}[(1 - n_K(1-\tau'))\sigma_y^2 + \sigma_z^2]\,\mathrm{d}t,$$

$$\mathrm{cov}(\mathrm{d}w, (1-\tau')\,\mathrm{d}u_K) = \alpha^2(1-\tau')\sigma_y^2\,\mathrm{d}t$$

and

Proposition 4.2. The mean return on bonds and the stochastic growth rate of the economy are

$$r_B = \alpha(1-\tau) + \frac{\gamma+\lambda}{n_B}\alpha^2(\sigma_y^2 - (1-\tau')n_K\sigma_y^2 - (1-\tau')n_B\sigma_y^2 + \sigma_z^2), \tag{25}$$

$$\phi = \frac{r_B n_B + (g-\tau)\alpha n_K + \tau_c(c/W)}{n_B} = \rho - (1+\tau_c)\frac{c}{W}. \tag{26}$$

The first term on the right-hand side of Eq. (25) is the net (after-tax) return on capital, which is the same as in Turnovsky (1995); the second term on the right-hand side is the stochastic component of the return on bonds.

With Proposition 4.2, we now have our main theorem of this section:

Theorem 4.3. The explicit solutions of the economic system are

$$\frac{c}{W} = \frac{\beta}{(\gamma+\tau_c)(1-\gamma-\lambda)/(1-\gamma)} - \frac{\alpha(1-\tau) + \frac{1}{2}(\gamma+\lambda)\alpha^2((2\tau'-1)\sigma_y^2 + \sigma_z^2)}{(\gamma+\tau_c)/(1-\gamma)}, \tag{27}$$

$$\phi = \alpha(1-\tau) + \alpha^2(\gamma+\lambda)(\tau'\sigma_y^2 + \sigma_z^2) - (1+\tau_c)\frac{c}{W}, \tag{28}$$

$$n_K = \frac{c/W}{\alpha(\tau-g) + (1+\tau_c)c/W - \alpha^2(\gamma+\lambda)(\tau'\sigma_y^2 + \sigma_z^2)} \tag{29}$$

$$n_B = 1 - n_K \tag{30}$$

and the TVC

$$\lim_{t\to\infty} E(W^{1-\gamma-\lambda}\mathrm{e}^{-\beta t}) = 0. \tag{31}$$

Proof. Notice the conditions

$$n_B + n_K = 1,$$

$$\rho = n_B r_B + n_K r_K(1-\tau),$$

$$r_B = \alpha(1-\tau) + \frac{\gamma+\lambda}{n_B}\alpha^2([\sigma_y^2 - (1-\tau')n_K\sigma_y^2 - (1-\tau')n_B\sigma_y^2] + \sigma_z^2).$$

We obtain

$$\rho = \alpha(1-\tau) + \alpha^2(\gamma+\lambda)(\tau'\sigma_y^2 + \sigma_z^2).$$

Thus, we have Eqs. (27) and (28). With Eq. (17), we have

$$\phi = \alpha(1-g) - \frac{c}{n_K W}$$

and Eq. (29).

Using Eqs. (25), (26), and the portfolio-selection constraint $n_B + n_K = 1$, we have Eq. (30). □

Please also note that the transversality condition (31) can be shown to be equivalent to $c/W > 0$. In fact, since

$$\mathrm{d}W = \phi W\,\mathrm{d}t + W\,\mathrm{d}w,$$

we have

$$W(t) = W(0)e^{(\phi - [(\gamma+\lambda)/2]\sigma_w^2)t + w(t) - w(0)}.$$

The TVC will be met if and only if

$$(1-\gamma-\lambda)\left(\phi - \frac{\gamma+\lambda}{2}\sigma_w^2\right) - \beta < 0. \tag{32}$$

By Eq. (27), we have

$$(1-\gamma-\lambda)\left(\alpha(1-\tau) + \frac{\gamma+\lambda}{2}\alpha^2((2\tau'-1)\sigma_y^2 + \sigma_z^2)\right) < \beta. \tag{32'}$$

Eq. (32′) is just the condition for a positive consumption–wealth ratio.

5. Comparative dynamics

Now, we discuss how stochastic shocks (in production and government spending) and government fiscal policies affect the equilibrium.

5.1. Effects of stochastic shocks

Differentiating with respect to σ_z^2 and σ_y^2, respectively, in Eq. (27), we have for $\gamma > 1$,

$$\frac{\partial c/W}{\partial \sigma_z^2} = -\frac{(1-\gamma)(\gamma+\lambda)\alpha^2}{2(\tau_c+\gamma)} > 0,$$

$$\frac{\partial c/W}{\partial \sigma_y^2} = -\frac{(1-\gamma)(\gamma+\lambda)(2\tau'-1)\alpha^2}{2(\tau_c+\gamma)} < 0.$$

Therefore, when the intertemporal elasticity of substitution is relatively small, a higher variance in government expenditure increases the consumption–wealth ratio, whereas the stochastic shock in production lowers the consumption–wealth ratio.

On the other hand, when $\gamma < 1$, we have just the opposite results, namely,

$$\frac{\partial c/W}{\partial \sigma_z^2} = -\frac{(1-\gamma)(\gamma+\lambda)\alpha^2}{2(\tau_c+\gamma)} < 0,$$

$$\frac{\partial c/W}{\partial \sigma_y^2} = -\frac{(1-\gamma)(\gamma+\lambda)(2\tau'-1)\alpha^2}{2(\tau_c+\gamma)} > 0.$$

From Eq. (28), the equilibrium growth rate, ϕ, varies with the stochastic shocks of government spending as follows. For all values of γ,

$$\frac{\partial \phi}{\partial \sigma_z^2} = \frac{\alpha^2(\gamma+\lambda)(1+3\tau_c+\gamma(1-\tau_c))}{2(\gamma+\tau_c)} > 0 \tag{33}$$

because $(\gamma+\lambda) > 0$. Therefore, more volatility in government spending always increases the rate of economic growth. This is true because an increase in σ_z^2 raises the risk of bonds. The agent reduces his holding of government bonds and invests more in capital, which in turn leads to more output growth.

But for the shocks to the productivity, the mean growth rate of the economy can increase or decrease depending on the values of γ and other parameters. For example, when $\gamma > 1$, and $\tau' < 50\%$,

$$\frac{\partial \phi}{\partial \sigma_y^2} = \alpha^2\left[\tau' + \frac{(2\tau'-1)(1+\tau_c)(1-\gamma)}{2(\gamma+\tau_c)}\right](\gamma+\lambda) < 0. \tag{34}$$

In this case, an increase in the variance of the productivity shocks lowers the growth rate. But when $\gamma < 1$, $\partial\phi/\partial\sigma_y^2$ has an ambiguous sign. Our results confirm the complicated pictures of the effects of stochastic shocks on output growth in Obstfeld (1994), Turnovsky (1995), and Grinols and Turnovsky (1996).

The dependence of the shares of asset holding on the stochastic shocks can be derived from Eq. (29):

$$\frac{\partial n_K}{\partial \sigma_z^2} = n_K\left\{\frac{[1 - n_K(1+\tau_c)]\partial(c/W)/\partial\sigma_z^2}{c/W} + \alpha^2(\gamma+\lambda)\frac{n_k}{c/W}\right\} > 0,$$

$$\frac{\partial n_K}{\partial \sigma_y^2} = n_K\left\{\frac{[1 - n_K(1+\tau_c)]\partial(c/W)/\partial\sigma_y^2}{c/W} + \frac{n_K}{c/W}\alpha^2(\gamma+\lambda)\tau'\right\}.$$

The first equation above tells us that the stochastic shock in government expenditure will enhance the holding of risky capital. In the second equation the effect of the stochastic shock in production on the holding of risky capital is ambiguous.

We have derived the value function $X(W,t)$ in Appendix B. Let $W(0)$ denote the initial stock of wealth. We have the following welfare function:

$$X(W(0)) = \delta W(0)^{1-\gamma-\lambda},$$

where

$$\delta = \frac{1}{(1+\tau_c)(1-\gamma-\lambda)}\left(\frac{c}{W}\right)^{-\gamma}.$$

However, $W(0)$ is itself endogenously determined by

$$W(0) = \frac{K_0}{n_K}.$$

Therefore, with some simple manipulations, welfare is given by

$$X(K_0) = n_K^{\gamma+\lambda-1}\frac{1}{(1+\tau_c)(1-\gamma-\lambda)}\left(\frac{c}{W}\right)^{-\gamma}K_0^{1-\gamma-\lambda}, \tag{35}$$

where c/W and n_K are determined as in Theorem 1. Taking differentiation in Eq. (35), we get

$$\frac{\mathrm{d}X}{X} = (\gamma+\lambda-1)\frac{\mathrm{d}n_K}{n_K} - \gamma\frac{\mathrm{d}(c/W)}{c/W}. \tag{36}$$

Now, we have

$$\frac{\partial X}{\partial \sigma_z^2} = (\gamma+\lambda-1)\frac{X\partial n_K/\partial\sigma_z^2}{n_K} - \gamma\frac{X\partial(c/W)/\partial\sigma_z^2}{c/W},$$

$$\frac{\partial X}{\partial \sigma_y^2} = (\gamma+\lambda-1)\frac{X\partial n_K/\partial\sigma_y^2}{n_K} - \gamma\frac{X\partial(c/W)/\partial\sigma_y^2}{c/W}.$$

These equations imply that the effects on welfare of the stochastic shocks in government expenditure and production are ambiguous.

5.2. Effects of fiscal policies

Now, we turn to how taxes on capital income and consumption impact on the equilibrium.

First, differentiating all endogenous variables with respect to the tax on the deterministic part of capital income, τ, in Eqs. (27)–(29), we have

$$\frac{\mathrm{d}(c/W)}{\mathrm{d}\tau} = \frac{\alpha(1-\gamma)}{\gamma+\tau_c}, \tag{37}$$

$$\frac{\mathrm{d}\phi}{\mathrm{d}\tau} = -\frac{\alpha(1-\gamma\tau_c+2\tau_c)}{\gamma+\tau_c}, \tag{38}$$

$$\frac{\mathrm{d}n_K}{\mathrm{d}\tau} = n_K\left\{\frac{(1-n_K(1+\tau_c))\partial(c/W)/\partial\tau}{c/W} - \alpha\frac{n_K}{c/W}\right\}, \tag{39}$$

$$\frac{\mathrm{d}X}{\mathrm{d}\tau} = X\left\{\frac{(\gamma+\lambda-1)\partial n_K/\partial\tau}{n_K} - \gamma\frac{\partial(c/W)/\partial\tau}{c/W}\right\}.$$

If $\gamma = 1$, c/W is independent of the tax rate, because in this case $c/W = \beta$, which is independent of τ. When $0 < \gamma < 1$, we notice that a rise in the taxation on the deterministic component of capital income has an ambiguous effect on welfare. But, it is clear that

$$\frac{\mathrm{d}(c/W)}{\mathrm{d}\tau} > 0, \quad \frac{\mathrm{d}\phi}{\mathrm{d}\tau} < 0. \tag{40}$$

Therefore, a higher tax on the deterministic component of capital income will increase the consumption–wealth ratio and decrease the economic growth rate. This can be explained as follows: a higher tax on capital income will lower the return on capital. As the agent switches away from capital to bonds and consumption, this reduces capital accumulation, lowers the growth rate, and increases the consumption–wealth ratio.

When $\gamma > 1$, we still find that capital income taxation reduces the holding share of risky capital and lowers the growth rate

$$\frac{\mathrm{d}\phi}{\mathrm{d}\tau} < 0, \quad \frac{\mathrm{d}n_K}{\mathrm{d}\tau} < 0. \tag{41}$$

But it reduces the consumption–wealth ratio: $\mathrm{d}(c/W)/\mathrm{d}\tau < 0$.

Second, we look at the effects on the equilibrium of the tax on the stochastic component of capital income:

$$\frac{\partial(c/W)}{\partial\tau'} = -\frac{\alpha^2(\gamma+\lambda)(1-\gamma)\sigma_y^2}{\gamma+\tau_c},$$

$$\frac{\partial\phi}{\partial\tau'} = \alpha^2(\gamma+\lambda)\sigma_y^2\frac{1-\gamma\tau_c+2\tau_c}{\gamma+\tau_c},$$

$$\frac{\partial n_K}{\partial\tau'} = n_K\frac{1-n_K(1+\tau_c)}{c/W}\frac{\partial(c/W)}{\partial\tau'} + \alpha^2(\gamma+\lambda)\sigma_y^2\frac{n_K^2}{c/W},$$

$$\frac{\partial X}{\partial\tau'} = X(\gamma+\lambda-1)\frac{\partial n_K/\partial\tau'}{n_K} - \gamma\frac{X\partial(c/W)/\partial\tau'}{c/W}.$$

These results are very similar to the ones for the tax on the deterministic component of capital income. Still,

$$\frac{\partial(c/W)}{\partial\tau'} < 0, \quad \frac{\partial\phi}{\partial\tau'} > 0$$

when $0 < \gamma < 1$; and

$$\frac{\partial(c/W)}{\partial\tau'} > 0, \quad \frac{\partial\phi}{\partial\tau'} > 0, \quad \frac{\partial n_k}{\partial\tau'} > 0$$

when $\gamma > 1$.

From the analysis above, the relationship between income taxes and growth is similar to the one in Turnovsky (1995): Raising the tax rate on the stochastic component of capital income has the opposite effect to raising the tax rate on the deterministic component of income.

Finally, we examine the effects of the consumption tax on the equilibrium. Recall that from the Ramsey–Cass–Koopmans model, the consumption tax does not affect the rate of economic growth and long-run capital accumulation. In the long run, it only crowds out private consumption. Here we have

$$\frac{\partial(c/W)}{\partial\tau_c} = -\frac{c/W}{\gamma+\tau_c} < 0.$$

That is to say, increasing the consumption tax will reduce the consumption–wealth ratio because a higher consumption tax decreases private consumption directly, and the agent has more money to invest in capital and bonds, which in turn increases wealth. Therefore, the consumption–wealth ratio decreases as a result of a higher consumption tax.

For the growth rate, a rise in the consumption tax results in

$$\frac{\partial \phi}{\partial \tau_c} = \frac{c/W(1-\gamma)}{\gamma + 2\tau_c}.$$

Hence, $\partial\phi/\partial\tau_c < 0$ when $\gamma > 1$; and $\partial\phi/\partial\tau_c > 0$ when $0 < \gamma < 1$. Because when $\gamma > 1$, the elasticity of intertemporal substitution is small, and the agent is less willing to sacrifice current consumption for future consumption. Therefore, the cut in investment is more than the cut in current consumption, which leads to a lower long-run growth rate. On the other hand, when the elasticity of intertemporal substitution is relatively large (i.e. $0 < \gamma < 1$), the agent is more willing to give up current consumption for investment in risky capital. As a result, a higher consumption tax leads to a higher growth rate.

As for welfare, we have

$$\frac{\partial X}{\partial \tau_c} = (\gamma + \lambda - 1)\frac{X\partial n_K/\partial\tau_c}{n_K} - \gamma\frac{X\partial(c/W)/\partial\tau_c}{c/W} - \frac{X}{1+\tau_c}$$

$$= \frac{X(1-\gamma)(\gamma+\lambda-1)(1+\tau_c)n_K - \lambda(1+\tau_c) + (1-\gamma)}{(\gamma+\tau_c)(1+\tau_c)}.$$

Therefore, $\partial X/\partial\tau_c < 0$ when $\gamma > 1$. The explanation is simple. Since the elasticity of intertemporal substitution is small, current consumption will not be severely cut as a result of a consumption tax, whereas current investment in assets is reduced. In the long run, the agent will accumulate less assets and earn less income. His consumption and asset holdings are all reduced in the long run. Since welfare is defined on both consumption and wealth accumulation, his long-run welfare is also lower. For $\gamma < 1$, the welfare effect of a consumption tax is ambiguous because the direct effect of a higher consumption tax reduces consumption. But with a larger elasticity of intertemporal substitution the agent may increase his asset holdings, which in turn can lead to more asset accumulation and more income. This rising income can give rise to more long-run consumption. Again since the agent's welfare is defined on both consumption and asset holdings, his welfare may also rise in this case.

6. Effects of the spirit of capitalism

In this section, we will discuss how the spirit of capitalism or the concern for social status affects asset pricing and economic growth. For simplicity, we set consumption tax, τ_c, to zero in this section.

First, we give the equilibrium asset-pricing relationships. Following Turnovsky (1995), we define the market portfolio as $Q = n_B W + n_K W$, and

the return rate on the market portfolio as

$$r_Q \equiv \rho = r_B n_B + r_K(1-\tau)n_K$$
$$= \alpha(1-\tau) + (\gamma+\lambda)\alpha^2(\tau'\sigma_y^2 + \sigma_z^2).$$

Now we have

Proposition 6.1. The equilibrium asset-pricing relationships are

$$r_i - \frac{\eta}{\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}} = \beta_i\left(r_Q - \frac{\eta}{\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}}\right), \tag{42}$$

where $i = B, K$,

$$\beta_B = \frac{\mathrm{cov}(\mathrm{d}w, \mathrm{d}u_B)}{\mathrm{var}(\mathrm{d}w)} = \frac{(1-n_K(1-\tau'))\sigma_y^2 + \sigma_z^2}{n_B(\sigma_y^2+\sigma_z^2)},$$

$$\beta_K = \frac{\mathrm{cov}(\mathrm{d}w, \mathrm{d}u_K)}{\mathrm{var}(\mathrm{d}w)} = \frac{(1-\tau')\sigma_y^2}{\sigma_y^2+\sigma_z^2}.$$

Proof. From

$$\frac{\eta}{\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}} = \alpha(1-\tau) - (\gamma+\lambda)\alpha^2(1-\tau')\sigma_y^2$$

and

$$r_Q = \alpha(1-\tau) + (\gamma+\lambda)\alpha^2(\tau'\sigma_y^2 + \sigma_z^2),$$

we obtain

$$r_Q - \frac{\eta}{\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}} = (\gamma+\lambda)\alpha^2(\sigma_y^2+\sigma_z^2)$$

and using Proposition 4.1, we get the result. □

Again $\eta/\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}$ can be regarded as the risk-free return. Eq. (42) indicates that the returns on risky assets (government bonds and capital) are given by the familiar consumption-based capital asset pricing model with r_Q as the return on the market portfolio.

Furthermore, if we define the return on the market portfolio in the absence of the spirit of capitalism as $\bar{r}_Q$, then, in our definition of the return of the market portfolio r_Q, we set $\lambda = 0$. Hence,

$$\bar{r}_Q = \alpha(1-\tau) + \gamma\alpha^2(\tau'\sigma_y^2 + \sigma_z^2).$$

This is just the return on the market portfolio in Turnovsky (1995). At the same time, we have

$$\frac{\eta}{\delta(1-\gamma)W^{1-\gamma}} = \alpha(1-\tau) - \gamma\alpha^2(1-\tau')\sigma_y^2.$$

Hence, we obtain the asset-pricing relationships as

$$\bar{r}_i - \frac{\eta}{\delta(1-\gamma)W^{1-\gamma}} = \beta_i\left(\bar{r}_Q - \frac{\eta}{\delta(1-\gamma)W^{1-\gamma}}\right). \tag{42'}$$

Because $\bar{r}_Q < r_Q$, simple calculations yield

$$r_i - \frac{\eta}{\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}} > \bar{r}_i - \frac{\eta}{\delta(1-\gamma)W^{1-\gamma}}. \tag{43}$$

Eq. (43) implies that, with the spirit of capitalism, the gap between the returns on risky assets and the return on the risk-free asset will be enlarged. Like Bakshi and Chen (1996), our findings can be used to partially explain the equity premium puzzle in Mehra and Prescott (1985).

For the growth rate, social welfare, and portfolio selection, we have

Proposition 6.2. The effects of the spirit of capitalism on c/W, n_K, ϕ, and X are as follows:

$$\frac{\partial(c/W)}{\partial\lambda} = \frac{(1-\gamma)}{2\gamma}\alpha^2((1-2\tau')\sigma_y^2 - \sigma_z^2) + \frac{\beta(1-\gamma)}{\gamma(1-\gamma-\lambda)^2}$$

$$= \frac{(1-\gamma)}{2\gamma}\alpha^2(\sigma_y^2 + \sigma_z^2) + \frac{\beta(1-\gamma)}{\gamma(1-\gamma-\lambda)^2} + \frac{1-\gamma}{\gamma}\alpha^2(\tau'\sigma_y^2 + \sigma_z^2), \tag{44}$$

$$\frac{\partial\phi}{\partial\lambda} = -\frac{(1-\gamma)}{2\gamma}\alpha^2(\sigma_y^2 + \sigma_z^2) - \frac{\beta(1-\gamma)}{\gamma(1-\gamma-\lambda)^2} + \frac{1}{\gamma}\alpha^2(\tau'\sigma_y^2 + \sigma_z^2), \tag{45}$$

$$\frac{\partial n_K}{\partial\lambda} = \frac{n_K}{c/W}\left[(1-n_K)\left(\frac{(1-\gamma)}{2\gamma}\alpha^2(\sigma_y^2 + \sigma_z^2) + \frac{\beta(1-\gamma)}{\gamma(1-\gamma-\lambda)^2}\right)\right.$$

$$\left. - \frac{n_K}{c/W}\frac{1-\gamma-n_K}{\gamma}\alpha^2(\tau'\sigma_y^2 + \sigma_z^2)\right., \tag{46}$$

$$\frac{\partial X}{\partial\lambda} = (\gamma+\lambda-1)\frac{X\partial n_K/\partial\lambda}{n_K} - \gamma\frac{X\partial(c/W)/\partial\lambda}{c/W}. \tag{47}$$

If $\gamma > 1$, we have $\lambda > 0$. Then

$$\frac{\partial \phi}{\partial \lambda} > 0, \quad \frac{\partial n_K}{\partial \lambda} > 0. \tag{48}$$

Similarly, if $\gamma < 1$, we have $\lambda < 0$. In this case $|\lambda|$ measures the spirit of capitalism, and

$$\frac{\partial \phi}{\partial(-\lambda)} > 0, \quad \frac{\partial n_K}{\partial(-\lambda)} > 0. \tag{49}$$

Therefore, an increase in the spirit of capitalism will always increase the growth rate and the holding share of risky capital. With a strong spirit of capitalism, the agent cares more about his social status and the power of wealth, and will accumulate more wealth and take more risk in investment in order to improve his social status.

If we further impose the condition that $\tau' < \frac{1}{2}(1 - \sigma_z^2/\sigma_y^2)$, then

$$\frac{\partial c/W}{\partial \lambda} < 0, \quad \frac{\partial X}{\partial \lambda} > 0, \tag{50}$$

when $\gamma > 1$ and $\lambda > 0$. Furthermore, with the same condition on the tax rate on the stochastic component of capital income, i.e., $\tau' < \frac{1}{2}(1 - \sigma_z^2/\sigma_y^2)$,

$$\frac{\partial c/W}{\partial(-\lambda)} < 0, \quad \frac{\partial X}{\partial(-\lambda)} > 0, \tag{51}$$

when $\gamma < 1$ and $\lambda < 0$. Given the assumption on the tax rate, a strong spirit of capitalism always reduces the consumption–wealth ratio. Since the agent's utility is defined on both consumption and wealth accumulation, his long-run welfare rises as a result of higher wealth and possibly even higher consumption.

7. Conclusion

In this paper, we have extended the existing frameworks of stochastic growth and asset pricing by including the spirit of capitalism and concern for social status — direct preferences for wealth. In this extended model, we have studied how stochastic shocks in production and government spending affect consumption, wealth accumulation, economic growth, and welfare. This paper has further extended the studies by Eaton, Grinols, Obstfeld, and Turnovsky, among others, to consider the impact of various taxes on the consumption–wealth ratio, growth, and welfare. The existence of the positive effect of a consumption tax on growth is a result of the spirit-of-capitalism or wealth-is-status

model. Without the spirit of capitalism, a consumption tax has no effect on output growth.

The direct effect of the spirit of capitalism on the economy has been also explicitly considered in this paper. It is shown that the existence of the spirit of capitalism can better explain the difference between the rates of return on government bonds and risky stock — the Mehra–Prescott risk-premium puzzle. In the spirit-of-capitalism or wealth-is-status model, the gap between the returns on risky assets and the risk-free asset is always larger. Furthermore, a higher spirit of capitalism or a stronger concern for social status can lead to higher output growth, more holdings of risky capital, and a lower consumption–wealth ratio.

This research can be extended in many directions. The discussion of monetary policy is a natural choice when wealth includes bonds, capital, and real balances. The results can be compared to the ones in Turnovsky (1995), Grinols (1996), Turnovsky and Grinols (1996) where only real balances are included in the utility function. Another interesting extension is to examine the optimal (welfare-maximizing) choices of capital income taxes and consumption tax following Corsetti (1992, 1997), Turnovsky (1995), and Turnovsky and Grinols (1996).

Appendix A

Consider the optimization problem:

$$\max E\int_0^\infty u(c_t, W_t)e^{-\beta t}\,dt \tag{A.1}$$

subject to

$$\frac{dW}{W} = \left(\rho - (1+\tau_c)\frac{c_t}{W_t}\right)dt + dw, \tag{A.2}$$

where

$$\rho = n_B r_B + n_K(1-\tau)r_K, \tag{A.3}$$

$$dw = n_B\,du_B + n_K(1-\tau')du_K. \tag{A.4}$$

From Eq. (A.4), we have

$$\sigma_w^2 = n_B^2\sigma_B^2 + n_K^2(1-\tau')^2\sigma_K^2 + 2n_B n_K(1-\tau')\sigma_{BK}. \tag{A.5}$$

To solve the problem, we define the value function $V(W,t)$

$$V(W,t) = e^{-\beta t}X(W,t)$$

and formally, it is also defined

$$L_W(V(W,t)) = \frac{\partial V}{\partial t} + \left(\rho - (1+\tau_c)\frac{c_t}{W_t}\right)W\frac{\partial V}{\partial W} + \frac{1}{2}\sigma_w^2 W^2 \frac{\partial^2 V}{\partial W^2}. \tag{A.6}$$

The Lagrangian function associated with the problem is

$$e^{-\beta t}u(c_t, W_t) + L_W(e^{-\beta t}X(W,t)) + e^{-\beta t}\eta(1 - n_B - n_K). \tag{A.7}$$

In this case, the corresponding first-order conditions for maximization are

$$\frac{\partial u(c,W)}{\partial c} = (1+\tau_c)X_W, \tag{A.8}$$

$$(r_B X_W W - \eta)\,dt + \mathrm{cov}(dw, du_B)X_{WW}W^2 = 0, \tag{A.9}$$

$$((1-\tau)r_K X_W W - \eta)\,dt + \mathrm{cov}(dw, (1-\tau')du_K)X_{WW}W^2 = 0, \tag{A.10}$$

$$n_B + n_K = 1. \tag{A.11}$$

These equations determine the optimal choices of c/W, n_B, n_K, and η as the functions of X_W and X_{WW}. Furthermore, the value function must satisfy the Bellman equation

$$u(c,W) - \beta X(W,t) + X_t(W,t) + \left(\rho - (1+\tau_c)\frac{c}{W}\right)WX_W + \frac{1}{2}\sigma_w^2 W^2 X_{WW} = 0. \tag{A.12}$$

Now, we have completed the proof of Proposition 3.1.

Appendix B

To show Proposition 4.1, we rewrite the utility function here:

$$u(c,W) = \frac{c^{1-\gamma}}{1-\gamma}W^{-\lambda}. \tag{B.1}$$

The form of the value function is postulated as

$$X(W,t) = \delta W^{1-\gamma-\lambda}, \tag{B.2}$$

where δ is to be determined.

Differentiating with respect to W yields

$$X_W = \delta(1-\gamma-\lambda)W^{-\gamma-\lambda}, \quad X_{WW} = \delta(1-\gamma-\lambda)(-\gamma-\lambda)W^{-\gamma-\lambda-1}.$$

Now the corresponding first-order conditions are

$$\frac{c}{W} = ((1+\tau_c)\delta(1-\gamma-\lambda))^{-1/\gamma}, \tag{B.3}$$

$$\begin{aligned}&(r_B\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda} - \eta)\,\mathrm{d}t \\ &\quad + \operatorname{cov}(\mathrm{d}w, \mathrm{d}u_B)\delta(1-\gamma-\lambda)(-\gamma-\lambda)W^{1-\gamma-\lambda} = 0,\end{aligned} \tag{B.4}$$

$$\begin{aligned}&\operatorname{cov}(\mathrm{d}w, (1-\tau')\,\mathrm{d}u_K)\delta(1-\gamma-\lambda)(-\gamma-\lambda)W^{1-\gamma-\lambda} \\ &\quad + ((1-\tau)r_K\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda} - \eta)\,\mathrm{d}t = 0.\end{aligned} \tag{B.5}$$

Substituting for c in the Bellman equation (A.12) leads to

$$\begin{aligned}&\frac{((1+\tau_c)\delta(1-\gamma-\lambda))^{-(1-\gamma)/\gamma}}{1-\gamma} - \beta\delta \\ &\quad + \delta(1-\gamma-\lambda)(\rho - ((1+\tau_c)\delta(1-\gamma-\lambda))^{-1/\gamma}) \\ &\quad + \frac{1}{2}\sigma_w^2\delta(1-\gamma-\lambda)(-\gamma-\lambda) = 0,\end{aligned}$$

or

$$((1+\tau_c)\delta(1-\lambda-\gamma))^{-1/\gamma} = \frac{\beta + \frac{1}{2}\sigma_w^2(1-\gamma-\lambda)(\gamma+\lambda) - \rho(1-\gamma-\lambda)}{(1+\tau_c)(1-\gamma-\lambda)/(1-\gamma) - (1-\gamma-\lambda)}. \tag{B.6}$$

Thus, we have obtained all the expressions in Proposition 4.1:

$$\frac{c}{W} = \frac{\beta + \frac{1}{2}\sigma_w^2(1-\gamma-\lambda)(\gamma+\lambda) - \rho(1-\gamma-\lambda)}{(1+\tau_c)(1-\gamma-\lambda)/(1-\gamma) - (1-\gamma-\lambda)}, \tag{B.7}$$

$$\left(r_B - \frac{\eta}{\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}}\right)\mathrm{d}t = (\gamma+\lambda)\,\mathrm{cov}(\mathrm{d}w, \mathrm{d}u_B), \tag{B.8}$$

$$\left(r_K(1-\tau) - \frac{\eta}{\delta(1-\gamma-\lambda)W^{1-\gamma-\lambda}}\right)\mathrm{d}t = (\gamma+\lambda)\,\mathrm{cov}(\mathrm{d}w, \mathrm{d}u_K(1-\tau')). \tag{B.9}$$

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第 4 章

收入分配的动态研究

Dynamics of income distribution

Hongyi Li *Faculty of Business Administration, Chinese University of Hong Kong*
Danyang Xie *School of Business and Management, Hong Kong University of Science & Technology*
Heng-fu Zou *School of Management, Peking University, and Institute for Advanced Study, Wuhan University*

Abstract. In this paper, we have obtained closed-form solutions in Cass-Koopmans growth models with heterogeneous agents. The relationship between the form of the production function and the dynamics of income distribution is made explicit. We then use this relationship to determine what production structure is simultaneously consistent with facts on growth and income inequality. Our empirical findings give support to models with decreasing returns in the reproducible factor. JEL Classification: D3, O1, O4

Dynamique de la répartition des revenus. Dans ce mémoire, les auteurs obtiennent des solutions pour des modèles de croissance à la Cass-Koopmans dans le cas où les agents sont hétérogènes. On explicite la relation entre la forme de la fonction de production et la dynamique de la répartition des revenus. On utilise alors cette relation pour déterminer quelle structure de production est arrimée aux faits connus à la fois quant à la croissance économique et à la répartition des revenus. Les résultats empiriques supportent les modèles où les rendements sur les acteurs de production reproductibles sont décroissants.

1. Introduction

A typical feature of endogenous growth models is that the production structure exhibits linearity in a reproducible factor. In Romer (1986), the reproducible factor is knowledge; in Lucas (1988), it is human capital; whereas in Rebelo (1991), it is a composite capital stock. Even in the models emphasizing technological change, such as Romer (1990), Grossman and Helpman (1991a, b), and Aghion and Howitt (1992), linearity is assumed to exist in the R&D sector.

In a number of empirical studies the validity of this linearity assumption is investigated. Barro and Sala-i-Martin (1992) find that *AK*-type models are incon-

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sistent with empirical evidence on convergence. Jones (1995a) and Kocherlakota and Yi (1996) test the persistence of policy shocks on economic growth and obtain contradictory results; for example, the latter supports the endogenous growth framework, whereas the former rejects it and instead advocates a semi-endogenous growth framework described in Jones (1995b).

In this paper, we test endogenous growth theory by exploring its implications for the dynamics of income distribution. Recent examples of theoretical and empirical studies on income distribution include Lucas (1992), Atkeson and Lucas (1992), Alesina and Rodrik (1994), and Persson and Tabellini (1994). Our paper, however, is closer to Chatterjee (1994) and Caselli and Ventura (1996). Chatterjee (1994) analyses the transitional dynamics and the distribution of wealth in a neoclassical growth model. His particular concern is how the form of the *utility* function may affect the results. Caselli and Ventura (1996) is much more general and rigorous than Chatterjee (1994), but again with a focus different from ours. They first demonstrate that income distribution can display any dynamic pattern once the utility function is not confined to the special classes studied in Chatterjee (1994). They use a U.S. panel data set on income at the family level and find a reversal in distributive dynamics during the 1970–90 period. They argue that this reversal, albeit consistent with broad consumer preferences, casts doubt on the simple framework of logarithmic utility function and the Cobb-Douglas technology.

Neither of these two studies, however, sheds any light on the debate that is the focus of this paper. The criticism of endogenous growth theory so far does not concern the form of the utility function used; typically, a CES utility function with zero subsistence consumption level is assumed. Instead, the criticism involves the *production* structure, which we investigate here. This is our point of departure from Chatterjee (1994) and Caselli and Ventura (1996). Moreover, we obtain closed-form solutions that make the analysis more accessible.

We show explicitly in a set of examples that if the initial capital stock in an economy is less than the golden-rule capital stock, wealth will become more evenly distributed over time when technology exhibits decreasing returns in the reproducible factor. Income distribution is time-invariant when technology is linear in the reproducible factor. This implication is then tested empirically.

In our empirical test, we use a cross-country panel data set from the World Bank recently compiled by Deininger and Squire (1996). We show that as an economy grows, income distribution improves. This holds even when we explicitly control for government spending on education, welfare, social security, health, infrastructure, and other programs that are intended to lower income inequalities. This empirical finding, therefore, gives support to models with decreasing returns in the reproducible factor.

The rest of the paper is organized as follows. In section 2 we describe the standard Cass-Koopmans model with heterogeneous individuals. In section 3, we present a version of an endogenous growth model and study its implications for the dynamics of income distribution. In section 4 we present an empirical test of the implications, and in section 5 we conclude.

2. An extended Cass-Koopmans model

We consider an economy with a single consumption good and an infinite number of long-lived agents situated in the real interval [0,1]. These agents are indexed by i, $i \in [0,1]$. The preferences of agent i are given by

$$\int_0^\infty \left[\frac{c_i^{1-\sigma} - 1}{1-\sigma} \right] e^{-\rho t} dt, \tag{1}$$

where c_i is individual i's consumption of the single good, σ is the inverse of the intertemporal elasticity of substitution, and ρ is the rate of time preference.

Let a_i denote the amount of an asset that individual i holds. We normalize the time so that each individual has one unit of labour to supply and the supply is inelastic. The accumulation of the asset is thus:

$$\dot{a}_i = ra_i + w - c_i \text{ with } a_i(0) \text{ given}, \tag{2}$$

where r is the market real interest rate and w the real wage.

Consumer i's decision regarding consumption and saving can be obtained by maximizing (1) subject to (2). The first-order condition is familiar:

$$\frac{\dot{c}_i}{c_i} = \frac{r - \rho}{\sigma}, \tag{3}$$

and the transversality condition for optimality is, as usual, $c_i^{-\sigma} a_i e^{-\rho t} \to 0$.

We assume that there are an infinite number of identical competitive firms, indexed by $j, j \in [0,1]$. The production function of firm j is

$$y_j = AK_j^\alpha L_j^{1-\alpha} \tag{4}$$

where K_j is the capital input and L_j is the labour input. Parameter A measures total factor productivity and α is in (0,1). These competitive firms take the real interest rate r and the real wage w as given. The usual profit-maximizing conditions for these firms are

$$r = \alpha AK_j^{\alpha-1} L_j^{1-\alpha} \tag{5}$$

$$w = (1-\alpha) AK_j^\alpha L_j^{-\alpha}. \tag{6}$$

Since these firms are assumed to be identical, we have $K_j \equiv K$, and $L_j \equiv L$ for any j.

In equilibrium, demand equals supply. Specifically, the aggregate demand for capital K equals the aggregate supply of funds available, $\int_0^1 a_i \, di$, and the aggregate demand for labour L equals the aggregate supply of labour, which is unity.[1]

1 Since the firms are identical and are assumed to be situated in the interval [0,1], it follows that the aggregate demand for capital is the same as the average demand for capital. Similarly, since individuals fill the interval [0,1], the aggregate supply of labour equals the average supply of labour, which is unity.

The question we address is: How will income distribution evolve over time if individuals' initial asset holdings $a_i(0)$, $i \in [0,1]$ are heterogeneous? Will income distribution become more equitable?

Even in this simple model, the answer can not be obtained directly. The difficulty is twofold: first, there is heterogeneity among the agents; second, the real interest rate r and the real wage w can change over time as the aggregate capital stock increases or decreases. Chatterjee (1994) shows that for some classes of utility function, including those we study here, income distribution will be more equitable as time evolves if the economy starts with a capital stock lower than the golden rule. Caselli and Ventura (1996) show that with more general preferences, income distribution can display any dynamic pattern. The mathematical proofs in these two papers are done skillfully, but most readers will have problems digesting them. In this paper, we will use a few examples in which closed-form solutions exist, so that readers may have a clearer picture of how income distribution evolves over time.

To obtain closed-form solutions, we must impose a constraint on the parameters across the utility function and the production function, namely, $\sigma = \alpha$. This is the same constraint imposed in Xie (1991, 1994) and Devarajan, Xie, and Zou (1998). We are not claiming that in reality σ and α are the same. The objective here is purely technical, since imposing $\sigma = \alpha$ greatly simplifies the dynamics and makes qualitative results readily accessible. This approach complements the rigorous analysis in Chatterjee (1994) and Caselli and Ventura (1996) in a useful way by allowing us to obtain an insight into how the form of the aggregate production function may affect the dynamics of income distribution.

The equations that govern the evolution of an individual's asset level can be summarized as follows:

$$\dot{a}_i = \alpha A K^{\alpha-1} a_i + (1-\alpha) A K^{\alpha} - c_i \tag{7}$$

$$\frac{\dot{c}_i}{c_i} = \frac{\alpha A K^{\alpha-1} - \rho}{\sigma}. \tag{8}$$

In these above equations, the real interest rate and the real wage have been substituted for by the expressions in equations (5) and (6). Given the initial asset $a_i(0)$ and the transversality condition, we can solve in principle for a_i once the aggregate capital stock is known. Therefore, what we must know is the evolution of aggregate capital stock.

Since $K = \int_0^1 a_i\, di$, we have

$$\dot{K} = \alpha A K^{\alpha-1} \int_0^1 a_i\, di + (1-\alpha) A K^{\alpha} - \int_0^1 c_i\, di,$$

$$= A K^{\alpha} - C \tag{9}$$

where $C = \int_0^1 c_i\,di$ is aggregate consumption. From equation (8), we see that the growth rate of c_i is independent of i. As a result, we have

$$\frac{\dot{C}}{C} = \frac{\alpha A K^{\alpha-1} - \rho}{\sigma}. \tag{10}$$

Equations (9) and (10) normally do not lead to an explicit optimal consumption rule, but they do given the assumption $\alpha = \sigma$. In fact, when $\alpha = \sigma$, the two equations above yield

$$\frac{\dot{C}}{C} - \frac{\dot{K}}{K} = \frac{C}{K} - \frac{\rho}{\alpha}, \tag{11}$$

which has an obvious solution, $C/K = \rho/\alpha$. Other solutions to (11) are invalid because they are not consistent with individual i's optimization behaviour that requires the transversality condition to be satisfied. $C = \rho K/\alpha$ is thus the only optimal consumption rule in the aggregate sense. Therefore, the evolution of aggregate capital stock is greatly simplified:

$$\dot{K} = AK^{\alpha} - \rho K/\alpha, \text{ with } K(0) = \int_0^1 a_i(0)\,di. \tag{12}$$

Next, we define $\varphi_i = c_i/C$. From equation (8) and (10), we notice that φ_i is constant over time, although it may be different for a different i. For the evolution of an individual's asset, we have the following theorem.

THEOREM 1. *The asset holding of individual i at time t is given by*

$$a_i(t) = \varphi_i K + (1-\alpha)A(\varphi_i - 1)K^{\alpha}/\rho, \tag{13}$$

where φ_i is given by

$$\varphi_i = \frac{\rho a_i(0) + (1-\alpha)AK(0)^{\alpha}}{\rho K(0) + (1-\alpha)AK(0)^{\alpha}}. \tag{14}$$

Proof. Obviously, c_i satisfies equation (8) because it is a constant factor of C. There are two things we must verify. First, given that K satisfies equation (12), a_i thus determined in (13) satisfies equation (7). This is straightforward and is checked. Second, we must show that a_i and c_i satisfy the transversality condition $c_i^{-\sigma} a_i e^{-\rho t} \to 0$. Note that equation (12) indicates that K will converge to a steady state K^*, where $K^* = [A\alpha/\rho]^{1/(1-\alpha)}$. Thus, C will converge to $\rho K^*/\alpha$. As a result, c_i and a_i also will converge to their steady-state values. The transversality condition is thus satisfied.

Remark. The result here is rather intuitive. Obviously φ_i should depend on individual i's initial asset holding relative to the initial aggregate (the average) capital stock. According to equation (14), φ_i will be greater (smaller) than unity if indi-

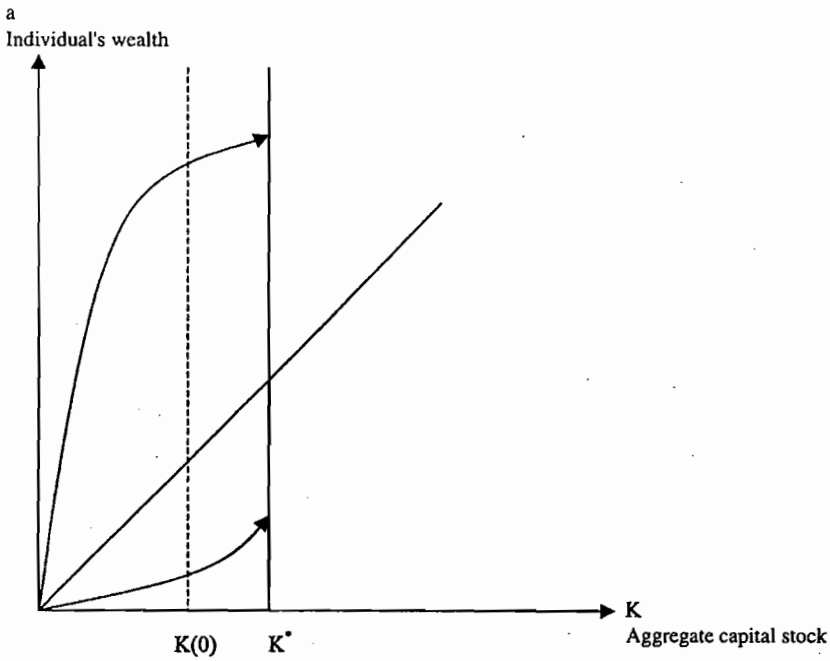

FIGURE 1 Standard Cass-Koopmans model

vidual i is initially richer (poorer) than the average. As a result, when individual i is richer than the average, a_i is a concave function of K. When individual i is poorer than the average, a_i is a convex function of K. This remark leads to the following corollary (see figure 1 for an illustration).

COROLLARY. *If $K(0) < K^*$, then income distribution improves over time. If $K(0) > K^*$, income distribution worsens over time.*

As we believe that no country has passed the golden rule steady state yet, the above corollary states that we should expect the income distribution to get better with income growth. This conclusion may break down, as we see in the next section, if endogenous growth is allowed.

3. A model of endogenous growth

We now introduce a positive externality in goods production to generate long-run growth as in Romer (1986) and Lucas (1988). The version presented here is adapted from Xie (1991). Specifically, the production function of the competitive firm j is extended to include an externality term:

$$y_j = AK_j^{\alpha} L_j^{1-\alpha} \Gamma(K), \tag{15}$$

where K denotes the aggregate capital stock as before. $\Gamma(K)$ is an increasing function of K, meaning that as aggregate capital increases, the productivity of capital and labour employed in firm j becomes higher. In this case, the real interest rate and the real wage can be calculated as follows:

$$r = \alpha A K_j^{\alpha-1} L_j^{1-\alpha} \Gamma(K) \tag{16}$$

$$w = (1-\alpha) A K_j^{\alpha} L_j^{-\alpha} \Gamma(K). \tag{17}$$

In equilibrium, we still have $K_j \equiv K$, and $L_j \equiv 1$. Thus, the evolution of K is determined by

$$\begin{aligned} \dot{K} &= \alpha A K^{\alpha-1} \Gamma(K) K + (1-\alpha) A K^{\alpha} \Gamma(K) - C \\ &= A K^{\alpha} \Gamma(K) - C. \end{aligned} \tag{18}$$

The equations that determine individual's asset accumulation are thus

$$\dot{a}_i = \alpha A K^{\alpha-1} \Gamma(K) a_i + (1-\alpha) A K^{\alpha} \Gamma(K) - c_i \tag{19}$$

$$\frac{\dot{c}_i}{c_i} = \frac{\alpha A K^{\alpha-1} \Gamma(K) - \rho}{\sigma}. \tag{20}$$

Again, from (20), we see that

$$\frac{\dot{C}}{C} = \frac{\alpha A K^{\alpha-1} \Gamma(K) - \rho}{\sigma}. \tag{21}$$

Unfortunately, these equations are not easy to solve for an arbitrary function of $\Gamma(K)$, even if we impose the assumption $\alpha = \sigma$. Numerical methods are therefore needed to reach any reliable conclusions. Before we call in the researchers equipped with numerical techniques, we want to see whether we can make some intelligent qualitative conjectures about how income distribution evolves as an economy expands.

To this end, let us look at one special functional form of $\Gamma(K)$, namely, $\Gamma(K) = K^{1-\alpha}$. In this case, the real interest rate is constant, $r = \alpha A$. Thus, the growth rate of consumption for all individuals is constant over time, as is that of the aggregate consumption. The evolution of aggregate capital and individual i's asset is as follows:

$$\dot{K} = AK - C \tag{22}$$

$$\dot{a}_i = \alpha A a_i + (1-\alpha) AK - c_i. \tag{23}$$

The solution is now obvious:

$$K = K(0) e^{(\alpha A - \rho)t/\sigma} \tag{24}$$

$$a_i = a_i(0) e^{(\alpha A - \rho)t/\sigma}. \tag{25}$$

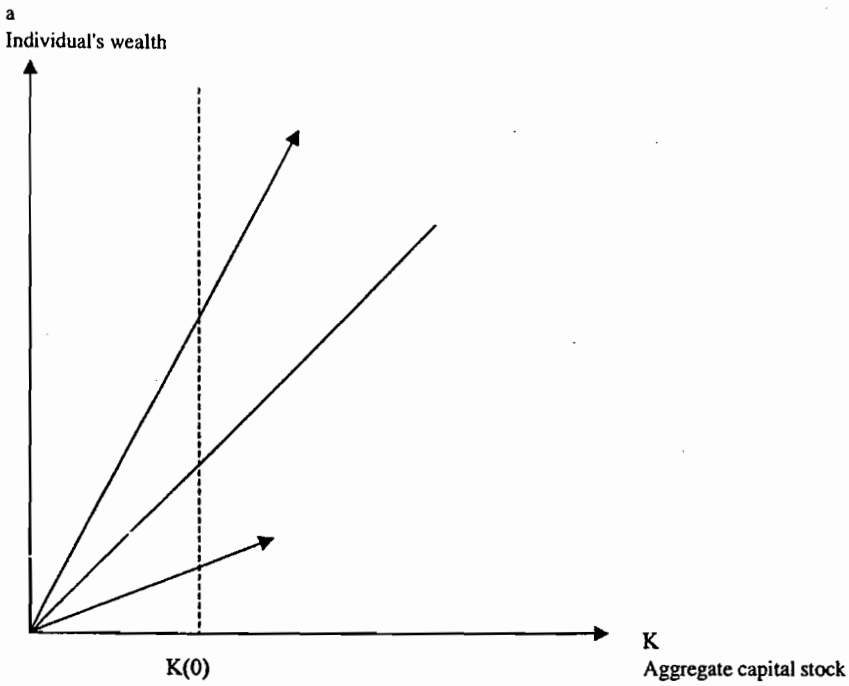

FIGURE 2 Endogenous growth with a linear technology

In other words, a_i is always proportional to K. As a result, income distribution stays the same over time (see figure 2 for an illustration).

Let us summarize what we have obtained thus far. The example in the last section corresponds to the case where $\Gamma(K) \equiv 1$. There, we find that the optimal trajectory is concave for $a_i(0) > K(0)$ and convex for $a_i(0) < K(0)$. In the case where $\Gamma(K) \equiv K^{1-\alpha}$, the optimal trajectory is linear for any $a_i(0)$. In both examples, these optimal trajectories can be extended back to the origin. If we look at these two examples closely, we find that the first example has the property that the aggregate production is concave in K, and in the second example the aggregate production function is linear in K. Based on this observation, we have the following conjecture.

Conjecture. If $\Gamma(K)$ is such that the aggregate production function $AK^{\alpha}\Gamma(K)$ is concave, then the optimal trajectory is concave for $a_i(0) > K(0)$ and convex for $a_i(0) < K(0)$. If the aggregate production function $AK^{\alpha}\Gamma(K)$ is convex,[2] then the optimal trajectory is convex for $a_i(0) > K(0)$ and concave for $a_i(0) < K(0)$.

If our conjecture is right, then, when the aggregate production function $AK^{\alpha}\Gamma(K)$ is convex, income distribution worsens as the economy expands.

2 To make sure that the optimization problem is well defined, we must assume that $\lim_{K\to\infty} AK^{\alpha}\Gamma(K) < \rho/(1-\sigma)$.

4. Empirical Testing

In our theoretical discussions above, we find that whether income distribution will improve over time depends on the strict concavity of technology. In principle, we can examine the empirical evidence on the dynamics of income distribution to determine whether the existing linearity feature assumed in the endogenous growth literature is valid or not. Given the fact that for any particular country, time series data on income distribution (the Gini coefficient) is available for only scattered periods, we have to enlarge the sample by pooling countries together. We then run a regression of Gini coefficients against income level to see if income distribution improves as an economy expands. If the answer is positive, then the production structure should exhibit decreasing returns in the reproducible factor rather than constant or increasing returns. Of course, we must control for other obvious variables that affect income distribution, namely, government spending and taxes. To this end, let us first describe the recently compiled data set on income distribution.

4.1. Data description

Many prior empirical studies have been hampered by data problems regarding income distribution. Commonly available data sets have used Gini coefficients with very different definitions and covered very few observations over time and across countries. In our study, data on income distribution (the Gini coefficients) are taken from Deininger and Squire (1996).[3] This is a recently compiled and greatly expanded data set on income distribution. To minimize the methodological differences in defining the Gini coefficients, only the Gini coefficients from national coverage household surveys based on gross income, net income, or expenditure are selected. This ensures a consistent definition of the Gini coefficients. We found that in our sample it is statistically significant that the Gini coefficients based on gross income are higher than those based on net income or expenditure by 4.0, while other differences in definitions, such as household vs. personal income, do not lead to a statistically significant difference in the Gini measurement. Thus, if the Gini coefficient is 35 based on gross income, then the definition-adjusted Gini coefficient is 31, which is comparable to the Gini coefficient based on net income or expenditure. Therefore, the Gini coefficient data used in our analysis represent an after-tax measurement of income inequality.

The current sample of the Gini coefficients (after adjustment for differences in definition, denoted as GINI) consists of eighty-four countries and a total of 583 observations over the time period 1950–92. It is a highly unbalanced panel data set. Among the eighty-four countries, thirty-seven have less than or equal to three observations; thirty have four to nine observations; eleven have ten to twenty observations; and six have more than twenty observations. See table 1 for the summary

3 We have utilized the new data set to study other dynamic issues related to income distribution; see Li and Zou (1998); and Li, Squire, and Zou (1998).

TABLE 1
Summary statistics for Gini adjusted for differences in definition (GINI)

Country	NOB	Mean	Std Dev	Minimum	Maximum	Country	NOB	Mean	Std Dev	Minimum	Maximum
ARG	3	41.97	1.60	40.40	43.60	JAM	5	44.66	3.31	41.78	50.31
AUS	10	31.54	2.72	28.02	36.05	JOR	2	37.70	4.38	34.60	40.80
AUT	2	32.36	0.82	31.78	32.94	JPN	22	30.65	1.21	28.50	33.20
BEL	9	32.83	5.45	25.04	39.75	KEN	1	57.46	.	57.46	57.46
BGD	9	31.22	2.88	25.00	35.00	KOR	10	30.55	3.03	25.82	35.10
BGR	12	19.90	2.48	16.81	26.15	LKA	9	36.97	5.25	30.10	44.28
BHS	3	43.10	3.80	38.90	46.30	LSO	1	56.02	.	56.02	56.02
BOL	1	42.02	.	42.02	42.02	MAR	2	39.20	0.01	39.19	39.20
BRA	14	53.79	2.34	50.19	57.76	MEX	9	48.18	6.81	38.90	58.40
BRB	1	44.86	.	44.86	44.86	MRT	1	42.53	.	42.53	42.53
BWA	1	54.21	.	54.21	54.21	MUS	3	37.40	5.88	30.70	41.70
CAF	1	55.00	.	55.00	55.00	MYS	6	46.36	1.96	44.00	49.00
CAN	23	27.17	1.67	23.41	28.97	NGA	2	40.82	3.65	38.24	43.40
CHE	1	36.87	.	36.87	36.87	NLD	10	28.73	1.20	26.66	30.55
CHL	15	49.24	3.46	41.64	52.98	NOR	9	33.97	3.03	30.57	37.52
CHN	12	28.68	3.78	21.70	33.80	NPL	2	37.53	16.22	26.06	49.00
CIV	5	39.55	1.94	36.90	41.41	NZL	11	28.91	1.74	26.02	31.43
COL	7	47.01	2.53	42.00	50.50	PAK	11	32.29	2.48	28.38	35.60
CRI	8	42.45	3.23	38.00	48.57	PAN	4	48.40	5.05	43.35	53.00
CSK	9	21.19	1.50	19.37	23.92	PER	4	44.74	5.42	39.00	51.87

DEU	8	32.81	3.85	28.13	41.42	PHL	7	39.67	2.25	36.03	41.30
DNK	3	30.21	2.91	26.99	32.65	POL	8	25.31	0.73	24.48	26.71
DOM	3	42.43	4.05	39.29	47.00	PRI	2	35.25	0.78	34.70	35.80
DZA	1	38.73	.	38.73	38.73	PRT	3	34.05	2.19	32.76	36.58
EGY	3	40.00	2.00	38.00	42.00	RWA	1	28.90	.	28.90	28.90
ESP	8	26.90	2.72	24.42	33.11	SEN	1	54.12	.	54.12	54.12
FIN	9	30.49	1.34	27.00	31.46	SGP	6	36.12	1.81	33.00	38.00
FRA	7	39.92	4.81	33.67	45.00	SLV	1	40.00	.	40.00	40.00
GAB	2	56.80	2.55	55.00	58.60	SUN	4	22.04	1.34	20.56	23.77
GBR	31	25.98	2.61	22.90	32.40	SWE	15	29.26	3.01	24.14	32.34
GHA	3	35.54	1.42	33.97	36.74	SYC	2	44.50	3.54	42.00	47.00
GNB	1	56.12	.	56.12	56.12	THA	8	41.48	3.78	37.28	47.50
GRC	3	37.04	0.55	36.64	37.67	TTO	4	42.21	3.79	37.72	47.00
GTM	3	52.79	3.27	49.04	55.06	TUN	5	42.66	1.11	41.00	44.00
GUY	1	37.92	.	37.92	37.92	TUR	3	46.36	5.98	40.09	52.00
HKG	9	39.33	3.42	33.30	44.70	TWN	23	29.48	1.58	27.70	33.60
HND	5	50.50	4.44	46.00	57.88	TZA	2	43.00	1.41	42.00	44.00
HUN	6	24.21	4.21	20.97	32.48	USA	42	31.31	1.33	29.50	34.16
IDN	7	34.29	2.27	32.01	38.59	VEN	8	38.83	1.94	35.42	41.17
IND	29	32.44	1.99	29.17	37.05	YUG	4	30.13	3.31	27.18	34.72
IRL	3	36.31	2.12	34.60	38.69	ZMB	3	49.84	5.83	43.51	55.00
ITA	15	34.93	2.61	32.02	41.00	ZWE	1	56.83	.	56.83	56.83

NOTES: Total number of countries = 84; NOB = Number of observations. Same for the following tables.

TABLE 2
Summary statistics for real per capita GDP (Y, or RGDPCH in Summers and Heston 1995)

Country	NOB	Mean	Std Dev	Minimum	Maximum	Country	NOB	Mean	Std Dev	Minimum	Maximum
ARG	3	4270.00	474.73	3836	4777	JAM	5	2424.60	451.00	1686	2916
AUS	10	12784.50	1343.46	10404	14854	JOR	2	3516.50	187.38	3384	3649
AUT	2	12156.00	981.46	11462	12850	JPN	22	8020.45	2701.68	3554	14331
BEL	9	10563.67	1656.51	7828	13484	KEN	1	914.00	.	914	914
BGD	9	1057.89	145.93	756	1261	KOR	10	2621.80	1463.19	1058	5607
BGR	12	5263.50	1031.86	3926	6868	LKA	9	1529.89	362.09	1105	2096
BHS	3	10451.67	2442.21	7742	12483	LSO	1	949.00	.	949	949
BOL	1	1658.00	.	1658	1658	MAR	2	2073.00	237.59	1905	2241
BRA	14	3822.21	549.90	2434	4317	MEX	9	4075.44	1239.45	2198	5566
BRB	1	6373.00	.	6373	6373	MRT	1	788.00	.	788	788
BWA	1	2662.00	.	2662	2662	MUS	3	4803.00	1028.80	3988	5959
CAF	1	514.00	.	514	514	MYS	6	3353.67	1022.31	2154	4674
CAN	23	12919.26	3455.88	6511	17524	NGA	2	975.50	3.54	973	978
CHE	1	14146.00	.	14146	14146	NLD	10	11728.50	745.02	10869	13196
CHL	15	3885.93	478.11	3200	4890	NOR	9	11354.89	3263.63	6078	15047
CHN	12	1227.92	168.72	963	1493	NPL	2	935.00	7.07	930	940
CIV	5	1451.00	143.80	1213	1558	NZL	11	10871.91	602.41	10045	11762
COL	7	2649.57	470.50	2140	3297	PAK	11	1113.45	222.05	706	1394
CRI	8	3222.88	526.69	2115	3821	PAN	4	2955.75	350.69	2584	3392
CSK	9	3275.22	742.82	1800	4110	PER	4	2716.50	382.59	2170	3062

DEU	8	11070.88	2288.69	7130	14709	PHL	7	1388.29	244.03	1047	1676
DNK	3	11841.00	1397.39	10921	13449	POL	8	4325.13	342.07	3804	4880
DOM	3	2214.67	193.07	2057	2430	PRI	2	5119.50	1801.00	3846	6393
DZA	1	2769.00	.	2769	2769	PRT	3	5639.67	1613.38	4459	7478
EGY	3	1032.33	256.60	780	1293	RWA	1	834.00	.	834	834
ESP	8	7569.75	1421.55	4580	9238	SEN	1	1120.00	.	1120	1120
FIN	9	10965.11	1461.66	8224	12730	SGP	6	7965.33	2422.01	4757	11059
FRA	7	8854.71	2672.41	5083	12034	SLV	1	2244.00	.	2244	2244
GAB	2	5930.00	339.41	5690	6170	SUN	4	7131.25	738.96	6119	7741
GBR	31	9759.26	1874.86	6971	13241	SWE	15	12989.60	1065.95	10963	14762
GHA	3	849.00	57.38	811	915	SYC	2	2601.00	296.98	2391	2811
GNB	1	593.00	.	593	593	THA	8	2424.50	1034.81	995	3942
GRC	3	5776.33	754.02	4967	6459	TTO	4	8200.50	2840.18	4940	11738
GTM	3	2273.00	264.65	2104	2578	TUN	5	2296.20	676.00	1236	2910
GUY	1	1546.00	.	1546	1546	TUR	3	2673.67	688.74	2109	3441
HKG	9	7638.33	4079.76	2935	15601	TWN	23	4298.87	1890.00	1542	8063
HND	5	1353.00	85.55	1207	1432	TZA	2	450.50	44.55	419	482
HUN	6	4973.83	702.55	3725	5650	USA	42	13069.79	2981.01	8772	18095
IDN	7	1450.00	347.06	978	1974	VEN	8	7246.88	977.97	5907	8257
IND	29	833.38	205.51	608	1264	YUG	4	4411.25	1478.80	2199	5268
IRL	3	6653.00	984.08	5595	7541	ZMB	3	1041.33	298.96	699	1251
ITA	15	10202.53	1278.18	8282	12602	ZWE	1	1182.00	.	1182	1182

TABLE 3
Summary statistics for GINI and Y by income groups

	Sample	NOB	Mean	Std Dev	Minimum	Maximum
GINI	Overall (NOC = 84)	583	34.66	8.63	16.81	58.6
	High-income (NOC = 24)	282	30.94	4.36	22.9	46.3
	Middle- and low-income (NOC = 60)	301	38.14	10.07	16.81	58.6
Y	Overall (NOC = 84)	583	6435.15	4655.66	419	18095
	High-income (NOC = 24)	282	10293.48	3465.47	1542	18095
	Middle- and low-income (NOC = 60)	301	2820.38	1922.87	419	11738

NOTE: Middle-, low-, and high-income samples are defined according to the *World Development Report* classification.

statistics of GINI by individual countries. The maximum value for GINI is 58.6 for Gabon, and the minimum value is 16.81 for Bulgaria.

In table 3 the summary statistics for GINI for different samples are reported. The overall mean and standard deviation are 34.66 and 8.63, respectively. We further divide the full sample into high-income and middle-to-low-income subsamples, following the classification in the *World Development Report* by the World Bank. There are twenty-four high-income countries and sixty middle-to-low-income countries. The high-income countries have a more equal income distribution, with a mean GINI of 30.94 and a standard deviation of 4.36, compared with 38.14 and 10.07 for the middle-to-low-income sample. Also, Gini coefficients for some of the former socialist countries in the middle-to-low-income sample are low.

The income level data (real per capita GDP in constant dollars expressed in international prices, Y), is taken from Summers and Heston (1995), in which it is denoted as RGDPCH. Since the coverage of the Gini coefficients determines the number of valid observations for most countries in our sample, we report results only with respect to the sample in which a match with the Gini data is found. Thus, the complete sample includes eighty-four countries and 583 observations. (See table 2 for summary statistics of the income level Y for individual countries.) The maximum value is $18,095 for the United States, and the minimum is $419 for Tanzania. The overall mean and standard deviation are $6,435 and $4,655, respectively. Finally, summary statistics for Y by subsample are reported in table 3. Note that the high-income sample has low mean Gini while the middle-to-low-income sample has high mean Gini. In other words, income level and Gini are, in general, negatively correlated.

4.2. Theoretical predictions and regression estimation results

The purpose of the empirical analysis is to see what production structure is consistent with facts on growth and income inequality. In particular, if we find that income distribution gets more even as income increases, then our theoretical sections argue

that the production function should exhibit decreasing returns in the reproducible factor. In this case, the empirical evidence would cast doubt on endogenous growth theories, which rely on linearity or convexity in factors such as knowledge, human capital, and physical capital.

We are interested in the sign of the coefficient in a regression of Gini against income level. As already stated, we need to control for taxation and government spending. Since taxation and government spending are highly correlated, we include only one of them in the regression. When taxation is included, the estimated coefficient on taxation is negative and statistically significant,[4] as expected. All the coefficients on Y are negative, but mostly insignificant. This is probably due to the loss of 35 per cent of our observations because some countries do not have taxation data from earlier years. Government spending data, however, are complete, and using this variable does not lead to any severe loss of observations. Therefore, let us focus on the following regression[5]:

$$\text{GINI}_{it} = \alpha_i + \beta_i Y_{it} + \eta_i G_{it} + u_{it}, \tag{26}$$

where i is the country index ($i = 1, 2, \ldots, N$), t is the time index ($t = 1, 2, \ldots, T$), and u_{it} are i.i.d. errors. The dependent variable GINI is the Gini coefficient adjusted for differences in definition. The independent variables are real per capita income Y and government spending, G, as a share of GDP (from Summers and Heston 1995). On the basis of our theoretical model, we expect β_i to be negative if a concave technology prevails and to be positive if a convex technology prevails. Also, η_i should be negative because, in theory, government spending would be expected to improve income distribution.

For the empirical estimation, we consider both fixed-effects and error components model specifications. For the fixed-effects model, we test for the equality of dummy coefficients. For the error components model, two specification tests are conducted, the Lagrangian Multiplier test and the Hausman (1978) test. The Lagrangian Multiplier test is a $\chi^2(1)$-test for error components, with the null

$$H_0\text{: Individual error components do not exist.} \tag{27}$$

The Hausman test is a $\chi^2(k)$-test for error components, with the null

$$H_0\text{: Error components model is the correct specification,} \tag{28}$$

where k is the number of regressors in the regression.[6] In general, our empirical results show that all of the specification tests for the fixed-effects model or error

4 The statistical test of significance for the regression coefficients is based on a 5 per cent t-test. This is the same for the other discussions unless otherwise specified.

5 We also considered a simpler version of regression (26), $\text{GINI}_{it} = \alpha_i + \beta_i Y_{it} + u_{it}$. Since the estimated regression coefficients and their statistical significance for Y are very close to those of regression (26), the results are not reported. They are available upon request.

6 Since the Gini data for individual countries are in general time series with many missing observations, we do not use various specification tests for serial correlation and causality, nor do we use lagged variables as instruments to account for possible endogeneity.

TABLE 4
Estimation results for regression (26)

Dependent variable: GINI

	Middle- and low-income sample		High-income sample		Complete sample	
Sample Model	(1) FE	(2) EC	(3) FE	(4) EC	(5) FE	(6) EC
Constant	–	45.20	–	37.88	–	41.58
	(–)	(24.12)	(–)	(21.12)	(–)	(28.96)
Y	−0.70	−0.83	−0.04	−0.05	−0.09	−0.17
	(−2.40)	(−3.15)	(−0.64)	(−0.77)	(−1.28)	(−2.43)
G	−0.16	−0.10	−0.30	−0.35	−0.19	−0.12
	(−2.21)	(−1.59)	(−2.41)	(−3.28)	(−3.40)	(−2.33)
R^2	0.91		0.72		0.90	
F-test	42.05		22.18		47.06	
LM-test		6413.59		1747.35		10874.18
H-test		3.01		0.99		16.80
NOB	301	301	282	282	583	583
NOC	60	60	24	24	84	84

NOTES: FE = Fixed-effects model; EC = Error-components model; $R^2 = R^2$ for OLS dummy regression (FE); F-test = F-test for equality of dummy coefficients; LM-test = Lagrange Multiplier test ($\chi^2(1)$) for error components, with null being 'individual error components do not exist'; H-test = Hausman (1978) χ^2 specification test, with the null being 'error components model is the correct specification.' For the fixed-effects model, the dummy coefficients are not reported. Same for other tables.

components model do not justify the use of a simple pooled regression. Thus, the pooled regression results are not reported.

In table 4 the estimation results of regression (26) are reported. Since the intent of some government spending (on education, welfare, social security, health, infrastructure, etc.) often is to provide a more equitable distribution in society, we expect it to reduce the degree of income inequality. Indeed, that is what we found in the estimation results. Government spending has coefficients that are negative and significant in most cases.[7]

Our main interest is in the sign of the coefficient for income level. In table 4 it is reported that the coefficients of Y are negative and significant for the middle-to-low-income sample. For the high-income sample, they are also negative, although insignificant. When using the full sample, the coefficients are negative, but significant only for the error components (EC) model. We interpret this regression result as support of a production structure that exhibits strict decreasing returns in the reproducible factor. Therefore, our study on the dynamics of income distribution complements the work of Barro and Sala-i-Martin (1992) and that of Jones (1995a), which question the validity of the endogenous growth framework.

7 This is also true for most of the cases in table 5, where we test the Kuznets hypothesis, and in tables 6 and 7, where we perform the sensitivity analysis.

4.3. The Kuznets hypothesis

A study on income distribution would be incomplete if the issue of the Kuznets hypothesis is not addressed. The Kuznets hypothesis suggests that inequality is low at a lower income level but later increases at a higher income level with economic growth. As the income level grows, inequality decreases. Thus the relationship between income distribution and income level can be described by an inverted *U*-curve. Empirically this can be verified if the coefficient of Y^2 is negative.

Since existing empirical findings give contradictory results, it would be interesting to know whether our new data set supports the Kuznets hypothesis. We directly test the Kuznets hypothesis between inequality and the level of income by considering the following regression:

$$\text{GINI}_{it} = \alpha_i + \beta_i Y_{it} + \gamma_i (Y_{it})^2 + u_{it}. \tag{29}$$

The literature on the Kuznets hypothesis is extensive, including both theoretical work and empirical studies; for example, see Adelman and Robinson (1989), Lindert and Williamson (1985), and Kaeible and Thomas (1991). Papanek and Kyn (1986) found that the relationship between income distribution and development is stable and robust to the inclusion of extra variables capable of capturing differences in policy choice. Note that Papanek and Kyn (1986) consider a panel of eighty-three countries with only 145 observations over 1952–78, while our data set has eighty-four countries with 583 observations covering 1950–92. Ram (1991), however, investigates the Kuznets hypothesis using post-war U.S. data on income distribution and does not find evidence supporting the Kuznets hypothesis. Kaelble and Thomas (1991) compare these and other empirical studies of the Kuznets hypothesis. While most previous empirical results are derived from cross-country studies, we are able to explore the relationship between income distribution and income level using the newly compiled time-series cross-sectional data set.

The results in panel 1 of table 5 show that the coefficients for Y are all negative in all six cases, although not significant for the middle-to-low-income sample. The coefficients for Y^2 are positive and significant for the high-income sample, but negative and insignificant for the middle-to-low-income sample. For the full sample, a regular *U*-curve is found. Therefore, our results provide only weak evidence in support of the Kuznets hypothesis for the middle-to-low-income sample.

We also control for the effects of government spending when testing the Kuznets hypothesis in regression (30):

$$\text{GINI}_{it} = \alpha_i + \beta_i Y_{it} + \gamma_i (Y_{it})^2 + \tau_i G_{it} + u_{it}. \tag{30}$$

The results are reported in panel 2 of table 5. The coefficients of Y and Y^2 and their statistical significance do not vary much from those in panel 1 for regression (29). The coefficients for government spending G, on the other hand, are all negative and significant.

Different functional forms are often used when the Kuznets hypothesis is tested. The most commonly used is the semi-log functional form. We re-estimate regres-

TABLE 5
Testing the Kuznets Hypothesis (estimation results for regressions (29) and (30))

Dependent variable: GINI

Panel 1: Base specification

	Middle- and low-income sample		High-income sample		Complete sample	
Sample Model	(1) FE	(2) EC	(3) FE	(4) EC	(5) FE	(6) EC
Constant	–	42.49	–	37.54	–	42.40
	(–)	(25.56)	(–)	(22.83)	(–)	(36.21)
Y	−0.09	−0.31	−0.95	−0.95	−0.98	−1.21
	(−0.13)	(−0.49)	(−3.67)	(−3.74)	(−3.93)	(−5.33)
Y^2	−0.07	−0.06	0.04	0.04	0.04	0.05
	(−1.09)	(−0.92)	(3.64)	(3.67)	(3.69)	(4.76)
R^2	0.91		0.73		0.90	
F-test	40.29		29.26		47.23	
LM-test		5522.24		2638.24		11755.77
H-test		0.68		0.33		5.53
NOB	301	301	282	282	583	583
NOC	60	60	24	24	84	84

Panel 2: Effect of government spending

	Middle- and low-income sample		High-income sample		Complete sample	
Sample Model	(1) FE	(2) EC	(3) FE	(4) EC	(5) FE	(6) EC
Constant	–	44.39	–	42.98	–	44.55
	(–)	(21.62)	(–)	(19.62)	(–)	(29.27)
Y	0.16	−0.23	−1.02	−1.02	−0.94	−1.21
	(0.23)	(−0.36)	(−3.99)	(−4.07)	(−3.78)	(−5.32)
Y^2	−0.09	−0.06	0.05	0.05	0.04	0.05
	(−1.36)	(−1.03)	(3.95)	(4.00)	(3.55)	(4.77)
G	−0.17	−0.11	−0.34	−0.38	−0.18	−0.12
	(−2.36)	(−1.67)	(−2.85)	(−3.60)	(−3.26)	(−2.40)
R^2	0.91		0.74		0.90	
F-test	41.15		23.97		47.79	
LM-test		5520.76		1808.76		11162.64
H-test		3.68		0.62		9.82
NOB	301	301	282	282	583	583
NOC	60	60	24	24	84	84

sions (29) and (30) using the natural logarithm of Y to see whether the results for regressions (29) and (30) are subject to functional form changes:

$$\text{GINI}_{it} = \alpha_i + \beta_i \ln Y_{it} + \gamma_i (\ln Y_{it})^2 + u_{it} \tag{31}$$

$$\text{GINI}_{it} = \alpha_i + \beta_i \ln Y_{it} + \gamma_i (\ln Y_{it})^2 + \tau_i G_{it} + u_{it}. \tag{32}$$

For regression (31), a regular U-curve is found for the full sample, but the coefficients are insignificant. When the subsamples are considered, the high-income sample can be seen to have a regular U-curve with significant coefficients. In contrast, an inverted U-curve is found for the middle-to-low-income sample, but also with insignificant coefficients. For regression (32), a regular U-curve for the high-income sample, but an inverted U-curve for the middle-to-low-income sample, is found. All of the coefficients are significant for $\ln Y$ and $(\ln Y)^2$ in the two cases. For the full sample, the coefficients for $\ln Y$ and $(\ln Y)^2$ are insignificant. Finally, all the coefficients for government spending are negative and significant in all cases. The results are similar to those reported in table 5 and therefore are not reported. The only substantive difference is that a statistically significant, inverted U-curve relationship is found for the middle-to-low-income sample.

4.4. Sensitivity analysis

In this section, we perform a sensitivity analysis to test the robustness of the results reported in the preceding sections. For a description of the methodology used here, see Levine and Renelt (1992). The essential idea is to see whether the regression results are sensitive to the inclusion of other related regressors. We add a list of extra variables into the base regressions discussed in the earlier sections to test the robustness of the estimation results for the variables of our main interest. The list of extra variables includes PGRW, OPEN, FNDP, and TOTSK (defined below).[8] The base regressions are re-estimated each time three different variables taken from the extra variable list are added.

The variable openness (OPEN) is taken from Summers and Heston (1995). Openness is measured as the total trade value (imports + exports) as a percentage of GDP. Other variables such as population growth (PGRW), financial development (FNDP, measured as M2/GDP) and terms-of-trade shocks (TOTSK, defined as $(\Delta \ln P_X - \Delta \ln P_M)$, where P_X and P_M are export unit price and import unit price, respectively) are taken from the Bank Economic and Social Database (BESD) of the World Bank. For detailed sources of all variables, see table 8 (data appendix).

Results of the sensitivity analysis are reported in table 6 for regression (26) and table 7 for regressions (29) and (30). Because of space limitations, only results for the fixed-effects model are reported. For regression (26), we are interested in testing the robustness of the regression coefficients for Y and G. For the middle-to-low-income sample, all the coefficients of Y are negative and significant. On the other hand, G has in some cases positive but insignificant coefficients. For the high-income sample, all the coefficients for Y are negative but insignificant. The regression coefficients for G are mostly negative and significant. For the full sample, some of the coefficients are insignificant, but all the signs are negative. These results suggest that the coefficients are mostly robust to the theoretical predications and also consistent with the base regression coefficient estimates.

8 One can consider a longer list of variables typically used in the growth literature, as in Levine and Renelt (1992). We use only a few important ones to highlight the main results.

TABLE 6
Sensitivity analysis for regression (26) (fixed-effects model)

Dependent variable: GINI

	1 (Base)	2	3	4	5	6	7
Middle-to-low-income sample							
Y	−0.70	−1.196	−1.463	−0.926	−1.826	−1.262	−1.209
	(−2.40)	(−3.289)	(−3.729)	(−2.395)	(−4.445)	(−3.129)	(−3.110)
G	−0.16	−0.16	−0.086	0.001	−0.062	0.037	−0.08
	(−2.21)	(−2.209)	(−0.877)	(0.010)	(−0.642)	(0.366)	(−0.725)
PGRW		−1.115	−0.241	−1.529			
		(−1.416)	(−0.276)	(−1.694)			
OPEN		0.054			0.06	0.069	
		(2.486)		(2.241)			(2.835)
FNDP		10.408		7.709		10.703	
		(3.379)		(2.425)		(3.452)	
TOTSK				−0.109		−0.461	−0.643
			(−0.047)		(−0.208)	(−0.287)	
NOB	301	285	252	247	256	259	240
R^2	0.905	0.905	0.91	0.914	0.917	0.926	0.921
F-test	42.05	26.122	26.487	26.425	39.751	44.035	39.156
High-income sample							
Y	−0.04	−0.01	−0.169	−0.028	−0.14	−0.014	−0.185
	(−0.64)	(−0.119)	(−1.806)	(−0.290)	(−1.569)	(−0.142)	(−1.797)
G	−0.30	−0.351	−0.194	−0.434	−0.233	−0.437	−0.226
	(−2.41)	(−2.690)	(−1.330)	(−3.017)	(−1.640)	(−3.045)	(−1.506)
PGRW		−0.416	0.659	0.078			
		(−0.773)	(1.113)	(0.147)			
OPEN		−0.029			−0.037	−0.007	
		(−2.110)			(−2.723)	(−0.518)	
FNDP			3.152		3.108		3.531
			(2.397)		(2.484)		(2.910)
TOTSK				0.362		0.137	1.254
				(0.189)		(0.070)	(0.674)
NOB	282	281	255	236	255	236	224
R^2	0.72	0.725	0.72	0.744	0.728	0.745	0.751
F-test	22.18	20.793	20.724	20.593	20.52	18.632	21.667
Full sample							
Y	−0.09	−0.127	−0.327	−0.084	−0.333	−0.09	−0.335
	(−1.28)	(−1.371)	(−3.094)	(−0.766)	(−3.211)	(−0.815)	(−2.747)
G	−0.19	−0.19	−0.061	−0.075	−0.073	−0.068	−0.053
	(−3.40)	(−3.230)	(−0.817)	(−0.933)	(−0.994)	(−0.856)	(−0.652)
PGRW		−0.35		0.366		−0.519	
		(−0.752)		(0.706)		(−1.022)	
OPEN		0.001			−0.008	0.014	
		(0.070)			(−0.628)	(1.113)	
FNDP			5.097		4.994		5.695
			(3.977)		(3.949)		(4.514)
TOTSK				0.192		0.327	0.422
				(0.126)		(0.217)	(0.285)
NOB	583	566	507	483	511	495	464
R^2	0.89	0.898	0.907	0.911	0.909	0.915	0.92
F-test	47.06	33.927	34.442	34.37	44.694	48.221	47.349

In the sensitivity analysis, a strong and positive statistical tie was identified between financial depth and income distribution. Population growth seems to have a positive effect on reducing income inequality in the middle-to-low-income sample. For the high-income sample and the full sample, however, population growth tends to increase income inequality. However, the relationship between population growth and income inequality is statistically weak in all cases.

Openness seems to be negatively related to income inequality for the high-income sample and vice versa for the middle-to-low-income sample. On the other hand, the terms-of-trade shock has a positive relationship with GINI for the full sample and the high-income sample, while for the middle-to-low-income sample the relationship is negative. For both variables, the relationship with GINI is not statistically significant.

For regressions (29) and (30) (the Kuznets hypothesis), the sensitivity analysis generally supports a regularly shaped *U*-curve for the high-income sample with a strong statistical significance. An inverted *U*-curve is found for the middle-to-low-income sample, however, although in most cases the coefficients on Y and Y^2 are insignificant. For the full sample, the results also indicate a regular shaped *U*-curve, similar to that of the high-income sample (see results in table 7). To summarize, the sensitivity analysis provides overall support for the results reported in the previous sections.

5. Conclusions

In this paper, we test the validity of the linearity assumption in the endogenous growth models. Our test is focused on the implications of this assumption for the dynamics of income distribution, which we illustrate using a set of examples with closed-form solutions. In particular, we see that in the standard Cass-Koopmans model with a concave production function, income distribution improves if the initial capital stock in the economy is less than the golden-rule steady state.[9] If the production function is linear in the reproducible factor, income distribution is time invariant.[10] With a convex production function, we conjecture that income distribution worsens with income growth. Our empirical results show that income distribution tends to improve over time with income growth. Therefore, our study on the dynamics of income distribution supports findings by Barro and Sala-i-Martin (1992) and Jones (1995a) that call into question the validity of the endogenous growth framework.

We have also obtained two empirical results concerning the issue of income distribution that are of independent interest. First, as we expected, income taxation

9 A similar result can be found in Stiglitz (1969). His result, however, is derived from an assumption about the saving function instead of the preference structure.

10 Bertola (1993) and Krusell, Quadrini, and Rios-Rull (1997) obtain similar results, but they address substantive issues different from ours.

TABLE 7
Sensitivity analysis for regressions (29) and (30) (fixed-effects model)

Dependent variable: GINI

	1 (Base)	2	3	4	5	6	7	8	9	10	11
Middle-to-low-income sample											
Y	−0.091	−1.226	−0.193	0.238	−0.464	−0.96	−0.315	1.003	−1.27	0.133	0.239
	(−0.132)	(−1.123)	(−0.173)	(0.230)	(−0.443)	(−1.016)	(−0.317)	(1.031)	(−1.276)	(0.134)	(0.254)
Y^2	−0.072	−0.055	−0.113	−0.138	−0.098	−0.021	−0.11	−0.187	−0.052	−0.129	−0.14
	(−1.092)	(−0.597)	(−1.226)	(−1.541)	(−1.124)	(−0.272)	(−1.258)	(−2.157)	(−0.614)	(−1.529)	(−1.686)
G	−0.162	−0.083	0	−0.065	0.022	−0.072					
	(−2.220)	(−0.841)	(0.002)	(−0.669)	(0.218)	(−0.651)					
PGRW		0.192	−0.823	−0.115		−1.061	0.189	−0.723			
		(0.208)	(−0.865)	(−0.117)	(−1.303)	(0.202)	(−0.746)				
OPEN	0.057	0.058		0.046	0.051			0.054	0.053		
		(2.018)	(2.103)		(1.596)	(2.085)			(1.916)	(1.973)	
FNDP		6.885		8.471	7.008		9.107		7.194		8.824
		(2.119)		(2.634)	(2.161)		(2.807)		(2.185)		(2.691)
TOTSK			−0.563	−0.382	−0.844			−0.039		−0.448	−0.676
			(−0.252)	(−0.172)	(−0.383)			(−0.017)		(−0.203)	(−0.303)
NOB	301	252	247	236	240	285	252	247	256	259	240
R^2	0.911	0.913	0.918	0.918	0.923	0.905	0.911	0.916	0.917	0.927	0.922
F-test	40.289	22.726	24.093	23.604	39.24	23.055	22.575	23.76	38.234	43.695	38.346
High-income sample											
Y	−0.949	−1.614	−0.779	−2.027	−1.969	−1.089	−1.718	−1.015	−1.525	−0.895	−1.884
	(−3.674)	(−4.432)	(−2.141)	(−4.578)	(−4.663)	(−3.667)	(−4.839)	(−2.905)	(−4.313)	(−2.666)	(−4.795)
Y^2	0.043	0.062	0.037	0.076	0.074	0.047	0.065	0.043	0.058	0.039	0.07
	(3.639)	(4.195)	(2.440)	(4.409)	(4.460)	(3.778)	(4.509)	(2.937)	(4.039)	(2.738)	(4.466)
G	−0.403	−0.142	−0.486	−0.154	−0.472	−0.162					
	(−3.155)	(−1.011)	(−3.414)	(−1.113)	(−3.325)	(−1.121)					

PGRW		−0.177	−0.323	−0.337		−0.868	−0.035	−0.548			
		(−0.293)	(−0.536)	(−0.557)		(−1.614)	(−0.060)	(−0.968)			
OPEN		−0.021	0.002		0.005	−0.018			−0.021	0.004	
		(−1.482)	(0.118)			(0.361)	(−1.314)	(−1.526)	(0.302)		
FNDP		6.504		7.549	7.564		6.023		5.921		6.947
		(5.039)		(5.810)	(5.790)		(4.259)		(4.238)		(5.003)
TOTSK			−0.085	0.49	0.74			−0.4		−0.155	0.54
			(−0.042)	(0.272)	(0.405)			(−0.211)		(−0.080)	(0.303)
NOB	282	255	236	224	224	281	255	236	255	236	224
R^2	0.728	0.745	0.741	0.772	0.772	0.74	0.743	0.755	0.746	0.754	0.774
F-test	29.26	25.095	22.523	27.432	25.733	22.127	23.329	21.469	22.574	19.476	24.647
Full sample											
Y	−0.982	−1.947	−1.163	−1.841	−1.985	−1.226	−1.848	−0.953	−1.914	−0.99	−1.703
	(−3.926)	(−5.402)	(−3.181)	(−4.652)	(−4.994)	(−4.086)	(−5.404)	(−2.779)	(−5.510)	(−2.895)	(−4.638)
Y^2	0.043	0.071	0.048	0.066	0.072	0.05	0.068	0.04	0.07	0.042	0.061
	(3.686)	(4.736)	(3.048)	(4.045)	(4.358)	(3.845)	(4.665)	(2.673)	(4.758)	(2.778)	(3.942)
G	−0.186	−0.063	−0.087	−0.061	−0.066	−0.058					
	(−3.214)	(−0.866)	(−1.084)	(−0.851)	(−0.838)	(−0.736)					
PGRW		−0.125	−0.753	−0.583		−0.757	−0.273	−0.99			
		(−0.237)	(−1.404)	(−1.051)		(−1.607)	(−0.521)	(−1.853)			
OPEN		0.013	0.026		0.026	0.015			0.013	0.027	
		(0.935)	(1.861)		(1.893)	(1.183)			(0.951)	(2.032)	
FNDP		7.511		7.905	7.928	7.473	7.449	7.919			
		(5.569)	(5.787)	(5.850)		(5.531)		(5.570)		(5.819)	
TOTSK			0.144	0.047	0.237			−0.215		0.107	0.036
			(0.096)	(0.032)	(0.164)			(−0.142)		(0.072)	(0.025)
NOB	583	507	483	460	464	566	507	483	511	495	464
R^2	0.903	0.912	0.913	0.922	0.924	0.901	0.912	0.912	0.914	0.917	0.923
F-test	47.227	35.184	34.206	36.577	49.217	34.894	35.609	34.315	46.902	48.347	49.172

TABLE 8
Data appendix

Variables	Sources
1) Gini coefficients (GINI)	Deininger and Squire (1996)
2) Real per capita income (Y)	Summers and Heston (1995)
3) Government spending (G)	Summers and Heston (1995)
4) Openness (OPEN)	(Export + Import) / GDP, Summers and Heston (1995)
5) Financial development (FNDP)	M2 / GDP, IFS, IMF
6) Terms of trade shocks (TOTSK)	Δ ln(Export price) − Δ ln(Import price), IFS (IMF) and World Bank Trade Statistics
7) Population growth (PGRW)	World Bank Social Indicators

and government spending lower income inequalities. Second, the Kuznets hypothesis on income inequality does not hold for the new data set when the full sample of countries of all income levels is used. There is some evidence, however, that the Kuznets hypothesis holds for the middle-to-low-income subsample.

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第 5 章

中国收入分配的变化

Explaining the changes of income distribution in China

Lixin Colin XU[a,b], Heng-fu ZOU[a,b,*]

[a]*Development Research Group, The World Bank, MC2-611, 1818 H St. NW, Washington, DC 20433, USA*
[b]*School of Management, Peking University, Beijing 100871, China*

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Abstract

China has experienced one of the most remarkable increases in inequality over the last decade: the Gini coefficient increasing from 25.7 in 1984 to 37.8 in 1992. Using the recent developments in the theory of income distribution [J. Polit. Econ. 101 (1993) 274; Rev. Econ. Stud. 60 (1993) 35.] and a new panel data set about Chinese provincial-urban-level income inequality, this paper finds that inequality increased with the reduction of the share of state-owned enterprises (SOEs) in GDP, high inflation, growth, and (less significantly) the increasing exposure to foreign trade. We also find some evidence for the Director's Law: income redistribution tends to shift resources from the rich and the poor to the middle class. We do not find schooling and urbanization to be a significant explanatory factor.

Keywords: Chinese economy; Income distribution; Economic growth

1. Introduction

Among developed countries, the UK has experienced an unparalleled rise in income in the 1980s, as Atkinson (1997) noticed:

> In the United States, the Gini coefficient of inequality for household income rose between 1968 and 1992 by three and a half percentage points ... This is a significant increase, but if you want to see a *big* increase then it is to the United Kingdom that one has to

* Corresponding author.
E-mail address: hzou@worldbank.org (H. Zou).

look. Between 1977 and 1991, the United Kingdom Gini coefficient rose by 10 percentage points.

Among developing countries, China shows a similar trend in rising income inequality. Starting from a relatively low Gini coefficient of household income of 25.7 on a scale of 100 in 1984, China reached a relatively high Gini coefficient of income of 37.8 in 1992. Over a short period of 8 years, the Gini coefficient in China increased 12 percentage points, and the rising trend has been continuing to the present. To illustrate the significance and uniqueness of the Chinese case, note that the Gini coefficient in India remained almost constant for 40 years (1951–1992) with a mean of 32.6 and a standard deviation of 2.0 (see Li et al., 1998; Li & Zou, 1998, for more details on the evidence of intertemporal stability in the Gini coefficients for over 40 countries).

The Chinese case is even more interesting when we consider its spectacular output growth since the economic reforms initiated in 1978. Over a period of 16 years (1978–1994), the average growth rate in terms of real GDP was 9.9%. This positive correlation between income growth and inequality immediately throws doubt on the significant negative association between income growth and inequality found in Alesina and Rodrik (1994) and Persson and Tabellini (1994) based on both theory and a cross-section of international data. This positive correlation between growth and inequality also contradicts an influential World Bank study *The East Asian Miracle* (World Bank, 1993), which found economic growth to be associated with low and declining levels of inequality for the eight East Asian countries excluding mainland China. On the other hand, this positive correlation seems to support the age-old Kuznets (1955) inverted U-curve and the more complicated theoretical relationship between economic growth and income inequality in Greenwood and Jovanovic (1990), Banerjee and Newman (1993), Galor and Zeira (1993), Perotti (1993), and Benabou (1996), among many others (see Benabou, 1996; Atkinson, 1997, for a survey and further developments).

What accounts for the rapid rise in income inequality in China? Recent advances in income distribution theory mentioned above provide plenty of channels. While many of these theoretical models have confronted cross-country data, very few examine individual countries. In this paper, we follow Banerjee and Newman (1993), Galor and Zeira (1993), and Atkinson (1997), and apply their theoretical insights to the case of China. Since 1978, China's experience provides a fertile field for testing the determinants of *changes* in income inequality explored in many recent theoretical contributions. We broaden the Benerjee–Newman and Galor–Zeira framework, and look at the role played by output growth, increasing exposure to international trade, urbanization, taxation and government spending, inflation, human capital formation, geography, and especially the sectoral structure of the economy (the share of state enterprises) in determining the changes of income inequality. Theoretical considerations of all these factors will be presented in Section 2.

Section 3 provides a brief description of our provincial panel data on urban income distribution and all explanatory variables in our empirical study. We provide detailed regression analysis on the determinants of income inequality in Chinese provinces in Sections 4 and 5. In Section 6, we summarize our findings and offer concluding remarks on the direction for further work.

2. Some analytical considerations

2.1. The occupational choice between the state sector and private sector

In China and other transition economies, the obvious choice facing individuals is whether to continue to work in the state sector or find new employment and set up a money-making business in the private sector. Since the reform starting in 1978, the share of state-owned industrial output has continued to decline. The reduction is most dramatic in coastal provinces like Hainan and Guangdong, where state-owned enterprise (SOE) share of industrial output had declined as much as 30 to 40 percentage points. To model this choice and its effect on income distribution, we follow the ideas in Banerjee and Newman (1993), and Galor and Zeira (1993). In general, the state sector continues to provide a stable and meager income plus various fringe benefits including free or cheap health care, schooling, and housing. These benefits are denoted w_s. All agents live for two periods as in Galor and Zeira (1993). In the first period, they can either work in the state sector or invest in the private sector. All agents in our model maximize their life-time earning. If agents work in the state sector, they earn w_s for both periods. During the first period, since they do not consume, their savings generate a capital income at a safe rate r. Therefore, their life-time income, y_s is:

$$y_s = (1 + r)(x + w_s) + w_s, \tag{1}$$

where x is the initial endowment for agents. As in Banerjee and Newman (1993), we assume that all agents are risk-neutral. The risk-neutral assumption allows us to exclude the role of risk aversion in risk-taking and occupational choices. Therefore, agents in the state sector maximize their expected life-time income or expected second-period consumption (Eq. (2)):

$$\text{MaxEU}(y_s) = E(y_s) = y_s = (1 + r)(x + w_s) + w_s, \tag{2}$$

where E is the expectation operator.

For agents undertaking investment in the private sector, the investment project is indivisible and requires an initial investment of I units of capital.[1] Here we can take I to be a combination of investment in both physical and human capital. If the project succeeds, it generates a random return πI where π is π_h or π_l with probabilities q and $1-q$, respectively, and $\pi_h > \pi_l > 0$. Since all agents are assumed to be risk-neutral, the agents in the private sector maximize their life-time expected income y_p (Eq. (3)):

$$\text{EU} = E(y_p) = (x - I)(1 + r) + I[q\pi_h + (1 - q)\pi_l] \tag{3}$$

if the initial endowment x is larger than I: $x > I$.

As in Banerjee–Newman and Galor–Zeira models, the credit market is assumed to be imperfect. In fact, in China, only the powerful and the well-connected agents have access to

[1] See the similar indivisibilities of investment in Galor and Zeira (1993) for human capital investment and Banerjee and Newman (1993) for physical capital investment. Indivisibilities are very essential for history dependence and multiple equilibria in the model. Otherwise, with decreasing returns to scale, it is possible for income distribution across individuals to become more equilized over time (see Stiglitz, 1968; Chatterjee, 1994; Caselli & Ventura, 1996; Li et al., 2000).

credit markets at reasonable borrowing costs. If agents intend to invest in the private sector by credit financing, the cost is given by:

$$h(b) = (1 + R - \delta)b + \frac{\mu}{2}b^2, \tag{4}$$

where b denotes the amount borrowed, R ($>r$) is the official borrowing rate, which is never available to the public, δ is the power index, and μ is a positive parameter reflecting convex borrowing costs. For the initial poor with no political power or connections, they have no access to the credit market at the official rate R. Actual lending rates in credit markets depend on the official rate, the power index, and a rising marginal cost of borrowing. Those agents choosing to borrow will maximize their expected income:

$$\mathrm{EU} = E(y_b) = (1 + r)(x + b - I) + I[q\pi_h + (1 - q)\pi_l] - (1 + R - \delta)b - \frac{\mu}{2}b^2. \tag{5}$$

The optimal choice of b is a function of the official lending rate R, the power or connection index δ, the deposit rate r, and the rising-cost parameter μ (Eq. (6)):

$$b = b(R, \delta, \mu, r). \tag{6}$$

Agents with an initial endowment x larger than I or initially rich agents choose not to work in the state sector if and only if:

$$[q\pi_h + (1 - q)\pi_l - (1 + r)]I > w_s(2 + r). \tag{7}$$

In inequality (7), the left-hand side is the expected excess return on the indivisible investment in the private sector, and the right-hand side is the life-time earning in the state sector. Therefore, if Eq. (7) holds, initially rich agents with investment in the private sector will become even richer in the second period compared to the employees in the state sector. In a province with a larger private sector, income distribution is likely to be more unequal compared to a province with a larger share of state ownership.

In this paper, we will call agents with power and connection, and access to credit finance as "powerful." The powerful will invest in the private sector instead of working in the state sector if and only if:

$$I[q\pi_h + (1 - q)\pi_l - (1 + r)] + b(R, \mu, \delta, r)(1 + r) - h(b(R, \mu, \delta, r)) > w_s(2 + r) \tag{8}$$

The left-hand side is the net gain from investment through borrowing in credit markets, and again the right-hand side is the life-time earning in the state sector. Therefore, agents even with poor initial resources but politically powerful are likely to become the new rich in the second period if credit costs are not exceedingly high. Agents with an initial endowment x smaller than I and without access to credit or cannot afford the credit will continue to work in the state sector. All things given, these poor agents in both economic and political terms will likely remain poor in the second period because they are excluded from the credit markets. The driving force for this result is the indivisibility of investment projects, as in Banerjee and Newman (1993) and Galor and Zeira (1993).

The model thus yields a few implications. The initial rich in the urban sector will become richer through their investment in the private sector; the initial poor will remain poor as the employees of the state sector if they lack political clout and access to credit markets; and the

powerful, even without sufficient initial resources, may gain as a result of their access to credit and profitable, money-making opportunities.

2.2. The role of other factors in determining income inequality

Our simple model allows us to consider the effects of various other factors on income distribution. First, aggregate growth can influence both the state sector and the private sector. An increase in the demand for the products manufactured in the state sector can lead to a higher wage w_s in Eq. (1) for the employees in the state sector, which may improve income distribution ceteris paribus. Meanwhile, the rising aggregate demand for products in the nonstate sector can lead to a higher probability of success in the private investment project q or a higher average return on the private investment. With rising expected profits from investment as a result of the rise in market demand, the powerful can afford to borrow more and improve their economic lot in life. Thus, the initial rich and the powerful may benefit from the increase in market demand disproportionally than the initial poor. If this is the case, income distribution can become even more unequal. For our empirical analysis, we take provincial GDP growth as an approximation for the aggregate change in market demand.

Second, foreign trade and foreign direct investment have played a special role in both the product market and the credit market in China. During the reform period, the government has granted export subsidies and foreign exchange retention to various special economic zones and open cities in different regions in order to promote exports. Their effects on wages and profitability can be favorable to both the state sector and the nonstate sector. Trade licenses and quotas seem to benefit the rich and the powerful much more than the poor. The powerful have a direct access to trade licenses and quotas, and the rich can obtain these trade privileges through bribery and numerous other measures. Foreign direct investment and joint ventures can create or reduce the imperfection of the credit or capital market in China. The powerful and the rich are in a better position to collude with foreign investors in granting licenses for foreign direct investment and joint ventures. In this way, the powerful and the rich can benefit disproportionally from the rents generated by foreign direct investment. On the other hand, the flow of foreign capital into China naturally reduces the high borrowing cost in the credit market, and that may increase the possibility even for the poor to set up private businesses as a result of lower borrowing cost parameters R and μ in Eqs. (4) and (5). Therefore, the net effect of foreign trade and foreign direct investment on income distribution is not clear.

Third, geographical location is relevant for income distribution across provinces. Coastal provinces like Guangdong and Fujian have a natural advantage in serving domestic and foreign demand through the sea ports and expanding their product markets to Hong Kong, Taiwan, the Pacific Rim, and Northern America. This partly explains why foreign direct investment and joint ventures have concentrated in coastal provinces in China. Since this concentration can significantly improve the access to the credit market not only for the rich and the powerful, but also for the poor in coastal provinces, geographical advantage may reduce income inequality in coastal provinces relative to inland provinces.

Fourth, large increases in the share of urban population are observed across provinces since 1978. Our model sheds light on the effect on urban income distribution of urbanization and migration from the rural sector to the urban sector. If migrants have accumulated a certain

amount initial capital through their individual efforts or through the contributions from their rural communities or extended families, and if these funds are sufficient for them to set up private businesses in the urban sector, their migration to cities and towns can increase the number of the middle class or they may even become the new rich. That may even improve urban income distribution. But if migrants are very poor peasants and go to cities and towns to find employment opportunities, they may earn a lower wage in the informal sector than employees in the state sector. As a result, they become the new poor of the urban sector, and urban income distribution can become more unequal. Thus, it is not clear how urbanization affects urban inequality.

Fifth, the importance of income policy in the distribution of personal income has been emphasized by Atkinson (1997). If taxation and public spending intend to remedy income inequality, the government can tax investment income in the private sector and subsidize the workers and the poor in the state sector. Accordingly, income distribution is expected to improve. But if tax revenues are channeled to subsidize credit for the politically powerful, income for the powerful may rise and income inequality may even increase. Furthermore, government spending may worsen income distribution if redistribution and public spending are tilted toward the middle class, the rich, and the powerful instead of the poor in education, health, and social welfare. Thus, the net effects of income policy on inequality are ambiguous.

Sixth, inflation can affect the poor more than the rich and the powerful. In reality, the assets of the rich and the powerful are more diversified (stocks, equities, land ownership, private housing, and business ventures), whereas the urban poor and the state sector employees depend mainly on salary and pension income, which are usually fixed at a nominal term and adjusted only slowly to the inflation rate. Thus, we expect that inflation raises income inequality and reduces the income share of the poor.

3. Data and the changes of income distribution in China, 1985–1995

Current descriptive studies on inequality in China have mainly relied on per capita income and per capita consumption comparisons across provinces because systemic data on regional income distribution is lacking. Many studies report alarming, ever-growing disparities across provinces in terms of per capita income and consumption (Lyons, 1991; Tsui, 1991, 1996). Yet there is no provincial-level data on income inequality. We try to fill this gap by employing the published results of average incomes of different percentiles for urban residents in each province (World Bank, 1996). This new data set allows us to examine more closely how the poor are doing in each province, how the incomes of the poor and the rich income are determined, and how the income of the poor and economic growth are linked.

It is useful to get to know the data before proceeding to examine the income distribution of Chinese provinces. Based on the urban household surveys, the data we use covers the period of 1985 to 1995 (except 1987 and 1988) on the income distribution of urban residents of each province. For the 1989–1995 period, there are 20 average incomes for each 5 percentiles (5 percentile, 10 percentile, and so on). For 1985 and 1986, the data are less perfect: we have the average incomes of the bottom 10 percentile, the next 10 percentile, the next three quintiles,

then the top two 10 percentiles.[2] Based on these data, we computed the Gini coefficients, the percentage of income of top quintile in total income (Q5), that of bottom quintile (Q1), and that of the third and fourth quintiles (Q34), and the ratio of the percentage of Q5 over that of Q1 (Q5/Q1).

While the computation of the rest of the measures is straightforward, the computation of the Gini coefficient is more complex. To compute this measure, we used an approximation method, which has the virtue of being simple and without imposing parametric assumptions about the Lorenz curve. In general, however, it underestimates the Gini with the assumption of a relative smooth Lorenz curve, and the downward bias decreases with the number of percentile points. When 20 5-percentiles are used, for instance, the upper bound of underestimation of the Gini is 0.025. When 7 percentiles (as in 1985 and 1986) are used, however, the underestimation bias should be larger. In all our future regressions, we correct for this problem by including a dummy variable whose value is 1 for the years of 1985 and 1986. This dummy variable should capture the underestimation of the Gini, and other systematic biases for quintiles in 1985 and 1986. Since we cannot determine exactly the size of the bias here our descriptive discussion of income distribution shall focus on the 1989 to 1995 period. In later regressions, we include 1985 and 1986 dummies to filter out the bias.

Since 1978, urban residents in most provinces have witnessed a worsening income distribution. Between 1989 and 1995, the Gini coefficient increased by 2.4 points (from 21.0 to 23.4). The ratio of Q5 over Q1 rose from 2.0 to 2.6. Underlying these figures is an increasing disparity between the rich and the poor: Q5's claim to total income went up from 27% to 31.7%, and Q1's share dropped from 14.6% to 12.5%. The middle class (Q34) also slightly suffered with the lapse of time: its share dropped by almost 1% from 41.

Worsening income distribution was by no means evenly shared among the provinces (Table 1). Some provinces, such as Guangdong, Guangxi, Hunan, Qinghai, did not change much; Xinjiang, located in the northwest corner of China, even improved its Gini by 1.3 point. Other provinces, in contrast, dramatically raised their Gini: Tianjin (one of the three municipalities) increased its Gini by more than 9.3 points, (inland) Henan by 9.5, (inland) Heilongjiang by 9.2, and (inland) Sichuan by 9 points. To summarize the changes in income distribution by provinces, Table 2 presents the trend of the Gini coefficient by province. We found that 19 of the 29 provinces had a positive and statistically significant trend. No province experienced a negative and significant trend in the Gini. More strikingly, Q5 increased significantly in 27 provinces, and Q1 decreased significantly in 24 provinces. The share of the middle class, Q34, dropped significantly in seven provinces, and increased significantly in three provinces. Thus, the more fundamental trend behind the worsening of the Gini is the increasing claim of wealth by the rich and the opposite for the poor in almost all provinces.

While the income distribution worsened, the total pie for the Chinese grew. The average per capita GDP growth rate was 8.8% (Table 3). The provinces exhibited a large difference in their growth. While the average growth rate was 4.8% for (inland) Qinghai, 5% for (inland) Heilongjiang, 6.3% for (inland) Guizhou, it was 14.2 for (coastal) Guangdong, 13.9 for

[2] In 1985, we also have the average income of the bottom 5 percentile.

Table 1
Some statistics of used variables: by province for the period of 1985 to 1995

	Gini					The real growth rate of provincial GDP					The inflation rate					% SOE output in provincial GDP				
	Mean	N	$x(T)-x(0)$	N	C.V.	Mean	N	$x(T)-x(0)$	N	C.V.	Mean	N	$x(T)-x(0)$	N	C.V.	Mean	N	$x(T)-x(0)$	N	C.V.
Anhui	19.69	11	4.76	8	0.11	10.68	24	1.47	19	0.88	10.2	5	6.3	15	0.67	49.1	7	−32.84	7	0.31
Beijing	17.89	2	4.27	7	0.12	7.95	14	−0.68	17	0.67	12.46	28	−6	1	0.46	59.26	16	−17.31	20	0.14
Fujian	22.56	25	6.56	17	0.14	12.72	27	−4.61	9	0.59	10.4	8	3.8	8	0.75	38.41	4	−38.81	3	0.33
Gansu	20.3	13	5.7	12	0.13	8.47	16	−5.21	7	0.4	10.74	15	8	19	0.62	77.08	28	−21.44	15	0.09
Guandong	24.89	28	3.44	2	0.12	14.22	29	−9.61	3	0.37	10.01	4	−2	4	0.88	35.51	3	−34.56	6	0.33
Guanxi	19.96	12	3.47	3	0.11	10.43	23	1.72	20	0.57	11.61	25	5.2	13	0.77	62.95	18	−35.57	5	0.22
Guizou	21.45	18	8.65	22	0.14	6.27	3	4.49	24	0.44	10.44	9	9.5	23	0.65	75.3	25	−12.43	24	0.07
Hainan	27.89	29	n.a.	n.a.	0.17	10.26	22	n.a.	n.a.	0.67	12.53	29	−1.5	5	0.77	65.93	19	−39.41	1	0.21
Hebei	18.12	3	6.33	16	0.17	9.14	17	2.04	22	0.62	9.67	3	8	19	0.77	46.22	6	−22.64	14	0.19
Heilongjiang	21.72	21	9.16	24	0.15	5	2	9.3	26	0.69	11.23	21	2.6	7	0.46	76.57	27	−13.12	23	0.07
Henan	22.16	23	9.45	26	0.19	9.15	18	4.53	25	0.63	8.66	1	10	24	0.87	49.58	8	−32.28	8	0.22
Hubei	18.57	7	5.69	10	0.16	7.72	11	−3.46	12	0.68	11.04	19	9.1	22	0.69	57.66	14	−29.4	9	0.17
Hunan	22.02	22	3.71	4	0.11	7.64	9	−4.35	10	0.48	11.43	23	4.4	10	0.7	57.04	13	−25.65	11	0.16
Jiangsu	19.02	10	6.86	18	0.17	11.74	26	−10.5	2	0.75	10.94	17	5.1	12	0.66	29.85	2	−19.31	17	0.24
Jiangxi	20.64	14	5.69	11	0.14	9.43	20	−3.53	11	0.51	10.46	10	7.6	18	0.76	58.45	15	−17.76	18	0.18
Jilin	21.38	17	6.03	15	0.18	6.3	4	3.68	23	0.96	10.39	7	4.5	11	0.54	67.73	21	−9.85	27	0.06
Liaoning	18.89	9	7.04	19	0.15	7.23	8	−6.13	6	0.66	10.59	12	4	9	0.6	56.28	12	−23.74	13	0.15
Inner Mongolia	22.23	24	5.72	13	0.12	7.89	12	−2.22	14	0.45	10.24	6	8.3	20	0.59	73.45	22	−15.3	21	0.08
Ningxia	21.59	19	3.93	5	0.2	7.93	13	−0.86	16	0.61	10.67	14	7.5	17	0.56	76	26	−10.64	25	0.05
Qinghai	21.19	16	4.09	6	0.09	4.82	1	n.a.	n.a.	0.72	11.52	24	5.6	14	0.56	82.51	30	4.44	29	0.03
Shaanxi	21.72	20	n.a.	n.a.	0.17	6.92	7	−12.57	1	0.66	11.34	22	10.5	27	0.69	66.43	20	−14.45	22	0.08
Shandong	18.5	5	5.91	14	0.14	11.51	25	1.84	21	0.6	9.56	2	7.1	16	0.67	39.87	5	−23.86	12	0.32
Shanghai	17.31	1	8.26	21	0.19	8.39	15	−2.85	13	0.59	12.42	27	−3.4	2	0.4	60.08	17	−37.98	4	0.23
Shanxi	23.15	26	n.a.	n.a.	0.16	6.73	6	11.28	27	0.69	10.51	11	8	19	0.67	55.24	10	−17.44	19	0.13
Sichuan	20.92	15	8.95	23	0.18	9.31	19	−4.89	8	0.64	10.62	13	10.2	26	0.74	56.11	11	−29.29	10	0.21
Tianjin	18.82	8	9.33	25	0.18	6.63	5	0.56	18	0.7	10.76	16	−3.3	3	0.4	53.05	9	−39.04	2	0.26
Xinjiang	23.45	27	−1.28	1	0.12	9.59	21	−7.48	5	0.42	11.86	26	8.6	21	0.57	78.76	29	−10.32	26	0.04
Yunnan	18.52	6	5.49	9	0.13	7.69	10	−1.63	15	0.41	10.98	18	10.1	25	0.64	74.61	23	−8.5	28	0.04
Zhejiang	18.44	4	7.93	20	0.16	13.89	28	−8.31	4	0.61	11.21	20	−0.5	6	0.63	25.53	1	−21.43	16	0.29

	SCH					TRADE					GEXPS			URBANGR				
	Mean	Rank	$x(T)-x(0)$	Rank	C.V.	Mean	Rank	$x(T)-x(0)$	Rank	C.V.	Mean	Rank	C.V.	Mean	Rank	$x(T)-x(0)$	Rank	C.V.
Anhui	30.14	8	9.74	19	0.13	6.68	6	4.3	6	0.28	9.99	5	0.24	0.48	12	−0.63	6	0.8
Beijing	64.57	30	10.17	21	0.09	62.73	29	210.47	30	1.49	11.88	13	0.18	0.77	25	0.01	23	0.84
Fujian	26.00	5	7.4	10	0.11	39.41	27	38.45	25	0.46	13.64	17	0.22	0.48	11	−0.21	17	1.57
Gansu	28.12	6	6.95	5	0.12	5.88	4	6.64	14	0.46	18.87	24	0.09	0.41	6	−0.12	18	0.9
Guandong	34.52	13	10.27	22	0.12	83.03	30	132.27	29	0.7	10.62	9	0.1	0.89	29	−0.95	4	0.78
Guanxi	30.18	9	8.41	14	0.14	12.96	18	7.49	18	0.34	15.4	20	0.2	0.49	14	−0.03	20	0.86
Guizou	19.98	3	7.39	9	0.12	4.79	1	7.17	17	0.49	18.55	23	0.12	0.39	4	0.06	24	1.64
Hainan	40.28	22	n.a.	n.a.	0.01	34.09	25	48.32	27	0.69	15.04	19	0.26	0.75	24	−0.47	8	0.92
Hebei	38.44	18	7.03	6	0.12	11.31	17	0.88	2	0.28	10.48	8	0.23	0.34	3	0.17	28	1.04
Heilong	45.54	25	9.59	17	0.1	10.92	16	5.34	10	0.35	13.25	16	0.18	0.64	22	−0.03	21	0.82
Henan	39.63	20	10.37	23	0.15	5.51	2	3.24	3	0.28	10.39	6	0.17	0.47	10	−0.24	16	0.72
Hubei	37.23	17	6.08	1	0.11	8.85	12	6.72	16	0.3	10.47	7	0.17	0.68	23	−1.87	1	1.16
Hunan	35.05	14	8.5	15	0.13	8.12	11	3.29	4	0.37	11.27	10	0.11	0.48	13	−0.32	14	1.03
Jiangsu	41.17	23	9.41	16	0.09	16.12	19	17.97	23	0.4	7.18	1	0.13	1	30	−0.07	19	1.09
Jiangxi	29.92	7	9.69	18	0.18	7.71	8	4.61	7	0.27	12.7	14	0.16	0.6	20	−0.29	15	1.55
Jilin	46.50	26	12.04	28	0.12	16.5	20	10.87	20	0.39	17.23	21	0.2	0.78	26	−0.65	5	0.93
Liaoning	48.62	27	6.4	2	0.07	30.68	23	6.68	15	0.18	11.8	12	0.15	0.55	16	−0.53	7	1.05
Neimeng	39.97	21	7.69	11	0.07	9.21	14	6.15	13	0.4	21	25	0.21	0.56	18	−0.41	10	0.86
Ningxia	33.72	11	11.89	27	0.16	8.07	9	5.22	9	0.26	24.92	27	0.29	0.58	19	−0.37	13	0.69
Qinghai	25.76	4	11.27	26	0.19	5.86	3	4.71	8	0.35	25.13	28	0.18	0.63	21	−1.23	2	1.79
Shaanxi	39.34	19	7.32	8	0.1	9.12	13	11.5	22	0.52	n.a.	n.a.	n.a.	0.52	15	−0.39	11	1.22
Shandong	35.53	15	10.77	24	0.1	16.5	21	8.54	19	0.22	8.12	2	0.18	0.8	27	−0.39	12	0.9
Shanghai	61.36	29	9.84	20	0.06	51.99	28	49.69	28	0.33	9.84	4	0.13	0.83	28	0.15	27	0.81
Shanxi	43.47	24	11.09	25	0.11	7.08	7	5.94	12	0.26	13.99	18	0.19	0.55	17	0.13	26	1.12
Sichuan	30.77	10	8.14	13	0.13	6.5	5	5.58	11	0.37	11.62	11	0.15	0.4	5	−0.43	9	1.09
Tianjin	52.63	28	7.88	12	0.06	38.92	26	47.89	26	0.45	13.09	15	0.21	0.45	8	0.26	29	1.49
Xinjiang	33.97	12	6.75	4	0.08	9.40	15	3.94	5	0.18	18.49	22	0.33	0.41	7	0.00	22	1.35
Yunnan	19.73	2	6.68	3	0.13	8.08	10	11.09	21	0.48	24.79	26	0.12	0.46	9	0.06	25	1.39
Zhejiang	36.64	16	7.31	7	0.1	17.77	22	19.18	24	0.42	8.53	3	0.18	0.32	2	−1.03	3	1.64

Source of data: various volumes of provincial statistical yearbooks.

Table 2
Trend of inequality measures over time (1985–1995)

	Gini		Q5/Q1		Q5		Q1		Q34	
Year	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1985	17.13	2.58	2.45	0.39	30.05	1.76	12.39	0.98	35.17	0.98
1986	16.43	2.11	2.38	0.36	29.57	1.21	12.59	1.06	35.54	0.55
1989	21.02	3.80	1.99	0.86	27.08	2.25	14.59	2.55	40.96	1.33
1990	20.25	2.60	1.84	0.27	27.01	1.94	14.85	1.25	40.74	0.98
1991	19.93	2.12	1.89	0.30	27.71	1.94	14.91	1.58	40.42	1.02
1992	20.81	2.57	2.10	0.33	28.80	2.02	13.89	1.32	40.55	0.80
1993	22.69	2.90	2.41	0.42	30.73	2.30	13.02	1.82	40.30	1.19
1994	24.63	2.88	2.75	0.55	32.05	2.69	11.93	1.53	40.63	1.20
1995	23.42	2.57	2.60	0.50	31.73	2.62	12.46	1.46	40.14	1.30

These income inequality measures are based on the authors' calculation based on the published accounts of the average incomes of urban residents for various percentiles. No data are provided for 1987 and 1988 because we do not have sources for these 2 years.

(coastal) Zhejiang, 12.7 for (coastal) Fujian, and 11.7 for (coastal) Jiangsu. The coefficient of variation for growth rate was also nontrivial: from 0.09 to 0.19. The correlation between the growth rate and the Gini coefficient is .27.

Accompanying the growth, the share of the volume of import and export to GDP increased dramatically. The highest trade shares, not surprisingly, were seen in Beijing, Fujian, Guangdong, Shanghai, and Tianjin, which are located near the seashore. The largest change in trade share over time also belonged to these trade giants. The dwarfs of trade were mostly inland provinces (the smallest being Guizhou, which saw a moderate increase in trade; Henan, which also had the second worst increase in trade share; Qinghai, which also had quite slow growth in trade share). The correlation between trade share and the Gini coefficient is .22.

Table 4 presents the correlation matrix for the variables we shall use. Note a high positive correlation between the Gini and inflation rate. The correlation between the Gini and schooling (as measured by the percentage of population having above secondary schooling) is −.02, small in magnitude. Government expenditure (as measured by the share of budgetary expenditure of total GDP) also had negligible correlation with the Gini. In

Table 3
Descriptive statistics of used variables

Variable	Obs	Mean	Standard deviation	Min	Max	Variable	Obs	Mean	Standard deviation	Min	Max
Gini	252	20.73	3.69	12.98	34.17	INFL	261	10.84	6.72	−4.40	26.8
Q1	247	13.41	1.90	5.05	19.49	SCH	259	36.62	12.10	1.53[a]	68.21
Q5	247	29.41	2.77	21.4	40.36	DISTA	261	0.79	0.77	0.00	3.65
Q5/Q1	247	2.27	0.56	1.10	5.94	TRADE	261	19.10	28.17	1.63	232.70
Q34	247	39.41	2.40	32.25	45.57	GEXPS	224	14.22	5.77	5.65	35.77
GDPGR	259	8.83	5.76	−5.72	26.16	URBANGR	261	0.58	0.64	−0.60	3.50
SOE	261	58.78	17.46	14.06	87.82						

[a] This low figure is attributed to Tibet. These income inequality measures are based on the authors' calculation based on the published accounts of the average incomes of urban residents for various percentiles.

Table 4
The correlation matrix of used variables

	Gini	Q1	Q5	Q5/Q1	Q34	GDPGR	SOES	INFL	SCH	DISTA	TRADE	GEXPS
Gini	1.00											
Q1	−.43	1.00										
Q5	.58	−.81	1.00									
Q5/Q1	.57[a]	−.94	.84	1.00								
Q34	.46	.18	−.25	−.15	1.00							
GDPGR	.27	−.36	.43	.36	−.06	1.00						
SOE	−.18	.14	−.15	−.12	−.31	−.43	1.00					
INFL	.40	−.23	.31	.30	.19	.25	−.27	1.00				
SCH	−.00	.22	−.23	−.10	.35	−.07	−.21	.11	1.00			
DISTA	.17	−.04	.05	.08	−.06	−.14	.54	−.01	−.37	1.00		
TRADE	.22	−.05	.10	.08	.17	.28	−.36	.15	.40	−.35	1.00	
GEXPS	−.03	.03	−.06	.02	−.29	−.30	.75	−.22	−.42	.50	−.26	1.00
URBANGR	.15	−.19	.28	.21	−.05	.39	−.20	.31	.11	−.14	.12	−.17

See the Appendix for definition of variables.

[a] This correlation is low because we pooled 1985–1986 with the data in 1989–1995. Recall that we had different number of observations for these two periods, and because of that, Gini is underestimated more in the first period than in the second. Not surprisingly, this correlation becomes .82 when we only used 1989–1995, and it turns to .98 when we use only 1985–1986.

addition, note the strong correlation of GDP growth with both the trade share and urbanization growth, and its negative correlation with the SOE share and that province's distance to the coast by railroad.

4. The empirical specifications and issues

Based on discussions in Section 2, our examination of income inequality involves these variables: (a) the occupational structure, specifically, the share of SOEs; (b) macro-economic policies, in particular, as an implicit transfer (from the poor to the rich), the inflation rate (INFL), and as an explicit transfer, the share of government budgetary expenditure as a share of GDP (GEXPS); (c) geography as measured by the distance of a province's capital to the nearest port by railroad (DISTA); (d) the share of residents with more than secondary schooling (SCH); (e) GDP growth rates; (f) the involvement of the provinces in foreign trade, as measured by the ratio of the value of the volume of import and export to GDP (TRADE); and finally (g) the change of urbanization level of a province, as measured by the growth rate of the share of nonagricultural population in the province (URBANGR).[3]

Note that the variables we use are province-level (not just the urban sector) measures. Ideally, one wants to use the urban measures, but unfortunately, it is not feasible given the

[3] We chose not to use the growth of urban population because urban population, by official statistics, consisted of both true urban residents and farmers. Urbanization should therefore be measured as the share of nonagricultural population.

data we have and all the sources we have checked. On the other hand, some variables have less problems. SOE, for instance, does not present as a major problem because all SOEs are located in the urban domain. In addition, INFL in urban areas should be quite closely related to provincial inflation rates. Lastly, URBANGR is the ideal measure, because we want to see how urbanization growth itself affected the income distribution within the urban sector. This said, now we estimate Eq. (9):[4]

$$y_{it} = \beta_0 + \beta_1 \mathrm{SOE}_{it} + \beta_2 \mathrm{INFL}_{it} + \beta_3 \mathrm{DISTA}_i + \beta_4 \mathrm{SCH}_{it} + \beta_5 \mathrm{GDPGR}_{it} + \beta_6 \mathrm{TRADE}_{it} + \beta_7 \mathrm{GEXPS}_{it} + \beta_8 \mathrm{URBGR}_{it} + \phi_i + \varepsilon_{it} \quad (9)$$

where y_{it} could be Gini, Q5/Q1, Q5, Q1, and Q34. We wish to examine how the explanatory variables affected the inequality (Gini, Q5/Q1), the rich (Q5), the poor (Q1), and the middle class (Q34). ϕ_i is unobserved province-specific factors that may affect y_{it}. The inclusion of ϕ_i is justified by the finding that inequality tends to persist over time (Li et al., 1997). When ϕ_i is correlated with the included explanatory variables (X_{it}), the fixed effects (FE) (or the least square dummy variables, LSDV) model is appropriate. When ϕ_i is not correlated with X_{it}, a random effects model is more efficient than an FE model. We can test the correlation by the Hausman–Wu test, whose basic idea is that, if ϕ_i is correlated with X_{it}, then FE estimates should differ significantly from RE estimates; consequently, if the difference of the two vectors of estimates is large, FE is preferred. In order to see whether the results are robust — since the theory does not tell us what conditioning information set is appropriate for the effects of variables of interests (Levine and Renelt, 1992) — we experimented with many different sets of regressors. In particular, we consider SOE, INFL, DISTA, SCH, and GDPGR as the base set of regressors about whose impacts on outcomes we are most concerned. Then we add accumulatively one variable at a time, and all results are reported.

While FE estimates should filter out the time-invariant province-specific factors, we still have to consider the potential correlation of some elements of X_{it} with ε_{it}. Among X_{it}, we consider DISTA, INFL, and SCH exogenous: (a) DISTA is a purely natural endowment; (b) SCH measures the percentage of population with more than secondary schooling, surveyed once every 5 years. This stock of human capital was largely a consequence of past history, unlikely to be correlated with ε_{it}; (c) INFL is seen as exogenous because the monetary policy was set by the central banks, and unlikely to be correlated with the province-specific time-variant ε_{it}. It is still possible that ε_{it} follows an AR(1) process, and that ε_{it-1} affected INFL_{it}; however, we have experimented with allowing ε_{it} to be distributed as AR(1), and the results remained largely similar to FE estimates. Since our main concern is the correlation of endogenous variables with ε_{it} — and we control for provincial dummies — the lagged value of the endogenous variables should be considered predetermined, likely to be uncorrelated with ε_{it}, and therefore, qualify as instruments. In addition, the share of rural industrial output in total rural output is strongly correlated with GDPGR and TRADE; yet it should not affect ε_{it}, which measures the contemporaneous shock affecting the province's urban sector. Thus, it is also a natural instrument.

[4] This specification is very close to Edwards (1997) and Li et al. (1998) for cross-country study on the determinants of income inequality. The SOE share and geographic location are the added, special features for China.

Table 5
Determinants of the Gini coefficients (dependent variable = Gini coefficient)

	Model (1)			Model (2)			Model (3)			Model (4)		
Model	FE[a]	RE	2SLS+FE	FE	RE	2SLS+FE	FE	RE	2SLS+FE	FE	RE	2SLS+FE
No. Obs.	251	251	250	247	247	246	239	239	238	239	239	238
R^2	.696	.687	.799	.701	.690	.800	.704	.695	.803	.704	.696	.690
Constant	21.328	23.066	28.501	18.344	21.229	26.064	17.328	19.839	25.725	17.461	19.819	11.950
	(6.080)	(12.115)	(4.710)	(5.035)	(11.241)	(3.950)	(4.705)	(9.977)	(3.929)	(4.728)	(9.833)	(1.332)
SOE	−0.115	−0.078	−0.153	−0.091	−0.052	−0.136	−0.094	−0.069	−0.152	−0.095	−0.070	−0.132
	(−6.115)	(−4.577)	(−5.337)	(−4.207)	(−2.867)	(−3.753)	(−4.368)	(−3.642)	(−4.131)	(−4.391)	(−3.689)	(−2.818)
INFL	0.106	0.123	0.094	0.121	0.136	0.104	0.127	0.142	0.108	0.130	0.144	0.162
	(5.178)	(5.943)	(4.192)	(5.712)	(6.599)	(4.036)	(5.707)	(6.712)	(4.006)	(5.725)	(6.658)	(3.764)
DISTA		1.534			1.695			1.484			1.496	
		(2.725)			(3.155)			(2.696)			(2.671)	
SCH	0.131	−0.002	0.176	0.149	−0.025	0.198	0.143	−0.011	0.159	0.140	−0.009	0.483
	(1.608)	(−0.068)	(0.969)	(1.829)	(−0.733)	(1.094)	(1.762)	(−0.305)	(0.869)	(1.724)	(−0.247)	(2.081)
GDPGR	0.053	0.069	0.010	0.037	0.050	0.002	0.050	0.066	0.037	0.055	0.070	0.154
	(2.281)	(2.846)	(0.207)	(1.563)	(2.042)	(0.041)	(1.993)	(2.602)	(0.703)	(2.097)	(2.648)	(1.389)
TRADE				0.050	0.060	0.029	0.049	0.056	0.020	0.049	0.056	0.053
				(2.640)	(3.730)	(0.844)	(2.619)	(3.513)	(0.598)	(2.599)	(3.485)	(1.337)
GEXPS							0.096	0.135	0.158	0.097	0.136	0.111
							(1.792)	(2.703)	(2.109)	(1.813)	(2.707)	(1.217)
URBANGR										−0.136	−0.126	−2.149
										(−0.661)	(−0.595)	(−1.682)
	$\chi^2(5)=29.47$[b]			$\chi^2(6)=24.60$			$\chi^2(7)=42.52$			$\chi^2(8)=28.86$		
	$P=.000$			$P=.000$			$P=.000$			$P=.000$		

In parentheses are the t statistics. See the Appendix for the definitions of the variables.

[a] In all these tables, the R^2 reported for FE and RE specifications are R^2 within. This is appropriate because we focus on the change of the dependent variables.

[b] The Hausman's (χ^2) test statistics: a large value favors the FE model (instead of RE model); P is the associated P value.

Table 6
Determinants of Q5/Q1 (dependent variable = Q5/Q1)

	Model (1)			Model (2)			Model (3)			Model (4)		
	FE	RE	2SLS+FE	FE	RE	2SLS+FE	FE	RE	2SLS+FE	FE	RE	2SLS+FE
No. Obs.	246	246	245	242	242	241	234	234	233	234	234	233
R^2 within	.412	.388	.548	.416	.393	.535	.412	.394	.519	.412	.395	.108
Constant	2.040	2.332	4.758	1.677	2.154	4.933	1.565	2.012	4.835	1.570	2.016	0.588
	(2.569)	(7.833)	(3.454)	(2.003)	(7.130)	(3.189)	(1.842)	(6.226)	(3.084)	(1.842)	(6.130)	(0.234)
SOE	−0.021	−0.010	−0.023	−0.018	−0.008	−0.024	−0.019	−0.011	−0.027	−0.019	−0.011	−0.021
	(−5.024)	(−3.193)	(−3.497)	(−3.726)	(−2.366)	(−2.879)	(−3.784)	(−2.908)	(−3.108)	(−3.778)	(−2.940)	(−1.703)
INFL	0.019	0.023	0.014	0.020	0.024	0.013	0.020	0.024	0.013	0.021	0.024	0.029
	(4.000)	(5.141)	(2.670)	(4.200)	(5.351)	(2.182)	(3.998)	(5.156)	(2.046)	(3.947)	(4.982)	(2.539)
DISTA		0.160			0.181			0.163			0.167	
		(1.949)			(2.214)			(1.939)			(1.940)	
SCH	0.025	−0.003	−0.026	0.028	−0.005	−0.027	0.027	−0.002	−0.034	0.026	−0.002	0.059
	(1.376)	(−0.527)	(−0.623)	(1.482)	(−0.934)	(−0.644)	(1.425)	(−0.425)	(−0.792)	(1.415)	(−0.400)	(0.961)
GDPGR	0.017	0.021	0.026	0.016	0.019	0.026	0.018	0.021	0.034	0.018	0.021	0.071
	(3.230)	(3.748)	(2.269)	(2.845)	(3.285)	(2.203)	(3.061)	(3.575)	(2.629)	(2.943)	(3.365)	(2.258)
TRADE				0.006	0.006	−0.002	0.006	0.005	−0.004	0.006	0.005	0.006
				(1.375)	(1.998)	(−0.258)	(1.294)	(1.685)	(−0.493)	(1.287)	(1.683)	(0.587)
GEXPS							0.013	0.018	0.031	0.013	0.018	0.021
							(1.022)	(1.690)	(1.705)	(1.027)	(1.685)	(0.890)
URBANGR										−0.008	0.003	−0.641
										(−0.159)	(0.057)	(−1.778)
	$\chi^2(5)=20.31$			$\chi^2(6)=18.88$			$\chi^2(7)=17.63$			$\chi^2(6)=16.84$		
	$P=.001$			$P=.004$			$P=.014$			$P=.032$		

In parentheses are the t statistics. See the Appendix for the definitions of the variables.

Table 7
Determinants of Q5 (dependent variable = Q5)

	Model (1)			Model (2)			Model (3)			Model (4)		
	FE	RE	2SLS + FE	FE	RE	2SLS + FE	FE	RE	2SLS + FE	FE	RE	2SLS + FE
No. Obs.	246	246	245	242	242	241	234	234	233	234	234	233
R^2 within	.530	.508	.618	.538	.515	.596	.548	.519	.626	.550	.523	.442
Constant	27.492	30.552	45.699	25.785	29.489	48.047	27.436	30.054	47.971	27.301	30.158	33.600
	(8.295)	(19.437)	(7.275)	(7.416)	(18.336)	(6.729)	(7.896)	(17.521)	(6.995)	(7.856)	(17.367)	(3.400)
SOE	−0.110	−0.068	−0.091	−0.095	−0.054	−0.101	−0.089	−0.049	−0.093	−0.088	−0.049	−0.071
	(−6.224)	(−4.443)	(−3.040)	(−4.644)	(−3.326)	(−2.589)	(−4.390)	(−2.788)	(−2.422)	(−4.326)	(−2.813)	(−1.483)
INFL	0.087	0.105	0.061	0.096	0.112	0.055	0.077	0.102	0.039	0.073	0.096	0.093
	(4.490)	(5.387)	(2.600)	(4.783)	(5.709)	(1.962)	(3.678)	(5.056)	(1.379)	(3.410)	(4.656)	(2.042)
DISTA		0.985			1.080			1.140			1.175	
		(2.182)			(2.407)			(2.457)			(2.495)	
SCH	0.148	−0.016	−0.303	0.156	−0.026	−0.342	0.152	−0.030	−0.286	0.155	−0.031	0.032
	(1.923)	(−0.552)	(−1.608)	(2.004)	(−0.912)	(−1.768)	(1.997)	(−1.003)	(−1.522)	(2.034)	(−1.007)	(0.132)
GDPGR	0.123	0.136	0.220	0.117	0.130	0.228	0.107	0.128	0.207	0.099	0.118	0.325
	(5.518)	(5.857)	(4.172)	(5.080)	(5.391)	(4.139)	(4.541)	(5.182)	(3.643)	(3.954)	(4.559)	(2.632)
TRADE				0.031	0.032	−0.018	0.026	0.032	−0.021	0.026	0.032	0.014
				(1.736)	(2.199)	(−0.492)	(1.453)	(2.141)	(−0.583)	(1.476)	(2.136)	(0.359)
GEXPS							−0.113	−0.048	−0.122	−0.116	−0.052	−0.156
							(−2.249)	(−1.009)	(−1.542)	(−2.310)	(−1.098)	(−1.668)
URBANGR										0.211 (1.087)	0.228 (1.112)	−2.105
												(−1.486)
	$\chi^2(5)=32.06$			$\chi^2(5)=31.87$			$\chi^2(5)=22.90$			$\chi^2(5)=21.81$		
	$P=.000$			$P=.000$			$P=.002$			$P=.005$		

In parentheses are the t statistics. See the Appendix for the definitions of the variables.

Table 8
Determinants of Q1 (dependent variable = Q1)

	Model (1)			Model (2)			Model (3)			Model (4)		
	FE	RE	2SLS+FE	FE	RE	2SLS+FE	FE	RE	2SLS+FE	FE	RE	2SLS+FE
No. Obs.	246	246	245	242	242	241	234	234	233	234	234	233
R^2 within	.469	.456	.600	.475	.463	.589	.470	.459	.571	.471	.460	.192
Constant	13.474	12.651	4.630	15.001	13.117	4.115	15.032	13.319	4.424	14.989	13.333	18.507
	(5.470)	(12.341)	(1.055)	(5.804)	(12.268)	(0.833)	(5.745)	(11.697)	(0.880)	(5.713)	(11.510)	(2.275)
SOE	0.068	0.043	0.070	0.056	0.036	0.079	0.056	0.040	0.087	0.056	0.041	0.065
	(5.208)	(4.027)	(3.365)	(3.674)	(3.217)	(2.919)	(3.646)	(3.248)	(3.075)	(3.659)	(3.278)	(1.648)
INFL	−0.053	−0.063	−0.031	−0.060	−0.067	−0.028	−0.059	−0.065	−0.027	−0.060	−0.066	−0.081
	(−3.650)	(−4.494)	(−1.916)	(−4.021)	(−4.698)	(−1.457)	(−3.720)	(−4.483)	(−1.322)	(−3.734)	(−4.413)	(−2.160)
DISTA		−0.540			−0.614			−0.569			−0.576	
		(−1.871)			(−2.085)			(−1.879)			(−1.867)	
SCH	−0.061	0.011	0.132	−0.071	0.018	0.124	−0.068	0.015	0.137	−0.067	0.014	−0.173
	(−1.071)	(0.592)	(1.003)	(−1.232)	(0.958)	(0.924)	(−1.182)	(0.751)	(0.995)	(−1.163)	(0.699)	(−0.867)
GDPGR	−0.067	−0.074	−0.126	−0.059	−0.067	−0.127	−0.061	−0.069	−0.146	−0.064	−0.071	−0.267
	(−4.054)	(−4.328)	(−3.421)	(−3.478)	(−3.788)	(−3.330)	(−3.432)	(−3.831)	(−3.507)	(−3.392)	(−3.718)	(−2.625)
TRADE				−0.024	−0.018	0.015	−0.022	−0.017	0.021	−0.022	−0.017	−0.012
				(−1.792)	(−1.820)	(0.598)	(−1.658)	(−1.647)	(0.811)	(−1.645)	(−1.653)	(−0.372)
GEXPS							−0.013	−0.026	−0.075	−0.014	−0.027	−0.043
							(−0.338)	(−0.775)	(−1.300)	(−0.363)	(−0.790)	(−0.560)
URBANGR										0.068	0.043	2.113
										(0.461)	(0.283)	(1.812)
	$\chi^2(5)=14.14$			$\chi^2(6)=14.36$			$\chi^2(7)=15.81$			$\chi^2(8)=14.90$		
	$P=.015$			$P=.026$			$P=.027$			$P=.061$		

In parentheses are the t statistics. See the Appendix for the definitions of the variables.

Table 9
Determinants of Q34 (dependent variable = Q34)

	Model (1)			Model (2)			Model (3)			Model (4)		
	FE	RE	2SLS + FE	FE	RE	2SLS + FE	FE	RE	2SLS + FE	FE	RE	2SLS + FE
No. Obs.	246	246	245	242	242	241	234	234	233	234	234	233
R^2 within	.855	.852	.851	.858	.853	.849	.854	.849	.844	.856	.850	.837
Constant	42.999	41.053	37.306	42.165	41.299	36.719	41.921	41.400	36.526	42.024	41.319	34.382
	(22.501)	(66.907)	(11.070)	(21.094)	(64.872)	(9.717)	(20.387)	(59.703)	(9.538)	(20.476)	(58.605)	(7.442)
SOE	0.003	−0.012	−0.016	0.009	−0.014	−0.019	0.007	−0.012	−0.025	0.007	−0.012	−0.022
	(0.294)	(−1.742)	(−0.969)	(0.741)	(−1.995)	(−0.912)	(0.625)	(−1.414)	(−1.169)	(0.548)	(−1.388)	(−0.974)
INFL	0.000	−0.007	−0.003	0.003	−0.008	−0.004	0.007	−0.007	−0.001	0.010	−0.004	0.008
	(0.025)	(−0.652)	(−0.273)	(0.273)	(−0.772)	(−0.294)	(0.552)	(−0.665)	(−0.040)	(0.810)	(−0.321)	(0.358)
DISTA		−0.013			−0.032			−0.033			−0.046	
		(−0.079)			(−0.189)			(−0.183)			(−0.250)	
SCH	−0.063	0.011	0.105	−0.055	0.012	0.131	−0.056	0.009	0.118	−0.059	0.010	0.165
	(−1.429)	(1.083)	(1.040)	(−1.241)	(1.073)	(1.278)	(−1.251)	(0.773)	(1.123)	(−1.302)	(0.840)	(1.456)
GDPGR	−0.014	−0.022	−0.022	−0.020	−0.023	−0.024	−0.018	−0.026	−0.013	−0.012	−0.020	0.006
	(−1.058)	(−1.774)	(−0.762)	(−1.476)	(−1.793)	(−0.824)	(−1.321)	(−1.925)	(−0.410)	(−0.800)	(−1.410)	(0.109)
TRADE				0.011	−0.005	−0.005	0.011	−0.005	−0.007	0.010	−0.004	−0.002
				(1.041)	(−0.815)	(−0.256)	(1.029)	(−0.665)	(−0.351)	(1.003)	(−0.626)	(−0.110)
GEXPS							0.022	−0.011	0.057	0.025	−0.009	0.053
							(0.742)	(−0.461)	(1.301)	(0.825)	(−0.373)	(1.206)
URBANGR										−0.163	−0.146	−0.330
										(−1.415)	(−1.287)	(−0.499)
	$\chi^2(5) = 13.74$			$\chi^2(6) = 11.83$			$\chi^2(7) = 10.42$			$\chi^2(8) = 11.69$		
	$P = .017$			$P = .066$			$P = .166$			$P = .165$		

In parentheses are the t statistics. See the Appendix for the definitions of the variables.

5. Results

Tables 5–9 report the empirical results. For each measure of income distribution (Gini, Q5/Q1, Q5, Q1, and Q34), we run OLS, FE, RE, and FE+2SLS model (in which we control for provincial dummies and also use the aforementioned instruments for two-staged least square estimation). The OLS results are not reported because all tests show them to be statistically inferior. In addition, we have experimented with an FE model (by controlling provincial dummies) with the AR(1) error term. The results are very similar to FE estimates; thus, we do not bother the reader with more numbers.

5.1. The Gini coefficient (Table 5)

For model (1) and model (2), the Hausman–Wu test favors FE and for models (3) and (4), it favors the RE model. The R^2 reported for FE and RE models are R^2 within, computed using FE model formulae — it measures the extent the deviation of the Gini from its provincial mean can be explained by using the explanatory variables. The R^2 between (measuring the ability of the model to explain the difference between provincial means) tended to be very small, suggesting that our FE estimates fail to explain the *level* of the Gini coefficient. Yet, the R^2 values within are quite high, all above .69. Thus, the changes of the provincial Gini can largely be explained by our measures.

The results for SOE, INFL, and SCH are robust. Provinces with higher SOE share had smaller Gini coefficients. The estimates suggest that an increase of a standard deviation of SOE would be associated with an increase of the Gini by 1.2 to 2.8. Provinces with higher inflation rates had higher Ginis: a standard deviation of INFL was associated with an increase of the Gini by 0.7 to 1.0. The finding supports our earlier discussion. By the preferred FE or 2SLS models, a higher education probably increased the Gini. Before rushing into any judgment, note that SCH did not show large variations across time in our data set, and that it was fixed in every 5 years; so, for the purpose of accounting for the *change* of income inequality, SCH is not capable of contributing much. In fact, when we look into a similar measure of the Gini, Q5/Q1, this result no longer holds.

Growth (GDPGR) increased the Gini and is quite significant in all specifications except in the 2SLS model that controls for provincial dummies; in the latter model the sign remains positive, but becomes insignificant and smaller when we do not control for URBANGR. When URBANGR is controlled for in model (4), however, GDPGR become marginally significant.[5] Similarly, the share of foreign trade in GDP (TRADE) was significant in FE and RE specifications for all models. The use of 2SLS does not alter its sign, but it becomes insignificant. Whereas government expenditure is supposed to reduce income inequality, the opposite is found: models (3) and (4) consistently suggest that it increased inequality; a standard deviation increase of GEXPS was associated with an increase of the Gini by 0.9 point (RE) to 1.2 point (2SLS). Finally, increasing urbanization (URBANGR) might have reduced income inequality; the large standard errors for estimates, however, urge caution.

[5] This finding is consistent with the positive association between inequality and growth in a cross-country study by Edwards (1997).

In examining Q5/Q1 (Table 6), we find similar results compared to the case of the Gini. This is hardly surprising. After all, they are both good summary statistics of inequality. A comforting discovery, though, is that GDPGR remains quite significant in the models of 2SLS with FE. Later, we shall add more support for this finding by examining how GDPGR improved Q5 and reduced Q1. Another finding is that the coefficient of schooling no longer approaches significance; and when we use 2SLS, the sign reverses. Lastly, GEXPS now has larger standard deviations, although the qualitative results remain intact.

5.2. Q5 (Table 7)

From model (1) to model (4), FE specification won the statistical contests convincingly, as witnessed by the small P values of the Hausman–Wu test. Moreover, the use of instruments in general does not fundamentally change any result. The R^2 values within for FE are not as high as in the case of the Gini.

The market from 1985 to 1995 certainly benefited the rich. Q5, for instance, increased significantly with INFL, whose increase of one standard deviation was associated with about 0.5 point increase of Q5. Furthermore, Q5 moved shoulder to shoulder with GDPGR, whose increase by one standard deviation increased Q5 by 0.6 to 0.7 according to point estimates. TRADE has ambiguous signs when we compare FE (and RE) with 2SLS and with provincial dummies. When we increase the conditioning information set from model (2) to model (4), it becomes increasingly less significant. The use of instruments made it flip signs, but the large standard error precludes any strong assertion here.

The restraining force for the increase of Q5 seems to come mainly from the state. First, a large SOE was associated with lower Q5, a finding consistent with our assumption in the model. Moreover, a standard deviation increase of GEXPS was associated with 0.8 point decrease of Q5. Unrelated to the state, the direction of the effects of URBANGR on Q5 is not clear: the large standard deviations for FE and 2SLS estimates warrant caution.

Provinces that are far away from the coast have a larger Q5; this is consistent with our conjecture that inland capital markets are more imperfect. Another finding is that, in FE models, SCH seems to raise Q5; yet once instruments are used, its sign flipped. This finding suggests that higher Q5 for provinces with higher SCH reflected probably just the positive correlation of SCH with the error term in FE estimation.

5.3. Q1 (Table 8)

FE specifications still dominate RE ones, except in model (3). But the inclusion of instruments seems to matter. The R^2 within are similar to Q1: whereas a bit less than half of the variance of the changes of Q1 can be explained by our variables, still more cannot be explained by our model.

The most noticeable finding is that the forces that increased Q5 also reduced Q1, thus the poor came out of this period as the loser. INFL certainly had reduced the income share of the poor. When INFL increased by one standard deviation, Q1 would decline by around 0.4 percentage point. GDPGR, another force that helped the rich, harmed the poor in terms of relative share of income. When GDPGR increased by one standard deviation, Q1

dropped by 0.4 point (FE), and 2SLS implies an even larger figure, especially when the conditioning information set is larger. TRADE, while helped the rich, again hurt the poor. The sign flip with the use of instruments does not suggest a strong effect of TRADE on the poor. Finally, the poor farther from the seashore claimed a smaller share of total income, an observation consistent with the role of imperfect capital markets in reducing the poor's income in inland areas.

The state did not help the poor. The reduction of SOE reduced Q1. One standard deviation decrease of SOE would at least reduce Q1 by a whopping 7 points, even by more than 10 points when a larger conditioning information set is used. In addition, GEXPS did not significantly help the poor. The consistently negative signs with large standard errors may even suggest the opposite. Finally, URBANGR did not give a consistent message: it was insignificant in FE and RE estimation, and approached significance in 2SLS.

5.4. Q34 (Table 9)

Although our variables are least useful in predicting the fortune of middle class, the within R^2 are the largest when compared to Q1 and Q5. This is hardly surprising. Q34 hardly changed on average over the period (at least for 1989–1995). For most models, the Hausman–Wu tests do not favor FE or RE consistently. Not a single variable significantly affected Q34 consistently. We have some weak evidence that GDPGR reduced Q34, but the standard errors of estimates are large.

6. Conclusion

Examining the experiences of 29 provinces over 11 years, we have focused on how the *change* of income distribution (and the income share of the rich, the poor, and the middle class) had been affected by the changing structure of economy (higher growth rates, increasing exposure to foreign trade), the role of the state (the reduction of SOE sector, and more decentralized fiscal expenditure), and increasing urbanization. We have found that inequality and Q5 increased with, and Q1 decreased with, the reduction of SOE share, higher inflation and growth rates, and (less significantly) the increasing extent of foreign trade. We have also found some evidence for Director's Law (Stigler, 1970): income redistribution through government spending tends to shift resources from the rich and the poor to the middle class, as witnessed by the positive sign on Q34, but generally negative signs of Q5 and Q1. Intriguingly, provinces farther from the coast had larger inequality, an observation probably reflecting the consequences of greater imperfection of capital market. Schooling and increasing urbanization did not play a significant role in the increasing income inequality during this period.

The findings of this paper answer some questions, but elicits more questions. Is it inevitable that growth and openness will increase income inequality? Will the poor necessarily be the loser of the growth gains? Under what circumstances do the above scenarios arise? If the scenario is true, what can governments do to reduce the suffering of the poor during growth and global economic integration processes? In addition, given the nature

of this data, and the short time-span we have, some questions evade answer. What determines, for instance, the level differences across different provinces? Further research is needed to answer these questions.

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Appendix A. Data appendix

Our empirical estimations are based on annual data for 29 provinces. Data sources are all official publications in China. Although over 100 volumes of statistical publications are involved, major data sources include China Statistical Yearbook and provincial statistical yearbooks for various years. Variables used for estimations are listed below with their data sources. Names of provincial areas included in our estimations are also listed.

GDPGR = the real growth rate of provincial GDP, measured at constant price level.
Source: For 1985–1995: China Statistical Yearbook (*Zhongguo Tongji Nianjian*) various issues.

TRADE = the degree of openness of a provincial economy, measured by the share of total volume of foreign trade (exports and imports) in provincial income.
Source: Almanac of China's Foreign Economic Relations and Trade (*Zhongguo Duiwai Jingji Maoyi Nianjian*), various issues in 1984–1994/95.

INFL = the inflation rate, measured by the overall social retail price index in each province.
Source: China Statistical Yearbook (*Zhongguo Tongji Nianjian*), various issues.

GEXPS = total provincial public spending over provincial GDP.
Source: For provincial population and government spending: various volumes of provincial statistical yearbooks.

URBANGR = the growth rate of the share of urban population of total provincial population.
Source: Various volumes of provincial statistical yearbooks.

SCH = share of population with more than secondary schooling in each province.
Source: Various volumes of provincial statistical yearbooks.

SOE = share of SOEs output in provincial GDP.
Source: Various volumes of provincial statistical yearbooks.

A.1. List of provincial areas

Beijing, Tianjin, Hebei, Shanxi, Neimenggu (Inner Mongolia), Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

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第 6 章

通货膨胀、经济增长与收入分配

Inflation, Growth, and Income Distribution: A Cross-Country Study

Hongyi Li

Department of Decision Sciences & Managerial Economics
Chinese University of Hong Kong
Shatin, NT, Hong Kong

and

Heng-fu Zou*

Guanghua School of Management, Peking University
Institute for Advanced Study, Wuhan University
The World Bank, Washington DC, 20433, USA

This short paper uses a newly compiled cross-country panel data on income distribution to explore the impact of inflation on income distribution and economic growth. We have found that inflation (1) worsens income distribution; (2) increases the income share of the rich; (3) has a negative but insignificant effect on the income shares of the poor and the middle class; and (4) reduces the rate of economic growth.

Key Words: Inflation; Income distribution; Growth.
JEL Classification Numbers: D3, E3, O4.

1. INTRODUCTION

Despite an enormous literature on the impact of inflation on welfare, employment, output, and economic growth (see survey studies by Driffill, et al., 1990, and McCallum, 1990), there are very few empirical studies that explore the effect of inflation on income distribution in an international setting. Of course, casual observations suggest large variations in income inequality and inflation rates across regions and countries in the world. The few empirical studies on the consequences of inflation on income and wealth

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distribution have focused disproportionally on the United States and to a lesser degree the United Kingdom (see Laidler and Parkin, 1975, Fischer and Modigliani, 1978, and Fischer, 1981). But from an international perspective, high and volatile inflation has mostly occurred in Latin America, Africa, Eastern Europe, and a few Asian countries. At the same time, on the average, many developing countries in Latin America, Asia, and Africa also have much more unequal income and wealth distribution than in most developed countries (see Table 1 of summary statistics on inflation and the Gini coefficient). Hence the main task of this paper is to see how inflation and income inequality relate to each other across developing and developed economies and over a relatively long time horizon.

Our study is also motivated by two more reasons. First, cross-country empirics on income distribution and its relation to growth have recently received considerable attention (see Alesina and Rodrik, 1994, Persson and Tabellini, 1994, Li, Squire, and Zou, 1998, among many others). Benabou (1996) has provided a comprehensive survey. But, to our best knowledge, most cross-country empirical studies do not explicitly consider inflation as a determinant of income inequality. Furthermore, recent empirical studies mainly focus on how income inequality affects growth, investment, and savings, whereas how income distribution itself is determined is largely ignored. Empirical case studies on the United States and the United Kingdom have suggested some ambiguous effects of inflation on income inequality (e.g., for early evidence see Laidler and Parkin, 1975, Fischer and Modigliani, 1978). However, Cardoso, et al. (1995) have identified inflation and unemployment as determinants of inequality in Brazil during the 1980s. We intend to provide a systematic, cross-country analysis on how inflation affects income distribution, especially the income shares of the poor, the rich, and the middle class. Hopefully we can find a clearer picture.

Second, while panel data on inflation are excellent, data on income distribution are rather limited in terms of country sample and time period. Hampered by the data problem, most studies on income distribution have been forced to work with few observations on income distribution at different times and with different definitions of the Gini coefficients of income. The World Bank has recently compiled a large data set covering 77 countries from 1949 to 1994 (Deininger and Squire, 1996; Li and Zou, 1998), which makes it possible to examine the relationship between inflation and income distribution with sufficient country sample and enough time length.

We organize our paper as follows. In section 2, we discuss how inflation affects income distribution through different channels as identified by existing theoretical and empirical studies. We emphasize the direct impact of inflation tax on nominal wage income and pension income. We also pay attention to the debtor-creditor relationships in altering income and wealth redistribution during inflation. Finally, we recognize the well-

known ambiguity of inflation on growth (the Tobin portfolio shift effect and the Sidrauski supernuetrality of money). In this sense, growth is itself endogenous, and we will treat as such in this paper.

In section 3, we first present some statistical analysis on income distribution (measured by the Gini coefficient of household income) and inflation. Then we proceed to a systematic regression analysis on the effects of inflation on the Gini coefficients; the income shares of the rich, the poor, and the middle class, and economic growth, while controlling other typical explanatory variables identified in recent empirics on income distribution and growth. We summarize our main findings in section 4.

2. THE CONSEQUENCES OF INFLATION ON INCOME DISTRIBUTION AND GROWTH

The redistributive role of inflation through its effect on wages has been widely recognized in the literature. Since David Hume, it has been believed that wages lag behind inflation. When inflation is taking place, price rises tend to run ahead of increases in money wages. Therefore inflation leads to a shift of income away from wage earners, and toward profits. On this ground, inflation is claimed to increase income inequality because it hurts the poor relatively more than the rich (see earlier surveys by Laidler and Parkin , 1975, and Fischer and Modigliani, 1978). But empirical studies on the United States seem to suggest that inflation has not generated major impact on the distribution of income. More surprisingly, according to Bach and Stephenson (1974), and Blinder and Esaki (1978), inflation has redistributed income to the lower-income quintiles and toward labor income. In this sense, inflation may even improve income distribution. On the other hand, the study by Cardoso, et al. (1995) provides some evidence on how inflation eroded the poor's income in Brazil during the 1980s. Similar empirical evidence has obtained for Russia, Poland, and China, three countries that experienced significant and rapid inflation during their transition to market economy.

Another main channel of redistribution of income and wealth through inflation is the debtor-creditor hypothesis. The redistribution is from nominal creditors to nominal debtors if interest rates on assets are denominated in terms of money without fully adjusted to the inflation rate. As summarized by Laidler and Parkin (1975), the losers from inflation appear to concentrate on the rich and the poor, because the middle-income group, having more nominal debt than those at either extreme of the wealth distribution, are less affected. But there is evidence that, in adjusting to inflation, the rich react more quickly than the poor. "The evidence on these matters is, however, overwhelmingly based on United States data and it is not clear to what extent one may generalize from it to other economies" (Laidler and

Parkin, 1975, p.789). The cross-country examination here addresses this point.

Inflation also affects income distribution also through its effect on economic growth. Since the 1960s many models have been produced to show that inflation can increase capital accumulation (the Tobin-Sidrauski portfolio shift model), or reduce capital accumulation (see Fischer, 1981), or does not affect capital accumulation (the Sidrauski superneutrality model). Empirically, there is equally conflicting evidence; see Bruno and Easterly (1996), and Clark (1997) for recent studies.

3. EMPIRICAL ANALYSIS

In general, theoretical discussions and some empirical evidence suggest a mixed picture about the effect of inflation on income distribution and economic growth. Here we turn to empirical evidence on the basis of the new data set by Deininger and Squire (1996). We will first offer some data analysis on income distribution and inflation across countries. Then we extend the regressions to include more variables in recent growth empirics (see Levine and Renelt, 1992) and conduct a sensitivity analysis to examine the relationship between inflation and income inequality and the relationship between inflation and growth.

3.1. Data description

We use data averaged over 5-year periods in our empirical analysis, as is done in other empirical studies; see Li, Squire, and Zou (1998); Li and Zou (1998); Li, Xu, and Zou (2000); and Li, Xie, and Zou (2000). Although for most of the variables we have yearly observations, our data on Gini coefficients are more limited – many countries have less than 10 observations, whereas only a few countries have more than 20 observations.[1] By using a 5-year average we obtain a more balanced data set. Because our aggregate measures of inequality are relatively stable over time, 5-year averages will not result in much loss of information. However, for other variables 5-year averages will reduce the short-run fluctuations and allow us to focus on the structural or long-run relationships that are of interest to us. The time period covered is from 1950 to 1992. For summary statistics on the inflation rate, the Gini coefficient, and the growth rate, see Table 1.

The inflation data are from the International Financial Statistics of the International Monetary Fund (IMF). For the full sample the average infla-

[1]The countries (by the World Bank and IMF three-letter country code) included in the analysis are: AUS, BEL, BGD, BGR, BRA, CAN, CHL, COL, CRI, CSK, DEU, DNK, DOM, ESP, FIN, FRA, GBR, HKG, HND, HUN, IDN, IND, IRN, ITA, JAM, JPN, KOR, LKA, MEX, MYS, NLD, NOR, NZL, PAK, PAN, PHL, POL, PRT, SGP, SWE, THA, TTO, TUN, USA, VEN and YUG.

TABLE 1.

Summary Statistics of Inflation Rate, Gini Coefficient and Growth Rate

	MEAN	STD. DEV.	MAXIMUM	MINIMUM
INFLATION RATE				
Full sample	16.449	43.275	514.208	0.026
Democracy sample	9.002	7.254	39.302	0.689
Non-democracy sample	25.315	62.835	514.208	0.486
High income sample	7.023	4.207	22.760	0.689
Low and middle income sample	23.518	56.176	514.208	0.026
OECD sample	7.086	4.380	22.760	0.689
Asian sample	12.523	35.959	338.675	0.250
Latin American sample	32.344	73.873	514.208	0.486
GINI COEFFICIENT				
Full sample	39.653	9.409	61.880	19.965
Democracy sample	36.759	7.629	54.500	23.380
Non-democracy sample	42.570	10.256	60.183	20.970
High income sample	33.966	5.212	49.000	23.380
Low and middle income sample	43.918	9.608	61.880	19.965
OECD sample	33.342	4.772	49.000	23.380
Asian sample	40.190	5.873	52.000	28.376
Latin American sample	50.571	5.139	61.880	41.545
GROWTH RATE				
Full sample	2.609	2.976	13.734	−8.061
Democracy sample	2.087	2.274	13.734	−4.719
Non-democracy sample	3.295	3.376	12.351	−4.793
High income sample	3.015	2.737	13.734	−5.449
Low and middle income sample	2.305	3.117	9.139	−8.061
OECD sample	2.517	2.467	13.734	−5.449
Asian sample	3.809	2.992	12.351	−4.793
Latin American sample	1.652	2.968	9.119	−4.719

tion rate is 16.45%. This seems to be too high because some of the countries in the sample experienced very high inflation or even hyperinflation. We have also divided the data into several subsamples, such as the democracy versus nondemocracy samples[2], the high- income versus low- and middle-income samples[3], the OECD sample and regional samples (Asian and Latin American). For the high-income or OECD samples, the average inflation rate is only around 7%. The Latin American sample has the largest average inflation rate at 32.34%.

Compared to other studies, the income inequality data are based on a newly developed data set of Gini coefficients by Deininger and Squire (1996) where several criteria were used to compile the data. First, all observations had to be from national household surveys for expenditure or income; second, the coverage had to be representative of the national population; third, all sources of income and uses of expenditure had to be accounted for, including own-consumption; and finally, each country should have a reasonable number of minimum observations, although this number can be quite small given the situation of Gini coefficients.

We also note that what is being measured by the Gini coefficient in our sample varies across countries. Inequality can be measured by gross income, net income, or expenditure, and it can be per capita or per household. Because variation in definitions can undermine the international and intertemporal comparability of the data, proper adjustment is necessary. Therefore, we have adjusted the data following a procedure recommended by Deininger and Squire (1996). Specifically, we adjust for differences between income-based and expenditure-based coefficients by systematically increasing the latter by 6.6 points (on a 1 to 100 point scale), this being the average difference observed by Deininger and Squire (1996).

For the full sample the average Gini is 39.65 with a standard deviation of 9.41. The maximum is 61.88, whereas the minimum is 19.97. Roughly speaking, the high- income sample and the OECD sample are very close to each other in their summary statistics. The means and standard deviations are among the smallest. The other samples have relatively large means and standard deviations. In particular, the Latin American sample has an average Gini of 50.57. For detailed documentation of the cross-country comparison of the Gini coefficients over time see Li, Squire and Zou (1998).

[2]The division of democracy and nondemocracy samples is based on a civil liberty index in Barro and Lee (1994). The index ranges from 1 to 7, with 1 for countries with the largest degree of civil liberties. Thus, a country is defined as a democracy if its civil liberty index is smaller or equal to 2, whereas nondemocracy is greater than 2. Note for some countries the index is not available.

[3]The division of high-income vs. low- and middle-income samples is based on the World Development Report classification by the World Bank (various issues).

FIG. 1. Correlation between Income Inequality and Inflation

The growth rate calculation is based on the real per capital GDP (PPP adjusted) in Summers and Heston (1994). The average growth rate of the full sample is 2.61%. The Asian sample has the highest average growth rate of 3.81%, whereas the Latin American sample has the lowest average growth rate of 1.65%.

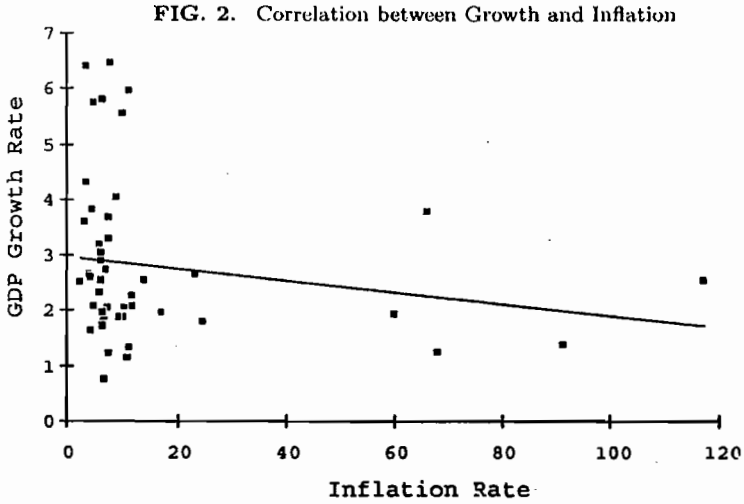
Figure 1 plots the cross-country average Gini against the average inflation rate for the 49 countries. The correlation coefficient is only 0.085. Note that there are five countries with average inflation rate greater than 40%. The correlation is largely affected by these numbers. If we delete these numbers, the correlation is 0.26. Figure 2 plots the cross-country average growth rate against the average inflation rate. The correlation coefficient is −0.17 (or −0.08 deleting countries with inflation rate larger than 40%).

3.2. Empirical Results

In this section we present an extensive analysis of the effects of inflation on income distribution and economic growth. In particular, we want to know about the effects of inflation on the income shares of the rich, the poor, and the middle class.

Following recent empirics on economic growth and income distribution, we consider a list of other control variables in our regression analysis, e.g., the primary years of schooling (PYR), financial development (FNDP, defined as the money supply M2 over GDP), government spending (GSPD, defined as government spending over GDP), population growth rate (PGRW), initial GDP level (INIGDP), the urbanization ratio (URBAN), openness (OPEN, defined as imports over GDP), terms-of-trade shock (TOTSK, defined as the difference of the change in export price and the change in

FIG. 2. Correlation between Growth and Inflation



import price), average arable land (AREA), initial distribution of wealth, or land Gini (LDGINI). These data are mostly obtained through World Bank national accounts, International Financial Statistics of the IMF, and Summers and Heston (1994). The primary years of schooling data are from Nehru et al. (1995).

The reduced form baseline regressions for the relationship between income distribution and inflation and for the relationship between growth and inflation are as follows:

$$\begin{aligned} Gini_{it} &= \alpha_0 + \alpha_1 INFL_{it} + \alpha_2 PYR_{it} + \alpha_3 FNDP_{it} + \alpha_4 GSPD_{it} \\ &+ \alpha_5 PGRW_{it} + \alpha_6 INIGDP_{it} + u_{it} \qquad (1) \\ GRW_{it} &= \beta_0 + \beta_1 INFL_{it} + \beta_2 PYR_{it} + \beta_3 FNDP_{it} + \beta_4 GSPD_{it} \\ &+ \beta_5 PGRW_{it} + \beta_6 INIGDP_{it} + \nu_{it} \qquad (2) \end{aligned}$$

where $Gini$ is the Gini coefficient, GRW is real per capita GDP growth. The country index is $i = 1, 2, \ldots, N$, and the time index is $t = 1, 2, \ldots, T$ (five-year time interval). In the baseline regressions we include PYR, $FNDP$, $GSPD$, $PGRW$, and $INIGDP$ as the right- hand variables.

Furthermore, we consider the income shares of the rich, the poor, and the middle class defined as the top 20%, bottom 20%, and middle 60% of population income by multiplying the income shares of the Gini coefficients of the corresponding population groups with the real per capita GDP. The following set of regressions (3) will be estimated to identify the effects of inflation as well as other variables on the income distribution among the

three income groups:

$$\begin{aligned} & YT20_{it}(\text{or } YB20_{it},\ YM60_{it}) \\ = \ & \beta_0 + \beta_1 INFL_{it} + \beta_2 PYR_{it} + \beta_3 FNDP_{it} \\ + \ & \beta_4 GSPD_{it} + \beta_5 PGRW_{it} + \beta_6 INIGDP_{it} + w_{it} \end{aligned} \tag{3}$$

where $YT20$, $YB20$, and $YM60$ are the income shares of the rich, the poor, and the middle class, respectively.

As noted earlier, the data set is unbalanced due to data availability on Gini coefficients. For some countries there are only four observations or less (in 9 five-year periods). Also some initial variables such as initial GDP and initial wealth distribution (land Gini coefficients) are without time variation. Therefore typical panel data models will not be applied. Our main concern is the endogeneity issue, which is constantly raised in the growth and income distribution literature. The instrumental variables method (IV) will be used to correct for the endogeneity in comparison with the simple OLS estimation results.

We will perform detailed sensitivity analysis to examine whether the baseline regression results are robust to the inclusion of extra variables typically considered in the empirical studies on growth and income distribution. Finally, we provide estimation results of subsamples to account for the issue of parameter heteroskedasticity. The full sample estimation assumes that the parameters are homoskedastic for all countries. However, due to significant differences in social, political, cultural, and economic structures, it will be reasonable to allow for parameter heteroskedasticity by subsample estimation. Next, we turn to the discussion of the empirical results.

The estimation results of regression (1) describing the relationship between income distribution and inflation are reported in Table 2. In the baseline regression by OLS, the estimated coefficient of inflation is 0.019 and the t-value is very close to the 5% significance level. The estimated coefficients of PYR, FNDP, and GSPD are all negative and significant.[4] Population growth has a positive and significant coefficient. Finally, the initial GDP level is positive, although insignificant. Note the dependent variable is the Gini coefficient, hence an increase in the inflation rate or population growth will increase income inequality, whereas an increase in human capital stocks, financial development, and government spending will reduce income inequality.

The instrumental variables (IV) estimation results are very close to the baseline OLS results. In the sensitivity regressions (A)-(E), the inclusion of sensitivity variables (TOTSK, OPEN, AREA, URBAN and LDGINI)

[4]The t-value will be used to test the significance of coefficients at a 5% level if not specified.

does not seem to change the results of the baseline regression variables. Only URBAN and LDGINI have significant coefficients. An increase in urbanization or inequality in initial wealth distribution results in higher income inequality. Finally, in regression (F) time period dummy variables are included.[5] Again, the baseline variables mostly remain the same. See the results in Table 2 for further details.

The estimation results of baseline regression (2) describing the relationship between economic growth and inflation are reported in Table 3. In the baseline regression by OLS, the estimated coefficient of inflation rate is -0.01 with a significant t-value. The estimated coefficients of GSPD, PGRW, and INIGDP are all negative and significant. Government spending and population growth hurt growth. In particular, high initial income level is associated with slower growth. PYR has a positive coefficient and FNDP has a negative coefficient, but both coefficients are insignificant.

The results of the baseline regression variables are fairly robust to instrumental variables (IV) estimation and sensitivity tests. In the sensitivity regressions, only LDGINI has a significant coefficient. Thus an increase in inequality in initial wealth distribution will result in lower growth. Finally, in regression (F) the estimated results for baseline variables mostly remain the same.

Tables 4-6 summarize the estimation results regarding the effects of inflation on the three population groups' income. In Table 4, inflation has a positive and significant coefficient in the rich's income regression, whereas in Tables 5 and 6, this coefficient is negative for the poor and for the middle class, although insignificant. These results seem to indicate that the rich can hedge their income against inflation, while the poor and the middle class will be hurt by inflation. It is also interesting to note that the t-value of the inflation coefficient in the poor's income regression (- 1.076) is more negative than that in the middle class' income regression (-0.18). The poor seem to be hurt most severely by inflation. This cross-country finding is consistent with the Brazilian case study by Cardoso et al (1995), but it stands in sharp contrast to the results in Bach and Stephenson (1974), and Blinder and Esaki (1978).

Financial development benefits all the three income groups, although judging from the significance level of the t-values, the poor's income will improve less compared to those of the rich and the middle class. On the other hand, government spending hurts all the three groups. But this time the rich will be affected more than the poor. It is also very interesting to note that population growth has little effect on the income of the rich, however, income will be significantly reduced for the poor. Finally, a high

[5]There are a total of nine five-year periods. Since the number of observations for the first five periods is small, time dummy variables are not used.

TABLE 2.

Income Distribution and Inflation

Dependent Variable: Gini

Ind. Var.	Base Reg.	IV	A	B	C	D	E	F
CNST	45.629	46.323	44.866	44.023	44.841	43.399	38.187	45.481
	(14.557)	(12.025)	(13.215)	(13.483)	(13.644)	(13.276)	(11.024)	(14.510)
INFL	0.019	0.033	0.019	0.020	0.019	0.015	0.012	0.016
	(1.980)	(3.104)	(1.979)	(2.076)	(1.960)	(1.588)	(1.349)	(1.662)
PYR	−0.961	−0.975	−0.909	−0.706	−0.527	−1.151	−0.757	−1.099
	(−2.768)	(−2.346)	(−2.542)	(−1.900)	(−1.362)	(−3.242)	(−2.111)	(−3.165)
FNDP	−5.643	−7.137	−5.241	−5.856	−6.015	−6.276	−4.192	−7.116
	(−2.282)	(−2.447)	(−2.014)	(−2.356)	(−2.387)	(−2.542)	(−1.655)	(−2.841)
GSPD	−0.329	−0.309	−0.316	−0.282	−0.304	−0.278	−0.276	−0.359
	(−4.791)	(−4.164)	(−4.315)	(−3.946)	(−4.197)	(−3.861)	(−3.533)	(−5.216)
PGRW	4.368	4.256	4.466	4.318	4.257	4.413	4.035	4.463
	(6.426)	(5.107)	(6.269)	(6.298)	(5.783)	(6.543)	(6.001)	(6.603)
INIGDP	−0.200	−0.203	−0.207	−0.313	−0.297	−0.437	−0.410	−0.095
	(−0.980)	(−0.929)	(−0.992)	(−1.396)	(−1.182)	(−1.906)	(−1.975)	(−0.463)
TOTSK			0.108					
			(0.052)					
OPEN				0.018				
				(0.956)				
AREA					−0.123			
					(−1.417)			
URBAN						0.059		
						(2.201)		
LDGINI							0.106	
							(4.509)	
YDM6								1.063
								(0.909)
YDM7								1.539
								(1.302)
YDM8								3.103
								(2.480)
YDM9								3.082
								(2.256)
NOB	232	211	223	228	221	232	217	232
F	50.07		38.35	38.30	34.80	44.34	51.45	31.47
R^2	0.572		0.555	0.549	0.534	0.581	0.633	0.587

TABLE 3.

Economic Growth and Inflation

Dependent Variable: GDP growth rate

Ind. Var.	Base Reg.	IV	A	B	C	D	E	F
CNST	6.953	6.702	7.531	6.727	6.868	7.134	9.417	7.356
	(5.643)	(4.002)	(5.668)	(5.303)	(5.291)	(5.513)	(6.912)	(6.494)
INFL	−0.010	−0.009	−0.010	−0.009	−0.009	−0.009	−0.008	−0.007
	(−2.436)	(−1.990)	(−2.416)	(−2.317)	(−2.270)	(−2.337)	(−1.968)	(−1.905)
PYR	−0.082	−0.137	−0.073	−0.094	−0.012	−0.069	−0.198	0.041
	(−0.631)	(−0.717)	(−0.534)	(−0.680)	(−0.085)	(−0.519)	(−1.479)	(0.342)
FNDP	0.737	0.838	0.342	0.705	0.861	0.801	−0.111	1.958
	(0.762)	(0.685)	(0.337)	(0.712)	(0.868)	(0.819)	(−0.109)	(2.157)
GSPD	−0.119	−0.105	−0.135	−0.115	−0.112	−0.124	−0.115	−0.093
	(−4.318)	(−3.286)	(−4.613)	(−3.975)	(−3.826)	(−4.224)	(−3.620)	(−3.638)
PGRW	−0.557	−0.518	−0.606	−0.542	−0.655	−0.557	−0.483	−0.702
	(−2.138)	(−1.452)	(−2.219)	(−2.064)	(−2.335)	(−2.135)	(−1.831)	(−2.942)
INIGDP	−0.322	−0.332	−0.353	−0.306	−0.397	−0.303	−0.239	−0.436
	(−4.112)	(−3.459)	(−4.378)	(−3.594)	(−4.251)	(−3.401)	(−2.980)	(−5.964)
TOTSK			−0.236					
			(−0.283)					
OPEN				0.005				
				(0.697)				
AREA					0.026			
					(0.761)			
URBAN						−0.005		
						(−0.464)		
LDGINI							−0.034	
							(−3.752)	
YDM6								−1.250
								(−2.910)
YDM7								−2.988
								(−6.883)
YDM8								−1.809
								(−4.019)
YDM9								−2.472
								(−5.365)
NOB	280	240	258	276	266	280	262	280
F	7.53		6.78	6.47	6.61	6.47	6.99	11.39
R^2	0.142		0.159	0.145	0.152	0.143	0.161	0.297

TABLE 4.

Top 20% Population's Income and Inflation

Dependent Variable: Top 20% population's income

Ind. Var.	Base Reg.	IV	A	B	C	D	E	F
CNST	0.501	0.395	0.528	−0.006	0.404	−0.105	0.363	0.025
	(1.126)	(0.752)	(1.138)	(−0.013)	(0.849)	(−0.231)	(0.755)	(0.065)
INFL	0.311	0.292	0.311	0.373	0.323	0.195	0.316	0.179
	(2.306)	(2.221)	(2.259)	(2.855)	(2.347)	(1.467)	(2.414)	(1.554)
PYR	0.046	0.073	0.044	0.047	0.066	0.003	0.063	0.016
	(0.961)	(1.297)	(0.897)	(0.921)	(1.216)	(0.066)	(1.272)	(0.403)
FNDP	1.688	1.884	1.668	1.477	1.752	1.574	1.582	1.231
	(4.905)	(4.660)	(4.703)	(4.373)	(4.917)	(4.743)	(4.385)	(4.166)
GSPD	−0.044	−0.051	−0.045	−0.033	−0.040	−0.029	−0.042	−0.048
	(−4.480)	(−4.845)	(−4.381)	(−3.291)	(−3.761)	(−2.870)	(−3.844)	(−5.808)
PGRW	0.039	0.086	0.043	0.074	0.023	0.056	0.023	0.132
	(0.424)	(0.784)	(0.454)	(0.841)	(0.235)	(0.640)	(0.251)	(1.693)
INIGDP	0.468	0.472	0.469	0.490	0.446	0.413	0.467	0.504
	(17.801)	(16.800)	(17.449)	(17.063)	(13.720)	(14.233)	(17.048)	(22.358)
TOTSK			0.008					
			(0.027)					
OPEN				0.010				
				(4.277)				
AREA					0.008			
					(0.739)			
URBAN						0.014		
						(3.953)		
LDGINI							0.001	
							(0.404)	
YDM6								0.631
								(4.649)
YDM7								0.908
								(6.494)
YDM8								0.991
								(7.017)
YDM9								1.091
								(7.014)
NOB	183	166	178	179	175	183	170	183
F	151.85		123.23	140.43	121.89	143.21	133.71	136.1
R^2	0.838		0.835	0.852	0.836	0.851	0.852	0.888

TABLE 5.

Bottom 20% Population's Income and Inflation

Dependent Variable: Bottom 20% population's income

Ind. Var.	Base Reg.	IV	A	B	C	D	E	F
CNST	0.324	0.330	0.337	0.265	0.283	0.208	0.401	0.288
	(3.443)	(2.828)	(3.441)	(2.684)	(2.899)	(2.147)	(3.750)	(3.045)
INFL	−0.031	−0.030	−0.030	−0.024	−0.026	−0.053	−0.019	−0.045
	(−1.076)	(−1.011)	(−1.046)	(−0.823)	(−0.907)	(−1.869)	(−0.663)	(−1.569)
PYR	0.003	0.004	0.002	0.003	0.004	−0.005	0.001	0.000
	(0.307)	(0.310)	(0.219)	(0.308)	(0.346)	(−0.507)	(0.076)	(0.016)
FNDP	0.143	0.181	0.141	0.116	0.177	0.121	0.122	0.100
	(1.964)	(2.019)	(1.880)	(1.561)	(2.428)	(1.712)	(1.515)	(1.364)
GSPD	−0.003	−0.003	−0.003	−0.001	−0.001	0.000	−0.002	−0.003
	(−1.257)	(−1.267)	(−1.292)	(−0.594)	(−0.634)	(0.109)	(−0.935)	(−1.515)
PGRW	−0.132	−0.141	−0.135	−0.128	−0.129	−0.128	−0.127	−0.124
	(−6.812)	(−5.774)	(−6.779)	(−6.587)	(−6.344)	(−6.845)	(−6.276)	(−6.452)
INIGDP	0.064	0.063	0.063	0.066	0.059	0.053	0.066	0.067
	(11.416)	(10.037)	(11.171)	(10.480)	(8.910)	(8.548)	(10.782)	(12.014)
TOTSK			−0.005					
			(−0.086)					
OPEN				0.001				
				(2.325)				
AREA					0.003			
					(1.258)			
URBAN						0.003		
						(3.555)		
LDGINI							−0.001	
							(−1.851)	
YDM6								0.048
								(1.427)
YDM7								0.071
								(2.065)
YDM8								0.101
								(2.906)
YDM9								0.099
								(2.588)
NOB	183	166	178	179	175	183	170	183
F	179.93		95.48	102.49	99.11	109.57	96.16	74.76
R^2	0.801		0.797	0.808	0.806	0.814	0.806	0.813

TABLE 6.

Middle 60% Population's Income and Inflation

Dependent Variable: Middle 60% population's income

Ind. Var.	Base Reg.	IV	A	B	C	D	E	F
CNST	0.733	0.960	0.789	0.140	0.469	0.459	1.407	0.279
	(1.321)	(1.456)	(1.366)	(0.245)	(0.829)	(0.781)	(2.287)	(0.545)
INFL	−0.030	−0.064	−0.036	0.029	0.003	−0.083	0.075	−0.165
	(−0.180)	(−0.388)	(−0.212)	(0.177)	(0.018)	(−0.481)	(0.446)	(−1.068)
PYR	0.093	0.084	0.089	0.130	0.131	0.074	0.082	0.063
	(1.555)	(1.193)	(1.440)	(2.001)	(2.014)	(1.200)	(1.299)	(1.159)
FNDP	1.821	1.955	1.789	1.677	2.053	1.769	1.757	1.349
	(4.241)	(3.850)	(4.048)	(3.906)	(4.835)	(4.117)	(3.800)	(3.408)
GSPD	−0.029	−0.037	−0.031	−0.014	−0.016	−0.022	−0.032	−0.033
	(−2.355)	(−2.791)	(−2.401)	(−1.116)	(−1.270)	(−1.683)	(−2.260)	(−3.007)
PGRW	−0.442	−0.494	−0.444	−0.420	−0.490	−0.435	−0.379	−0.353
	(−3.885)	(−3.589)	(−3.767)	(−3.731)	(−4.162)	(−3.821)	(−3.245)	(−3.392)
INIGDP	0.640	0.649	0.642	0.639	0.572	0.614	0.657	0.674
	(19.480)	(18.380)	(19.166)	(17.501)	(14.771)	(16.366)	(18.717)	(22.357)
TOTSK			−0.207					
			(−0.576)					
OPEN				0.009				
				(2.875)				
AREA					0.035			
					(2.584)			
URBAN						0.006		
						(1.380)		
LDGINI							−0.012	
							(−2.940)	
YDM6								0.633
								(3.482)
YDM7								0.841
								(4.492)
YDM8								1.017
								(5.373)
YDM9								1.149
								(5.515)
NOB	183	166	178	179	175	183	170	183
F	229.57		185.59	204.97	203.00	196.06	196.45	173.83
R^2	0.887		0.884	0.894	0.895	0.888	0.895	0.910

initial income level is positively related to income for all the three groups. For the detailed estimation results of IV and sensitivity regressions, see Tables 4-6.

4. CONCLUSIONS

This short paper uses a newly compiled cross-country panel data on income distribution to explore the impact of inflation on income distribution and growth. We have found that inflation (1) worsens income distribution; (2) increases the income share of the rich; (3) has a negative but insignificant effect on the income shares of the poor and the middle class; and (4) reduces the rate of economic growth.

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第 7 章

公共支出的波动性对经济增长的影响

Effects of Growth and Volatility in Public Expenditures on Economic Growth: Theory and Evidence*

Liutang Gong

Guanghua School of Management, Peking University, Beijing,100871, China
Institute for Advanced Study, Wuhan University, Wuhan, 430072, China
ltgong@gsm.pku.edu.cn

Heng-fu Zou

Guanghua School of Management, Peking University, Beijing,100871, China
Institute for Advanced Study, Wuhan University, Wuhan, 430072, China
Development Research Group, The World Bank, USA
hzou@worldbank.org

This paper sets up a theoretical model linking the growth rate of the economy to the growth rate and volatility of different government expenditures. On a theoretical basis, it is found that volatility in government spending can be positively or negatively associated with economic growth depending on the intertemporal elasticity in consumption. On an empirical basis, it is rather surprising to find no association between growth in capital expenditure and output growth, whereas growth in current expenditure seems to stimulate output growth. In particular, growth in transportation and communication seems to have a negative effect on output growth. It is also very interesting to find that the rises in the volatility in the growth of general public services, transportation, and communication have a positive effect on output growth.

Key Words: Public expenditures; Volatility; Economic growth.
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1. INTRODUCTION

The present paper explores growth and volatility in public expenditures and their effects on economic growth. At the theoretical level, we offer a stochastic model linking the growth and volatility in the composition

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of public expenditures to economic growth. At the empirical level, we use a data set covering more than 90 countries over the period of 1970-1994 in order to examine the effects on economic growth of (i) the growth and volatility in current and capital expenditures, and (ii) the growth and volatility in general public services, defense, education, human welfare services, economic services, and transportation and communication.

The effects of public expenditures on economic growth have been studied since the 1980s. Kormendi and Meguire (1985); Aschauer (1989); Barro (1990); and Fischer (1993), among many others, have studied aggregate government spending and its effects on growth and productivity. Those studies divide government spending into aggregate public consumption and aggregate public investment. At the same time, Easterly and Rebelo (1993); and Devarajan, Swaroop, and Zou (1996) have made a systematic examination of the relationship between the composition of public expenditures and economic growth. To our best knowledge, none of the existing studies has explicitly considered the effects of growth and volatility in various public expenditures on economic growth. There is also an enormous body of literature on the growth of government and public expenditures; see Peltzman (1980), North (1985), and Borcherding(1985). The growth of government and various public sectors are associated with per capita GDP and the rate of GDP growth. The issue here is the reverse relationship: how the growth and volatility of the public sector affect economic growth.

Our present study is in the spirit of Bertola and Drazen (1993); Gali (1994); and especially Ramey and Ramey (1995). The volatility of government spending on macroeconomic stabilization has been examined by Bertola and Drazen (1993); and Gali (1994). The effects of the volatility in aggregate government spending on investment and growth have been examined by Ramey and Ramey (1995), but they have not explicitly addressed the volatility in various components of government expenditures. Furthermore, they have not dealt with the potentially differentiated effects of growth and volatility in public expenditures on economic growth— a clear result from our theoretical model. Our approach can also be regarded as an extension of the study on political instability and economic growth by Alesina *et al* (1996). Political instability typically affects the sector allocation of public expenditures and leads to different degrees of volatility in different public sectors, say, education, infrastructure, and defense.

The paper is organized as follows. Section 2 sets up a stochastic growth model and discusses the effects of growth and volatility of multiple public expenditures on economic growth. The expected growth rate of output, asset, and consumption is derived explicitly from the stochastic differential equations describing the motion of asset accumulation and consumption. Section 3 is devoted to the empirical analysis of the effects of growth and volatility of government expenditures on economic growth for more than 90

countries over the time period 1970-94. Section 4 summarizes theoretical and empirical findings.

2. ANALYTICAL MODEL

Following Arrow and Kurz (1970); Barro (1990); Turnovsky (1995); Turnovsky and Fisher (1995); and Devarajan, Swaroop, and Zou (1996), we consider the representative-agent model with the utility function defined on private consumption, c, and various public services, $g_1, \ldots, g_n$, namely,

$$u(c, g_1, \ldots, g_n).$$

Suppose the representative agent derives positive but diminishing marginal utility from private consumption good and various public services, i.e.

$$u_c > 0, u_{cc} < 0, u_{g_i} > 0, u_{g_i g_i} < 0, \quad i = 1, \ldots, n.$$

Without loss of any generality, we take $n = 2$.

As in Eaton (1981); Gertler and Grinols (1982); Grinols and Turnovsky (1992, 1993); and Turnovsky (1993, 1995), output is produced by a stochastic technology,

$$dY = f(k)\,dt + h(k)\,dy, \quad f' > 0, \quad f'' \leq 0 \tag{1}$$

which asserts that the flow of output over the period $(t, t + dt)$, consists of two components. First, there is the deterministic component, described by the first term on the right side, with $f(k)$ representing the mean rate of output per unit of time. In addition, there is a stochastic component, reflecting the various random influences that impact on production.[1] The stochastic term dy can be explained as stochastic shock and assumed to be a temporally independent, normally distributed with mean zero and variance $\sigma_y^2 dt$:

$$E(dy) = 0, \; V(dy) = \sigma_y^2 dt.$$

Extending the model specifications in Bertola and Drazen (1993); and Turnovsky (1995), we suppose that the two kinds of government spending follow the stochastic processes

$$dg_i = g_i(t)\,dt + m_i(k)\,dz, \quad i = 1 \text{ and } 2, \tag{2}$$

where the stochastic component dz is an intertemporally independent, normally distributed, random variable with mean zero and variance $\sigma_z^2 dt$.

[1] In order to derive explicit solutions to asset accumulation and the growth rate, government spending is excluded from the production function.

There are two assets: capital stock, k, and government bonds, b, in our model. The returns on the two assets, k and b, are R_k and R_b, respectively. The stochastic processes of these two returns are given as follows:

$$dR_k = \frac{dY}{k} \equiv r_k dt + du_k,$$

$$dR_b = r_b dt,$$

where r_k is the mean return on capital and du_k is its stochastic component with mean zero; and r_b is the deterministic return on government bonds.

There is an income tax, τdY. The two kinds of government expenditures are financed by the income tax and new bond issues minus interest payments on government bonds:

$$dg_1 + dg_2 = \tau dY + db - bdR_b.$$

Given the income tax and the two assets in the economy, the budget constraint for the representative agent can be written as

$$dw = ((1-\tau) r_k n_k w + r_b (1-n_k) w - c) dt + wdv \tag{3}$$

Where $w = k + b$, and it is the agent's total wealth. n_k and n_b are the holding shares of capital and bonds, respectively, which are defined as

$$n_k = \frac{k}{w}, n_b = \frac{b}{w}, \tag{4}$$

and dv is a stochastic process defined by

$$dv \equiv (1-\tau) n_k du_k \tag{5}$$

Now, the representative agent choose his consumption path, $c(t)$, and asset holding shares,n_k and n_b, to maximize his discounted utility

$$\max E_0 \int_0^\infty u(c, g_1, g_2) e^{-\rho t} dt$$

subject to budget constraint (3) and the portfolio constraint

$$n_k + n_b = 1.$$

In order to derive explicit solutions to consumption and asset holdings, we specify the technology, government expenditures, and the utility func-

tion as follows

$$dY = Ak(dt + dy), \tag{6}$$

$$dg_i = \mu_{g_i} g_i dt + \sigma_{g_i} g_i dz_i \quad (i = 1, 2), \tag{7}$$

$$u(c, g) = \frac{c^{1-\gamma}}{1-\gamma} g_1^{-\lambda_1} g_2^{-\lambda_2}, \tag{8}$$

where A, μ_{g_i} and σ_{g_i} $(i = 1\text{and}2)$ are constants, and λ_1, λ_2, and γ satisfy the following conditions: $-1 < \lambda_1, \lambda_2 > 0$, when $0 < \gamma < 1$; and $\lambda_1, \lambda_2 > 0$, when $\gamma > 1$. μ_{g_i} is the mean of the growth rate of the i-th item of public expenditure, and σ_{g_i} measures the volatility in the growth rate of the i-th item of public expenditure. These function forms are not new if taken individually. For example, the production technology in (6) is used by Eaton (1981) and Turnovsky (1995); the geometric Brownian motion describing government spending in (7) is very similar to the ones in Bertola and Drazen (1993); and Turnovsky (1995), among many others; and the utility function in (8) can be regarded as an extension of Barro (1990); Turnovsky and Fisher (1995); and Devarajan, Swaroop, and Zou (1996) with multiple public goods. But the combination of these conventional specifications of technology, government expenditures, and preferences allows us to obtain explicit stochastic differential equations of consumption and asset accumulation, and hence to obtain the expected growth rate of consumption and wealth accumulation.

Substituting equation (6) into the budget constraint (3), we can rewrite the budget constraint as

$$\frac{dw}{w} = \left[(1-\tau) An_k + r_b (1 - n_k) - \frac{c}{w}\right] dt + dv. \tag{9}$$

To solve the problem, we introduce the value function

$$V(w, g_1, g_2, t),$$

and define

$$V(w, g_1, g_2, t) = X(w, g_1, g_2) e^{-\rho t}.$$

Now, we define the differential operator, $L(X(w, g_1, g_2, t) e^{-\rho t})$, by

$$\begin{aligned} & L\left(X(w, g_1, g_2, t) e^{-\rho t}\right) \\ = & \{-\rho X + X_w [(1-\tau) An_k w + r_b (1 - n_k) w - c] + X_{g_1} \mu_{g_1} g_1 \\ + & X_{g_2} \mu_{g_2} g_2 + \frac{1}{2} X_{ww} n_k^2 w^2 \sigma_y^2 + \frac{1}{2} X_{g_1 g_1} g_1^2 \sigma_{g_1}^2 + \frac{1}{2} X_{g_2 g_2} g_2^2 \sigma_{g_2}^2 \\ + & \frac{1}{2} X_{wg_1} n_k w g_1 \sigma_{yg_1} + \frac{1}{2} X_{wg_2} g_2 n_k w \sigma_{yg_2} + \frac{1}{2} X_{g_1 g_2} g_1 g_2 \sigma_{g_1 g_2} \} e^{-\rho t}. \end{aligned}$$

The problem is equivalent to maximizing the following Lagrangian expression with respect to $c(t)$ and n_k

$$\begin{aligned} & u(c, g_1, g_2) - \rho X + X_w [(1-\tau) A n_k w + r_b (1-n_k) w - c] + X_{g_1} \mu_{g_1} g_1 \\ + & X_{g_2} \mu_{g_2} g_2 + \frac{1}{2} X_{ww} n_k^2 w^2 \sigma_y^2 + \frac{1}{2} X_{g_1 g_1} g_1^2 \sigma_{g_1}^2 + \frac{1}{2} X_{g_2 g_2} g_2^2 \sigma_{g_2}^2 \\ + & \frac{1}{2} X_{wg_1} n_k w g_1 \sigma_{yg_1} + \frac{1}{2} X_{wg_2} g_2 n_k w \sigma_{yg_2} + \frac{1}{2} X_{g_1 g_2} g_1 g_2 \sigma_{g_1 g_2}. \end{aligned}$$

The first-order conditions are

$$u_c(c, g_1, g_2) = X_w, \tag{10}$$

$$X_w [(1-\tau) A w - r_b w] + X_{ww} n_k w^2 \sigma_y^2 + \frac{1}{2} X_{wg_1} w g_1 \sigma_{yg_1} + \frac{1}{2} X_{wg_2} g_2 w \sigma_{yg_2} = 0. \tag{11}$$

From equations (10) and (11), we can derive the optimal values of $c(t)$ and n_k as the functions of X, X_w, and X_{ww}. With the optimal values of $c(t)$ and n_k, the value function must satisfy the Bellman equation

$$\begin{aligned} & u(c, g_1, g_2) - \rho X + X_w [(1-\tau) A n_k w + r_b (1-n_k) w - c] + X_{g_1} \mu_{g_1} g_1 \\ + & X_{g_2} \mu_{g_2} g_2 + \frac{1}{2} X_{ww} n_k^2 w^2 \sigma_y^2 + \frac{1}{2} X_{g_1 g_1} g_1^2 \sigma_{g_1}^2 + \frac{1}{2} X_{g_2 g_2} g_2^2 \sigma_{g_2}^2 \\ + & \frac{1}{2} X_{wg_1} n_k w g_1 \sigma_{yg_1} + \frac{1}{2} X_{wg_2} g_2 n_k w \sigma_{yg_2} + \frac{1}{2} X_{g_1 g_2} g_1 g_2 \sigma_{g_1 g_2} = 0. \end{aligned} \tag{12}$$

For the special utility function in equation (8), we postulate the value function as

$$X(w, g_1, g_2) = \delta w^{1-\gamma} g_1^{-\lambda_1} g_2^{-\lambda_2},$$

where the coefficient, δ, is to be determined.

Taking partial differentiation, we have

$$\begin{aligned} X_w &= \delta (1-\gamma) w^{-\gamma} g_1^{-\lambda_1} g_2^{-\lambda_2 - 1}, \\ X_{g_1} &= -\delta \lambda_1 w^{1-\gamma} g_1^{-\lambda_1 - 1} g_2^{-\lambda_2}, \\ X_{g_2} &= -\delta \lambda_2 w^{1-\gamma} g_1^{-\lambda_1} g_2^{-\lambda_2 - 1}, \\ X_{wg_1} &= -\delta \lambda_1 (1-\gamma) w^{-\gamma} g_1^{-\lambda_1 - 1} g_2^{-\lambda_2}, \\ X_{ww} &= -\delta \gamma (1-\gamma) w^{-\gamma - 1} g_1^{-\lambda_1} g_2^{-\lambda_2}, \\ X_{g_1 g_1} &= \delta \lambda_1 (\lambda_1 + 1) w^{1-\gamma} g_2^{-\lambda_1 - 2} g_2^{-\lambda_2}, \end{aligned}$$

$$
\begin{aligned}
X_{g_2g_2} &= \delta\lambda_2(\lambda_2+1)\,w^{1-\gamma}g_1^{-\lambda_1}g_2^{-\lambda_2-2},\\
X_{wg_2} &= -\delta\lambda_2(1-\gamma)\,w^{-\gamma}g_1^{-\lambda_1}g_2^{-\lambda_2-1},\\
X_{g_1g_2} &= \delta\lambda_1\lambda_2 w^{1-\gamma}g_1^{-\lambda_1-1}g_2^{-\lambda_2-1}.
\end{aligned}
$$

Substituting the above expressions into the first-order conditions (10), (11), and the Bellman equation (12), we have

$$\frac{c}{w} = [\delta(1-\gamma)]^{-\frac{1}{\gamma}}, \tag{13}$$

$$n_k = \frac{[(1-\tau)A - r_b] - \frac{1}{2}\lambda_1\sigma_{yg_1} - \frac{1}{2}\lambda_2\sigma_{yg_1}}{\gamma\sigma_y^2}, \tag{14}$$

and

$$
\begin{aligned}
&[\delta(1-\gamma)]^{-\frac{1}{\gamma}} - \rho + (1-\gamma)\left[(1-\tau)An_k + r_b(1-n_k) - [\delta(1-\gamma)]^{-\frac{1}{\gamma}}\right]\\
&- \lambda_1\mu_{g_1} - \lambda_2\mu_{g_2} - \frac{1}{2}\gamma(1-\gamma)n_k^2\sigma_y^2 + \frac{1}{2}\lambda_1(\lambda_1+1)\sigma_{g_1}^2 + \frac{1}{2}\lambda_2(\lambda_2+1)\sigma_{g_2}^2\\
&- \frac{1}{2}\lambda_1(1-\gamma)n_k\sigma_{yg_1} - \frac{1}{2}\lambda_2(1-\gamma)n_k\sigma_{yg_1} + \frac{1}{2}\lambda_1\lambda_2\sigma_{g_1g_2} = 0.
\end{aligned} \tag{15}
$$

Therefore, we have

$$
\begin{aligned}
\frac{c}{w} &= [\delta(1-\gamma)]^{-\frac{1}{\gamma}}\\
&= \frac{\rho - (1-\gamma)[(1-\tau)An_k + r_b(1-n_k)] + \lambda_1\mu_{g_1} + \lambda_2\mu_{g_2}}{\gamma}\\
&+ \frac{\frac{1}{2}\gamma(1-\gamma)n_k^2\sigma_y^2 - \frac{1}{2}\lambda_1(\lambda_1+1)\sigma_{g_1}^2 - \frac{1}{2}\lambda_2(\lambda_2+1)\sigma_{g_2}^2}{\gamma}\\
&+ \frac{\frac{1}{2}\lambda_1(1-\gamma)n_k\sigma_{yg_1} + \frac{1}{2}\lambda_2(1-\gamma)n_k\sigma_{yg_1} - \frac{1}{2}\lambda_1\lambda_2\sigma_{g_1g_2}}{\gamma}.
\end{aligned} \tag{16}
$$

With c/w given in (16) and n_k in (14), we have the explicit stochastic differential equation describing the motion of wealth accumulation from equation (9):

$$\frac{dw}{w} = \left[(1-\tau)\,An_k + r_b(1-n_k) - \frac{c}{w}\right]dt + dv.$$

Taking expectation in equation (13), we have the expected growth rate of consumption and capital accumulation:

$$\phi = E\frac{dw}{w} = \left[(1-\tau)\,An_k + r_b\,(1-n_k) - [\delta\,(1-\gamma)]^{-\frac{1}{\gamma}}\right], \qquad (17)$$

with n_k and $[\delta\,(1-\gamma)]^{-\frac{1}{\gamma}}$ given in (14) and (16), respectively. It is obvious that the expected growth rate, ϕ, is a very complicated function of various parameters in the model. Our main concern here is to see how the mean growth rates of various government expenditures and the volatility in the growth of government expenditures affect the growth rate of the economy.

First, to see how the volatility in various kinds of government spending affects long-run growth in equation (17), we differentiate the expected growth rate with respect to $\sigma^2_{g_i}(i = 1\text{and}2)$ in equation (17), and get

$$\frac{\partial\phi}{\partial\sigma^2_{g_i}} = \frac{\frac{1}{2}\lambda_i\,(\lambda_i+1)}{\gamma}.$$

From the expression above, we know that

$$\frac{\partial\phi}{\partial\sigma^2_{g_i}} > 0,$$

when $\gamma > 1$; and

$$\frac{\partial\phi}{\partial\sigma^2_{g_i}} < 0,$$

when $-1 < \lambda_i < 0, 0 < \gamma < 1$. That is to say, when the elasticity of intertemporal substitution in consumption, which is equal to the inverse of γ in our model, is relatively low, a rise in the volatility of government expenditures leads to more savings and investment and a higher growth rate. On the other hand, when the elasticity of intertemporal substitution in consumption is relatively high, a rise in the volatility of government expenditures reduces the long-run growth rate. This observation incorporates two trends of literature on the relationship between volatility and growth, as clearly observed by Ramey and Ramey (1995). For example, in very different theoretical contexts, if there are irreversibility in investment, higher volatility can lead to lower investment and growth; see Pindyck (1991). But in another theoretical framework, if there is a precautionary motive for savings, higher volatility should result in higher savings and growth rates (Ramey and Ramey, 1995). In addition, Obstfeld (1994) has also obtained an ambiguity on the relationship between volatility and growth in an optimal investment and portfolio-choice model. Our focus here is

rather different since we try to identify the effects of volatility of public expenditures on the growth rate of the economy.

Next we examine how the growth rate of capital accumulation is linked to the mean of the growth rates of public expenditures. In (17), we differentiate ϕ with respect to μ_{g_i}:

$$\frac{\partial \phi}{\partial \mu_{g_i}} = \frac{-\lambda_i}{\gamma}.$$

Hence,

$$\frac{\partial \phi}{\partial \mu_{g_i}} > 0$$

if $0 < \gamma < 1$; and

$$\frac{\partial \phi}{\partial \mu_{g_i}} < 0$$

if $\gamma > 1$. Therefore, the link between the mean in the growth rates of public expenditures and the growth rate of the economy is rather similar to the relationship between the volatility in public expenditures and economic growth. Theoretically it is possible that a higher growth in public expenditures gives rise to lower economic growth. In view of these theoretical ambiguities, it is important for us to confront the theory with empirical data.

3. EMPIRICAL EVIDENCE

To test the effects of the growth and volatility of government expenditures on the growth rate of the economy, we use data for more than 90 countries over a period from 1970-94. The data on various public expenditures by central governments are from the International Monetary Fund's Government Finance Statistics (GFS).[2] In the GFS, government expenditures are classified by two main approaches: economic type and function. Economic type of government expenditures are divided into (1) current expenditure (including purchase of goods and services, wages, salary, interest payments, and subsidies), and (2) capital expenditure (including investment in stocks, land, capital assets, and capital transfers). Government expenditures by function are divided into six categories: (1) general public service, (2) defense (including national defense and public order and safety), (3) education, (4) human welfare services (including health, social security, housing, community amenities, recreations, cultural, and religious

[2]GFS provides the most comprehensive data on spending by central governments and contains much less information on subnational or local governments.

affairs), (5) transportation (roads, water transport, rail transport, and air transport) and communication, and (6) economic affairs and services (including public spending on fuel and energy, agriculture, forestry, fishing, mining, manufacturing, and construction). The summary statistics of these different public expenditures for all the countries in our data set are provided in the summary statistics tables A and B. The mean growth rate and variance of the growth rates of current and capital expenditures over the period from 1970-94 are in Table A. The mean growth and variance of the growth in the six categories of public expenditures by function during 1970-94 are provided in Table B.

Our theoretical analysis relates the growth rate of the economy to the growth and volatility of various public expenditures:

$$\phi = \phi\left(\mu_{g_1}, \mu_{g_2}, \ldots, \mu_{g_n}, \sigma^2_{g_1}, \sigma^2_{g_2}, \ldots, \sigma^2_{g_n}, Z\right)$$

where μ_{g_i} $(i = 1, \ldots, n)$ and $\sigma^2_{g_i}$ $(i = 1, \ldots, n)$ are the mean growth rate and variance of the growth rate of the i-th item of public spending by economic type or by function as given in Tables A and B. Z denotes a vector of other variables affecting growth: (i) initial GDP defined as per capita real GDP in year 1970 from the Summers-Heston data base; (ii) openness measured by the sum of exports and imports over GDP from the International Monetary Fund's *International Financial Statistics* (IFS); (iii) population growth rate from IFS; (iv) human capital measured by the secondary school enrollment from *World Development Indicators* (WDI) published by the World Bank; (v) population growth from WDI; (vi) democracy index or civil liberty index from *Freedom in the World* by R. Gastil (various issues); and (vi) the average tax rate from the GFS. These control variables are widely used in many empirical studies on economics growth; see Levine and Renelt (1992) for an example.

3.1. Effects of government expenditures by economic type

Our first group of cross-section regression analysis is presented in Table 1. In the baseline regression, Eq (1), the average output growth rate from 1970 to 1994 is positively and significantly associated with the mean growth of current expenditure; whereas it has no statistically significant relationship with the mean growth of capital expenditure. This finding is surprising because we would expecte capital expenditure and its growth to have a more significant, positive effect on economic growth. This intuitive argument is not validated by our empirical results. Please also note that this finding is consistent with our theoretical model, which admits both positive and negative effects of public expenditure growth on output growth.

Compared to other empirical studies, Barro (1990) found that from a cross-country regression the ratio of public consumption over GDP, which is closely related to current expenditure, is associated with lower per capita

output growth. Devarajan, Swaroop, and Zou (1996) found a positive association between the share of current expenditure in total government spending and economic growth and a negative association between the share of capital expenditure in total government spending and economic growth for a sample of 43 developing countries. Our results here are different. Growth in both public consumption or current expenditure and public investment or capital expenditure is associated with higher output growth. The former association is statistically significant, whereas the latter is not. Of course, the comparison has its limitation here because we are looking at the growth rate and volatility in different public expenditures, and not at their shares in GDP or in total government spending. Our empirical approach is more in line with the stochastic growth model, which differentiates the effects of mean growth from the effects of volatility.

Turning to the uncertainty or volatility in current and capital expenditure growth, Eq (1) in Table 1 presents very strong evidence of a negative effect of government expenditure volatility on output growth. The variances of both current and capital expenditure growth are negatively and significantly associated with output growth. This finding supports the argument that instability and uncertainty in macroeconomic policies tend to reduce the rate of private investment and output growth (Pindyck and Solimano, 1993; and Ramey and Ramey, 1995). This more detailed examination of volatility in both current and capital expenditure extends the result that aggregate government spending-induced volatility is negatively associated with output growth in Ramey and Ramey (1995). Please also note that in Ramey and Ramey's (1995) analysis the difference between growth and volatility in government expenditures are not explicitly examined.

For other control variables in Eq (1) in Table 1, we find that the estimated coefficient for initial GDP is negative, but not significant. The coefficient for the inflation rate is positive and significant, supporting the Mundell-Tobin portfolio-shift effect. Openness has a positive, significant estimated coefficient, whereas population growth has a negative, significant coefficient. Except for the strong, positive effect of inflation on output growth, all other estimated coefficients in Eq (1) are broadly consistent with the results in many recent growth empirics.

To examine the robustness of our results in Eq (1), we gradually introduce a few other control variables into our regressions. Eq (2) presents the regression result when the average tax rate is added as another explanatory variable. The tax rate has no significant relationship with output growth. But at the same time, all other variables still retain qualitatively the same estimates as in Eq (1). When the variable of democracy is introduced into Eq (3), it has no significance on economic growth as it does in Alesina and Rodrik (1994). The only major change as a result of the inclusion of

TABLE 1. Cross-Section Estimations (t-statistics are in brackets)

	Dependent Variable: per-capita GDP growth rate			
Explanatory variables	Eq (1)	Eq (2)	Eq (3)	Eq (4)
constant	0.009	0.008	0.002	−0.011
	[0.821]	[0.572]	[0.140]	[−0.554]
mean of current	0.409	0.409	0.374	0.370
expenditure growth	[3.808]	[3.695]	[3.243]	[3.415]
mean of capital	0.020	0.020	0.015	0.028
expenditure growth	[0.473]	[0.474]	[0.364]	[0.735]
variance of current	−0.086	−0.086	−0.075	−0.074
expenditure growth	[−2.668]	[−2.722]	[−2.187]	[−2.284]
variance of capital	−0.005	−0.005	−0.005	−0.005
expenditure growth	[−2.585]	[−2.646]	[−2.539]	[−2.534]
initial GDP	−1.31E-06	−1.33E-06	−1.94E-06	−3.66E-06
	[−1.441]	[−1.458]	[−2.097]	[−3.127]
inflation rate	0.005	0.005	0.005	0.005
	[2.299]	[2.301]	[2.172]	[2.272]
openness	0.018	0.018	0.018	0.013
	[3.315]	[3.055]	[2.763]	[1.620]
population growth rate	−1.143	−1.138	−0.973	−0.658
	[−3.674]	[−3.155]	[−1.991]	[−1.182]
tax rate		0.001	0.001	0.001
		[0.047]	[0.055]	[0.038]
democracy			0.012	0.004
			[0.914]	[0.359]
human capital				0.0004
				[2.570]
R-squared	0.447	0.447	0.418	0.435
Adjusted R-squared	0.396	0.389	0.344	0.353
Observations	96	96	90	88
Durbin-Watson stat	1.934	1.934	1.695	1.685

variable of democracy in the regression is that the estimated coefficient for initial GDP is now becoming negative and significant. Finally, in Eq (4) of Table 1 the variable of human capital in included in the regression. Now human capital has a very significant, positive estimate, suggesting that human capital formation has a positive effect on output growth. At the same time, the estimated coefficient for initial GDP becomes even more significant, and the one for openness becomes less significant. The coefficient for the inflation rate is still positive and significant. Across Eq (2) to Eq (4), the mean growth rate in current expenditure is always positively and significantly associated with output growth; the mean growth rate of

capital expenditure is positively, but highly insignificantly, associated with output growth; and the volatility in the growth of both current and capital expenditures is negatively and significantly associated with output growth.

3.2. Effects of government expenditures by function

In Table 2, we offer another perspective on the effects of the growth and volatility in various public expenditures by function on output growth. Across Eq (1) to Eq (4), the mean growth rate in general public services is negatively, but not significantly, associated with output growth, whereas the variance of its growth rate is positively and significantly associated with output growth. Unlike the case of public expenditure by economic type, we find here that volatility in certain public spending can even promote economic growth—a result consistent with our theoretical model and with other theoretical studies.[3] While the estimated coefficients for the growth rates in defense spending, education spending, human welfare spending, and economic services spending are all positive, only the coefficient for economic services spending is statistically significant. It is rather surprising to find that spending growth in the most important public infrastructure—transportation and communication— is negatively, but almost not significantly, associated with output growth. Furthermore the coefficient for the variance of the growth in transportation and communication is positive and weakly significant. The volatility in defense spending has a significant, negative effect on output growth, whereas the estimated coefficients for the volatility in education spending and economic services are negative and weakly significant. Throughout these regressions, the volatility in human welfare spending has no association with output growth.

The negative association between growth in transportation and communication expenditure and output growth stands in contrast to the positive association between the share of transportation and communication spending in GDP and output growth in Easterly and Rebelo (1993). Our result is more in line with Devarajan, Swaroop, and Zou (196) who found a negative, statistically significant association between the share of transportation and communication spending in total government spending and GDP growth for a sample of 43 developing countries. But again the comparison is of limited value because our explanatory variable is the growth rate in transportation and communication spending. From these empirical exercises, we shall pay particular attention to the relationship between transportation and communication expenditure and output growth. We need to make sure that their spending share in GDP, their spending share in total government spending, and their growth rate can give rise to very different effects on output growth.

[3]See Ramey and Ramey (1995) for a survey on the positive impact of uncertainty on investment and output growth.

TABLE 2. Cross-Section Estimations (t-statistics are in brackets)

	Dependent Variable: per-capita GDP growth rate			
Explanatory variables	Eq (1)	Eq (2)	Eq (3)	Eq (4)
constant	0.025	0.031	0.029	0.011
	[2.582]	[2.169]	[1.266]	[0.508]
mean of general public	−0.0004	−0.0004	−0.0004	−0.0005
service growth	[−0.239]	[−0.269]	[−0.242]	[−0.304]
mean of defense	0.087	0.079	0.086	0.091
expenditure growth	[1.277]	[1.146]	[1.158]	[1.220]
mean of education	0.084	0.092	0.072	0.056
expenditure growth	[1.201]	[1.287]	[0.951]	[0.774]
mean of human welfare	0.069	0.070	0.092	0.078
expenditure growth	[1.105]	[1.113]	[1.447]	[1.285]
mean of economic service	0.155	0.157	0.153	0.154
expenditure growth	[3.227]	[3.261]	[2.871]	[2.976]
mean of transporation and	−0.035	−0.040	−0.046	−0.032
communication expenditure growth	[−1.512]	[−1.664]	[−1.618]	[−1.094]
variance of general public	0.001	0.001	0.001	0.001
service growth	[3.224]	[2.974]	[2.828]	[2.971]
variance of defense	−0.028	−0.028	−0.029	−0.030
expenditure growth	[−2.257]	[−2.220]	[−2.298]	[−2.416]
variance of education	−0.059	−0.063	−0.061	−0.030
expenditure growth	[−1.120]	[−1.216]	[−1.070]	[−0.534]
variance of human welfare	0.010	0.009	0.009	0.012
expenditure growth	[0.521]	[0.463]	[0.470]	[0.689]
variance of economic service	−0.020	−0.020	−0.021	−0.021
expenditure growth	[−1.435]	[−1.491]	[−1.477]	[−1.532]
variance of transporation and	0.001	0.002	0.002	0.001
communication expenditure growth	[1.511]	[1.642]	[1.566]	[1.171]
initial GDP	−1.87E-06	−1.71E-06	−1.79E-06	−3.17E-06
	[−2.045]	[−1.843]	[−1.948]	[−2.930]
inflation rate	0.005	0.005	0.005	0.005
	[4.762]	[4.701]	[4.602]	[4.392]
openness	0.018	0.020	0.020	0.016
	[2.925]	[3.067]	[3.020]	[2.347]
population growth rate	−1.571	−1.701	−1.587	−1.222
	[−4.904]	[−4.166]	[−2.867]	[−2.234]
tax rate		−0.024	−0.025	−0.017
		[−0.749]	[−0.751]	[−0.542]
democracy			0.002	−0.0004
			[0.131]	[−0.022]
human capital				0.0003
				[2.390]
R-squared	0.535	0.539	0.537	0.560
Adjusted R-squared	0.429	0.425	0.409	0.430
Observations	87	87	84	84
Durbin-Watson stat	1.830	1.85	1.506	1.47

TABLE 3. Cross-Section Estimations (t-statistics are in brackets)

	Dependent Variable: per-capita GDP growth rate			
Explanatory variables	Eq (1)	Eq (2)	Eq (3)	Eq (4)
constant	0.013	0.008	0.001	−0.006
	[1.419]	[0.581]	[0.068]	[−0.314]
mean of current	0.192	0.223	0.210	0.209
expenditure growth	[3.834]	[4.145]	[3.588]	[3.504]
mean of capital	0.109	0.115	0.115	0.118
expenditure growth	[2.901]	[2.703]	[2.550]	[2.523]
variance of current	−0.037	−0.013	−0.008	−0.004
expenditure growth	[−1.387]	[−0.352]	[−0.210]	[−0.131]
variance of capital	−0.015	−0.015	−0.015	−0.016
expenditure growth	[−3.369]	[−3.200]	[−3.050]	[−3.009]
initial GDP	−4.68E-07	−5.27E-07	−7.17E-07	−1.59E-06
	[−0.703]	[−0.840]	[−1.003]	[−1.856]
inflation rate	0.002	0.003	0.002	0.002
	[0.709]	[0.728]	[0.703]	[0.696]
openness	0.008	0.007	0.006	0.004
	[1.444]	[1.327]	[1.161]	[0.733]
population growth rate	−0.682	−0.652	−0.428	−0.286
	[−3.064]	[−2.247]	[−1.315]	[−0.814]
tax rate		0.012	0.014	0.011
		[0.346]	[0.426]	[0.349]
democracy			0.008	0.004
			[0.675]	[0.374]
human capital				0.0002
				[1.746]
R-squared	0.188	0.204	0.188	0.188
Adjusted R-squared	0.170	0.183	0.162	0.159
Observations	363	343	326	323

TABLE 4. Cross-Section Estimations (t-statistics are in brackets)

	Dependent Variable: per-capita GDP growth rate			
Explanatory variables	Eq (1)	Eq (2)	Eq (3)	Eq (4)
constant	0.011	0.001	−0.004	−0.006
	[1.075]	[0.043]	[−0.212]	[−0.355]
mean of general public	−0.003	0.008	0.008	0.009
service growth	[−0.109]	[0.252]	[0.270]	[0.281]
mean of defense	−0.056	−0.050	−0.049	−0.048
expenditure growth	[−0.677]	[−0.593]	[−0.534]	[−0.513]
mean of education	0.209	0.201	0.197	0.195
expenditure growth	[2.151]	[2.056]	[1.901]	[1.852]
mean of human welfare	0.170	0.223	0.260	0.259
expenditure growth	[2.899]	[2.889]	[3.063]	[3.031]
mean of economic service	0.027	0.039	0.026	0.028
expenditure growth	[1.218]	[1.096]	[0.692]	[0.717]
mean of transporation and	−0.005	−0.010	−0.014	−0.014
communication expenditure growth	[−0.502]	[−0.881]	[−1.205]	[−1.169]
variance of general	6.60E-05	−0.001	−0.001	−0.001
public service growth	[0.031]	[−0.264]	[−0.247]	[−0.262]
variance of defense	0.018	0.017	0.018	0.017
expenditure growth	[0.819]	[0.716]	[0.684]	[0.663]
variance of education	−0.163	−0.155	0.169	−0.167
expenditure growth	[−1.409]	[−1.231]	[−1.210]	[−1.177]
variance of human welfare	−0.036	−0.047	−0.052	−0.052
expenditure growth	[−2.238]	[−2.407]	[−2.626]	[−2.611]
variance of economic service	−0.003	−0.007	−0.003	−0.004
expenditure growth	[−0.591]	[−0.486]	[−0.229]	[−0.251]
variance of transporation and	0.0002	0.0004	0.001	0.001
communication expenditure growth	[0.249]	[0.514]	[0.730]	[0.727]
initial GDP	−1.20E-06	−1.45E-06	−1.43E-06	−1.74E-06
	[−1.568]	[−1.713]	[−1.486]	[−1.691]
inflation rate	0.005	0.006	0.006	0.006
	[1.140]	[1.246]	[1.254]	[1.247]
openness	0.009	0.009	0.008	0.008
	[1.352]	[1.303]	[1.184]	[1.024]
population growth rate	−0.577	−0.510	−0.326	−0.281
	[−2.352]	[−1.681]	[−1.119]	[−0.987]
tax rate		0.026	0.033	0.032
		[0.754]	[1.038]	[0.977]
democracy			−0.0002	−0.001
			[−0.012]	[−0.132]
human capital				8.68E-05
				[0.522]
R-squared	0.204	0.232	0.231	0.231
Adjusted R-squared	0.157	0.181	0.175	0.172
Observations	288	276	265	265

The positive association between the volatility in the growth rates of general public services and transportation and communication spending and output growth confirms the positive impact of uncertainty and volatility on economic growth predicted by many theoretical models. While our results from the analysis of the volatility in current and capital expenditures are consistent with the finding from aggregate government spending by Ramey and Ramey (1995), our results from government spending by various functions show the possibility of a positive association between the volatility in some components of government spending and economic growth. This suggests that there is some value added in offering a more micro-oriented examination of the relationship between the volatility in the various components of government expenditures and economic growth. Instead of an aggregate, negative association between volatility in government spending and output growth, we can say something more: uncertainty in infrastructure and general public services is likely to promote output growth, whereas uncertainty in other government expenditures may retard output growth.

As for other control variables in Table 2, their estimates are consistent with the ones in Table 1. For example, the estimated coefficients for initial GDP is negative and significant; the inflation rate is positively and significantly associated with output growth; openness and human capital formation have highly significant and positive effects on output growth; population growth is negatively and statistically significantly associated with output growth; and the tax rate and democracy have no association with output growth.

4. CONCLUSIONS

This paper sets up a theoretical model linking the growth rate of the economy to the growth rates and volatility in various government expenditures. On a theoretical basis, it is found that volatility in government spending can be positively or negatively associated with economic growth depending on the intertemporal elasticity of consumption. Empirically, we have found the following:

(1) When public expenditures are classified by economic type, the mean growth rate in current expenditure is positively and significantly associated with output growth, whereas, surprisingly, the mean growth in capital expenditure has no relationship with output growth. At the same time, the volatility in the growth of current and capital expenditures have a significant, negative effedt on output growth.

(2) When public expenditures are classified by function, the mean growth rate in general public services is negatively, but not significantly, associated with output growth, whereas the variance of its growth rate is positively and significantly associated with output growth. While the esti-

mated coefficients for the growth rates in spending for defense, education, human welfare, and economic services are all positive, only the coefficient for economic services spending is statistically significant. On the other hand, growth in transportation and communication is negatively, and almost not significantly, associated with output growth. Furthermore the variance of the growth in transportation and communication is positively, weakly significantly, associated with output growth.

A few important points should be emphasized here. First, unlike many existing studies on the relationship between public expenditure and economic growth, our paper has differentiated the effects of growth and volatility in public spending on economic growth. This approach is more in line with recent theoretical advances examining the economic effects of government spending in stochastic environments. Second, our approach has offered new empirical insights on the relationship between output growth and public spending growth. For example, it is rather surprising to find that growth in capital expenditure has no association with output growth, whereas growth in current expenditure seems to stimulate output growth. In particular, growth in transportation and communication seems to have a negative impact on output growth. These findings indicate that rapid and excessive investment in infrastructure may be harmful for economic growth if spending on administration, education, and basic economic services are neglected. Third, it is very interesting to find that the positive association between the volatility in public spending and output growth can be empirically validated. In fact, the volatility in the growth of general public services as well as transportation and communication has been shown to have a positive effect on output growth.

Appendix A: Summery Statistics of variables

IMF's Country Code	per-capita GDP growth rate	initial GDP	inflation rate	population growth rate	openness	mean of current expenditure growth	mean of capital expenditure growth	variance of current expenditure growth	variance of capital expenditure growth
USA	0.013	12963	0.058	0.010	0.176	0.030	0.028	0.001	0.040
GBR	0.020	8537	0.090	0.002	0.516	0.034	0.028	0.001	0.026
AUT	0.028	7510	0.047	0.003	0.714	0.045	0.047	0.001	0.023
BEL	0.023	8331	0.054	0.002	1.229	0.039	0.004	0.002	0.010
DNK	0.018	9670	0.069	0.002	0.642	0.036	0.013	0.001	0.028
FRA	0.022	9200	0.070	0.006	0.415	0.037	0.028	0.000	0.020
DEU	0.021	9425	0.039	0.013	0.514	0.048	0.018	0.002	0.024
ITA	0.035	7568	0.105	0.003	0.393	0.064	−0.005	0.003	0.093
LUX	0.045	9782	0.051	0.007	1.810	0.060	0.061	0.001	0.017
NLD	0.021	9199	0.045	0.007	1.009	0.030	0.007	0.001	0.017
NOR	0.028	8034	0.072	0.005	0.786	0.038	0.024	0.001	0.006
SWE	0.015	10766	0.078	0.004	0.597	0.048	−0.004	0.001	0.054
CHE	0.015	12942	0.041	0.005	0.686	0.048	−0.010	0.002	0.005
JPN	0.027	7307	0.051	0.008	0.223	0.061	0.030	0.003	0.010
FIN	0.025	8108	0.077	0.004	0.557	0.057	−0.007	0.002	0.010
GRC	0.029	4224	0.160	0.007	0.439	0.056	0.007	0.011	0.017
ISL	0.035	6772	0.288	0.012	0.728	0.048	0.037	0.007	0.051
IRL	0.033	5015	0.094	0.008	1.066	0.052	0.039	0.003	0.011
MLT	0.055	2424	0.043	0.007	1.697	0.068	0.117	0.004	0.097
PRT	0.035	3306	0.157	0.004	0.612	0.064	0.085	0.006	0.051
ESP	0.024	5861	0.110	0.006	0.357	0.067	0.019	0.002	0.015
TUR	0.005	2202	0.446	0.023	0.342	0.085	0.038	0.012	0.051
AUS	0.018	10756	0.079	0.015	0.328	0.051	0.029	0.002	0.025
NZL	0.011	9392	0.098	0.009	0.565	0.053	−0.004	0.003	0.016
ZAF	0.007	3254	0.122	0.025	0.521	0.055	0.033	0.002	0.055

Appendix A: Summary Statistics of variables (continued)

IMF's Country Code	per-capita GDP growth rate	initial GDP	inflation rate	population growth rate	openness	mean of current expenditure growth	mean of capital expenditure growth	variance of current expenditure growth	variance of capital expenditure growth
ARG	0.005	5637	3.805	0.015	0.167	0.008	0.010	0.032	0.302
BOL	0.018	1813.92	5.408	0.019	0.451	0.085	0.173	0.007	7.278
BRA	0.015	2434	9.400	0.022	0.170	0.104	0.003	0.055	0.198
CHL	0.054	3605	0.819	0.017	0.636	0.038	0.051	0.008	0.064
COL	0.028	2140	0.224	0.022	0.298	0.086	0.036	0.009	0.218
CRI	0.036	2904	0.185	0.024	0.716	0.083	0.082	0.016	0.102
DOM	0.013	1536	0.166	0.027	0.514	0.032	0.083	0.018	0.110
ECU	0.028	1789	0.273	0.027	0.507	0.025	0.224	0.004	0.151
SLV	−0.014	1810	0.143	0.021	0.569	0.016	0.105	0.009	0.151
GTM	0.007	2028	0.127	0.029	0.407	0.015	0.071	0.005	0.128
HTI	−0.014	834	0.114	0.021	0.542	0.038	0.205	0.018	0.643
MEX	0.022	3987	0.368	0.026	0.254	0.073	0.044	0.032	0.038
NIC	0.012	2359	12.516	0.037	0.620	0.046	0.436	0.055	1.180
PAN	0.024	2584	0.039	0.025	1.335	0.054	0.112	0.011	0.317
PRY	0.030	1394	0.173	0.030	0.473	0.059	0.160	0.010	0.225
PER	−0.016	2736	5.246	0.023	0.323	0.004	0.070	0.026	0.118
URY	0.004	4121	0.620	0.006	0.384	0.034	0.092	0.010	0.111
VEN	0.012	7753	0.201	0.031	0.525	0.046	0.124	0.012	0.238
BHS	0.002	7742	0.061	0.021	1.310	0.032	0.108	0.003	0.501
BRB	0.016	4638	0.090	0.004	1.197	0.032	0.016	0.009	0.038
GUY	0.013	1816	0.128	0.007	1.390	0.023	0.134	0.013	0.542
BLZ	0.015	3943	0.036	0.024	1.213	0.071	0.071	0.005	0.157
KNA	0.080	3070	0.043	0.003	1.429	0.093	0.119	0.010	0.385

Appendix A: Summery Statistics of variables (continued)

IMF's Country Code	per-capita GDP growth rate	initial GDP	inflation rate	population growth rate	openness	mean of current expenditure growth	mean of capital expenditure growth	variance of current expenditure growth	variance of capital expenditure growth
LCA	0.063	2211	0.085	0.013	1.827	0.060	0.086	0.016	0.069
VCT	0.057	2411	0.062	0.001	1.459	0.071	0.177	0.010	0.369
SUR	−0.020	2970	0.328	0.003	0.993	0.039	0.393	0.004	0.280
TTO	0.010	6795	0.110	0.008	0.788	0.105	0.050	0.015	0.032
BHR	−0.003	10151	0.061	0.041	2.072	0.072	0.032	0.005	0.058
CYP	0.054	3753	0.061	0.008	1.030	0.089	0.089	0.004	0.053
IRN	0.034	4796	0.165	0.031	0.375	0.085	0.088	0.115	0.115
ISR	0.029	6004	0.677	0.026	0.927	0.057	0.097	0.031	0.089
JOR	0.006	1422	0.085	0.036	1.105	0.047	0.042	0.015	0.058
SYR	0.006	2294	0.155	0.034	0.502	0.071	0.115	0.042	0.105
EGY	0.025	1163	0.129	0.024	0.515	0.028	0.112	0.014	0.244
BGD	0.029	1280	0.133	0.022	0.213	0.245	0.245	0.704	0.704
LKA	0.045	1243	0.105	0.015	0.659	0.075	0.082	0.029	0.097
IND	0.023	802	0.087	0.022	0.143	0.081	0.068	0.004	0.007
IDN	0.066	718.346	0.123	0.021	0.459	0.078	0.110	0.013	0.033
KOR	0.089	1680	0.109	0.014	0.629	0.114	0.112	0.004	0.066
MYS	0.045	2154	0.044	0.028	1.170	0.080	0.254	0.006	0.147
PAK	0.053	1029	0.097	0.011	0.312	0.089	0.077	0.006	0.065
PHL	0.001	1403	0.142	0.026	0.494	0.052	0.098	0.028	0.114
BWA	0.065	823	0.115	0.038	1.121	0.128	0.072	0.009	0.025
CMR	−0.002	804	0.091	0.027	0.460	0.038	−0.026	0.021	0.149
ZAR	0.015	686	13.239	0.029	0.560	−0.116	−0.069	0.057	0.219
ETH	−0.027	296	0.085	0.035	0.256	0.019	0.076	0.019	0.161
GMB	0.005	722	0.124	0.036	0.973	0.113	0.274	0.011	0.412
GHA	−0.017	1059	0.394	0.028	0.339	0.041	0.051	0.058	0.143

Appendix A: Summery Statistics of variables (continued)

IMF's Country Code	per-capita GDP growth rate	initial GDP	inflation rate	population growth rate	openness	mean of current expenditure growth	mean of capital expenditure growth	variance of current expenditure growth	variance of capital expenditure growth
KEN	−0.025	586	0.147	0.041	0.594	0.025	−0.003	0.009	0.083
LSO	0.014	419	0.138	0.027	1.305	0.070	0.211	0.014	0.132
LBR	−0.036	982	0.074	0.030	1.079	0.019	0.084	0.017	0.221
MDG	−0.007	1146	0.139	0.032	0.392	0.069	−0.050	0.008	0.044
MWI	−0.021	440	0.180	0.032	0.587	0.030	−0.078	0.026	0.036
MUS	0.061	2398	0.106	0.012	1.148	0.077	0.098	0.012	0.071
MAR	0.017	1342	0.074	0.024	0.485	0.060	0.082	0.012	0.084
NER	0.000	805	0.064	0.033	0.479	0.068	0.301	0.018	0.010
ZWE	0.011	1082	0.133	0.032	0.567	0.066	0.095	0.016	0.159
RWA	−0.034	647	0.091	0.032	0.285	0.047	0.218	0.013	0.171
SEN	−0.006	1146	0.079	0.028	0.698	0.023	0.435	0.011	0.214
SLE	−0.034	1435	0.425	0.021	0.504	0.075	0.098	0.123	0.258
SOM	−0.019	921	0.268	0.052	0.325	0.119	0.186	0.057	0.135
NAM	−0.001	2642	0.128	0.024	1.233	0.014	0.012	0.011	0.066
SDN	−0.001	817	0.277	0.030	0.220	0.017	0.120	0.017	0.184
SWZ	0.026	2531	0.122	0.031	1.575	0.048	0.164	0.009	0.285
TUN	0.028	1442	0.068	0.031	0.755	0.026	−0.021	0.002	0.007
UGA	0.034	647	0.807	0.031	0.281	0.154	0.276	0.336	0.211
BFA	0.025	374	0.063	0.027	0.477	0.075	0.088	0.022	0.193
ZMB	−0.052	1117	0.987	0.033	0.748	−0.029	0.347	0.108	2.157
FJI	0.020	2592	0.082	0.017	1.000	0.045	0.028	0.007	0.037
PNG	0.010	1896	0.072	0.021	0.870	0.037	0.013	0.003	0.091
HUN	0.007	3358	0.113	−0.0003	0.504	0.006	−0.119	0.004	0.030
total	0.022		0.581	0.021	0.739	0.060	0.100	0.031	0.272

Appendix B: Summery Statistics of Variables

IMF's Country Code	mean of general public services growth	mean of defense expenditure growth	mean of edu expenditure growth	mean of human welfare growth	mean of economic service growth	mean of transportation and communication growth	variance of general public services growth	variance of defense expenditure growth	variance of edu expenditure growth	variance of human welfare growth	variance of economic service growth	variance of transportation and communication growth
USA	0.070	0.004	0.008	0.036	0.030	0.009	0.015	0.003	0.006	0.002	0.046	0.004
GBR	0.003	0.003	0.065	0.043	0.020	−0.012	0.011	0.002	0.011	0.001	0.043	0.027
AUT	0.051	0.023	0.045	0.044	0.061	0.027	0.007	0.003	0.001	0.001	0.091	0.010
BEL	0.008	0.018	0.030	0.046	0.037	0.004	0.018	0.002	0.003	0.002	0.059	0.009
DNK	0.033	0.006	0.016	0.031	0.041	−0.007	0.011	0.002	0.005	0.002	0.054	0.007
FRA	0.037	0.018	0.017	0.039	0.090	−0.020	0.010	0.004	0.001	0.001	0.158	0.015
DEU	0.098	0.012	0.054	0.045	0.071	0.022	0.063	0.001	0.030	0.002	0.061	0.008
ITA	−0.016	0.056	0.039	0.085	0.153	0.155	0.028	0.004	0.002	0.006	0.231	0.075
LUX	0.082	0.048	0.065	0.065	0.038	0.056	0.020	0.028	0.011	0.002	0.055	0.011
NLD	0.051	0.002	0.008	0.033	0.008	0.017	0.016	0.001	0.001	0.001	0.020	0.003
NOR	0.056	0.023	0.056	0.045	0.026	0.036	0.003	0.002	0.002	0.001	0.012	0.006
SWE	−0.003	0.007	0.001	0.053	0.086	0.038	0.022	0.001	0.009	0.002	0.058	0.034
CHE	0.023	0.004	0.027	0.059	0.019	0.024	0.002	0.003	0.004	0.006	0.004	0.008
CAN	0.026	0.019	0.025	0.035	0.001	0.004	0.006	0.003	0.009	0.002	0.022	0.030
JPN	0.041	0.003	0.036	0.118	0.072	0.065	0.000	0.000	0.000	0.000	0.002	0.010
FIN	0.019	0.035	0.034	0.063	0.053	−0.006	0.015	0.007	0.002	0.002	0.018	0.005
GRC	0.090	0.026	0.066	0.062	0.033	0.015	0.046	0.025	0.015	0.005	0.059	0.021
IRL	0.034	0.008	0.032	0.026	0.008	0.035	0.007	0.003	0.002	0.002	0.036	0.012
MLT	0.076	0.109	0.069	0.084	0.102	0.085	0.052	0.055	0.008	0.009	0.105	0.064
ESP	0.054	0.025	0.036	0.065	0.007	0.083	0.038	0.020	0.006	0.005	0.025	0.069
TUR	0.126	0.056	0.106	0.153	0.050	0.053	0.079	0.012	0.046	0.101	0.086	0.044

Appendix B: Summery Statistics of Variables (continued)

IMF's Country Code	mean of general public services growth	mean of defense expenditure growth	mean of edu expenditure growth	mean of human welfare growth	mean of economic service growth	mean of transportation and communication growth	variance of general public services growth	variance of defense expenditure growth	variance of edu expenditure growth	variance of human welfare growth	variance of economic service growth	variance of transportation and communication growth
AUS	0.046	0.014	0.091	0.076	0.037	0.010	0.003	0.002	0.037	0.009	0.021	0.011
NZL	0.069	0.021	0.035	0.056	0.032	0.022	0.031	0.006	0.005	0.002	0.041	0.022
ARG	0.048	−0.074	−0.023	0.040	0.010	−0.017	0.247	0.031	0.040	0.026	0.138	0.115
BOL	0.251	0.033	0.105	0.089	0.110	0.241	0.357	0.021	0.013	0.030	0.489	0.119
BRA	0.071	0.046	0.066	0.045	−0.065	0.256	0.043	0.071	0.077	0.011	0.113	1.005
CHL	−0.023	0.040	0.029	0.044	0.033	0.039	0.031	0.039	0.026	0.021	0.176	0.068
COL	0.093	0.105	0.103	0.078	0.039	0.039	0.046	0.027	0.009	0.012	0.682	0.070
CRI	0.260	0.002	0.061	0.111	0.210	0.040	1.008	0.033	0.026	0.043	0.320	0.088
DOM	0.000	0.015	0.036	0.062	0.039	0.072	0.067	0.024	0.031	0.035	0.059	0.052
ECU	0.063	0.064	0.055	0.145	0.094	0.023	0.058	0.033	0.052	0.058	0.151	0.083
SLV	0.012	0.049	−0.004	0.064	0.082	0.074	0.050	0.045	0.014	0.064	0.118	0.109
GTM	0.029	0.056	0.068	0.053	0.077	0.025	0.071	0.023	0.224	0.070	0.339	0.064
HND	0.269	0.098	0.071	0.084	0.264	0.098	0.703	0.017	0.006	0.032	0.307	0.157
MEX	0.640	0.060	0.086	0.061	0.048	0.035	10.016	0.016	0.020	0.019	0.059	0.051
NIC	0.456	−0.031	0.027	0.083	0.578	0.149	1.919	0.106	0.050	0.071	1.936	0.342
PAN	0.039	−0.002	0.035	0.071	−0.007	0.070	0.090	0.022	0.007	0.008	0.083	0.111
PRY	12.111	0.036	0.098	0.107	0.131	0.673	0.061	0.018	0.027	0.048	0.266	8.227
URY	12.008	0.066	0.020	0.048	0.111	0.127	0.040	0.065	0.019	0.022	0.260	0.282
BRB	0.016	0.204	0.029	0.054	0.021	0.123	0.097	1.270	0.013	0.014	0.032	0.137
GUY	−0.044	0.194	−0.042	−0.005	0.112	0.049	0.004	0.425	0.015	0.074	0.188	0.293
BLZ	0.076	0.085	0.087	0.180	0.035	0.054	0.077	0.010	0.013	0.078	0.106	0.206
TTO	0.267	0.111	0.034	0.130	−0.029	0.183	0.201	0.059	0.006	0.036	0.089	0.232

Appendix B: Summery Statistics of Variables (continued)

IMF's Country Code	mean of general public services growth	mean of defense expenditure growth	mean of edu expenditure growth	mean of human welfare growth	mean of economic service growth	mean of transportation and communication growth	variance of general public services growth	variance of defense expenditure growth	variance of edu expenditure growth	variance of human welfare growth	variance of economic service growth	variance of transportation and communication growth
BHR	0.155	0.152	0.075	0.075	0.021	0.112	0.453	0.127	0.018	0.112	0.056	0.179
CYP	0.046	0.071	0.080	0.106	0.074	0.083	0.015	0.050	0.003	0.005	0.037	0.050
IRN	0.036	0.068	0.091	0.109	0.099	0.068	0.067	0.145	0.039	0.059	0.121	0.124
ISR	0.019	0.032	0.093	0.162	0.180	0.074	0.059	0.066	0.040	0.124	0.555	0.134
JOR	0.012	0.032	0.097	0.103	−0.007	0.159	0.049	0.047	0.027	0.104	0.060	0.491
SYR	0.194	0.064	0.068	0.223	0.121	0.109	0.459	0.063	0.098	0.480	0.092	0.141
EGY	−0.007	−0.021	0.058	0.040	−0.035	0.120	0.051	0.015	0.011	0.015	0.039	0.049
BGD	0.147	0.170	0.060	0.096	0.090	0.299	0.049	0.088	0.027	0.125	0.068	0.709
LKA	0.059	0.244	0.063	0.068	0.137	0.104	0.100	0.349	0.020	0.029	0.428	0.138
IND	0.087	0.050	0.076	0.063	0.052	0.052	0.013	0.005	0.018	0.017	0.010	0.024
IDN	0.191	0.039	0.104	0.350	0.094	0.137	0.366	0.013	0.019	1.052	0.025	0.152
KOR	0.079	0.100	0.119	0.145	0.157	0.275	0.021	0.012	0.013	0.028	0.128	1.055
MYS	0.150	0.124	0.091	0.149	0.197	0.185	0.201	0.023	0.011	0.042	0.167	0.055
PHL	0.087	0.048	0.044	0.043	0.126	0.076	0.089	0.057	0.016	0.031	0.174	0.057
BWA	0.099	0.193	0.126	0.132	0.073	0.082	0.025	0.110	0.013	0.050	0.031	0.089
BDI	0.159	0.086	0.088	0.074	0.062	0.414	0.166	0.014	0.117	0.028	0.043	1.414
CMR	−0.006	−0.037	−0.023	−0.010	0.136	−0.032	0.106	0.024	0.027	0.075	0.886	0.287
ZAR	−0.131	−0.036	−0.118	−0.090	0.003	0.250	0.077	0.290	0.097	0.078	0.223	1.627
ETH	−0.034	0.051	0.022	0.039	0.087	−0.017	0.035	0.083	0.021	0.025	0.072	0.044
GHA	0.027	0.044	0.043	0.045	0.039	0.094	0.116	0.133	0.072	0.082	0.100	0.176
KEN	0.030	0.014	0.011	−0.014	0.025	−0.028	0.049	0.064	0.011	0.020	0.079	0.063

Appendix B: Summery Statistics of Variables (continued)

IMF's Country Code	mean of general public services growth	mean of defense expenditure growth	mean of edu expenditure growth	mean of human welfare growth	mean of economic service growth	mean of transportation and communication growth	variance of general public services growth	variance of defense expenditure growth	variance of edu expenditure growth	variance of human welfare growth	variance of economic service growth	variance of transportation and communication growth
LSO	0.023	0.042	0.142	0.211	0.105	0.209	0.033	0.049	0.105	0.125	0.110	0.435
LBR	0.009	0.105	0.013	−0.016	0.134	0.074	0.034	0.144	0.062	0.052	0.277	0.337
MDG	−0.078	−0.007	0.118	0.156	−0.034	2.634	0.057	0.028	0.102	0.140	0.112	54.962
MWI	−0.020	−0.109	0.022	−0.038	0.013	−0.050	0.049	0.041	0.017	0.025	0.046	0.057
MUS	0.044	0.165	0.091	0.092	0.091	0.265	0.028	0.228	0.024	0.036	0.088	0.411
MAR	0.069	0.080	0.063	0.037	0.104	0.035	0.135	0.026	0.010	0.012	0.136	0.075
NER	0.102	0.107	0.204	0.231	0.082	0.299	0.025	0.014	0.009	0.061	0.112	0.313
NGA	−0.093	−0.141	−0.127	0.111	0.365	0.053	0.081	0.022	0.153	0.184	0.437	0.087
ZWE	0.008	0.077	0.107	0.057	0.113	0.040	0.022	0.045	0.043	0.016	0.081	0.057
SEN	−0.090	−0.091	−0.041	0.053	0.216	0.398	0.036	0.008	0.008	0.011	0.080	0.963
SLE	0.022	−0.045	−0.056	0.018	−0.058	0.053	0.137	0.034	0.035	0.113	0.103	0.259
SOM	0.082	0.248	0.258	0.067	0.100	0.028	0.059	0.289	0.046	0.047	0.098	0.091
SDN	0.378	−0.033	0.054	0.069	0.380	0.261	1.406	0.047	0.066	0.823	1.994	0.913
SWZ	0.026	0.038	0.081	0.084	0.023	0.190	0.055	0.032	0.034	0.075	0.031	0.593
TUN	0.038	−0.043	0.033	0.057	0.007	−0.060	0.046	0.016	0.003	0.017	0.057	0.022
UGA	0.218	0.113	0.165	0.034	0.186	0.065	0.618	0.056	0.278	0.112	0.123	0.254
BFA	0.150	0.048	0.083	0.116	0.126	1.862	0.283	0.032	0.025	0.028	0.139	27.186
FJI	0.085	0.153	0.046	0.057	0.023	0.034	0.039	0.054	0.009	0.017	0.059	0.119
PNG	−0.025	0.103	0.032	0.029	0.045	0.020	0.034	0.162	0.009	0.012	0.019	0.020
HUN	−0.022	−0.001	0.077	0.052	−0.070	−0.057	0.039	0.065	0.036	0.003	0.019	0.070
total	0.189	0.053	0.063	0.080	0.101	0.171	0.235	0.115	0.041	0.076	0.246	1.108

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第 8 章

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A FISCAL FEDERALISM APPROACH TO OPTIMAL TAXATION AND INTERGOVERNMENTAL TRANSFERS IN A DYNAMIC MODEL [1]

LIUTANG GONG
Guanghua School of Management, Peking University, 100871, China
Institute for Advanced Study, Wuhan University, 430072, China
HENG-FU ZOU
Guanghua School of Management, Peking University, 100871, China
Institute for Advanced Study, Wuhan University, 430072, China
Development Research Group, World Bank, USA

ABSTRACT

In this paper, we study the optimal choices of the federal income tax, federal transfers, and local taxes in a dynamic model of capital accumulation and with explicit game structures among private agents, the local government, and the federal government. When the federal government is the leader and the local government is the follower in a Stackelberg game with both the consumption tax and property tax available to the local government, the optimal local property tax is zero, and local consumption tax is positive. But federal transfers to the local government are negative, and the federal income tax can be positive or negative. In this case, the local consumption tax is used to finance both local and federal public spending.

Key Words: income tax, property tax, consumption tax, intergovernmental transfer, capital accumulation, fiscal federalism.
JEL Classification #: E0, H2, H4, H5, H7, O4, R5

[1]Mailing address: Heng-fu Zou, The World Bank, MC2-611, 1818 H St. NW, Washington, DC 20433, USA. E-mail: Hzou@worldbank.org. Project 70271063 Supported by the National Nature Science Foundation of China

1 Introduction

This paper considers optimal choices of the federal income tax, local property tax, local consumption tax, and federal transfers to local governments in an intertemporal model of capital accumulation. There exists an enormous literature on optimal income and commodity taxation. Classical contributions include, for example, Ramsey [26], Mirrlees [20], Diamond and Mirrlees [13], Atkinson and Stiglitz [2, 3], and Samuelson [29]. Comprehensive literature reviews are provided by Atkinson and Stiglitz [4], and Myles [21]. In most of these contributions, the government has often taken to be a single identity without introducing the structure of tax assignments and expenditure assignments among multiple levels of government. But in reality, income tax is mainly collected by central governments in Europe and jointly by the federal government and state governments in the United States, property tax is mainly collected by local governments, and commodity tax is collected by both central governments and local governments in Europe or by local governments in the United States. In most developed countries, each level of government has the power to determine tax rates and tax bases. In addition, intergovernmental transfers in various forms exist among different levels of government in every country of reasonable population size. It is natural to see how the structure of fiscal federalism affects optimal taxation and intergovernmental transfers.

In an earlier contribution to optimal taxation and revenue sharing in the context of fiscal federalism, Gordon [15] has utilized a static model to consider how local governments set the rules of local taxes including tax rates and types of taxes in a decentralized form of decision-making while allowing the central government the role of correcting externalities through grants, revenue sharing, and regulations on local tax bases. Recently, Persson and Tabellini [24, 25] have considered risk sharing and redistribution across local governments in a federation using static models involving risk.

In this paper, on the basis of the contributions by Gordon [15], and Persson and Tabellini [24, 25], we analyze the optimal choices of federal taxes, federal transfer, and local taxes in a dynamic model of capital accumulation and with explicit game structures among private agents, local governments, and the federal government.[2] For ease of the treatment, we

[2]See Zou [33, 34], Brueckner [7], Devarajan, Swaroop, Zou [11], Davoodi and Zou [10], and Zhang and Zou [32] for related dynamic approaches to multi-level government spending, intergovernmental transfers, federal taxes, and local taxes in a "federation".

focus on federal income tax, local property tax, local consumption tax, and federal matching grant for local public spending. Our dynamic approach is timely because the optimal design of tax assignments, expenditure assignments, and intergovernmental transfers among different levels of government has received considerable attention in the 1990s in the context of fiscal federalism, public sector reforms, and economic growth for both developing and developed countries. One of the most important goals of establishing a sound intergovernmental fiscal relationship is supposed to promote local as well as national economic growth (see Rivlin [28], Bird [6], ; Gramlich [16], ; and Oates [23]). The paper intends to provide an analytical framework for the ongoing discussion on fiscal federalism and economic growth.

Section 2 presents the optimal choices of taxes and transfer from the dynamic Cournot-Nash game between the federal and local government while assuming the Stackelberg (leader-follower) games between the local government and the private agent and between the federal government and the private agent. Section 3 derives the optimal choices of taxes and transfer by studying the Stackelberg game between the local government and the federal government, while retaining the same Stackelberg games between the two levels of government and the private agent. Section 4 concludes.

2 The framework

There are three actors in the economy: a representative agent, a local government, and the federal government.

2.1 The agent

Like Arrow and Kurz [1], Barro [5], Turnovsky [30], and Turnovsky and Fisher [31], government expenditures are introduced into the representative agent's utility function. Unlike those studies, public expenditures are divided into the federal and local ones in the model. The agent derives a positive, but diminishing, marginal utility from the expenditures of both the federal and local governments and private consumption. Let f, s, and c be federal expenditure, local expenditure, and private consumption, respectively. If the utility function $u(c, f, s)$ is twice differentiable, the assumption is equivalent to:

$$u_c > 0, u_f > 0, u_s > 0, u_{cc} < 0, u_{ff} < 0, u_{ss} < 0. \tag{1}$$

For the cross effects u_{cf}, u_{cs}, and u_{fs}, they are assumed to be positive in general. In addition, $u(c, f, s)$ satisfies the Inada condition:

$$\begin{aligned} \lim_{s\to 0} u_s &= \infty, \ \lim_{f\to 0} u_f = \infty, \ \lim_{c\to 0} u_c = \infty \\ \lim_{s\to \infty} u_s &= 0, \ \lim_{f\to \infty} u_f = 0, \ \lim_{c\to \infty} u_c = 0 \end{aligned} \tag{2}$$

The representative agent's discounted utility is given by

$$U = \int_0^\infty u(c, f, s)e^{-\rho t}dt, \tag{3}$$

where ρ is the positive, constant time preference.

Again following Arrow and Kurz [1], Barro [5], and Turnovsky [30], output y is produced by a constant-return-to-scale production function with three inputs: private capital stock, k, federal government expenditure, f, and local government expenditure, s, namely

$$y = y(k, f, s), \tag{4}$$

where all variables are in per capita terms. For simplicity, the size of population or the labor force is assumed to be constant.

The marginal productivity of private capital stock, federal government expenditure, and local government expenditure are positive and decreasing:

$$y_k > 0, y_f > 0, y_s > 0, y_{cc} < 0, y_{ff} < 0, y_{ss} < 0. \tag{5}$$

Federal government expenditure, f, is financed by the income tax on the agent. Local government expenditure, s, is the sum of the consumption tax[3], $\tau_c c$, the capital or property tax, $\tau_k k$, and federal government's transfer, gs. τ_f, τ_c, and τ_k are the federal income tax rate, local consumption tax rate, and local capital or property tax rate, respectively, and g is the rate of federal matching grant for local spending. Hence, the budget constraints for the federal government and local government can be written as follows

[3]The consumption tax has been analyzed recently in growth models with one level of government by King and Rebelo [18], Rebelo [27], and Jones, Manuelli, and Rossi [17], and Turnovsky [30].

$$f = \tau_f y - gs \tag{6}$$

$$s = gs + \tau_k k + \tau_c c \tag{7}$$

respectively, and the budget constraint for the representative agent can be written as

$$\frac{dk}{dt} = (1 - \tau_y)y(k, f, s) - \delta k - \tau_k k - (1 + \tau_c)c \tag{8}$$

where δ is the rate of capital depreciation.

The representative agent is assumed to have an infinite planning horizon, to face a perfect capital market, and to have perfect foresight. Given these assumptions, he chooses his consumption path and capital-accumulation path to maximize his discounted utility

$$\max U = \int_0^\infty (u(c) + v(f) + w(s))e^{-\rho t}dt \tag{9}$$

subject to (8). His initial capital stock is given by $k(0) = k_0$. For simplicity, we have taken the utility function to be separable in c, f, and s in (9).

The Hamiltonian associated with the optimization problem is defined as

$$H = u(c) + v(f) + w(s) + \lambda((1 - \tau_y)y(k, f, s) - \delta k - \tau_k k - (1 + \tau_c)c) \tag{10}$$

where λ is the costate variable, and it represents the marginal utility of wealth.

The first-order conditions for individual optimization are

$$\frac{dk}{dt} = (1 - \tau_f)y(k, f, s) - (1 + \tau_c)c - (\delta + \tau_k)k \tag{11}$$

$$\frac{d\lambda}{dt} = -\lambda[(1 - \tau_f)\frac{\partial y}{\partial k} - \rho - \delta - \tau_k] \tag{12}$$

$$u_c = (1 + \tau_c)\lambda. \tag{13}$$

And from the last condition (13), we have

$$c = c(\lambda, \tau_c). \tag{14}$$

2.2 Local government

The local government and the private agent play the Stackelberg game with the local government as the leader and private agent the follower[4]. At the same time, in this section, we also assume that the local and the federal government react to each other along Cournot-Nash lines. That is to say, given the federal income tax rate, federal matching grant, and federal spending, the local government maximizes the agent's welfare by fully incorporating the agent's first-order conditions in section 2.1 into its own maximization. Specifically, the local government will choose optimal taxes τ_c and τ_k, public expenditure, s, private capital stock, $k(t)$, and the marginal utility of private wealth, $\lambda(t)$, to maximize the agent's welfare

$$\max_{\lambda,k,\tau_c,\tau_k,s} \int_0^\infty [u(c(\lambda,\tau_c)) + v(f) + w(s)]e^{-\rho t}dt \tag{15}$$

subject to its own budget constraint

$$s - gs = \tau_c c + \tau_k k \tag{16}$$

and the first-order conditions for private agent's optimization

$$\frac{dk}{dt} = (1-\tau_f)y(k,f,s) - (1+\tau_c)c(\lambda,\tau_c) - (\delta+\tau_k)k \tag{17}$$

$$\frac{d\lambda}{dt} = -\lambda[(1-\tau_f)\frac{\partial y}{\partial k} - \rho - \delta - \tau_k] \tag{18}$$

where we have already used the optimal consumption for the private agent in the objective function: $c = c(\lambda,\tau_c)$.

Define the Hamiltonian for local government's optimization problem as

$$\begin{aligned} H = \; & u(c(\lambda,\tau_c)) + v(f) + w(s) + \beta\{-\lambda[(1-\tau_f)\frac{\partial y}{\partial k} - \rho - \delta - \tau_k]\} \\ & +\alpha[(1-\tau_f)y(k,f,s) - (1+\tau_c)c(\lambda,\tau_c) - (\delta+\tau_k)k] \\ & +\xi[\tau_c c(\lambda,\tau_c) + \tau_k k + gs - s] + \mu\tau_k + \upsilon\tau_c \end{aligned}$$

[4]A similar technique is used by Chamley [8, 9], Lucas [19], Devarajan *et al* [11] in the treatment of optimal taxation of capital income with one level of government and a representative agent.

where α is the "local" costate variable associated with the agent's dynamic budget constraint; β is the "local" costate variable associated with the agent's Euler equation of optimal consumption; ξ is the multiplier for local government's budget constraint; μ is the multiplier for the inequality constraint that $0 \square \tau_k < 1$, v is the multiplier for the nonnegative consumption tax constraint $\tau_c \geqslant 0$.

The first-order conditions for local government's optimization are

$$\frac{\partial H}{\partial s} = w' + \alpha(1-\tau_f)\frac{\partial y}{\partial s} - \beta\lambda(1-\tau_f)\frac{\partial^2 y}{\partial k \partial s} + \xi(g-1) = 0 \tag{19}$$

$$\frac{\partial H}{\partial \tau_c} = u' c_{\tau_c} - \alpha c - \alpha(1+\tau_c)c_{\tau_c} + \xi c + \xi \tau_c c_{\tau_c} + v = 0 \tag{20}$$

$$v\tau_c = 0, v \geqslant 0 \tag{21}$$

$$\frac{\partial H}{\partial \tau_k} = -\alpha k + \beta\lambda + \xi k + \mu = 0 \tag{22}$$

$$\mu\tau_k = 0, \mu \geqslant 0 \tag{23}$$

$$\begin{aligned} \frac{d\alpha}{dt} &= \rho\alpha - \frac{\partial H}{\partial k} \\ &= \rho\alpha - \alpha[(1-\tau_f)\frac{\partial y}{\partial k} - \delta - \tau_k] + \beta\lambda(1-\tau_f)\frac{\partial^2 y}{\partial k^2} - \xi\tau_k \end{aligned} \tag{24}$$

$$\begin{aligned} \frac{d\beta}{dt} &= \rho\beta \cdot\cdot \frac{\partial H}{\partial \lambda} \\ &= \rho\beta - u' c_\lambda + \alpha(1+\tau_c)c_\lambda + \beta[(1-\tau_f)\frac{\partial y}{\partial k} - \rho - \delta - \tau_k] - \xi\tau_c c_\lambda. \end{aligned} \tag{25}$$

2.3 The federal government

We assume that the federal government and the agent play the Stackelberg game with the federal government as the leader and the agent the follower, whereas the federal government and the local government play the Cournot-Nash game. Therefore, taking as given local government's choices of τ_c, τ_k, and s, the federal government incorporates the private agent's first-order conditions for his optimization into the federal optimization program by choosing

federal income tax, τ_f, federal public spending, f, the rate of federal transfer to the local government, g, private capital stock, k, and the marginal utility of private wealth, λ, to maximize the agent's welfare, namely,

$$\max \int_0^{\infty} [u(c(\lambda, \tau_c)) + v(f) + w(s)]e^{-\rho t}dt \tag{26}$$

subject to the agent's optimization conditions:

$$\frac{dk}{dt} = (1-\tau_f)y(k,f,s) - (1+\tau_c)c(\lambda,\tau_c) - (\delta+\tau_k)k \tag{27}$$

$$\frac{d\lambda}{dt} = -\lambda[(1-\tau_f)\frac{\partial y(k,f,s)}{\partial k} - \rho - \delta - \tau_k(k,\lambda,\alpha,\beta)] \tag{28}$$

and the federal budget constraint

$$f + gs = \tau_f y \tag{29}$$

with the initial private capital stock $k(0)$ given.

Define the Hamiltonian function for the federal government as

$$\begin{aligned} H_f &= u(c(\lambda,\tau_c)) + v(f) + w(s) + \theta_2\{-\lambda[(1-\tau_f)\frac{\partial y(k,f,s)}{\partial k} - \rho - \delta - \tau_k]\} \\ &\quad +\theta_1[(1-\tau_f)y(k,f,s) - (1+\tau_c)c(\lambda,\tau_c) - (\delta+\tau_k)k] \\ &\quad +\eta[\tau_f y - f - gs] + \omega g \end{aligned}$$

where θ_1 is the "federal" costate variable associated with the agent's dynamic budget constraint; θ_2 is the "federal" costate variable associated with the agent's Euler equation of optimal consumption; η is the multiplier for the federal budget constraint; and ω is the multiplier for the requirement of a non-negative rate of federal transfer, i.e., $g \geqslant 0$.

The first-order conditions for the federal government's optimization are

$$\frac{\partial H_f}{\partial f} = v' + [\eta\tau_f + \theta_1(1-\tau_f)]\frac{\partial y}{\partial f} - \theta_2\lambda(1-\tau_f)\frac{\partial^2 y}{\partial k \partial f} - \eta = 0 \tag{30}$$

$$\frac{\partial H_f}{\partial \tau_f} = -\theta_1 y + \theta_2\lambda\frac{\partial y}{\partial k} + \eta y = 0 \tag{31}$$

$$\begin{aligned} \frac{d\theta_1}{dt} &= \rho\theta_1 - \frac{\partial H_f}{\partial k} \qquad (32) \\ &= \rho\theta_1 - \theta_1[(1-\tau_f)\frac{\partial y}{\partial k} - \delta - \tau_k] + \theta_2\lambda[(1-\tau_f)\frac{\partial^2 y}{\partial k^2} - \eta\tau_f\frac{\partial y}{\partial k} \end{aligned}$$

$$\frac{d\theta_2}{dt} = \rho\theta_2 - \frac{\partial H_f}{\partial \lambda} \tag{33}$$

$$= \rho\theta_2 - u' c_\lambda + \theta_1(1+\tau_c)c_\lambda + \theta_2[(1-\tau_f)\frac{\partial y}{\partial k} - \rho - \delta - \tau_k]$$

$$-\eta s + \omega = 0, \omega g = 0, \omega \geqslant 0. \tag{34}$$

2.4 Some results from the Cournot-Nash equilibrium for the federal and local governments

The full dynamic system is extremely complicated. But some results regarding the optimal choices of taxes and federal transfer along the Cournot-Nash lines can be derived from the steady-state or long-run analysis of the full dynamic system. In the steady state,

$$\frac{dk}{dt} = \frac{d\lambda}{dt} = \frac{dc}{dt} = \frac{df}{dt} = \frac{ds}{dt} = \frac{d\tau_f}{dt} = \frac{d\tau_c}{dt} = \frac{d\tau_k}{dt} = \frac{dg}{dt} = 0 \tag{35}$$

and so are various costate variables and multipliers:

$$\frac{d\alpha}{dt} = \frac{d\beta}{dt} = \frac{d\xi}{dt} = \frac{d\mu}{dt} = \frac{d\theta_1}{dt} = \frac{d\theta_2}{dt} = \frac{d\eta}{dt} = \frac{d\omega}{dt} = 0. \tag{36}$$

Therefore,

$$(1-\tau_f)y(k,f,s) - (1+\tau_c)c(\lambda,\tau_c) - (\delta+\tau_k)k = 0 \tag{37}$$

$$-\lambda[(1-\tau_f)\frac{\partial y}{\partial k} - \rho - \delta - \tau_k] = 0 \tag{38}$$

$$u_c = (1+\tau_c)\lambda \tag{39}$$

$$s - gs = \tau_c c + \tau_k k \tag{40}$$

$$w' + \alpha(1-\tau_f)\frac{\partial y}{\partial s} - \beta\lambda(1-\tau_f)\frac{\partial^2 y}{\partial k \partial s} + \xi(g-1) = 0 \tag{41}$$

$$u' c_{\tau_c} - \alpha c - \alpha(1+\tau_c)c_{\tau_c} + \xi c + \xi\tau_c c_{\tau_c} + \upsilon = 0 \tag{42}$$

$$\upsilon\tau_c = 0, \upsilon \geqslant 0. \tag{43}$$

$$-\alpha k + \beta\lambda + \xi k + \mu = 0 \tag{44}$$

$$\mu\tau_k = 0, \ \mu \geqslant 0 \tag{45}$$

$$\beta\lambda(1-\tau_f)\frac{\partial^2 y}{\partial k^2}-\xi\tau_k=0 \tag{46}$$

$$\rho\beta-u^{'}c_\lambda+\alpha(1+\tau_c)c_\lambda-\xi\tau_c c_\lambda=0 \tag{47}$$

$$f+gs=\tau_f y \tag{48}$$

$$v^{'}+[\eta\tau_f+\theta_1(1-\tau_f)]\frac{\partial y}{\partial f}-\theta_2\lambda(1-\tau_f)\frac{\partial^2 y}{\partial k\partial f}-\eta=0 \tag{49}$$

$$-\theta_1 y+\theta_2\lambda\frac{\partial y}{\partial k}+\eta y=0 \tag{50}$$

$$\theta_2\lambda(1-\tau_f)\frac{\partial^2 y}{\partial k^2}-\eta\tau_f\frac{\partial y}{\partial k}=0 \tag{51}$$

$$\rho\theta_2-u^{'}c_\lambda+\theta_1(1+\tau_c)c_\lambda=0 \tag{52}$$

$$-\eta s+\omega=0,\omega g=0,\omega\geqslant 0. \tag{53}$$

Proposition 1 *The steady-state optimal property tax rate is zero, but the steady-state consumption tax is positive.*

Proof: First from equation (46), we have

$$\beta\lambda(1-\tau_f)\frac{\partial^2 y}{\partial k^2}=\xi\tau_k\geqslant 0. \tag{54}$$

Hence, $\beta\leqslant 0$.

Suppose the optimal property tax rate is strictly positive: $\tau_k>0$. From equations (44) and (47), we have

$$(\xi-\alpha)k+\beta\lambda=0, \tag{55}$$

$$u^{'}-\alpha(1+\tau_c)+\xi\tau_c=\frac{\rho\beta}{c_\lambda}. \tag{56}$$

Substituting equations (55) and (56) into equation (42), we obtain

$$\frac{\rho\beta}{c_\lambda}c_{\tau_c}-\beta\lambda\frac{c}{k}+v=0. \tag{57}$$

From equation (39), we have

$$c_\lambda = \frac{1+\tau_c}{u_{cc}},\ c_{\tau_c} = \frac{\lambda}{u_{cc}}. \tag{58}$$

Substituting equation (58) into equation (57), we get

$$\frac{\beta\lambda}{1+\tau_c}(\rho - \frac{(1+\tau_c)c}{k}) + v = 0. \tag{59}$$

Substituting equations (37) and (38) into equation (59), we have

$$\frac{\beta\lambda}{1+\tau_c}(1-\tau_f)(\frac{\partial y}{\partial k} - \frac{y}{k}) + v = 0. \tag{60}$$

Because of the assumption on the production function, we have

$$\frac{\partial y}{\partial k}k < y. \tag{61}$$

If $\tau_c \geqslant 0$, we have $v \geqslant 0$. Now, equation (60) implies

$$\beta = 0. \tag{62}$$

Hence, from equations (44) and (46), we have

$$\xi = \alpha = 0. \tag{63}$$

Then, from equation (41), we obtain

$$w'(s) = 0, \tag{64}$$

which is impossible because $w'(s)$ is strictly positive by our assumptions. Therefore, we must have $\tau_k = 0$.

Q.E.D.

This result is rather intuitive. For the local government, consumption tax has no distortionary effect on private production and private capital accumulation, whereas local property tax directly reduces private capital accumulation. It is always welfare maximizing for the local government to finance local public spending through the less distortionary consumption tax instead of capital or property tax.

Proposition 2 *The steady-state federal transfer is zero:* $g = 0$.

Proof: Suppose that g is not equal to zero. Then, from equation (53), we have

$$\omega = 0, \eta = 0. \tag{65}$$

That is to say, from equation (51),

$$\theta_2 = 0. \tag{66}$$

Then, from equation (50),

$$\theta_1 = 0. \tag{67}$$

Now from equation (49) we must have

$$v'(f) = 0. \tag{68}$$

This contradicts our assumption that $v'(f) > 0$. Therefore, we must have

$$g = 0. \tag{69}$$

Q.E.D.

This is also intuitively convincing. The federal government and the local government decide their optimal choices along the Cournot-Nash lines without taking into consideration the interactions of their choices. In this case it is always in the federal government's interest to provide zero subsidy to the local government. In the next section this picture will dramatically change when the two governments play a Stackelberg game with the federal government as the leader and the local government as the follower.

Before we conclude this section, please note the following three points. First, the steady-state consumption tax and property tax cannot be zero at the same time. This is true because, from proposition 2, we know that the steady-state government matching grant is zero. From equation (40), if $\tau_k = \tau_c = 0$, we have $s = 0$, which cannot be optimal in view of the Inada conditions (2) on the utility function. Second, if the local consumption tax is set to zero, i.e., $\tau_c = 0$, then local spending must be financed by a positive capital or property tax. Still, the Cournot-Nash game between the federal and local governments will result in a zero federal transfer to locality: $g = 0$. The proof is similar to the one in proposition 2. Finally, along the Cournot-Nash lines, the optimal federal income tax must be positive because of the Inada condition for federal spending.

3 The Stackelberg game between the federal government and local government

In section 2, we find that if the federal and local governments play the Cournot-Nash game in choosing their individually optimal taxes and transfer, respectively, then federal transfer to the local government is zero. Here we suppose that the federal and the local governments play a Stackelberg game while retaining the same game structures of the private agent versus the two levels of government. In the new setting, it is natural to let the federal government be the leader, and the local government be the follower. In order to by-pass the complexity of the general solutions of these complicated, multi-stage Stackelberg games, and provide some explicit solutions to the optimal choices of taxes and federal transfer, we use specific utility function and production technology.

3.1 The agent

The production function of the agent is assumed to take the following form

$$y = k^{\alpha} f^{\beta} s^{\gamma}, \tag{70}$$

where $\alpha > 0$, $\beta > 0$, $\gamma > 0$ and $\alpha + \beta + \gamma < 1$. In equation (70), the output and inputs are all measured in terms of the representative agent's labor input. This is why $\alpha + \beta + \gamma < 1$. For simplicity, the agent's labor input is assumed to be constant.

His utility function is logarithmic:

$$u(c, f, s) = \ln c + \vartheta_1 \ln f + \vartheta_2 \ln s \tag{71}$$

where ϑ_1 and ϑ_2 are constant and positive.

With these choices of preferences and technology, it is simple to show that steady-state capital, output, and consumption are the functions of federal income tax, federal spending, local property tax, local consumption tax, local spending, and various technology and preference parameters:

$$\begin{aligned} k &= \left(\frac{\rho + \delta + \tau_k}{\alpha(1 - \tau_f)}\right)^{\frac{1}{\alpha - 1}} f^{\frac{\beta}{1-\alpha}} s^{\frac{\gamma}{1-\alpha}} \\ y &= \left(\frac{\rho + \delta + \tau_k}{\alpha(1 - \tau_f)}\right)^{\frac{\alpha}{\alpha - 1}} f^{\frac{\beta}{1-\alpha}} s^{\frac{\gamma}{1-\alpha}} \end{aligned} \tag{72}$$

$$c = \frac{\rho+(1-\alpha)(\delta+\tau_k)}{\alpha(1+\tau_c)}\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{1}{\alpha-1}} f^{\frac{\theta}{1-\alpha}} s^{\frac{\gamma}{1-\alpha}}.$$

3.2 The local government

The local government maximizes the steady-state agent's welfare

$$\max_{\tau_c,\tau_k,s,} \ln c + \vartheta_1 \ln f + \vartheta_2 \ln s \tag{73}$$

subject to the individual's optimal choices of consumption and capital stock given in equation (72), and its own budget constraint:

$$s - gs = \tau_c c + \tau_k k. \tag{74}$$

Substituting equation (72) into equation (16) yields

$$\begin{aligned} s &= \frac{\tau_c}{1-g}\frac{\rho+(1-\alpha)(\delta+\tau_k)}{\alpha(1+\tau_c)}\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{1}{\alpha-1}} f^{\frac{\theta}{1-\alpha}} s^{\frac{\gamma}{1-\alpha}} \\ &\quad + \frac{\tau_k}{1-g}\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{1}{\alpha-1}} f^{\frac{\theta}{1-\alpha}} s^{\frac{\gamma}{1-\alpha}} \\ &= \frac{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}{\alpha(1+\tau_c)}\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{1}{\alpha-1}} f^{\frac{\theta}{1-\alpha}} s^{\frac{\gamma}{1-\alpha}} \frac{1}{1-g}. \end{aligned}$$

Therefore, we have

$$s = \left(\frac{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}{\alpha(1+\tau_c)}\right)^{\frac{1-\alpha}{1-\alpha-\gamma}} \left(\frac{1}{1-g}\right)^{\frac{1-\alpha}{1-\alpha-\gamma}} \left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{-1}{1-\alpha-\gamma}} f^{\frac{\theta}{1-\alpha-\gamma}} \tag{75}$$

Now, the local government's objective function upon substitution becomes:

$$\begin{aligned} \ln c + \vartheta_2 \ln s &= \ln(\rho+(1-\alpha)(\delta+\tau_k)) - \ln(1+\tau_c) + \frac{1}{\alpha-1}\ln(\rho+\delta+\tau_k) \\ &\quad + \left(\frac{\gamma}{1-\alpha}+\vartheta_2\right)\ln s + \text{constant} \\ &= \ln(\rho+(1-\alpha)(\delta+\tau_k)) - \ln(1+\tau_c) + \frac{1}{\alpha-1}\ln(\rho+\delta+\tau_k) \\ &\quad + \left(\frac{\gamma}{1-\alpha}+\vartheta_2\right)\frac{1-\alpha}{1-\alpha-\gamma}[\ln(\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k)\text{-}\ln(1+\tau_c)] \\ &\quad - \left(\frac{\gamma}{1-\alpha}+\vartheta_2\right)\frac{1}{1-\alpha-\gamma}\ln(\rho+\delta+\tau_k) + \text{constant} \end{aligned}$$

(76)

Hence, the local government's optimization problem is equivalent to maximizing equation (76) by determining τ_c and τ_k.The first-order conditions for the optimal choices of taxes of the local government are:

$$\frac{1-\alpha}{\rho+(1-\alpha)(\delta+\tau_k)}+\frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma}\frac{\tau_c+\alpha}{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}$$
$$-\frac{\vartheta_2(1-\alpha)+\gamma}{(1-\alpha)(1-\alpha-\gamma)}\frac{1}{\rho+\delta+\tau_k}+\frac{1}{\alpha-1}\frac{1}{\rho+\delta+\tau_k}=0,$$

(77)

$$-\frac{1}{1+\tau_c}+\frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma}[\frac{\rho+(1-\alpha)\delta+\tau_k}{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}-\frac{1}{1+\tau_c}]=0. \quad (78)$$

To simplify the calculations, the rate of capital depreciation is set to zero: $\delta=0$.

Now we have the following results

Proposition 3 *If it is required that $\tau_k \geqslant 0$, the optimal property tax and consumption tax are*

$$\tau_k=0 \quad (79)$$

$$\tau_c=\frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma}. \quad (80)$$

Therefore, the constrained optimal property tax is always zero as shown in proposition 1. With the specific example in this section, we can obtain explicit solutions to optimal local tax rates

Proposition 4 *If τ_k can take any value, we have*

$$\tau_k = -\rho\frac{\vartheta_2}{1-\alpha-\gamma}-\rho\frac{\gamma}{(1-\alpha)(1-\alpha-\gamma)}, \quad (81)$$
$$\tau_c = \frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma}+\frac{\rho(\vartheta_2(1-\alpha)+\gamma)}{(1-\alpha)(1-\alpha-\gamma)-\vartheta_2(1-\alpha)-\gamma}.$$

In this case, the optimal τ_k for the local government is in fact negative, whereas τ_c is strictly positive. This result conforms to our intuition. The local government taxes consumption to subsidize capital investment. This tax subsidy scheme leads to more welfare for the agent in the long run.

3.3 The federal government

Unlike the Cournot-Nash game between the federal and local governments, in the Stackelberg game the federal government takes into consideration the optimal choices of both the agent and the local government when it maximizes the agent's steady-state welfare

$$\max \ln c + \vartheta_1 \ln f + \vartheta_2 \ln s \tag{82}$$

by choosing τ_f, g, τ_c, τ_k, f, and s. The federal budget constraint is still

$$f + gs = \tau_f y. \tag{83}$$

Substituting equations (72) and (75) into equation (83), we have

$$\begin{aligned}
f &= \tau_f\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{\alpha}{\alpha-1}}\left(\frac{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}{\alpha(1+\tau_c)}\right)^{\frac{\gamma}{1-\alpha-\gamma}} \\
&\quad \times\left(\frac{1}{1-g}\right)^{\frac{\gamma}{1-\alpha-\gamma}}\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{-1}{1-\alpha-\gamma}\frac{\gamma}{1-\alpha}} f^{\frac{\beta}{1-\alpha-\gamma}} \\
&\quad -g\left(\frac{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}{\alpha(1+\tau_c)}\right)^{\frac{1-\alpha}{1-\alpha-\gamma}}\left(\frac{1}{1-g}\right)^{\frac{1-\alpha}{1-\alpha-\gamma}}\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{-1}{1-\alpha-\gamma}} f^{\frac{\beta}{1-\alpha-\gamma}} \\
&= f^{\frac{\beta}{1-\alpha-\gamma}}\left\{\tau_f\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{\alpha}{\alpha-1}}\left(\frac{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}{\alpha(1+\tau_c)}\right)^{\frac{\gamma}{1-\alpha-\gamma}}\right. \\
&\quad \times\left(\frac{1}{1-g}\right)^{\frac{\gamma}{1-\alpha-\gamma}}\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{-1}{1-\alpha-\gamma}\frac{\gamma}{1-\alpha}} \\
&\quad \left.-g\left(\frac{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}{\alpha(1+\tau_c)}\right)^{\frac{1-\alpha}{1-\alpha-\gamma}}\left(\frac{1}{1-g}\right)^{\frac{1-\alpha}{1-\alpha-\gamma}}\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{-1}{1-\alpha-\gamma}}\right\}.
\end{aligned}$$

Therefore, we have

$$f = \left\{\tau_f\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}A^{\gamma} - \frac{g}{1-g}A^{1-\alpha}\right\}^{\frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}}\left(\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}\right)^{\frac{-1}{1-\alpha-\beta-\gamma}}\left(\frac{1}{1-g}\right)^{\frac{\gamma}{1-\alpha-\beta-\gamma}}, \tag{84}$$

where $A = \left(\frac{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}{\alpha(1+\tau_c)}\right)^{\frac{1}{1-\alpha-\gamma}}$.

Substituting equations (72), (75), and (84) into the federal government's objective function yields

$$
\begin{aligned}
& \ln c + \vartheta_1 \ln f + \vartheta_2 \ln s \\
= \; & \frac{1}{1-\alpha}\ln(1-\tau_f) + (\frac{\gamma}{1-\alpha}+\vartheta_2)[-\frac{1-\alpha}{1-\alpha-\gamma}\ln(1-g) + \frac{1}{1-\alpha-\gamma}\ln(1-\tau_f)] \\
& +[(\frac{\gamma}{1-\alpha}+\vartheta_2)\frac{\beta}{1-\alpha-\gamma} + \frac{\beta}{1-\alpha} + \vartheta_1]\ln f + \text{constant} \\
= \; & \frac{1}{1-\alpha}\ln(1-\tau_f) + (\frac{\gamma}{1-\alpha}+\vartheta_2)[-\frac{1-\alpha}{1-\alpha-\gamma}\ln(1-g) + \frac{1}{1-\alpha-\gamma}\ln(1-\tau_f)] \\
& +[(\frac{\gamma}{1-\alpha}+\vartheta_2)\frac{\beta}{1-\alpha-\gamma} + \frac{\beta}{1-\alpha} + \vartheta_1]\{ \\
& \frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}\ln[\tau_f\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}A^\gamma - \frac{g}{1-g}A^{1-\alpha}] \\
& +\frac{1}{1-\alpha-\beta-\gamma}\ln(1-\tau_f) - \frac{\gamma}{1-\alpha-\beta-\gamma}\ln(1-g)\} + \text{constant}.
\end{aligned}
\tag{85}
$$

Given substitutions above, τ_c, τ_k, f, and s are all functions of τ_f and g. Now the federal government's optimization is equivalent to maximize the agent's welfare in equation (85) by choosing τ_f and g. The first-order conditions for maximization are

$$
\begin{aligned}
& \frac{(1+\vartheta_2)}{1-\alpha-\gamma} + [(\frac{\gamma}{1-\alpha}+\vartheta_2)\frac{\beta}{1-\alpha-\gamma} + \frac{\beta}{1-\alpha} + \vartheta_1] \\
& \{\frac{1}{1-\alpha-\beta-\gamma} + \frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}\frac{-\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}A^\gamma(1-g)}{\tau_f\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}(1-g)A^\gamma - gA^{1-\alpha}}\} \\
= \; & 0,
\end{aligned}
\tag{86}
$$

$$
\begin{aligned}
& \frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma} + [(\frac{\gamma}{1-\alpha}+\vartheta_2)\frac{\beta}{1-\alpha-\gamma} + \frac{\beta}{1-\alpha} + \vartheta_1] \\
& \{\frac{\gamma}{1-\alpha-\beta-\gamma} + \frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}\frac{-A^{1-\alpha}}{\tau_f\frac{\rho+\delta+\tau_k}{\alpha(1-\tau_f)}(1-g)A^\gamma - gA^{1-\alpha}}\} \\
= \; & 0.
\end{aligned}
\tag{87}
$$

From these two first-order conditions, we have

Proposition 5 *The optimal federal income tax and federal transfer to the local government are*

$$\tau_f = 1 - \frac{\frac{C\alpha}{1-\alpha-\beta-\gamma} + \frac{1+\alpha\vartheta_2-\gamma}{1-\alpha-\gamma}}{\frac{1+\vartheta_2}{1-\alpha-\gamma} + \frac{C}{1-\alpha-\beta-\gamma}} \frac{1}{1-\frac{\alpha}{\rho}A^{1-\alpha-\gamma}} \tag{88}$$

$$g = 1 - \frac{\frac{C\alpha}{1-\alpha-\beta-\gamma} + \frac{1+\alpha\vartheta_2-\gamma}{1-\alpha-\gamma}}{\frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma} + \frac{C\gamma}{1-\alpha-\beta-\gamma}} \frac{\frac{\alpha}{\rho}A^{1-\alpha-\gamma}}{1-\frac{\alpha}{\rho}A^{1-\alpha-\gamma}}$$

where

$$C = (\frac{\gamma}{1-\alpha}+\vartheta_2)\frac{\beta}{1-\alpha-\gamma} + \frac{\beta}{1-\alpha} + \vartheta_1 \tag{89}$$

$$A = (\frac{\tau_c(\rho+(1-\alpha)\delta)+(\tau_c+\alpha)\tau_k}{\alpha(1+\tau_c)})^{\frac{1}{1-\alpha-\gamma}}.$$

It is interesting that when the consumption tax is available to the local government, and when the federal government acts as the leader in the Stackelberg game with the local government, federal transfer to the local government can be negative. At the same time, it is unclear whether federal income tax must be positive. The reason is now obvious enough: with a less distortionary consumption tax at the local level, and given the Stackelberg game between the federal and local governments, the federal government can impose a negative transfer to locality and at the same time ask the local government to levy a high rate of consumption tax. Hence, the local consumption tax can be used to finance both federal and local spending, and subsidize private investment.

To see how the signs of federal income tax and federal transfer are determined, we make some numerical calculations based on propositions 3 and 5. In this case, $\tau_k = 0$ and $\tau_c = \frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma}$. We let the marginal utility of local public spending, ϑ_2, take different values. Other parameters are fixed as follows: $\alpha = 0.3$, $\beta = 0.2$, $\gamma = 0.1$, $\vartheta_1 = 0.1$, and $\rho = 0.05$. From Table 1, as ϑ_2 rises from 0.05 to 0.30, (i.e., the marginal utility of local public spending rises), τ_c increases from 18.5% to 92.5%. Without the constraint

that $g \geqslant 0$, g is negative all the time, and the "reverse" transfer rate from locality to the federal government rises from 18.8% to 191.7%. At the same time, the federal income tax, τ_f, decreases and eventually becomes negative. Thus the local consumption tax finances local public spending, federal public spending through a negative federal transfer, and federal subsidies to private production through a negative income tax.

Table 1: Optimal Tax Rates and Federal Transfer

ϑ_2	0.05	0.10	0.15	0.20	0.25	0.30
τ_c	0.184615	0.283333	0.40	0.54	0.711111	0.925
τ_f	0.232575	0.187222	0.132	0.0641538	-0.0203292	-0.1275
g	-0.0188034	-0.345833	-0.675676	-1.03143	-1.43593	-1.91731

If we impose the condition that federal transfer to the local government must be positive in the federal government's optimization problem, it is easy to show the next proposition.

Proposition 6 *If $g \geqslant 0$, the optimal federal income tax is*

$$\begin{aligned} \tau_f &= \frac{\frac{C(1-\alpha-\gamma)}{1-\alpha-\beta-\gamma}}{\frac{1+\vartheta_2}{1-\alpha-\gamma}+\frac{C}{1-\alpha-\beta-\gamma}} \\ g &= 0. \end{aligned}$$

In this case, since it is not feasible for the federal government to collect any revenues from the local government, federal income tax is strictly positive with the Inada conditions on the utility function. As an illustration, we still choose $\tau_k = 0$ and $\tau_c = \frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma}$ from local government's optimal choices of tax rates in proposition 3. We also let ϑ_2 vary and let other parameters be fixed at $\alpha = 0.3, \beta = 0.2, \gamma = 0.1, \vartheta_1 = 0.1$, and $\rho = 0.05$. The optimal federal transfer is always zero, and the optimal federal income tax and optimal local consumption tax are calculated in Table 2.

Table 2: Optimal Tax Rates

ϑ_2	0.05	0.10	0.15	0.20	0.25	0.30
τ_c	0.184615	0.283333	0.40	0.54	0.711111	0.925
τ_f	0.248529	0.233333	0.218766	0.204918	0.191972	0.180282

In Table 2, as ϑ_2 rises from 0.05 to 0.30, the marginal utility of local public services rises sharply, and so does the local consumption tax, which increases from 18.5% to 92.5%. At the same time, as $\vartheta_1 = 0.1$, the marginal utility of federal public spending falls relative to local public spending. Therefore, it is less socially desirable to finance as much of federal public spending as before. Hence, federal income tax falls from 24.9% to 18%.

3.4 The case of zero consumption tax

In our optimal-tax framework with a multiple levels of government the optimal property tax is always zero or negative given the availability of consumption tax for the local government. In reality, of course, local governments in most developed countries rely on property tax to finance their local public services. While we do not want to argue whether the reality deviates from the theoretical optimality, we can allow some role of a positive, optimal property tax if we set local consumption tax to zero. Then, letting $\tau_c = 0$ in equation (77), we have

$$\begin{aligned} & \frac{1-\alpha}{\rho+(1-\alpha)(\delta+\tau_k)} + \frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma}\frac{1}{\tau_k} \\ & - \frac{\vartheta_2(1-\alpha)+\gamma}{(1-\alpha)(1-\alpha-\gamma)}\frac{1}{\rho+\delta+\tau_k} + \frac{1}{\alpha-1}\frac{1}{\rho+\delta+\tau_k} \\ = \; & 0. \end{aligned} \tag{90}$$

Now from equation (90) we have the optimal local property tax τ_k. From equations (86) and (87), we have the optimal federal income tax and federal transfer, τ_f and g, respectively.

Proposition 7 *The optimal property tax, optimal federal income tax, and optimal federal transfer are*

$$\begin{aligned} \tau_k = & \frac{\sqrt{[4\alpha(\gamma+(1-\alpha)\vartheta_2](1-\alpha)(1+\vartheta_2)\rho^2+[\alpha^2(1+\vartheta_2)+\gamma+\vartheta_2-(3\vartheta_2+2)\alpha]^2\rho^2}}{2\alpha(1-\alpha)(1+\vartheta_2)} \\ & + \frac{[\alpha^2(1+\vartheta_2)+\gamma+\vartheta_2-(3\vartheta_2+2)\alpha]\rho}{2\alpha(1-\alpha)(1+\vartheta_2)} \end{aligned} \tag{91}$$

$$\tau_f = 1 - \frac{\frac{C\alpha}{1-\alpha-\beta-\gamma} + \frac{1+\alpha\vartheta_2-\gamma}{1-\alpha-\gamma}}{\frac{1+\vartheta_2}{1-\alpha-\gamma} + \frac{C}{1-\alpha-\beta-\gamma}} \frac{1}{1-\frac{\alpha}{\rho}\tau_k} \tag{92}$$

$$g = 1 - \frac{\frac{C\alpha}{1-\alpha-\beta-\gamma} + \frac{1+\alpha\vartheta_2-\gamma}{1-\alpha-\gamma}}{\frac{\vartheta_2(1-\alpha)+\gamma}{1-\alpha-\gamma} + \frac{C\gamma}{1-\alpha-\beta-\gamma}} \frac{\frac{\alpha}{\rho}\tau_k}{1-\frac{\alpha}{\rho}\tau_k} \tag{93}$$

where

$$C = (\frac{\gamma}{1-\alpha} + \vartheta_2)\frac{\beta}{1-\alpha-\gamma} + \frac{\beta}{1-\alpha} + \vartheta_1. \tag{94}$$

To provide some intuition on how the optimal tax and transfer rates are determined, we compute the three optimal rates in Table 3 for different values of α, which measures the productivity of private capital stock. For all other parameters, their values are fixed at $\beta = 0.2$, $\gamma = 0.1$, $\vartheta_1 = 0.1$, $\vartheta_2 = 0.1$, and $\rho = 0.05$.

Table 3: Optimal Property Tax, Income Tax, and Transfer

α	0.2	0.25	0.3	0.35	0.40
τ_k	0.0446251	0.035477	0.0232356	0.0187604	0.0157411
τ_f	0.24934	0.262329	0.264068	0.261329	0.256353
g	0.0541665	0.180578	0.230509	0.249001	0.250828

From Table 3 it is clear that, because local property tax is highly distortionary, the optimal property tax declines steadily from 4.46% to 1.57% as the productivity of private capital stock rises from .2 to .4. At the same time, the federal government raises its transfer rate to the local government sharply from 5.4% to 25%, without significantly altering the rate of federal income tax.

4 Summary

In this paper, we have studied the optimal choices of federal income tax, federal transfer, and local taxes in a dynamic model of capital accumulation and with explicit game structures among the representative agent, the local

government, and the federal government. We summarize our main findings as follows.

When the federal and the local governments choose their optimal tax rates and transfer scheme along the Cournot-Nash lines, optimal local property tax is zero, optimal local consumption tax is strictly positive, optimal federal income tax is strictly positive, and optimal federal transfer is zero.

When the federal government is the leader and the local government is the follower in a Stackelberg game with both consumption tax and property tax available to the local government, again, the optimal local property tax is zero, and local consumption tax is positive. But federal transfer to the local government is negative, and federal income tax can be positive or negative. In this case, the local consumption tax can be used to finance both local and federal public spending. This "reverse" transfer from the local government to the federal government is optimal from the perspective of welfare maximization because the local consumption tax is less distortionary than both local property tax and federal income tax. When the local consumption tax is set to zero, optimal local property tax can be positive, as are the federal income tax and federal transfer to the local government.

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第 9 章

多级政府条件下的最优税收与转移支付

Optimal taxation and intergovernmental transfer in a dynamic model with multiple levels of government

Liutang Gong[a,b], Heng-fu Zou[a,b,c,*]

[a]*Guanghua School of Management, Peking University, Beijing, China*
[b]*Institute for Advanced Study, Wuhan University, Wuhan, China*
[c]*Development Research Group, The World Bank, USA*

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Abstract

In this paper, we study the optimal choices of the federal income tax, federal transfers, and local taxes in a dynamic model of capital accumulation and with explicit game structures among multiple private agents, multiple local governments, and the federal government. In general, the optimal local property tax is zero if the local property tax is constrained to be nonnegative, whereas the optimal local consumption tax is always positive. When the local consumption tax is chosen optimally, the federal income tax can be either positive or negative. For most reasonable parameter values, our numerical calculations have shown that with a positive local consumption tax there exists a reverse transfer from local governments to the federal government.

JEL classification: E0; H2; H4; H5; H7; O4; R5

Keywords: Income tax; Property tax; Consumption tax; Intergovernmental transfers; Capital accumulation; Fiscal federalism

* Corresponding author. Development Research Group, The World Bank, MC2-611, 1818 H St. N.W. Washington, DC 20433, USA. We thank the National Science Foundation of China for support.
E-mail address: hzou@worldbank.org (H.-f. Zou).

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1. Introduction

In an earlier contribution to optimal taxation and revenue-sharing in the context of fiscal federalism, Gordon (1983) has utilized a static model to consider how local governments set the rules of local taxes including tax rates and types of taxes in a decentralized form of decision-making, while allowing the federal government the role of correcting externalities through grants, revenue-sharing, and regulations on local tax bases. Recently, Persson and Tabellini (1996a, b) have considered risk-sharing and redistribution across local governments in a federation in static models involving risk.

Following Gordon (1983), and Persson and Tabellini (1996a, b), we analyze the optimal choices of federal taxes, federal transfers, and local taxes in a dynamic model of capital accumulation with multiple levels of government.[1] This study considers multiple private agents and multiple local governments and it allows us to see how the optimal choices of federal taxation and federal transfers relate to heterogeneity across different private agents and different local governments.

Our approach goes one step further in bringing the existing optimal taxation study closer to reality. In the existing literature on optimal income and commodity taxation,[2] the government is often taken to be a single identity, without introducing the structure of tax assignments and expenditure assignments among multiple levels of government. But in reality, the income tax is collected by central governments in Europe and jointly by the federal government and state governments in the United States; the property tax is collected by local governments, and the commodity tax is collected by both central governments and local governments in Europe, and by local governments in the United States. In most developed countries, each level of government has the power to determine tax rates and tax bases. In addition, there exist intergovernmental transfers in various forms among different levels of government in every country of reasonable population size. It is natural to see how the structure of fiscal federalism affects the structure of optimal taxation and intergovernmental transfers.

Our dynamic approach is timely given that the design of tax assignments, expenditure assignments, and intergovernmental transfers among different levels of government has received considerable attention in the 1990s in the context of fiscal federalism, public sector reforms, and economic growth for both developing and developed countries. One of the most important goals of

[1] See Zou (1994, 1996), Brueckner (1996), Devarajan et al. (1996, 1998), Davoodi and Zou (1998), and Zhang and Zou (1998) for related dynamic approaches to multi-level government spending, intergovernmental transfers, federal taxes, and local taxes in a 'federation'.

[2] Classical contributions include, for example, Ramsey (1927), Mirrlees (1971), Diamond and Mirrlees (1971), Atkinson and Stiglitz (1972, 1976), and Samuelson (1986). For comprehensive literature reviews see Atkinson and Stiglitz (1980), and Myles (1995).

establishing a sound intergovernmental fiscal relationship is to promote local as well as national economic growth (see Rivlin, 1992; Bird, 1993; Gramlich, 1993; Oates, 1993, 1999). Our dynamic model is a small step toward linking fiscal federalism and optimal economic growth within the context of some specific institutional arrangements in a federation.

The paper is organized as follows. In Section 2 we set up the general framework for the dynamic Stackelberg (leader-follower) games (i) between local governments (the leaders) and private agents (the followers), and (ii) between the federal government (the leader) on one side and local governments (the followers) and private agents (the followers) on the other. Our analysis will focus on open-loop equilibria because closed-loop specifications would be more difficult, and would also raise problems with time consistency. In this general, abstract form, we derive some results regarding the optimal choices of local taxes, the federal income tax, and federal transfers. In Section 3, we show how the optimal choices of the income tax, the consumption tax, and the property tax with one level of government are different from the corresponding choices with two levels of government. In Sections 4 and 5, through a concrete example, we see how the optimal choices of taxes and federal transfers with two levels of government can be computed. Since explicit solutions to complicated dynamic games are hard to come by, we provide some comparative analysis based on numerical calculations. We conclude this paper in Section 6.

2. The framework

Following Gordon (1983), and Persson and Tabellini (1996a, b), we examine a two-tier federal system with many local governments. For our dynamic analysis, it suffices to assume that there are two agents, two local governments, and the federal government in the economy. Agent 1 lives in locality 1, and agent 2 lives in locality 2. The federal government levies a uniform income tax on agents 1 and 2 at a flat rate of τ_f, whereas local government i ($i = 1,2$) levies a consumption tax, $\tau^i_{c_i}$, and a property or capital tax,[3] $\tau^i_{k_i}$. Federal public spending is f in the national jurisdiction, and local public spending in local jurisdiction i ($i=1,2$) is s_i. Local government i ($i=1,2$) also receives a matching federal transfer, gs_i, with g as the uniform matching rate.

2.1. *Agents* ($i = 1,2$)

As in Arrow and Kurz (1970), Barro (1990), Turnovsky (1995), and Turnovsky and Fisher (1995), government expenditures are introduced into

[3] In this model, capital includes real estate property, and the property tax can be viewed as a tax on capital (Mieszkowski, 1972). But, in general, these two are not equivalent because capital is more mobile than real estate property from a local government's perspective.

the representative agent's utility function. Unlike those studies, the model introduces public expenditures at both the federal and local levels. The agent derives a positive, but diminishing, marginal utility from the expenditures of both the federal and local governments and private consumption. Let f, s_i, and c_i be federal expenditure, local expenditure, and private consumption, respectively. If the utility function $u(c_i, f, s_i)$ is twice differentiable, the assumption is equivalent to

$$u_{c_i} > 0, \quad u_f > 0, \quad u_{s_i} > 0, \quad u_{c_i c_i} < 0, \quad u_{ff} < 0, \quad u_{s_i s_i} < 0. \tag{1}$$

In addition, $u(c_i, f, s_i)$ satisfies the Inada conditions

$$\lim_{s_i \to 0} u_{s_i} = \infty, \quad \lim_{f \to 0} u_f = \infty, \quad \lim_{c_i \to 0} u_{c_i} = \infty,$$

$$\lim_{s_i \to \infty} u_{s_i} = 0, \quad \lim_{f \to \infty} u_f = 0, \quad \lim_{c_i \to \infty} u_{c_i} = 0. \tag{2}$$

Agent i's discounted utility is given by

$$U_i = \int_0^\infty u_i(c_i, f, s_i) e^{-\rho t} \, dt, \tag{3}$$

where ρ is the positive, constant time preference.

Again following Arrow and Kurz (1970), Barro (1990), and Turnovsky (1995), agent i's output, y_i, is produced by a constant-return-to-scale production function with four inputs: capital stock, k_i, labor input l_i, federal government expenditure, f, and local government expenditure, s_i, namely

$$y_i = y_i(k_i, l_i, f, s_i).$$

For simplicity, we assume that the agent's labor input is fixed at one unit: $l_i = 1$. Therefore, we just write agent i's production function as

$$y_i = y_i(k_i, f, s_i). \tag{4}$$

The marginal productivity of private capital stock, federal government expenditure, and local government expenditure are positive and decreasing:

$$y_{k_i} > 0, \quad y_f > 0, \quad y_{s_i} > 0, \quad y_{c_i c_i} < 0, \quad y_{ff} < 0, \quad y_{s_i s_i} < 0. \tag{5}$$

Federal government expenditure, f, is financed by the income tax on the agent. Local government expenditure, s_i, is the sum of the consumption tax,[4] $\tau^i_{c_i} c_i$, the capital tax, $\tau^i_{k_i} k_i$, and federal government's transfer, gs_i. τ_f, $\tau^i_{c_i}$,

[4] Consumption tax has been analyzed recently in growth models with one level of government by King and Rebelo (1990), Rebelo (1991), and Jones et al. (1993), and Turnovsky (1995).

and $\tau^i_{k_i}$ are the federal income tax rate, local consumption tax rate, and local capital or property tax rate, respectively, and g is the matching rate of federal grant for local spending.[5] Hence, the budget constraints for the federal government and local government i ($i = 1,2$) can be written as follows:

$$f + gs_1 + gs_2 = \tau_f y^1 + \tau_f y^2, \tag{6}$$

$$s_i - gs_i = \tau^i_{c_i} c_i + \tau^i_{k_i} k_i, \tag{7}$$

respectively.

Agent i maximizes a discounted utility over an infinite time horizon

$$\text{Max} \int_0^\infty u_i(c_i, f, s_i) e^{-\rho t}\, dt$$

subject to his budget constraint

$$\frac{dk_i}{dt} = (1 - \tau_f) y_i(k_i, f, s_i) - (1 + \tau^i_{c_i}) c_i - (\delta + \tau^i_{k_i}) k_i. \tag{8}$$

His initial capital stock is given by $k_i(0) = k_{i0}$.

Solving the optimization problem, we obtain the first-order conditions

$$\frac{dk_i}{dt} = (1 - \tau_f) y_i(k_i, f, s_i) - (1 + \tau^i_{c_i}) c_i - (\delta + \tau^i_{k_i}) k_i,$$

$$\frac{d\lambda_i}{dt} = -\lambda_i \left[(1 - \tau_f) \frac{\partial y_i}{\partial k_i} - \rho - \delta - \tau^i_{k_i} \right], \tag{9}$$

$$u_{c_i} = (1 + \tau^i_{c_i}) \lambda_i. \tag{10}$$

From Eq. (10), we have

$$c_i = c_i(\lambda_i, k_i, \tau^i_{c_i}, f, s_i). \tag{11}$$

At the steady state, we have

$$(1 - \tau_f) y_i(k_i, f, s_i) - (1 + \tau^i_{c_i}) c_i(\lambda_i, k_i, \tau^i_{c_i}, f, s_i) - (\delta + \tau^i_{k_i}) k_i = 0, \tag{12}$$

$$(1 - \tau_f) \frac{\partial y_i}{\partial k_i} - \rho - \delta - \tau^i_{k_i} = 0. \tag{13}$$

[5] The matching grant here is justified on the ground that the federal government intends to provide incentives for local public services. It can also be viewed as the way to transfer resources among different levels of government. A straightforward extension is to allow externalities (benefit spillover) in local public services in both utility functions and production functions.

2.2. Local governments ($i = 1,2$)

In each locality, the local government and the private agent play the Stackelberg game with the local government as the leader and private agent the follower.[6] At the same time, in this section we assume that the local government is the follower in the Stackelberg game with the federal government.[7] That is to say, given the federal income tax rate, the federal matching grant, and federal spending, the local government maximizes the agent's welfare by fully incorporating the agent's first-order conditions in Section 2.1 into its own maximization. Specifically, the local government will choose its optimal taxes, $\tau^i_{c_i}$ and $\tau^i_{k_i}$, and its public expenditure, s_i, private capital stock, k_i, and the marginal utility of private wealth, λ_i, to maximize the agent's steady-state welfare:

$$\max_{\tau^i_{c_i},\tau^i_{k_i},s_i} u_i(c_i, f, s_i)$$

subject to the steady-state conditions for individual i, (10), (12), and (13), and the budget constraint of locality i, (7).

Now, the first-order conditions of locality i are as follows:

$$\frac{\partial L_i}{\partial c_i} = \frac{\partial u_i(c_i, f, s_i)}{\partial c_i} - \theta^i_1(1 + \tau^i_{c_i}) + \theta^i_4\tau^i_{c_i} + \theta^i_3 u_{c_i c_i} = 0, \tag{14}$$

$$\frac{\partial L_i}{\partial s_i} = \frac{\partial u_i(c_i, f, s_i)}{\partial s_i} + \theta^i_1(1 - \tau_f)\frac{\partial y_i(k_i, f, s_i)}{\partial s_i} + \theta^i_2(1 - \tau_f)\frac{\partial^2 y_i}{\partial k_i \partial s_i} + \theta^i_4(g_i - 1) = 0, \tag{15}$$

$$\frac{\partial L_i}{\partial \lambda_i} = -\theta^i_3\lambda_i(1 + \tau^i_{c_i}) = 0. \tag{16}$$

$$\frac{\partial L_i}{\partial k_i} = \theta^i_1\left[(1 - \tau_f)\frac{\partial y_i}{\partial k_i} - \delta - \tau^i_{k_i}\right] + \theta^i_2(1 - \tau_f)\frac{\partial^2 y_i}{\partial k_i^2} + \theta^i_4\tau^i_{k_i} = 0, \tag{17}$$

[6] See a similar technique used by Turnovsky and Brock (1980), Judd (1985), Chamley (1985, 1986), and Lucas (1990) in the context of the representative agent model with one level of government.

[7] The choices of federal government as the leader and local governments as followers are natural in the light of recent policy discussions on how to harden the budget constraint on local governments and how to avoid bailouts of local governments by the federal government in both developing and developed countries. See Wildasin (1998).

$$\frac{\partial L_i}{\partial \tau_{c_i}^i} = -\theta_1^i c_i - \theta_3^i \lambda_i + \theta_4^i c_i + \theta_6^i = 0, \tag{18}$$

$$\theta_6^i \tau_{c_i}^i = 0, \quad \theta_6^i \geq 0, \tag{19}$$

$$\frac{\partial L_i}{\partial \tau_{k_i}^i} = -\theta_1^i k_i - \theta_2^i + \theta_4^i k_i + \theta_5^i = 0, \tag{20}$$

$$\theta_5^i \tau_{k_i}^i = 0, \quad \tau_{k_i}^i \geq 0, \ \theta_5^i \geq 0, \tag{21}$$

where θ_1^i is the multiplier associated with Eq. (12); θ_2^i is the multiplier associated with Eq. (13); θ_3^i is the multiplier associated with Eq. (10); θ_4^i is the multiplier associated with locality's budget constraint equation (7); θ_1^i is the multiplier associated with the nonnegative constraint on the property tax, $\tau_{k_i}^i \geq 0$; θ_6^i is the multiplier associated with the nonnegative constraint on the consumption tax, $\tau_{c_i}^i \geq 0$.

Proposition 1. The optimal steady-state property taxes in the two localities are zero.[8]

Proof. Suppose $\tau_{k_i}^i \neq 0$. From Eqs. (18) and (20), we have

$$\text{sign}(\theta_2^i) = \text{sign}(-\theta_1^i + \theta_4^i) = -\text{sign}(\theta_6^i) \leq 0.$$

But from Eq. (17), we have

$$\theta_1^i \rho + \theta_2^i (1 - \tau_f) \frac{\partial^2 y_i}{\partial k_i^2} + \theta_4^i \tau_{k_i}^i = 0$$

and $\theta_1^i \rho \geq 0$, $\theta_2^i (1 - \tau_f) \partial^2 y_i / \partial k_i^2 \geq 0$, and $\theta_4^i \tau_{k_i}^i \geq 0$. Therefore, we must have

$$\theta_1^i \rho = 0, \quad \theta_2^i (1 - \tau_f) \frac{\partial^2 y_i}{\partial k_i^2} = 0, \quad \theta_4^i \tau_{k_i}^i = 0.$$

We also know

$$\theta_1^i = \theta_2^i = \theta_3^i = \theta_4^i = \theta_5^i = 0.$$

[8] The optimal property tax would be negative without the nonnegative constraint on the property tax, $\tau_{k_i}^i \geq 0$.

Then, from Eq. (15)

$$\frac{\partial u_i(c_i, f, s_i)}{\partial s_i} = 0,$$

which is impossible by our assumption. Hence, we must have $\tau^i_{k_i} = 0$. □

The intuition is as follows. For local governments, the consumption tax is less distortionary than the capital (property) tax in its adverse effect on private production and capital accumulation. Without the nonnegative constraint on the property tax, $\tau^i_{k_i} \geq 0$, the optimal local property tax is negative. The proof is left as an exercise for the reader.

2.3. *The federal government*

Given the optimal choices of local governments and agents, the federal government as the leader in its Stackelberg game with both the agents and local governments chooses $k_i, s_i, g_i, \tau^i_{c_i}$ $(i = 1,2)$, τ_f, and f to maximize the weighted steady-state welfare of the two agents in the two localities with χ_i $(i = 1,2)$ as the weights.:

$$\max_{k_i, s_i, g_i, \tau^i_{c_i}, \tau^i_{k_i}, \tau_f} \chi_1 u_1(c_1, f, s_1) + \chi_2 u_2(c_2, f, s_2)$$

subject to the first-order conditions of the two localities: Eqs. (10), (7), (12)–(21), and the budget constraint (6).

Define the Lagrangian function

$$\begin{aligned}
L = {} & \chi_1 u_1(c_1, f, s_1) + \chi_2 u_2(c_2, f, s_2) \\
& + \sum_{i=1}^{2} \xi^i_1 [(1 - \tau_f) y_i(k_i, f, s_i) - (1 + \tau^i_{c_i}) c_i - \delta k_i] \\
& + \sum_{i=1}^{2} \xi^i_2 \left[(1 - \tau_f) \frac{\partial y_i}{\partial k_i} - \rho - \delta \right] \\
& + \sum_{i=1}^{2} \xi^i_3 \left[\frac{\partial u_i(c_i, f, s_i)}{\partial c_i} - \theta^i_1 (1 + \tau^i_{c_i}) + \theta^i_4 \tau^i_{c_i} \right] \\
& + \sum_{i=1}^{2} \xi^i_4 \left[\frac{\partial u_i(c_i, f, s_i)}{\partial s_i} + \theta^i_1 (1 - \tau_f) \frac{\partial y_i(k_i, f, s_i)}{\partial s_i} \right. \\
& \left. + \theta^i_2 (1 - \tau_f) \frac{\partial^2 y_i}{\partial k_i \partial s_i} + \theta^i_4 (g - 1) \right]
\end{aligned}$$

$$+\sum_{i=1}^{2}\xi_5^i\left[\theta_1^i\rho+\theta_2^i(1-\tau_f)\frac{\partial^2 y_i}{\partial k_i^2}\right]+\sum_{i=1}^{2}\xi_{10}^i[\tau_{c_i}^i c_i-s_i+gs_i]$$

$$+\sum_{i=1}^{2}\xi_6^i[-\theta_1^i c_i+\theta_4^i c_i+\theta_6^i]+\sum_{i=1}^{2}\xi_7^i[\theta_6^i\tau_{c_i}^i]+\sum_{i=1}^{2}\xi_8^i\theta_6^i+\sum_{i=1}^{2}\xi_9^i\tau_{c_i}^i$$

$$+\eta[\tau_f y^1+\tau_f y^2-f-gs_1-gs_2],$$

where $\xi_1^i, \xi_2^i, \xi_3^i, \xi_4^i, \xi_5^i, \xi_6^i, \xi_7^i, \xi_8^i, \xi_9^i$, and ξ_{10}^i are the multipliers associated with Eqs. (12)–(19), and (7), respectively, and η is the multiplier associated with the federal budget constraint (6). Now, we have the first-order conditions for federal optimization

$$\frac{\partial L}{\partial \tau_f}=-\sum_{i=1}^{2}\xi_1^i y_i(k_i,f,s_i)-\sum_{i=1}^{2}\xi_4^i\left[\theta_1^i\frac{\partial y_i(k_i,f,s_i)}{\partial s_i}+\theta_2^i\frac{\partial^2 y_i}{\partial k_i\partial s_i}\right]$$
$$-\sum_{i=1}^{2}\xi_5^i\theta_2^i\frac{\partial^2 y_i}{\partial k_i^2}+\eta(y^1+y^2)-\sum_{i=1}^{2}\xi_2^i\frac{\partial y_i}{\partial k_i}=0, \tag{22}$$

$$\nu\tau_f=0,\quad \nu\geq 0,$$

$$\frac{\partial L}{\partial g}=\sum_{i=1}^{2}\xi_4^i\theta_4^i+\sum_{i=1}^{2}\xi_{10}^i s_i-\eta(s_1+s_2)+\kappa=0,\quad \kappa g=0,\ \kappa\geq 0, \tag{23}$$

$$\frac{\partial L}{\partial \tau_{c_i}^i}=-\xi_1^i c_i+\xi_3^i(-\theta_1^i+\theta_4^i)+\xi_{10}^i c_i+\xi_7^i\theta_6^i+\xi_9^i=0,$$
$$\xi_9^i\tau_{c_i}^i=0,\ \xi_9^i\geq 0, \tag{24}$$

$$\frac{\partial L}{\partial \theta_6^i}=\xi_6^i+\xi_7^i\tau_{c_i}^i+\xi_8^i=0,\quad \xi_8^i\theta_6^i=0,\ \xi_9^i\geq 0, \tag{25}$$

$$\frac{\partial L}{\partial \theta_2^i}=\xi_4^i(1-\tau_f)\frac{\partial^2 y_i}{\partial k_i\partial s_i}+\xi_5^i(1-\tau_f)\frac{\partial^2 y_i}{\partial k_i^2}=0, \tag{26}$$

$$\frac{\partial L}{\partial \theta_4^i}=\xi_3^i\tau_{c_i}^i+\xi_4^i(g-1)+\xi_6^i c_i=0, \tag{27}$$

$$\frac{\partial L}{\partial \theta_1^i}=-\xi_3^i(1+\tau_{c_i}^i)+\xi_4^i(1-\tau_f)\frac{\partial y_i(k_i,f,s_i)}{\partial s_i}+\xi_5^i\rho-\xi_6^i c_i=0, \tag{28}$$

$$\frac{\partial L}{\partial k_i} = \xi_1^i \left[(1-\tau_f)\frac{\partial y_i}{\partial k_i} - \delta\right] + \xi_4^i \left[\theta_1^i(1-\tau_f)\frac{\partial y_i^2(k_i,f,s_i)}{\partial s_i \partial k_i} + \theta_2^i(1-\tau_f)\frac{\partial^3 y_i}{\partial k_i^2 \partial s_i}\right] + \xi_5^i \theta_2^i(1-\tau_f)\frac{\partial^3 y_i}{\partial k_i^3} + \eta\tau_f\frac{\partial y_i}{\partial k_i} + \xi_2^i(1-\tau_f)\frac{\partial^2 y_i}{\partial k_i^2} = 0, \tag{29}$$

$$\frac{\partial L}{\partial f} = \chi_1\frac{\partial u_1(c_1,f,s_1)}{\partial f} + \chi_2\frac{\partial u_2(c_2,f,s_2)}{\partial f} + \sum_{i=1}^{2}\xi_1^i(1-\tau_f)\frac{\partial y_i(k_i,f,s_i)}{\partial f} + \sum_{i=1}^{2}\xi_2^i(1-\tau_f)\frac{\partial^2 y_i}{\partial k_i \partial f} + \sum_{i=1}^{2}\xi_3^i\frac{\partial u_i^2(c_i,f,s_i)}{\partial c_i \partial f} + \sum_{i=1}^{2}\xi_4^i\left[\frac{\partial u_i^2(c_i,f,s_i)}{\partial s_i \partial f} + \theta_1^i(1-\tau_f)\frac{\partial y_i^2(k_i,f,s_i)}{\partial s_i \partial f} + \theta_2^i(1-\tau_f)\frac{\partial^3 y_i}{\partial k_i \partial s_i \partial f}\right] + \sum_{i=1}^{2}\xi_5^i\theta_2^i(1-\tau_f)\frac{\partial^3 y_i}{\partial k_i^2 \partial f} + \eta\left[\tau_f^1\frac{\partial y_1(k_i,f,s_i)}{\partial f} + \tau_f\frac{\partial y_2(k_i,f,s_i)}{\partial f} - 1\right], \tag{30}$$

$$\frac{\partial L}{\partial c_i} = \chi_i\frac{\partial u_i(c_i,f,s_i)}{\partial c_i} - \xi_1^i(1+\tau_{c_i}^i) + \xi_3^i\frac{\partial u_i^2(c_i,f,s_i)}{\partial c_i^2} + \xi_4^i\frac{\partial u_i^2(c_i,f,s_i)}{\partial s_i \partial c_i} + \xi_{10}^i\tau_{c_i}^i + \xi_6^i(\theta_4^i - \theta_1^i) = 0, \tag{31}$$

$$\frac{\partial L}{\partial s_i} = \chi_i\frac{\partial u_i(c_i,f,s_i)}{\partial s_i} + \xi_1^i(1-\tau_f)\frac{\partial y_i(k_i,f,s_i)}{\partial s_i} + \xi_2^i(1-\tau_f)\frac{\partial^2 y_i}{\partial k_i \partial s_i} + \xi_4^i\left[\frac{\partial u_i^2(c_i,f,s_i)}{\partial c_i \partial s_i} + \theta_1^i(1-\tau_f)\frac{\partial y_i^2(k_i,f,s_i)}{\partial s_i^2} + \theta_2^i(1-\tau_f)\frac{\partial^3 y_i}{\partial k_i \partial s_i^2}\right] + \xi_5^i\theta_2^i(1-\tau_f)\frac{\partial^3 y_i}{\partial k_i^2 \partial s_i} + \xi_{10}^i(g-1) - \eta g + \xi_3^i\frac{\partial u_i^2(c_i,f,s_i)}{\partial c_i \partial s_i} + \eta\left[\tau_f^1\frac{\partial y_1(k_i,f,s_i)}{\partial s_1} + \tau_f\frac{\partial y_2(k_i,f,s_i)}{\partial s_1}\right] = 0 \tag{32}$$

plus Eqs. (12)–(19), and (7).

Proposition 2. If the local consumption tax is strictly positive, then the federal transfer to localities can be negative or positive.

The proof is a mechanical, tedious demonstration that a negative value of g and a positive value of g are both consistent with the first-order conditions for federal maximization. Perhaps it first appears surprising that the federal transfer to localities can be negative. The intuition is quite convincing. With a less distortionary consumption tax available at the local level, and with the Stackelberg game between the federal government (the leader) and local governments (the followers), the federal government can levy a smaller income tax, which is more distortionary than the local consumption tax. At the same time, the federal government can 'force' a reverse transfer from local governments to the federal government. In this way, part of the local consumption tax finances federal spending.

Furthermore, we cannot exclude the possibility that the federal income tax is negative when the local consumption tax is available.

Proposition 3. If the local consumption tax is strictly positive, the federal income tax can be positive or negative.

Again, the proof of this proposition follows from a mechanical procedure that both a negative value of τ_f and a positive value of τ_f are consistent with the first-order conditions for federal optimization. In this case, the local consumption tax is utilized to finance both federal spending and federal subsidy for private production. For a concrete example, see Table 2 in Section 4.

Proposition 3 stands in sharp contrast to the result from the optimal taxation model where there is only one government. In the one government model, we can show that, if a consumption tax is available, it is always optimal to set a positive consumption tax, while levying no income tax. To illustrate this point, we turn to the analysis of optimal consumption tax, income tax, and property tax with one government. This analysis also provides a benchmark for our normative discussions in the context of multiple levels of government.

3. Taxes with one government

Suppose there are one individual and one government.[9] The individual has a preference defined on private consumption good, c, and public good, G:

$$U(c, G). \tag{33}$$

[9] The model in this section is an extension of Chamley (1986) and Lucas (1990) with a consumption tax.

For simplicity, we take the utility function to be separable, that is

$$U(c,G)=u(c)+v(G).$$

Output, y, is produced by the production function

$$y(k,G) \tag{34}$$

which is defined on private capital, k, and public good, G.

It is further assumed that both the utility function and the production function satisfy the usual Inada conditions.

The government collects a consumption tax, $\tau_c c$, an income tax, $\tau_y y$, and a property tax, $\tau_k k$. Hence, we have the balanced budget constraint for the government

$$\tau_c c+\tau_y y+\tau_k k=G. \tag{35}$$

3.1. Individual maximization

The budget constraint for individual can be written as

$$\frac{\mathrm{d}k(t)}{\mathrm{d}t}=(1-\tau_y)y(k,G)-(1+\tau_c)c-(\delta+\tau_k)k. \tag{36}$$

The representative agent chooses his consumption path, $c(t)$, and capital accumulation path, $k(t)$, to maximize his discounted utility, namely

$$\text{Max}\int_0^\infty [u(c)+v(G)]\mathrm{e}^{-\rho t}\,\mathrm{d}t$$

subject to the budget constraint (36). The initial capital stock, $k(0)=k_0$, is given.

Define the Hamiltonian as

$$H=u(c)+v(G)+\lambda((1-\tau_y)y(k,G)-(1+\tau_c)c-(\delta+\tau_k)k).$$

The first-order conditions are

$$\frac{\partial u(c)}{\partial c}=(1+\tau_c)\lambda, \tag{37}$$

$$\frac{\mathrm{d}\lambda}{\mathrm{d}t}=-\lambda\left\{(1-\tau_y)\frac{\partial y_i(k,G)}{\partial k}-\rho-\delta-\tau_k\right\} \tag{38}$$

and the transversality condition is

$$\lim_{t\to\infty} \lambda k e^{-\rho t} = 0.$$

From condition (37), we have

$$c = c(\tau_c, \lambda).$$

At the steady state, we have

$$(1-\tau_y)\frac{\partial y_i(k,G)}{\partial k} - \rho - \delta - \tau_k = 0, \tag{39}$$

$$(1-\tau_y)y(k,G) - (1+\tau_c)c(\tau_c,\lambda) - (\delta+\tau_k)k = 0. \tag{40}$$

3.2. Government maximization

Given the optimal choices for the individual, the government chooses its public service, G, and its taxes τ_y, τ_k, and τ_c to maximize the steady-state agent's welfare subject to its budget constraint, that is

$$\max U(c(\tau_c,\lambda),G) = u(c(\tau_c,\lambda)) + v(G)$$

subject to the individual's first-order conditions (37), (39), (40), the budget constraints of the government, (35), and the nonnegative constraints for the tax rates:

$$\tau_y \geq 0, \quad \tau_k \geq 0, \ \tau_c \geq 0.$$

Now, define the Lagrangian function as

$$\begin{aligned} L = {} & U(c(\tau_c,\lambda),G) + \mu_1\left[(1-\tau_y)\frac{\partial y(k,G)}{\partial k} - \rho - \delta - \tau_k\right] \\ & + \mu_2[(1-\tau_y)y(k,G) - (1+\tau_c)c(\tau_c,\lambda) - (\delta+\tau_k)k] \\ & + \mu_3[\tau_c c(\tau_c,\lambda) + \tau_y y + \tau_k k - G] + \mu_4\tau_k + \mu_5\tau_c + \mu_6\tau_y, \end{aligned}$$

where μ_1 is the multiplier associated with Eq. (39), μ_2 is the multiplier associated with Eq. (40), μ_3 is the multiplier associated with Eq. (35), μ_4, μ_5 and μ_6 are the multipliers associated with the nonnegative constraints of tax rates, respectively.

The first-order conditions are

$$\frac{\partial L}{\partial \tau_y} = -\mu_1\frac{\partial y(k,G)}{\partial k} - \mu_2 y(k,G) + \mu_3 y + \mu_6 = 0, \tag{41}$$

$$\mu_6\tau_y = 0, \quad \mu_6 \geq 0, \tag{42}$$

$$\frac{\partial L}{\partial \lambda} = \frac{\partial U(c,G)}{\partial c}\frac{\partial c}{\partial \lambda} - \mu_2(1+\tau_c)\frac{\partial c}{\partial \lambda} + \mu_3\tau_c\frac{\partial c}{\partial \lambda} = 0, \tag{43}$$

$$\frac{\partial L}{\partial k} = \mu_1(1-\tau_y)\frac{\partial^2 y(k,G)}{\partial k^2} + \mu_2\left\{(1-\tau_y)\frac{\partial y(k,G)}{\partial k} - (\delta+\tau_k)\right\} + \mu_3\tau_k = 0, \tag{44}$$

$$\frac{\partial L}{\partial G} = \frac{\partial u(c,G)}{\partial G} + \mu_1(1-\tau_y)\frac{\partial^2 y(k,G)}{\partial k \partial G} + \mu_2(1-\tau_y)\frac{\partial y(k,G)}{\partial G} - \mu_3 = 0, \tag{45}$$

$$\frac{\partial L}{\partial \tau_c} = -\mu_2 c + \mu_3 c + \frac{\partial U(c,G)}{\partial c}\frac{\partial c}{\partial \tau_c} - \mu_2(1+\tau_c)\frac{\partial c}{\partial \tau_c} + \mu_3\tau_c\frac{\partial c}{\partial \tau_c} + \mu_5 = 0, \tag{46}$$

$$\mu_5\tau_c = 0, \quad \mu_5 \geq 0, \tag{47}$$

$$\frac{\partial L}{\partial \tau_k} = -\mu_1 - \mu_2 k + \mu_3 k + \mu_4 = 0, \tag{48}$$

$$\mu_4\tau_k = 0, \quad \mu_4 \geq 0. \tag{49}$$

Proposition 4. The steady-state property tax and income tax are zero, and the steady-state consumption tax is positive.

Proof. Step 1: it is obvious that all three taxes cannot be positive at the same time.

Step 2: any two taxes among the three cannot be positive at the same time. This can be seen as follows:

1. If $\tau_k > 0$, $\tau_c > 0$, from Eqs. (43), (46), and (48), we have

$$-\mu_2 + \mu_3 = 0, \quad \mu_1 = 0.$$

Then, from Eq. (44), we have

$$\mu_2\left[(1-\tau_y)\frac{\partial y(k,G)}{\partial k} - \delta\right] = 0.$$

Hence,

$$\mu_2 = \mu_3 = 0, \quad \mu_1 = 0.$$

Then, from (43),

$$\frac{\partial U(c,G)}{\partial c}\frac{\partial c}{\partial \lambda} = 0$$

which is impossible.

2. If $\tau_y > 0$, $\tau_c > 0$, from Eqs. (41), (43), and (46), we have

$$-\mu_2 + \mu_3 = 0, \quad \mu_1 = 0.$$

Then, again from Eq. (44), we have

$$\mu_2 = \mu_3 = 0, \quad \mu_1 = 0$$

which again requires the impossible:

$$\frac{\partial U(c,G)}{\partial c}\frac{\partial c}{\partial \lambda} = 0.$$

3. If $\tau_y > 0$, $\tau_k > 0$. from Eqs. (41), (43), and (48), we have

$$\mu_1 \frac{\partial y(k,G)}{\partial k} + \mu_2 y(k,G) - \mu_3 y = 0,$$

$$-\mu_1 - \mu_2 k + \mu_3 k = 0.$$

Then,

$$\frac{\partial y(k,G)}{\partial k} k = y$$

which is impossible.

Step 3: we prove that it is impossible to have $\tau_c = 0$. In fact, from Eqs. (43) and (46), we have

$$\text{sign}(-\mu_2 + \mu_3) = -\text{sign}(\mu_5) \leq 0.$$

If $\tau_y > 0$, $\mu_6 = 0$, from Eq. (41), we have

$$\text{sign}(\mu_1) = \text{sign}(-\mu_2 + \mu_3) \leq 0.$$

Furthermore, from Eq. (44), we have

$$\mu_1(1 - \tau_y)\frac{\partial^2 y(k,G)}{\partial k^2} + \mu_2 \rho = 0,$$

which leads to

$$\mu_1 = 0 = \mu_2.$$

But from (41), we must have

$$\mu_2 = \mu_3 = 0, \quad \mu_1 = 0,$$

which again contradicts (43). Therefore, $\tau_y = 0$.

If $\tau_k > 0$, from Eq. (48), we have

$$\text{sign}(\mu_1) = \text{sign}(-\mu_2 + \mu_3) \leq 0.$$

Combining with Eq. (44), we have

$$\mu_1(1 - \tau_y)\frac{\partial^2 y(k, G)}{\partial k^2} + \mu_2 \rho + \mu_3 \tau_k = 0,$$

which in turn implies

$$\mu_2 = \mu_3 = 0, \quad \mu_1 = 0.$$

This is again impossible. Hence $\tau_k = 0$.

Now since government spending, G, enters both the utility function and the production function, and since the Inada conditions hold, government spending must be financed by the consumption tax. Therefore, $\tau_c > 0$. □

The intuition is rather simple: the consumption tax is less distortionary than the income tax and the property tax. In a one-level government, it is optimal to only tax consumption to finance public spending. But when there are two levels of government, this result does not hold anymore, as shown in Section 2. Now we turn back to our analysis of optimal taxes and federal transfer when there are two levels of government.

4. An example

One of the difficulties with the optimal taxation literature is that we cannot make too much intuitive sense out of the numerous first-order conditions. Very often explicit solutions are very hard to obtain even in static models. In this section, we show that with some specific production and utility functions, we can obtain explicit solutions to the long-run optimal local taxes, optimal federal income tax, and optimal federal transfers in a dynamic framework. However, hard and tedious calculations with a sense of guessing and good luck are a prerequisite.

Let the production function be

$$y_i = A_i k_i^{\alpha} l_i^{\varepsilon} f^{\beta} s_i^{\gamma} = A_i k_i^{\alpha} f^{\beta} s_i^{\gamma},$$

where $\alpha + \varepsilon + \beta + \gamma = 1$, and $\alpha + \beta + \gamma < 1$ because $0 < \varepsilon < 1$ and $l_i = 1$ by our assumption.

Let the utility function be

$$u(c_i, f, s_i) = \ln c_i + \omega_1^i \ln f + \omega_2^i \ln s_i.$$

First, from private optimization, we have

$$k_i = \left(\frac{\rho + \delta + \tau_{k_i}^i}{\alpha(1-\tau_f)}\right)^{1/(\alpha-1)} f^{\beta/(1-\alpha)} s_i^{\gamma/(1-\alpha)}, \quad i = 1,2,$$

$$y_i = \left(\frac{\rho + \delta + \tau_{k_i}^i}{\alpha(1-\tau_f)}\right)^{\alpha/(\alpha-1)} f^{\beta/(1-\alpha)} s_i^{\gamma/(1-\alpha)}, \quad i = 1,2,$$

$$c_i = \frac{\rho + (1-\alpha)(\delta + \tau_{k_i}^i)}{\alpha(1+\tau_{c_i}^i)} \left(\frac{\rho + \delta + \tau_{k_i}}{\alpha(1-\tau_f)}\right)^{1/(\alpha-1)} f^{\beta/(1-\alpha)} s_i^{\gamma/(1-\alpha)}, \quad i = 1,2. \tag{50}$$

Second, local government i maximizes

$$\max_{\tau_{c_i}^i, \tau_{k_i}^i, s_i} \ln c_i + \omega_1^i \ln f + \omega_2^i \ln s_i$$

subject to (50) and its budget constraint

$$s_i - g s_i = \tau_{c_i}^i c_i + \tau_{k_i}^i k_i. \tag{51}$$

Substituting Eq. (50) into (51), we have

$$s_i = \frac{\tau_{c_i}^i}{1-g} \frac{\rho + (1-\alpha)(\delta + \tau_{k_i}^i)}{\alpha(1+\tau_{c_i}^i)} \left(\frac{\rho + \delta + \tau_{k_i}^i}{\alpha(1-\tau_f)}\right)^{1/(\alpha-1)} f^{\beta/(1-\alpha)} s_i^{\gamma/(1-\alpha)}$$

$$+ \frac{\tau_{k_i}^i}{1-g} \left(\frac{\rho + \delta + \tau_{k_i}^i}{\alpha(1-\tau_f)}\right)^{1/(\alpha-1)} f^{\beta/(1-\alpha)} s_i^{\gamma/(1-\alpha)}$$

$$= \left(\frac{\tau_{c_i}^i(\rho + (1-\alpha)\delta) + (\tau_{c_i}^i + \alpha)\tau_{k_i}^i}{\alpha(1+\tau_{c_i}^i)}\right)$$

$$\left(\frac{\rho + \delta + \tau_{k_i}^i}{\alpha(1-\tau_f)}\right)^{1/(\alpha-1)} f^{\beta/(1-\alpha)} s_i^{\gamma/(1-\alpha)} \frac{1}{1-g}.$$

Therefore, we get

$$s_i = \left(\frac{\tau_{c_i}^i(\rho + (1-\alpha)\delta) + (\tau_{c_i}^i + \alpha)\tau_{k_i}^i}{\alpha(1+\tau_{c_i}^i)}\right)^{(1-\alpha)/(1-\alpha-\gamma)} \left(\frac{1}{1-g}\right)^{(1-\alpha)/(1-\alpha-\gamma)}$$

$$\times \left(\frac{\rho + \delta + \tau_{k_i}^i}{\alpha(1-\tau_f)}\right)^{-1/(1-\alpha-\gamma)} f^{\beta/(1-\alpha-\gamma)}. \tag{52}$$

Now, the objective function for the local government can be rewritten as

$$\begin{aligned}
\ln c_i + \omega_2^i \ln s_i &= \ln(\rho + (1-\alpha)(\delta + \tau_{k_i}^i)) - \ln(1+\tau_{c_i}^i) \\
&\quad + \frac{1}{\alpha - 1}\ln(\rho + \delta + \tau_{k_i}^i) \\
&\quad + \left(\frac{\gamma}{1-\alpha} + \omega_2^i\right)\ln s_i + \text{constant} \\
&= \ln(\rho + (1-\alpha)(\delta + \tau_{k_i}^i)) - \ln(1+\tau_{c_i}^i) \\
&\quad + \frac{1}{\alpha-1}\ln(\rho+\delta+\tau_{k_i}^i) + \frac{\omega_2^i(1-\alpha)+\gamma}{1-\alpha-\gamma} \\
&\quad \times [\ln(\tau_{c_i}^i(\rho + (1-\alpha)\delta) + (\tau_{c_i}^i + \alpha)\tau_{k_i}^i) - \ln(1+\tau_{c_i}^i)] \\
&\quad - \frac{\omega_2^i(1-\alpha)+\gamma}{(1-\alpha)(1-\alpha-\gamma)}\ln(\rho+\delta+\tau_{k_i}^i) + \text{constant}.
\end{aligned} \tag{53}$$

The local government's optimization problem is equivalent to maximizing the expression in Eq. (53) with respect to $\tau_{c_i}^i$ and $\tau_{k_i}^i$. Thus, we have

$$\begin{aligned}
&\frac{1-\alpha}{\rho + (1-\alpha)(\delta + \tau_{k_i}^i)} + \frac{\omega_2^i(1-\alpha)+\gamma}{1-\alpha-\gamma}\frac{\tau_{c_i}^i + \alpha}{\tau_{c_i}^i(\rho + (1-\alpha)\delta) + (\tau_{c_i}^i + \alpha)\tau_{k_i}^i} \\
&\quad - \frac{\omega_2^i(1-\alpha)+\gamma}{(1-\alpha)(1-\alpha-\gamma)}\frac{1}{\rho+\delta+\tau_{k_i}^i} + \frac{1}{\alpha-1}\frac{1}{\rho+\delta+\tau_{k_i}^i} = 0, \\
&- \frac{1}{1+\tau_{c_i}^i} + \frac{\omega_2^i(1-\alpha)+\gamma}{1-\alpha-\gamma} \\
&\quad \times \left[\frac{\rho + (1-\alpha)\delta + \tau_{k_i}^i}{\tau_{c_i}^i(\rho + (1-\alpha)\delta) + (\tau_{c_i}^i + \alpha)\tau_{k_i}^i} - \frac{1}{1+\tau_{c_i}^i}\right] = 0.
\end{aligned}$$

From the above two equations, we can determine $\tau_{c_i}^i$ and $\tau_{k_i}^i$ as

$$\begin{aligned}
\tau_{c_i}^i &= \frac{\omega_2^i(1-\alpha)+\gamma}{1-\alpha-\gamma}, \\
\tau_{k_i}^i &= 0.
\end{aligned} \tag{54}$$

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Third, for the federal government, it maximizes the weighted steady-state welfare of the two agents in the two localities

$$\max \sum_{i=1,2} \chi_i(\ln c_i + \omega_1^i \ln f + \omega_2^i \ln s_i)$$

subject to the optimal behaviour of private agents and local governments and its budget constraint:

$$f + gs_1 + gs_2 = \tau_f y^1 + \tau_f y^2 \tag{55}$$

Substituting Eqs. (51) and (52) into Eq. (55) yields

$$\begin{aligned} f = \sum_{i=1}^{2} \Bigg\{ & \tau_f \left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{\alpha/(\alpha-1)} \left(\frac{\tau_{c_i}^i \rho}{\alpha(1+\tau_{c_i}^i)}\right)^{\gamma/(1-\alpha-\gamma)} \\ & \times \left(\frac{1}{1-g}\right)^{\gamma/(1-\alpha-\gamma)} \left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{-1/(1-\alpha-\gamma)\gamma/(1-\alpha)} f^{\beta/(1-\alpha-\gamma)} \\ & - g \left(\frac{\tau_{c_i}^i \rho}{\alpha(1+\tau_{c_i}^i)}\right)^{(1-\alpha)/(1-\alpha-\gamma)} \left(\frac{1}{1-g}\right)^{(1-\alpha)/(1-\alpha-\gamma)} \\ & \times \left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{-1/(1-\alpha-\gamma)} f^{\beta/(1-\alpha-\gamma)} \Bigg\} \\ = \sum_{i=1}^{2} \Bigg\{ & f^{\beta/(1-\alpha-\gamma)} \Bigg\{ \tau_f \left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{\alpha/(\alpha-1)} \left(\frac{\tau_{c_i}^i \rho}{\alpha(1+\tau_{c_i}^i)}\right)^{\gamma/(1-\alpha-\gamma)} \\ & \times \left(\frac{1}{1-g}\right)^{\gamma/(1-\alpha-\gamma)} \left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{-1/(1-\alpha-\gamma)\gamma/(1-\alpha)} \\ & - g \left(\frac{\tau_{c_i}^i \rho}{\alpha(1+\tau_{c_i}^i)}\right)^{(1-\alpha)/(1-\alpha-\gamma)} \left(\frac{1}{1-g}\right)^{(1-\alpha)/(1-\alpha-\gamma)} \\ & \times \left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{-1/(1-\alpha-\gamma)} \Bigg\} \Bigg\}, \end{aligned}$$

$$\begin{aligned} f^{(1-\alpha-\beta-\gamma)/(1-\alpha-\gamma)} = \sum_{i=1}^{2} \Bigg\{ & \tau_f \left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{\alpha/(\alpha-1)} \left(\frac{\tau_{c_i}^i \rho}{\alpha(1+\tau_{c_i}^i)}\right)^{\gamma/(1-\alpha-\gamma)} \\ & \times \left(\frac{1}{1-g}\right)^{\gamma/(1-\alpha-\gamma)} \left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{-1/(1-\alpha-\gamma)\gamma/(1-\alpha)} \end{aligned}$$

$$
\begin{aligned}
&- g\left(\frac{\tau_{c_i}^i \rho}{\alpha(1+\tau_{c_i}^i)}\right)^{(1-\alpha)/(1-\alpha-\gamma)}\left(\frac{1}{1-g}\right)^{(1-\alpha)/(1-\alpha-\gamma)} \\
&\times\left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{-1/(1-\alpha-\gamma)}\Bigg\} \\
&= \sum_{i=1}^{2}\left\{\tau_f \frac{\rho}{\alpha(1-\tau_f)}A_i^{\gamma} - \frac{g}{1-g}A_i^{1-\alpha}\right\} \\
&\left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{-1/(1-\alpha-\gamma)}\left(\frac{1}{1-g}\right)^{\gamma/(1-\alpha-\gamma)},
\end{aligned}
$$

where $A_i = (\frac{\tau_{c_i}^i \rho}{\alpha(1+\tau_{c_i}^i)})^{1/(1-\alpha-\gamma)}$.

Now, we have

$$
\begin{aligned}
f = &\left\{\left[\tau_f \frac{\rho}{\alpha(1-\tau_f)}A_1^{\gamma} - \frac{g}{1-g}A_1^{1-\alpha}\right]\right. \\
&\left. + \left[\tau_f \frac{\rho}{\alpha(1-\tau_f)}A_2^{\gamma} - \frac{g}{1-g}A_2^{1-\alpha}\right]\right\}^{(1-\alpha-\gamma)/(1-\alpha-\beta-\gamma)} \\
&\times\left(\frac{\rho}{\alpha(1-\tau_f)}\right)^{1/(1-\alpha-\beta-\gamma)}\left(\frac{1}{1-g}\right)^{\gamma/(1-\alpha-\beta-\gamma)}. \qquad (56)
\end{aligned}
$$

Hence, the objective function of the federal government can be written as

$$
\begin{aligned}
&\chi_1(\ln c_1 + \theta_1^1 \ln f + \theta_2^1 \ln s_1) + \chi_2(\ln c_2 + \theta_1^2 \ln f + \theta_2^2 \ln s_2) \\
&= \chi_1\left\{\frac{1}{1-\alpha}\ln(1-\tau_f) + \left(\frac{\gamma}{1-\alpha} + \theta_2^1\right)\right. \\
&\left.\left[-\frac{1-\alpha}{1-\alpha-\gamma}\ln(1-g) + \frac{1}{1-\alpha-\gamma}\ln(1-\tau_f)\right]\right\} \\
&+ \chi_2\left\{\frac{1}{1-\alpha}\ln(1-\tau_f) + \left(\frac{\gamma}{1-\alpha} + \theta_2^2\right)\right. \\
&\left.\left[-\frac{1-\alpha}{1-\alpha-\gamma}\ln(1-g) + \frac{1}{1-\alpha-\gamma}\ln(1-\tau_f)\right]\right\} \\
&+ [\chi_1 C_1 + \chi_2 C_2]\frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}
\end{aligned}
$$

$$\ln\left\{\left[\tau_f \frac{\rho}{\alpha(1-\tau_f)}(A_1^\gamma + A_2^\gamma) - \frac{g}{1-g}(A_1^{1-\alpha} + A_2^{1-\alpha})\right]\right.$$
$$+ [\chi_1 C_1 + \chi_2 C_2]\left\{\frac{1}{1-\alpha-\beta-\gamma}\ln(1-\tau_f)\right.$$
$$\left.\left. + \frac{-\gamma}{1-\alpha-\beta-\gamma}\ln(1-g)\right\} + \text{constant}, \tag{57}$$

where

$$C_i = \left(\frac{\gamma}{1-\alpha} + \theta_2^i\right)\frac{\beta}{1-\alpha-\gamma} + \frac{\gamma}{1-\alpha} + \theta_2^i, \quad i = 1,2.$$

The federal government's optimization problem is equivalent to maximizing the expression in Eq. (57) with respect to τ_f and g. Thus, we have

$$-\chi_1 \frac{(1-\alpha)\theta_2^1 - \gamma}{1-\alpha-\gamma} - \chi_2 \frac{(1-\alpha)\theta_2^1 - \gamma}{1-\alpha-\gamma} - [\chi_1 C_1 + \chi_2 C_2]\frac{\gamma}{1-\alpha-\beta-\gamma}$$
$$[\chi_1 C_1 + \chi_2 C_2]\frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}\frac{\frac{1}{1-g}(A_1^{1-\alpha} + A_2^{1-\alpha})}{\tau_f \frac{\rho}{\alpha(1-\tau_f)}(A_1^\gamma + A_2^\gamma) - \frac{g}{1-g}(A_1^{1-\alpha} + A_2^{1-\alpha})}$$
$$= 0,$$

$$-\chi_1 \frac{1+\theta_2^1}{1-\alpha-\gamma} - \chi_2 \frac{1+\theta_2^2}{1-\alpha-\gamma} - [\chi_1 C_1 + \chi_2 C_2]\frac{1}{1-\alpha-\beta-\gamma}$$
$$[\chi_1 C_1 + \chi_2 C_2]\frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}\frac{\frac{\rho}{\alpha(1-\tau_f)}(A_1^\gamma + A_2^\gamma)}{\tau_f \frac{\rho}{\alpha(1-\tau_f)}(A_1^\gamma + A_2^\gamma) - \frac{g}{1-g}(A_1^{1-\alpha} + A_2^{1-\alpha})}$$
$$= 0.$$

From these derivations above, we have

Proposition 5. The optimal local taxes, optimal federal income tax, and optimal federal transfers are given by

$$\tau_{c_i}^i = \frac{\omega_2^i(1-\alpha) + \gamma}{1-\alpha-\gamma},$$

$$\tau_{k_i}^i = 0,$$

$$g = 1 - \frac{(K - K_2 + K_1)(A_1^{1-\alpha} + A_2^{1-\alpha})}{K_1[(A_1^{1-\alpha} + A_2^{1-\alpha}) - \frac{\rho}{\alpha}(A_1^\gamma + A_2^\gamma)]},$$

Table 1
Optimal tax rates and transfers versus the productivity of local spending

γ	0.0	0.05	0.1	0.15	0.20	0.25	0.30
τ_c^1	0.12	0.206154	0.30667	0.425455	0.568	0.742222	0.96
τ_c^2	0.1	0.184615	0.283333	0.4	0.54	0.711111	0.925
τ_f	0.244043	0.23142	0.216711	0.199333	0.178483	0.153002	0.121152
g	−0.753848	−0.42049	−0.329976	−0.300318	−0.298075	−0.313655	−0.344829
τ_k^1	0	0	0	0	0	0	0
τ_k^2	0	0	0	0	0	0	0

$$\tau_f = 1 - \frac{(K - K_2 + K_1)\frac{\rho}{\alpha}(A_1^{\gamma} + A_2^{\gamma})}{K_2[(A_1^{1-\alpha} + A_2^{1-\alpha}) - \frac{\rho}{\alpha}(A_1^{\gamma} + A_2^{\gamma})]},$$

where

$$K_1 = \chi_1 \frac{(1-\alpha)\theta_2^1 - \gamma}{1-\alpha-\gamma} + \chi_2 \frac{(1-\alpha)\theta_2^1 - \gamma}{1-\alpha-\gamma} + [\chi_1 C_1 + \chi_2 C_2]\frac{\gamma}{1-\alpha-\beta-\gamma},$$

$$K_2 = \chi_1 \frac{1+\theta_2^1}{1-\alpha-\gamma} + \chi_2 \frac{1+\theta_2^2}{1-\alpha-\gamma} + [\chi_1 C_1 + \chi_2 C_2]\frac{1}{1-\alpha-\beta-\gamma},$$

$$K = [\chi_1 C_1 + \chi_2 C_2]\frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}.$$

In this proposition, as a result of specific assumptions on the utility function and technology, local consumption tax at locality i ($i = 1, 2$) only depends on its own preference and technology parameters. However the optimal federal income tax and transfers clearly depend on all preference and technology parameters of the two localities plus the social-welfare weights assigned to agent 1 and agent 2.

In order to get some intuition out of these explicit solutions of optimal taxes and transfer schemes, let us make some numerical simulations.

In Table 1, we focus on how the change in the productivity of local public spending measured by the parameter γ affects the choices of taxes and transfers. All other exogenous parameters take the following values: $\alpha = 0.3$, $\beta = 0.2$, $\omega_1^1 = 0.2$, $\omega_1^2 = 0.12$, $\omega_2^1 = 0.2$, $\omega_2^2 = 0.1$, $\chi_1 = 0.6$, $\chi_2 = 0.4$, and $\rho = 0.05$. When $\gamma = 0$, local public spending does not contribute to private production.[10] But at the same time, the productivity of federal public spending is set at a relatively high value: $\beta = 0.2$. Therefore, it is optimal to let localities 1 and 2 levy consumption taxes and transfer a large share of local revenues to

[10] Local spending does enter the utility function of the agents as $\omega_2^1 = 0.2$ and $\omega_2^2 = 0.1$.

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Table 2
Optimal tax rates and transfers versus the productivity of private

Capital

α	τ_c^1	τ_c^2	τ_f	g	τ_k^1	τ_k^2
0.10	0.26	0.2375	0.153934	−0.0232071	0	0
0.15	0.269333	0.246667	0.136664	−0.105997	0	0
0.20	0.28	0.257143	0.118314	−0.200658	0	0
0.25	0.292328	0.269231	0.09863336	−0.309935	0	0
0.30	0.306667	0.283333	0.0772916	−0.437486	0	0
0.35	0.323636	0.3	0.0538344	−0.588302	0	0
0.40	0.344	0.32	0.0276274	−0.769371	0	0
0.45	0.368889	0.344444	−0.00224604	−0.990787	0	0
0.50	0.4	0.375	−0.0371607	−1.26769	0	0
0.55	0.44	0.414286	−0.0792772	−1.62389	0	0

the federal government to finance federal spending. As local public spending gradually becomes more productive (i.e., γ rises from zero to 0.30), local consumption taxes rises sharply from around 10% to more than 90%. Please note the difference in the rates of the consumption tax between locality 1 and locality 2, which results from the difference in the effects of local spending on private utility in the two localities. That is to say, since $\omega_2^1 = 0.2 > \omega_2^2 = 0.1$, it is always optimal for locality 1 to levy a higher consumption tax than locality 2: $\tau_c^1 > \tau_c^2$. As federal income tax is more distortionary than pure consumption tax, the federal income tax rate gradually decreases from 24.4% to 12.1%. At the same time, federal transfers are always negative, and local consumption taxes are utilized to finance federal spending. These 'reverse' federal transfers are always optimal when a local consumption tax is available and when the federal government is the leader in its Stackelberg game with local governments and private agents.

It is also possible for the federal government to levy a negative income tax (provide a production subsidy) and 'force' the two local governments to tax consumption and remit their revenues to the federal government. Therefore, the less distortionary consumption tax can be used to finance federal spending and to subsidize private production. This case is illustrated in Table 2.

This table shows the responses of the optimal tax rates and federal transfers to changes in the productivity of private capital measured by the parameter α. All other preference and production parameters are fixed at the following values: $\beta = 0.1$, $\gamma = 0.1$, $\omega_1^1 = 0.1$, $\omega_1^2 = 0.12$, $\omega_2^1 = 0.1$, $\omega_2^2 = 0.1$, $\chi_1 = 0.6$, $\chi_2 = 0.4$, and $\rho = 0.05$. As α rises from 0.10 to 0.55, federal income tax decreases from 15.4% to −7.9%. The rate of federal transfers changes from −2.3% to −162%.

Table 3
Optimal tax rates and transfers versus the productivity of federal spending

β	0.01	0.05	0.1	0.15	0.20	0.25	0.30
τ_c^1	0.30667	0.30667	0.30667	0.30667	0.30667	0.30667	0.30667
τ_c^2	0.283333	0.283333	0.283333	0.283333	0.283333	0.283333	0.283333
τ_f	0.33980	0.354832	0.373571	0.392311	0.41105	0.429789	0.448529
g	0	0	0	0	0	0	0
τ_k^1	0	0	0	0	0	0	0
τ_k^2	0	0	0	0	0	0	0

While there does exist a rationale for optimal reverse transfers from local to federal governments, the reality in developed countries shows the opposite. We will not argue whether reality is a violation of the theoretical optimality here. But it is interesting to note that, if we impose the condition $g \geq 0$, we have

Proposition 6. When $g \geq 0$, the optimal local taxes, federal income tax, and federal transfers are

$$\tau_{c_i}^i = \frac{\omega_2^i(1-\alpha)+\gamma}{1-\alpha-\gamma},$$

$$\tau_{k_i}^i = 0,$$

$$\tau_f = 1 - \frac{K_1}{K_2}\frac{\rho}{\alpha}\frac{A_1^\gamma + A_2^\gamma}{A_1^{1-\alpha} + A_2^{1-\alpha}},$$

$$g = 0.$$

Therefore, federal transfers are always zero. This 'forced' choice of federal transfers effectively precludes the federal government from taking the advantage of the less distortionary local consumption to finance federal spending and subsidize private production. A simple example is given in Table 3.

In Table 3, the measure of the productivity of federal spending rises from 0.01 to a very high value of 0.30. Other parameter values are set to be: $\alpha = 0.3$, $\gamma = 0.1$, $\omega_1^1 = 0.2$, $\omega_1^2 = 0.12$, $\omega_2^1 = 0.2$, $\omega_2^2 = 0.1$, $\chi_1 = 0.6$, $\chi_2 = 0.4$, and $\rho = 0.05$. It is clear that, since $g = 0$, federal spending can only be financed by the federal income tax. As its productivity increases, the federal income tax rate rises from 34% to 44%. As a result of our chosen utility and production functions, local consumption taxes remain constant since they are independent of the productivity of federal spending.

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5. The case of a positive property tax

In most developed countries, the local property tax is positive. In order to generate a positive property tax in our model, it is easiest to set the local consumption tax at zero. In this case, it can be shown that

Proposition 7. If the local consumption tax is zero, then

$$\tau_k^1 = \frac{\sqrt{[4\alpha(\gamma + (1-\alpha)\omega_2^1](1-\alpha)(1+\omega_2^1)\rho^2 + [\alpha^2(1+\omega_2^1) + \gamma + \omega_2^1 - (3\omega_2^1 + 2)\alpha]^2\rho^2}}{2\alpha(1-\alpha)(1+\omega_2^1)}$$
$$+ \frac{[\alpha^2(1+\omega_2^1) + \gamma + \omega_2^1 - (3\omega_2^1 + 2)\alpha]\rho}{2\alpha(1-\alpha)(1+\omega_2^1)}$$

$$\tau_k^2 = \frac{\sqrt{[4\alpha(\gamma + (1-\alpha)\omega_2^2](1-\alpha)(1+\omega_2^2)\rho^2 + [\alpha^2(1+\omega_2^2) + \gamma + \omega_2^2 - (3\omega_2^2 + 2)\alpha]^2\rho^2}}{2\alpha(1-\alpha)(1+\omega_2^2)}$$
$$+ \frac{[\alpha^2(1+\omega_2^2) + \gamma + \omega_2^2 - (3\omega_2^2 + 2)\alpha]\rho}{2\alpha(1-\alpha)(1+\omega_2^2)}$$

$$g = 1 - \frac{(K - K_2 + K_1)(B_1^{1-\alpha} + B_2^{1-\alpha})}{K_1[(B_1^{1-\alpha} + B_2^{1-\alpha}) - \frac{\rho}{\alpha}(B_1^{\gamma} + B_2^{\gamma})]},$$

$$\tau_f = 1 - \frac{(K - K_2 + K_1)\frac{\rho}{\alpha}(B_1^{\gamma} + B_2^{\gamma})}{K_2[(B_1^{1-\alpha} + B_2^{1-\alpha}) - \frac{\rho}{\alpha}(B_1^{\gamma} + B_2^{\gamma})]},$$

where

$$B_i = (\tau_k^i)^{1/(1-\alpha-\gamma)},$$

$$K_1 = \chi_1 \frac{(1-\alpha)\omega_2^1 - \gamma}{1-\alpha-\gamma} + \chi_2 \frac{(1-\alpha)\omega_2^1 - \gamma}{1-\alpha-\gamma} + [\chi_1 C_1 + \chi_2 C_2]\frac{\gamma}{1-\alpha-\beta-\gamma},$$

$$K_2 = \chi_1 \frac{1+\omega_2^1}{1-\alpha-\gamma} + \chi_2 \frac{1+\omega_2^2}{1-\alpha-\gamma} + [\chi_1 C_1 + \chi_2 C_2]\frac{1}{1-\alpha-\beta-\gamma},$$

$$K = [\chi_1 C_1 + \chi_2 C_2]\frac{1-\alpha-\gamma}{1-\alpha-\beta-\gamma}.$$

Table 4 illustrates how local property taxes change with respect to the productivity of private capital.

Table 4
Optimal tax rates and transfers versus private productivity

α	0.2	0.25	0.3	0.35	0.40
τ_k^1	0.0548904	0.0357433	0.0264897	0.0210318	0.0174299
τ_k^2	0.0446251	0.0305477	0.0232356	0.0187604	0.0157411
τ_f	0.278583	0.292879	0.292324	0.286295	0.277641
g	0.0161731	0.171493	0.228833	0.248805	0.249675
τ_c^1	0	0	0	0	0
τ_c^2	0	0	0	0	0

In Table 4, we have set all other parameter values at $\gamma=0.1$, $\beta=0.2$, $\omega_1^1=0.2$, $\omega_1^2=0.12$, $\omega_2^1=0.2$, $\omega_2^2=0.1$, $\chi_1=0.6$, $\chi_2=0.4$, and $\rho=0.05$. As the productivity of private capital, α, rises, optimal property taxes in both localities decrease steadily. In the meantime, federal transfers to local governments rise. The rising federal transfers are financed from the federal income tax, which first increases and then declines—a typical Laffer curve. The reason for this result is as follows. Local property taxes are always more distortionary than the federal income tax. As the productivity of private capital rises, it is optimal to reduce local property taxes and stimulate capital accumulation. To maintain local public spending, the federal government will raise its income tax and its transfers to localities. With a cut in the property tax in both localities, coupled with rising productivity, private capital accumulation accelerates. In the end, the tax base for the federal income tax expands, and the federal government can raise even more revenues through a reduced income tax rate. Therefore, the federal income tax is a Laffer curve of the productivity of private capital.

6. Conclusion

This paper has presented a fiscal federalism approach to the optimal federal income tax, local consumption tax, local property tax, and federal transfers in a dynamic model of capital accumulation with some complicated structure of the Stackelberg games among private agents, local governments, and the federal government. In general, the optimal long-run local property tax is zero if the local property tax is constrained to be nonnegative, whereas the optimal local consumption tax is always positive. When the local consumption tax is chosen optimally, the federal income tax can be either positive or negative. For most reasonable parameter values, our numerical calculations have shown that with a positive local consumption tax, there is a reverse transfer from local governments to the federal government. In this case, the local consumption tax is used to finance federal spending and even finance federal subsidy to private production if private capital is very productive relative to federal

and local public expenditures. These results stand in sharp contrast to the real world where local governments usually receive transfers from the federal government. Of course, in light of a large body of literature on optimal taxation since the 1970s, it is not surprising to find that many optimal tax (subsidy) formulas have not been carried out in practice. Whereas the actual implementation of taxes and transfers in different countries are a result of political, economic, and historical circumstances, our theoretical inquiry does illustrate the potential welfare gain from using the local consumption tax to finance federal spending and even to subsidize private production. However, our finding of a negative federal transfer is, at least partially, a result of assuming away interjurisdictional benefit spillovers from local spending. In the presence of such external benefits, decentralized decisions about spending would typically lead to the underprovision of such goods, hence makes it efficient for the federal government to use a system of matching grants that reduce the marginal cost of local spending and, thus, encourage a higher level of spending on those goods that generate positive externalities.[11]

It is also worthwhile to note that, without the multi-tier government structure, namely, if there exists only a one-level government, it is always optimal to set both the property tax and the income tax to zero when there is a consumption tax. Once we have a two-tier system of federal government with the Stackelberg game between the federal government (the leader) and local governments (the followers) and private agents (the followers), the federal income tax can be positive.

In general, if the local consumption tax is set to zero, then the local property tax is positive. Furthermore, in this case, the federal income tax and federal transfers to local governments are always positive. This is because a federal income tax is less distortionary than a local property tax in its adverse effect on private capital accumulation.

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第 10 章

公共开支与经济增长

The growth impact of intersectoral and intergovernmental allocation of public expenditure: With applications to China and India

Tao ZHANG[a,b], Heng-fu ZOU[c,*]

[a]*Guanghua School of Management, Peking University, Beijing, China*
[b]*Institute for Advanced Studies, Wuhan University, Wuhan, China*
[c]*Development Research Group, World Bank, MC2-611, 1818 H Street NW, Washington, DC 20433, USA*

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Abstract

The negative association between fiscal decentralization and provincial economic growth has been found to be consistently significant and robust in China. For India, however, we have found that fiscal decentralization is positively, and even statistically significantly, associated with state economic growth. The state allocation of public spending in various sectors is broadly consistent with "growth maximizing," whereas increases in the central allocation of its budget among development projects, nondevelopment projects, and social and community services by cutting the center's spending on all other functions can promote regional growth.

JEL classification: E62; H2; H4; O4; R5

Keywords: Fiscal decentralization; Public spending; Growth; Chinese economy; Indian economy

1. Introduction

Currently, there have been three approaches to studying the growth impact of public expenditures on economic growth: (1) Aschauer (1989) and Barro (1990), among many others, have studied the impact of aggregate government spending on growth and productivity. In

* Corresponding author. Development Research Group, World Bank, MC2-611, 1818 H Street NW, Washington, DC 20433, USA. Tel.: +1-202-473-7939; fax: +1-202-522-1154.
E-mail address: hzou@worldbank.org (H. Zou).

those studies, government spending is divided either into aggregate consumption and aggregate investment or into aggregate spending in different sectors. The growth impact of various spending by different levels of government has not been carefully examined. (2) Devarajan, Swaroop, and Zou (1996) have taken the first step toward a systematic examination of the relationship between the composition of public expenditure and economic growth. While they have focused on the growth effects of various central government's expenditures, they have largely ignored the corresponding role of state and local government spending in the growth process. (3) Finally, Davoodi and Zou (1998), Xie, Zou, and Davoodi (1999), and Zhang and Zou (1998) have explored the growth effect of aggregate public spending by different levels of government along the line of fiscal-federalism arguments, but they have not looked into the composition of various public spending by different levels of government.

This paper unifies and extends the three above-mentioned approaches by dealing with the growth impact of the allocation of public expenditures among multiple sectors with multiple levels of government. Positively, we need this broad framework to make actual decisions on the allocations of public spending among different sectors (such as health, education, transportation, and social welfare) and among different levels of government (such as local, state, and federal). This complete theoretical and empirical evaluation is important for two reasons.

First, out of the 75 developing and transitional economies with populations greater than 5 million, all but 12 claim to have embarked on some type of transfer of power to local governments (Dillinger, 1994). Fiscal decentralization, the devolution of fiscal power of national government to subnational governments, is seen as part of a package to reform the inefficient public sector, to increase competition among subnational governments in efficient delivery of public services, and to escape from low economic growth (Bahl & Linn, 1992; Bird & Wallich, 1993; Oates, 1993, 1999). In the decentralization process, the knowledge of the productivity of aggregate public spending or the productivity of central government expenditures is not sufficient, because we need to know the relative productivity and relative efficiency of different public expenditures by different levels of government in order to achieve optimal expenditure assignments among different levels of government. This is the core of public expenditure reviews routinely undertaken both by international agencies (the United Nations, the IMF, and the World Bank) and all governments in the world.

Second, both central governments and local governments in many countries have been facing hardening budget constraints or have been running budget deficits. Budget cutting involves not only the cut in the aggregate government spending, it also demands a clear picture on the budget sizes of central and local governments. Shall we cut the central government budget more than the local budget? Which component of public expenditures should be cut for both the center and localities? These hard choices and realities depend on the relative contributions of different public spending by different levels of governments to economic growth.

To these ends, we first provide a general, theoretical framework to integrate the allocation of public expenditures among various public sectors and among different levels of governments in Section 2 of this paper. We focus on one important dimension: economic growth. Our emphasis on the growth dimension is due to three reasons. First, economic growth is often cited as one objective of fiscal decentralization and efficient public expenditures.

Second, a stated objective of many governments is to adopt policies that lead to a sustained increase in per capita income. Third, per capita growth is easier to measure and interpret.

In Sections 3 and 4, as two examples of practical implementation of the general analytical framework, we investigate the effects on provincial (state) economic growth of fiscal decentralization and various public expenditures by both the central governments and provincial (state) governments in China and India, respectively. We summarize our main findings in Section 5.

2. Analytical framework

We develop a theoretical model that links multiple sectors of public spending by multiple levels of government to economic growth in this section. To be as general as possible, the model assumes that there are three levels of government: federal, state, and local. In the model, fiscal decentralization is defined as spending by each level of government as a fraction of total government spending. For example, fiscal decentralization increases if spending by state and local governments rises relative to spending by the federal government. Furthermore, for each level of government, there are various public expenditures. The model then allows us to analyze the efficiency gains of fiscal decentralization and to evaluate the growth impact of various public spending by the three levels of government.

Following Barro (1990), we begin with an endogenous growth model consisting of a production function with multiple inputs: private capital and multiple public spending by the three levels of government. Let k be private capital stock, g the total government spending, f the vector of federal government spending, s the vector of state government spending, and l the vector of local government spending (see Eqs. (1) and (2)):

$$f = (f_1, \ldots, f_i, \ldots, f_I) \tag{1}$$

$$s = (s_1, \ldots, s_j, \ldots, s_J)$$

$$l = (l_1, \ldots, l_h, \ldots, l_H)$$

and

$$\sum_{i=1}^{I} f_i + \sum_{j=1}^{J} S_j + \sum_{h=1}^{H} l_h = g \tag{2}$$

The production function is a nested Cobb–Douglas[1] (Eq. (3))

$$y = k^{\alpha}\left[\prod_{i=1}^{I} f_i^{\beta_i}\right]^{\beta}\left[\prod_{j=1}^{J} s_j^{\gamma_j}\right]^{\gamma}\left[\prod_{h=1}^{H} l_h^{\omega_h}\right]^{\omega} \tag{3}$$

[1] The use of more general functional forms such as the CES would not alter our analysis qualitatively (see Devarajan et al., 1996; Xie et al., 1999).

where y is per capita output, $1>\alpha>0$, $1>\beta>0$, $1>\gamma>0$, $1>\omega>0$, $\alpha+\beta+\gamma+\omega=1$, $\beta_i>0$ for $i=1,\ldots,I$, $\sum_i\beta_i\leq 1$, $\gamma_j>0$ for $j=1,\ldots,J$, $\sum_j\gamma_j\leq 1$, $\omega_h>0$ for $h=1,\ldots,H$, and $\sum_h\omega_h\leq 1$.

The introduction of public spending by different levels of government creates a link between differential effects of various expenditures by the three levels of government and growth. The division of consolidated or total government spending g among different levels of government takes the following form (Eqs. (4)–(6)):

$$\sum_{i=1}^{I} f_i = \theta_f g \tag{4}$$

$$\sum_{j=1}^{J} s_j = \theta_s g \tag{5}$$

$$\sum_{h=1}^{H} l_h = \theta_h g \tag{6}$$

and $\theta_f+\theta_s+\theta_l=1$ and $0<\theta_i<1$ for $i=f$, s, and l. Thus, θ_f is the share of federal government in total spending, θ_s is the share of state governments, and θ_l the share of local governments. It is further assumed that the federal government spends a share of δ_i ($i=1,\ldots,I$) on its ith item f_i, state governments spend a share of δ_j ($j=1,\ldots,J$) on their jth item s_j, and local governments spend a share of δ_h ($h=1,\ldots,H$) on their hth item s_h. Therefore, Eq. (7) holds true.

$$f_i = \delta_i\theta_f g \text{ for } i = 1,\ldots,I \text{ and } \sum \delta_i = 1 \tag{7}$$

$$s_j = \delta_j\theta_s g \text{ for } j = 1,\ldots,J \text{ and } \sum \delta_s = 1$$

$$l_h = \delta_h\theta_l g \text{ for } h = 1,\ldots,H \text{ and } \sum \delta_h = 1$$

The consolidated government spending g is financed by a flat income tax at rate τ (Eq. (8)):

$$g = \tau y \tag{8}$$

The representative agent's preference is given by

$$U = \int_0^{\infty} u(c, f, s, l)e^{-\rho t}dt \tag{9}$$

where c is per capita private consumption, ρ is the positive time discount rate, and $u(c,f,s,l)$ is an increasing, concave, and differentiable utility function.

The dynamic budget constraint of the representative agent is:

$$\frac{\mathrm{d}k}{\mathrm{d}t} = (1-\tau)y - c = (1-\tau)k^{\alpha}\left[\prod_{i=1}^{I} f_i^{\beta_i}\right]^{\beta}\left[\prod_{j=1}^{J} S_j^{\gamma_j}\right]^{\gamma}\left[\prod_{h=1}^{H} l_h^{\omega_h}\right]^{\omega} - c \tag{10}$$

For analytical simplicity, let

$$u(c,f,s,l) = \ln c + \sigma_f \ln \prod_{i=1}^{I} f_i^{\beta_i} + \sigma_s \ln \prod_{j=1}^{J} S_j^{\gamma_j} + \sigma_l \ln \prod_{h=1}^{H} l_h^{\omega_h} \tag{11}$$

where σ_f, σ_s, and σ_l are positive (Eq. (11)). While the productivity of the expenditures by the federal, state, and local governments are measured by β, γ, and ω, respectively, their impacts on the representative agent's utility are measured by θ_f, θ_s, and σ_l, respectively. All government expenditures enter the production function and the utility function in the Cobb–Douglas form. That is to say, production and consumption services from public expenditures are generated through a specific production technology. Again, the Cobb–Douglas form is adapted here for analytical tractability.

We further assume a constant tax rate τ along the balanced growth path. Hence, the ratio (g/y) is constant. With simple, but tedious calculation (Eq. (12)),

$$\frac{y}{k} = \frac{g}{\tau k} = \tau\frac{1-\alpha}{\alpha}\left[\prod_{i=1}^{I}\delta_i^{\beta_i}\right]^{\frac{\beta}{\alpha}}\left[\prod_{j=1}^{J}\delta_j^{\gamma_j}\right]^{\frac{\gamma}{\alpha}}\left[\prod_{h=1}^{H}\delta_h^{\omega_h}\right]^{\frac{\omega}{\alpha}}\theta_f^{\frac{\beta}{\alpha}\sum_{i=1}^{I}\beta_i}\theta_s^{\frac{\gamma}{\alpha}\sum_{j=1}^{J}\gamma_j}\theta_l^{\frac{\omega}{\alpha}\sum_{h=1}^{H}\omega_h} \tag{12}$$

Given the total government spending g, the constant tax rate τ, and the shares of spending by different levels of government (θ_i's, $i=f,s,l$) among the aggregate government spending, and the shares of allocations of public expenditures among various sectors by each level of government (δ_i, $i=1,\ldots,I$, δ_j, $j=1,\ldots,J$, and δ_h, $h=1,\ldots,H$), representative agent's choices are determined by maximizing Eq. (9) with respect to c and k subject to Eq. (10) and initial conditions. Along the balanced growth, the solution for the per capita growth rate of the economy is given by:

$$\frac{\mathrm{d}y/\mathrm{d}t}{y} = \alpha(1-\tau)\frac{y}{k} - \rho$$

or

$$\frac{\mathrm{d}y/\mathrm{d}t}{y} = \alpha(1-\tau)\tau^{\frac{1-\alpha}{\alpha}}\left[\prod_{i=1}^{I}\delta_i^{\beta_i}\right]^{\frac{\beta}{\alpha}}\left[\prod_{j=1}^{J}\delta_j^{\gamma_j}\right]^{\frac{\gamma}{\alpha}}\left[\prod_{h=1}^{H}\delta_h^{\omega_h}\right]^{\frac{\omega}{\alpha}}\theta_f^{\frac{\beta}{\alpha}\sum_{i=1}^{I}\beta_i}\theta_s^{\frac{\gamma}{\alpha}\sum_{j=1}^{J}\gamma_j}\theta_l^{\frac{\omega}{\alpha}\sum_{h=1}^{H}\omega_h} - \rho \tag{13}$$

For the case that, $\sum\beta_i = 1$, $\sum\gamma_j = 1$, and $\sum\omega_h = 1$, the expression can be further simplified to:

$$\frac{\mathrm{d}y/\mathrm{d}t}{y} = \alpha(1-\tau)\tau^{\frac{1-\alpha}{\alpha}}\left[\prod_{i=1}^{I}\delta_i^{\beta_i}\right]^{\frac{\beta}{\alpha}}\left[\prod_{j=1}^{J}\delta_j^{\gamma_j}\right]^{\frac{\gamma}{\alpha}}\left[\prod_{h=1}^{H}\delta_h^{\omega_h}\right]^{\frac{\omega}{\alpha}}\theta_f^{\frac{\beta}{\alpha}}\theta_s^{\frac{\gamma}{\alpha}}\theta_l^{\frac{\omega}{\alpha}} - \rho \tag{14}$$

Both Eqs. (13) and (14) show that the long-run growth rate of per capita output is a function of the tax rate, shares of spending by different levels of government, and the shares of spending allocation on various public expenditures undertaken by the three levels of government, respectively. This understanding is the theoretical foundation for our empirical investigation on the relationship between growth and intersectoral and intergovernmental allocations of public expenditures. Please note that, for a given share of total government spending in GDP, a reallocation of public spending among different levels of government and among different sectors can lead to higher economic growth if the existing allocation is different from the growth-maximizing allocation of public expenditures. To show this point, we maximize the growth rate in the simple case of Eq. (14) (Eq. (15)):

$$\text{Max}\left\{\alpha(1-\tau)\tau^{\frac{1-\alpha}{\alpha}}\left[\prod_{i=1}^{I}\delta_i^{\beta_i}\right]^{\frac{\beta}{\alpha}}\left[\prod_{j=1}^{J}\delta_j^{\gamma_j}\right]^{\frac{\gamma}{\alpha}}\left[\prod_{h=1}^{H}\delta_h^{\omega_h}\right]^{\frac{\omega}{\alpha}}\theta_f^{\frac{\beta}{\alpha}}\theta_s^{\frac{\gamma}{\alpha}}\theta_l^{\frac{\omega}{\alpha}}-\rho\right\} \tag{15}$$

by choosing δ_i (i=1,..., I), δ_j (j=1,..., J), δ_h (h=1,..., H), θ_f, θ_s, and θ_l subject to the constraint $\theta_f+\theta_s+\theta_l=1$, $\sum\delta_i=1$, $\sum\delta_j=1$, and $\sum\delta_h=1$. The solution to this problem involves the following formulae for the growth-maximizing case:

$$\theta_f^* = \frac{\beta}{\beta+\gamma+\omega} \tag{16}$$

$$\theta_s^* = \frac{\gamma}{\beta+\gamma+\omega} \tag{17}$$

$$\theta_l^* = \frac{\omega}{\beta+\gamma+\omega} \tag{18}$$

$$\delta_i^* = \frac{\beta_i}{\sum\beta_i} = \beta_i \text{ for } i = 1,\ldots,I \tag{19}$$

$$\delta_j^* = \frac{\gamma_j}{\sum\gamma_j} = \gamma_j \text{ for } j = 1,\ldots,J \tag{20}$$

$$\delta_h^* = \frac{\omega_h}{\sum\omega_h} = \omega_h \text{ for} h = 1,\ldots,H \tag{21}$$

Therefore, as long as the actual θ_f, θ_s, θ_l, δ_i (i=1,..., I), δ_j (j=1,..., J), and δ_h(h = 1,..., H) differ from the growth-maximizing ones θ_f^*, θ_s^*, θ_l^*, δ_i^* (i=1,..., I), δ_j^* (j=1,..., J), and δ_h^* (h=1,..., H) as in Eqs. (16)–(21), the growth rate can always be increased without any change in the tax rate and the total budget size in the GDP.

We also have simple explanations for the growth-maximizing shares for different levels of government spending θ_f^*,θ_s^*,θ_l^*, and the multisector allocation of public spending by the three levels of government δ_i^* (i = 1,..., I), δ_j^* (j=1.,..., J), and δ_h^* (h = 1,..., H) as in Eqs. (16)–(21). We can regard β, γ, and ω as the measures for the total productivity of federal, state, and local government spending, respectively, and ($\beta+\gamma+\omega$) as the aggregate productivity of all

government spending. The growth-maximizing shares for public spending allocation among three levels of government are just the ratios of individual productivity over the total productivity. Similarly, we can take the vectors $\{\beta_i\}_{i=1}^{I}$, $\{\gamma_j\}_{j=1}^{J}$, and $\{\omega_h\}_{h=1}^{H}$ to be the vectors of sectoral productivity (in generating productive services) for the multisector expenditures by the federal, state, and local governments, respectively. For each level of government, these productivity measures sum to unity. The growth-maximizing rule for each sector allocation at each level of government is again the ratio of its productivity over the total productivity, which is 1. Of course, these explanations depend on our specific assumptions on the production technology. For a general production technology, it is difficult to have the nice separability in the rules for allocating public spending among different levels of government from the rules for spending among multiple sectors by each level of government.

Regarding fiscal decentralization and the allocation of budget among different levels of government, an important point can be derived from this theoretical exercise: It does not hold true that the more decentralized a country's fiscal system becomes, the faster its economy grows. As far as economic growth is concerned, there exists only an optimal degree of fiscal decentralization, which is determined by the relative productivity of different levels of government spending in our specific example.

In our specific example, it is very easy to show that the growth-maximizing allocation rules for public expenditures are the same as the welfare-maximizing rules for public spending as a result of logarithmic utility function. This is an extension of the result obtained by Xie et al. (1999).

From our theoretical analysis in Eq. (14), the growth rate is determined directly by the tax rate, the allocation of public spending among different levels of governments, the allocation of spending among different sectors by each level of government, and other exogenous variables. For a linear approximation, we have the following regression equation:

$$\frac{dy/dt}{y} = \mu_0 + \mu_\tau \tau + \mu_s \theta_s + \mu_l \theta_l + \sum_{i=1}^{I-1} \mu_i \delta_i + \sum_{j=1}^{J-1} \mu_j \delta_j + \sum_{h=1}^{H-1} \mu_h \delta_h + \mu_z Z \tag{22}$$

where Z is a vector of other exogenous variables in growth literature that we will control in our estimations and μ's are the coefficients to be estimated. It shall be noted that we have dropped θ_f, δ_I, δ_J, δ_H in Eq. (22) because of the various add-up conditions for these share variables.

3. Application to China

3.1. Trend in fiscal allocations between central and local governments: 1978–1992

Since the late 1970s, China has gone through several rounds of fiscal reforms in an effort to decentralize its fiscal system and fiscal management (Wong, Heady, & Woo, 1993; World Bank, 1990, 1992, 1995, 1996; Zhou & Yang, 1992). Can we say that the fiscal system is

now more decentralized? The following examination suggests that the question should be answered very carefully.

3.1.1. Overall fiscal status

In China, official government spending appears in three ways: budgetary spending, extrabudgetary spending, and consolidated spending, which is the sum of budgetary and extrabudgetary spending.

Budgetary spending accounted for 18.3% of GDP in 1992 compared to 30.8% in 1978.[2] Although rises were insignificant from 1978 to 1979, 1985 to 1986, and 1988 to 1989, the budgetary spending-to-GDP ratio declined continuously since the beginning of the reform in 1978. As for the share of extrabudgetary spending relative to GDP, changes were rather limited, and it rose from 14.2% in 1982 to 15.2% in 1992.[3] Consolidated budgetary spending as a share of GDP shows an inverted-U shape. It first increased during 1982–1986 from 36.4% in 1982 to 40.4% in 1986 (except for a small decline in 1985), and then declined during 1986–1992, up to 33.5% in 1992. This shows that overall government fiscal spending as a share of GDP, and especially budgetary expenditures, fell during the reform period.

3.1.2. Relative fiscal status between the central and local governments

In the literature on fiscal federalism, fiscal decentralization is measured by the relative sizes of local spending and revenue collection and central spending and revenue collection. In China, however, the relative size of local revenue collection is not a good indicator of decentralization. For many years in our sample period, most tax revenues were levied by the center, even though they were mainly collected by local governments. Locally collected revenues generally were not spent locally, so they did not reflect local tax autonomy. We take this into account in this study by focusing on the relative size of government spending between the central and local governments.

In 1978, spending by local governments, including the spending financed by transfers from the central government, was 16.4% of GDP. This accounts for 53.1% of total budgetary spending by both the central and local governments in the same year. These shares became 10.3% and 57.4%, respectively, in 1992, indicating slight progress in budgetary decentralization. The share of local budgetary spending out of total budgetary spending first declined to 46.0% in 1981, before climbing to 63.7% in 1989 and subsequently declining again, almost to its original level. Overall, the share of local budgetary spending increased over most of the decade.

By contrast, local extrabudgetary spending demonstrated a trend of fiscal centralization over the entire postreform period. Local governments spent 9.8% of GDP as extrabudgetary expenditures in 1978, and 8.4% in 1992; the share of local extrabudgetary spending in total extrabudgetary spending declined from 69.1% in 1982 to 56.4% in 1992. If we combined budgetary and extrabudgetary spending, the local share of consolidated spending fluctuated up and down from 57.5% in 1982 to 62.5% in 1989 and back to 56.9% in 1992.

[2] The data used in our calculation are described in Appendix A.

[3] The central and provincial aggregate data on extrabudgetary spending became available in 1982.

3.1.3. Fiscal decentralization from the provincial perspective

First, there is significant variation between provinces in terms of fiscal status.[4] From 1980 to 1992, the ratio of budgetary spending to provincial income ranged from 9.0% in Jiangsu (a coastal province) to 40.5% in Ningxia (an inland autonomous region), indicating a general tendency for provincial governments to participate less in developed areas and more in underdeveloped areas. Further complications are observed when considering the three metropolitan cities, Beijing, Tianjin, and Shanghai, which represent high ranks in per capita income and above average ratios of budgetary spending to provincial income.

Second, great variations in fiscal decentralization can be found between provinces. During the period 1978–1992, the average ratio of provincial budgetary spending to central budgetary spending ranged from 0.01 in Ningxia to 0.09 in Guangdong (known as a leading province in economic reforms). Because Chinese provinces vary in terms of geographic area and population size, we adjust the fiscal-decentralization measure in per capita terms. Accordingly, the ratio of per capita provincial budgetary spending to per capita central budgetary spending was as low as 0.78 in Henan (an inland province) and as high as 4.31 in Beijing (the nation's capital).[5] For extrabudgetary spending during 1986–1992, the average province-to-center ratio in Ningxia was only 5% of that in Liaoning, a China's heavy industrial center. Since extrabudgetary spending has been financed mostly by the revenues and profits of state-owned enterprises during our sample period, we adjust the measure of decentralization for the income size. The ratios of provincial extrabudgetary spending to central extrabudgetary spending, each expressed relative to income, varied from 0.71 in Guizhou (a mountainous minority province) to 2.84 in Beijing. In terms of the ratio of per capita provincial consolidated spending to per capita central consolidated spending, the degree of fiscal decentralization varied from 0.82 in Henan to 6.67 in Shanghai, China's largest metropolitan city.

Third, fiscal decentralization within a province also varies over time. Guangdong, a coastal province favored by the central government policies and among the first to undertake economic reforms in 1978, experienced the greatest fiscal decentralization. In terms of the ratio of per capita provincial budgetary spending to per capita central budgetary spending, Guangdong had an annual average increase of 6.6% during 1978–1992. At the other extreme, Ningxia, one of the eight minority provincial areas, experienced hardly any increase in its per capita budgetary spending relative to the central government. In fact, this ratio decreased by 1.6% annually during this period. Between Guangdong and Ningxia are mostly inland provinces. In terms of the ratio of provincial per capita budgetary spending relative to the central government, the annual growth rate was 3.0% in Sichuan, the most populous province in China, and 1.8% in Henan, a political and economic center of ancient China.

[4] Of the total 30 provincial areas in China, two provincial areas, Tibet and Hainan, are excluded due to their special status. For a complete list of the 28 provincial areas used in this study, see Appendix A.

[5] The central per capita spending is the central spending divided by the total population of China.

3.2. Expenditure allocation

3.2.1. Functionwise allocation of central budgetary expenditures

In the Chinese budgeting system, budgetary expenditures are classified into 27 categories according to the use of budgetary funds. To better served our empirical analysis in Section 3.3, we now rearrange the Chinese budgetary expenditure into six groups: administration, development, human capital, national defense, urban maintenance, and other expenditures.

For the central government, among the five categories of expenditures listed, development expenditure took a share of 43.47% on the average during the period of 1978–1994. Expenses on administration and human capital took the same percentage of the total budgetary spending at 15.15% each. Another 10.61% was spent on national defense. The rest expenses accounted for 15.61%.

This pattern of functionwise distribution has not been the same during the period of 1978–1994. Development and defense spent 53.30% and 15.11% each in their total budgetary spending, and the numbers dropped to 29.56% and 8.94%, respectively. On the other hand, the expenses on administration and human capital increased respectively from 7.72% and 10.14% in 1978 to 20.70% and 20.75% in 1994. After 16 years of fiscal reforms, the central budget has become more concentrated on noneconomic activities. More than half of the central budgetary expenditures are spent on administration, on agency expenses of culture, education, public health care, and science, and on defense. The total development spending accounts less than one-third of the total spending.

3.2.2. Provincial expenditure allocation: 1987–1993

For all the 29 provinces during the period of 1987–1993, urban maintenance and development (including urban youth employment) had the highest rate of nominal growth of budgetary spending, 31.0%. The next item was administrative expenses, increased by 22.4%. The growth pattern of consolidated provincial budgetary spending behaved consistently with the one at the national level, as mentioned earlier.

Starting with administration expenditure, we find that Chinese provinces spent less, on the average, on administration in 1993 than in 1987, the first year in which the data are available. The share of administration expenses was 28.88% in 1987, and it became 24.23% in 1993. In the meantime, the central government spent 7.69% of its total budgetary expenditure on administration in 1987 and 9.05% in 1993.

Provincial spending on administration varied among the 29 provinces. In 1987, the highest spending percentage, 36.41%, was produced by Anhui, and the lowest, 20.46%, by Ningxia. The max – min difference became larger in 1993, as 33.28% by Jilin and 12.69% by Shanghai. The intertemporal changes in the budgetary spending on "administration" are also found to be different across province. Although all but two provinces reduced their spending on administration, only three provinces saw their decreases by more than 10%: Jiangsu, Liaoning, and Anhui.

For development spending, provinces in China experienced a minor decrease on the average during the period 1987–1993, whereas the central government also reduced its spending on development from 59.46% in 1987 to 41.51% in 1993. Among the 29 provinces,

20 provinces reduced their spending on development, while the remaining nine others increased development spending, most of them are fast-growing economic areas.

Both the center and most of the 29 provinces raised their spending on human capital. However, the increases are all moderate. The central government spent 4.2% on human capital in 1978 and 5.17% in 1993. The biggest increase was produced by Anhui, from 22.65% in 1987 to 29.12% in 1993.

Due to the incomplete data availability on provincial spending on urban maintenance and development, we only report its across-province distribution in 1993, the latest year in which data are completely available. The least proportion of spending, 1.46%, was provided by Qinghai, and the highest, 8.37%, by Tianjin. Generally speaking, provincial spending on urban maintenance and development took only a small proportion of their total budgetary expenditures, with an average 4.42% in the 1987–1993 period.

3.3. Empirical estimations with provincial-level data

3.3.1. Variables

Our empirical estimations are based on the annual data over the period from 1987 to 1993 for 29 provinces. The dependent variable is provincial GDP growth rate in real terms. The explanatory variables fall into four categories: (1) production inputs; (2) fiscal decentralization; (3) variables that measure the compositions of the budgetary expenditures of the central and provincial governments; and (4) standard control variables such as the investment rate, labor growth, tax rates, foreign trade, and the inflation rate.

We use the following data in our estimations:

Y = real growth rate of provincial GDP, measured in the annual percentage change;
LB = growth rate of the provincial labor force, measured by the annual percentage change in the total number of social labor force;
I = provincial investment rate, measured by the ratio of investment (accumulation in fixed asset and circulating funds) to provincial GDP;
FT = degree of openness of provincial economy, measured by the share of total volume of foreign trade (exports and imports) in provincial GDP;
TAX = tax rate;
R = inflation rate, measured by the overall social retail price index in each province;
FDC = degree of total fiscal decentralization, measured by the ratio of consolidated provincial budgetary spending to central budgetary spending;
CADM = the share of central budgetary spending on administration in total central budgetary spending;
CDEV = the share of central budgetary spending on development in total central budgetary spending;
CDFN = the share of central budgetary spending on defense in total central budgetary spending;
CHUM = the share of central budgetary spending on human capital in total central budgetary spending;

PADM = the share of provincial budgetary spending on administration in total provincial budgetary spending in each province;
PDEV = the share of provincial budgetary spending on development in total provincial budgetary spending in each province;
PURB = the share of provincial budgetary spending on urban maintenance in total provincial budgetary spending in each province; and
PHUM = the share of provincial budgetary spending on human capital in total provincial budgetary spending in each province.

3.3.2. Regression results

In our regression analysis, the measure of fiscal decentralization, FDC, is defined as the ratio of the consolidated provincial budgetary spending to central budgetary spending. Since Chinese provinces have different sizes in terms of population size, area, and GDP, we can make the ratios more comparable across provinces using an adjusted measure: the ratio of per capita state spending in each province to per capita central spending. But the results are qualitatively the same.[6]

The regression results are reported in Table 1. The first column shows the estimates when only the measure of fiscal decentralization and the shares of public spending at the central and provincial levels and a constant term are included. The estimate has shown a negative association between fiscal decentralization and real output growth. The coefficient is − 1.79 and it is significant at the conventional 5% level. The estimated coefficient for central administration is positive and significant; the estimated coefficient for central development spending is positive but insignificant; the estimated coefficient for central defense spending is negative and significant; and the coefficient for central human capital spending is positive but insignificant. On the other hand, the estimated coefficient for provincial share of administration spending is negative and significant; the coefficient for provincial development spending is negative but insignificant; the coefficient for provincial urban maintenance and development spending is positive but insignificant; and finally, the coefficient for provincial human capital spending is positive but insignificant.

The second column shows the estimates of the model when provincial fixed effects (i.e. provincial dummy variables) are included. By including fixed effects, effects of volatility on growth that occurs because of differences in the average growth rates across provinces can be removed. The estimate of fiscal decentralization, FDC, is still negative and significant. The associations between output growth and the share variables found in the first column remain unchanged. So does their significance status.

The third through fifth columns report estimation results when other variables are introduced. The results show that the negative association between fiscal decentralization and output growth remains significant and quite robust with the inclusion of other control variables. The estimated coefficients for various shares of central and provincial spending are also consistent with the ones for our baseline regression in columns 1 and 2.

[6] See Zhang and Zou (1998) for more regression results on the basis of various measures of fiscal decentralziation.

Table 1
Effect of intersectoral and intergovernmental alllocation of budgetary expenditure in China (dependent variable: real growth of provincial GDP)

Independent variables	1	2	3	4	5	6
CONSTANT	3.12					
	(4.02)					
Tax (tax rate)	−10.06	−10.63	−10.79	−10.87	−14.70	−15.00
	(−3.31)	(−3.80)	(−3.84)	(−4.06)	(−2.51)	(−3.52)
LB (labor)	0.30	0.29	0.25	0.27	0.29	0.36
	(.90)	(.70)	(.58)	(.64)	(.68)	(1.33)
FDC	−1.79	−2.00	−1.96	−1.99	−2.50	−2.42
(fiscal decentralization)	(−2.72)	(−3.29)	(−3.23)	(−3.43)	(−2.77)	(−3.59)
CADM	6.93	7.48	7.87	7.55	9.22	9.61
	(4.09)	(4.63)	(4.59)	(4.56)	(3.28)	(4.75)
CDEV	1.07	1.12	1.15	1.12	1.68	1.71
	(2.83)	(3.21)	(3.30)	(3.61)	(2.31)	(3.22)
CDFN	−6.23	−6.13	−6.52	−6.37	−7.79	−8.63
	(−6.14)	(−6.49)	(−6.17)	(−6.01)	(−3.53)	(−5.38)
CHUM	0.47	0.03	0.15	−0.04	−0.38	0.34
	(.61)	(.04)	(.21)	(−.06)	(−.44)	(.56)
PADM	−0.44	−0.39	−0.40	−0.33	−0.33	−0.29
	(−4.18)	(−2.17)	(−2.20)	(−1.83)	(−1.81)	(−2.15)
PDEV	−0.14	−0.18	−0.20	−0.25	−0.25	−0.21
	(−1.45)	(−1.37)	(−1.52)	(−1.95)	(−2.01)	(−2.14)
PHUM	0.51	0.18	0.29	0.34	0.30	0.44
	(3.91)	(1.04)	(1.58)	(1.90)	(1.65)	(3.00)
PURB	0.07	0.33	0.29	0.15	0.15	
	(.36)	(.93)	(.81)	(.40)	(.41)	
I (investment)			−0.04	0.04	0.05	0.04
			(−.54)	(.46)	(.58)	(.72)
FT (foreign trade)				0.09	0.07	0.02
				(1.12)	(.75)	(.29)
R (inflation rate)					−0.12	−0.17
					(−.74)	(−1.48)
R^2	0.63	0.77	0.78	0.79	0.79	0.75
Adjusted R^2	0.60	0.68	0.69	0.69	0.69	0.69
S.E. of regression	0.04	0.03	0.03	0.03	0.03	0.03
Obs.	136	136	135	125	125	192
Number of provinces	29	29	29	29	29	29
Provincial fixed-effects	not included	included	included	included	included	included

t Statistics are in parentheses. Source: See the data in Appendix A.

Considering the limited data on provincial urban maintenance and development spending, we run our estimations in the sixth column by dropping the variable PURB. In this case, the negative correlations between provincial spending on administration and on development and output growth become significant, and the positive correlation between provincial expendi-

tures on human capital and output growth also become significant. The impacts of other variables on output growth are found consistent with those in the previous estimations.

4. Application to India

4.1. Fiscal decentralization, public spending, and growth in India: 1970–1994

The constitution of the Republic of India can be described as quasifederal in character because it provides for a federal structure with a strong unitary feature. The states have a substantial degree of autonomy within the area of responsibility granted to them by the constitution. At the same time, local government affairs are entirely within the states' sphere, and local governments do not have constitutional status (see Agarwala, 1992; Chelliah, 1990; Rao, 1997, Rao & Sen, 1996; Singh, 1997 for details).

For expenditure assignments between the center and states, the constitution provides three lists: the Union list, the States list, and the concurrent list. All matters relating to defense, currency, banking, foreign affairs, and interstate relations are in the exclusive domain of the central government. The states are responsible for maintenance of law and order and the courts, the social sector, agriculture, infrastructure, trade within the state, and overall development of the state economy. The concurrent list of responsibility includes important civil matter such as law, marriage, succession, administration of justice, trusts and civil procedure, economic and social planning, social security, education, trade unions, and electricity. By international comparison, especially among developing countries, India is quite decentralized by the conventional measure of fiscal decentralization: the share of subnational (state) government spending out of the total (state and central) government spending. According to IMF's Government Finance Statistics (GFS), from 1974 to 1993, this ratio was between 60% and 64% and remained stable.

On the revenue side, the constitutional assignment of tax powers has been based on two principles. The first is the avoidance of assigning any one tax to the center and the states at the same time. The second is that the most important taxes, which have economywide implications or which can be collected most efficiently and economically by the central government, should be assigned to the center. In the end, the center has the power to levy individual and corporate income tax, all excise taxes, and custom duties. Therefore, the central government has the most productive sources of revenue with wide bases. According to the IMF's GFS, the share of state revenue collection out of total government tax revenue ranged from 31% to 36% from 1974 to 1993. Therefore, the revenue measure of fiscal decentralization is relatively low compared to the corresponding spending measure.

For fiscal decentralization, we will consider both spending measure and revenue measure of decentralization for India. The revenue measure for India is more appropriate than for China because central revenues have been collected by the center instead by the states. In our empirical analysis, we will also make the ratios more comparable across states using two adjusted measures: (1) the ratio of per capita state spending in each state to per capita central spending and (2) the ratio of per capita state revenue collection in each state to per capita

central revenue collection. We will see later that these adjustments can significantly change the regression results, which is not true in the case of China.

For the composition of central government expenditures according to the IMF's GFS, defense spending relative to other services was the highest, about 15–26% of the total budget. Spending on health, education, and transportation were relatively low, ranging from 1% to 3%. Spending was moderate on general public services (6–9%), agriculture (5–10%), housing (3–7%), mining (2–8%), and other economic services (5–9%). Spending on mining decreased steadily from 9% to 2% from 1977 to 1993, while spending on housing rose substantially from 3% to 7% during the same period. At the same time, its spending share on general public services remained stable.

Another perspective on central spending is provided by India Economic Statistics (various years). It divides spending into three major categories: development spending, nondevelopment spending, and social and community services. From 1970 to 1990, on the average, the central government spent 31% of its budget on development, 47.5% on nondevelopment services, and 6.4% on social and community services.[7]

For the composition of state spending by function according to the IMF's GFS, major budget allocation went to education (22–25%), agriculture (14–25%), and general public services (14–18%). Spending for health, housing, social security, energy, and transportation was moderate. ranging between 4% and 7% of total state spending. We also note that total state spending on various functions was highly stable in terms of the allocation ratios.

In order to have a better understanding of public spending at the individual state level, we have collected spending data for 16 major Indian states in four categories: administration, economic services, education, and health. These data show large variations in public spending across states and over time. For example, on the average, Kerala spent about 7% of its total budget on administration, while Bihar and Punjab spent about 11% on administration. In the state of Assam, the spending share on administration varied from a minimum of 1.4% to a maximum of 14.5% in Assam between 1970 and 1994. Many other states also experienced large changes in spending for administration.

Spending for economic services was the largest single item of state spending across Indian states. On the average, their spending share ranged from 27% in West Bengal to 46% in Haryana. Over time, the spending share for economic services was also much more stable than the share for administration.

Education spending varied across states and over time. For example, spending share for education varied from 2% to 22.7% in Himachal Pradesh. On the average, however, it accounted for 16–28% of state budget from 1970 to 1994.

As with administration, state spending shares on health varied significantly from highs of 6.7% in Haryana to 13% in Himachal Pradesh to lows of 0.2% in Madhya Pradesh, 0.4% in Maharashtra, 0.5% in Orissa, and 0.6% in Punjab.

Across the 16 major Indian states from 1970 to 1994, all states experienced large variations in their per capita income growth rates with episodes of significant, negative growth in per

[7] See Zhang and Zou (1998) for more details.

capita income. During the 24 years in our sample, Gujarat, Tamil Nadu, and Maharashtra performed relatively well, with an average growth rate greater than 3%. At the same period, Rajasthan, West Bengal, and Bihar performed poorly, with an average annual growth rate of around 1%.

4.2. Data and variables

Our regression analysis is based on the panel data from 1970 to 1994 for 16 major Indian states. The dependent variable is real per capita income growth rate in each state. We take a 5-year forward-moving average of per capita real income growth in our regression analysis in order to eliminate short-term fluctuations.[8]

The regression equation is defined as follows:

$$Y^i_{t+1,t+5} = \beta_0 \mathrm{FDC}^i_t + \beta_1 \mathrm{CDEV}_t + \beta_2 \mathrm{CNONDEV}_t + \beta_3 \mathrm{CSOCCOM}_t + \beta_4 \mathrm{SADM}^i_t + \beta_5 \mathrm{SEDU}^i_t + \beta_6 \mathrm{SHLTH}^i_t + \beta_7 \mathrm{SECON}^i_t + \Theta Z^i_t$$

where the variables are:

$Y_{(t+1,t+5)}{}^i$: Five-year forward-moving average of per capita real income growth in state i.

FDC^i_t: Measures of fiscal decentralization across states at time t. Four alternatives will be utilized in this paper:

1. FDCEXP^i_t=(total state public spending in state i)/(total central spending);
2. $\mathrm{FDCEXPPC}^i_t$=(per capita state spending in state i)/(per capital central spending);
3. FDCTAX^i_t=(total state own revenue in state i)/(total central revenue); and
4. $\mathrm{FDCTAXPC}^i_t$=(per capita state revenue in state i)/(per capital central revenue).

CDEV_t: Ratio of central development spending to total central spending at time t.

$\mathrm{CNONDEV}_t$: Ratio of central nondevelopment spending to total central spending at time t.

$\mathrm{CSOCCOM}_t$: Ratio of central social and community service spending to total central spending at time t.

SADM^i_t: Ratio of state administration spending to total state spending in state i at time t.

SEDU^i_t: Ratio of state education spending to total state spending in state i at time t.

SHLTH^i_t: Ratio of state health spending to total state spending in state i at time t.

SECON^i_t: Ratio of state economic development spending to total state spending in state i at time t.

Z^i_t: A vector of other control variables in standard growth regression analysis such as the area of each state (AREA), initial (year 1970) per capita real income in each state (GDP70), secondary school enrollment (SCHOOLING) in each state, the ratio of state own tax revenue to state aggregate income (SOTAX) in each state, and the central tax rate (CTAX) defined as the ratio of total central tax revenue over national GDP in India.

[8] Growth rates of Indian states have much higher year-to-year variations the ones of Chinese provinces. For methodological details on the lagged structure of growth rates, see Devarajan et al. (1996).

4.3. Regression results

We divide our regression analysis into four parts depending on the choice of the four measures of fiscal decentralization listed in the subsection above. The results are presented in Tables 2–5. These four tables generate very consistent results for most variables, so we summarize the main results next.

Table 2
Effect of intersectoral and intergovernmental allocation of public expenditure in India (dependent variable: real per capita net state product growth rate)

Independent variables	1	2	3	4	5
CONSTANT	−0.719	−0.72	−0.731	−0.734	−1.192
	(−3.662)	(−3.648)	(−3.699)	(−3.724)	(−5.869)
FDCEXP	−0.042	−0.083	−0.199	−0.15	−0.519
	(−0.055)	(−0.082)	(−0.195)	(−0.147)	(−0.535)
CDEV	1.162	1.164	1.177	1.163	2.245
	(3.087)	(3.071)	(3.104)	(3.075)	(5.626)
CNONDEV	0.476	0.477	0.478	0.458	0.813
	(3.041)	(3.033)	(3.041)	(2.911)	(5.032)
CSOCCOM	2.583	2.579	2.563	2.586	9.513
	(3.514)	(3.489)	(3.466)	(3.508)	(7.55)
SADM	0.052	0.053	0.043	0.018	0.051
	(0.450)	(0.453)	(0.369)	(0.15)	(0.414)
SEDU	−0.068	−0.067	−0.058	−0.051	−0.093
	(−1.393)	(−1.285)	(−1.075)	(−0.945)	(−1.763)
SHLTH	0.028	0.028	0.027	−0.006	−0.073
	(0.408)	(0.401)	(0.385)	(−0.09)	(−1.094)
SECON	−0.008	−0.008	−0.012	−0.015	−0.004
	(−0.321)	(−0.326)	(−0.476)	(−0.576)	(−0.164)
AREA		0	0	0	0
		(0.061)	(0.435)	(0.593)	(0.147)
GDP70			0	0	0
			(1.012)	(0.95)	(−0.54)
SCHOOLING				0.108	0.0133
				(1.643)	(2.19)
CTAX					−6.392
					(−6.685)
SOTAX					0.253
					(2.622)
Number of observations	272	272	272	272	272
R^2	0.11	0.112	0.115	0.124	0.259
Adjusted R^2	0.084	0.081	0.081	0.0870	222
S.E. of regression	0.027	0.027	0.027	0.027	0.025
Durbin–Wats	1.403	1.405	1.39	1.375	1.53

t Statistics are in parentheses. Data source: See data in Appendix A.

Table 3
Effect of intersectoral and intergovernmental allocation of public expenditure in India (dependent variable: real per capita net state product growth rate)

Independent variables	1	2	3	4	5
CONSTANT	−0.709	−0.691	−0.699	−0.707	−1.193
	(−3.621)	(−3.507)	(−3.524)	(−3.567)	(−5.872)
FDCTAX	0.087	0.111	0.099	0.085	0.018
	(1.382)	(1.561)	(1.263)	(1.083)	(−0.22)
CDEV	1.132	1.101	1.11	1.108	2.237
	(3.015)	(2.91)	(2.927)	(2.925)	(5.601)
CNONDEV	0.467	0.458	0.46	0.444	0.815
	(2.988)	(2.917)	(2.925)	(2.821)	(5.048)
CSOCCOM	2.594	2.613	2.607	2.621	9.561
	(3.548)	(3.568)	(3.553)	(3.581)	(7.605)
SADM	0.045	0.04	0.036	0.014	0.03
	(0.395)	(0.346)	(0.312)	(0.119)	(0.242)
SEDU	−0.071	−0.085	−0.079	−0.069	−0.097
	(−1.45)	(−1.616)	(−1.451)	(−1.269)	(−1.831)
SHLTH	0.043	0.043	0.042	0.009	−0.065
	(0.632)	(0.64)	(0.614)	(−0.125)	(−0.979)
SECON	−0.012	−0.01	−0.011	−0.014	−0.002
	(−0.471)	(−0.407)	(−0.455)	(−0.554)	(−0.067)
AREA		0	0	0	0
		(−0.727)	(−0.4)	(−0.107)	(0.321)
GDP70			0	0	0
			(0.406)	(0.428)	(−0.558)
SCHOOLING				0.099	0.132
				(1.516)	(2166)
CTAX					−6.379
					(−6.66)
SOTAX					0.229
					(2.166)
Number of observations	272	272	272	272	272
R^2	0.118	0.12	0.12	0.128	0.258
Adjusted R^2	0.091	0.089	0.086	0.091	0.221
S.E. of regression	0.027	0.027	0.027	0.027	0.025
Durbin–Wats	1.396	1.386	1.385	1.361	1.527

t Statistics are in parentheses. Data source: See data in Appendix A.

First, except for one measure of fiscal decentralization, FDCEXP, the other three measures have positive and even significant estimated coefficients. Therefore, fiscal decentralization, especially decentralization in tax revenue collection, is in general positively associated with Indian regional economic growth on the basis our preliminary statistical analysis. It is interesting to note that when the explanatory variable is the ratio of state spending to central spending in each state, FDCEXP, the estimated coefficients under different specifications of the regression equations have very insignificant, negative signs (Table 2). When the ratio is

Table 4
Effect of intersectoral and intergovernmental allocation of public expenditure in India (dependent variable: real per capita net state product growth rate)

Independent variables	1	2	3	4	5
CONSTANT	−0.724	−0.741	−0.742	−0.739	−1.206
	(−3.697)	(−3.753)	(−3.754)	(−3.742)	(−5.916)
FDCEXPPC	0.068	0.101	0.081	0.038	0.053
	(1.012)	(1.239)	(0.882)	(0.404)	(0.594)
CDEV	1.169	1.197	1.195	1.171	2.265
	(3.11)	(3.166)	(3.157)	(3.096)	(5.649)
CNONDEV	0.462	0.463	0.466	0.453	0.812
	(2.949)	(2.948)	(2.96)	(2.881)	(5.033)
CSOCCOM	2.673	2.699	2.672	2.641	9.647
	(3.624)	(3.652)	(3.601)	(3.56)	(7.627)
SADM	0.048	0.049	0.044	0.019	0.039
	(0.414)	(0.432)	(0.378)	(0.163)	(0.323)
SEDU	−0.058	−0.038	−0.04	−0.043	−0.082
	(−1.146)	(−0.675)	(−0.694)	(−0.758)	(−1.448)
SHLTH	−0.003	−0.014	−0.005	−0.018	−0.087
	(−0.034)	(−0.186)	(−0.067)	(−0.234)	(−1.181)
SECON	−0.013	−0.018	−0.017	−0.017	−0.005
	(0.497)	(−0.67)	(−0.671)	(−0.646)	(−0.224)
AREA		0	0	0	0
		(0.717)	(0.764)	(0.76)	(0.047)
GDP70			0	0	0
			(0.489)	(0.648)	(−0.719)
SCHOOLING				0.099	0.122
				(1.448)	(1.929)
CTAX					−6.41
					(−6.703)
SOTAX					0.236
					(2.527)
Number of Observations	272	272	272	272	272
R^2	0.115	0.117	0.117	0.124	0.259
Adjusted R^2	0.088	0.086	0.0836	0.087	0.221
S.E. of regression	0.027	0.027	0.027	0.027	0.025
Durbin–Wats	1.395	1.407	1.402	1.377	1.531

t Statistics are in parentheses. Data source: See data in Appendix A.

adjusted by population size, FDEXPPC, the estimated coefficients are all positive and with much higher *t* statistics ranging from 0.4 to 1.24, weak evidence for the positive impact of fiscal decentralization on state economic growth in India (Table 4). When the measure of fiscal decentralization is the ratio of state own revenue collection to central revenue collection, FDCTAX, four estimated coefficients out the five in Table 3 are positive with *t* statistics between 1.08 and 1.56. When the decentralization measure is the ratio of per capita state tax revenues to per capita central tax revenue, FDTAXPC (Table 5), these

Table 5
Effect of intersectoral and intergovernmental allocation of public expenditure in India (dependent variable: real per capita net state product growth rate)

Independent variables	1	2	3	4	5
CONSTANT	−0.697	−0.707	−0.654	−0.658	−1.19
	(−3.581)	(−3.617)	(−3.323)	(−3.352)	(−5.876)
FDCTAXPC	0.01	0.011	0.026	0.026	0.021
	(2.139)	(2.241)	(2.708)	(2.683)	(1.315)
CDEV	1.11	1.126	1.044	1.033	2.225
	(2.974)	(3.005)	(2.778	(2.757)	(5.591)
CNONDEV	0.453	0.457	0.428	0.408	0.821
	(2.912)	(2.929)	(2.741)	(2.619)	(5.098)
CSOCCOM	2.622	2.612	2.675	2.693	9.414
	(3.604)	(3.585)	(3.683)	(3.719)	(7.484)
SADM	0.066	0.07	0.136	0.111	0.022
	(0.575)	(0.614)	(1.135)	(0.919)	0.148)
SEDU	−0.083	−0.073	−0.11	−0.103	−0.098
	(−1.684)	(−1.429)	(−2.01)	(−1.866)	(−1.877)
SHLTH	0.041	0.045	0.066	0.033	−0.047
	(0.614)	(0.674)	(0.975)	(0.47)	(−0.701)
SECON	−0.02	−0.024	−0.032	−0.035	−0.012
	(−0.795)	(−0.911)	(−1.226)	(−1.318)	(−0.483)
AREA		0	0	0	0
		(0.674)	(0.109)	(0.355)	(−0.106)
GDP70			0	0	0
			(−1.812)	(−1.82)	(−1.407)
SCHOOLING				0.104	−0.132
				(1.617)	(2.192)
CTAX					−6.079
					(−6.186)
SOTAX					0.07
					(0.44)
Number of Observations	272	272	272	272	272
R^2	0.127	0.128	0.139	0.147	0.263
Adjusted R^2	0.1	0.098	0.106	0.111	0.226
S.E. of regression	0.027	0.027	0.027	0.026	0.025
Durbin–Wats	1.395	1.404	1.437	1.397	1.553

t Statistics are in parentheses. Data source: See data in Appendix A.

positive estimates are statistically even more significant with the t statistics between 1.3 and 2.7.

Second, all shares of central government spending on development (CDEV), nondevelopment (CNONDEV), and social and community services (CSOCCOM) are positively and statistically significantly associated with state economic growth (Tables 2–5). Thus, increases in the central allocation of its budget among these three functions by cutting the center's spending on all other functions can promote regional growth.

Third, all shares of state spending on administration (SADM), education (SEDU), health (SHLTH), and economic development (SECON) have rather mixed signs with no statistical significance (Tables 2–5). These results suggest that state public spending shares are broadly consistent with growth-maximizing allocation of public spending.

Fourth, the central tax (CTAX) is negatively associated with state economic growth, suggesting that the central tax rate is on the wrong side of the "Laffer curve" in the sense of the Barro (1990) model. At the same time, the state tax has a positive, significant effect on economic growth and is on the left side of the "Laffer curve." These results indicate the possibility that central tax collection is too high relative to state collection, and a further decentralization in revenue collection promotes regional economic growth. Since both the central tax and state tax revenues finance productive public spending, the effect of a moderately distortionary tax may be outweighed by the substantial productive effect of tax revenues. Our preliminary results support this theoretical prediction for the state tax, not for the central tax.

5. Summary

The negative association between fiscal decentralization and provincial economic growth has been found to be consistently significant and robust in China. Perhaps this is understandable given the current stage of economic development in China, where the central government is constantly constrained by the limited resources for public investment in national priorities such as highways, railways, power stations, telecommunications, and energy. Such key infrastructure projects may have a far more significant impact on growth across provinces than their counterparts in each province. This is supported by the empirical results shown in Table 1, in which the association between central government development spending and economic growth is positive and significant. At the same time, provincial government development spending is negatively associated with growth.

For India, however, we have found that, in many cases of our regressions, fiscal decentralization is positively, and even statistically significantly, associated with state economic growth. The state allocation of public spending in various sectors is broadly consistent with "growth maximizing," whereas increases in the central allocation of its budget among development projects, nondevelopment projects, and social and community services by cutting the center's spending on all other functions can promote regional growth.

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Appendix A

A.1. Data appendix for China

Our empirical estimations are based on annual data for 28 provinces. Data sources are all official publications in China. Although over 100 volumes of statistical publications are involved, major data sources include *China Statistical Yearbook* and provincial statistical yearbooks for various years. Variables used for estimations are listed below with their data sources. Names of provincial areas included in our estimations are also listed.

Y = the real growth rate of provincial income, measured at constant price level. Source: For 1980–1985: *China National Income Statistics* 1949–1985 (*Guomin Shouru Tongji Ziliao Huibian* 1949–1985); for 1985–1992: *China Statistical Yearbook* (*Zhongguo Tongji Nianjian*) various issues.

L = the growth rate of the provincial labor force. Source: For 1980–1985, various volumes of provincial statistical yearbooks; for 1986–1992: *China Statistical Yearbook* (*Zhongguo Tongji Nianjian*), various issues.

I = the provincial investment rate, measured by the rate of accumulation in fixed assets and circulating funds. Source: For 1980–1985: *China National Income Statistics* 1949–1985 (*Guomin Shouru Tongji Ziliao Huibian* 1949–1985); for 1985–1992: *China Statistical Yearbook* (*Zhongguo Tongji Nianjian*), various issues.

F = the degree of openness of provincial economy, measured by the share of total volume of foreign trade (exports and imports) in provincial income. Source: *Almanac of China's Foreign Economic Relations and Trade* (*Zhongguo Duiwai Jingji Maoyi Nianjian*), various issues in 1984–1994/1995.

TAX = the tax rate. Source: Various volumes of provincial statistical yearbooks.

R = the inflation rate, measured by the overall social retail price index in each province. Source: *China Statistical Yearbook* (*Zhongguo Tongji Nianjian*), various issues.

FDC = decentralization measured by the ratio of provincial spending to central spending. Source: For provincial population: various volumes of provincial statistical yearbooks; for the central government, national population is used, *China Statistical Yearbook* (*Zhongguo Tongji Nianjian*), various issues.

Data sources for the following variables are derived by the authors from various provincial statistical yearbooks, and Ministry of Finance, *Finance Yearbook of China* (*Zhongguo Caizhang Tongji Nianjian*) 1993 and 1994; Ministry of Finance, *China Government Finance Statistics* (*Zhongguo Caizheng Tongji*) 1950–1985, 1950–1988, and 1950–1991.

CADM = the share of central budgetary spending on administration out of total central budgetary spending.

CDEV = the share of central budgetary spending on development out of total central budgetary spending, including expenses on capital construction, enterprise upgrading, technical R&D, and support for the agricultural sector.

CDFN = the share of central budgetary spending on defense out of total central budgetary spending.

CHUM = the share of central budgetary spending on human capital out of total central budgetary spending, including expenses on culture, education, public health care, and science.

PADM = the share of provincial budgetary spending on administration out of total provincial budgetary spending in each province.

PDEV = the share of provincial budgetary spending on development out of total provincial budgetary spending in each province.

PURB = the share of provincial budgetary spending on urban maintenance out of total provincial budgetary spending in each province.

PHUM = the share of provincial budgetary spending on human capital out of total provincial budgetary spending in each province.

A.1.1. List of provincial areas

Beijing, Tianjin, Hebei, Shanxi, Neimenggu (Inner Mongolia), Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

A.2. Data appendix for India

Our empirical analysis is based on the aggregate data from *Government Finance Statistics*, International Monetary Fund, and on the annual data for 16 states during the period of 1972/1973–1992/1993. Major data sources include *Public Finance: India's Central and State Government* (1996) and *Profiles of States* (1997) by Economic Intelligence Service, India and various publications by Ministry of Finance of the Government of India. Variables used for estimations are listed below with their data sources. Names of states included in our estimations are also listed.

(1) Data for the following variables for all the 16 states, except for Andhra Pradesh, Madhya Pradesh, and Orissa, are taken from various publications by Ministry of Finance of the Government of India:

(2) Data for the variables mentioned above for Andhra Pradesh, Madhya Pradesh, and Orissa are taken from *Public Finance: India's Central and State Government* (1996) by Economic Intelligence Service, India.

(3) Data for the following two variables are taken from *Profiles of States* (1997 issue) by Economic Intelligence Service, India.

A.2.1. List of states included in the estimations

Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal.

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第 11 章

财政联邦主义、公共资本与内生经济增长

Fiscal Federalism, Public Capital Formation, and Endogenous Growth*

Liutang Gong

Guanghua School of Management, Peking University, Beijing, 100871, China
Institute for Advanced Study, Wuhan University, Wuhan, 430072, China
E-mail: ltgong@gsm.pku.edu.cn

and

Heng-fu Zou

Guanghua School of Management, Peking University, Beijing, 100871, China
Institute for Advanced Study, Wuhan University, Wuhan, 430072, China
Development Research Group, The World Bank, Washington, DC 20433, USA
E-mail: Hzou@worldbank.org

This paper extends the Barro (1990) growth model with one aggregate government spending and one flat income tax to include federal and local public consumption, federal and local public capital formation, federal and local taxes, and federal transfers to locality. It derives the rate of endogenous growth and examines how the growth rate and welfare respond to changes in federal taxes, local taxes, and federal transfers.

Key Words: Fiscal federalism; Public expenditures; Public capital; Taxes; Federal transfers; Endogenous growth.
JEL Classification Numbers: E0, G1, H0, O0.

1. INTRODUCTION

In an endogenous growth model, Barro (1990) has examined the effects on economic growth of aggregate government spending including both aggregate public consumption and aggregate public investment. The Barro model does not consider the effects of public expenditures by different levels of government. Subsequent work has extended Barro's analysis by looking into the composition of government expenditures and economic growth.

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For example, Easterly and Rebelo (1993); and Devarajan, Swaroop, and Zou (1996) have studied the growth effects of public spending on education, transportation, defense, and social welfare. In addition, Davoodi and Zou (1997); and Zhang and Zou (1997) have examined the growth effects of various public expenditures by different levels of government. But in all these studies, public capital formation is not explicitly considered.

Another strand of literature on endogenous growth has considered public capital accumulation by extending the early work of Arrow and Kurz (1970), but it does not model capital accumulation by multiple levels of government. For example, Glomm and Ravikumar (1994); Hulten (1994); Devarajan, Xie, and Zou (1998); among many others, have paid particular attention to the association between infrastructure and output growth.[1]

At the same time, the structure of public expenditures and taxes among different levels of government has a fundamental impact on economic growth in light of the arguments in fiscal federalism; see Oates (1972, 1993). In fact, the proper assignments of expenditures and taxes among multiple levels of government and the proper design of intergovernmental transfers are prerequisite for efficient and equitable public service provision at both the national and local levels. One of the most important goals of establishing a sound intergovernmental fiscal relationship is to promote local as well as national economic growth (see Rivlin, 1992; Bird, 1993; Gramlich, 1993; and Oates, 1993).

In view of the important link from the design of intergovernmental fiscal relationship to economic growth, it is natural for us to extend the Barro model and provide an analytical framework for both theoretical and empirical research on the growth effects of public consumption, public capital formation, taxes, and federal transfers in a federation or in the context of multiple levels of government. This is the main task of our paper.

Our model extends the Arrow-Kurz-Barro approach in the following aspects. (1) We allow public consumption and public capital accumulation at both the federal and local level, corresponding to expenditure assignments among different levels of government in fiscal federalism; (2) on the revenue side, our model specifies federal taxes and local taxes in light of tax assignment among different levels of government in a federation; (3) our model takes care of federal transfers to locality in the forms of matching grants for both local public capital formation and local public consumption; (4) with specific production function and utility function, we derive analytical solution to the rate of balanced growth; (5) with simulations, we derive the responses of the growth rate with respect to federal income tax, federal

[1]Of course, the empirical analyses in many of these studies have followed the much-cited work by Aschauer (1989).

consumption tax, local income tax, local property tax, local consumption tax, and federal grants for local public investment and consumption.

The paper is organized as follows. Section 2 sets up a much extended Arrow-Kurz-Barro model. Section 3 derives the rate of endogenous growth. Section 4 studies how the rate of endogenous growth changes with respect to federal taxes, local taxes, and federal transfers. Section 5 presents the welfare analysis. Section 6 concludes.

2. THE MODEL

In this paper, there are two levels of government: the federal government and local governments. Their consumption expenditures are f and s, and their capital stocks are k_f and k_s, respectively. In Arrow and Kurz (1970) and Barro (1990), among many others, government spending and public capital accumulation have been introduced into the utility function in aggregate terms, i.e., total government spending (Barro, 1990), or total public capital (Arrow, and Kurz, 1970), or total public consumption and investment (Barro, 1990). Along this line, we introduce public consumption and capital stocks at both the federal and local levels into the representative agent's utility function as

$$u(c, f, k_f, s, k_s)$$

where c is private consumption.

If the utility function $u(c, f, k_f, s, k_s)$ is twice differentiable, we further assume that

$$\begin{aligned} u_c &> 0, u_f > 0, u_s > 0, u_{cc} < 0, u_{ff} < 0, u_{ss} < 0 \\ u_{k_f} &> 0, u_{k_s} > 0, u_{k_f k_f} < 0, u_{k_s k_s} < 0. \end{aligned} \tag{1}$$

The cross effects u_{cf}, u_{cs},and u_{fs} are in general assumed to be positive.

The representative agent's discounted utility and welfare are given by

$$U = \int_0^\infty u(c, f, k_f, s, k_s) e^{-\rho t} dt \tag{2}$$

where ρ is the constant rate of time preference.

Again, by broadening the frameworks in Arrow and Kurz (1970), and Barro (1991), we assume that output y is produced by a constant-return-to-scale production function with three inputs: private capital stock, k_p, federal government capital stock, k_f, and local government capital stock, k_s, namely,

$$y = y(k_p, k_f, k_s). \tag{3}$$

As in Arrow and Kurz (1970), the marginal productivities of private capital stock, federal government capital stock, and local government capital stock are positive and decreasing. Suppose the production function is twice differentiable, then,

$$y_{k_p} > 0, y_{k_f} > 0, y_{k_s} > 0, y_{k_p k_p} < 0, y_{k_f k_f} < 0, y_{k_s k_s} < 0 \tag{4}$$

In this paper, to derive the analytical solution to the relationship between the growth rate on the one hand and tax rates and federal transfers on the other, we choose the utility function to be logarithmic

$$u(c, f, k_f, s, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s, \tag{5}$$

where $\theta_0, \theta_1, \theta_2, \theta_3$, and θ_4 are positive constants satisfy $\theta_0 + \theta_1 + \theta_2 + \theta_3 + \theta_4 = 1$. And we take the production function to be Cobb-Douglas

$$y(k_p, k_s, k_f) = k_p^{\omega_1} k_s^{\omega_2} k_f^{\omega_3} \tag{6}$$

where ω_1, ω_2, and ω_3 are positive constants satisfying $\omega_1 + \omega_2 + \omega_3 = 1$.

2.1. The agent's optimization problem

The representative agent's budget constraint is given by the condition that the after-tax income is to equal to the spending on his consumption, $(1 + \tau_{cf} + \tau_{cs})c$, and his gross investment, $\frac{dk_p}{dt}$, namely

$$\frac{dk_p}{dt} = (1 - \tau_f - \tau_s) y(k_p, k_s, k_f) - (1 + \tau_{cf} + \tau_{cs}) c - \tau_k k_p - \delta k_p \tag{7}$$

where τ_f and τ_s are the income tax rates of the federal government and local government , respectively; τ_{cf} and τ_{cs} are the consumption tax rates of the federal government and local government, respectively; and τ_k is the property tax rate. To provide some illustrations from the reality, please note that τ_s can be regarded as the state income tax in the United States, τ_{cf} can be regarded as sales tax and consumption-based value-added tax collected by many central governments in Europe, τ_{cs} is the standard sales tax in the United States, and τ_k is the property tax collected by local governments in most countries in the world.

Given the taxes, public consumption, and public capital formation at both the federal and local levels, the agent chooses his consumption path, $c(t)$, and capital accumulation path, $k_p(t)$, to maximize his discounted utility, i.e.

$$\max_{c(t), k_p(t)} \int_0^\infty u(c, s, k_s, f, k_f) e^{-\rho t} dt \tag{8}$$

subject to budget constraint (7) and the initial capital stock $k_p(0)$

2.2. Federal government's optimization problem

The federal government collects capital income tax, τ_f , and consumption tax, τ_{cf}, as its revenue. On the spending side, first, it makes two kinds of transfers to the local government in the forms of matching grants for investment at the rate α and for local public consumption at the rate β, i.e., $\alpha\frac{dk_s}{dt} + \beta s$; second, the federal government undertakes its own public consumption, f, and its own gross investment, $\frac{dk_f}{dt} + \delta k_f$, namely,

$$\frac{dk_f}{dt} = \tau_f y + \tau_{cf} c - \alpha\frac{dk_s}{dt} - \beta s - f - \delta k_f. \tag{9}$$

Now, taking local government and private behaviors as given, the federal government chooses its expenditure path, $f(t)$, and its capital accumulation path, $k_f(t)$, to maximize the agent's welfare, i.e.,

$$\max_{f(t),k_f(t)} \int_0^\infty u(c, s, k_s, f, k_f)e^{-\rho t}dt \tag{10}$$

subject to its budget constraint (9). The initial federal capital stock, $k_f(0)$, is given. Again, for the federal government, private consumption, c, private capital stock, k_p, local public consumption, s, and local public capital stock, k_s, are all given.

In our specification of federal government's optimization problem, the rates of federal taxes and federal transfers are exogenously given, whereas federal consumption and federal capital accumulation are endogenous. The same approach will be applied to local government's optimization problem in the next subsection. We take this approach for the following reasons. Our focus of our paper is to see how federal taxes, local taxes, and federal transfers affect capital accumulation and consumption by the private sector, the federal government, and local governments. Once the optimal responses of accumulation and consumption with respect to taxes and transfers have determined, the optimal choices of taxes and transfers can be derived from welfare maximization or growth maximization. This will be our main tasks in our simulation analysis in sections 4 and 5. In this sense, our approach can be viewed as a two-stage optimization.

2.3. Local government's optimization problem

The local government collects its income tax, $\tau_s y$, its consumption tax, $\tau_{cs}c$, and its property tax, $\tau_k k_p$ at each time period. In additional, the local government receives federal transfer for its investment and consumption as the rates of α and β,respectively: $\alpha\frac{dk_s}{dt} + \beta s$. Hence, the budget constraint

for the local government can be written as

$$\frac{dk_s}{dt} = \alpha\frac{dk_s}{dt} + \beta s - s + \tau_s y + \tau_k k_p + \tau_{cs} c - \delta k_s \tag{11}$$

Given the choices of the federal government and private agent, the local government chooses its consumption path, $s(t)$, and its investment path, $k_s(t)$, to maximize the agent's welfare, i.e.,

$$\max \int_0^\infty u(c, s, k_s, f, k_f)e^{-\rho t}dt$$

subject to budget constraint (11) with the initial capital stock $k_s(0)$ given.

3. THE BALANCED GROWTH RATE

To derive the balanced growth rate, we solve the optimization problems for the private agent, the federal government, and the local government, respectively.

First, from private agent's optimization, we get

$$\begin{aligned}\frac{\frac{dc}{dt}}{c} &= \{(1-\tau_f-\tau_s)\frac{\partial y(k_p,k_s,k_f)}{\partial k_p} - \rho - \tau_k - \delta\} \\ &= (1-\tau_f-\tau_s)\omega_1(\frac{k_s}{k_p})^{\omega_2}(\frac{k_f}{k_p})^{\omega_3} - \rho - \tau_k - \delta\end{aligned} \tag{12}$$

$$\begin{aligned}\frac{\frac{dk_p}{dt}}{k_p} &= (1-\tau_f-\tau_s)\frac{y(k_p,k_s)}{k_p} - \tau_k - (1+\tau_{cf}+\tau_{cs})\frac{c}{k_p} - \delta \\ &= (1-\tau_f-\tau_s)(\frac{k_s}{k_p})^{\omega_2}(\frac{k_f}{k_p})^{\omega_3} - \tau_k - \delta - (1+\tau_{cf}+\tau_{cs})\frac{c}{k_p}\end{aligned} \tag{13}$$

and the transversality condition

$$\lim_{t\to\infty} u_c k_p(t)e^{-\rho t} = 0. \tag{14}$$

Next, from the federal government's optimization, we have

$$\begin{aligned}\frac{\frac{df}{dt}}{f} &= \tau_f\frac{\partial y(k_p,k_s,k_f)}{\partial k_f} - \rho - \delta + \frac{\theta_2}{\theta_1}\frac{f}{k_f} \\ &= \tau_f\omega_3\frac{k_p}{k_f}(\frac{k_s}{k_p})^{\omega_2}(\frac{k_f}{k_p})^{\omega_3} - \rho - \delta + \frac{\theta_2}{\theta_1}\frac{f}{k_f}\end{aligned} \tag{15}$$

$$\begin{aligned}\frac{\frac{dk_f}{dt}}{k_f} &= \tau_f \frac{y(k_p,k_s,k_f)}{k_f} + \tau_{cf}\frac{c}{k_f} - \frac{f}{k_f} - \alpha\frac{\frac{dk_s}{dt}}{k_f} - \beta\frac{s}{k_f} - \delta \\ &= \tau_f \frac{k_p}{k_f}(\frac{k_s}{k_p})^{\omega_2}(\frac{k_f}{k_p})^{\omega_3} + \tau_{cf}\frac{c}{k_p}\frac{k_p}{k_f} - \frac{f}{k_f} \\ &- \alpha\frac{\frac{dk_s}{dt}}{k_s}\frac{k_s}{k_p}\frac{k_p}{k_f} - \beta\frac{s}{k_p}\frac{k_p}{k_f} - \delta\end{aligned} \tag{16}$$

and the transversality condition

$$\lim_{t\to\infty} u_f k_f(t) e^{-\rho t} = 0. \tag{17}$$

Finally, from the local government's optimization problem, we obtain

$$\begin{aligned}\frac{\frac{ds}{dt}}{s} &= \frac{\tau_s}{1-\alpha}\frac{\partial y(k_p,k_s,k_f)}{\partial k_s} - \rho + \frac{1-\beta}{1-\alpha}\frac{\theta_4}{\theta_3}\frac{s}{k_s} - \frac{\delta}{1-\alpha} \\ &= \frac{\omega_2\tau_s}{1-\alpha}\frac{k_p}{k_s}(\frac{k_s}{k_p})^{\omega_2}(\frac{k_f}{k_p})^{\omega_3} - \rho - \frac{\delta}{1-\alpha} + \frac{1-\beta}{1-\alpha}\frac{\theta_4}{\theta_3}\frac{s}{k_s},\end{aligned} \tag{18}$$

$$\begin{aligned}\frac{\frac{dk_s}{dt}}{k_s} &= \frac{\tau_s}{1-\alpha}\frac{y(k_p,k_s,k_f)}{k_s} \\ &+ \frac{\tau_k}{1-\alpha}\frac{k_p}{k_s} + \frac{\tau_{cs}}{1-\alpha}\frac{c}{k_s} - \frac{1-\beta}{1-\alpha}\frac{s}{k_s} - \frac{\delta}{1-\alpha} \\ &= \frac{\tau_s}{1-\alpha}\frac{k_p}{k_s}(\frac{k_s}{k_p})^{\omega_2}(\frac{k_f}{k_p})^{\omega_3} + \frac{\tau_{cs}}{1-\alpha}\frac{c}{k_p}\frac{k_p}{k_s} \\ &+ \frac{\tau_k}{1-\alpha}\frac{k_p}{k_s} - \frac{1-\beta}{1-\alpha}\frac{s}{k_s} - \frac{\delta}{1-\alpha},\end{aligned} \tag{19}$$

and the transversality condition

$$\lim_{t\to\infty} u_s k_s(t) e^{-\rho t} = 0. \tag{20}$$

It can be easily shown that, so long as all seven endogenous variables in the model grow at constant rates, these growth rates will be the same:

$$\frac{\frac{dk_s}{dt}}{k_s} = \frac{\frac{dk_p}{dt}}{k_p} = \frac{\frac{ds}{dt}}{s} = \frac{\frac{dc}{dt}}{c} = \frac{\frac{dy}{dt}}{y} = \frac{\frac{dk_f}{dt}}{k_f} = \frac{\frac{df}{dt}}{f} = \phi \tag{21}$$

where we denote the common growth rate as ϕ.

From equations (12) and (21) , we have

$$\frac{\phi + \rho + \tau_k + \delta}{\omega_1(1 - \tau_f - \tau_s)} = (\frac{k_s}{k_p})^{\omega_2}(\frac{k_f}{k_p})^{\omega_3}. \tag{22}$$

Using equations (13) and (21), we get

$$\frac{c}{k_p} = \frac{(1-\omega_1)\phi + (1-\omega_1)(\tau_k + \delta) + \rho}{(1 + \tau_{cf} + \tau_{cs})\omega_1}. \tag{23}$$

Substituting equation (22) into equations (18) and (19) and using equation (21), we obtain

$$\frac{k_s}{k_p} = \frac{(1 + \frac{\theta_3}{\theta_4}\omega_2)\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)} + \tau_{cs}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1} + \tau_k}{\frac{\theta_3}{\theta_4}(\phi + \rho + \frac{\delta}{1-\alpha}) + \phi + \frac{\delta}{1-\alpha}} \tag{24}$$

and

$$\frac{s}{k_s} = \frac{\theta_3}{\theta_4}\frac{1-\alpha}{1-\beta}\{\phi + \rho + \frac{\delta}{1-\alpha} - \omega_2\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)} \tag{25}$$
$$\frac{\frac{\theta_3}{\theta_4}(\phi + \rho + \frac{\delta}{1-\alpha}) + \phi + \frac{\delta}{1-\alpha}}{(1 + \frac{\theta_3}{\theta_4}\omega_2)\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)} + \tau_{cs}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1} + \tau_k}\}.$$

Substituting equations (22) and (24) into the federal government's first-order conditions (15) and (16), we get

$$
\begin{aligned}
&\frac{\theta_1}{\theta_2}(\phi+\rho+\delta)+\phi+\delta \\
=\ &\{(1+\frac{\theta_1}{\theta_2}\omega_3)\tau_f\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}+\tau_{cf}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1} \\
&-\alpha\phi\frac{(1+\frac{\theta_3}{\theta_4}\omega_2)\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}+\tau_{cs}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1}+\tau_k}{\frac{\theta_3}{\theta_4}(\phi+\rho+\frac{\delta}{1-\alpha})+\phi+\frac{\delta}{1-\alpha}} \\
&-\frac{\beta[(\phi+\rho+\frac{\delta}{1-\alpha})}{\frac{\theta_3}{\theta_4}(\phi+\rho+\frac{\delta}{1-\alpha})+\phi+\frac{\delta}{1-\alpha}}\left[(1+\frac{\theta_3}{\theta_4}\omega_2)\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}\right. \\
&\left.+\tau_{cs}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1}+\tau_k\right] \\
&-\omega_2\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}]\frac{1-\alpha}{1-\beta}\frac{\theta_3}{\theta_4}\}\frac{k_p}{k_f},
\end{aligned}
$$

or

$$
\begin{aligned}
\frac{k_f}{k_p} = \ &\frac{1}{\frac{\theta_1}{\theta_2}(\phi+\rho+\delta)+\phi+\delta}\left\{(1+\frac{\theta_1}{\theta_2}\omega_3)\tau_f\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}\right. \\
&+\tau_{cf}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1} \\
&-\alpha\phi\frac{(1+\frac{\theta_3}{\theta_4}\omega_2)\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}+\tau_{cs}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1}+\tau_k}{\frac{\theta_3}{\theta_4}(\phi+\rho+\frac{\delta}{1-\alpha})+\phi+\frac{\delta}{1-\alpha}} \\
&-\beta\left[\frac{(\phi+\rho+\frac{\delta}{1-\alpha})}{\frac{\theta_3}{\theta_4}(\phi+\rho+\frac{\delta}{1-\alpha})+\phi+\frac{\delta}{1-\alpha}}\left[(1+\frac{\theta_3}{\theta_4}\omega_2)\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}\right.\right. \\
&\left.+\tau_{cs}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1}+\tau_k\right] \\
&\left.\left.-\ \omega_2\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}\right]\frac{1-\alpha}{1-\beta}\frac{\theta_3}{\theta_4}\right\}. \qquad (26)
\end{aligned}
$$

Thus, we have

$$
\frac{f}{k_f}=[\phi+\rho+\delta-\tau_f\omega_3\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}(\frac{k_p}{k_f})]\frac{\theta_1}{\theta_2}. \qquad (27)
$$

Now, substituting equations (24) and (26) into equation (18), we get

$$
\begin{aligned}
&\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)} \\
&= \left(\frac{(1+\frac{\theta_3}{\theta_4}\omega_2)\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}+\tau_{cs}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1}+\tau_k}{\frac{\theta_3}{\theta_4}(\phi+\rho+\frac{\delta}{1-\alpha})+\phi+\frac{\delta}{1-\alpha}}\right)^{\omega_2} \\
&\left\{\frac{1}{\frac{\theta_1}{\theta_2}(\phi+\rho+\delta)+\phi+\delta}\left\{(1+\frac{\theta_1}{\theta_2}\omega_3)\tau_f\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}+\right.\right. \\
&\tau_{cf}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1} \\
&-\alpha\phi\frac{(1+\frac{\theta_3}{\theta_4}\omega_2)\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}+\tau_{cs}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1}+\tau_k}{\frac{\theta_3}{\theta_4}(\phi+\rho+\frac{\delta}{1-\alpha})+\phi+\frac{\delta}{1-\alpha}} \\
&\beta\left[\frac{(\phi+\rho+\frac{\delta}{1-\alpha})}{\frac{\theta_3}{\theta_4}(\phi+\rho+\frac{\delta}{1-\alpha})+\phi+\frac{\delta}{1-\alpha}}\left[(1+\frac{\theta_3}{\theta_4}\omega_2)\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}\right.\right. \\
&\left.+\tau_{cs}\frac{(1-\omega_1)\phi+(1-\omega_1)(\tau_k+\delta)+\rho}{(1+\tau_{cf}+\tau_{cs})\omega_1}+\tau_k\right] \\
&\left.\left.-\omega_2\frac{\tau_s}{1-\alpha}\frac{\phi+\rho+\tau_k+\delta}{\omega_1(1-\tau_f-\tau_s)}\right]\frac{1-\alpha}{1-\beta}\frac{\theta_3}{\theta_4}\right\}\right\}^{\omega_3} \\
&\triangleq \psi(\phi,\tau_f,\tau_s,\tau_{cs},\tau_{cf},\tau_k,\alpha,\beta,\omega_1,\omega_2,\omega_3,\theta_0,\theta_1,\theta_2,\theta_3,\theta_4\rho,\delta). \qquad (28)
\end{aligned}
$$

which is a highly nonlinear equation defining the balanced growth rate, ϕ, as a function of taxes ($\tau_f, \tau_s, \tau_{cs}, \tau_{cf}$, and τ_k), federal transfers (α and β), technology parameters ($\omega_1, \omega_2, \omega_3$, and δ), and preference parameters ($\theta_0, \theta_1, \theta_2, \theta_3$, θ_4, and ρ). We admit that we cannot even obtain a nonlinear equation defining the balanced growth rate when the preferences and technology are assumed to be CES instead of Cobb-Douglas. But without public capital accumulation by the federal and local governments, nonlinear or even explicit solutions to the growth rate are possible with more general preferences and production technology; see Gong and Zou (1997).

4. EFFECTS OF TAXES AND TRANSFERS ON THE GROWTH RATE

Although the growth rate defined in equation (28) is highly nonlinear in taxes and federal transfers, it is rather simple to find out the effects of various taxes and federal transfers on economic growth with simulations. In this section, we report some results on the simulation exercise based on equation (28).

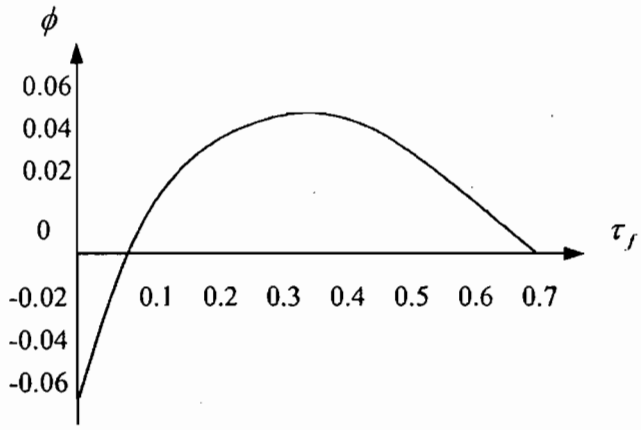

FIG. 1. Growth rate versus the federal income tax rate. Where the production function and utility function are specified as $y = k_p^{\omega_1} k_f^{\omega_2} k_s^{\omega_3}$ and $u(c, f, s, k_f, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s$, respectively. Parameters are selected as: $\theta_0 = 0.5$, $\theta_1 = 0.1$, $\theta_2 = 0.1$, $\theta_3 = 0.1$, $\theta_4 = 0.1$, $\omega_1 = 0.5$, $\omega_2 = 0.25$, $\omega_3 = 0.25$, $\rho = 0.08$, $\delta = 0.08$, $\tau_s = 0.10$, $\alpha = \beta = 0.3$, $\tau_k = 0.01$, $\tau_{cf} = 0$, and $\tau_{cs} = 0.05$.

Figure 1 shows the relationship between the rate of endogenous growth, ϕ, and federal government's income tax rate, τ_f, on the basis of the following base values for the structure of other taxes and transfers: a federal consumption tax at zero percent, $\tau_{cf} = 0$, a local income tax at ten percent: $\tau_s = .10$, a local consumption tax at five percent, $\tau_{cs} = .05$, a capital tax or local property tax at two percent: $\tau_k = .02$, a federal matching grant for local investment at thirty percent: $\alpha = .3$, and a federal matching grant for local consumption also at thirty percent, $\beta = .3$. The preference and technology parameters are all the same for all simulations, and they are given in the legend of each figure. Figure 1 presents a typical Laffer curve relating the growth rate to federal income tax. Given local taxes, federal transfers, and all other parameters in our model, a rise in federal income tax will increases the growth rate before the tax rate hits around thirty percent. In fact, when the federal income tax is zero, coupled with a zero rate of federal consumption tax, the growth rate is negative. With the rise of federal income tax rate from zero to ten percent, the growth rate rises from a negative seven percent to a positive three percent. After the federal income tax reaches thirty percent, further increases in the federal income taxation lower the growth rate. The growth rate is around zero when federal income tax is seventy percent.

The explanation for this Laffer curve is now becoming standard; see Barro (1990). A change in federal income tax has three effects. First, a higher federal income tax reduces the return on private capital and the

growth rate directly. But second, a larger tax revenue implies a higher federal consumption and capital investment that are assumed to increase both private utility and private productivity, which raises the growth rate. Third, at the same time, a larger tax revenue can lead to more federal transfers to the local government whose public consumption and public investment are also utility- and productivity-enhancing. When the federal income tax rate is initially very small, the second and the third forces dominate the first force. When the federal income tax is already high, the first force will dominate the second and the third forces.

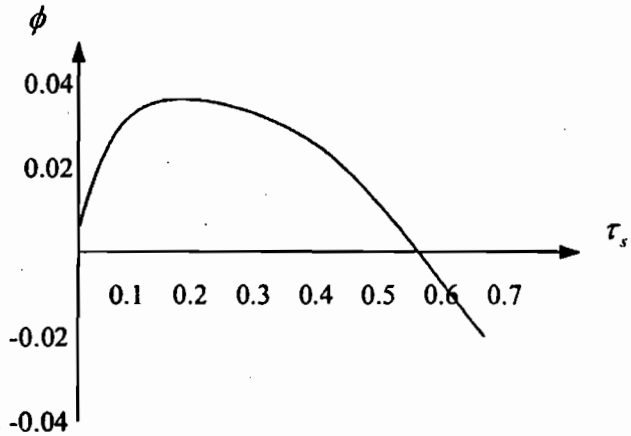

FIG. 2. Growth rate versus the local income tax rate. Where the production function and utility function are specified as $y = k_p^{\omega_1} k_f^{\omega_2} k_s^{\omega_3}$ and $u(c, f, s, k_f, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s$, respectively. Parameters are selected as: $\theta_0 = 0.5$, $\theta_1 = 0.1$, $\theta_2 = 0.1$, $\theta_3 = 0.1$, $\theta_4 = 0.1$, $\omega_1 = 0.5$, $\omega_2 = 0.25$, $\omega_3 = 0.25$, $\rho = 0.08$, $\delta = 0.08$, $\tau_f = 0.20$, $\alpha = \beta = 0.3$, $\tau_k = 0.01$, $\tau_{cf} = 0$, and $\tau_{cs} = 0.05$.

The similar picture appears in figure 2, which shows the relationship between the growth rate, ϕ, and local income tax rate, τ_s on the basis of the following base values for the structure of federal taxes, local taxes other than local income tax, and federal transfers: a federal income tax at twenty percent, $\tau_f = .20$, a federal consumption tax at zero percent, $\tau_{cf} = 0$, a local consumption tax at five percent, $\tau_c = .05$, a capital tax or local property tax at two percent: $\tau_k = .02$, a federal matching grant for local investment at 30 percent: $\alpha = .3$, and a federal matching grant for local consumption also at thirty percent, $\beta = .3$.

Since the base federal income tax is already at a relatively high rate of twenty percent, the growth rate is rising with local income tax until τ_s reaches about eighteen percent. When local income tax rate is set at fifty-five percent, the growth rate is zero. Because the local government receives two matching grants from the federal government at a rate of thirty percent

each, and because it also raises tax revenues from the consumption tax and property tax, the local government can still finance its productive public expenditures without resorting to income tax. This is why the growth rate is still positive even though local income tax is zero in figure 2.

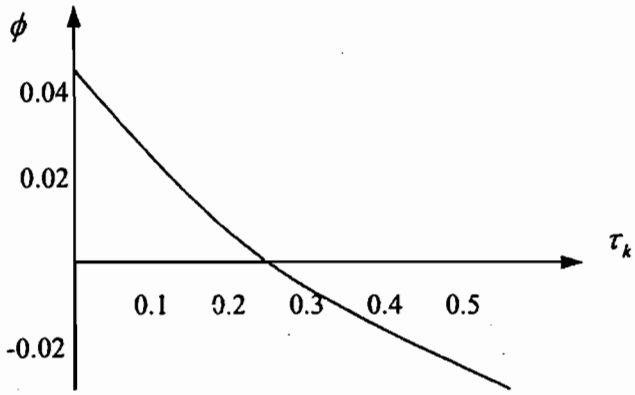

FIG. 3. Growth rate versus the property tax rate. Where the production function and utility function are specified as $y = k_p^{\omega_1} k_f^{\omega_2} k_s^{\omega_3}$ and $u(c, f, s, k_f, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s$, respectively. Parameters are selected as: $\theta_0 = 0.5$, $\theta_1 = 0.1$, $\theta_2 = 0.1$, $\theta_3 = 0.1$, $\theta_4 = 0.1$, $\omega_1 = 0.5$, $\omega_2 = 0.25$, $\omega_3 = 0.25$, $\rho = 0.08$, $\delta = 0.08$, $\tau_s = 0.10$, $\alpha = \beta = 0.3$, $\tau_f = 0.20$, $\tau_{cf} = 0$, and $\tau_{cs} = 0.05$.

Figure 3 reveals the alarming negative effect of local property tax on the growth rate. The curve is drawn by assuming a federal income tax at twenty percent, a federal consumption tax at zero percent, a local income tax at ten percent, a local consumption tax at five percent, and the two federal matching grants at thirty percent each. Given the distortions of federal and local taxes, the growth rate is around six percent when the property tax is zero; and it reaches zero when the property tax hits twenty-four percent. Compared to local income tax and local consumption tax, local property tax is the most distortionary tax in raising local public revenue.

Figure 4 illustrates the relationship between the growth rate, ϕ, and federal consumption tax, τ_{cf}, by assuming that a federal income tax at twenty percent: $\tau_f = .20$, a local income tax at ten percent: $\tau_s = .10$, a capital tax or local property tax at two percent: $\tau_k = .02$, a local consumption tax at five percent, $\tau_c = .05$, a federal matching grant for local investment at 30 percent: $\alpha = .3$, and a federal matching grant for local consumption also at thirty percent, $\beta = .3$. We find that federal consumption tax has a positive effect on the growth rate. When the consumption tax increases from zero to one hundred percent, the growth rate rises from five percent to 8.5 percent in figure 4. This is because a high consumption tax raises the cost of consumption and forces the consumer to save more (the sub-

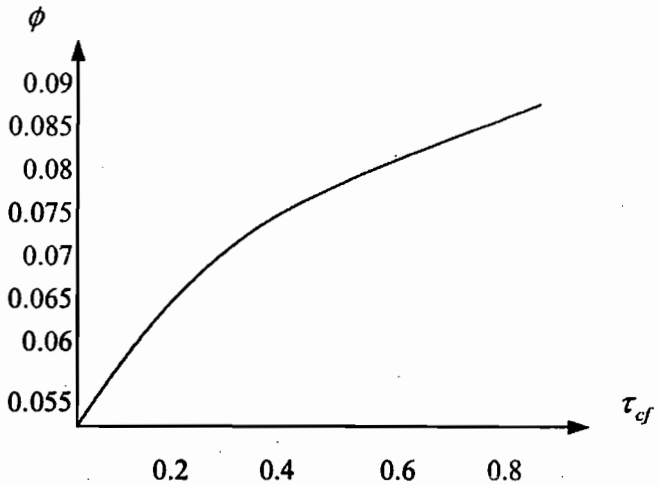

FIG. 4. Growth rate versus the federal consumption tax rate. Where the production function and utility function are specified as $y = k_p^{\omega_1} k_f^{\omega_2} k_s^{\omega_3}$ and $u(c, f, s, k_f, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s$, respectively. Parameters are selected as: $\theta_0 = 0.5$, $\theta_1 = 0.1$, $\theta_2 = 0.1$, $\theta_3 = 0.1$. $\theta_4 = 0.1$, $\omega_1 = 0.5$, $\omega_2 = 0.25$, $\omega_3 = 0.25$, $\rho = 0.08$, $\delta = 0.08$,$\tau_s = 0.10$,$\alpha = \beta = 0.3$,$\tau_f = 0.20$,$\tau_k = 0.01$, and $\tau_{cs} = 0.05$.

stitution effect dominating the income effect with our specifications on the preferences and technology). The rise in savings results in more capital accumulation and higher economic growth. Please note that the effect of a rise in consumption tax on the growth rate is relatively modest in our simulation given the existing tax distortions of federal and local income taxes and local property tax.

Figure 5 illustrates the relationship between the growth rate and local consumption tax τ_{cs}. It has essentially the same feature as the relationship between federal consumption tax and the growth rate in figure 4, namely, a rise in local consumption growth rate raises the growth rate. As shown in figure 5, a rise of local consumption tax from zero percent to 100 percent can raise the growth rate from 4.5 percent to around seven percent.

Figure 6 relates the growth rate, ϕ, to federal matching grants for local investment and consumption, α and β. A rise in the rate of the matching grant for local investment always raises the growth rate (the curve $\phi(\alpha)$), whereas a rise in the rate of the matching grant for local consumption always reduces the growth rate (the curve $\phi(\beta)$). Obviously enough, federal matching grant for local investment stimulates local public capital formation, which in turn raises private marginal productivity of capital and increases the growth rate. For example, in figure 6, when the matching grant for local investment from zero rises to sixty percent, the growth rate increases from around four percent to seven percent. But we also need to note

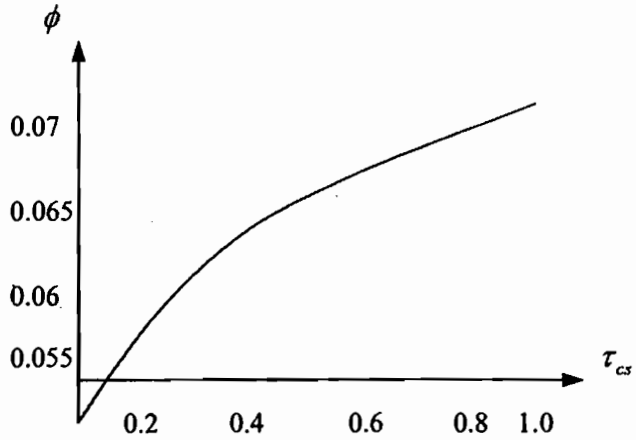

FIG. 5. Growth rate versus the local consumption tax rate. Where the production function and the utility function are specified as $y = k_p^{\omega_1} k_f^{\omega_2} k_s^{\omega_3}$ and $u(c,.f, s, k_f, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s$, respectively. Parameters are selected as: $\theta_0 = 0.5$, $\theta_1 = 0.1$, $\theta_2 = 0.1$, $\theta_3 = 0.1$, $\theta_4 = 0.1$, $\omega_1 = 0.5$, $\omega_2 = 0.25$, $\omega_3 = 0.25$, $\rho = 0.08$, $\delta = 0.08$,$\tau_s = 0.10$,$\alpha = \beta = 0.3$,$\tau_f = 0.20$,$\tau_k = 0.01$, and $\tau_{cf} = 0$.

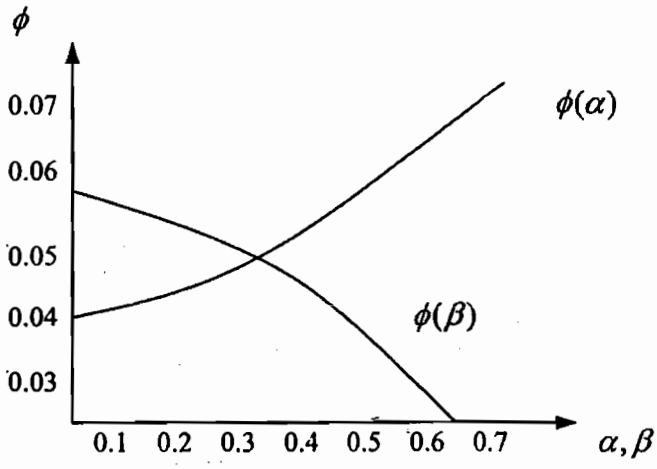

FIG. 6. Growth rate versus the federal transfers. Where the production function and the utility function are specified as $y = k_p^{\omega_1} k_f^{\omega_2} k_s^{\omega_3}$ and $u(c, f, s, k_f, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s$, respectively. Parameters are selected as: $\theta_0 = 0.5$, $\theta_1 = 0.1$, $\theta_2 = 0.1$, $\theta_3 = 0.1$, $\theta_4 = 0.1$, $\omega_1 = 0.5$, $\omega_2 = 0.25$, $\omega_3 = 0.25$, $\rho = 0.08$, $\delta = 0.08$,$\tau_s = 0.10$,,$\tau_f = 0.20$,$\tau_k = 0.01$, and $\tau_{cs} = 0.05$.

that a federal matching grant for local consumption has both a income effect and a price (substitution) effect. While the price effect of federal grant for local consumption discourages local investment, the income effect does encourage local investment. From our simulation, the price effect of federal

grant for local consumption always dominates the its income effect.[2] In fact, when the matching rate for local public consumption increases from zero to sixty-five percent, the growth rate is down from 5.8% to around two percent.

5. WELFARE ANALYSIS

With ϕ implicitly defined in (28), we can now determine the time paths of various capital stocks, $k_p(t)$, $k_f(t)$, and $k_s(t)$), private consumption, $c(t)$, federal consumption, $f(t)$, and local consumption $s(t)$:

$$\begin{aligned} k_p(t) &= k_p(0)e^{\phi t},\ k_f(t) = k_f(0)e^{\phi t},\ k_s(t) = k_s(0)e^{\phi t}, \\ c(t) &= c(0)e^{\phi t},\ f(t) = f(0)e^{\phi t},\ s(t) = s(0)e^{\phi t}, \end{aligned} \tag{29}$$

where the initial capital stocks $k_p(0), k_f(0)$, and $k_s(0)$ are given. $c(0)$ is determined by equation (23), $s(0)$ is determined from equation (25), and $f(0)$ is determined from equation (27).

The agent's welfare is given as

$$\begin{aligned} W &= \int_0^\infty u(c,s,k_s,f,k_f)e^{-\rho t}dt \\ &= \int_0^\infty (\theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s)e^{-\rho t}dt \\ &= \int_0^\infty (\theta_0 \ln c(0) + \theta_1 \ln f(0) + \theta_2 \ln k_f(0) + \theta_3 \ln s(0) + \theta_4 \ln k_s(0) + 5\phi t)e^{-\rho t}dt \\ &= \frac{1}{\rho}(\theta_0 \ln c(0) + \theta_1 \ln f(0) + \theta_2 \ln k_f(0) + \theta_3 \ln s(0) + \theta_4 \ln k_s(0)) + \frac{5\phi}{\rho^2} \end{aligned} \tag{30}$$

Unlike Barro (1990), it is not a simple exercise here to show that welfare maximization and growth maximization are consistent from equation (30) because the complicated relationship between the growth rate and the initial values of private consumption, federal consumption, and local consumption. But for reasonable values of initial capital stocks in our simulations, welfare is indeed an increasing function of the growth rate. That is to say, in equation (30), the term $\frac{5\phi}{\rho^2}$ far dominates the term $\frac{1}{\rho}(\theta_0 \ln c(0) + \theta_1 \ln f(0) + \theta_2 \ln k_f(0) + \theta_3 \ln s(0) + \theta_4 \ln k_s(0))$. This is not surprising because ρ^2 is rather small, and $\frac{5\phi}{\rho^2}$ can be rather big, whereas the sum of $(\theta_0 \ln c(0) + \theta_1 \ln f(0) + \theta_2 \ln k_f(0) + \theta_3 \ln s(0) + \theta_4 \ln k_s(0))$ is not very significant with the logarithmic utility function and the coefficient constrain, i.e., $\theta_0 + \theta_1 + \theta_2 + \theta_3 + \theta_4 = 1$. Therefore, in our simulations, we find

[2]See Zou (1994, 1996) for related discussions on the ambiguities of matching grants on local public consumption and public investment in dynamic models.

that welfare effects of federal taxes, local taxes, and federal transfers are qualitatively the same as the growth effects. For example, figure 7 presents the Laffer curve of welfare versus federal income taxation, which is similar to the Laffer curve of growth rate versus federal income taxation in figure 1. Figure 8 relates welfare to local property tax, and it has the same shape as figure 3. Finally figure 9 suggests that consumption tax always raises welfare. It may sound surprising. But the reason is obvious after a second thought. A higher consumption tax raises the growth rate, and income will rise faster. With fast-rising income, the agent's actual consumption after paying a high consumption tax is also rising, which leads to a higher welfare.

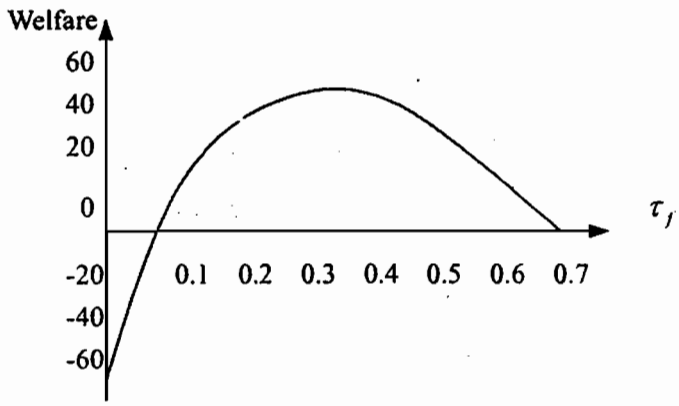

FIG. 7. Welfare versus the federal income tax rate. Where the production function and the utility function are specified as $y = k_p^{\omega_1} k_f^{\omega_2} k_s^{\omega_3}$ and $u(c, f, s, k_f, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s$, respectively. Parameters are selected as: $\theta_0 = 0.5$, $\theta_1 = 0.1$, $\theta_2 = 0.1$, $\theta_3 = 0.1$, $\theta_4 = 0.1$, $\omega_1 = 0.5$, $\omega_2 = 0.25$, $\omega_3 = 0.25$, $\rho = 0.08$, $\delta = 0.08$, $\tau_s = 0.10$, $\alpha = \beta = 0.3$, $\tau_k = 0.01$, $\tau_{cf} = 0$, and $\tau_{cs} = 0.05$.

6. CONCLUSIONS

This paper has extended the Barro (1990) model with one aggregate government spending and one flat income tax to include federal and local public consumption, federal and local public capital formation, federal and local taxes, and federal transfers to locality. It has derived the rate of endogenous growth and examined how the growth rate and welfare respond to changes in federal taxes, local taxes, and federal transfers. With simulations, the paper has examined how the rate of endogenous growth changes with respect to federal income tax, federal consumption tax, local income tax, local consumption tax, local property tax, and federal transfers. Even though, analytically, the growth-maximizing choices of taxes and transfers

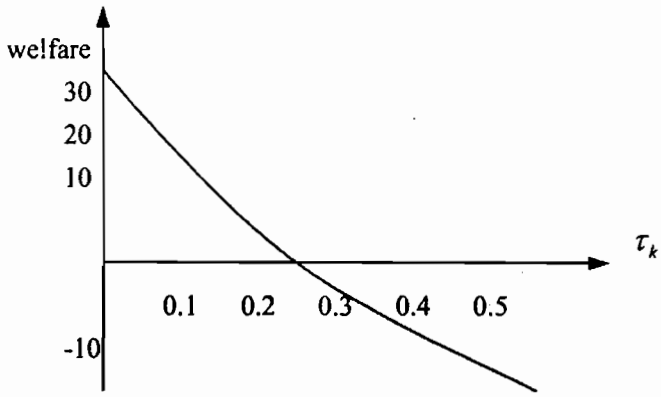

FIG. 8. Welfare versus the property tax rate. Where the production function and the utility function are specified as $y = k_p^{\omega_1} k_f^{\omega_2} k_s^{\omega_3}$ and $u(c, f, s, k_f, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s$, respectively. Parameters are selected as: $\theta_0 = 0.5$, $\theta_1 = 0.1$, $\theta_2 = 0.1$, $\theta_3 = 0.1$, $\theta_4 = 0.1$, $\omega_1 = 0.5$, $\omega_2 = 0.25$, $\omega_3 = 0.25$, $\rho = 0.08$, $\delta = 0.08$,$\tau_s = 0.10$,$\alpha = \beta = 0.3$,$\tau_f = 0.20$,$\tau_{cf} = 0$, and $\tau_{cs} = 0.05$.

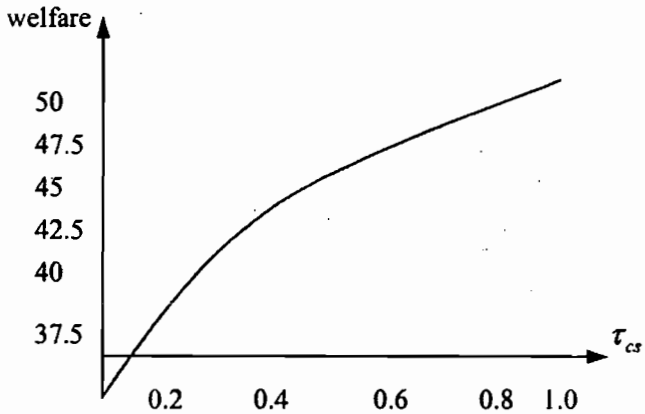

FIG. 9. welfare versus the local consumption tax rate. Where the production function and the utility function are specified as $y = k_p^{\omega_1} k_f^{\omega_2} k_s^{\omega_3}$ and $u(c, f, s, k_f, k_s) = \theta_0 \ln c + \theta_1 \ln f + \theta_2 \ln k_f + \theta_3 \ln s + \theta_4 \ln k_s$, respectively. Parameters are selected as: $\theta_0 = 0.5$, $\theta_1 = 0.1$, $\theta_2 = 0.1$, $\theta_3 = 0.1$, $\theta_4 = 0.1$, $\omega_1 = 0.5$, $\omega_2 = 0.25$, $\omega_3 = 0.25$, $\rho = 0.08$, $\delta = 0.08$,$\tau_s = 0.10$,$\alpha = \beta = 0.3$,$\tau_f = 0.20$,$\tau_k = 0.01$, and $\tau_{cf} = 0$.

are not the same as the welfare-maximizing choices, simulations show that these two kinds choices are consistent.

The model in this paper sets up a positive framework for evaluating how the assignments of taxes and expenditures among different levels of government and intergovernmental transfers affect economic growth. For example, in our very preliminary simulation analysis it has been shown

that local property tax has the largest negative impact on the rate of economic growth, whereas both federal and local consumption taxes are always growth-enhancing. This positive effect of consumption taxes shall be compared to Rebelo (1991). Without public spending , public capital formation, and taxation by multiple levels of government, Rebelo (1991) has found that a consumption tax has no effect on the growth rate. It is also interesting to note that higher consumption taxes at both the federal and local levels are welfare-improving through their positive effects on economic growth. Our analysis also sheds light on the role of intergovernmental transfers in economic growth. The matching grant for local public investment always promotes economic growth, whereas the matching grant for local public consumption is growth-retarding.

For future work, theoretically, we can formulate a game-theoretical growth model allowing strategic interactions between the federal government and multiple local governments in taxes, public expenditures, and intergovernmental transfers. Empirically, we can examine the effects of federal taxes, local taxes, federal transfers on private capital accumulation, federal consumption and investment, and local consumption and investment. Furthermore, the model is also useful for normative discussion on the welfare-maximizing and growth maximizing choices of taxes, transfer, and expenditures in the context of fiscal federalism.

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第 12 章

预算软约束对中国地方政府规模的影响

9 Soft-Budget Constraints and Local Government in China

Jing Jin and Heng-fu Zou

A significant feature of China's economic reform since 1978 is the devolution of the central government's control over the economy to subnational governments. The fiscal system is decentralized among five levels of government—national, provincial, municipal, county, and township governments—which are broadly categorized into center, provincial, and local governments (all subprovincial governments). This chapter mainly focuses on soft budget constraints in the relationship between the central government and the provinces. The term *local* refers to the levels below provinces and *subnational* to the levels below the center unless otherwise specified.

China's subsidy, taxation, credit, and administrative pricing systems are all subject to soft budget constraints. Prior to 1994 under the Chinese fiscal regime, the collection of all taxes and profits followed the prereform pattern: local government collections were remitted to the center and then transferred back to the provinces according to expenditure needs approved by the center. Policymakers in the central government decided what type of revenues should be collected and how these revenues were to be reallocated for national and local public good provisions. Most expenditures at subnational levels were financed by central transfers and complemented by a few self-retained local tax receipts. The prereform fiscal system resulted in a fundamental lack of incentives and efficiency, which became the major concern of the central authorities. In the 1980s, a series of reforms were implemented to revamp the fiscal relations between the central and subnational governments. Although incentives to spur tax collection efforts by local governments were successful to a certain extent, they also reduced the share of revenues passed on to the central government.[1] Before the 1994 tax system reform, the central government's share of total revenue declined from 44 percent in 1978 to 23 percent in 1993,

while the total subnational revenue share increased from roughly 56 percent to 77 percent during same period. At the same time, the consolidated government revenue share in GDP also shrank, from 47 percent in 1978 to 13 percent in 1993. Although fiscal decentralization in the 1980s shifted more resources to local governments in terms of increased share in total revenues, the shrinking pie also considerably reduced the budgetary resources allocated at the provincial level (table 9.1).

Throughout the 1980s, the central government's inability to cut spending to stay within declining revenue created persistent budget deficits that contributed to mounting inflationary pressures. At the same time, subnational governments faced greatly expanded expenditure responsibilities stemming from obligations imposed by national policy (Wong 1991). As the central government responded to fiscal pressure by attempting to devolve expenditure responsibilities to lower levels of government, it left provincial governments starved for revenues. Apart from the intensified bargaining between central and local governments over the sharing schemes, fiscal pressures created by the contract system of the 1980s led to undesirable responses by subnational governments. Examples include the diversion of resources from budgetary to extrabudgetary channels, the duplication of industries to capture revenues that formerly flowed to the national treasury, generous tax concessions to local state-owned enterprises (SOEs) under their own jurisdictions, and expanded local bank lending to these SOEs. All of these measures circumvented the central government's efforts to impose hard budget constraints and weakened overall financial discipline.

As the country moved toward economic federalism with the fiscal decentralization coincident with a continuous decline of government revenue as a percentage of national income in the fiscal sphere, the unitary political system was also transformed and decentralized. Although the central bureaucratic hierarchy continued to select, assign, and promote top provincial cadres (Huang 1996), since 1983, bureau-level officials (e.g., the heads of provincial fiscal bureaus and the managers of provincial branches of national banks) have been selected by provincial governments and appointed by the corresponding level of the People's Congress. No central approval is required. Driven by common economic interests and the pressure to seek growth, the most important measure of their political performance, the directors of fiscal and banking agencies tend to "stand where they sit" rather than

Table 9.1
Central and provincial government revenue shares in total revenue and GDP

Year	Tax revenue (without SOE remittance) (billion yuan)	Revenue from enterprises (Profit remittance, billion yuan)[a]	Total revenue (billion yuan)	Central tax revenue (billion yuan)	Total central revenue (billion yuan)	Subnational revenue (billion yuan)	Share of total central revenue in total revenue (%)	Share of subnational revenue in total revenue (%)	GDP (billion yuan)	Total government revenue as a percentage in GDP (%)
1978	113.2	57.2	170.4	17.6	74.8	95.6	43.9	56.1	362.4	47.0
1979	114.6	49.5	164.1	23.1	72.6	91.5	44.2	55.8	403.8	40.6
1980	116	43.5	159.4	28.4	71.9	87.5	45.1	54.9	451.8	35.3
1981	117.6	35.4	153	31.1	66.5	86.5	43.5	56.5	486.2	31.5
1982	121.2	29.6	150.8	34.7	64.3	86.5	42.6	57.4	529.5	28.5
1983	136.7	24.1	160.8	49	73.1	87.7	45.5	54.5	593.5	27.1
1984	164.3	27.7	191.9	66.5	94.2	97.7	49.1	50.9	717.1	26.8
1985	200.5	4.4	204.9	77	81.4	123.5	39.7	60.3	896.4	22.9
1986	212.2	4.2	216.4	77.8	82	134.4	37.9	62.1	1,020.2	21.2
1987	219.9	4.3	224.2	73.6	77.9	146.3	34.7	65.3	1,196.3	18.7
1988	235.7	5.1	240.7	77.4	82.5	158.2	34.3	65.7	1,492.8	16.1
1989	266.5	6.4	272.9	82.3	88.7	184.2	32.5	67.5	1,690.9	16.1
1990	293.7	7.8	301.5	99.2	107	194.5	35.5	64.5	1,854.8	16.3
1991	314.9	7.5	322.4	93.8	101.3	221.1	31.4	68.6	2,161.8	14.9
1992	348.3	6	354.4	98	104	250.4	29.3	70.7	2,663.8	13.3
1993	434.9	4.9	439.8	95.8	100.7	339.1	22.9	77.1	3,463.4	12.7
1994[b]	521.8		521.8	290.7	290.7	231.1	55.7	44.3	4,675.9	11.2
1995	624.2		624.3	325.7	325.7	298.6	52.2	47.8	5,847.8	10.7
1996	740.8		740.7	366.1	366.1	374.6	49.4	50.6	6,788.4	10.9
1997	865.1		865.1	422.7	422.7	442.4	48.9	51.1	7,446.3	11.6
1998	987.6		987.6	489.2	489.2	498.4	49.5	50.5	7,939.6	12.4

Sources: China Statistical Yearbook (1999); *China Government Finance Yearbook* (various issues).
[a]Before 1984, a considerable amount of central revenue came from SOEs' profit remittance, which exclusively went to the central treasury. Since 1984, the profit remittance had been increasingly replaced by enterprises income tax. Profit remittance from SOEs remained as a residual category until 1993 before it terminated.
[b]Tax assignment system reform introduced. Data after 1994 are not compatible with those before 1994.

delegate to their central line administrators. As a result, the former hierarchical management has been considerably weakened and increasingly transformed into horizontal administration featured by a highly fragmented economy. The central authority's attempt to strengthen the hierarchical management by strengthening personnel management at the level of provincial party secretaries and governors thus may not necessarily be able to penetrate the horizontal alignment coalitions increasingly shaped by common interests and contiguity at the subnational level. According to Yang (1997), the heads of faster-growing provinces now tend to be promoted more quickly than otherwise would be the case. Bo (1996) also finds that provincial leaders of more populous and richer provinces are more likely to be promoted than those in less populous and less developed ones.

This chapter outlines some major economic and administrative mechanisms that undermine the central government's endeavor to harden the budget constraint on provincial governments. Section 9.1 describes briefly the evolution of China's intergovernmental fiscal relations in the postreform period, section 9.2 presents the major channels of soft budget constraints on provincial governments, and section 9.3 sets out the conclusions.

9.1 Evolution of Intergovernmental Fiscal Relations, 1980s–1990s

9.1.1 1980–1993: Fiscal Contract System (Tax-Sharing System)

In 1980, the centralized fiscal regime was replaced with the fiscal contract system whereby each level of government contracted with the next level up to meet certain revenue and expenditure targets. Central and subnational governments shared the revenue proportionately or in the form of a fixed quota plus a percentage share. At the same time, subnational governments were required to finance their own expenditures through self-generated and shared revenues, a step in the direction of hardening the budget constraint on local governments.

Unlike other countries where taxes are collected by the central government and then allocated to subnational governments, local authorities in China collected all tax revenues and remitted a portion to higher levels of government. The amount submitted to the central coffers depended on provincial receipts and the sharing formula between the center and provinces. Given such a highly decentralized revenue collection system, the center had to resort to various instruments to ensure

revenue remittance from local authorities. These instruments in turn led to perverse reactions from the provinces, which always found ways to retain more revenues through their relaxed revenue collection for and the negotiations with the center regarding shared revenue.

From 1980 through the early 1990s, four revenue-sharing systems were employed, with many variations. Until the tax system reform in 1994, six different contract types were in use between the central government and provinces, with many more at the subprovincial level (table 9.2) (also see World Bank 1993 and Bahl and Wallich 1992).

Type A: Incremental contract Based on 1987 revenues, the provincial retention rate of all tax revenues ranged from 28 percent to 80 percent, while local remittance the center needed was to increase from 3.5 percent to 6.5 percent (contracted growth rate) on an annual basis. Tax revenues in excess of the stipulated growth rates were retained entirely by provinces.

Type B: Basic proportional sharing A fixed proportion of all revenues was remitted to the center.

Type C: Proportional sharing and incremental sharing A certain proportion of the actual revenue collection of the previous year was retained, and then a different (usually higher) proportion of revenues was retained for the incremental amount in excess of the total revenues for the previous year.

Type D: Remittance incremental contract A specific nominal amount was transferred to the center in the initial year; in subsequent years, the remitted amount increased at a contracted rate (9 percent for Guangdong province and 7 percent for Hunan province).

Type E: Fixed remittance A specific nominal amount was transferred to the center with no annual adjustments.

Type F: Fixed subsidy Deficit provinces received fixed subsidies.[2]

Two crucial features survived every change in revenue-sharing systems. First, central fixed revenues were not subject to revenue sharing, so whatever was designated as central revenues left the pool of revenues to which revenue-sharing formulas were applied.[3] Second, enterprise income, both remitted profits and direct tax revenues (after 1984), was still divided among governments according to their administrative subordination—state-owned enterprises subordinated to the central, provincial, and local governments, respectively.

Table 9.2
Revenue-sharing system between the central and provincial governments, 1988–1992

	Type A		Type B	Type C		Type D		Type E	Type F
	Incremental contract		Basic proportional sharing	Proportional sharing and incremental sharing		Remittance incremental contract		Fixed Remittance	Fixed Subsidy
	Contracted growth rate (%)		Retention rate (%)	Proportion	Incremental sharing	Remittance (100 million)	Incremental contract (%)	(100 million yuan)	
Beijing	4.00	50.00							
Hebei	4.50	70.00							
Liaoning	3.50	58.30							
Shenyang	4.00	30.30							
Haerbin	5.00	45.00							
Jiangsu	5.00	41.00							
Zhejiang (exl. Ningpo)	6.50	61.50							
Ningpo	5.30	27.90							
Henan	5.00	80.00							
Chongqing[a]	4.00	33.50							
Tianjin			46.50						
Shanxi			87.60						
An Hui			77.50						
Da Lian				27.70	27.30				
Qingdao				16.00	34.00				
Wuhan[a]				17.00	25.00				
Guangdong						14.10	9.00		
Hunan						8.00	7.00		

Shanghai	105.00	
Heilongjiang	2.90	
Shangdong (exl. Qingdao)	4.90	
Hubei (exl. Wuhan)		1.22
Ji Lin		1.07
Sichuan (exl. Chongqing)		1.79
Jiangxi		0.50
Sha'anxi		1.20
Gansu		1.30
Fujian		0.50
Inner Mongolia		18.40
Guangxi		6.10
Tibet		9.00
Ningxia		5.30
Xinjiang		15.30
Guizhou		7.40
Yunan		6.70
Qinghai		6.60
Hainan		1.40

Source: Ministry of Finance, P.R. China. Also see Bahl and Wallich (1992), World Bank (1993).
[a]After the cities of Wuhan and Chongqing were treated differently from Hubei and Sichuan provinces, the provinces changed from net providers to the state to net recipients of subsidies from the state.

9.1.2 *Problems of the Fiscal Contract System*

Declining Central Revenue as a Percentage of Total Revenue

The decentralized nature of tax collection by local governments meant that the central government lacked effective supervision of tax collections and remittances by provincial governments. Consequently, local governments avoided sharing revenues with the center through various means. For example, if the total revenue collected by Jiangsu provincial government was within the total amount of the previous year (took taking 1987 as the base year) plus a 5 percent increase, Jiangsu provincial government could retain 41 percent of the total revenue collected. Any amount exceeding the total increased revenue can be retained by the provincial government. Frequently, tax revenues stagnated for years, limiting the amount for sharing with the center. This phenomenon was prevalent among the provinces under contracts A, B, and C. Assuming some growth in taxes accruing to the provinces by transferring budgetary revenue to extrabudgetary items or allowing generous tax recessions to local enterprises so that benefits could be accrued within the enterprises under the jurisdiction of subnational governments, the center's share would decrease.

In other cases, tax remitted to the center was fixed in nominal terms for many years, and growth was retained by the province. Guangdong, one of the fastest-growing economies in China, is a case at point. Its remittance was fixed at 1.4 billion yuan for many years. Not until 1988 was the remittance incremental contract implemented (table 9.2), under which its remittance was set at an annual increase of 9 percent, with 1987 as the base year. By 1993, its remittance increased to 2.4 billion yuan, barely 7 percent of its total 34.7 billion revenue.

With the power of tax collection, provincial governments acted strategically to escape sharing their revenues with the center, which resulted in a decline of central revenue share in relation to that of the local government in total revenue (table 9.1). Tax generation in such a fiscal system tends to be inelastic with respect to GDP and procyclical. In a rapidly growing economy with fiscal contracts containing a large fixed component, the rate of increase in tax revenues would be less than that of income growth. Tax policy thus becomes a procyclical mechanism that exacerbates economic fluctuations instead of moderating them (Agarwala 1992). When government expenditure increases in line with GDP, the deficit is likely to expand as a consequence.

Extrabudgetary Fund

The rapid growth of extrabudgetary revenues was a striking feature of tax reform during the 1980s. By 1992, the size of such revenue was almost equal to state revenue and accrued mostly to state-owned enterprises and their supervisory agencies (see section 9.2). Richer provinces could raise extrabudgetary funds more easily than poorer ones.

Regional Disparity

The fiscal contract system led to an increasing regional disparity. Provinces with enormous economic potential such as Guangdong accumulated a substantial and growing revenue base by retaining most of the incremental revenues within the province through a contract system that, in fact, favored better-off provinces with more bargaining power, and for some other provinces, moving revenues to extrabudgetary funds without sharing with the center. This shift in financial flows from the early 1980s, where central government received more from the provinces with surpluses than it paid out in transfers and grants (Ahmad 1997), handcuffs the central government in stabilizing the economy and bridging horizontal imbalances.

Administrative Decentralization

The transition from a vertical hierarchy to horizontal administration began with Mao's decentralization of state enterprise ownership among the central, provincial, and county governments and local communes during the 1970s (Sachs, Woo, and Yang 2000). During the 1980s, the central authorities gave subnational governments the power to nominate and assign most provincial officials. Before 1983, the Cadre that dominated the Chinese Communist party appointed and promoted officials two levels down, as evidenced by the fact that the the Department of Organization (DOO) under the Central Committee of the CCP managed this process. Since 1983, the central government has been less involved in supervising provincial-level appointments, making the appointment system only "one level down." Directors of fiscal agencies and tax bureaus are now determined by provincial governments and their party committees (Huang 1996). This new decentralized organization includes managers of local branches of state banks (a point that will be elaborated later).

In combination with fiscal decentralization, provincial governments
e the wherewithal and authority to circumvent central plans

and policies in favor of regional priorities. Although provincial fiscal agencies and tax bureaus were subject to the hierarchical (professional) instructions of the Ministry of Finance at the center, they are, in fact, under the leadership of their respective provincial governments. The new mechanism has problems of its own: "The shortcoming of the two-level downward system was excessive centralization and unwieldiness; the problem with the one-level system was that it encouraged nepotism and localism because it concentrated too many appointment decisions locally" (Manion 1985).

9.1.3 1994–Present: Dual Track System of Tax Assignments Together with the Contract System

The central government introduced the tax assignment system in 1994 to strengthen the central government's ability to achieve macroeconomic stabilization, regional equalization, and efficient public goods provisions. At the same time, the reform introduced more rigorous budget constraints on local governments.

The objectives of the reform package were fourfold: (1) to simplify and rationalize the tax structure by reducing tax types, tax rates, unifying the tax burden on taxpayers, and reducing exemptions; (2) raise the revenue-to-GDP ratio; (3) raise the central-to-total revenues ratio; and (4) put central-local revenue sharing on a more transparent, objective basis by shifting the negotiated sharing of general revenues to a tax assignment system.

Under the new system, taxes were reassigned between the central and local governments as follows:

- Taxes exclusive to the central government: Tariff duties, income taxes of state-owned enterprises (SOEs) under the jurisdiction of the central government, consumption taxes, import-related consumption taxes, and taxes imposed on banks, nonbank financial institutions and insurance companies, and taxes on railroads
- Taxes exclusive to provincial governments: Sales taxes (provided that sales taxes applicable to banks and railroads would be payable to the central government), income taxes from SOEs under the jurisdiction of provincial governments and collectively owned enterprises, and personal income taxes
- Shared taxes: The value-added tax (VAT) (at the fixed rate of 75 percent for the central government, and 25 percent for local govern-

ments), stamp duties on securities transactions, taxes on natural resources, and other taxes

In order to implement this tax assignment system and ensure the effective collection of the central government's portion of revenues, the central and provincial tax collection bureaus were to be separated. Once separation was fully implemented, the central and provincial governments were to collect their own exclusive taxes. The shared taxes were to be levied and collected by the central tax bureau and then shared between the central and provincial governments.

This new tax assignment system met with unprecedented resistance from provincial authorities, and significant concessions by the central government were obtained (for details, see Wang 1997). As a compromise, the revised scheme would ensure provincial interests of fait accompli with the new assignments applied only to the incremental receipts (with 1993 as the base year).

The revenue-sharing contracts negotiated under the old system were allowed to remain effective at the same time. The provinces were still supposed to remit a specified amount of locally collected revenues to, or receive a certain amount of subsidies from, the central government. In practice, after the provinces share taxes with the center under the new rule effective since 1994, they have had to "hand over remittances to or receive subsidies from the center according to the old revenue-sharing contracts. In the end, no one knew what constituted real central revenue or local revenue" (Wang 1997).

The de facto dual track system that combined tax assignment with the contract regime thus limited the ability of the central government to harden budget constraints on local governments. Moreover, a policy to ensure the provincial revenue level in 1993 triggered sudden inflated receipts in their 1993 reported budgetary revenues.[4] Provinces that tried to underreport their revenues in order to avoid sharing with the center in the previous fiscal contract system now faced the opposite problem. More 1993 budgetary revenues also meant more return transfers the provinces could receive from the center. In 1993, the actual total subnational revenues increased by 88.8 billion within a single year, from 250.3 billion yuan in 1992 to 339.1 billion yuan, which was 28.3 percent higher than the budgeted amount and 39.9 percent higher than the previous year.[5] The Ministry of Finance agreed to top up the reported 1993 revenues of provinces with one proviso: if the province's revenue growth rate of 1994 was not parallel to that of 1993, the 1993

base amount would be subjected to readjustment according to the lower growth rate of 1994, and the extra transfers for 1993 would be deducted from the transfers for 1994.

The implementation of the new tax system increased central revenues from 95.8 billion yuan in 1993 to 290.7 billion yuan in 1994 and correspondingly raised the central share in total revenues from 22 percent in 1993 to 55.7 percent in 1994, and decreased aggregated provincial revenues from 339.1 billion yuan in 1993 to 231.1 billion yuan in 1994 (table 9.1). According to the deal between the central and provincial authorities, the reduced amount was to be topped up by central return transfers. Therefore, in 1994, the central expenditure was 4,14.4 billion yuan (including transfers), although the budgetary spending at the discretion of central government was only 175.4 billion yuan. Transfers from the center to provinces soared from 54.5 billion yuan in 1993 to 238.9 billion yuan in 1994, among which roughly 180 billion was the return transfers from the center to top up to their 1993 revenue level.[6]

After all these adjustments, the redistribution of revenues did not improve. The central government's revenues continued to experience a decline (52.2 percent in 1995, 49.4 percent in 1996, and 48.9 percent in 1997)[7] because local government tax revenues from the agricultural tax, individual income tax, and business tax increased at a faster pace than central government tax revenues from the VAT, certain customs tariffs, and consumption taxes. In addition, the central government increased export VAT rebates and reduced customs tariffs in order to encourage exports and technology imports and attract foreign direct investment.

9.2 Forms of the Soft Budget Constraint

The fiscal year in China follows the calendar year. State budgets are prepared every September, and the National Budget Department of the MOF collects the spending plans and revenue estimates from ministries and agencies of the central and provincial governments. The aggregated budget prepared by the MOF (for central and aggregated subnational governments combined) is then submitted to the State Council. After the State Council approves the budget, the draft budget is sent to the National People's Congress (NPC), usually by March of the next year, for final approval, when the processing budget has already been executed for three months. Pursuant to the budget law

effective January 1, 1995, the NPC reviews and approves the budget for the central government. The budget law also lays out rules and procedures for the review and approval by the corresponding people's congresses of the corresponding local governments' budgets. In practice, the review and approval of subnational budgets follow the approval of the budget by NPC at the superior level. Only after the aggregated national budget is approved can the NPC at the provincial level start to review the aggregated provincial budget. The auditing of the national budget by the National Auditing Office is carried out in June of the next year.

Prior to 1994, budget deficits were financed through a combination of credits from the People's Bank of China (PBC) and domestic and international borrowing as debt revenues. The new budget law (effective January 1, 1995) states in its first chapter that budgets at all levels of government shall be balanced. Chapter 10 of the same law stipulates that any violation of the balanced budget approved by the legal process would result in administrative prosecution against parties directly responsible. The government now finances its budget deficits only through domestic and international borrowings, and such borrowing is no longer counted as debt revenues in the state budget.

9.2.1 Legacies of 1994 Fiscal Reform and Central-Provincial Bargaining

One way for subnational governments to balance their budgets each year is by increasing transfers from the center through grant allocations and revenue bargaining. Fiscal redistribution by earmarked grants occurs through an ad hoc case-by-case process, which is often poorly targeted and provides grants too small to meet basic needs in poorer regions. Also, the arbitrary nature of central grant allocations has led to extensive negotiations and rent seeking by local authorities, tying up valuable administrative resources.

Under the contract system of the 1980s and early 1990s, transfers were obtained by local authorities through negotiating or renegotiating the contracted rates and periods under each sharing method. Remittance revenues were subject to adjustment and resulted in a default by subnational governments. For example, in 1991, in response to the regional flood in some eastern areas (Hua Dong region), the central government waived or reduced the required remittances from the affected provinces (Gao 1993). The budget constraint suffered a

considerable discount during the bargaining process between the center and provinces.

The fragmented data released by the Chinese government after 1994 provide little information on the outcomes in the post-fiscal reform period. Hence, a quantitative assessment not possible at present. However, several facts have indicated the difficulties of hardening budget constraints on subnational governments.

Transfers

Tax assignment reform implemented in 1994 fixed transfers to ensure the fait accompli of provincial revenue in 1993. This left the central authorities with little revenue to narrow regional disparity. From 1995 to 1997, the annual transfers averaged only 3 billion yuan, which was unlikely to contribute to horizontal balance. Bargaining for central transfers increased among poorer provinces when the allocations of grants remained arbitrary in nature and the introduction of a formula-based transfer scheme lagged behind.

Revenue Assignments

The 1994 reform redefined the fiscal relations only between the center and provinces. It authorized provinces to define the intergovernmental fiscal relations between provinces and their localities. When provinces reshaped their fiscal relations with the localities, they followed the central government's suit by assigning themselves the most stable and biggest chunk of revenues. As a result, local fiscal difficulties were exacerbated, and deficits further devolved down along the hierarchy. This reform therefore lacks any way to ensure the fiscal capacity of local governments to deliver their public good provisions.

Expenditure Assignments

The 1994 reform focused on only the revenue side as manifested by the emphasis on raising the two ratios (total government revenue as a percentage in GDP and central government revenue as a percentage in total government revenue) without clarifying and adjusting expenditure responsibilities among levels of government. Although the central government specified that framework provincial budgets should follow, such guidance consists solely of some general principles "Budget Law," 1994). In addition, expenditure pressure has increased at the provincial level, partly due to the centralization efforts in revenue and partly due to the increasing spending mandated by the central

authority.[8] Like the central government in the 1980s, provinces now attempt to devolve expenditure responsibilities to lower levels. Without local government elections to restrain subnational governments' excessive taxing power, some of the expenditures are ultimately devolved to the individuals in the forms of proliferated charges, fees, and fines.

Tax Administration

In the prereform era before 1994, tax policies could not be implemented as intended because tax collection was manipulated by the subnational governments to act strategically with the center in prioritizing their needs. As a consequence, the central government may not have full control over its tax bases and marginal tax rates because tax administration in China became ruled by negotiation rather than law (Vehorn and Ahmad 1997).

The structure of tax administration was overhauled during 1994, when the system was split into a central administration responsible for the collection of central and shared taxes and a parallel provincial (or local) tax administration for local taxes. In September 1993, when the State Council officially approved the reform plan, to be effective on January 1, 1994, only three months were left for the preparation. The tax bureaus could not be split before the new rules came into effect (Wang 1997).

Although the central government reserves sole authority over tax bases and rates, this administrative arrangement tends to encourage better collection effort for taxes retained at the subnational level but relatively less effort for taxes that are transferred upward. The central authorities believed that the continued decline of central revenue share in total revenue after 1994 was partially attributed to such implementation bias of subnational tax administration. As shown in table 9.3, the increase in provincial taxes was by far outpaced that of central taxes, in particular for personal income tax and other charges. Consequently, the share of central tax in total revenue declined, as did the aggregate central revenue share in total government revenue.

Although the 1994 tax system reform is a substantial move toward tax assignments, lagged reforms in other areas forbid the central government from hardening the budget constraints on provinces. For example, the ownership and the income tax of SOEs are still defined by the enterprises' jurisdictional subordination. As a result, SOEs continue to be the arenas where the budget constraints on lower

Table 9.3
Selected central and provincial tax shares in total government tax revenue, 1994–1997

Central revenue in each year	Revenue at central level (billion yuan)	Share in total revenue (%)	VAT (billion yuan)	Share in total revenue (%)	Central SOE income tax (billion yuan)	Share in total revenue (%)	Consumption tax (billion yuan)	Share in total revenue (%)
1994	290.7	55.7	172.8	33.1	38.9	7.5	48.7	9.3
1995	325.7	52.2	194.8	31.2	48.3	7.7	54.1	8.7
1996	366.1	49.4	222	30	51.2	6.9	62	8.4
1997	422.7	48.9	246	28.5	35.6	4.1	67.9	7.9
Average annual growth rate	13.3		12.5		11.7		–3.3	

Provincial revenue each year	Revenue at local level (billion yuan)	Share in total revenue (%)	Business tax (billion yuan)	Share in total revenue (%)	Local SOE income tax (billion yuan)	Share in total revenue (%)	Personal income tax (billion yuan)	Share in total revenue (%)	Other charges (billion yuan)	Share in total revenue (%)
1994	231.2	44.3	64.7	12.4	19.3	3.7	7.3	1.4	27.1	5.2
1995	298.6	47.8	82.8	13.3	23.2	3.7	13.1	2.1	45.1	7.2
1996	374.7	50.6	100.6	13.6	25.7	3.5	19.3	2.6	63.3	8.6
1997	442.4	51.2	116.1	13.4	37	4.3	26	3	80.2	9.3
Average annual growth rate	24.2		21.5		24.2		52.8		43.5	

Source: Liu (1999).

levels of government are softened (center to provinces, provinces to localities).

9.2.2 *Subsidies*

Subnational governments in China pay huge subsidies to SOEs for their losses resulting from market or price distortions. With direct ownership of SOEs, subnational governments can subsidize their respective loss-making enterprises and list such financial transactions as negative revenues in their budgets. Less explicit forms of subsidies are debt forgiveness and reduced or refunded government taxes and charges.

Between 1985 and 1995, total subsidies declined from 50.7 billion yuan to 32.8 billion. Their share in total expenditure (including SOE subsidies) dropped from 20 percent in 1985 to 4.6 percent in 1995 (figure 9.1). Such a significantly diminished role of subsidies may be largely attributed to a comparatively rapid increase in total expenditure when subsidies remained around their 1985 level. In practice, a portion of the government assistance to SOEs covers the operational inefficiencies of these enterprises (Lall and Hofman 1995).

At the same time, SOEs are obligated to employ redundant workers and bear the cost of related services, such as housing, health care, child care, schooling, and pensions. Many SOEs share the spending responsibilities of local governments and have become conduits for central-local financial transfers. As Steinfeld (1999) explains, SOEs are continually exposed to intervention by local state agencies, empowered

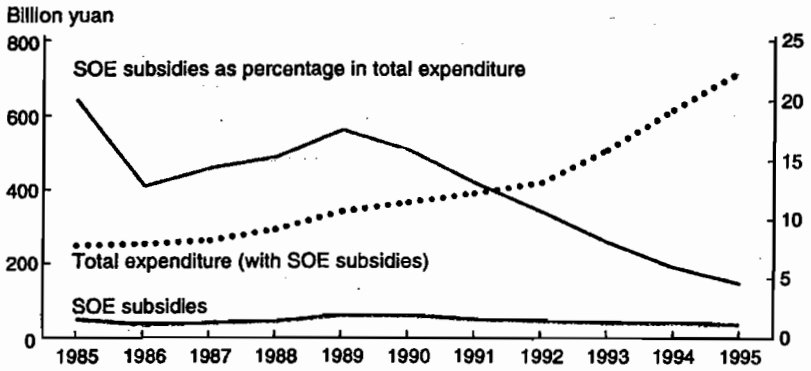


Figure 9.1
Subsidies to loss-making enterprises as percent of total expenditures. *Source*: Finance Yearbook of China (1997).

by the very policies of governmental decentralization that were intended to undermine command planning. Meanwhile, profit contracts—arrangements intended to rationalize the relationship between firm and state—fail to protect the firm from the state yet encourage the firm to overproduce and overexpand. Overproduction is then fostered by soft credit, capital made available through a banking system that was supposed to be the linchpin of market reform. On top of all that, new accounting standards, intended to permit managers the kind of autonomy that would encourage market behavior, make the misapplication of funds or outright decapitalization of the firm even easier.

9.2.3 Credit Plan and Borrowing from Commercial Banks

Prior to the economic reforms in China, the credit plan, together with the cash plan, the central government budget, and the foreign exchange plan, represented the financial side of the physical plan. Although plans are still drafted, their significance has steadily diminished since 1978. The reestablishment of the banking system in the early reform period (1978–1994) led to the independent operation of the People's Construction Bank of China (renamed China Construction Bank, CCB) and the Bank of China (BOC), which were subordinates under MOF and PBC, respectively, before the reform. At the same time, the Agricultural Bank of China (ABC) was established to take over the PBC's rural banking business. By 1994, there were three policy banks,[9] four state commercial banks,[10] four universal banks,[11] and a number of other local commercial banks and nonbank financial institutions.

The Credit Plan

The annual credit plan,[12] which was formulated by the PBC, in consultation with the MOF and State Planning Commission (renamed the State Development and Planning Commission, SDPC), took into account the need for investment in fixed capital and working capital, as well as PBC's direct financing of the government's deficit.[13] Ultimately, the credit plan was approved by the State Council and implemented by the PBC's provincial and local branches and, later, through a set of credit quotas for each specialized and universal bank. As banks have been transformed into financing institutions, local governments have gained a powerful influence over the administration of bank lending through the appointment of regional bank leaders. Apart from these formal controls, local governments retain intangible influences

that banks ignore at their own peril. For example, the supply of water and electricity, housing, recruitment of bank employees, and schooling of children all are potentially under the influence of local governments (Huang 1996). These relationships further undermine central control over subnational governments and possibly lead to corruption. "Contiguity brings personalism to relationships, and personalism is the enemy of arm's length relationships" (Tanzi 1995). Local governments thus gained substantial control over the credit supply, which has become a source of soft budget constraints of local governments and SOEs, as well as inflation (Qian and Rolland 1998).

The commercialization of banks has enhanced the profit motives of lending operations, merging the economic interests of banks with those of the local governments, both of which want to develop industries with high accounting profits (Huang 1996). Thus, the developmental urges of banks are now similar to those of the local industrial bureaus. This convergence of incentives means that it is harder for the central government to achieve its industrial policy goal through the credit plans. Moreover, although the formal power over credit creation rests with the headquarters of the PBC (and ultimately with the State Council), the operational autonomy granted to the local bank branches attenuates this central power. Bank branches are motivated to create credits on their own by converting deposits into loans (Bowles and White 1993).

The credit plan also allocates preferential interest rates to some regions and sectors. In addition to making direct contributions to the capital of the bank, the MOF provides indirect support to the bank through interest subsidies allocated each year in the annual budget of the government to the projects receiving loans from the bank. These subsidies are intended to further the government's economic development policies by enabling borrowers to obtain loans at interest rates below commercial rates (World Bank 1993).

Local officials' easy influence on the pattern of overlending combined with underpricing of loans contributed to the excessive expansion of banks' credit and a mounting number of bad and nonperforming loans. Even frequent interest rate changes could not curb the situation, partly because the soft budget constraints on SOEs make them unresponsive to the cost of borrowing. In fact, the impact of interest rate changes was felt much more on household savings than on bank lending (Mehran, Quintyn, Nordman, and Laurens 1996). According to a statement by the governor of the PBC, Dai Xianglong, the share

of nonperforming loans in the portfolios of the four largest state-owned banks increased to 25 percent by the end of 1997. "Ultimately the borrowers of nonperforming loans may default, requiring the lender to absorb the loss, drawing on either reserves or its own capital" (Lardy 1998). In 1998, the MOF issued 270 billion yuan in government bonds to recapitalize these state-owned banks. Such capital rejection injections are an indirect measure of the center's bailout to local governments.

Following the commercialization of the banking system,[14] China's State Development Bank was established on March 17, 1994, replacing the PCBC as the policy-oriented bank fostering economic development through long-term financing for policy-oriented and related projects in accordance with the government's development plan and industrial policies. More specifically, its mission is to extend loans to policy-oriented medium- and large-scale construction, technological transformation, and related projects for key state infrastructure facilities, basic industries, and pillar industries.

According to China's 1994 budget law, local governments are forbidden to borrow on the capital market. However, local enterprises (which provide public services) can and do borrow from banks and on the capital market despite their dependence on government subsidies of various kinds, which often makes them de facto government agencies. Given the still limited direct and indirect transfers from the center to provinces, such borrowing from local commercial banks by enterprises (under the jurisdiction of local governments) actually finances much subnational spending. This in turn creates contingent liabilities for local governments and, given the lack of transparency, is less easily controlled than explicit government borrowing.

Although the central government reserved credit resources such as bank loans and capital market access for use only by state-approved projects and it strengthened the traditional investment plan and approval mechanism, local authorities still maintained considerable latitude in securing and deploying financial resources. For example, subnational government maintained the power to approve investment projects below 50 million yuan (projects above 50 million yuan require approval by SDPC) and technical transformation or technology promotion projects below 30 million yuan (projects above 30 million yuan require approval by the State Economic and Trade). These projects can be funded by commercial and indirect borrowing. These rules have resulted in redundant investment of medium- and small-sized invest-

ment projects directly under the jurisdiction of subnational governments. Moreover, in the fiscal system before 1994, the product tax and business tax were both exclusively assigned to the subnational government, leading to the expansion of capital construction, particularly those industries (e.g., tobacco and alcohol) that generate high revenue from the product tax and business tax.

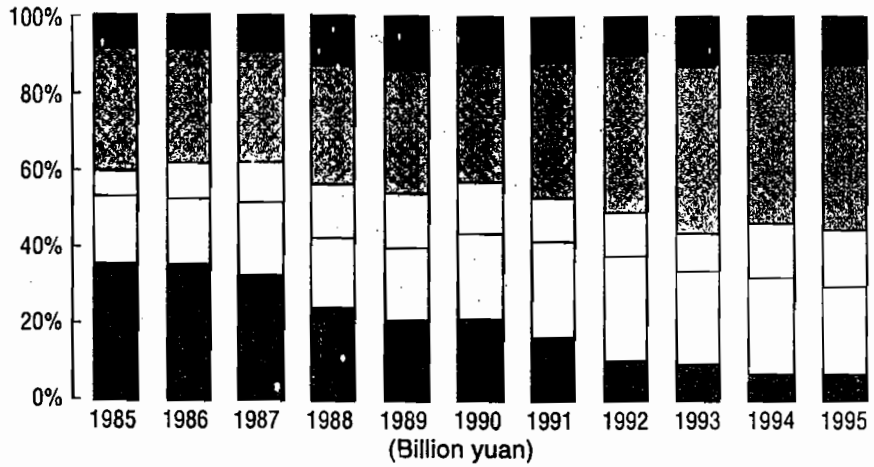
Chinese funding statistics are separated into five categories: budget, domestic credit, foreign capital, own funds ("self-raised," retained, or extrabudgetary funds), and, more recently, other sources, like stocks and bonds (World Bank 1995). Investment in aggregate and individual projects relies on a combination of funding sources, and the portfolio of sources has been changing over time. The nature of budget finance of enterprise investments has changed from direct capital grants to an annual lump-sum allocation to the capital construction fund, managed by SDPC. Budgetary financing for investment has declined in local budgets, and consequently recourse to alternative finance sources has become more common (World Bank 1993). As the share of budgetary funds fell, investments increasingly were financed by nonbudgetary sources (foreign capital, domestic credit, and other) in the second half of the 1980s, with an increasing reliance on own funds in the early 1990s. The share of self-raised funds increased substantially from 32 percent in 1985 to 43 percent in 1995, and the share of foreign capital increased from 7 percent in 1985 to 15 percent in 1995 (figures 9.2 and 9.3). By 1991, the amount of nonbudgetary financial resources used for local projects equaled central projects and largely exceeded the investment on central projects by 1995 (figure 9.4). The domestic credit level reached 22 percent in 1990 and increased modestly to 23 percent in 1995.

9.2.4 Indirect Borrowing and Foreign Borrowing

Indirect Borrowing

Provincial and local governments undertake indirect borrowing mainly by creating dummy financial companies that are able to borrow and provide resources for local government expenditures. Another method of indirect borrowing has been through a buildup of arrears, as well as IOUs on the procurement of agricultural products (Ahmad 1997).

Thus, soft budget constraints are reflected in the proliferation of trust and investment companies (TICs) and securities houses under the jurisdictions of provincial and local governments. According to



	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
■ Other	9.2	10.4	12.7	20.1	21.8	20.8	25.4	29.6	60.9	58.4	90.0
▣ Self-raised funds	34.0	34.5	38.3	48.9	49.5	53.0	74.7	124.3	199.1	282.0	312.2
□ Foreign capital	7.4	11.0	13.9	21.8	22.1	22.4	24.0	33.4	45.6	91.2	105.5
□ Domestic credit	18.8	20.0	25.5	28.5	29.3	37.9	52.7	83.1	111.8	158.3	164.6
■ Budgetary funds	38.1	41.7	43.9	38.2	32.3	36.4	34.8	30.8	43.2	43.5	49.2

Figure 9.2
Source of funds. *Source*: China Statistical Yearbook (1996).

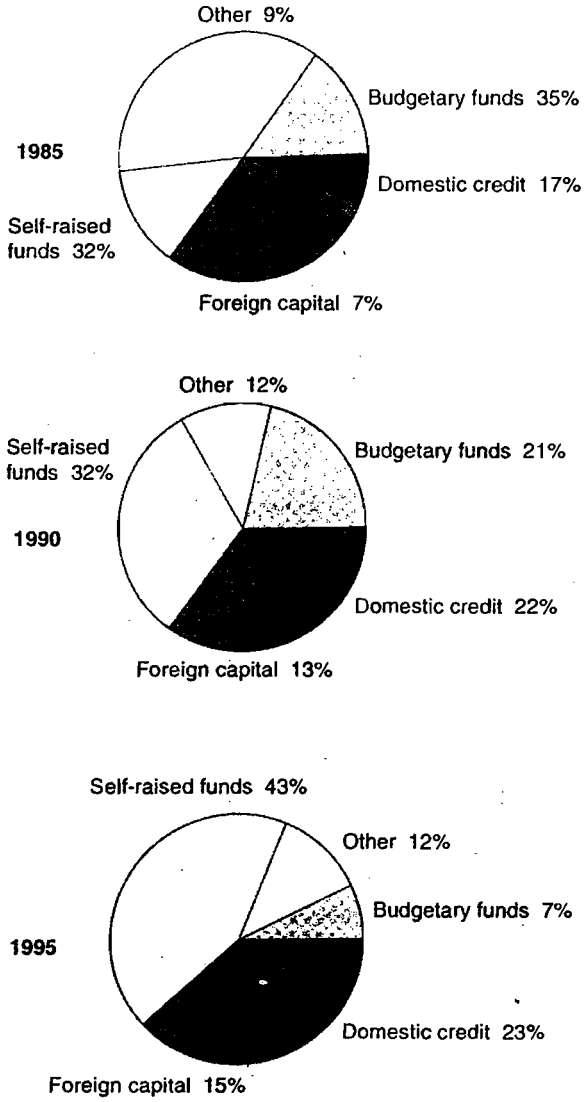


Figure 9.3
Sources of funds. *Source*: China Statistical Yearbook (1996).

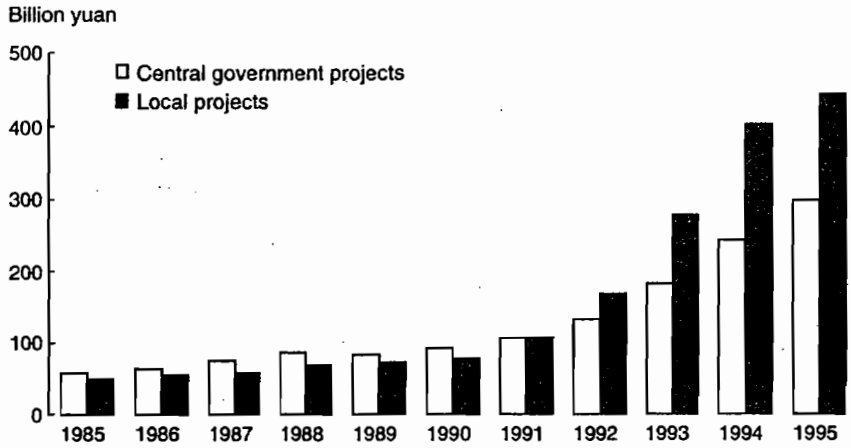


Figure 9.4
Investment of nonbudgetary resources. *Source*: China Statistical Yearbook (1996).

Mehran, Quintyn, Nordman, and Laurens (1996), TICs receive government and enterprise trust deposits or entrusted deposits. The larger companies also underwrite and broker securities. Most TICs were established by the four state-owned specialized banks, while other banks, the MOF, and some municipalities also own TICs. Banks initially established these TICs to circumvent the credit quotas, but most TICs have been increasingly engaged in the banking business, taking household deposits, and granting working capital loans. In the late 1980s, as many as 365 TICs were operating throughout China. A portion of these TICs are engaged in international business and referred to as international trust and investment companies (ITICs). Some of them are involved in external borrowing.

External Borrowing

SDPC authorizes and establishes quotas for external debt. The State Administration of Foreign Exchange (SAFE) monitors and regulates compliance with these quotas for external borrowing through a registration process. Under the budget law, local governments are not allowed to incur foreign indebtedness unless otherwise permitted by law. However, external borrowing by the central and local government-owned financial institutions has been managed by a "window" management system, under which the issuance of debt requires a quota from the SDPC and an approval from SAFE. This system of

quotas and approvals favors a limited number of predesignated window companies. The window management system is being replaced by a credit management system, whereby the quotas and approvals will be granted to central and local government-owned enterprises and financial institutions (including leasing companies) on the basis of their demonstrated capacity to repay the borrowings, their free-standing creditworthiness, and China's balance-of-payments situation. Unless otherwise stated by the central government in the relevant debt issuance documents or other official PRC documents, borrowings by these entities are not guaranteed by any direct or indirect credit support from the central government. Most of these local window financial institutions are TICs controlled by local governments. Before Guangdong International Trust and Investment Company (GITIC) went bankrupt in the first half of 1999, other local financial institutions enjoying the same treatment included Fujian ITIC, Tianjin ITIC, Shanghai ITIC, Dalian ITIC, Shangdong ITIC, and Shenzhen ITIC. By the end of 1998, the external debt of domestic financial institutions (including central agencies) was $41.99 billion, accounting for 28.8 percent of China's total external debt.[15] With the bankruptcy of GITIC, the first since the economic reform, the central government took a step forward in hardening budget constraint on subnational governments by refusing to bail out GITIC. Should financial difficulties emerge on a large scale among these ITICs, it is not clear whether the central government will join forces with provincial authorities to bail them out.

9.2.5 *Tax Incentive Policies*

Tax incentive policies are widely adopted by developing countries to attract foreign direct investment or serve their industrial policy (e.g., increase infrastructure investment and high- and new-technology investment). One of the most salient features of China's tax incentive policies is its strong discrimination against domestic investors in favor of foreign investors and its regional and industry preferences (World Bank 1999).[16] In addition to general fiscal incentives, the application of these tax incentives, especially the exemptions and reductions of corporate income tax, can be more generous within the special economic zones (SEZs), coastal open economic zones, economic and technology development zones (EDTZs), and high- and new-technology development zones.[17] These policies sparked keen competition among subnational governments for the right to establish such special economic

zones, which adversely affected the central government. First, subnational governments' offer of ever-greater tax relief reduced government revenues. Second, the establishment of unauthorized SEZs weakened the ability of the central government to set and control macroeconomic policy.

Only four cities—Shenzhen, Xiamen, Zhuhai, and Shantou—were opened as SEZs in 1980. In 1984, fourteen more coastal cities were opened to foreign investment as ETDZs, allowing them to grant SEZ-like incentives. Through the 1990s, special zones extended to all coastal provinces, which were authorized to give tax incentives or attractive commercial terms to foreign investors. Special incentives for developing projects in the interior were also created, especially for provincial capital cities (Rosen 1999). Yang (1997) reported 111 development zones in 1991 (only 27 of which were centrally approved), 1,951 by September 1992, and as many as 8,700 by mid-1993.

9.2.6 *Extrabudgetary Funds*

Although public finance has been centrally controlled since 1949, certain revenues and expenditures of SOEs, local governments, agencies of the central government, and certain public institutions have historically been excluded from the state budget. These extrabudgetary revenues and expenditures are subject to varying degrees of control and regulation by the central government.

Since 1980, a devolution of expenditures from central to local governments, down to the township level, has led to a rapid increase in local expenditures, particularly administrative costs, health, education, and scientific research expenditures. The decentralization of expenditures over the reform period can be attributed to the following shifts: (1) a new emphasis on functions traditionally administered at local levels, such as social expenditures; (2) increases in administrative expenses and wages (largely due to the rapid increase in the number of civil servants at local level), which fell more heavily on local governments; and (3) sharp rises in locally administered but centrally set price subsidies. The local own-tax sources of revenues have not kept pace with rising expenditures, and local governments have become increasingly dependent on their extrabudgetary funds to perform their functions. In 1992, for example, the total extrabudgetary funds at both the central and subnational levels represented 46 percent of total expenditures, whereas extrabudgetary funds financed 41

percent of local expenditure and 54 percent of central expenditure (figure 9.5).

Extrabudgetary funds fall under three broad institutional categories: (1) extrabudgetary funds of local fiscal bureaus, including surcharges on taxes set by local governments (e.g., agricultural surcharges); (2) extrabudgetary funds of administrative agencies and institutions (non-profit agencies, *shi ye dan wei*), including highway maintenance and other cost-recovery fees, market, and other fees, collected by government units; and (3) extrabudgetary funds of SOEs, including earmarked funds for the technical transformation and major maintenance funds (e.g., depreciation funds), retained profits, and short-term loans for circulation purposes (i.e., working capital). Foreign investment and international loans are sometimes included in this category. Before 1992, about 80 percent of these funds were owned by the enterprise sector (figure 9.6).[18]

Initially, the explicit objective of extrabudgetary transactions was to allow increased flexibility. They were also supposed to change the structure of incentives to help revitalize SOEs, speed up growth, and in general improve incentives for government units.

The increasing use of price subsidies and SOE subsidies during the second half of the 1980s pushed more pressing expenditures off the budget. This allowed a rapid growth of extrabudgetary funds, which became a particularly striking feature of the tax reform period of the 1980s (figure 9.7). A combination of reform initiatives (e.g., the profit-retention schemes, enterprise retention of depreciation funds, and the

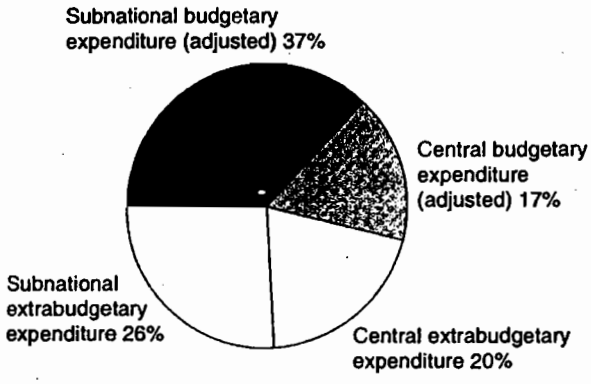


Figure 9.5
Composition of total expenditure, 1992. *Source*: Finance Yearbook of China (1997).

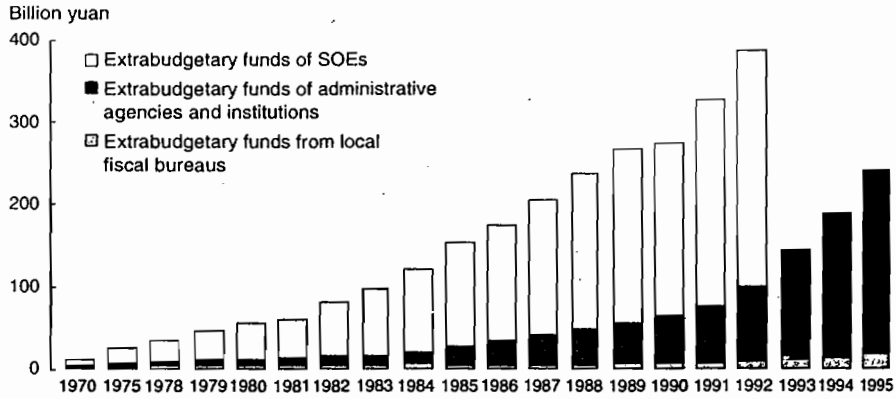


Figure 9.6
Composition of extrabudgetary revenue. *Source*: Finance Yearbook of China (1997).

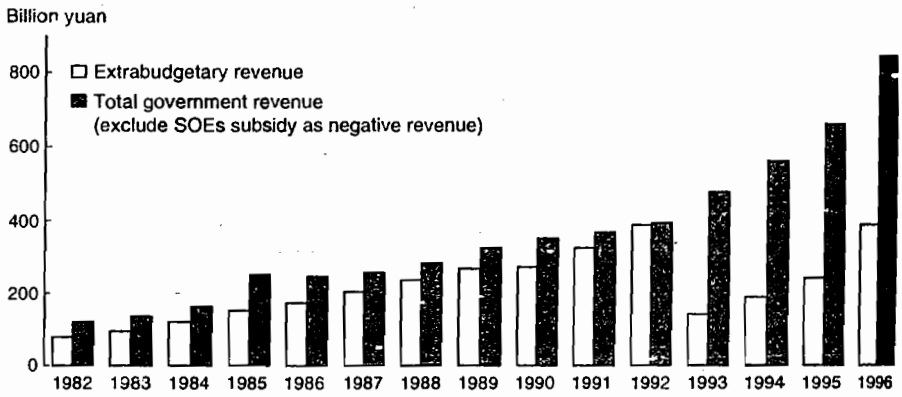


Figure 9.7
Extrabudgetary revenue as a percentage of total government revenue. *Source*: Finance Yearbook of China (1997).

deduction of pretax amortization before tax payments, which transferred resources from the government to the enterprise sector) gave the SOEs more autonomy but at the same time reduced fiscal control over resources. Starting in 1993, extrabudgetary funds of SOEs were abolished, which then led to a substantial increase of extrabudgetary funds in the other two categories (see figure 9.6). In 1996, for example, the aggregated extrabudgetary revenue of central administrations increased by nearly 200 percent and that of the provincial governments increased by 41 percent.[19]

Extrabudgetary funds together with local government self-raised funds (all off the budget) are used in ways that supplement the budget: to finance fixed-asset investment, major maintenance, bonuses and welfare payments, administrative expenditures, expenditures in the social sectors, transfers and taxes paid to the central government, increases in working capital, and other earmarked programs (figure 9.8).[20]

From the second half of 1980s to the first half of the 1990s, the extrabudgetary funds became the central government's major concern. Since provinces are required to report extrabudgetary revenues only in very broad aggregated categories and there are no requirements for them to report their extrabudgetary expenditures to the MOF, the central authority lacked any effective instruments to monitor the funds. Although MOF resorted to restricting the number of banking accounts, that is, requiring all extrabudgetary funds be deposited into the specific fiscal accounts with each extrabudgetary fund having one bank account, this measure actually made the fiscal departments rely on the banking sector for the surveillance. Nonetheless, the banking sector was experiencing a substantial decentralization under which each bank was urged to depend on its own funding resources. As branches of different banks at localities started to solicit more clients, they were more than happy to offer shelter for extrabudgetary funds, among which a

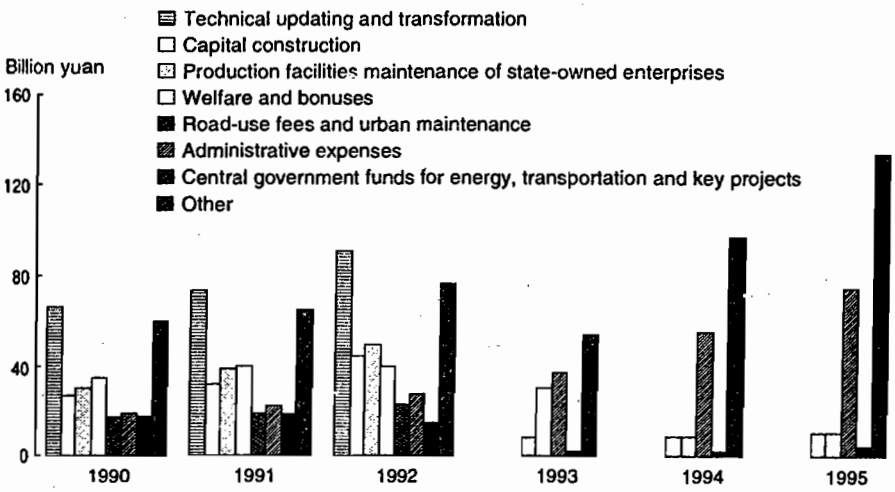


Figure 9.8
Extrabudgetary expenditures. *Source*: Finance Yearbook of China (1997).

portion came from local fiscal departments.[21] As a result, one agency could end up with several accounts for one kind of extrabudgetary fund.

The growth of extrabudgetary funds has undermined control over the scale of total government expenditures by enabling growth-oriented local governments to spend more freely outside the purview of central budgetary control. Local governments have tended to spend virtually all the revenues generated from ad hoc off-budget fiscal levies (Lall and Hofman 1995). In 1996, the twenty-ninth decree of the State Council brought thirteen extrabudgetary funds, totaling 150 billion yuan, under the supervision of the MOF (Ding 1997). According to the decree, all revenues generated from these funds are to be remitted to the treasury, and their expenditure is subjected to financial management by the MOF based on the proposed plans drafted by line administrations. The income from these extrabudgetary funds is to be earmarked for specific projects and not used for any other purposes or to balance the budgets. The decree further stated that similar measures would be introduced as the government sees fit.

Although the policy measures introduced in 1993 and 1996 shrank the extrabudgetary funds statistically, with high investment demand and limited financing, extrabudgetary funds have remained, proliferating at all levels of government. For local governments, which control most of these funds, they have become an important financing source. The proliferation of extrabudgetary funds has blurred the distinction among budgetary priorities and weakened the budgetary control mechanisms essential to a well-functioning fiscal system.

9.3 Conclusion

During the fiscal reform of the 1980s and 1990s, local governments in China responded to tightening budget constraints in ways that undermine desired fiscal discipline by (1) expanding the local tax base at the cost of the central government; (2) turning budgetary into extrabudgetary funds and tapping enterprises' extrabudgetary funds for government purposes; (3) pushing expenditures into extrabudget items, sometimes financed by indirect local borrowing, which placed additional demands on local banks and strains macroeconomic stability; (4) raising funds through internal and external borrowings; and (5) extending tax preferential policies by lavishly establishing SEZs. In addition, local governments have reduced effective tax rates on enter-

prise profits below the statutory rate by enterprise profit contracts. They have offered tax concessions to enterprises that affect the size of taxable income, to the detriment of tax buoyancy—for instance, by manipulating the rules for pretax repayment of investment loans. And because the resource-strapped local governments depend on local enterprises for their revenues, they are tempted into inefficient regional competition and local protectionism made possible by gaps in competition regulations.

The reform introduced in 1994 continues to meet significant resistance at the local level. The premise that taxes belong to the central government unless specifically assigned to the localities is not accepted at the local level. The goals of uniformity and transparency were compromised at the outset when the central government set the transfer rule based on the assurance of the status quo distribution in 1993.

In addition, the reform's effectiveness on hardening the budget constraints on provinces is undermined when (1) expenditure assignments are not clarified between levels of governments and provinces can always pass on expenditure responsibilities to the lower levels, (2) provinces are allowed to define the fiscal relations with localities and have the opportunity to squeeze most of the revenues (left by the center) for themselves, and (3) local officials are not restrained by any form of institutionalized local political participation so that they can pass their deficits on to local residents.

A shift to the tax assignment system by itself cannot harden budget constraints. The highly fragmented authoritarian arrangement still features the ownership of enterprises by local governments that have strong links to financial intermediaries. Thus, local governments enjoy both a soft budget constraint and autonomy in lending decisions, which enables them to resort to SOEs for both delivery of public services and debt financing. Soft budgets are thus incurred for both the SOEs and local governments. At the same time, SOEs treat tax liabilities lightly in an environment where the local finance bureaus play the double role of tax collector and owner and in a situation where taxes are frequently contracted rather than assessed. Budgetary financing of SOE investment is still virtually free; repayment ratios of the banks are extremely low or repayments are canceled out against tax obligation. This works to the detriment of banking sector stability.

The separation of policy and commercial lending is not enough by itself to foster commercialization of the banking sector. Specialized banks are still subject to lending quotas, are obliged to provide working

capital loans to SOEs, can lend only for government-approved projects, and finance SDB through the compulsory purchase of its bonds. Banks cannot operate on a commercial basis until project-specific credit allocation has been eliminated. A hard budget constraint on local governments and SOEs cannot be established until local governments and the banking sector are separated and distributed ownership is phased out.

In the past twenty years, tax preferential policies played a significant role in attracting foreign direct investment to facilitate the economic reform agenda in China. However, the lavish adoption of such a policy by subnational governments without the approval of the center largely undermined fiscal discipline and negatively affected the industrial restructuring and regional development agenda set by the central government. The tax system reform should also address this issue by cleaning up the SEZs and tax preferential policies.

Notes

1. Unlike the previous system, reform in the 1980s allowed provincial authorities to retain all or a proportion of the tax collected after sharing with the center.

2. Bahl and Wallich (1992).

3. Examples are income taxes from railways, coal mining, and the petroleum and airline industries, as well as income taxes of banks, insurance companies, and other organizations.

4. Most of which clustered in the last three months of the year after the central government promulgated the tax reform plan in September 1993 (Wang 1997).

5. Ma Hong and Sun Shangqing quoted in Wang (1997).

6. *Finance Yearbook of China* (1997). All revenue and expenditure figures exclude debt.

7. *Finance Yearbook of China* (1998).

8. For example, the Agricultural Law, Education Law, and Science and Technology Law all put forward that subnational governments' spending in these areas shall increase at a higher rate than that of the government's current revenue.

9. State Development Bank of China (renamed the China Development Bank, CDB), Agricultural Development Bank of China, and Export and Import Bank of China.

10. Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, and People's Construction Bank of China.

11. Bank of Communications, China International Trust and Investment Corportation (CITIC)'s Industrial Bank, China Everbright Bank, and Hua Xia Bank.

12. See World Bank (1993).

13. World Bank (1990).

14. The five specialized banks: Bank of China, Construction Bank of China, Industrial and Commercial Bank of China, Agriculture Bank of China, and the Bank of Communications.

15. Ministry of Finance.

16. For detailed information about tax exemptions and reductions, see World Bank (1999, 21–25).

17. Besides the widely applied income tax holidays, the reduction in corporate income tax rate is also substantial; whereas the corporate income tax rate is 33 percent, many activities and regions enjoy reduced tax rates of between 15 and 24 percent. In addition, many investment projects in those regions and activities are exempted from the 17 percent import tariffs on imports of equipment and raw materials. Export-oriented enterprises in the special economic zones and the economic technological development zones where the enterprise income tax has already been reduced to 15 percent would be taxed at 10 percent (World Bank 1999).

18. Since 1993, the extrabudgetary funds of SOEs are categorized not as extrabudgetary funds but as enterprises' own fund.

19. *Finance Yearbook of China* (1997).

20. Data on extrabudgetary revenues have been collected since 1952, but data on extrabudgetary expenditures were not recorded until 1982.

21. Some of the local fiscal agencies moved their budgetary fund to extrabudgetary accounts.

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第 13 章

财政分权对地方政府规模的影响

How does fiscal decentralization affect aggregate, national, and subnational government size?

Jing Jin [c] and Heng-fu Zou [a,b,c,*]

[a] *School of Management, Peking University, Beijing, China*
[b] *Institute for Advanced Study, Wuhan University, Wuhan, China*
[c] *Development Research Group, The World Bank, Room MC 3-639, 1818 H St. NW, Washington, DC 20433, USA*

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Abstract

Beyond conducting the usual regression analysis of the relationship between fiscal decentralization and aggregate government size (national and subnational combined), this paper makes the first attempt to examine how different fiscal decentralization measures affect the sizes of national and subnational (state and local combined) governments. An econometric analysis using panel data from 32 industrial and developing countries, 1980–1994, finds that (1) expenditure decentralization leads to smaller national governments, larger subnational governments, and larger aggregate governments; (2) revenue decentralization increases subnational governments by less than it reduces national governments, hence leads to smaller aggregate governments; and (3) vertical imbalance tends to increase the sizes of subnational, national, and aggregate governments.

JEL classification: H5; H7; R5

Keywords: Fiscal decentralization; Size of government; Vertical imbalance; Borrowing constraints

* Corresponding author.
E-mail address: hzou@worldbauk.org (H.-f. Zou).

1. Introduction

With the dramatic growth of the public sector during the twentieth century, many economists have questioned the effectiveness of the government's role in public service provision and created a presumption in favor of reducing the size of the public sector by giving more power to both the market and local jurisdictions. Fiscal decentralization is seen as a mechanism to control the growth of the public sector and improve the efficiency in public services (see Tanzi [1] for a recent review, and Davoodi and Zou [2] and Zhang and Zou [3] for empirical evidence). It is also proposed as an important element of public-sector reform in developing countries in the last two decades (Bahl and Linn [4], Shah [5], Fukasaku and de Mello [6], and Inman and Rubinfeld [7]).

General discussions center on two important channels through which fiscal decentralization could reduce the size of government—political participation and fiscal (tax) competition. The political participation argument suggests giving citizens and their elected representatives more power in public decision making. Since the local population has strong incentives to discipline local public officials and can monitor the local authorities closely, to the extent that local services are financed by the jurisdiction's own revenue, decentralization can lead to higher civic participation, improved citizen control over the action of the public officials, and a smaller government (Stein [8]).

The fiscal (tax) competition argument suggests decentralization itself is a powerful constraint on the Leviathan: "Competition among governments in the context of the interjurisdictional mobility of persons in pursuit of 'fiscal gains' can offer partial or possibly complete substitutes for explicit fiscal constraints on the taxing power" (Brennan and Buchanan [9]).

But Oates [10] indicates that from the perspective of economies of scale, fiscal decentralization may be relatively expensive in budgetary terms. An even stronger hypothesis suggested by John Wallis (quoted in Oates [10]) is that, since individuals have more control over public decisions at the subnational levels than at the national level, they may empower the local public sector with an even wider range of functions and responsibilities when they are carried out by local levels of government. Thereby, the size of subnational (state and local) governments can be larger, the more decentralized is fiscal decisionmaking.

Despite many efforts by scholars of fiscal decentralization, including Oates's [10], there is no theoretical or empirical consensus on a systematic relationship between fiscal decentralization and the relative size of aggregate public sector (the sum of national and subnational governments). If we consider the effects of fiscal decentralization on national and subnational government size (state and local combined) separately, the relationship at each level may be different. It is obvious that decentralization should increase the size of subnational governments while shrinking the size of the national government. But the effect of fiscal decentralization on aggregate government size cannot be automatically

determined because it depends on the relative magnitude of its effects on the sizes of subnational and national governments.

This paper extends recent studies on the relationship between fiscal decentralization and government size by taking the following approaches: (1) considering three different measures of fiscal decentralization—expenditure and revenue decentralization, and vertical imbalance—and their different effects on aggregate government size, (2) disaggregating the effects of fiscal decentralization on government size at national and subnational levels (per John Wallis's suggestion), and (3) controlling for political and administrative decentralization in the econometric analyses.

Section 2 reviews theoretical and empirical studies on the relationship between fiscal decentralization and aggregate government size. Section 3 describes our approaches, the panel data set, and the empirical methodology used. Section 4 reports the regression results. Section 5 summarizes the findings and concludes.

2. Theoretical arguments and existing empirical evidence

2.1. Theoretical arguments

From the perspective of allocative efficiency, various arguments have long been put forward in the public finance literature to support the view that decentralization would lead to greater efficiency and a leaner public sector (Tiebout [11] and Oates [12]). The Leviathan model by Brennan and Buchanan [9] presents the most dramatized theoretical case on how fiscal decentralization can reduce the size of government. In their model, government is a monolithic entity that systematically seeks to maximize fiscal revenues, and it can only be limited by constitutional constraints. In particular, the decentralization of revenue and expenditure assignments can create a market-like solution and therefore limit government's excessive taxing power at the corresponding levels. Furthermore, when mobile individuals seeking maximum fiscal benefits "vote with their feet," this behavior generates competition among jurisdictions. Such competition, which is in line with the Tiebout model, limits a subnational government's excessive taxing power, encourages cost-efficient production and supply of local public goods and services, and thereby, restrains growth of the subnational governments and hence the aggregate public sector. In brief, "total government intrusions into the economy should be smaller, *ceteris paribus*, the greater the extent to which taxes and expenditures are decentralized" (Brennan and Buchanan [9]). Moreover, introducing elements of competition into the political process could improve governments' responsiveness. With democratic election of government officials at subnational levels, decentralization could increase the accountability of government actions, and endow voters with more power to discipline public officials (Stein [8]).

Challengers of the Leviathan model outline conditions under which decentralization could be a less attractive policy tool (Prud'homme [13] and Tanzi [1]).

Supply efficiency (economies of scale). For example, Prud'homme [13] argues that (1) the hypothesis that decentralization will better serve the demands generated by diversified preferences only holds if supply is always efficient; and (2) the Leviathan model lacks an emphasis on supply efficiency in the context of economies of scale. If economies of scale in the provision of public services are substantial, decentralization may result in larger government (Stein [8]).

Political participation. The Leviathan model also assumes that taxpayers/voters of each jurisdiction will express their preferences in their votes, and that higher civic participation and better citizen control over the actions of public officials will result in a smaller public sector. According to Prud'homme [13], this hypothesis may not hold for local electoral behavior in developing countries. Where local elections exist, they are usually decided on the basis of personal, tribal, or political party loyalties.

Flypaper effect. Fiscal imbalances bridged with intergovernmental grants can significantly stimulate expenditures by recipient subnational governments (Oates [10,14]; see also Nelson [15] and Zax [16]). Stein [8] comes to a similar conclusion: subnational governments that receive transfers spend them more easily than they spend local tax revenues. The implication is that if a significant part of subnational government spending is financed through transfers from the higher level of government, decentralization could lead to growth in government.

The problem of the commons. This problem arises from a disconnection between beneficiaries of public services and those who pay for them. If revenues remain centralized to a large degree while expenditures are decentralized, and if discretionary transfers bridge such vertical imbalance, the commons problem may be more serious than using a transfer mechanism based on predetermined formula. Because discretionary transfers tend to be allocated to those jurisdictions that are in financial trouble (Stein [8]), subnational governments will overspend in order to ask for additional funds from the national government. Thus, fiscal decentralization with a large discrepancy between subnational revenues and expenditures may be morally hazardous and contribute to the growth of governments.

Soft budget constraints. Soft budget constraints on subnational governments resulting from borrowing autonomy can potentially lead to capital-market debt liabilities being directly or indirectly passed on to the national government. If the national government is always ready to bail out indebted subnational governments, then subnational governments can follow an expansion policy with

less concern about their ability to pay off the debt. This simple hypothesis of soft budget constraints suggests that borrowing autonomy by subnational governments is associated with increased government sizes. This association could be even more significant when discretionary transfers are involved.

The quality of local bureaucracies. Because national government bureaucracies are more likely to offer qualified people better careers and more possibilities of promotion, and because talented individuals tend to choose fields that offer better opportunities for advancement over the longer run, the resulting poor quality of local bureaucrats is likely to reduce the benefits of decentralization (Prud'homme [13]). For example, the lack of qualified officials at subnational levels may result in weak public expenditure management and higher costs.

Corruption. Prud'homme [13] believes that corruption may be more prevalent at subnational levels for the following reasons: (1) Opportunities for corruption at subnational levels are more likely because politicians and bureaucrats are more accessible and susceptible to pressing demands from local interest groups (whose money and votes count) in matters such as taxation or authorizations. (2) Corruption in many cases requires the cooperation of both politicians and bureaucrats. Such cooperation is more easily aligned at the local level where bureaucrats have less independence from local politicians than national bureaucrats do from national politicians. (3) Local officials usually have more discretion than national decisionmakers. Thus, decentralization may increase the overall level of corruption (see Brueckner [17]).

Tanzi [1] shares the same argument by reasoning that corruption is often stimulated by contiguity, that is, by the fact that officials and citizens live and work close to one another in local communities. When this occurs, the public interest often takes a back seat, and decisions that favor particular individuals or groups are made.

Public expenditure management systems. The necessary elements of good public expenditure management—clear budgetary classifications, an informative accounting system, and skilled people to forecast expected revenues and anticipate spending (Tanzi [1])—are usually missing or insufficient, especially in developing countries and transition economies, and, in particular, at subnational government levels.

2.2. Existing empirics

Oates [12], in his earlier empirical study using a cross-section sample of 57 countries, finds that higher fiscal centralization is associated with a smaller public sector. Specifically, he finds a strong and statistically significant negative association between the size of the public sector (measured by tax revenues

as a fraction of national income) and a fiscal centralization ratio (measured by central government tax revenues as a percentage of total tax revenue). Another test by Oates [14], using a cross-section sample of 43 countries, reaches a similar conclusion. He regresses the size of the public sector (measured by aggregate tax revenue in each country as a fraction of GDP) on central revenue as a fraction of total revenue, and central expenditure as a fraction of total expenditure. His findings do not support the Leviathan hypothesis, but rather suggest that a relatively decentralized public sector is typically comparatively large (Oates [14, p. 754]). Control variables such as income, population, and government transfers, however, contribute to a more powerful explanation for government size than the two measures of fiscal centralization alone.

A mixed picture emerges from empirical studies undertaken since Oates's pioneering efforts. For example, Marlow [18] models the association between decentralization and government size for the United States at the aggregate level (federal and state level combined) using time series data for 1946–1985. He measures aggregate public-sector size by taking total government expenditure as a percentage of GNP. His regression of the aggregate public expenditure on subnational expenditure as a fraction of total government expenditures and two other control variables (real per capita disposable income in 1972 and population), demonstrates that fiscal decentralization is negatively associated with government size.

Grossman [19] explores this relationship in the US data by emphasizing the role of intergovernmental grants, which are supposed to encourage expansion of the public sector by concentrating taxing power in the national government and by weakening the fiscal discipline imposed on subnational governments for financing of their own expenditures. Grossman regresses aggregate government size (total government expenditures as a share of GNP) on expenditure decentralization (the share of state and local expenditures in total government expenditures) and vertical imbalance (measured by the share of federal grants to state and local governments in total state and local receipts). His result supports the Leviathan model and indicates in particular that grants serve to encourage the expansion of the public sector.

From a cross-country, cross-section perspective, Ehdaie's [20] findings support the Leviathan hypothesis: fiscal decentralization (subnational own source revenue over total subnational–national expenditure) is found to have a statistically significant negative impact on government size (subnational–national government expenditures over GDP), whereas transfers to localities (national revenue transfers over total subnational–national expenditure) have a positive impact on government size. As transfers offset the negative impact of decentralization on government size, his study highlights the importance of decentralizing taxing decisions along with expenditure responsibilities.

More recently, Stein [8] has examined the Leviathan hypothesis by employing cross-section data from 20 Latin American countries and some OECD countries.[1] In addition to the explanatory variables of fiscal decentralization (i.e., expenditure decentralization, vertical imbalance, and borrowing autonomy), Stein includes other control variables, i.e., level of public debt in 1989, degree of openness of the economy (measured by the share of total exports and imports in GDP), and share of the population over 65 years of age. His regression results for the Latin American case—that decentralized governments tend to be larger—do not support the Leviathan model.

3. Approaches, data, and methodology

3.1. Approaches

The objective of this research is to enhance our understanding of the relationship between fiscal decentralization and government size from the following aspects:

1. *Relative changes of government size at both national and subnational levels.* Beyond conducting the usual regression analysis of the relationship between fiscal decentralization and aggregate government size, we examine how decentralization affects the sizes of national and subnational governments. A test only at the aggregate government level cannot distinguish the possible differentiated effects on government size at different levels.
2. *Time series.* Unlike the cross-section studies by Oates [14], Ehdaie [20], and Stein [8], we add time series for each country in our cross-country regressions to explore the dynamics of the relationship between fiscal decentralization and government size.
3. *Variables measuring fiscal decentralization.* Three different variables are used to proxy the level of fiscal decentralization: expenditure decentralization, measured as the ratio of subnational to total government expenditure; revenue decentralization, measured as the ratio of subnational own source revenue to total government revenue; and vertical imbalance, measured as the percentage of expenditures at the subnational level financed by central transfers. Our approach explores the effects of these three measures of fiscal decentralization and disaggregates their potential for differentiated effects on government size.
4. *Political and administrative decentralization.* Although there have been extensive discussions and research about political and administrative decen-

[1] A closely related study is Fornasari et al. [21].

tralization, little empirical research has touched upon this issue in the context of fiscal decentralization. We use four variables to capture political and institutional effects on government size:

- Borrowing constraints. The borrowing autonomy of subnational governments can potentially lead to soft budget constraints. As a result, subnational governments may directly or indirectly pass on capital-market liabilities to upper tiers of government. National government bailouts of subnational governments in financial distress undermine the incentives for the latter to behave in a fiscally responsible way. Any prohibition or non-discretionary rules to constrain subnational government access to the financial market would result in less borrowing, which may suggest a reduction in subnational government size.
- Unitary versus federal state. Economic constitutions make a difference. A federal form of government with decisionmaking shared by all levels of government is considered more decentralized in terms of decision-making and therefore conducive to greater freedom of choice, political participation, innovation, and accountability. A federal regime with a more decentralized institutional arrangement is supposed to be more efficient and thus lead to smaller government in comparison with a unitary regime.
- Elected vs. non-elected subnational government. Decentralization assumes that the taxpayers/voters will express their preferences through votes and that such voting-with-their-feet behavior would restrain subnational governments' taxing power.
- Lack of independence of the central bank. It is believed that an independent monetary authority is more likely to restrain governments from pursuing short-term expansionary policies, and possibly limit governments' size. Therefore, monetary institutions may also be instrumental to a better fiscal outcome.

5. *Inflation.* Because government size may be related to revenue and expenditure assignments, inflation is likely to erode tax revenues and restrain government growth if government revenue collections are not adjusted fast enough to account for the effects of inflation, or if there is a delay in revenue collections in nominal terms.
6. *Other control variables.* In order to establish the robustness of our result, we further control other macro variables such as per capita growth rate of GDP; per capita GDP in constant terms; urbanization, measured by urban population as a share of total population; and openness, measured by total imports and exports as percentage of GDP. These variables are quite conventional in existing studies on government size.

Table 1
Countries included in the study

Argentina	Colombia	Ireland	South Africa
Australia	Denmark	Israel	Spain
Austria	France	Luxembourg	Sweden
Belgium	Germany	Malaysia	Switzerland
Bolivia	Iceland	Mexico	Thailand
Brazil	India	Netherlands	United Kingdom
Canada	Indonesia	Norway	United States
Chile	Iran	Paraguay	Zimbabwe

3.2. Data

All countries included in the current study have data for at least two levels of government in the International Monetary Fund's (IMF) *Government Financial Statistics* (GFS) [22]. Based on the availability of data, primarily at the subnational level, we end up with 17 industrial and 15 developing countries over 15 years from 1980–1994 (Table 1).

3.2.1. Dependent variables

The three dependent variables analyzed are subnational, national, and aggregate government size, all measured by the ratio of total expenditure at corresponding government level to GDP. In the case of aggregate government size, national and subnational government expenditures are combined. All the data come from the IMF's GFS.

Table 2A provides some descriptive statistics on government sizes for each country from 1980 to 1994. On average, public sectors at subnational, national, and aggregate levels are substantially larger for the industrial countries (17, 37, and 54%, respectively) than the ones for developing countries (6, 24, and 29%, respectively). Moreover, subnational government size varies more significantly in industrial countries than that in developing countries as indicated by the standard deviation (1.6 versus 1.3). The descriptive statistics of each country show that in the industrial-country group, subnational government size varies from 7% of GDP in Belgium to 32% in Denmark, whereas the same variable for developing countries ranges from 0.4% of GDP in Paraguay to 14% in Brazil. In addition, national and aggregate government sizes are more widely dispersed in developing countries than the ones in industrial countries (with a standard deviation of 4.4 versus 2.5 for national government size, and 5.7 versus 4.2 for aggregate government size). Over the same time period, the average national government size in the developing-country group ranges from 10% of GDP in South Africa to 60% in Israel, and aggregate government size ranges from 11% of GDP in Paraguay to 66% in Israel. For industrial countries, the average national government size ranges from 22% of GDP in Switzerland to 45% in Ireland,

Table 2A
Descriptive statistics of government sizes for each country (1980–1994)

Country	Subnational govt. size				National govt. size				Total govt. size			
	Mean	Min	Max	SD	Mean	Min	Max	SD	Mean	Min	Max	SD
Developing countries	**6.0**	**4.2**	**8.4**	**1.3**	**23.9**	**17.6**	**31.4**	**4.4**	**29.0**	**20.2**	**38.9**	**5.7**
Argentina	8.4	5.0	10.4	1.7	13.6	9.4	18.2	2.5	22.0	17.7	25.0	2.7
Bolivia	4.2	1.5	9.4	2.1	18.1	12.4	24.0	4.2	20.8	1.5	32.0	8.3
Brazil	13.9	9.4	19.4	3.7	27.1	20.2	37.2	6.0	41.0	29.8	56.7	9.3
Chile	2.2	1.1	3.4	0.6	26.2	19.9	34.1	5.0	27.0	20.4	37.6	5.7
Colombia	5.9	5.2	6.6	0.4	14.5	13.4	16.0	1.0	16.9	11.5	21.7	3.8
India	13.3	11.8	14.3	0.8	16.0	13.0	17.9	1.7	28.6	15.8	32.2	4.0
Indonesia	2.5	2.0	3.1	0.3	20.1	16.5	24.4	2.5	21.3	14.6	27.4	3.9
Iran	1.0	0.8	1.3	0.2	25.8	17.7	35.7	6.5	24.9	18.6	37.0	5.8
Israel	7.2	5.5	8.6	0.7	60.2	37.7	89.1	16.0	66.3	43.2	97.7	16.5
Malaysia	6.8	4.8	8.3	1.2	29.1	21.9	38.4	4.4	35.9	26.7	46.7	5.4
Mexico	4.7	3.7	6.6	0.9	20.0	14.4	30.3	5.3	24.8	19.3	34.0	4.8
Paraguay	0.4	0.2	0.6	0.2	10.2	8.1	13.5	1.8	10.7	8.6	13.8	1.6
South Africa	10.4	7.0	19.9	4.1	30.8	22.1	38.0	4.1	41.3	31.4	54.6	6.5
Thailand	1.5	1.1	3.5	0.5	17.2	14.1	20.5	2.2	18.7	15.2	22.3	2.5
Zimbabwe	7.0	4.3	11.0	2.0	28.7	23.5	33.8	2.6	35.0	29.0	44.8	4.4
Industrial countries	**17.4**	**14.8**	**19.9**	**1.6**	**37.0**	**32.9**	**40.8**	**2.5**	**54.1**	**46.5**	**60.0**	**4.2**
Australia	17.7	15.5	19.7	1.3	25.3	22.7	27.1	1.5	43.0	38.1	46.3	2.6
Austria	17.2	16.4	18.8	0.9	39.3	36.6	42.0	1.5	56.6	53.1	60.8	2.3
Belgium	6.9	5.9	8.4	0.9	51.4	48.2	56.0	3.0	58.3	54.2	63.9	3.8
Canada	31.3	23.7	35.5	2.8	23.7	21.1	25.3	1.3	55.0	47.9	60.8	3.6
Denmark	32.2	29.7	34.9	1.4	40.4	37.3	43.0	1.9	72.5	67.1	76.8	2.9
France	10.5	7.8	16.7	3.0	44.1	39.5	47.2	2.0	54.5	47.3	60.9	3.9
Germany	22.9	19.2	24.5	1.9	33.0	30.2	33.9	1.4	56.0	49.4	58.1	3.3
Iceland	9.0	7.9	10.4	0.8	29.7	24.8	34.4	3.4	37.5	32.2	44.3	4.3
Ireland	14.4	11.8	16.9	1.9	45.1	38.1	51.4	4.9	59.5	50.7	67.7	6.7
Luxemburg	7.5	6.1	9.0	0.9	42.6	39.1	46.5	2.2	49.3	36.4	54.4	4.1
Netherlands	17.7	15.6	20.3	1.5	53.9	48.0	57.7	2.7	71.6	64.0	78.0	4.0
Norway	18.5	16.7	20.7	1.3	38.0	33.7	43.2	3.2	56.6	50.4	63.2	4.4
Spain	10.9	3.3	16.5	4.5	33.2	26.5	39.4	3.6	44.1	29.8	55.9	8.0
Sweden	25.0	22.9	26.9	1.4	43.9	39.3	51.7	3.6	68.9	62.8	77.2	3.8
Switzerland	23.1	21.3	24.9	1.5	22.5	18.4	26.6	3.5	42.1	22.4	51.5	9.5
United Kingdom	12.8	12.2	13.7	0.5	39.4	33.9	43.2	2.6	52.2	46.2	56.3	2.8
United States	18.2	16.5	20.2	1.4	23.4	22.0	25.0	0.9	41.6	38.8	44.6	1.6

and aggregate government size ranges from 36% of GDP in Iceland to 73% in Denmark.

The time path of the dependent variables is shown in Table 2B. For the whole sample, the average subnational government size increased from 11.3% of GDP in 1980 to 14.5% in 1994; the average national government size fluctuated around 32% of GDP; and the total government size rose from 41.3% of GDP in 1980 to 44.8% in 1983, and it then declined to 39.8% of GDP and rose again to a high level of 45.2% in 1994. The three government sizes for the developing-country group are relatively rather stable, whereas the corresponding ones for the industrial-country group have shown a rising trend. Specifically, for the industrial-country group, subnational government size rose from 16.3% of GDP in 1980 to more than 18% in the 1990s; national government size and total government size increased quickly in the early 1980s and fluctuated around 38% of GDP and 55% of GDP, respectively, from 1983 to 1994.

Table 2B
The time path of average government sizes by country group

Years	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
All countries															
Subnational govt. size	11.3	11.9	12.4	12.4	11.8	11.0	11.0	11.3	11.1	11.4	12.4	13.0	13.4	13.7	14.5
National govt. size	30.1	32.0	33.3	33.6	32.2	32.4	31.7	31.6	30.5	29.8	30.9	30.3	31.8	32.6	33.1
Total govt. size	41.3	42.7	44.6	44.8	44.1	42.3	42.6	42.0	40.7	39.5	39.8	40.9	43.1	44.1	45.2
Developing countries															
Subnational govt. size	5.5	6.0	6.1	6.2	5.9	5.7	5.7	6.0	5.7	5.7	6.6	6.4	6.5	6.9	8.8
National govt. size	24.8	26.9	28.0	28.0	26.2	25.6	24.9	24.7	23.3	22.7	23.2	21.1	22.8	23.6	24.2
Total govt. size	30.3	31.3	32.6	32.5	32.1	29.7	30.6	29.6	28.0	27.0	27.3	25.5	27.9	28.9	30.9
Industrial countries															
Subnational govt. size	16.3	16.6	17.5	17.4	17.0	16.3	16.3	16.3	16.2	16.6	16.8	17.7	18.4	18.5	18.1
National govt. size	34.7	36.1	37.5	38.2	37.5	38.7	38.4	38.1	37.3	36.4	37.1	36.8	38.1	39.0	38.6
Total govt. size	51.0	52.7	55.1	55.5	54.5	55.0	54.7	54.3	53.5	52.0	51.6	54.5	56.5	57.5	55.3

3.2.2. *Fiscal decentralization variables*

As indicated earlier, three different variables are used to proxy the level of fiscal decentralization: expenditure decentralization (measured as the ratio of subnational to total government expenditure), revenue decentralization (measured as the ratio of subnational own source revenue to total government revenue), and vertical imbalance (measured as the percentage of expenditures at the subnational level financed by central transfers). Table 3A summarizes the descriptive statistics of these fiscal decentralization measures for each country averaged over the period of 1980 to 1994. Generally, expenditures are 5% more decentralized than revenues for developing and industrial countries alike as shown by the mean values. In addition, industrial countries are more decentralized than developing countries in both expenditures and revenues (32 and 27% for industrial countries versus 20 and 15% for developing countries). Vertical imbalance is larger in the industrial countries (41%) than in developing countries (35%). It is also more widely dispersed in developing countries (with an average standard deviation of 11%) than in industrial countries (with an average standard deviation of 6%).

Table 3B presents the time path of the three decentralization measures by country groups. For the whole sample of 32 countries, both expenditures and revenues were increasingly decentralized from 25 and 20%, respectively, in the mid-1980s to around 29 and 25% in 1994. Vertical imbalance presented a declining trend from around 40% in the early 1980s to around 35% in the early 1990s.

If we look at developing- and industrial-country groups separately, the most salient feature for the developing-country group is that vertical imbalance substantially and consistently decreased from 45% in 1982 to 29% in 1994—a reduction of 16%. Revenue decentralization had stabilized at around 14% until 1985 before it continuously increased to 20% in 1994, while expenditure decentralization fluctuated widely between 20 and 31%.

For industrial countries, vertical imbalance decreased from 40% in the 1981 to 36% in 1989 and then increased to 43% in 1992 before it dropped back to 39% in

Table 3A
Descriptive statistics of fiscal decentralization measures for each country (1980–1994)

Country	Expenditure decentralization				Revenue decentralization				Vertical imbalance			
	Mean	Min	Max	SD	Mean	Min	Max	SD	Mean	Min	Max	SD
Developing countries	19.7	15.2	25.0	3.0	15.0	11.1	18.3	2.3	34.9	19.6	54.3	10.7
Argentina	38.3	22.2	46.8	7.1	32.7	16.5	42.4	9.1	28.3	0.0	62.5	19.1
Bolivia	19.3	14.8	29.4	3.8	18.6	13.7	23.0	3.0	14.4	−14.8	52.4	17.4
Brazil	33.7	28.7	42.4	3.4	24.9	18.6	30.0	3.8	36.3	25.0	42.9	5.4
Chile	7.6	3.7	9.8	1.4	5.8	2.5	7.1	1.2	23.0	1.2	49.4	15.8
Colombia	29.0	26.3	32.1	1.9	19.1	15.7	21.4	1.8	53.3	47.5	58.6	3.6
India	45.5	43.1	47.6	1.4	33.2	31.2	35.8	1.3	50.1	47.1	52.6	1.7
Indonesia	11.2	9.6	12.6	1.0	2.8	2.2	3.7	0.4	77.5	70.3	82.7	3.6
Iran	3.8	2.6	4.9	0.9	4.7	2.4	6.7	1.6	16.4	4.8	31.2	8.1
Israel	11.2	8.1	14.3	2.2	7.2	3.6	9.7	2.5	51.4	35.7	73.6	13.6
Malaysia	18.9	17.0	21.5	1.5	16.1	13.0	20.9	1.9	21.7	0.2	43.6	15.7
Mexico	20.1	11.0	30.5	6.2	20.4	17.8	22.9	1.5	15.5	−2.9	32.5	11.8
Paraguay	3.8	1.8	5.9	1.7	3.0	1.1	5.1	1.5	17.8	6.8	34.6	7.9
South Africa	24.9	18.4	36.6	6.3	14.0	10.3	17.1	2.1	55.9	46.3	79.2	9.9
Thailand	8.1	7.0	15.8	2.1	5.5	4.7	6.2	0.4	32.6	14.7	76.5	15.6
Zimbabwe	19.4	13.5	24.5	3.6	17.0	12.9	22.3	2.6	29.1	12.0	42.0	10.7
Industrial countries	32.0	28.9	34.8	1.9	27.3	24.6	29.5	1.6	41.9	31.6	50.7	6.3
Australia	41.2	39.4	43.5	1.3	28.2	23.8	33.7	3.6	46.6	35.3	54.7	6.4
Austria	30.4	29.5	31.4	0.6	27.1	26.3	28.6	0.8	24.0	17.3	28.2	3.2
Belgium	11.8	10.7	14.1	1.0	62.0	60.6	63.1	0.8	60.2	50.9	71.9	6.3
Canada	56.8	49.4	58.5	2.2	51.5	45.3	53.1	1.9	31.8	28.2	36.3	2.5
Denmark	44.4	42.6	47.5	1.2	31.2	28.8	32.2	1.0	45.7	42.3	52.3	3.5
France	19.0	16.2	27.5	4.0	11.9	9.6	13.6	1.4	43.7	33.4	73.3	13.5
Germany	41.4	38.9	43.6	1.0	35.1	33.5	36.7	1.0	26.8	21.2	32.8	3.7
Iceland	23.3	21.1	27.0	1.8	22.9	21.2	25.2	1.3	8.5	−0.7	19.9	5.2
Ireland	24.2	21.6	26.5	1.1	8.8	7.9	9.7	0.5	74.3	67.6	79.8	3.8
Luxemburg	15.0	12.5	16.9	1.5	8.7	6.5	10.7	1.4	42.5	34.0	60.9	8.9
Netherlands	24.7	23.3	26.0	0.9	7.7	5.7	11.0	1.6	76.4	64.9	83.3	6.0
Norway	32.8	31.5	34.5	0.8	21.6	20.1	22.9	0.9	39.4	37.3	41.1	1.3
Spain	23.6	11.0	31.1	6.5	14.7	11.1	17.4	1.7	47.1	7.9	64.9	19.2
Sweden	36.3	31.7	40.1	2.2	32.9	29.6	35.8	2.1	21.4	13.1	26.2	3.9
Switzerland	51.0	48.3	50.3	2.2	45.6	43.8	47.3	1.5	25.8	20.4	31.3	3.7
United Kingdom	24.6	22.7	26.5	1.2	13.3	8.0	16.8	3.5	56.2	41.6	74.5	12.6
United States	43.8	40.8	47.3	2.1	40.4	35.6	43.1	2.1	26.1	22.7	30.6	2.5

Table 3B
The time path of average decentralization measures by country group

Years	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
All countries															
Expenditure decentralization	26.7	27.8	26.9	25.7	26.7	25.0	25.2	24.5	24.8	26.1	26.4	27.9	27.6	26.8	28.5
Revenue decentralization	21.1	21.7	21.6	21.8	21.4	19.7	20.0	20.2	21.3	22.0	21.9	23.1	23.0	23.3	24.8
Vertical imbalance	38.0	41.2	41.7	41.0	38.3	37.6	36.3	35.3	34.9	32.7	34.8	34.9	36.8	35.3	35.3
Developing countries															
Expenditure decentralization	19.7	30.7	26.6	21.9	27.0	26.5	27.1	23.6	23.1	29.0	20.9	25.7	28.4	30.8	26.3
Revenue decentralization	14.0	15.0	14.5	14.6	14.3	13.2	13.8	13.8	15.9	15.8	16.2	17.1	16.4	17.0	20.0
Vertical imbalance	39.4	42.6	44.7	44.3	40.0	38.1	35.1	32.8	32.2	29.1	32.3	30.9	30.1	28.9	28.7
Industrial countries															
Expenditure dcentralization	32.4	25.0	27.1	29.0	26.4	23.6	23.5	25.3	26.2	22.6	30.6	29.5	26.8	22.6	30.4
Revenue decentralization	27.0	26.8	27.1	27.2	27.2	25.8	25.8	25.9	26.0	27.4	26.2	27.4	27.6	27.8	27.8
Vertical imbalance	36.8	40.1	39.3	38.5	36.9	37.0	37.3	37.5	37.3	35.7	36.6	37.8	41.8	39.9	39.4

1994. Revenue decentralization stabilized between 26 and 28% while expenditure decentralization fluctuated between 23 and 32%.

It is interesting to observe that for both developing and industrial countries, expenditure decentralization tends to fluctuate dramatically—between 20 and 31% for developing countries and between 23 and 32% for industrial countries—in comparison with the relatively stable levels of revenue decentralization, which stayed around 14% until 1987 before gradually increasing to 20% in 1994 for developing countries and staying between 26 to 28% for industrial countries. This pattern indicates that expenditures can be easily altered (in the legal or operational sense) with the change in fiscal policies and economic environments.

3.2.3. *Political/institutional variables*

Four variables are used to measure the influence of political/institutional factors on government size at one or more levels. The first variable measures the lack of independence of the central bank (called political central bank). A dummy variable equals one if the central bank governor changes within 6 months of a political transition and zero otherwise. The source of this information is Cukierman and Webb [23] and the Europa World Yearbook [24].

The two additional variables are dummies to measure the possible effects of the political environment on central and/or subnational public finance: (1) Unitary state versus federal state. A dummy variable equals one if the country is a federation and zero otherwise. (2) Elected versus non-elected subnational governments. A dummy variable equals one if the subnational government is elected and zero otherwise. The source of this information is primarily the Europa World Yearbook [24], with additional information from the country reports by The Economist Intelligence Unit [25].

Other researchers have found that constraints on subnational borrowing could help improve fiscal performance of subnational governments and restrain the overall size of government (Ter-Minassian and Craig [26] and IDB [27]). The dummy variable designed to capture this effect equals one if the country has any form of prohibition against borrowing by subnational government or a non-discretionary rule to constraint it ex ante, which are the two types of constraints Ter-Minassian and Craig [26] considered, and zero otherwise.

3.2.4. *Control variables*

To ensure that any correlation between fiscal decentralization and government sizes is not due to the effect of the general macroeconomic environment, five control variables are included in the analysis: (1) the growth rate of real per capita GDP, (2) real GDP per capita, (3) changes in the consumer price index (CPI) with a one-year lag, (4) openness, measured by the sum of imports and exports as a percentage in GDP, and (5) the percentage of urban population. Sources of these variables are the *International Financial Statistics* (IFS) of the IMF [22] and the *World Development Indicators* (WDI) of the World Bank [28].

3.3. Methodology

To investigate the relationship between the size of government and fiscal decentralization and other political and economic variables, the following model is adopted:

$$\text{GovtSize}_{i,t} = \alpha_i + \alpha_1 \text{FD}_{i,t} + \alpha_2 \text{Political}_{i,t} + \alpha_3 \text{Control}_{i,t} + \varepsilon_{i,t},$$

where $\text{GovtSize}_{i,t}$ represents the three different measures of government size, i.e., $\text{GovtSize}_{i,t}$ is the aggregate government size, or national government size, or subnational government size; α_i is the country fixed effects; $\text{FD}_{i,t}$ represents the three different measures of fiscal decentralization, i.e., $\text{FD}_{i,t}$ is the expenditure decentralization, or revenue decentralization, or vertical imbalance. When measuring fiscal decentralization using vertical imbalance, an interaction term between vertical imbalance and borrowing constraints is added to capture at least part of the effect of having hard/soft budget constraints at the subnational level (see Stein [8]). $\text{Political}_{i,t}$ represents the four political/institutional variables, i.e., the presence of borrowing constraints, subnational government elected, federal versus unitary states, and politicai central bank. $\text{Control}_{i,t}$ is the other five control variables in our regression analysis.

First, all coefficients are estimated using the fixed-effects approach. Second, since the fixed-effects approach has the disadvantage of dropping the variables that may reflect important economic and, in particular, institutional aspects of the model, the feasible generalized least squares (FGLS) method is also adopted with the corrections for panel heteroskedasticity and panel serial correlation. This approach is used because in many cross-section data sets the variance for each of the panels differs. Moreover, the correlation parameter of serial correlation may also be unique for each panel.

4. Results

Tables 4A, 5A, and 6A present the regression results on how fiscal decentralization affects subnational, national, and aggregate government size using the fixed-effects approach, and Tables 4B, 5B, and 6B report the corresponding FGLS results. As we mentioned earlier, it is obvious that decentralization should increase the size of subnational governments while shrinking the size of the national government. This almost tautological point is fully supported in our regression analyses (using both the fixed-effects approach and FGLS).

4.1. Subnational government size

Table 4A shows the fixed-effects estimations on the relationship between fiscal decentralization and subnational government size. Expenditure decentralization,

Table 4A
Decentralization and subnational government size (fixed effects)

Explanatory variable	Dependent variable: subnational government size		
	Coefficients	Coefficients	Coefficients
Expenditure decentralization	0.363[c]		
	(15.911)		
Revenue decentralization		0.122[c]	
		(3.417)	
Vertical imbalance			0.046[b]
			(2.469)
Vertical imbalance * borrowing constraints			0.063[c]
			(3.090)
Real GDP per capita (USD)	-5.75×10^{-5}	-7.29×10^{-5}	-3.9×10^{-5}
	(−1.249)	(−1.194)	(−0.804)
Real GDP growth rate	−0.063[c]	−0.059[b]	−0.032
	(−3.307)	(−2.304)	(−1.569)
Presence of borrowing constraints	dropped	dropped	dropped
Subnational govt. elected	−1.228[a]	0.678	−1.783[b]
	(−1.993)	(0.909)	(−2.843)
Federal vs. unitary state	dropped	dropped	dropped
Political Central Bank	1.032[c]	0.416	0.681[b]
	(4.326)	(1.455)	(2.691)
Urban population	0.111[b]	0.112	0.286[c]
	(2.158)	(1.627)	(5.133)
Openness	−0.005	−0.012	−0.007
	(−0.554)	(−0.963)	(−0.630)
Lag CPI inflation	0.000	0.000	0.000
	(−0.840)	(0.593)	(2.399)
Constant	−3.037	3.012	−9.080[b]
	(−0.991)	(0.751)	(−2.710)
Number of observations	345	346	347
Number of groups	32	32	32
R^2 within	0.4883	0.1003	0.4171
R^2 between	0.6802	0.2277	0.068
R^2 overall	0.6667	0.2142	0.0854

The number in parentheses represents the t-statistic associated with each coefficient.

[a] Indicates a significance level at 10%.

[b] Indicates a significance level at 5%.

[c] Indicates a significance at 1%.

revenue decentralization, and vertical imbalance are all found to be positively and significantly associated with subnational government size. The FGLS regressions in Table 4B demonstrate very similar results with a close magnitude of estimated coefficients. These findings confirm John Wallis's hypothesis that fiscal decentralization may lead to larger subnational governments because local constituents with more control over public decisions at subnational levels than

Table 4B
Decentralization and subnational government size (FGLS)

Explanatory variable	Dependent variable: subnational government size		
	Coefficients	Coefficients	Coefficients
Expenditure decentralization	0.316[c]		
	(22.025)		
Revenue decentralization		0.172[c]	
		(9.062)	
Vertical imbalance			0.065[c]
			(4.012)
Vertical imbalance * borrow constraints			−0.007
			(−0.383)
Real GDP per capita (USD)	3.150×10^{-4} [c]	4.638×10^{-4} [c]	0.001[c]
	(14.857)	(10.239)	(16.260)
Real GDP growth rate	−0.048[c]	−0.044[c]	−0.056[c]
	(−5.866)	(−4.578)	(−5.314)
Presence of borrowing constraints	0.004	−1.745	0.941
	(0.015)	(−1.435)	(0.898)
Subnational govt. elected	−0.419	0.825[b]	1.277[c]
	(−1.467)	(2.105)	(3.711)
Federal vs. unitary state	−1.007[c]	−3.237[c]	−2.787[c]
	(−2.559)	(−6.310)	(−5.098)
Political Central Bank	0.385[c]	0.287[b]	0.354[c]
	(3.729)	(2.174)	(2.910)
Urban population	0.008[a]	−0.044[c]	−0.035[c]
	(1.637)	(−3.288)	(−2.633)
Openness	0.001	−0.003	−0.014[b]
	(0.249)	(−0.604)	(−2.217)
Lag CPI inflation	-1.033×10^{-4}	1.630×10^{-5}	1.190×10^{-4} [c]
	(−1.484)	(0.218)	(3.233)
Constant	−1.359[c]	6.449[c]	4.00[c]
	(−3.509)	(4.207)	(3.172)
Number of observations	345	346	347
Number of groups	31	31	31
χ^2	2287	533	746
Log likelihood	−158	−236	−234
P	0.000	0.000	0.000
Computed R^2	0.879	0.530	0.614

The number in parentheses represents the t-statistic associated with each coefficient.

[a] Indicates a significance level at 10%.

[b] Indicates a significance level at 5%.

[c] Indicates a significance at 1%.

at the national level may empower local governments with a wider range of functions and responsibilities.

In the equations using expenditure decentralization and vertical imbalance variables, we find that elected subnational governments tend to be smaller

(Table 4A). But when using FGLS estimations with the control of revenue decentralization and vertical imbalance, elected subnational governments tend to expand (Table 4B). These seemingly contradictory, inconclusive findings indicate that political participation may not be a powerful institutional constraint on subnational governments. In particular, political participation could be relatively ineffective in restraining the growth of the public sector at the subnational level when more revenues are at the discretion of local officials.

Table 4B shows that a federal state tends to have a smaller subnational government than a unitary state. This effect is not detected in the fixed-effects estimations because the variable is dropped (see Table 4A). Both Tables 4A and 4B indicate that a less independent central bank (political central bank), as predicted, increases subnational government size resulting from less independent monetary policy and perhaps even monetization of fiscal deficits. But the effect of borrowing constraints on subnational government size has not been consistent and/or significant in Table 4B.

Among the other control variables, real GDP growth rate is negatively related to subnational government size. Urban population is positively associated with subnational government size, as is the lagged CPI inflation in the equation using vertical imbalance. But the borrowing constraints/vertical imbalance interaction variable tends to have mixed and even insignificant signs.

4.2. National government size

Tables 5A and 5B show the regression results for the relationship between fiscal decentralization and national government size using the fixed-effects approach and FGLS, respectively. As expected, both expenditure and revenue decentralization lead to a smaller national government. But note that a vertical imbalance, besides its positive effect on subnational government size (Table 4A), increases the size of national government as well. A possible explanation is that intergovernmental transfers in the form of matching grants to subnational governments gives them more incentive to expand spending in order to lure more transfers from the central government. When matching grants increase, national spending itself will also rise proportionally. That is to say, to make lots of grants to subnational governments, the national government must itself be large.

For the two estimation approaches (Tables 5A and 5B), a less independent central bank significantly increases national government size; and a nation with elected subnational governments does not necessarily have a smaller size of the national government. Furthermore, a federal state is likely to reduce the sizes of both national (Table 5B) and subnational governments (Table 4B). Among other control variables, the presence of borrowing constraints tends to have mixed effects on national government size; higher GDP growth rates reduce national government size; and openness is significantly and positively associated with the size of the public sector at the national level. In addition, the interaction variable

Table 5A
Decentralization and national government size (fixed-effects)

Explanatory variable	Dependent variable: national government size		
	Coefficients	Coefficients	Coefficients
Expenditure decentralization	−0.316[c]		
	(−3.844)		
Revenue decentralization		−0.435[c]	
		(−4.542)	
Vertical imbalance			0.101[a]
			(1.727)
Vertical imbalance * borrowing constraints			0.108
			(1.705)
Real GDP per capita (USD)	-1.111×10^{-4}	-9.333×10^{-5}	-3.72×10^{-5}
	(−0.672)	(−0.569)	(−0.243)
Real GDP growth rate	−0.243[c]	−0.240[c]	−0.201[c]
	(−3.521)	(−3.509)	(−3.120)
Presence of borrowing constraints	dropped	dropped	dropped
Subnational govt. elected	1.341	−0.307	−4.697[b]
	(0.605)	(−0.142)	(−2.249)
Federal vs. unitary state	dropped	dropped	dropped
Political Central Bank	3.355[c]	4.223[c]	3.8844[c]
	(3.911)	(4.959)	(4.928)
Urban population	−0.412[b]	−0.313	−0.180
	(−2.227)	(−1.689)	(−1.038)
Openness	0.063[a]	0.062[a]	0.089[b]
	(1.817)	(1.790)	(2.742)
Lag CPI inflation	0.000	0.000	0.000
	(−0.436)	(−0.500)	(−0.161)
Constant	63.735[c]	58.975[c]	34.134[c]
	(5.784)	(5.447)	(3.252)
Number of observations	345	346	347
Number of groups	32	32	31
R^2 within	0.1603	0.1754	0.2848
R^2 between	0.07	0.0469	0.004
R^2 overall	0.0546	0.0357	0.009

The number in parentheses represents the t-statistic associated with each coefficient.

[a] Indicates a significance level at 10%.

[b] Indicates a significance level at 5%.

[c] Indicates a significance level at 1%.

of borrowing constraints/vertical imbalance has opposite effects on national government size for the two estimation approaches.

4.3. Aggregate government size

Tables 6A and 6B report the regression results on the relationship between fiscal decentralization and aggregate government size using the fixed-effects

Table 5B
Decentralization and national government size (FGLS)

Explanatory variables	Dependent variable: national government size		
	Coefficients	Coefficients	Coefficients
Expenditure decentralization	−0.313[c]		
	(−9.698)		
Revenue decentralization		−0.238[c]	
		(−6.861)	
Vertical imbalance			0.263[c]
			(9.535)
Vertical imbalance * borrow constraints			−0.138[c]
			(−4.207)
Real GDP per capita (USD)	2.788×10^{-4}[c]	1.859×10^{-4}[b]	2.830×10^{-5}
	(3.248)	(2.237)	(0.495)
Real GDP growth rate	−0.176[c]	−0.175[c]	−0.123[c]
	(−6.324)	(−5.535)	(−3.969)
Presence of borrowing constraints	−0.721	2.027	4.615[b]
	(−0.420)	(1.172)	(2.467)
Subnational govt. elected	0.581	0.058	−1.712
	(0.454)	(0.045)	(−1.591)
Federal vs. unitary state	−1.751	1.876	−2.706[b]
	(−0.855)	(1.177)	(−2.494)
Political Central Bank	1.120[c]	1.640[c]	1.258[c]
	(2.971)	(3.606)	(3.253)
Urban population	0.202[c]	0.212[c]	0.298[c]
	(4.930)	(5.087)	(9.895)
Openness	0.038[b]	0.074[c]	0.100[c]
	(2.332)	(4.310)	(7.849)
Lag CPI inflation	-2.172×10^{-4}	-2.592×10^{-4}	-1.537×10^{-4}
	(−0.865)	(−0.936)	(−0.782)
Constant	19.392[c]	11.652[c]	−2.980[a]
	(8.670)	(5.027)	(−1.881)
Number of observations	345	345	345
Number of groups	31	31	31
χ^2	241	180	1430
Log likelihood	−518	−549	−546
P	0.000	0.000	0.000
Computed R^2	0.189	0.141	0.567

The number in parentheses represents the t-statistic associated with each coefficient.

[a] Indicates a significance level at 10%.

[b] Indicates a significance level at 5%.

[c] Indicates a significance level at 1%.

approaches and FGLS, respectively. It is found that aggregate government size is negatively and significantly associated with revenue decentralization with the fixed-effects approach (Table 6A). This is because the rise of subnational revenue

Table 6A
Decentralization and aggregate government size (fixed-effects)

Explanatory variable	Dependent variable: aggregate government size		
	Coefficients	Coefficients	Coefficients
Expenditure decentralization	0.048		
	(1.484)		
Revenue decentralization		−0.293[c]	
		(−2.519)	
Vertical imbalance			0.134[b]
			(2.019)
Vertical imbalance * borrowing constraints			0.185[b]
			(2.588)
Real GDP per capita (USD)	-1.686×10^{-4}	-1.695×10^{-4}	-2.058×10^{-4}
	(−0.850)	(−0.849)	(−1.208)
Real GDP growth rate	−0.307[c]	−0.283[c]	−0.223[c]
	(−3.704)	(−3.397)	(−3.037)
Presence of borrowing constraints	dropped	dropped	dropped
Subnational govt. elected	0.113	3.646	−3.677
	(0.043)	(1.496)	(−1.666)
Federal vs. unitary state	dropped	dropped	dropped
Political Central Bank	4.387[c]	4.618[c]	4.441[c]
	(4.266)	(4.456)	(4.990)
Urban population	−0.301	−0.187	0.126
	(−1.358)	(−0.831)	(0.640)
Openness	0.058	0.048	0.079[b]
	(1.387)	(1.136)	(2.161)
Lag CPI inflation	0.000	0.000	0.000
	(−0.554)	(0.420)	(1.200)
Constant	60.698[c]	58.411[c]	23.699[b]
	(4.595)	(4.449)	(2.011)
Number of observations	345	346	347
Number of groups	32	32	32
R^2 within	0.1159	0.1286	0.3737
R^2 between	0.2883	0.2072	0.0605
R^2 overall	0.2324	0.1539	0.0974

The number in parentheses represents the t-statistic associated with each coefficient.

[a] Indicates a significance level at 10%.

[b] Indicates a significance level at 5%.

[c] Indicates a significance level at 1%.

share in total revenues reduces national government size (Table 5A) by more than it increases subnational government size (Table 4A).

Like Oates's [14] empirical results based on cross-section, cross-country regressions, we also find a positive association between expenditure decentralization and aggregate government size for both approaches. Whereas the estimated coefficient for FGLS is highly significant, the corresponding one from the fixed-

Table 6B
Decentralization and aggregate government size (FGLS)

Explanatory variable	Dependent variable: aggregate government size		
	Coefficients	Coefficients	Coefficients
Expenditure decentralization	0.119[c]		
	(2.781)		
Revenue decentralization		−0.015	
		(−0.237)	
Vertical imbalance			0.265[c]
			(7.545)
Vertical imbalance * borrowing constraints			−0.034
			(−0.837)
Real GDP per capita (USD)	5.00×10^{-4}[c]	0.001[c]	0.001[c]
	(4.482)	(6.840)	(5.874)
Real GDP growth rate	−0.256[c]	−0.235[c]	−0.225[c]
	(−6.790)	(−6.056)	(−5.819)
Presence of borrowing constraints	−0.652	−1.305	−0.656
	(−0.334)	(−0.600)	(−0.253)
Subnational govt. elected	0.703	0.570	1.820
	(0.497)	(0.337)	(1.221)
Federal vs. unitary state	−6.936[b]	−4.498	−5.781[c]
	(−2.020)	(−1.391)	(−3.045)
Political Central Bank	2.041[c]	1.785[c]	2.095[c]
	(4.572)	(3.130)	(3.817)
Urban population	0.238[c]	0.152[c]	0.300[c]
	(5.148)	(2.924)	(6.911)
Openness	0.021	0.056[c]	0.058[c]
	(1.028)	(2.775)	(2.934)
Lag CPI inflation	-2.800×10^{-4}	-1.33×10^{-4}	2.18×10^{-4}
	(−0.751)	(−0.231)	(0.428)
Constant	16.804[c]	19.540[c]	1.595
	(2.454)	(6.989)	(0.865)
Number of observations	345	346	347
Number of groups	31	31	31
χ^2	388	302	1266
Log likelihood	−615	−640	−649
P	0.000	0.000	0.000
Computed R^2	0.240	0.191	0.494

The number in parentheses represents the t-statistic associated with each coefficient.

[a] Indicates a significance level at 10%.

[b] Indicates a significance level at 5%.

[c] Indicates a significance level at 1%.

effects model is not significant. This inconsistency may suggest that given the sample countries and the time span of this regression, expenditure decentralization would increase subnational government size and reduce national government

size to nearly the same extent and hence affect aggregate government size marginally.

Since vertical imbalance, as demonstrated in Tables 4A and 5A and is positively associated with both subnational and national government size, it leads to a larger aggregate government size (Tables 6A and 6B). This finding confirms the common belief that vertical imbalance exacerbates the problem of the commons, amplifies the flypaper effect, and consequently encourages the expansion of the public sector at subnational level and forces the national government to grow proportionately. As a result, the greater the share of intergovernmental transfers in subnational public spending, the bigger the aggregate government size. This outcome is fully consistent with the results of Oates [14], Grossman [19], Edhaie [20], Stein [8], and others.

As for other variables, it is found that a less independent central bank (political central bank) increases both subnational and national government sizes significantly, leading to a larger aggregated public sector. A federal state, with a more decentralized regime than a unitary one, has a smaller aggregate public sector (Table 6B). The presence of borrowing constraints, however, shows no significant effect on aggregate government size. The rate of real GDP growth is negatively associated with aggregate government size, whereas inflation has no significant effect. Moreover, both urbanization and openness raise aggregate government size. Finally, the interaction variable of borrowing constraints/vertical imbalance has mixed and even insignificant effects on aggregate government size.

5. Summary

This paper is the first attempt to examine the effects of fiscal decentralization on the sizes of the subnational, national, and aggregate governments. Using an econometric analysis of a panel of 32 industrial and developing countries, 1980–1994, we find that expenditure decentralization leads to larger aggregate and subnational governments, and smaller national governments. Revenue decentralization leads to larger subnational governments, but it reduces national government size by more than it increases subnational government size, and therefore leads to a smaller aggregate government. Vertical imbalance is the only fiscal variable that can increase the sizes of public sector at all levels (subnational, national, and aggregate).

Controlling for political and institutional variables, the analysis shows that a less independent central bank is associated with larger governments at both subnational and national levels, and hence larger aggregate government. When using expenditure decentralization and vertical imbalance as decentralization measures, elected subnational government seems effective in restraining the public sector at subnational level. In the regression using revenue decentralization,

an elected subnational government is likely to expand, although the effect is insignificant.

The feasible generalized least squares (FGLS) estimations also indicate that, in general, borrowing constraints have no significant effect on government size at any level (subnational, national and aggregate). Federal states, with a more decentralized regime than a unitary one, tend to have a smaller overall public sector.

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第 14 章

财政分权与财政赤字对宏观经济的影响

The Macroeconomic Impact of Decentralized Spending and Deficits: International Evidence

Francesca Fornasari, Steven B. Webb

The World Bank, 1818 H St. NW, Washington, DC 20433, USA

and

Heng-fu Zou

Guanghua School of Management, Peking University, Beijing, 100871, China
Institute for Advanced School, Wuhan University, Wuhan, 43007, China
The World Bank, 1818 H St. NW, Washington, DC 20433, USA

The main macroeconomic questions about decentralization are whether it has led to an overall expansion of the public sector or to unsustainable fiscal deficits. In the long term, subnational spending contributes to a larger overall government sector, but steady subnational deficits do not affect the average level of central government deficits, according to our economic analysis of 32 industrial and developing countries, 1980-94. Increases of subnational spending and deficits, however, lead to increases in spending and deficits at the national level. The relationships are strong economically as well as significant statistically. We can reject the hypothesis that increases of transfers between central and subnational governments are usually determined exogenously by the center.

Key Words: Decentralization; Public spending; Deficits.
JEL Classification Numbers: E5, E6, H5.

1. INTRODUCTION

Decentralization of government has occurred in OECD countries for decades, or longer. In developing countries it is a recent and strong trend as new democracies strengthen local demands for resources or central governments cut expenditures by transferring service responsibilities to lower levels of government (IDB 1997; Pasha 1997; and Fukasaku and de Mello 1997). There are many reasons to decentralize. To economists it seems

more efficient for the local community to choose the basket of services it favors and is willing to pay for (Tiebout 1956; Oates 1972; Bahl and Linn 1992; and Shah 1994). Also, local control can reduce the principal-agent problems in monitoring and management. From a political perspective, decentralization can enhance local democratic participation, mollify separatist tendencies, and help restrain dictatorial tendencies of central governments (Inman and Rubinfeld 1997; Tanzi 1996; and Weingast 1997).

Fiscal decentralization can also cause problems, however. For one reason, it often separates spending decisions more from the tax decisions. For example, subnational governments may overspend expecting to get more resources from the common pool of national resources. Geographically dispersed interests also present the danger, theoretical and actual, that some subnational representatives to the national government will collude to extract more resources from the common pool (Alesina and Perotti 1994). Thus, there are efficiency and equity concerns, and other concerns that decentralization will lead to problems with macroeconomic management (Tanzi 1996; Prud' homme 1995). For example, potential problems include hampering the central government's ability to carry out stabilization policy because they have to share or totally relinquish the more efficient tax bases, creating higher average deficits of the central government because its direct spending is not reduced as it increases transfers or gives up tax bases to subnational governments, and accumulating unsustainable deficits by subnational governments that expect some bailout from the center (Dillinger, Perry and Webb, 2000).

These concerns have been theoretical, anecdotal, and prescriptive. Decentralization does not necessarily lead to more deficits, they argue, because the central government can set strict limits on its support to subnationals. Subnationals in turn should have political incentives to restrain spending for which their taxpayers and voters pay in full at the margin. Anecdotes point to countries like the United States and Sweden who have been successful in using such means to prevent subnational finances from disrupting macrofiscal management. Counter-examples of macro-mismanagement in decentralized systems are also cited and duly condemned. Prescriptions then follow, to keep a hard budget constraint, to restrain local borrowing, etc. (Ter-Minassian 1997). It is hard to fault the recommendations, except to ask which are most important.

The question remains. Does decentralization cause deficits frequently enough to be a major worry for countries moving in this direction? Systematic evidence to confirm success or failure is scarce. For states and cities in the United States, there is evidence on which type of self- regulations by states works best. Of course, subnational deficits are rarely a major macroeconomic worry, despite the extreme degree of decentralization of the U.S. public sector (see for instance Inman and Rubinfield 1997).

With a cross-section of Latin American and OECD countries, Stein (1997) finds that greater decentralization, measured by the subnational share of total public spending, is associated with more total public-sector spending, but not with higher deficits of the total public sector. They find that the interaction term of decentralization with lack of borrowing constraints is associated with larger aggregate deficits. Fukasaku and de Mello (1997) investigate a sample of OECD and large developing countries to distinguish between subnational and central government fiscal variables. Their cross-section data show that subnational government size (spending as a share of GDP) is uncorrelated with central government balance in the whole sample, but is correlated negatively with the subnational government balance in the whole sample, and with the central government balance in the subsample of developing countries. The samples were too small for most results to be significant, and it was not possible to control for other influences. The strongest result is that larger subnational spending share is negatively correlated with growth for the developing country subsample, and for the Latin and Asian subsamples.[1]

Thus the cross-section evidence leaves us with suspicion that more subnational government spending means trouble, but we are unsure of the result or how it operates. This paper pushes the investigation further with panel data. The main question it seeks to answer is: Does the multi-country evidence show that subnational spending and deficits contribute to problems with the management of central government finances?

2. EXPECTED RELATIONSHIPS

To examine the possible role of fiscal decentralization in macroeconomic management problems, we first clarify the statistical relationships expected under various types of intergovernmental fiscal relations. While no actual system follows a pure type, the relationship between central and subnational governments can be seen as mixture of three main cases: complete independence; transfers controlled by the central government; and transfers controlled by the provinces, municipalities and other subnational entities (henceforth, provinces).

2.1. Complete independence between the central and subnational government

[1]The negative relation of growth with subnational spending share in the developing sample is significant at the 1 percent level, which corroborates Davoodi and Zou (1998), and Zhang and Zou (1998). For OECD countries, Fukasaku and de Mello (1997) find a weak (10 percent significant) positive correlation of growth with subnational spending shares.

In this first case, completely independent provinces raise their own taxes and decide their own spending. If higher subnational tax revenue comes at the expense of the tax base of the central government, and this leads to higher national deficits, then one would expect a positive correlation (cross-section average) between subnational taxes and central government deficits in the longer term. For short-term fluctuations within a country, one would expect no correlation of central and subnational fiscal variables, after controlling for common effects of the economic environment.

No country today fits this description completely, but a number of decentralized countries have assigned major tax bases to subnational governments for their exclusive use. Brazil assigns the general value added tax to the states. India assigns them the sales tax. As their revenue bases decline the central governments often retain or even increase their spending responsibilities, resulting in larger fiscal deficits.[2] The 1988 Brazilian Constitution accelerated the decline in centrally retained tax revenue, contributing to larger fiscal deficits (Tanzi 1996). In Argentina, when faced with the need to cut fiscal deficits and maintain macroeconomic balances, the authorities introduced major tax reforms in the early 1990s and sharply raised the share of taxes in gross domestic product (GDP). "But the potential impact of this effort on reducing the public sector's deficit was dissipated by the revenue-sharing arrangement, which required that 57 percent of any additional tax revenue coming from the central government's effort be shared with the provincial governments, which immediately spent the additional revenue" (Tanzi 1996, p.308). In addition, as the Argentine central government tried to reduce its spending through privatization and employment reductions, provincial governments were expanding their employment and spending, partly as a result of the additional tax revenue received. Thus, the revenue-sharing system can make deficit reduction more difficult at the national level.

2.2. Transfers controlled by the central government

In the second case of intergovernmental fiscal relations, the central government shifts spending responsibility to subnational governments and provides transfer money to finance them, but the center retains full control over the amount, or it is specified by a rule related to revenues of the center. In other words, at least in their relations to the center, subnational governments face hard budget constraints. They can spend as much as the central government decides to give them, plus whatever they raise through their own taxes and borrowing. With this type of intergovernmental fiscal relationship, the subnational government is spending federal money on av-

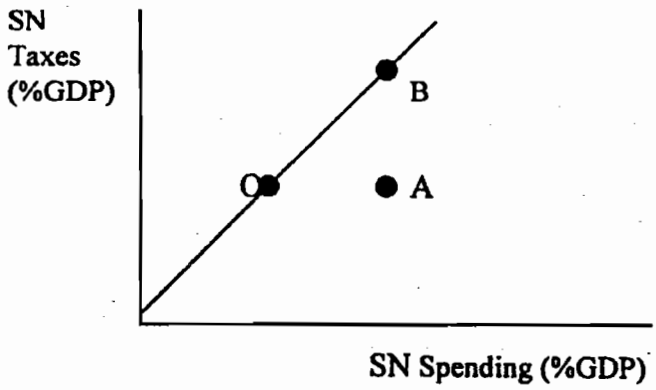
[2]See Tanzi (1996).

erage but not at the margin, as long as they raise some nontrivial resources of their own.

If the transfers count as central government spending, which is necessary in this investigation, because direct data on the amount of intergovernmental transfers are not reliable, then there would be a positive correlation between central and subnational spending when the system was in place and the transfer changed in order to finance a particular change in subnational spending. Examples of this arrangement are Chile and the United States, where all of the transfers are in the budget, although they might be too small to affect the aggregate econometric result. Transfers could also be by a formula to share federally collected taxes, in which case they would not appear as federal expenditure but might be counted as states' own revenue, as in Argentina and Brazil.

Figure 1 is useful to understand the arithmetic. If subnational spending moves by 1 unit (say, % of GDP) for O to A, with no increase in local taxes, then transfers of the central government would increase by 1. But does the central government cut back its own direct spending, leading to no change is overall central government outlays (transfers plus direct spending)?

FIG. 1. Subnational finances



In a steady state, long-term average, if subnational governments were financing more of their spending with taxes, they would be getting less from the center. Shorter-term fluctuations in central spending, however, would not correlate with subnational taxes or deficits. If subnational spending is fully financed with taxes, moving from O to B (perhaps as in case 1), then the central government does not have to increase transfers and they could cut their own outlays (including transfers) if the subnational spending fills a function on which the central government can stop spending.

Central government deficits would not depend on subnational fiscal variables, for one would not expect the central government to borrow to make

planned transfers. So, fiscal decentralization of this sort would not lead to greater deficits at the national government level.

2.3. Transfers controlled by subnational governments

In the third case, although the central government has theoretical control over its transfers to subnationals, in practice it may surrender some control to subnational governments or to their representatives in the national legislature. In the simplest case, if the subnational government increases spending beyond the increase of its initial transfer plus local taxes, the central government increases the current transfer to make up the difference. Typically the central government would exercise some political discretion in deciding such ad hoc transfers.

More complex cases arise when the subnational governments do not get enough transfers to fill their gap, they run a deficit, borrow, and then go to the central government for a bailout later when the debt burden becomes unsustainable. In some cases, the subnational debt goes through the banking system to end up at the central bank, and only shows up on the central government accounts when it has to make up losses of the central bank. Argentina before the stabilization of 1991 and Brazil in the 1980s and 90s provide a variety of examples (Dillinger and Webb 1999). Brazil's state debt crisis was the largest subnational debt crises ever experienced in a developing country. At its peak in 1995, states were in default on roughly US$8 billion in interest owed to the federal government. In 1996, the operational deficit of state government constituted half of the total public sector deficit (Dillinger 1997). Other countries have also experienced the adverse effect of local government borrowing on government budget and macroeconomic stability. As reported in Tanzi (1996), the Argentine provinces were able to finance a deficit of about 0.7 percent of GDP; and in Mexico the finances of its thirty-two states have been described as "precarious," and some states as "bankrupt."

In cases of the third type, the subnational government is spending other peoples' money not only on average and but also at the margin, effectively getting rewarded with a larger subsidy for spending more–the common pool resource problem. In these situations, fiscal decentralization would contribute to deficits as well as increased spending at the national level. Thus, one would expect national spending to depend not only on subnational spending, as with the hard-budget transfers (type 2), but also on subnational deficits. Subnational spending would have a positive coefficient and taxes would have a negative coefficient. The subnational deficit would also have a positive coefficient, but it would not be for the current year. If calendar years of observations corresponded to the fiscal years, then a subnational deficit would occur only to the extent that a federal transfer did not fill the gap. Any increase of central government spending

and borrowing to pay for debt relief to subnational government would come with a lag after they ran deficits.

When a central government loses control of its transfers to subnational governments it is usually partly due to a combination of political and economic factors. The size of outstanding subnational debt is also potentially important, for a larger debt is likely to exceed the threshold to get a bailout from the center. The hardness of the central government's own budget constraint should also affect its willingness to bailout the provinces, as it apparently has in Argentina (Dillinger and Webb 1999). Central bank independence is one identifiable factor that supposedly hardens the central government budget constraint.

The political independence of the subnational governments—and whether they are democratically elected and are constitutionally independent (federal vs. unitary)—may possibly explain their determination to spend more with resources from the center. But the degree to which the center controls the subnational levels may explain the willingness of the center to provide extra resources. So empirical evidence would have to resolve whether subnational political independence has a stronger effect on the supply or the demand for extra resources from the center.

3. DATA AND METHOD

To investigate how subnational spending and deficits affect the management of central government finance, this paper looks at the experience of 17 developed (upper income) and 15 developing countries over 15 years, 1980-94. See appendix Table A-1.

3.1. Data

All of the countries included in the current study are reported in the International Monetary Fund (IMF)-Government Financial Statistics (GFS) as having at least two levels of government. The binding constraint in the choice and number of countries included is the availability of data, primarily at the subnational level: we included all countries with at least eight years of data during 1980-94. The variables fall into four categories: central government' fiscal performance, subnational governments' fiscal performance, political/institutional characteristics, and macroeconomic control variables.

3.1.1. Central government's fiscal performance

The two central government fiscal variables are the main dependent variables: primary expenditure and primary deficit, both as percentages of GDP. Primary expenditure and primary deficit exclude interest payments

and there are two main reasons for this. First, it can be argued that interest payments are a function of the exogenous interest rate and the predetermined stock of debt and hence would not be affected by the current subnational fiscal behavior. Second, the interest expense data are especially inconsistent concerning accrued as well as cash interest payment, and adjustments for inflation. Central government spending also includes transfers to the subnational level. It would have been useful to analyze this category separately, but it was not reported consistently. All the data come from the IMF-GFS.

Appendix Tables A-2 and A-3 provide descriptive statistics on the central government fiscal position. The average primary surpluses for all countries is 0.2 percent of GDP, while the average overall balance is a deficit of −3.5 percent. The average balances for the upper-income and developing subsamples are very similar. The developing countries on average have much lower primary (and total) expenditures: 20.99 (24.87) percent of GDP compared to 33.75 (37.33) percent in developed countries. It is important to note that these averages hide very different realities. For example, Brazil has an average primary surplus of 4.16 percent of GDP, with the overall balance in a deficit equivalent to 7.24 percent of GDP; Luxembourg boasts an average primary surplus of 2.43 percent of GDP and an overall surplus of 1.98 percent of GDP. Tax revenue in developing countries is lower also, by an even larger margin, mainly because non-tax revenues are more important there (mainly royalties from minerals).

3.1.2. Subnational government's fiscal performance

Three different variables are used to proxy both the level of fiscal decentralization and the performance of subnational governments: expenditure, tax revenue, and deficits.[3] These figures include all the levels of government reported in the IMF-GFS other than the central government. Like in the previous group, all variables are transformed in percentage of GDP.

Appendix Tables A-4 and A-5 provide descriptive statistics on subnational government fiscal variables. Many of the observations for the central national government fiscal variables carry over to lower levels of government. Namely, on average, developing countries have lower primary (total) subnational expenditure: 5.6 (5.9) percent of GDP compared to 16.5 (17.5) for developed countries. Subnational governments' average tax revenue is

[3]Tax revenue figures from the IMF-GFS include the subnational government's own tax revenue and, in at least some cases, revenue resulting from tax-sharing arrangements with the central government. The latter limits the usefulness of the subnational tax data.

also lower in developing countries: 2.2 percent of GDP vs. 7.5 percent. While developing countries have much smaller subnational public sectors on average, the upper-income countries have an average primary surplus of 0.35 percent of GDP while the corresponding figure for developing countries is a deficit of 0.43 percent. Still, subnational governments of developing countries on average have about the same overall deficits: 0.68 percent vs. 0.70 percent of GDP for upper income. As two sharply different realities representative of the differences between developed and developing countries, one should note the case of India and the United States. Both are considered very decentralized countries, however, the United States subnational governments have an aggregated average primary (overall) surplus equivalent to 1.31 (0.91) percent of GDP, while India's subnational governments' primary (overall) balance is a deficit of 1.8 (2.92) percent of GDP.

3.1.3. Political/institutional variables

Six variables capture some of the political/institutional incentives that might affect expansionary fiscal behavior of one or more levels of government. The first variable measures the lack of independence of the central bank. It is composed of a linear combination of the five-year moving average of the number of changes by the central bank director per year and a dummy for the change of the central bank governor within 6 months of a political transition (any change of government leaders). The value of the latter variable persists throughout the tenure of the economy. The source of this information is Cukierman and Webb (1995), and the Europa Yearbook (1995) and correspondence with central banks. The interpretation of this variable is the following: more frequent turnover indicates a lower degree of central bank independence, as does a change of the governor immediately following a change of government leaders.[4]

Other researchers have found that constraints on subnational borrowing could help improve fiscal performance of subnational governments and to restrain the overall size of government (Ter-Minassian and Craig 1997; IDB 1997). So some investigation seemed warranted. Our variable is a dummy equal to 1 if Ter-Minassian and Craig (1997) said the country had either a complete prohibition against borrowing or a non-discretionary rule to constrain it ex ante, which were the two types of constraints they considered to be effective. The variable is only a cross- section for the 1990s; it does

[4]Furthermore we assumed that if a government changed the central bank governor in the first six months, then the government was marked as interventionist for its entire term.

not show changes over time and is not accurate for the 1980s for some countries. The interview sources for much of their information would not be usable to recover comparable information for the 1980s.

The four additional variables are dummies to measure the possible effects of the political environment on central or subnational public finance. These latter are: (i) unitary vs. federal state; (ii) elected vs. unelected subnational governments; (iii) any major political transition, from an authoritarian (democratic) regime to a democratic (authoritarian) regime within that year; and (iv) a dummy variable describing the exchange rate regime (i.e., pegged vs. flexible). The source of this information was primarily the Europa Yearbook (1995), with additional information from The Economist Intelligence Unit country reports.

3.1.4. Control variables

To ensure that any correlation between fiscal decentralization and central government's performance is not due to the effect of the general macroeconomic environment, four control variables are also included in the analysis: (i) the growth rate of real GDP,[5] (ii) the log of per capita GDP in U.S. dollars in 1980, (iii) a transformed measure of Consumer Price Index (CPI) inflation,[6] and (iv) the percentage of urban population. The source of these variables is the IMF- IFS and the World Bank's *World Development Indicators*.

3.2. Models and Method

To investigate the relationship between central and subnational finances and other political and economic variables, three models are presented. The first (Basic Model) excludes all political variables:

$$\text{CGFiscal}_{i,t} = \alpha_0 + \alpha_1 * \text{SNGFiscal}_{i,t} + \alpha_2 * \text{Control}_{i,t} + \epsilon_{i,t}; \qquad (1)$$

where $\text{CGFiscal}_{i,t}$ represents the proxy for the central government's fiscal behavior, $\text{SNGFiscal}_{i,t}$ represents the proxy for the subnational government's fiscal behavior, and $\text{Control}_{i,t}$ represents the control variables included in the empirical analysis.

[5]Measured in 1987 prices.

[6]The transformed measure of CPI inflation is calculated in the following way: $\pi/(1+\pi)$, where π is the CPI inflation rate and where $\pi = 1$ refers to an inflation rate of 100 percent.

The second model (Unconditional Political Model) includes political variables as additional elements:

$$\begin{aligned} \text{CGFiscal}_{i,t} &= \alpha_0 + \alpha_1 * \text{SNGFiscal}_{i,t} + \alpha_2 * \text{Political}_{i,t} \\ &+ \alpha_3 * \text{Control}_{i,t} + \epsilon_{i,t}; \end{aligned} \tag{2}$$

where $\text{Political}_{i,t}$ represents the political/institutional variables which might contribute to any correlation between central and subnational government finances.

The third model considers the possibility that the *impact* of subnational fiscal variables on central government fiscal variables, i.e., the coefficient α_1, depends on a set of political variables, i.e.:

$$\begin{aligned} \text{CGFiscal}_{i,t} &= \alpha_0 + \alpha_1 * \text{SNGFiscal}_{i,t} + \alpha_2 * \text{Political}_{i,t} \\ &+ \alpha_3 * \text{Control}_{i,t} + \epsilon_{i,t}; \end{aligned} \tag{3}$$

$$\alpha_1 = \delta_0 + \delta_1 * \text{Political}_{i,t} + \nu_{i,t} \tag{4}$$

Thus leading to the following model (Conditional Political Model):

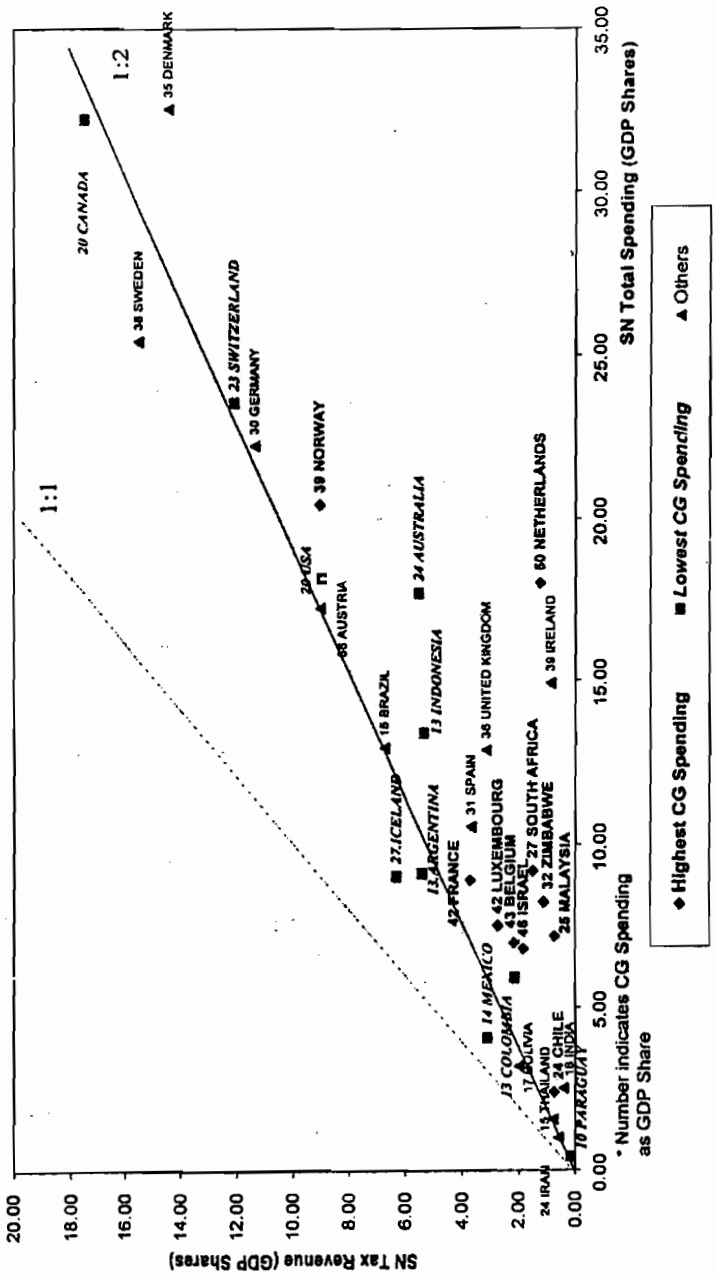
$$\begin{aligned} \text{CGFiscal}_{i,t} &= \alpha_0 + \delta_0 * \text{SNGFiscal}_{i,t} + \delta_1 * \text{Political}_{i,t} * \text{SNGFiscal}_{i,t} \\ &+ \alpha_3 * \text{Political}_{i,t} + \alpha_4 * \text{Control}_{i,t} + \eta_{i,t}; \end{aligned} \tag{5}$$

where $\eta_{i,t} = \nu_{i,t} + \epsilon_{i,t}$ are iid. This is a more general version of the Unconditional Political Model because it allows the political variables to influence both directly and indirectly through subnational fiscal behavior, central government primary expenditure and deficit.

Most regressions (see Tables 2-3) are done with all fiscal variables in first differences. Augmented Dickey-Fuller Tests and the Durbin-Watson statistics of regressions run using levels indicate that the series are not stationary.

All panel data estimates are done with the Feasible Generalized Least Squares (FGLS) method, which corrects for cross-section heteroskedasticity by estimated cross-section residual variances. Furthermore, White's heteroskedasticity correction is used, thus making the covariance robust to general heteroskedasticity problems. This form of heteroskedasticity is more general than the cross-section heteroskedasticity, since variances within a cross-section are allowed to differ across time.

FIG. 2. Central government spending as a function of SN spending and taxes



4. RESULTS

4.1. Cross-section

Cross-section data give a picture of longer term relationships. Figure 2 shows the data laid out in the same space as Figure 1. The location of each observation shows the GDP share of subnational spending and taxes—the main independent variables in column 4 of table 1. Countries that are farther out on the x-axis have more subnational expenditures as a share of GDP. If subnational governments paid for all their expenditures with their own taxes, they would be on the 1:1 line, but no country with much decentralization is close to that line. The most self-reliant are only a little above the 1:2 line—own revenues paying for about half of subnational expenditures.

The number by each observation and the font of the country name show the central government spending shares—one of the dependent variables in the subsequent statistical analysis. Almost all of the countries that are far below the 1:2 line and close to the x-axis (heavy transfer dependency) had relatively central government spending (among the top third of the sample, labeled in bold).[7] Most of those on or above the 1:2 line had small central governments (in the bottom third of the sample. bold italics). In other words, having subnational spending financed mostly with transfers increase the size of the central government and of total government.

We investigate the relations more systematically with regressions, with the results shown in Table 1. The dependent variables are either central government primary spending or primary deficits. In addition to the standard control variables, the subnational fiscal variable is either subnational total spending and taxes, as a group, or lagged subnational overall deficits. Only two coefficients have t-statistics indicating significant difference from zero: subnational expenditure and tax revenue respectively raise and decrease central government's primary expenditure. A number of control variables are also included, and they do not have much effect on the signs and significance of the subnational fiscal variables.[8]

[7]The industrial and developing countries were divided and then each group was ranked according to the average GDP share of central government spending and divided into equal sized groups of high, medium and low central government spending. Of the 32 in the sample, the high central government spending group was Netherlands, Belgium, Luxembourg, France, Norway, Israel, Zimbabwe, South Africa, Malaysia, and Chile. The low central government spending group was Iceland, Austria, Switzerland, United States, Canada, Mexico, Argentina, Indonesia, Colombia, and Paraguay.

[8]We also ran some cross-section regressions with sub-national spending and deficits as the dependent variables. For subnational spending, none of the coefficients were significant at even the 10 percent level. For subnational deficits the borrowing controls

TABLE 1.
Basic Model: Cross Section
Overall Sample Estimates[a]
(All dependent variables are net of interest payments)

Dependent Variable	CG Deficit to GDP	CG Exp. to GDP	CG Deficit to GDP	CG Exp. to GDP
Constant	5.404**	0.619	5.867**	−5.506
	2.250	*0.056*	*2.211*	*− 0.566*
SN Tot Expenditure			−0.041	1.009**
to GDP			*−0.384*	*2.556*
SN Tax Revenue			0.033	− 2.110**
to GDP			*0.180*	*−3.132*
Lag Overall SN	0.758*	−0.199		
Deficit to GDP	*1.884*	*−0.108*		
Lag CPI Inflation	−0.073**	−0.206	−0.068**	−0.122
	−2.691	*−1.649*	*−2.167*	*−1.060*
Percentage Urban	−0.029	0.160	−0.026	0.128
Population	*−1.162*	*1.398*	*−0.959*	*1.268*
1980 GDP Per	−0.272	2.157	−0.248	2.836**
Capita in US$	*−0.799*	*1.380*	*− 0.661*	*2.065*
Real GDP Growth	−0.539**	0.586	−0.570*	0.320
	−2.096	*0.496*	*−2.012*	*0.309*
Adj. R-Squared	0.25	0.36	0.13	0.52
No. Time Observations	1	1	1	1
No. Cross Section	32	32	32	32

Note: a. The number in italics represents the *t*-statistic associated with each coefficient. Furthermore, * indicates significance level of 10 percent, while ** indicates a significance level of 5 percent.

The coefficient on subnational spending is about 1.0, which implies that, holding subnational taxes constant, subnational spending is correlated in a one-to-one ratio with central government spending. As noted earlier, if the central government were reducing its own spending as local governments took on more responsibility, the coefficient would have been about zero (since local taxes were in the regression). So the subnational spending not funded by local taxes (and therefore mostly paid with transfers) seems to have been largely additional to central government spending, not a substitute. In contrast, the coefficient for subnational taxes is approximately −2.0 and statistically significant. This suggests that for a given level of

variable had a negative coefficient significant at the 6 percent level and being a federal system had a positive coefficient significant at the 5 percent level.

subnational spending, more financing with local taxes has a double effect in reducing central government outlays. Local taxation not only relieves the central government of making transfers to finance the local spending, but it also seems to occur in situations where local spending is a substitute for central government spending.

These results suggest that on average: (1) decentralization of spending by transfers increases the size of total government, a result consistent with what Stein (IDB 1997) got with an all-Latin America sample; and (2) to the extent that subnational governments finance themselves with their own taxes, the public sector at the national level tends to be smaller by about as much as the subnational spending, leaving the overall size of the public sector about the same. From the cross-sectional evidence it is not possible to draw conclusions about causality and sequencing, but the intriguing possibilities suggest the benefit of further research on the way that decisions to finance with local taxation are related to the decisions about the allocation of service responsibilities.

Cross-section regressions with subnational deficits indicate that they did not on average affect the national spending or the national level deficit, nor did the subnational spending have a statistically significant relation with the national government deficits. This implies that when countries are decentralized in a long-run steady state—which is the interpretation of these of these cross-country regressions on averages per country—they do not have higher national deficits on average than the less decentralized countries. They have presumably developed institutions—and raised taxes—at least adequate to avert the macroeconomic fears concerning deficits.

4.2. Panel Data

The panel regression with changes in the national and subnational fiscal variables got very different results[9] (see Table 2). They show that increases of subnational spending and deficits lead to higher spending and deficits at the national level. The relationships are strong economically as well as statistically significant.[10] The results in columns 1 and 2 have the clearest meaning–An increase in subnational deficits is associated with an economically and statistically significant increase in central government spending and deficits in the subsequent period. This is consistent with a pattern

[9]First differences were used because the time series of values in levels were nonstationary, and the errors in the regressions were serially correlated.

[10]These results show up when we look at changes between 5-year periods, as well as with annual changes. They also show up in the subsets for developing and industrial countries.

of the central government bailing out states and cities when they have increased borrowing too much. During 1980-95, most of the countries in the sample were reducing their central government deficits. But the ones that had the largest average increases of subnational spending and deficits—ranked to the right in the charts—decreased their central deficits the least, or increased them on average (see fig. 2).

The results with the panel data focus on changes over time in each country. Since we are unable to reject the nonstationary hypothesis [11] and the Durbin-Watson statistics strongly indicated serial correlation of errors, the regressions are estimated with fiscal data in first differences (see Tables 2 and 3 to 3.2). The current subnational deficit was dropped because it was usually not significant when included in the same equation with the lagged deficit and a priori we would expect the subnational deficits to effect national finances with a lag, as noted earlier.

In interpreting these results, it is important to recognize the use of first differences means that the results are determined mainly by the countries and periods when the levels of spending and deficits at the national and subnational levels are changing rapidly: that is, by those in which increased decentralization is taking place. In these times and places, we can reject the hypothesis that the transfers between central and subnational governments are usually determined exogenously by the center. The process of fiscal decentralization tends to cause problems. These results are powerful arguments against rapid decentralization without adequate safeguards.

The results in the panel data held up even with the inclusion of political-institutional variables–major national political transitions and central bank independence and two that pertained directly to decentralization–election of subnational officials and unitary/federal constitution. The political (institutional) variables by themselves usually have little influence on central government performance, but were often influential in interaction with the subnational fiscal variables.[12]

Whether or not local officials were elected had no effect on the intergovernmental fiscal relations considered here. In other words, local democracy does not seem to worsen, or improve macroeconomic fiscal management on average. Being a unitary state (rather than a federation), on the other hand, significantly increased the extent to which national government

[11] Tests were based on the Augmented Dickey Fuller Test.

[12] In the Conditional Political Model the proxy for central bank independence and the dummy for high transition countries are included also directly because of their possible impact on central government fiscal behavior through avenues not related to subnational government finances.

TABLE 2.
Basic Model: Panel Data, Fiscal Variables in First Differences[a]
Overall Sample Estimates[b]
(All dependent variables are net of interest payments)

Dependent Variable	CG Deficit to GDP	CG Exp. to GDP	CG Deficit to GDP	CG Exp. to GDP
Constant	−0.045	0.459*	−0.413	−0.069
	−0.092	*1.838*	*−0.932*	*−0.312*
SN Tot Expenditure			0.322**	0.538**
to GDP			*4.007*	*8.121*
SN Tax Revenue			−0.176	−0.073
to GDP			*−1.004*	*−0.571*
Lag Overall SN	0.234**	0.261**		
Deficit to GDP	*2.805*	*7.902*		
Lag CPI Inflation	−0.054**	−0.013	−0.057**	−0.028
	−2.806	*−0.592*	*−3.368*	*−1.509*
Percentage Urban	−0.007**	−0.013**	−0.010**	−0.012**
Population	*−2.019*	*−4.657*	*−2.693*	*−4.959*
1980 GDP Per	0.070	0.089**	0.123*	0.128**
Capita in US$	*0.985*	*2.113*	*1.878*	*3.393*
Real GDP Growth	−0.150**	−0.194**	−0.143**	−0.142**
	−8.141	*−13.545*	*−8.896*	*−12.706*
Adj. R-Squared	0.10	0.23	0.14	0.33
D. W. Statistic	2.12	1.77	2.13	1.82
No. Time Observations	13	13	13	13
No. Cross Section	32	32	32	32

Notes:
a. In all the following regressions, i.e., Tables 3 to 6, the only variables that are in first difference are the dependent variable and the fiscal explanatory variables, i.e., total expenditure, tax revenue, and deficit.
b. The number in italics represents the t-statistic associated with each coefficient. Furthermore, * indicates significance level of 10 percent, while ** indicates a significance level of 5 percent.

spending was related to subnational spending and deficits, but this might just reflect the fact that the national spending figure includes some transfers to states and one would expect budgeted transfers (rather than tax sharing or delegated taxes) to be more important in a unitary state. Being a unitary state does not significantly affect the transmission of subnational deficits to national deficits.

The significant coefficient on subnational deficits in the equations for both spending and deficits of the central government suggests that cen-

TABLE 3.
Conditional Political Model in First Differences[a]
Overall Sample Estimates[b]
(All dependent variables are net of interest payments)

Dependent Variable	CG Deficit to GDP	CG Exp. to GDP	CG Deficit to GDP	CG Exp. to GDP
Constant	0.379	0.808**	−0.093	0.021
	0.683	*2.391*	*−0.179*	*0.076*
SN Tot Expenditure			0.816**	1.158**
to GDP			*3.539*	*8.286*
SN Tax Revenue			−0.147	−0.168
to GDP			*−0.875*	*−1.261*
Lag Overall SN Deficit	0.443*	0.678**		
to GDP	*1.919*	*2.725*		
Cond. Political Central	1.900**	1.386**	0.161	0.230
Bank[c]	*2.481*	*2.912*	*0.364*	*0.675*
Cond. SN Government	−0.276	0.047	0.095	0.009
Elected	*−0.693*	*0.206*	*0.344*	*0.050*
Cond. High Transition	−5.194**	−3.606**	−0.144	−0.411**
	−5.243	*−5.983*	*−0.707*	*−2.851*
Cond.Federal State	0.044	−0.604**	−0.732**	−0.641**
	0.134	*−3.365*	*−2.801*	*−4.221*
Cond. Fixed Exchange	−0.506*	−0.377**	−0.002	0.006**
Rate	*−1.916*	*−2.050*	*−0.295*	*2.153*
Political Central Bank	−0.429**	−0.309**	−0.528**	−0.021
	−2.546	*−2.287*	*−2.335*	*−0.152*
High Transition	1.415**	−0.110	1.340**	1.200**
	2.726	*−0.238*	*2.151*	*3.230*
Lag CPI Inflation	−0.056**	−0.019	−0.058**	−0.024
	−2.831	*−0.837*	*−3.413*	*−1.154*
Percentage Urban Pop	−0.004	−0.011**	−0.007**	−0.011**
	−1.073	*−3.714*	*−2.007*	*−3.561*
1980 GDP Per Capita	0.002	0.046	0.076	0.100**
in US$	*0.025*	*0.893*	*1.020*	*2.100*
Real GDP Growth	−0.174**	−0.217**	−0.139**	−0.128**
	−9.173	*−12.494*	*−8.918*	*−12.120*
Adj. R-Squared	0.19	0.24	0.17	0.37
D. W. Statistic	2.10	1.76	2.22	1.88
No. Time Observations	13	13	13	13
No. Cross Section	32	32	32	32

Notes:
a. In all the following regressions, i.e., Tables 2.1 to 3, the only variables that are in first difference are the dependent variable and the fiscal explanatory variables, i.e., total expenditure, tax revenue, and deficit.
b. The number in italics represents the t-statistic associated with each coefficient. Furthermore, * indicates significance level of 10 percent, while ** indicates a significance level of 5 percent.
c. The term "conditional" means that the political variable has been multiplied by either the lagged value of the SN Overall Deficit (the case of the first two regressions represented in this table) or by the SN Total Expenditure (the case of the last two regressions).

TABLE 3.1.
Conditional Political Model in First Differences[a]
Developing Countries Estimates[b]
(All dependent variables are net of interest payments)

Dependent Variable	CG Deficit to GDP	CG Exp. to GDP	CG Deficit to GDP	CG Exp. to GDP
Constant	0.157	−0.781	1.184	0.396
0.110	*−0.774*	*1.096*	*0.513*	
SN Tot Expenditure			0.600**	1.493**
to GDP			*2.650*	*4.093*
SN Tax Revenue			−0.473	−0.668
to GDP			*−0.664*	*−1.053*
Lag Overall SN	0.657**	−0.001		
Deficit to GDP	*2.458*	*−0.003*		
Cond. Political	2.358**	2.649**	0.450	0.150
Central Bankc	*6.110*	*6.028*	*1.160*	*0.420*
Cond. SN Government	−1.427**	−0.024	−0.927	1.293
Elected	*−1.976*	*−0.024*	*−0.744*	*1.447*
Cond. High Transition	−4.715**	−2.588**	0.031	−0.338
	−8.198	*−4.412*	*0.096*	*−1.404*
Cond.Federal State	−0.665	−1.774	−0.105	−2.358**
	−0.905	*−1.629*	*−0.113*	*−2.937*
Cond. Fixed Exchange	0.747	−0.738	0.003	0.191**
Rate	*1.041*	*−1.018*	*0.023*	*2.484*
Political Central	0.157	0.570**	0.131	0.696**
Bank	*0.790*	*2.605*	*0.516*	*2.796*
High Transition	1.269**	−0.023	1.355**	1.056**
	2.826	*−0.068*	*2.267*	*2.789*
Lag CPI Inflation	−0.068**	−0.023	−0.075**	0.002
	−3.725	*−1.249*	*−3.108*	*0.107*
Percentage Urban Pop	−0.011	−0.016**	−0.012	−0.021**
	−1.301	*−2.193*	*−1.636*	*−3.030*
1980 GDP Per Capita	0.033	0.218	−0.104	0.051
in US$	*0.131*	*1.258*	*−0.575*	*0.384*
Real GDP Growth	−0.160**	−0.010**	−0.158**	−0.086**
	−5.876	*−3.334*	*−5.739*	*−3.030*
Adj. R-Squared	0.26	0.15	0.09	0.18
D. W. Statistic	2.24	1.75	2.43	1.98
No. Time Observations	13	13	13	13
No. Cross Section	15	15	15	15

Notes:
a. In all the following regressions, the only variables that are in first difference are the dependent variable and the fiscal explanatory variables, i.e., total expenditure, tax revenue, and deficit.
b. The number in italics represents the t-statistic associated with each coefficient. Furthermore, * indicates significance level of 10 percent, while ** indicates a significance level of 5 percent.
c. The term "conditional" means that the political variable has been multiplied by either the lagged value of the SN Overall Deficit (the case of the first two regressions represented in this table) or by the SN Total Expenditure (the case of the last two regressions).

TABLE 3.2.
Conditional Political Model in First Differences[a]
Developed Countries Estimates[b]
(All dependent variables are net of interest payments)

Dependent Variable	CG Deficit to GDP	CG Exp. to GDP	CG Deficit to GDP	CG Exp. to GDP
Constant	2.955	1.965	1.261	0.355
	0.907	*1.351*	*0.307*	*0.291*
SN Tot Expenditure			1.258*	1.137**
to GDP			*1.880*	*6.861*
SN Tax Revenue			*−0.008*	*−0.047*
to GDP			*−0.042*	*−0.203*
Lag Overall SN	0.300	1.110**		
Deficit to GDP	*0.657*	*2.408*		
Cond. Political	1.965**	1.089**	−0.548	−0.114
Central Bankc	*2.668*	*2.518*	*−1.277*	*−0.202*
Cond. SN Government	−0.141	−0.162	−0.034	−0.240
Elected	*−0.207*	*−0.349*	*−0.045*	*−0.988*
Cond.Federal State	0.182	−0.776**	−1.064**	−0.393**
	0.429	*−2.351*	*−3.056*	*−2.018*
Cond. Fixed Exchange	−0.565	−0.629*	0.001	0.007
Rate	*−1.614*	*−1.963*	*0.152*	*1.330*
Political Central	−1.005**	−1.007**	−1.184**	−1.034**
Bank	*−3.351*	*−4.140*	*−4.305*	*−3.692*
Lag CPI Inflation	−0.042	−0.010	−0.043*	−0.055*
	−1.379	*−0.227*	*−1.781*	*−1.755*
Percentage Urban Pop	−0.002	−0.007	−0.003	−0.006
	−0.313	*−1.633*	*−0.585*	*−1.450*
1980 GDP Per	−0.280	−0.088	−0.098	0.049
Capita in US$	*−0.780*	*−0.569*	*−0.215*	*0.371*
Real GDP Growth	−0.177**	−0.276**	−0.149**	−0.216**
	−6.467	*−8.713*	*−4.954*	*−7.140*
Adj. R-Squared	0.23	0.44	0.21	0.51
D. W. Statistic	2.02	1.72	2.13	1.84
No. Time Observations	13	13	13	13
No. Cross Section	17	17	17	17

Notes:
a. In all the following regressions, the only variables that are in first difference are the dependent variable and the fiscal explanatory variables, i.e., total expenditure, tax revenue, and deficit.
b. The number in italics represents the t-statistic associated with each coefficient. Furthermore, * indicates significance level of 10 percent, while ** indicates a significance level of 5 percent.
c. The term "conditional" means that the political variable has been multiplied by either the lagged value of the SN Overall Deficit (the case of the first two regressions represented in this table) or by the SN Total Expenditure (the case of the last two regressions).

tral governments spend more and borrow more to help out subnational governments after they have overspent and run up debt. The significant coefficient on subnational spending in the central government deficit equation reinforces the impression that the relations are often of the unhealthy variety, as in case 3.

Lack of central bank independence in interaction with subnational deficits (lagged) has significantly positive and large (around 2.0) coefficients in both subsamples and for both central primary deficits and central spending. This implies that the central government is much more likely to bailout overindebted subnationals. For the developing countries, lack of central bank independence directly effects central government spending. It is surprising that central bank independence does not affect their deficits as well and that the upper-income countries have negative and usually significant coefficients on the variable for lack of central bank independence when entered by itself.

Subnational borrowing constraints showed no systematic effects in improving fiscal performance of the central government. So the results were not reported. This is not surprising. To the extent that the borrowing constraints work, their effect would already be reflected in the variables for subnational borrowing and spending (although the regressions with subnational spending and deficits as dependent variables do not show significant effects of borrowing constraints). So entering the variable in the equations for central government deficits and spending is mainly asking whether the subnational spending and borrowing and spending that occurs, despite the borrowing constraints, have a less pernicious effect on the center if borrowing constraints are present. Also, fiscal problems at the center as a result of subnational fiscal behavior might cause the introduction of the borrowing constraints–reverse causality.

The variable for elected subnational governments did not have significant coefficients for either a direct effect or an interaction with the subnational spending and deficits. Perhaps this is because there were so few observations of unelected subnational governments.

Major political transitions-coups or transitions to democracy-occurred only in the developing countries in our sample years. The variable by itself has a positive and significant coefficient in the equations for central government primary deficits, but not usually for central spending. So central deficits are higher on average in years of political transition. But the coefficients are significantly negative for the interaction of transitions with subnational deficits, indicating that the subnationals are less likely to get

a bailout in a transition year. This is not surprising, given the distractions of the central government at such a time.

To summarize, whereas in the cross-section regression the steady-state level of subnational borrowing (implicitly sustainable) is not associated with higher central government spending and deficits, when subnational governments increase their borrowing (potentially unsustainable) the central government seems to have to spend and borrow more in the subsequent period. This implies that transitions to decentralization and fluctuations of borrowing by subnationals typically cause problems for macroeconomic management, but evidently many countries with long-standing decentralized public sectors have developed institutions to prevent these problems. Although many of these countries are outside Latin America, the experiences in the region show important positive as well as negative lessons for macroeconomic management in decentralized democracies.

The variable for a fixed exchange—rate regime did not usually have a significant coefficient by itself or in interaction with subnational deficits and spending. When it was significant, the signs were inconsistent. Further study of the role of institutional and political variables seems warranted.

For the economic control variables, there is strong evidence that faster GDP growth lowers both primary expenditure and deficits. This remains true regardless of the model specification or of the sample of countries employed. Also, lagged CPI inflation seems to decrease the central government's primary deficit, and a high percentage of urban population is negatively correlated with central government primary expenditure.

We also ran regressions where net credit from the central bank and net credit from the money deposit banks were included as dependent variables. The tables including these results are not presented because the conclusions are not as clear cut as with the previous regressions. Nonetheless, three preliminary conclusions can be reported. First, increases of subnational expenditure and tax revenue both result in higher net credit from the monetary authority. Second, higher lagged subnational deficits lead to higher net credit from the monetary authority. Finally, net credit from money deposit banks varies positively with subnational expenditure and negatively with subnational tax revenue.

4.2.1. Causes of subnational spending and deficits.

We also looked to see whether variables reflecting the institutional and economic environment could explain subnational spending and deficits. Table 4 reports the results for the panel data regressions.

TABLE 4.
Unconditional Political Model of Subnational Spending and Deficits
(first differences)[a b]

(All dependent variables are net of interest payments)

	Overall Sample		Developing Countries		Developed Countries	
Dependent Variable	**SN Def. To GDP**	**SN Exp. to GDP**	**SN Def. to GDP**	**SN Exp. to GDP**	**SN Def. to GDP**	**SN Exp. to GDP**
Constant	−0.059	0.032	−0.212	−0.514**	0.284	1.015**
	−0.419	*0.297*	*−1.195*	*−1.961*	*0.602*	*2.357*
Political Central	−0.099**	−0.271**	−0.064	−0.087	−0.216**	−0.455**
Bank	*−2.663*	*−6.330*	*−1.286*	*−1.259*	*−3.753*	*−6.647*
SN Government	−0.020	0.214**	−0.019	0.119	0.102	−0.176
Elected	*−0.793*	*5.166*	*−0.583*	*0.931*	*0.533*	*−0.797*
High Transition	0.089**	0.863	0.085**	0.887		
	3.895	*0.670*	*2.996*	*0.840*		
Federal State	0.011	0.082**	0.021	0.169	−0.010	0.067*
	0.403	*2.709*	*0.614*	*1.218*	*−0.231*	*1.693*
Fixed Exchange	−0.053	−0.094**	−0.246	0.174	−0.013	−0.084**
Rate	*−1.383*	*−3.035*	*−0.332*	*0.834*	*−0.289*	*−1.982*
Lag CPI Inflation	−0.003*	−0.006**	−0.003**	−0.008**	−0.001	0.004
	−1.879	*−2.111*	*−2.139*	*−3.388*	*−0.535*	*1.520*
Percentage Urban	0.001	−0.002**	0.001	−0.002	0.002	−0.002
Population	*1.035*	*−2.057*	*0.540*	*−0.826*	*1.036*	*−1.184*
1980 GDP Per	0.001	0.012	0.024	0.082	−0.050	−0.041
Capita in US$	*0.046*	*0.606*	*0.745*	*1.595*	*−0.931*	*−0.982*
Real GDP Growth	0.001	−0.026**	0.003**	−0.005**	−0.018**	−0.079**
	0.643	*−7.175*	*4.870*	*−2.478*	*−2.719*	*−6.402*
Adj. R-Squared	0.00	0.10	−0.01	0.06	0.01	0.22
D. W. Statistic	2.32	1.79	2.58	2.20	2.23	1.63
No. Time Obs.	13	13	13	13	13	13
No. Cross Section	32	32	15	15	18	18

Notes:
a. In all the following regressions, the only variables that are in first difference are the dependent variable and the fiscal explanatory variables, i.e., total expenditure, tax revenue, and deficit.
b. The number in italics represents the t-statistic associated with each coefficient. Furthermore, * indicates significance level of 10 percent, while ** indicates a significance level of 5 percent.

Three findings stand out. First, countries with high-level political transitions have higher subnational government deficits in the transition years. Second, fixed exchange rates are associated with lower subnational government spending: this is particularly true of developed countries. Finally, lack of central bank independence leads to lower spending and deficits at the subnational level, especially in developed countries. Subnational borrowing constraints (not shown) did not enter significantly in panel data regressions, except that in a 1990-94 subsample, the period for which the borrowing constraint variable is most accurate, it has a significantly positive coefficient, which is consistent with reverse causality, although does not prove it. Of the economic environment variables, inflation and real growth both have a significant negative effect on subnational government spending and deficits.

5. CONCLUSIONS

Although the econometric evidence is primitive in many ways, it gives an unequivocal indication that a problem exists for countries where the subnational spending and borrowing and spending are increasing–subnational spending and deficits can lead to higher spending and deficits at the national level. We can reject the idea that on average subnational governments fiscal policy has no effect on central government fiscal policy. Therefore, the theoretical possibility– complete independence between the central and subnational governments–does not hold in practice for most countries in our sample. On the contrary, our empirical findings indicate that the center is likely to take care of subnational governments when the latter are in fiscal difficulties; or subnational governments are usually facing soft-budget constraints from the center.

We can also reject the hypothesis that the transfers between central and subnational governments are usually determined exogenously by the center. If the center had such a good control of the situation, we would not see the significant coefficients for subnational interest payments and lagged deficits in the equation for central spending. Nor would we see the significant coefficients for subnational fiscal variables in the equation for central government deficits.

Countries seem to develop ways to minimize these problems, for the deficit relationships do not show up in the cross-section analysis. The main potential problem in the long-run, revealed in the cross-section analysis, is that subnational spending financed with transfers or something else other that local taxes tend to increase the overall size of the government.

Having a less independent central bank as indicated by frequent and politically motivated changes of the governor, are associated with increased influence of subnational spending and deficits on the central government's fiscal situation. Central governments in a unitary state are more likely to bailout their subnationals than in a federal public sector. Major political transitions, between authoritarian and democratic regimes, lead to higher central government deficits, on average, but make the central governments less likely to aid the subnationals in that year.

Further research may reveal more explicit links in intergovernmental transfers, by investigating the nature of the linkage and the institutional arrangements that affect the linkage, which make it more or less difficult for subnationals to spend other people's money.

APPENDIX A

TABLE A1.
Countries Included in the Empirical Study

Argentina	Israel
Australia	Luxembourg
Austria	Malaysia
Belgium	Mexico
Bolivia	Netherlands
Brazil	Norway
Canada	Paraguay
Chile	Romania
Colombia	South Africa
Denmark	Spain
France	Sweden
Germany	Switzerland
Iceland	Thailand
India	United Kingdom
Indonesia	United States
Iran	Zimbabwe
Ireland	

TABLE A2.
Central Government Descriptive Statistics.
(Averages of the percentages of GDP between 1980-1994)

Country	Primary Deficit	Overall Deficit	Primary Expenditure	Total Expenditure	Tax Revenue
Argentina	1.40	3.06	13.26	14.92	11.75
Bolivia	−4.08	−2.87	17.13	18.34	8.62
Brazil	−4.16	7.24	24.64	36.05	17.05
Chile	−2.16	−0.72	24.34	25.79	20.36
Colombia	0.48	1.54	12.95	14.01	11.02
India	4.07	7.18	13.01	16.12	10.53
Indonesia	−0.87	1.03	17.99	19.89	16.78
Iran	5.17	5.26	24.27	24.35	7.64
Israel	−2.93	8.93	45.76	57.62	37.32
Malaysia	−0.52	4.91	24.61	30.05	20.84
Mexico	−2.41	5.36	13.49	21.26	14.48
Paraguay	−0.90	−0.27	9.76	10.39	8.89
South Africa	1.26	5.13	26.51	30.38	23.77
Thailand	−1.04	0.93	15.34	17.32	14.84
Zimbabwe	4.33	9.17	31.73	36.57	26.38
Developing Countries	**−0.16**	**3.73**	**20.99**	**24.87**	**16.68**
Australia	−0.66	1.23	23.66	25.54	21.78
Austria	1.63	4.68	36.37	39.42	32.27
Belgium	−0.46	8.52	42.91	51.89	42.45
Canada	0.03	4.07	19.83	23.87	17.67
Denmark	−4.12	1.62	35.02	40.77	33.29
France	0.84	2.80	41.77	43.73	37.65
Germany	0.07	1.67	29.63	31.23	28.06
Iceland	0.32	3.02	27.28	29.98	23.84
Ireland	−0.47	7.50	38.67	46.64	35.15
Luxembourg	−2.43	−1.98	42.35	42.79	40.24
Netherlands	0.12	4.28	50.43	54.58	44.38
Norway	−2.32	0.44	39.10	41.86	36.60
Spain	2.53	5.05	30.59	33.12	26.41
Sweden	0.63	6.03	38.09	43.49	33.85
Switzerland	0.23	0.85	22.01	22.63	19.56
United Kingdom	−0.90	2.68	35.71	39.29	32.56
United States	0.67	4.03	20.36	23.71	18.14
Developed Countries	**−0.25**	**3.32**	**33.75**	**37.33**	**30.82**
Overall	**−0.21**	**3.51**	**27.77**	**31.49**	**24.19**

TABLE A3.
Central Government Descriptive Statistics.
(Min and Max of the percentages of GDP between 1980-1994)

Country	Primary Deficit		Overall Deficit		Primary Expenditure		Total Expenditure		Tax Revenue	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Argentina	−1.73	9.51	−0.62	11.84	8.72	19.05	9.42	22.41	8.47	14.87
Bolivia	−32.93	1.16	−32.15	3.56	10.42	34.75	11.12	35.54	3.91	11.64
Brazil	−20.59	2.43	0.45	16.06	7.61	15.58	15.58	37.37	14.49	19.78
Chile	−6.18	1.58	−5.39	2.97	18.39	33.57	20.33	34.10	16.21	25.50
Colombia	−5.08	3.86	−3.94	4.72	10.26	15.13	11.49	15.99	8.94	14.01
India	1.54	6.33	5.46	9.28	11.30	14.73	13.02	17.93	9.51	11.33
Indonesia	−3.02	1.43	−1.36	3.55	14.40	23.60	16.41	24.39	14.29	20.30
Iran	0.19	13.27	0.20	13.80	17.70	35.18	17.71	35.71	5.88	9.12
Israel	−14.59	8.97	−0.69	25.10	29.16	62.27	35.38	84.57	23.66	46.28
Malaysia	−8.21	11.81	−4.48	16.14	20.85	34.88	24.57	38.43	17.05	23.52
Mexico	−8.24	7.66	−4.56	14.20	10.45	22.60	15.74	30.26	13.07	15.28
Paraguay	−3.87	1.44	−2.93	1.90	7.57	12.60	8.10	13.52	7.76	10.01
South Africa	−4.20	4.45	0.23	10.15	20.30	32.23	22.12	37.92	19.88	27.87
Thailand	−6.37	4.39	−4.70	6.36	11.95	18.20	14.04	20.47	12.66	17.59
Zimbabwe	1.20	8.56	5.90	15.02	26.69	36.71	29.35	43.64	19.21	29.51
Developing Countries	**−7.47**	**5.79**	**−3.24**	**10.31**	**15.05**	**27.40**	**17.63**	**32.82**	**13.00**	**19.77**
Australia	−4.01	2.14	−2.07	3.69	21.04	26.49	22.73	27.98	19.59	23.93
Austria	−0.16	3.72	3.08	5.98	34.81	37.50	37.36	41.24	31.58	33.51
Belgium	−5.16	5.69	4.51	13.32	38.11	49.55	48.16	56.40	40.88	43.77
Canada	−2.38	2.94	2.25	6.54	17.55	21.51	21.29	25.56	16.14	19.20
Denmark	−11.47	3.45	−4.51	8.08	31.33	38.94	38.13	44.00	30.63	36.55
France	−0.99	2.87	0.07	5.67	38.67	44.27	39.50	47.06	36.64	38.35
Germany	−1.31	1.18	0.16	2.50	27.98	31.68	29.45	33.82	26.95	30.21
Iceland	−1.03	1.94	0.70	5.05	22.80	31.24	25.53	34.37	21.80	26.18
Ireland	−6.54	7.35	0.98	14.83	31.61	44.16	39.23	53.12	32.24	37.33
Luxembourg	−10.23	9.69	−9.62	9.85	36.28	46.65	36.62	47.07	37.86	44.29
Netherlands	−4.34	4.37	0.50	7.62	47.24	54.02	51.65	57.72	42.84	46.45
Norway	−6.86	4.83	−3.65	7.38	34.10	45.73	36.76	48.29	34.67	39.34
Spain	−0.62	6.49	2.25	8.29	26.42	35.05	26.67	39.41	21.68	29.94
Sweden	−6.16	10.99	−1.84	16.07	35.06	46.81	39.32	51.89	29.41	38.39
Switzerland	−0.67	2.04	−0.11	2.80	18.71	26.32	19.27	27.09	18.10	21.19
United Kingdom	−5.19	3.64	−1.55	6.47	30.60	40.63	33.95	43.33	30.61	33.82
United States	−0.73	2.77	2.59	5.97	19.48	21.66	22.02	25.25	17.13	19.13
Developed Countries	**−3.99**	**4.48**	**−0.37**	**7.65**	**30.11**	**37.78**	**33.39**	**41.39**	**28.75**	**33.03**
Overall Average	**−5.62**	**5.09**	**−1.71**	**8.90**	**23.05**	**32.91**	**26.00**	**37.37**	**21.37**	**26.82**

TABLE A4.
Sub-National Government Descriptive Statistics.
(Averages of the percentages of GDP between 1980-1994)

Country	Primary Deficit	Overall Deficit	Primary Expenditure	Total Expenditure	Tax Revenue
Argentina	2.78	2.92	9.00	9.15	5.44
Bolivia	−0.13	−0.07	3.13	3.19	2.00
Brazil	0.82	1.71	12.04	12.93	6.76
Chile	0.15	0.15	2.39	2.39	0.75
Colombia	0.07	0.15	5.82	5.90	2.18
India	1.80	2.92	12.28	13.40	5.36
Indonesia	−0.04	−0.04	2.51	2.52	0.41
Iran	0.00	0.00	0.98	0.98	0.60
Israel	0.20	0.69	6.30	6.79	1.85
Malaysia	0.30	0.30	7.13	7.13	0.76
Mexico	0.28	0.28	4.08	4.08	3.12
Paraguay	0.03	0.03	0.39	0.39	0.16
South Africa	0.11	0.46	8.85	9.20	1.51
Thailand	−0.10	−0.10	1.54	1.54	0.79
Zimbabwe	0.13	0.86	8.12	8.85	1.10
Developing Countries	**0.43**	**0.68**	**5.64**	**5.90**	**2.19**
Australia	−0.96	0.62	16.12	17.70	5.54
Austria	−0.38	0.22	16.62	17.22	9.02
Belgium	−0.52	0.48	5.98	6.98	2.18
Canada	0.17	3.15	28.49	32.06	17.46
Denmark	−0.24	0.15	32.15	32.54	14.39
France	−0.26	0.54	8.11	8.92	3.74
Germany	0.06	1.34	20.93	22.21	11.35
Iceland	−0.09	0.32	8.61	9.02	6.33
Ireland	0.07	1.15	13.81	14.90	0.88
Luxembourg	0.01	0.39	7.19	7.57	2.76
Netherlands	−1.43	0.94	15.62	18.00	1.26
Norway	0.01	0.91	19.51	20.41	9.05
Spain	0.23	0.72	10.07	10.56	3.71
Sweden	0.04	0.76	24.69	25.41	15.48
Switzerland	−0.27	0.86	22.42	23.54	12.09
United Kingdom	−0.95	0.20	11.72	12.87	3.17
United States	−1.35	−0.91	17.70	18.15	8.99
Developed Countries	**−0.35**	**0.70**	**16.45**	**17.53**	**7.49**
Overall	**0.02**	**0.69**	**11.38**	**12.08**	**5.01**

TABLE A5.
Sub National Government Descriptive Statistics.
(Min and Max of the percentages of GDP between 1980-1994)

Country	Primary Deficit		Overall Deficit		Primary Expenditure		Total Expenditure		Tax Revenue	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Argentina	0.65	6.17	0.80	6.24	7.13	10.27	7.14	10.43	2.15	8.48
Bolivia	−0.98	0.45	−0.87	0.48	1.36	5.88	1.50	5.94	1.27	2.83
Brazil	0.04	1.84	0.52	3.02	3.70	18.11	4.55	19.50	4.93	9.04
Chile	−0.12	1.31	−0.12	1.31	1.08	3.44	1.08	3.45	0.52	0.94
Colombia	−0.55	0.46	−0.44	0.56	5.11	6.54	5.20	6.64	1.94	2.31
India	0.47	2.55	2.24	3.38	11.14	13.06	11.74	14.40	4.72	5.95
Indonesia	−0.32	0.19	−0.30	0.19	2.02	3.12	2.03	3.13	0.31	0.52
Iran	−0.08	0.05	−0.08	0.05	0.80	1.35	0.80	1.35	0.47	0.72
Israel	−0.32	0.91	0.02	2.07	4.93	7.05	5.14	8.21	0.95	2.40
Malaysia	−1.34	2.38	−1.34	2.38	5.35	8.31	5.35	8.31	0.64	0.86
Mexico	−0.09	0.77	−0.09	0.77	3.16	6.80	3.16	6.80	2.57	3.68
Paraguay	0.00	0.06	0.00	0.06	0.18	0.57	0.18	0.58	0.07	0.27
South Africa	−0.31	0.56	0.08	0.99	6.84	16.61	7.03	16.84	1.14	2.38
Thailand	−0.22	0.00	−0.22	0.00	1.08	3.52	1.08	3.52	0.65	0.96
Zimbabwe	−0.45	0.91	0.32	1.76	5.08	12.91	5.53	13.76	0.96	1.66
Developing Countries	**−0.24**	**1.24**	**0.03**	**1.55**	**3.93**	**7.84**	**4.10**	**8.19**	**1.55**	**2.87**
Australia	−2.20	−0.33	−0.43	1.35	14.30	17.86	15.50	19.82	4.59	6.88
Austria	−0.90	0.34	−0.35	0.80	15.95	18.20	16.61	18.61	8.54	10.06
Belgium	−1.34	0.57	−0.17	1.91	5.09	7.24	5.92	8.58	1.85	2.46
Canada	−1.87	3.31	1.22	6.49	26.75	31.39	29.70	35.77	16.65	18.22
Denmark	−1.74	0.41	−1.31	0.74	29.96	35.13	30.31	35.69	13.55	15.35
France	−0.59	0.39	0.21	1.07	7.12	9.17	7.75	10.01	2.93	4.41
Germany	−1.03	1.29	0.25	2.46	18.09	23.33	19.22	24.57	10.18	12.01
Iceland	−0.91	0.47	−0.64	0.88	7.62	9.94	7.89	10.35	5.80	7.00
Ireland	−1.00	1.53	−0.38	2.99	11.44	15.57	11.89	17.50	0.78	1.16
Luxembourg	−0.86	2.28	−0.35	2.51	5.77	8.61	6.16	9.08	2.18	3.33
Netherlands	−2.79	1.22	−0.12	3.52	13.78	17.37	15.66	20.25	0.84	1.63
Norway	−1.24	2.35	−0.46	3.00	17.32	21.65	18.15	22.72	8.08	9.70
Spain	−0.26	1.08	0.04	1.77	3.11	15.56	3.28	16.54	2.18	4.47
Sweden	−0.59	2.63	0.11	3.17	22.96	26.00	23.54	26.91	14.20	18.70
Switzerland	−1.36	0.86	−0.29	2.00	21.27	24.09	22.40	25.38	11.31	12.62
United Kingdom	−1.80	−0.19	−0.82	1.13	11.17	12.44	12.19	13.70	1.22	4.39
United States	−1.83	−0.75	−1.36	−0.24	16.18	19.82	16.56	20.32	8.14	9.67
Developed Countries	**−1.31**	**1.03**	**−0.29**	**2.09**	**14.58**	**18.43**	**15.46**	**19.75**	**6.65**	**8.36**
Overall	**−0.81**	**1.13**	**−0.14**	**1.84**	**9.59**	**13.47**	**10.13**	**14.33**	**4.26**	**5.78**

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第 15 章

军事开支与经济增长

Military spending and stochastic growth

Liutang Gong[a], Heng-fu Zou[a,b,c,*]

[a] *School of Management, Peking University, Beijing 100871, China*
[b] *Institute for Advanced Study, Wuhan University, Wuhan 430072, China*
[c] *Development Research Group, World Bank, Room MC3-639, 1818 H St. NW, Washington, DC 20433, USA*

Abstract

This study examines capital accumulation, military spending, arms accumulation, and output growth in a stochastic endogenous growth model. The analysis shows that higher (lower) growth in foreign military spending leads to faster (slower) economic growth in the home country if the home country's intertemporal substitution elasticity in consumption is smaller (larger); but more volatility in foreign military spending can lead to higher economic growth in the home country when its intertemporal substitution elasticity is large. In addition, shocks to output production may stimulate economic growth.

JEL classification: E20; E22; H56; O10; O40

Keywords: Military spending; Arms race; Capital accumulation; Stochastic growth

1. Introduction

The relationship between competitive arms accumulation and economic growth has been a major topic of dynamic economics and international relations in the political science. Earlier mathematical models of arms race presented by Richardson (1960) and Saaty (1968) have been extended and refined in numerous contributions in the 1970s–1990s, and notable ones are Brito (1972), Intriligator (1975), Simaan and Cruz (1975), Intriligator and Brito (1976), Deger and Sen (1984), van der Ploeg and de Zeeuw (1990), and Chang et al. (1996). At the same time, economic consequences of military spending and arms accumulation have also received enormous attention in both

* Corresponding author. Development Research Group, World Bank, Room MC3-639, 1818 H St. NW, Washington, DC 20433, USA. Tel.: 202-473-7939; fax: 202-522-1154.
E-mail address: hzou@worldbank.org (H.-f. Zou).

empirical studies and policy discussions. For example, Benoit (1973, 1978) and Deger and Sen (1983) have shown a positive, although sometimes not significant, effect of defense spending on economic growth, whereas Deger (1986) has found that defense spending definitely reduces national savings rates. The usual arguments for a positive effect of military spending on growth have been often put as follows: Rising military spending leads to increased security, demand creation, utilization of excess capacity, and various indirect spinoffs through education, employment, infrastructure, and other services that the military can provide (see Deger and Sen (1992) or Deger and Sen (1995) for a comprehensive survey). On the other hand, the direct resource allocation effect transfers potential investment resources to the military, reducing investment and growth. In a more sophisticated regression analysis, Landau (1993) has demonstrated that, for a sample of 71 countries over the time period 1969–1989, there exists a non-linear (quadratic) relationship between military spending and growth: At low levels of military expenditure, there will be a positive impact due to increased security and efficiency, while at higher levels of military expenditure, the negative resource-use effect will lead to lower growth.

As far as we know, all aforementioned empirical studies have approached their problems without explicit intertemporal optimization frameworks involving both capital and arms accumulation, although dynamic optimization is a routine component of theoretical studies on competitive arms accumulation. But theoretical studies on arms race have hardly taken into consideration of output production and capital accumulation. Instead, they have focused on the optimal allocation of consumption and military spending in an endowment economy without physical investment. When a formal dynamic model dealing with both arms and capital accumulation is presented by Zou (1995a), the finding is rather surprising: Competitive arms races among countries have no effect on capital accumulation in the long run, even though it can stimulate productive investment and output in the short run.

This paper intends to show that in a stochastic environment typical in a world of competitive arms races, military spending and arms accumulation affect long-run capital accumulation and growth rates in a rather complicated way. The introduction of stochastic elements to the model on arms races and capital accumulation seems to be a natural result of recent analytical advances in modeling government fiscal and monetary policies, public spending, private investment, and output growth in stochastic environments as in Eaton (1981), Gertler and Grinols (1982), Bertola and Drazen (1993), Pindyck and Solimano (1993), Turnovsky (1993, 2000), Grinols and Turnovsky (1993, 1994), Obstfeld (1994), and Ramey and Ramey (1995). Defense spending has been and may always be an important component of public policies and government expenditures, and a change in a country's military investment crucially depends on stochastic elements in domestic and international economic, political, and military factors. As this paper is going to show, a stochastic setting not only makes the model more realistic, it also produces rather different analytical results.

We organize the paper as follows. In Section 2, we present a simple stochastic growth model treating military spending as a pure consumption good and with some special function forms for preferences and production technology derive a closed-form solution linking the long-run economic growth rate to technology, preferences, and military

instability (shocks). In Section 3, treating military spending as an investment good and allowing explicit dynamics of arms accumulation, we obtain another closed-form solution of the expected endogenous growth rate of capital and arms accumulation. We summarize our main findings in Section 4.

2. Model one: military spending as a consumption good

As in Brito (1972), Deger and Sen (1984), van der Ploeg and de Zeeuw (1990), and Zou (1995a), there are two countries in this model: the home country and the foreign country, and they are in a state of military confrontation. Suppose the preference of the home country is defined on its consumption, c, its military spending, $m(t)$, and foreign military spending, m^*: $u(c,m,m^*)$. Suppose the utility function $u(c,m,m^*)$ is twice differentiable and concave. Following Brito (1972), Deger and Sen (1983,1984), van der Ploeg and de Zeeuw (1990), and Zou (1995a), we assume that

$$u_1 > 0, \quad u_2 > 0, \quad u_3 < 0, \quad u_{11} < 0, \quad u_{22} < 0,$$
$$u_{12} = u_{21} > 0, \quad u_{13} = u_{31} < 0, \quad u_{23} = u_{32} > 0. \tag{1}$$

The assumptions in (1) imply that the home country's marginal utility from its consumption and military spending is positive and diminishing, but the marginal utility from the foreign country's military spending (foreign military threat) is negative and diminishing. The assumption $u_{23} = u_{32} > 0$ implies that an increase in the foreign military threat will increase the marginal utility of the home country's defense, whereas $u_{12} = u_{21} > 0$ states that more security (military defense) for the home country raises its marginal utility of consumption and, similarly, $u_{13} = u_{31} < 0$ asserts that a rise in the foreign military threat reduces the home country's marginal utility of consumption.[1]

Following Eaton (1981) and Turnovsky (2000), output is produced by a stochastic technology,

$$\mathrm{d}Y = F(k)\,\mathrm{d}t + H(k)\,\mathrm{d}y, \quad F'(k) > 0, \; F''(k) < 0. \tag{2}$$

The equation above asserts that the flow of output over the period $(t, t+\mathrm{d}t)$ consists of two components. First, there is the deterministic component, described by the first term on the right-hand side, with $F(k)$ representing the mean rate of output production per unit time. In addition, there is a stochastic component, $H(k)\mathrm{d}y$, reflecting the various random elements affecting output production. The stochastic term $\mathrm{d}y$ is assumed to be temporally independent, normally distributed with mean zero and variance $\sigma_y^2\,\mathrm{d}t$. See more explanations and justifications in Turnovsky (2000).

[1] van der Ploeg and de Zeeuw (1990) have nicely justified these assumptions as follows: The welfare of one country depends on the level of security which is perceived to be an increasing function of its own weapons stock and a decreasing function of the foreign weapons stock. This may be because any imbalance in weapons stocks increases the likelihood of loosing a possible war and increases the likelihood that a war might in fact be initiated. Alternatively, a country may simply feel that it gains international prestige from having an army superior to its rivals. Both of these factors can in principle lead to a balance of terror.

We also assume that foreign military spending m^* follows a stochastic process,

$$\mathrm{d}m^* = \alpha m^* \,\mathrm{d}t + \sigma m^* \,\mathrm{d}z, \tag{3}$$

where $\alpha m^* \,\mathrm{d}t$ is the known mean level of foreign military spending, and $\sigma m^* \,\mathrm{d}z$ is the stochastic component. The stochastic term $\mathrm{d}z$ is assumed to be temporally independent, normally distributed with mean zero and variance $\sigma^2 \,\mathrm{d}t$. Eq. (3) is a special case of the more general form of government spending adopted by Bertola and Drazen (1993) in a continuous-time stochastic environment. In this paper, our model is not really a game, and some stochastic process is assumed on the foreign country.[2]

Suppose the covariance of $\mathrm{d}y$ and $\mathrm{d}z$ is

$$cov(\mathrm{d}y, \mathrm{d}z) = \sigma_{yz} \,\mathrm{d}t.$$

Since we take military spending as a consumption good, we can write the budget constraint for the home country as

$$\mathrm{d}k = \mathrm{d}Y - c\mathrm{d}t - m\mathrm{d}t. \tag{4}$$

The home country chooses its consumption path, $c(t)$, capital accumulation path, $k(t)$, and military spending path, $m(t)$, to maximize its discounted welfare with a constant time discount rate, ρ $(0 < \rho < 1)$, namely,

$$\max \mathrm{E}_0 \int_0^{\infty} u(c, m, m^*)\mathrm{e}^{-\rho t} \,\mathrm{d}t \tag{5}$$

subject to (4) with the technology and foreign military spending given in Eqs. (2) and (3), respectively, and with the initial capital stock in the home country given by $k(0)$.

2.1. Optimalities

To solve the problem, we introduce the value function, $V(k, m^*, t)$, and define the differential operator of it by

$$\begin{aligned} L(V(k, m^*, t)) &= \lim_{\mathrm{d}t \to 0} \mathrm{E}\left(\frac{\mathrm{d}V}{\mathrm{d}t}\right) \\ &= V_t + V_k(F(k) - c - m) + V_{m^*}\alpha m^* + \tfrac{1}{2} V_{km^*}\sigma_{yz}H(k)\sigma m^* \\ &\quad + \tfrac{1}{2} V_{kk}H(k)^2\sigma_y^2 + \tfrac{1}{2} V_{m^*m^*}\sigma^2 m^{*2}. \end{aligned}$$

Given the exponential time discounting, the value function can be assumed to be of the form

$$X(k, m^*)\mathrm{e}^{-\rho t} = V(k, m^*, t).$$

[2] We thank the referee for emphasizing this point.

Now, the home country chooses consumption and military spending to maximize the expression

$$\begin{aligned} &u(c,m,m^*)+L(X(k,m^*)\mathrm{e}^{-\rho t}) \\ &\quad = u(c,m,m^*)-\rho X + X_k(F(k)-c-m)+X_{m^*}\alpha m^* + \tfrac{1}{2}X_{km^*}\sigma_{yz}H(k)m^* \\ &\qquad + \tfrac{1}{2}X_{kk}H(k)^2\sigma_y^2 + \tfrac{1}{2}X_{m^*m^*}\sigma^2 m^{*2}. \end{aligned}$$

Taking partial derivatives with respect to c and m, respectively, of the above expression and canceling the term $\mathrm{e}^{-\rho t}$, we have

$$\begin{aligned} &\frac{\partial u(c,m,m^*)}{\partial c} = X_k, \\ &\frac{\partial u(c,m,m^*)}{\partial m} = X_k, \end{aligned} \tag{6}$$

which asserts that the marginal values of consumption and military spending must be equal at an optimum. And from Eq. (6), we can determine the optimal values for c/k and m/k as the functions of X_k and X_{kk}. Furthermore, the value function must satisfy the Bellman equation

$$\max_{c,m}\{u(c,m,m^*)+L(X(k,m^*)\mathrm{e}^{-\rho t})\}=0.$$

Substituting the optimal values from Eq. (6), we have

$$\begin{aligned} &u(\tilde{c},\tilde{m},m^*)-\rho X + X_k(F(k)-\tilde{c}-\tilde{m})+X_{m^*}\alpha m^* + \tfrac{1}{2}X_{km^*}\sigma_{yz}H(k)m^* \\ &\quad + \tfrac{1}{2}X_{kk}H(k)^2\sigma_y^2 + \tfrac{1}{2}X_{m^*m^*}\sigma^2 m^{*2} = 0, \end{aligned} \tag{7}$$

where $\tilde{}$ denotes the optimal value.

2.2. Explicit solutions

Now from Eqs. (6) and (7), we get the optimal consumption, optimal military spending, and the value function. In order to find the explicit solutions, we specify the utility function and technology as follows:

$$u(c,m,m^*)=\frac{1}{1-\gamma}(c^\theta m^{1-\theta})^{1-\gamma}(m^*)^{-\lambda}, \tag{8}$$

$$F(k)=Ak, \quad H(k)=Ak \tag{9}$$

with parameters satisfying $0<\theta<1$; $\lambda>0$ when $0<\gamma<1$; $\lambda<0$ when $\gamma>1$; and A is a positive constant. The restrictions on λ and γ are made to ensure that $\partial u/\partial m^*<0$ for all possible cases. Furthermore, this utility function also can be regarded

as being defined on the relative military status of the two countries since it can be rewritten as

$$c^{\theta(1-\gamma)}\left(\frac{1}{1-\gamma}\right)\left[\frac{m^{(1-\theta)(1-\gamma)}}{(m^*)^{\lambda}}\right],$$

where the term $(1/(1-\gamma))[m^{(1-\theta)(1-\gamma)}/(m^*)^{\lambda}]$ measures the relative military power of the home country versus the foreign country. It should be noticed that the production technology is the same as in Eaton (1981) and Turnovsky (1993, 2000), whereas the utility function is an extension of the ones in many continuous-time stochastic models on growth and asset pricing when the two military goods are included.

It is natural to conjecture that a solution for the value function takes the following form:

$$X(k,m^*)=\delta k^{1-\gamma}(m^*)^{-\lambda}, \tag{10}$$

where δ is to be determined. Therefore, we have

$$X_k=\delta(1-\gamma)k^{-\gamma}(m^*)^{-\lambda};\quad X_{kk}=-\delta(1-\gamma)\gamma k^{-\gamma-1}(m^*)^{-\lambda}. \tag{11}$$

Substituting Eq. (11) into optimal condition (6) yields

$$\theta(c^{\theta}m^{1-\theta})^{-\gamma}(m^*)^{-\lambda}c^{\theta-1}m^{1-\theta}=X_k,$$
$$(1-\theta)(c^{\theta}m^{1-\theta})^{-\gamma}(m^*)^{-\lambda}c^{\theta}m^{-\theta}=X_k. \tag{12}$$

We define the total consumption as the sum of consumption and military spending

$$C=c+m.$$

From Eq. (12), we have

$$c=\theta C,\quad m=(1-\theta)C. \tag{13}$$

In addition, substituting Eq. (11) into Eq. (12), we obtain the total consumption-capital ratio as

$$\frac{C}{k}=[\delta(1-\gamma)(\theta^{\theta}(1-\theta)^{1-\theta})^{\gamma-1}]^{-1/\gamma}. \tag{14}$$

Substituting Eq. (14) into Eq. (7) leads to

$$\frac{1}{1-\gamma}(\theta^{\theta}(1-\theta)^{1-\theta})^{1-\gamma}[\delta(1-\gamma)(\theta^{\theta}(1-\theta)^{1-\theta})^{\gamma-1}]^{(\gamma-1)/\gamma}k^{1-\gamma}(m^*)^{-\lambda}$$
$$-\rho\delta k^{1-\gamma}(m^*)^{-\lambda}+\delta(1-\gamma)k^{-\gamma}(m^*)^{-\lambda}(Ak-C)-\lambda\delta k^{1-\gamma}(m^*)^{-\lambda-1}\alpha m^*$$
$$-\frac{1}{2}\delta(1-\gamma)k^{1-\gamma}(m^*)^{-\lambda}A\sigma_{yz}+\frac{1}{2}\delta(1-\gamma)(-\gamma)k^{-\gamma-1}(m^*)^{-\lambda}A^2k^2\sigma_y^2$$
$$+\frac{1}{2}\delta\lambda(\lambda+1)k^{1-\gamma}(m^*)^{-\lambda-2}\sigma^2m^{*2}=0.$$

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From which we can determine the coefficient δ from the following expression:

$$\frac{C}{k} = [\delta(1-\gamma)(\theta^{\theta}(1-\theta)^{1-\theta})^{\gamma-1}]^{-1/\gamma}$$

$$= \frac{\lambda\alpha + \frac{1}{2}(1-\gamma)\gamma A\sigma_y^2 - \frac{1}{2}\lambda(\lambda+1)\sigma^2 - (1-\gamma)A + \rho + \frac{1}{2}\lambda(1-\gamma)A\sigma_{yz}}{\gamma}.$$

Once δ is determined, the value function is in turn determined.

Now, we have the dynamic equation for the capital stock

$$\mathrm{d}k = (Ak - C)\mathrm{d}t + Ak\,\mathrm{d}y$$

$$= k\left[\left(A - \frac{C}{k}\right)\mathrm{d}t + A\,\mathrm{d}y\right]. \tag{15}$$

Hence, the expected growth rate of consumption and the capital stock, denoted as ϕ_1, is

$$\phi_1 = \mathrm{E}\frac{\mathrm{d}c/\mathrm{d}t}{c} = \mathrm{E}\frac{\mathrm{d}k/\mathrm{d}t}{k} = \left(A - \frac{C}{k}\right). \tag{16}$$

From which the solution of the capital stock starting from the initial capital $k(0)$ at time 0, is

$$k(t) = k(0)\mathrm{e}^{(\phi_1 - (\gamma/2)A^2\sigma^2)t + Ay(t) - Ay(0)}.$$

The stochastic path for the foreign military expenditure can be derived from Eq. (6) as

$$m^*(t) = m^*(0)\mathrm{e}^{(\alpha - [(\lambda+1)/2]\sigma^2) + \sigma z(t) - \sigma z(0)}.$$

The transversality condition

$$\lim_{t\to\infty} \mathrm{E}[\delta k^{1-\gamma}(m^*)^{-\lambda}\mathrm{e}^{-\rho t}] = 0$$

will be met if and only if

$$(1-\gamma)\left(A - \frac{C}{k} - \frac{\gamma}{2}A^2\sigma_y^2\right) - \lambda\left(\alpha - \frac{\lambda+1}{2}\sigma^2\right) - \rho < 0$$

which is equivalent to $C/k > 0$.

2.3. Comparative dynamics

Now, we focus on the effects of the growth and shocks in foreign military spending on the home country. For the mean growth in the foreign military threat, its effect on

the home country's economic growth rate is given by

$$\frac{\partial \phi_1}{\partial \alpha} = -\frac{\lambda}{\gamma}.$$

Since $\lambda > 0$ when $0 < \gamma < 1$; and $\lambda < 0$ when $\gamma > 1$, we have $\frac{\partial \phi_1}{\partial \alpha} > 0$ when $\gamma > 1$; and $\frac{\partial \phi_1}{\partial \alpha} < 0$, when $0 < \gamma < 1$. That is to say, a higher (lower) growth in foreign military spending leads to faster (slower) economic growth in the home country if the home country's elasticity of intertemporal substitution in consumption, which is $1/\gamma$, is smaller (larger). These findings indicate that, when the foreign country raises its average level of military spending, the home country's marginal utility of military spending rises and it increases its current military spending and reduces its capital investment when its intertemporal substitution is relatively elastic, i.e., $0 < \gamma < 1$. Therefore the long-run growth rate is reduced. On the other hand, when $\gamma > 1$, the home country's elasticity of intertemporal substitution is small and it will cut consumption, raise investment, and produce more output.

As for the stochastic shocks to the foreign military threat, their effect on the home country's economic growth is given by

$$\frac{\partial \phi_1}{\partial \sigma^2} = \frac{\frac{1}{2}\lambda(\lambda + 1)}{\gamma}.$$

Hence, $\partial \phi_1/\partial \sigma^2 > 0$ when $0 < \gamma < 1$ or when $\lambda < -1$ and $\gamma > 1$; $\partial \phi_1/\partial \sigma^2 < 0$ when $\gamma > 1$ and $0 > \lambda > -1$. These results seem to suggest that a higher elasticity of intertemporal substitution in consumption in the home country will result in higher economic growth in the home country when there is more volatility in the foreign military threat. But even in this case, caution should be exercised in order to avoid drawing a simple conclusion. It can also be the case that, when the foreign military threat causes larger disutility to the home country, i.e., a large absolute value of λ, a higher variance in the foreign military threat can lead to higher economic growth in the home country even for a small elasticity of intertemporal substitution (i.e., $\gamma > 1$). Furthermore, from our discussions above we notice that the mean and variance in foreign military growth tend to have opposite effects on the home country's economic growth.

In addition, the stochastic shocks to output production in the home country have the same qualitative effect on economic growth as the mean growth in foreign military spending:

$$\frac{\partial \phi_1}{\partial \sigma_y^2} = -\frac{\frac{1}{2}\gamma A(1 - \gamma)}{\gamma}.$$

Therefore, $\partial \phi_1/\partial \sigma_y^2 > 0$ when $\gamma > 1$; and $\partial \phi_1/\partial \sigma_y^2 < 0$ when $0 < \gamma < 1$. The general lesson to be drawn here is that shocks to output production are not always harmful for output growth. In our model they can even stimulate output growth when the elasticity of intertemporal substitution is less than one (or $\gamma > 1$). This is a confirmation of the theoretical ambiguity between production risk and output growth pointed out earlier by

Devereux and Smith (1994) and Obstfeld (1994). Interested readers could see Ramey and Ramey (1995) for more contrasting views and further discussions.

3. Model two: military spending as an investment good

When treating military spending as an investment good, the model allows capital accumulation as well as arms accumulation. To economize notations, in this section we use $m(t)$ to denote the weapons stock of the home country and $m^*(t)$ the weapons stock of the foreign country. The home country's total wealth is the sum of its capital and weapons stocks:

$$w = k + m,$$

where w is the home country's total wealth.

Similarly, the total wealth of the foreign country, $w^*(t)$, is the sum of its capital and weapons stocks: $k^*(t)$; and $m^*(t)$:

$$w^* = k^* + m^*.$$

The preferences of the home country are defined on its consumption, c, its total wealth, $w(t)$, and the foreign country's total wealth, $w^*(t)$: $u(c, w, w^*)$. To us, the inclusion of both the capital stock and arms in the utility function provides a more realistic picture of a country's power and status in a competitive arms race over a longer time period because a higher capital stock always produces more output, which can lead to more military spending and more arms accumulation. Arms accumulation without substantial capital accumulation and output expansion is hardly sustainable in the long run as shown by the current situations in North Korea and Cuba and the recent history of the Soviet Union. Of course, defining the utility function on wealth is not new at all, and it has been adopted for various other applications: nationalism and mercantilism in the sense of Bardhan (1967) and Zou (1997); the psychological benefits (costs) of foreign asset holding (foreign borrowing) in Blanchard (1983); and wealth effects or social-status effects of wealth in Kurz (1968), Frank (1985), Cole et al. (1992), Zou (1994, 1995b), and Bakshi and Chen (1996). Our approach includes the existing utility functions in the arms-race literature as special cases when total wealth is just weapons. Of course, the general results derived from our extended model can apply to those special cases. In particular, our analysis will continue to hold if we assume that the utility function is defined only on weapons stocks such as $u(c, m, m^*)$. In our current context, we will continue to assume that the utility function $u(c, w, w^*)$ still has the following properties as in the last section:

$$u_1 > 0, \quad u_2 > 0, \quad u_3 < 0, \quad u_{11} < 0, \quad u_{22} < 0,$$

$$u_{12} = u_{21} > 0, \quad u_{13} = u_{31} < 0, \quad u_{23} = u_{32} > 0. \tag{17}$$

With slight modification, the foreign country's total wealth, w^*, is assumed to follow a Brownian motion,

$$\mathrm{d}w^* = \alpha_{w^*} w^* \,\mathrm{d}t + \sigma_{w^*} w^* \,\mathrm{d}z^*, \tag{18}$$

where the stochastic term dz^* is assumed to be a temporally independent, normally distributed with mean zero and variance dt.

Now, the budget constraint for the home country is

$$dw = dk + dm = dY - c\,dt, \tag{19}$$

which states that the net increase in the home country's wealth (capital and weapons) is its net savings (output minus consumption).

The home country chooses its capital stock, weapon stock, and consumption to maximize its discounted utility, namely,

$$\max E_0 \int_0^\infty u(c, w, w^*)e^{-\rho t}\,dt$$

subject to the budget constraint (19) and the initial stocks given by $k(0)$ and $m(0)$, respectively.

3.1. Optimalities

We define the discounted value function $\bar{V}(w, w^*, t)$ to be

$$\bar{V}(w, w^*, t) = \bar{X}(w, w^*)e^{-\rho t}.$$

Denote the share of the weapons stock in total wealth as

$$n = \frac{m}{k+m}.$$

The home country chooses the share of the weapons stock in total wealth, n, and consumption path, $c(t)$, to maximize the following expression:

$$u(c, w, w^*) - \rho\bar{X} + \bar{X}_w(F((1-n)w) - c) + \bar{X}_{w^*}\alpha_{w^*}w^*$$
$$+ \tfrac{1}{2}\bar{X}_{ww^*}\sigma_{yz^*}H((1-n)w)w^* + \tfrac{1}{2}\bar{X}_{ww}H((1-n)w)^2\sigma_y^2 + \tfrac{1}{2}\bar{X}_{w^*w^*}\sigma_{w^*}^2 w^{*2}.$$

The conditions for the optimization problem are

$$\frac{\partial u(c, w, w^*)}{\partial c} = \bar{X}_w, \tag{20}$$

$$-\bar{X}_w F'((1-n)w) - \tfrac{1}{2}\bar{X}_{ww^*}\sigma_{yz^*}H'((1-n)w)w^*$$
$$-\bar{X}_{ww}H((1-n)w)H'((1-n)w)\sigma_y^2 = 0. \tag{21}$$

From Eqs. (20) and (21), we can derive the optimal choices for the weapons share and the consumption path as the functions of $\bar{X}_w$, $\bar{X}_{ww^*}$, and $\bar{X}_{ww}$. With the substitution of the optimal values for the weapons share and consumption, the value function must

satisfy the following Bellman equation:

$$u(c,w,w^*) - \rho\bar{X} + \bar{X}_w(F((1-n)w) - c) + \bar{X}_{w^*}\alpha_{w^*}w^* + \tfrac{1}{2}\bar{X}_{ww^*}\sigma_{yz^*}H((1-n)w)w^* + \tfrac{1}{2}\bar{X}_{ww}H((1-n)w)^2\sigma_y^2 + \tfrac{1}{2}\bar{X}_{w^*w^*}\sigma_{w^*}^2 w^{*2} = 0. \tag{22}$$

3.2. Explicit solutions

To derive the explicit solutions for the weapons share and consumption path, we specified the utility function as

$$u(c,w,w^*) = \frac{c^{1-\xi}}{1-\xi}\left(\frac{w}{w^*}\right)^{-\eta}, \tag{23}$$

where ξ and η satisfy the following conditions: if $0 < \xi < 1$, then $-1 < \eta < 0$; if $\xi > 1$, then $\eta > 0$. These conditions guarantee that the utility function is increasing and concave in the relative wealth ratio of the home country to over the foreign country, (w/w^*).

The home country's production technology is the same as in the last section:

$$F(k) = Ak, \quad H(k) = Ak$$

and

$$\mathrm{d}Y = Ak\,\mathrm{d}t + Ak\,\mathrm{d}y.$$

Given the specified utility function (23), the value function is conjectured as

$$\bar{X}(w,w^*) = \chi w^{1-\xi-\eta}(w^*)^{\eta}, \tag{24}$$

where the coefficient χ is to be determined.

Taking partial derivations, we have

$$\bar{X}_w = \chi(1-\xi-\eta)w^{-\xi-\eta}(w^*)^{-\eta}, \quad \bar{X}_{ww} = \chi(1-\xi-\eta)(-\xi-\eta)w^{-\xi-\eta-1}(w^*)^{\eta},$$
$$\bar{X}_{w^*} = \chi\eta w1^{-\xi-\eta}(w^*)^{\eta-1}, \quad \bar{X}_{ww^*} = \chi(1-\xi-\eta)\eta w^{-\xi-\eta}(w^*)^{\eta-1}.$$

Substituting the above expressions of partial derivatives into Eqs. (20) and (21), we have

$$c^{-\xi} = \chi(1-\xi-\eta)w^{-\xi}$$

or

$$\frac{c}{w} = (\chi(1-\xi-\eta))^{-1/\xi}, \tag{25}$$

$$-(1-\xi-\eta)A\chi w^{1-\xi-\eta}(w^*)^{\eta} - \tfrac{1}{2}(1-\xi-\eta)\eta\sigma_{yz^*}\chi w^{1-\xi-\eta}(w^*)^{\eta} + (1-\xi-\eta)(\xi+\eta)\chi w^{1-\xi-\eta}(w^*)^{\eta}(1-n)\sigma_y^2 = 0$$

or

$$-(1-\xi-\eta)A-\tfrac{1}{2}(1-\xi-\eta)\eta\sigma_{yz^*}+(1-\xi-\eta)(\xi+\eta)(1-n)\sigma_y^2=0. \tag{26}$$

Substituting Eqs. (25) and (26) into the Bellman equation yields

$$\begin{aligned}
&(\chi(1-\xi-\eta))^{-(1-\xi)/\xi}\frac{w^{1-\xi}}{1-\xi}\left(\frac{w}{w^*}\right)^{-\eta}-\rho\chi w^{1-\xi-\eta}(w^*)^{\eta}+\chi\eta w^{1-\xi-\eta}(w^*)^{\eta-1}\alpha_{w^*}w^*\\
&\quad+\chi w^{1-\xi}\left(\frac{w}{w^*}\right)^{-\eta}(1-\xi-\eta)(A(1-n)-(\chi(1-\xi-\eta))^{-1/\xi})\\
&\quad+\frac{1}{2}\chi(1-\xi-\eta)\eta(1-n)w^{1-\xi}\left(\frac{w}{w^*}\right)^{-\eta}\sigma_{yz^*}\\
&\quad-\frac{1}{2}(1-\xi-\eta)(\xi+\eta)\chi(1-n)^2w^{1-\xi}\left(\frac{w}{w^*}\right)^{-\eta}\sigma_y^2\\
&\quad+\frac{1}{2}\eta(\eta+1)\sigma_{w^*}^2\chi w^{1-\xi}\left(\frac{w}{w^*}\right)^{-\eta}=0.
\end{aligned} \tag{27}$$

From the above equation, we have

$$\begin{aligned}
&(\chi(1-\xi-\eta))^{-1/\xi}\\
&\quad=\frac{(1-\xi-\eta)\frac{1}{2}[(\xi+\eta)(1-n)^2\sigma_y^2-\eta(1-n)\sigma_{yz^*}-2A(1-n)]}{(1-\xi-\eta)\xi/(1-\xi)}\\
&\qquad+\frac{\rho-\eta\alpha_{w^*}-\frac{1}{2}\eta(\eta+1)\sigma_{w^*}^2}{(1-\xi-\eta)\xi/(1-\xi)}.
\end{aligned} \tag{28}$$

Substitution Eq. (28) into Eq. (25), we have

$$\frac{c}{w}=\frac{\rho-\eta\alpha_{w^*}+(1-\xi-\eta)\frac{1}{2}[(\xi+\eta)(1-n)^2\sigma_y^2-\eta(1-n)\sigma_{yz^*}-2A(1-n)]-\frac{1}{2}\eta(\eta+1)\sigma_{w^*}^2}{(1-\xi-\eta)\xi/(1-\xi)}$$

and from Eq. (26) we can determine the optimal weapons share in total wealth n as

$$n=\frac{-A-\frac{1}{2}\eta\sigma_{yz^*}}{(\xi+\eta)\sigma_y^2}+1.$$

Similarly, we get the mean growth rate of the economy, denoted as ϕ_2,

$$\phi_2=\mathrm{E}\left(\frac{\mathrm{d}w/\mathrm{d}t}{w}\right)=\left(A(1-n)-\frac{c}{w}\right). \tag{29}$$

The transversality condition in this case is

$$\lim_{t\to\infty}\mathrm{E}[\delta w^{1-\xi-\eta}(w^*)^{-\eta}\mathrm{e}^{-\rho t}]=0,$$

which is also equivalent to the positivity of the consumption–wealth ratio.

3.3. Comparative dynamics

As in Section 2.3, we first examine how the change in the mean growth of the foreign wealth and weapons stock affects the economic growth of the home country. From (29) and the corresponding optimal conditions for c/w and n, we have

$$\frac{\partial \phi_2}{\partial \alpha_{w^*}} = \frac{(1-\xi)\eta}{\xi(1-\xi-\eta)}.$$

Because $\eta < 0$ if $0 < \xi < 1$; and $\eta > 0$ if $\xi > 1$, we obtain

$$\frac{\partial \phi_2}{\partial \alpha_{w^*}} > 0,$$

when $\xi > 1$, and $\eta > 0$;

$$\frac{\partial \phi_2}{\partial \alpha_{w^*}} < 0$$

when $0 < \xi < 1$ and $\eta < 0$.

This result is quite similar to the one in Section 2 when we treat military spending as a consumption good: a rise in the growth of foreign wealth and weapons stock raises the home country's economic growth, i.e., capital and weapon growth, if the home country has a lower elasticity of intertemporal substitution in consumption.

As for the stochastic shocks to the foreign wealth, their effect on the home country's economic growth is given by $\partial\phi_2/\partial\sigma^2_{w^*}$.

$$\frac{\partial \phi_2}{\partial \sigma^2_{w^*}} = \frac{\frac{1}{2}(1-\xi)\eta(\eta-1)}{\xi(1-\xi-\eta)}.$$

Therefore,

$$\frac{\partial \phi_2}{\partial \sigma^2_{w^*}} < 0$$

when $\xi > 1$ and $0 < \eta < 1$;

$$\frac{\partial \phi_2}{\partial \sigma^2_{w^*}} > 0$$

when $0 < \xi < 1$ and $-1 < \eta < 0$; and when $\xi > 1$ and $\eta > 1$.

Even though the expressions seem more complicated than in the case of military spending as a consumption good, the economic reasoning and intuition are almost identical. If the home country's elasticity of intertemporal substitution in consumption is relatively larger, it reacts to rising volatility in the foreign military and capital stocks by cutting consumption and investing more in arms and capital accumulation, and a higher economic growth rate follows in the home country. On the other hand, with

a lower elasticity of intertemporal substitution in consumption, the home country will raise spending on consumption and weapons and cut capital investment as a result of rising volatility in foreign military and capital stocks. Hence, the home country's economic growth suffers. Furthermore, if the home country derives a higher intensity of utility from security and relative economic and military power measured by η in the expression of $(1-\xi)^{-1}(w/w^*)^{-\eta}$ in our model, then a higher value of η ($\eta > 1$) can lead to higher economic growth even with a relatively lower elasticity of intertemporal substitution, i.e., $\xi > 1$.

Once more, we notice that the mean growth and stochastic shocks in foreign capital and weapons stocks have opposite effects on the home country's economic growth.

Our findings in this section and the last section regarding the effects of a foreign military threat on domestic economic growth stand in sharp contrast to Zou's (1995a). In a first deterministic dynamic optimization framework with both investment and military spending, Zou finds that, when the utility function is separable between consumption and the weapon stocks, an unanticipated rise in current military threat reduces current investment and an anticipated rise in future military threat stimulates current investment. But in the long run capital accumulation and output production is independent of the military conflicts among nations regardless of the forms of the utility function. The introduction of stochastic elements to the model has offered new and deep insights on the interaction between military spending and capital accumulation.

For stochastic shocks to domestic output production, σ_y^2, their effects on economic growth are not clear-cut because they may interact with the foreign capital and weapons stocks. But, when $\sigma_{yz^*} = 0$, the effects of σ_y^2 on output growth are given by

$$\frac{\partial \phi_2}{\partial \sigma_y^2} = -\frac{A^2}{(\xi+\eta)(\sigma_y^2)^2}\frac{\xi+1}{2\xi}.$$

Hence

$$\frac{\partial \phi_2}{\partial \sigma_y^2} > 0$$

when $0 < \xi < 1$ and $-1 < \eta < -\xi$. And

$$\frac{\partial \phi_2}{\partial \sigma_y^2} < 0$$

when $0 < \xi < 1$ and $0 > \eta > -\xi$; or when $\xi > 1$ and $\eta > 0$. The general lesson is again quite clear: stochastic shocks to output production may raise precautionary savings and investment and accelerate output growth under certain circumstances. Our analysis involving both capital and arms accumulation offers further insights on the ongoing theoretical and empirical inquiry into volatility and output growth with an additional perspective on national security and output production by modeling the interaction between military spending and productive investment.

4. Concluding remarks

This study has examined capital accumulation, military spending, arms accumulation, and output growth in a stochastic endogenous growth model. The analysis shows that higher (lower) growth in foreign military spending leads to faster (slower) economic growth in the home country if the home country's intertemporal substitution elasticity in consumption is smaller (larger); but more volatility in foreign military spending can lead to higher economic growth in the home country when its intertemporal substitution elasticity is large. In addition, shocks to output production may stimulate economic growth.

Given these highly complicated theoretical relationships between military spending and output growth, it is not strange at all that we can see both negative and positive associations between economic growth and military spending in many cross-country, time-series studies in 1970s–1990s; see Landau (1993) and Ram (1995) for a review on the empirics on military expenditures and economic growth. To single out a few recent cases, a positive association between military spending and growth is found by Stewart (1991), Mueller and Atesoglu (1993); Macnair et al. (1995); a negative association is found by Mintz and Huang (1990), and Ward and Davis (1992); a nonlinear relationship is found by Landau (1993); and no significant association is found by Mintz and Stevenson (1995).

Our theoretical relationships are obtained without taking into consideration of the often-mentioned military spinoffs of positive externalities on output production though education, research and development, and technological innovations. A straightforward extension of our model is to introduce military spending into the production. It is expected that the positive effect of military sector on economic growth is stronger, but analytical (explicit) solutions in the stochastic setting are more difficult to obtain when the production function has two inputs: capital and weapons stocks.

To have a more realistic picture of the power struggle in international politics, it also seems desirable to extend our model to consider the two-country dynamic equilibrium in arms race and capital accumulation without assuming the foreign country's action as an exogenous stochastic process. The analytical tool for a much simpler environment of financial market equilibrium with two-person dynamics is provided by Dumas (1989), but the military threat to each other in our two-country case will be an analytical challenge if we want to have explicit solutions as in Dumas.

While the Cold War has ended, ethnic conflicts have erupted into civil wars in eastern Europe, central Asia, and, especially, Africa. The economic causes and consequences of civil conflicts and violence have received considerable attention in recent years, and, of the 27 major armed conflicts that occurred in 1999, all but two took place within national boundaries (Collier, 1999, 2000). Our model can be viewed as an initial approach to exploring how ethnic and civil conflicts affect military spending and economic growth within a nation.

Finally, the rise and decline of nations and great powers in the last five hundred years have been extensively studied by various authors, and two notable cases are Olson (1982) and Kennedy (1987). To us, a serious attempt to the rise and decline of nations and powers should necessarily incorporate production technology and military

technology in dynamic models. This is a topic we should pursue in the near future. To be honest, as long as military conflicts among nations and within nations are a constant companion of human beings, the study on arms and economic growth will have its permanent value in our effort to understand the economic, political, and social behavior of the human race.

5. For further reading

The following references may also be of interest to the reader: Brito and Intriligator (1995); Cole et al., 1995; Fershtman and Weiss 1993; Fershtman et al., 1996; Merton,1971.

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第 16 章

外国援助对国内资本积累的影响

Foreign Aid Reduces Domestic Capital Accumulation and Increases Foreign Borrowing: A Theoretical Analysis

Liutang Gong

Guanghua School of Management, Peking University, Beijing, 100871, China
Institute for Advanced Study, Wuhan University, Wuhan, 430072, China
E-mail: ltgong@gsm.pku.edu.cn

and

Heng-fu Zou*

Guanghua School of Management, Peking University, Beijing, 100871 China
Institute for Advanced Study, Wuhan University, Wuhan, 430072 China
Development Research Group, The World Bank, Washington, DC 20433, USA
E-mail: Hzou@worldbank.org

In an infinite-horizon model with endogenous time preferences, foreign aid, foreign borrowing, and domestic capital accumulation, a permanent increase in foreign aid leads to a reduction in long-run capital accumulation, a rise in domestic consumption, and an increase in foreign borrowing. Short-run analysis shows that an initial increase in foreign aid leads to a rise in investment, and a reduction in consumption and external borrowing. On the other hand, a temporal increase in foreign aid results in an increase in consumption and foreign borrowing, and a reduction in investment.

Key Words: Foreign aid; Foreign borrowing; Capital accumulation.
JEL Classification Numbers: E2, F34, F35, F43, O1, O4.

1. INTRODUCTION

The effects of foreign aid and external borrowing on investment and growth in developing countries have received considerable attention in both academic studies and policy discussions in the 1990s. Recent studies by Boone (1994a, 1994b); White and Luttik (1994); Taylor and Williamson (1994); Feyzioglu, Swaroop, and Zhu (1997); World Bank (1997); Obstfeld (1999); Gong and Zou (2000); and Burnside and Dollar (2000) have reexam-

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ined various critical issues related to external finance and capital inflows to developing countries, which were heatedly debated in the 1960s and 1970s. In a series of studies by Hollis Chenery and his associates, they have found that, on the basis of the Harrod-Domar model and realistic parameters on different developing countries, foreign aid and foreign capital inflows can accelerate investment and speed the transition to a targeted self-sustained growth path; see Chenery and Bruno (1962); Adelman and Chenery (1966); Chenery and Strout (1966); and Chenery and Eckstein (1970).The critics of this optimistic view have argued that external resource inflows may mainly increase consumption, depress domestic savings, and slow down investment and output growth; see Griffin (1970); and Griffin and Enos (1970). The controversy seems to continue mainly on the empirical side. For conflicting empirical findings on the impact of external finance on savings, investment and output growth, see Rahman (1968); Papanek (1972, 1973); Fry (1978, 1980); Levy (1987, 1988a, 1988b); and Giovannini (1983, 1985), among many others.

More recently, Boone (1994a, 1994b) finds that foreign aid has hardly any effect on investment; in particular, foreign aid mainly serves to augment the consumption of those who are relatively well-off in developing countries. Even if foreign aid is tied to specific sectors and purposes, Feyzioglu *et al* (1997) have found that most of foreign aid appears to be fungible, and many developing countries have diverted foreign aid to public consumption (see also Pack and Pack, 1990, 1993). These recent empirical findings naturally suggest that foreign aid has very little positive impact on capital formation and output growth in developing countries.

In a recent theoretical paper, Obstfeld (1999) has developed a simple Cass-Koopmans optimal growth model relating foreign aid to domestic savings and growth. He finds that foreign aid has no effect on long-run capital accumulation, and that it increases long-run consumption dollar for dollar. But in the short-run, foreign aid stimulates investment and speeds up the transition to the long-run steady state of the economy. Taken together, Obstfeld's analysis still predicts some positive impact of foreign aid on investment and short-run output growth.

Our study intends to broaden the Obstfeld model in a few aspects: first, we follow Uzawa (1968); Obstfeld (1981, 1982 , 1990); Lucas and Stokey (1984); and Becker and Mulligan (1997), and postulate an endogenous time preference; second, we consider both foreign aid and foreign borrowing in an infinite horizon model of optimal capital accumulation; third, we follow Judd (1985, 1987) and quantify the short-run impact of foreign aid on investment and foreign borrowing. In sharp contrast to Obstfeld (1999), our main findings show that a permanent rise in foreign aid reduces long-run capital accumulation and increases long-run reliance on external borrowing.

The paper is organized as follows. Section 2 sets up the analytical model. Section 3 studies the long-run properties of the dynamic system and examines how foreign aid affects steady-state capital accumulation, consumption, and external foreign borrowing. Section 4 looks at the short-run (including both initial and temporal) effects of foreign aid on investment, consumption, and external borrowing. Section 5 summarizes the main findings.

2. THE MODEL

We consider an infinite-horizon model of foreign aid, foreign borrowing, and domestic accumulation in an open economy, which is populated by many identical agents. Each agent has an instantaneous utility function defined on consumption, $u(c(t))$, which is increasing, concave, and twice differentiable:

$$u_c > 0, u_{cc} < 0. \tag{1}$$

For the agent's time preference, Δ_t, we follow Uzawa (1968) and Obstfeld (1981, 1982, 1990)[1], and assume that the time preference of the agent is a function of the agent's utility, namely

$$\Delta_t = \int_0^t \delta_s ds, \tag{2}$$

where δ_s is the instantaneous subjective discounted rate at time s and is defined as

$$\delta_s = \delta[u(c(s))], \tag{3}$$

which has the following properties as in Uzawa (1968):

$$\delta(u) > 0, \delta'(u) > 0, \delta''(u) > 0, \quad \delta(u) - u\delta'(u) > 0. \tag{4}$$

The second condition of equation (4) implies that an increase in the consumption level at a certain future date will increase the discounted rate for all consumption made forward, while the third condition is given as in Uzawa (1968), which is used to derive a continuous consumption function; see the detail in Uzawa (1968). The last condition in equation (4) implies that the agent prefers consumption with higher instantaneous utility.

[1]See Lucas and Stokey (1984); and Becker and Mulligan (1997) for more justification for this approach to endogenizing the time preference.

Now, the representative agent's discounted utility can be written as

$$\int_0^\infty u(c)e^{-\Delta t}dt. \tag{5}$$

Output is produced by a typical neoclassical production function, $f(k(t))$ with $k(t)$ denoting the capital input at time t:

$$f'(k(t)) > 0, f''(k(t)) < 0. \tag{6}$$

Let $B(t)$ be the accumulated foreign borrowing at time t. As for the cost of foreign borrowing, $h(B(t))$, we intend to include the constant marginal cost of foreign borrowing, namely, $h(B(t)) = r(t)B(t)$ with $r(t)$ the interest rate in the world capital market, as a special case. Along with Bardhan (1967) and Pitchford (1989), we assume $h(B(t))$ to be an increasing, convex function of the accumulated debt:

$$h'(B(t)) > 0, h''(B(t)) > 0, \tag{7}$$

which implies that the more the agent borrows, the higher the marginal cost he must pay. All analysis in this paper still holds when $h(B(t)) = r(t)B(t)$.

With the inflows of foreign aid, $A(t)$, at time t, the budget constraint for the representative agent can be written as

$$\frac{dk(t)}{dt} - \frac{dB(t)}{dt} = f(k(t)) - c(t) - h(B(t)) + A(t). \tag{8}$$

Denote the net wealth of the agent at time t as $W(t)$, which is defined by

$$W(t) = k(t) - B(t). \tag{9}$$

A simple transformation gives

$$\frac{dW(t)}{dt} = f(k(t)) - c(t) - h(B(t)) + A(t). \tag{10}$$

A representative agent with perfect foresight will choose his consumption path, $c(t)$, capital accumulation path, $k(t)$, and the foreign borrowing path, $B(t)$, to maximize his discounted utility, namely

$$\max \int_0^\infty u(c)e^{-\Delta t}dt$$

subject to initial conditions $k(0) = k_0$, $B(0) = B_0$, and the budget constraints (9) and (10).

From equations (2) and (3), we have

$$dt = \frac{d\Delta_t}{\delta[u(c(t))]}. \tag{11}$$

With equation (11), we can transform the optimization problem as

$$\max \int_0^\infty \frac{u(c)}{\delta[u(c(t))]} e^{-\Delta} d\Delta \tag{12}$$

subject to

$$\frac{dW}{d\Delta} = \frac{1}{\delta[u(c(t))]}[f(k) - c - h(B) + A], \tag{13}$$

and constraint (9) and the initial conditions.

Define the Hamiltonian as

$$H = \frac{u(c)}{\delta[u(c(t))]} + \lambda[\frac{f(k) - c - h(B) + A}{\delta[u(c(t))]}] + \mu(k - B - W),$$

where λ is the costate variable, which represents the imputed marginal utility of wealth. μ is the multiplier associated with the net wealth constraint (9).

The first-order conditions for an optimum are

$$\{1 - \frac{\delta'}{\delta}[u(c) + \lambda(f(k) - c - h(B) + A)]\}u_c = \lambda, \tag{14}$$

$$-\delta\mu = \lambda h'(B), \tag{15}$$

$$\lambda\frac{1}{\delta}f'(k) + \mu = 0, \tag{16}$$

$$\frac{d\lambda}{d\Delta} = \lambda + \mu, \tag{17}$$

and the transversality condition

$$\lim_{\Delta\to\infty} \lambda W e^{-\Delta} = 0. \tag{18}$$

To explain equation (14), with substitutions we write it as

$$u_c = \lambda + \frac{\delta'}{\delta}[u + \lambda(f(k) - c - h(B) + A)]u_c. \tag{19}$$

The left-hand side is the marginal utility of consumption, the right-hand side is the sum of the marginal utility of wealth and the marginal increase in the present value of the imputed income due to a marginal decrease in the rate of the time preference. Equation (19) says the these two marginal values must equal in the equilibrium.

From equations (15) and (16), we obtain

$$f'(k) = h'(B). \tag{20}$$

Equation (20) implies that the marginal cost of foreign borrowing must equal the marginal productivity of capital at an optimum.

Equation (17) is the familiar Euler equation. Combining it with equation (16) leads to:

$$\frac{d\lambda}{d\Delta} = \lambda(1 - \frac{1}{\delta}f'(k)). \tag{21}$$

Using condition (11), we rewrite equation (21) as follows

$$\frac{d\lambda}{dt} = \lambda(\delta - f'(k)). \tag{22}$$

3. DYNAMICS AND LONG-RUN ANALYSIS

3.1. Dynamic system

In this section we derive the dynamic system for consumption, c, capital stock, k, and foreign borrowing, B, with the aid of the first-order conditions given in the last section.

First, from equation (20), we can represent B as a function of k, namely

$$B = B(k). \tag{23}$$

Differentiating with respect to time, we get

$$\frac{dB}{dt} = B_k \frac{dk}{dt}, \tag{24}$$

where

$$B_k = \frac{f''}{h''(B)} < 0, \tag{25}$$

because $f'' < 0$, and $h''(B) > 0$. Equation (25) asserts that an increase in the capital stock will decrease foreign borrowing.

Notice that with equation (14), we can write λ as a function of B, c, and k in the following form

$$\lambda = \frac{(\delta - \delta' u)u_c}{\delta + \delta' u_c(f(k) - c - h(B) + A)}. \tag{26}$$

Taking total differentiation in equation (26) and combining it with the Euler equation (22), we have

$$\begin{aligned} \frac{d\lambda}{dt} &= \lambda_c \frac{dc}{dt} + \lambda_k \frac{dk}{dt} + \lambda_B \frac{dB}{dt} \\ &= \lambda(\delta - f'(k)), \end{aligned} \tag{27}$$

where the coefficients λ_c, λ_k, and λ_B are given in the appendix. In fact, we are only interested in their values at the steady state.

Now, the total dynamic system of the economy can be summarized as

$$\frac{dk}{dt} - \frac{dB}{dt} = f(k) - c - h(B) + A,$$

$$\frac{dB}{dt} = B_k \frac{dk}{dt},$$

and

$$\lambda_c \frac{dc}{dt} + \lambda_k \frac{dk}{dt} + \lambda_B \frac{dB}{dt} = \lambda(\delta - f'(k)),$$

with λ determined by equation (26).

From the above equations we derive the dynamic equations for consumption, c, and capital accumulation, k. Here, the dynamic equation for foreign borrowing can be determined by the dynamic paths of c and k because of equation (24).

$$\frac{dk}{dt} = \frac{h''}{h'' - f''}(f(k) - c - h(B) + A), \tag{28}$$

$$\frac{dc}{dt} = \frac{\lambda}{\lambda_c}(\delta - f'(k)) + \frac{\lambda_B}{\lambda_c}(f(k) - c - h(B) + A), \tag{29}$$

$$(\frac{dB}{dt} = B_k \frac{dk}{dt}),$$

where λ, λ_c, and λ_B are given in the appendix.

With equations (28), (29), the initial condition $k(0) = k_0$, and the transversality condition we can determine the optimal consumption path,

$c(t)$, and capital accumulation path, $k(t)$. Finally, from equation (24), and the initial condition $B(0) = B_0$ we can determine the foreign borrowing path, $B(t)$.

3.2. The steady state

Obstfeld (1999) has studied the long-run effects of foreign aid in the traditional Cass-Koopmans optimal growth model. He finds that foreign aid generates no long-run effect on domestic capital accumulation, and that it only increases the consumption level by the same amount. Here, we reexamine this issue and see how foreign aid can affect not only long-run consumption, but also long-run domestic capital accumulation and external borrowing.

The steady state of the economy, reached when $\frac{dk}{dt}$ and $\frac{dc}{dt}$ equal zero, is characterized by

$$\frac{h''}{h'' - f''}(f(k^*) - c^* - h(B^*) + A) = 0, \tag{30}$$

$$\frac{\lambda^*}{\lambda_c^*}(\delta - f'(k^*)) + \frac{\lambda_B^*}{\lambda_c^*}(f(k^*) - c^* - h(B(k^*)) + A) = 0. \tag{31}$$

And equations (30) and (31) are equivalent to

$$\begin{aligned} f(k^*) - c^* - h(B(k^*)) + A &= 0, \\ \delta - f'(k^*) &= 0. \end{aligned} \tag{32}$$

Now, from the steady-state conditions, the steady-state values of λ^*, λ_c^*, λ_B^*, and λ_k^* for λ, λ_c, λ_B, and λ_k are determined as follows

$$\begin{aligned} \lambda^* &= \frac{\delta - \delta' u}{\delta} u_c > 0, \\ \lambda_c^* &= \frac{1}{\delta}((\delta - \delta' u)u_{cc} - \delta'' u_c^2 u) < 0, \\ \lambda_B^* &= \frac{1}{\delta^2}(\delta - \delta' u)u_c \delta' u_c h'(B) > 0, \\ \lambda_k^* &= -\frac{1}{\delta^2}(\delta - \delta' u)\delta' u_c^2 f'(k) < 0. \end{aligned} \tag{33}$$

Equations in (32) characterize the steady-state conditions. The first equation says that output and foreign aid are used to consume and pay for the cost of foreign borrowing in the equilibrium. The second one shows that the steady-state marginal productivity of capital equals the consumer's time preference.

The linearized system associated with (28) and (29) around the steady state is

$$\begin{pmatrix} \frac{dk}{dt} \\ \frac{dc}{dt} \end{pmatrix} = \begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix} \begin{pmatrix} k - k^* \\ c - c^* \end{pmatrix},$$

where

$$\begin{aligned} \phi_{11} &= \frac{h''}{h'' - f''}(f' - h'B_k), \phi_{12} = -\frac{h''}{h'' - f''}, \\ \phi_{21} &= -\frac{\lambda^*}{\lambda_c^*}f'' + \frac{\lambda_B^*}{\lambda_c^*}(f' - h'B_k), \phi_{22} = \frac{\lambda^*}{\lambda_c^*}\delta' u_c - \frac{\lambda_B^*}{\lambda_c^*}. \end{aligned}$$

The determinant of the coefficient matrix is

$$D = -\frac{h''}{h'' - f''}\frac{\lambda^*}{\lambda_c^*}(f'' - \delta' u_c(f' - h'B_k)) < 0.$$

Thus, we know that the steady state is saddle-point stable, i.e., there exists a unique perfect-foresight path. Along this path, consumption, $c(t)$, the capital stock, $k(t)$, and foreign borrowing, $B(t)$, converge to the steady state in the long run.

For the long-run effects of foreign aid on the economy, we have derived the following results in the appendix.

PROPOSITION 1. *A permanent rise in foreign aid reduces long-run capital formation and increases long-run foreign debt:*

$$\frac{dk^*}{dA} = \frac{\delta' u_c}{f'' - \delta' u_c(f' - h'B_k)} < 0, \tag{34}$$

$$\frac{dc^*}{dA} = \frac{f''}{f'' - \delta' u_c(f' - h'B_k)} > 0, \tag{35}$$

and

$$\frac{dB^*}{dA} = \frac{B_k \delta' u_c}{f'' - \delta' u_c(f' - h'B_k)} > 0, \tag{36}$$

because $f'' - \delta' u_c(f' - h'B_k) < 0$, *and* $B_k < 0$.

Now, from equation (34) we know that the a permanent rise in foreign aid decreases the steady-state capital stock. This is because a permanent increase in foreign aid raises the income level of the agent. The agent then

can afford to increase his consumption and reduce his investment while maintaining a higher level of long-run consumption, as shown by equation (35). In the end, foreign aid reduces the long-run accumulation of capital stock. This is a powerful result. In a modified Cass-Koopmans model with an exogenously given time preference rate and without foreign borrowing, Obstfeld (1999) has found that a rise in foreign aid has no effect on the long-run accumulation of capital, but it increases the speed of the transition to the steady state. In this sense, foreign aid still has a stimulating role for investment and economic growth in developing countries. But from our analysis, a permanent rise in foreign aid always depresses domestic investment and output growth in developing countries in both the short run and long run. Of course, both models have reached the similar conclusion that foreign aid stimulates consumption.

An equally surprising case is equation (36). It implies that a permanent increase in foreign aid leads to a higher level of foreign debt accumulation. With a permanent rise in foreign aid and, therefore, permanent income, the agent's proportional increase in short-run consumption will be more than the decrease in savings and investment through external borrowing. Therefore short-run external finance will rise. With reduced capital accumulation and lower output in the long run, the long-term level of external debt will also rise.

Our analysis raises some fundamental doubt about the effectiveness of foreign aid on economic growth in developing countries. Foreign aid seems to have no role in breaking "foreign dependency" and establishing "economic independence" in many very poor countries. On the contrary, our analysis predicts that a rising level of foreign aid leads to reduced savings, lower investment and capital accumulation, and more reliance on foreign borrowing in the long run. Our theoretical analysis renders strong support for the negative associations between external finance and domestic savings in Griffin (1970); Griffin and Enos (1970); Fry (1978, 1980); Giovannini (1983, 1985); Taylor and Williamson (1994). Furthermore, our analysis is also in line with the finding that there exists no association between foreign aid and domestic investment and growth by Boone (1994a, 1994b).

4. SHORT-RUN ANALYSIS

In the last section, we discussed the effects of a permanent increase in foreign aid on the steady-state capital stock, k^*, consumption level, c^*, and foreign borrowing, B^*. To make the short-run analysis of the effects of temporal foreign aid, we follow Judd (1982, 1985, 1987).

As in Judd (1982, 1985), suppose the economy is in the steady-state k^* and c^* with foreign aid A^* at time $t = 0$. And at time $t = 0$, foreign aid

changes as follows

$$A = A^* + \epsilon z(t), \tag{37}$$

where ϵ is a parameter; function $z(t)$ represents the intertemporal change of various parameters. In this paper, the function $z(t)$ can be regarded as a step function of time. Then a temporary change of foreign aid during time $t \in [0, T]$ can be represented by $z(t) = 1, t \in [0, T]$ and $z(t) = 0$ otherwise.

Substituting equation (37) into the dynamic system of equations (28) and (29), we get

$$\frac{dk}{dt} = \frac{h''}{h'' - f''}(f(k) - c - h(B) + A + \epsilon z(t)), \tag{38}$$

$$\frac{dc}{dt} = \frac{\lambda}{\lambda_c}(\delta - f'(k)) + \frac{\lambda_B}{\lambda_c}(f(k) - c - h(B) + A + \epsilon z(t)). \tag{39}$$

Again, the linearized system associated with the system of (38) and (39) has two eigenvalues, one negative and the other positive, which we denote as μ.

Differentiating with respect to ϵ at $\epsilon = 0$ in equations (38) and (39), we get

$$\begin{pmatrix} \frac{dk_\epsilon(t)}{dt} \\ \frac{dc_\epsilon(t)}{dt} \end{pmatrix} = \begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix} \begin{pmatrix} k_\epsilon \\ c_\epsilon \end{pmatrix} + \begin{pmatrix} \frac{h''}{h''-f''} z(t) \\ \frac{\lambda_B}{\lambda_c} z(t) \end{pmatrix}, \tag{40}$$

where

$$\begin{aligned}
\phi_{11} &= \frac{h''}{h'' - f''}(f' - h'B_k) > 0, \phi_{12} = -\frac{h''}{h'' - f''} < 0, \\
\phi_{21} &= -\frac{\lambda^*}{\lambda_c^*} f'' + \frac{\lambda_B^*}{\lambda_c^*}(f' - h'B_k) < 0, \\
\phi_{22} &= \frac{\lambda^*}{\lambda_c^*}\delta' u_c - \frac{\lambda_B^*}{\lambda_c^*} = \frac{1}{\lambda_c^*}\frac{1}{\delta^2}(\delta - \delta' u) u_c^2 \delta'(\delta - h'(B)).
\end{aligned}$$

For notational simplicity, we denote

$$c_\epsilon(t) = \frac{\partial c}{\partial \epsilon}(t, 0), \frac{dc_\epsilon(t)}{dt} = \frac{\partial}{\partial t}(\frac{\partial c}{\partial \epsilon})(t, 0).$$

Furthermore, we denote the Laplace transforms by the upper case letters of the associated variables in lower case letters. For example,

$$C_\epsilon(s) = \int_0^\infty c_\epsilon(t) e^{-st} dt.$$

Making the Laplace transform in equation (40), we have

$$s\begin{pmatrix} K_\epsilon(s) \\ C_\epsilon(s) \end{pmatrix} = \begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix}\begin{pmatrix} K_\epsilon(s) \\ C_\epsilon(s) \end{pmatrix} + \begin{pmatrix} \frac{h''}{h''-f''}z(s) + k_\epsilon(0) \\ \frac{\lambda_B}{\lambda_c}z(s) + c_\epsilon(0) \end{pmatrix}. \quad (41)$$

Because the stock of capital (the state variable) cannot jump initially, we have $k_\epsilon(0) = 0$. To determine the initial consumption change $c_\epsilon(0)$, we follow Judd (1985). Please notice that, because the steady state is saddle-point stable, both $C_\epsilon(s)$ and $K_\epsilon(s)$ are bounded when $s = \mu$ (the positive eigenvalue). But when $s = \mu$, the coefficient matrix of the above linear equation is singular. By Cramer's rule, in order to maintain the existence and finiteness for solutions $C_\epsilon(s)$ and $K_\epsilon(s)$ when $s = \mu$, the determinants of the following matrices must be zero

$$\begin{pmatrix} \frac{h''}{h''-f''}z(s) & -\phi_{12} \\ \frac{\lambda_B}{\lambda_c}z(s) + c_\epsilon(0) & \mu - \phi_{22} \end{pmatrix}, \begin{pmatrix} \mu - \phi_{11} & \frac{h''}{h''-f''}z(s) \\ -\phi_{21} & \frac{\lambda_B}{\lambda_c}z(s) + c_\epsilon(0) \end{pmatrix}$$

namely,

$$(\frac{\lambda_B}{\lambda_c}z(\mu) + c_\epsilon(0))(\mu - \phi_{22}) + \phi_{12}\frac{h''}{h'' - f''}z(\mu) = 0, \quad (42)$$

and

$$(\frac{\lambda_B}{\lambda_c}z(s) + c_\epsilon(0))(\mu - \phi_{11}) + \phi_{21}\frac{h''}{h'' - f''}z(s) = 0. \quad (43)$$

From equation (42), we get the initial jump in consumption

$$c_\epsilon(0) = -(\frac{\lambda_B}{\lambda_c} + \frac{h''}{h'' - f''}\frac{\phi_{12}}{(\mu - \phi_{22})})z(\mu). \quad (44)$$

Remark 4.1. Because μ is the eigenvalue of the coefficient matrix, we have $(\mu - \phi_{11})(\mu - \phi_{22}) - \phi_{21}\phi_{12} = 0$. Hence, we can derive the same conclusion from equation (43).

Substituting equation (44) back into equation (40), we have

$$\begin{aligned} \frac{dk_\epsilon(0)}{dt} &= \phi_{12}c_\epsilon(0) + \frac{h''}{h'' - f''}z(0), \\ \frac{dc_\epsilon(0)}{dt} &= \phi_{22}c_\epsilon(0) + \frac{\lambda_B}{\lambda_c}z(0). \end{aligned} \quad (45)$$

PROPOSITION 2. *An initial increase in foreign aid will raise the initial investment rate and decrease the rate of initial foreign borrowing.*

Proof. This can be derived from differentiating equation (45),

$$\frac{d}{dz(0)}\left(\frac{dk_\epsilon(0)}{dt}\right) = \frac{h''}{h'' - f''} > 0, \tag{46}$$

and from equation (24), we get

$$\frac{d}{dz(0)}\left(\frac{dB_\epsilon(0)}{dt}\right) = B_k \frac{h''}{h'' - f''} < 0. \tag{47}$$

∎

This is true because an initial increase in foreign aid causes a dollar for dollar increase in the consumption level. To smooth the consumption path, the agent will increase the initial saving rate, namely, $\frac{d}{dz(0)}\left(\frac{dk_\epsilon(0)}{dt}\right) > 0$. With more income available today, the agent will also reduce his rate of initial foreign borrowing.

Proposition 2 supports the analysis in Obstfeld (1999) in a very limited sense; that is to say, foreign aid can accelerate short-run investment if it is perceived as a one-shot rise in income. If foreign aid lasts for a slightly longer period, its effects on investment and foreign borrowing are just the opposite of those predicted by proposition 2 as we will see below.

Effects of temporal foreign aid

Suppose foreign aid is temporal, i.e.,

$$\begin{cases} z(t) = 1, & t \in [0, T]; \\ z(t) = 0, & \text{otherwise.} \end{cases} \tag{48}$$

Then, we have

$$Z(\mu) = \frac{1 - e^{-\mu T}}{\mu}. \tag{49}$$

PROPOSITION 3. *A temporal increase in foreign aid will increase the initial consumption level and foreign borrowing rate. At the same time, it will decrease the initial investment rate.*

Proof. From equation (44), we get

$$\frac{dc_\epsilon(0)}{dZ(\mu)} = -\left(\frac{\lambda_B}{\lambda_c} + \frac{h''}{h'' - f''}\frac{\phi_{12}}{(\mu - \phi_{22})}\right). \tag{50}$$

Because the two eigenvalues, μ(positive) and ν (negative) of matrix $\begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix}$ satisfy

$$\mu + \nu = \phi_{11} + \phi_{22},$$

we have $\mu - \phi_{22} = \phi_{11} - \nu > 0$. Hence, we have

$$\frac{dc_\epsilon(0)}{dZ(\mu)} > 0.$$

From equation (45), we get

$$\frac{d}{dZ(\mu)}\left(\frac{dk_\epsilon(0)}{dt}\right) = \phi_{12}\frac{dc_\epsilon(0)}{dZ(\mu)} < 0, \tag{51}$$

and from equation (24), we obtain

$$\frac{d}{dZ(\mu)}\left(\frac{dB_\epsilon(0)}{dt}\right) = B_k\phi_{12}\frac{dc_\epsilon(0)}{dZ(\mu)} > 0. \tag{52}$$

∎

Proposition 3 means that with a temporal increase in foreign aid the agent will increase his initial consumption level as his income rises. In addition, rising income provides him with an incentive to lower his current savings rate and increase his reliance on external financing.

Proposition 3 has a close link to Proposition 1 when the time horizon of foreign aid is sufficiently large. If the time horizon is infinite, these two prepositions coincide, and both predict that a permanent rise in foreign aid reduces capital accumulation and increases external borrowing.

5. SUMMARY

In an infinite-horizon model with endogenous time preferences, foreign aid, foreign borrowing, and domestic capital accumulation, we find that a permanent increase in foreign aid leads to a reduction in long-run capital accumulation, a rise in domestic consumption, and an increase in foreign borrowing. Short-run analysis shows that an initial increase in foreign aid leads to a rise in investment, and a reduction in consumption and external borrowing. On the other hand, a temporal increase in foreign aid results in an increase in consumption and foreign borrowing, and a reduction in investment.

Our theoretical findings support many empirical results on the negative impact of external finance on domestic savings, investment, and growth. It also raises some fundamental doubt about the effectiveness of foreign aid in accelerating economic growth and development in developing countries.

APPENDIX A

In the expression

$$\lambda = \frac{(\delta - \delta' u)u_c}{\delta + \delta' u_c(f(k) - c - h(B) + A)},$$

we differentiate with respect to c, B, and k

$$\lambda_c = \frac{(\delta - \delta' u)u_{cc} - \delta'' u_c^2 u}{\delta + \delta' u_c(f(k) - c - h(B) + A)} - \frac{(\delta - \delta' u)u_c(f(k) - c - h(B) + A)(\delta'' u_c^2 + \delta' u_{cc})}{(\delta + \delta' u_c(f(k) - c - h(B) + A))^2}, \tag{A.1}$$

$$\lambda_B = \frac{(\delta - \delta' u)u_c \delta' u_c h'(B))}{(\delta + \delta' u_c(f(k) - c - h(B) + A))^2}, \tag{A.2}$$

and

$$\lambda_k = -\frac{(\delta - \delta' u)u_c \delta' u_c f'(k)}{(\delta + \delta' u_c(f(k) - c - h(B) + A))^2}. \tag{A.3}$$

Using the steady-state conditions (32), we get

$$\begin{aligned}
\lambda^* &= \frac{\delta - \delta' u}{\delta} u_c, \lambda_c^* = \frac{1}{\delta}((\delta - \delta' u)u_{cc} - \delta'' u_c^2 u), \\
\lambda_B^* &= \frac{1}{\delta^2}(\delta - \delta' u)u_c \delta' u_c h'(B), \\
\lambda_B^* &= -\frac{1}{\delta^2}(\delta - \delta' u)\delta' u_c^2 f'(k).
\end{aligned}$$

These are just the equations in (33) in the text.

For the proof of proposition 1 in section 3, we take a total differentiation in equation (32)

$$\begin{pmatrix} f' - h' B_k & -1 \\ -f'' & \delta' u_c \end{pmatrix} \begin{pmatrix} dk^* \\ dc^* \end{pmatrix} = \begin{pmatrix} -1 \\ 0 \end{pmatrix} dA.$$

Therefore, we obtain the long-run effects of a permanent increase in foreign aid on the capital stock and consumption

$$\frac{dk^*}{dA} = \frac{\delta' u_c}{f'' - (f' - h' B_k)\delta' u_c} < 0,$$

$$\frac{dc^*}{dA} = \frac{f''}{f'' - (f' - h'B_k)\delta' u_c} > 0.$$

From equation (24), we have

$$\frac{dB^*}{dA} = \frac{\delta' u_c B_k}{f'' - (f' - h'B_k)\delta' u_c} > 0.$$

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第 17 章

外国援助对劳动力供给和资本积累的影响

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Foreign Aid Reduces Labor Supply and Capital Accumulation

*Liutang Gong and Heng-fu Zou**

Abstract

In an optimal growth model with foreign aid, foreign borrowing, and endogenous leisure-and-consumption choices, it is shown that a permanent rise in foreign aid reduces long-run capital accumulation and labor supply, increases long-run consumption, and has no effect on long-run foreign borrowing.

1. Introduction

Since the 1960s, researchers have modeled and empirically tested the role of foreign aid inflows on developing-country capital accumulation and growth. In a series of studies by Hollis Chenery and his associates, they have found that, on the basis of the Harrod–Domar model and realistic parameters on different developing countries, foreign aid and foreign capital inflows can accelerate investment and speed the transition to a targeted self-sustained growth path.

At the same time, the critics of this optimistic view have argued that external resource inflows may mainly increase consumption, depress domestic savings, and slow down investment and output growth; see Griffin (1970) and Griffin and Enos (1970) for early empirical evidence. The controversy has been continuing mainly on the empirical side. For conflicting empirical findings on the impact of external finance on savings, investment, and output growth, see Rahman (1968), Papanek (1972), Fry (1978), Levy (1987), and Giovannini (1983, 1985), among many others.

In the 1990s, the effects of foreign aid and external finance on investment and growth in developing countries have received considerable attention in both academic studies and policy discussions. Studies by Boone (1994a,b); Claessens et al. (1995), Calvo (1996), Feyzioglu et al. (1998), Taylor and Sarno (1997), Obstfeld (1999), Gong and Zou (2000), and Burnside and Dollar (2000) have re-examined various critical issues related to external finance, capital formation, and growth. Boone (1994a,b) finds that foreign aid has hardly any effect on investment; in particular, foreign aid mainly serves to augment the consumption of those who are relatively well-off in developing countries. Even if foreign aid is tied to specific sectors and purposes, Feyzioglu et al. (1997) have found that most of foreign aid appears to be fungible, and many developing countries have diverted foreign aid to public consumption (see also Pack and Pack, 1990, 1993). The implication of these more recent empirical findings naturally suggests that foreign aid has very little positive impact on capital formation and output growth in developing countries.

In a theoretical attempt to understand the rationale for many empirical findings, Obstfeld (1999) has developed a simple Cass–Koopmans optimal-growth model relating foreign aid to domestic savings and growth. He finds that foreign aid has no effect

* Gong: Peking University, Wuhan University, Wuhan, China. Tel: (86-10)6275-7768; Fax: (86-10)6275-7764; E-mail: ltgong@gsm.pku.edu.cn. Zou: Wuhan University, Peking University, Beijing, China, and Development Research Group, the World Bank, 1818 H St NW, Washington, DC 20433, USA. Tel. (202) 473-7939; Fax (202) 522-1154; E-mail: hzou@worldbank.org.

on long-run capital accumulation, and that it increases long-run consumption dollar for dollar. But in the short run, foreign aid stimulates investment and speeds up the transition to the long-run steady state of the economy. Taking together, Obstfeld's analysis still predicts some positive impact of foreign aid on investment and short-run output growth.

Our study intends to offer a theory that is more consistent with the negative association between foreign aid and savings and investment in many empirical studies. In our theoretical approach, we first follow the contributions by William Brock and Stephen Turnovsky and introduce the utility function that is defined on both consumption and leisure. (See Brock (1974, 1975) and especially Turnovsky (1995) for lucid expositions on this type of utility function in economic dynamics.) Then, extending the simple framework in Obstfeld (1999), we consider foreign aid, foreign borrowing, leisure, and investment in an infinite-horizon model of optimal accumulation. Finally, we follow Turnovsky (1995) and examine both long-run and short-run effects of foreign aid on capital accumulation, foreign borrowing, and labor input (or leisure); we also consider the welfare effect of foreign borrowing.

Section 2 sets up the analytical model. Section 3 studies the long-run properties of the dynamic system and examines how foreign aid affects steady-state capital accumulation, labor input, external foreign borrowing, consumption, and welfare. Section 4 looks at the effects of temporal foreign aid. Section 5 summarizes the main findings of the paper.

2. The Model

Along with Brock (1974, 1975) and Turnovsky (1995), we let the utility function of the representative agent, $u(c, l)$, be defined on consumption, c, and labor, l. The agent derives disutility from labor, and positive, but diminishing, marginal utility from consumption. Suppose the utility function is twice differentiable. Then, we have

$$u_c > 0, \quad u_l < 0, \quad u_{cc} < 0, \quad u_{ll} < 0. \tag{1}$$

Output is produced by a neoclassical production function, $f(k, l)$, with two inputs, capital stock, k, and labor supply, l. Therefore:

$$f_k > 0, \quad f_l > 0, \quad f_{kk} < 0, \quad f_{ll} < 0, \quad f_{kl} > 0. \tag{2}$$

Furthermore, we assume that the production function is homogeneous of degree one in capital and labor, and it is concave:

$$f_{kk} f_{ll} - f_{kl}^2 > 0, \quad f(k,l) = f_k k + f_l l. \tag{3}$$

As for foreign borrowing, b, along with Bardhan (1967) and Pitchford (1989) we assume that both the cost schedule of foreign borrowing, $h(b)$, and the marginal cost of foreign borrowing, $h'(b)$, are increasing with the level of accumulated debt, b; namely:

$$h'(b) > 0, \quad h''(b) > 0, \tag{4}$$

which implies that the more a country borrows, the higher the borrowing cost and the higher the marginal borrowing cost. This general specification of the cost function of external borrowing includes the constant interest rate, r, in the world capital market as a special case; namely, $h(b) = rb$.

Now the representative agent will choose his consumption rate, c, labor supply, l, capital stock, k, and foreign borrowing, b, to maximize his discounted utility

$$\max \int_0^\infty u(c,l)e^{-\rho t}dt \tag{5}$$

subject to

$$\frac{dk}{dt} = \frac{db}{dt} + f(k,l) + a - c - h(b) \tag{6}$$

and the initial conditions $k(0) = k_0$ and $b(0) = b_0$; where ρ is the rate of time preference, and a is foreign aid.

Denote the net wealth of the consumer as W, so that

$$W = k - b. \tag{7}$$

A simple substitution yields

$$\frac{dW}{dt} = f(k,l) + a - c - h(b). \tag{8}$$

Define the Hamiltonian as

$$H = u(c,l) + \lambda(f(k,l) + a - c - h(b)) + \mu(k - b - W),$$

where λ is the costate variable associated with the budget constraint (8) and represents the marginal utility of wealth, and μ is the multiplier associated with the wealth identity in (7).

The first-order conditions for optimization are

$$u_c = \lambda, \tag{9}$$

$$u_l = -\lambda f_l, \tag{10}$$

$$\lambda h'(b) + \mu = 0, \tag{11}$$

$$\lambda f_k + \mu = 0, \tag{12}$$

$$\frac{d\lambda}{dt} = \rho\lambda + \mu, \tag{13}$$

and the transversality condition (TVC)

$$\lim_{t\to\infty} \lambda W e^{-\rho t} = 0. \tag{14}$$

Equation (9) implies that at an optimum the marginal utility of consumption must equal the marginal utility of wealth. Equation (10) asserts that the marginal utility of leisure equals the marginal utility of consumption weighted by the real wage rate. Equations (12) and (13) require that in the equilibrium the marginal productivity of capital must equal the marginal cost of foreign borrowing, namely:

$$f_k = h'(b). \tag{15}$$

Equation (13) is the familiar Euler equation. The transversality condition (15) asserts that in the long run the present discounted value of wealth must approach zero.

Short-Run Equilibrium

First, from equations (9), (10), and (15), we can solve for c, l, and b as

$$c = c(\lambda, k), \tag{16}$$

$$l = l(\lambda, k), \tag{17}$$

$$b = b(\lambda, k). \tag{18}$$

Differentiating equations (9), (10), and (15) with respect to λ and k, we have

$$c_\lambda = \frac{u_{ll} + \lambda f_{ll} + u_{cl} f_l}{\Delta} < 0, \quad c_k = \frac{u_{cl} \lambda f_{kl}}{\Delta}, \tag{19}$$

$$l_\lambda = -\frac{u_{cc} + u_{cl}}{\Delta} > 0, \quad l_k = -\frac{u_{cc} \lambda f_{kl}}{\Delta} > 0, \tag{20}$$

$$b_\lambda = -\frac{f_{kl}(u_{cc} + u_{cl})}{h''\Delta} > 0, \quad b_k = \frac{f_{kk} + l_k f_{kl}}{h''} < 0, \tag{21}$$

where we have used the facts that

$$\begin{aligned} f_{kk} + l_k f_{kl} &= f_{kk} - f_{kl} \frac{u_{cc} \lambda f_{kl}}{\Delta} \\ &= \frac{f_{kk}(u_{cc} u_{ll} - u_{cl}^2) + \lambda u_{cc}(f_{kk} f_{ll} - f_{kl}^2)}{\Delta} < 0, \end{aligned}$$

and $\Delta = u_{cc}(u_{ll} + \lambda f_{ll}) - u_{cl}^2 = u_{cc} u_{ll} - u_{cl}^2 + u_{cc} \lambda f_{ll} > 0$.

Equations (19), (20), and (21) imply that with the increase of the marginal utility of wealth, labor supply and foreign borrowing will increase, but the consumption level will decrease. For the effects of changes in the capital stock, an increase in the capital stock will raise labor supply and reduce foreign borrowing: $l_k > 0$ and $b_k < 0$. This is true because an increase in the capital stock will lead to a higher marginal productivity of labor ($f_{kl} > 0$), thus the real wage rate will increase, and the agent will work more. At the same time, more capital stock leads to more output, and the agent will reduce his foreign borrowing. For the effect of the capital stock on consumption, it is reasonable to assume that the marginal utility of consumption increases with leisure, in which case, $u_{cl} < 0$, as in Turnovsky (1995). Hence an increase in the capital stock reduces consumption: $c_k < 0$.

Dynamic System

Substituting equations (16), (17), and (18) into equations (6) and (13), we have the following dynamic system:

$$\frac{d\lambda}{dt} = \lambda(\rho - f_k(k, l(\lambda, k))), \tag{22}$$

$$\frac{dk}{dt} = \frac{1}{1 - b_k}[f(k, l(\lambda, k)) + a - c(\lambda, k) - h(b(\lambda, k)) + \lambda b_\lambda(\rho - f_k(k, l(\lambda, k)))]. \tag{23}$$

Equations (22) and (23) determine the intertemporal k and λ. With k and λ, we can determine consumption, labor supply, and foreign borrowing from equations (16), (17), and (18).

The steady-state k^* and λ^* of k and λ for the dynamic system of (22) and (23), reached when $d\lambda/dt = dk/dt = 0$, can be derived from the following equations:

$$\lambda^*(\rho - f_k(k^*, l(\lambda^*, k^*))) = 0, \tag{24}$$

$$\frac{f(k^*, l(\lambda^*, k)) + a - c(\lambda^*, k^*) - h(b(\lambda^*, k^*)) + \lambda^* b_\lambda(\rho - f_k(k^*, l(\lambda^*, k^*)))}{1 - b_k} = 0. \tag{25}$$

Equations (24) and (25) are equivalent to

$$\rho - f_k(k^*, l(\lambda^*, k^*)) = 0, \tag{26}$$

$$f(k^*, l(\lambda^*, k^*)) + a - c(\lambda^*, k^*) - h(b(\lambda^*, k^*)) = 0. \tag{27}$$

Equations (26) and (27) describe the long-run behavior of the economy. Equation (26) implies that the long-run marginal productivity of capital stock equals the time preference of the consumer. Equation (27) states that, in the long run, output and foreign aid are used to consume and pay the cost of foreign borrowing.

Linearizing the system of (22) and (23) at the steady state, we obtain

$$\begin{pmatrix} \frac{dk}{dt} \\ \frac{d\lambda}{dt} \end{pmatrix} = \begin{pmatrix} w_{11} & w_{12} \\ -\lambda^* w_{21} & -\lambda^* w_{22} \end{pmatrix} \begin{pmatrix} k - k^* \\ \lambda - \lambda^* \end{pmatrix}, \tag{28}$$

where

$$w_{11} = \frac{1}{1 - b_k}(f_k + f_l l_k - c_k - h' b_k - \lambda b_\lambda f_{kl} - \lambda b_\lambda f_{kl} l_k),$$

$$w_{12} = \frac{1}{1 - b_k}(f_l l_\lambda - c_\lambda - h' b_\lambda - \lambda b_\lambda f_{kl} l_\lambda),$$

$$w_{21} = f_{kk} + f_{kl} l_k < 0, \quad w_{22} = f_{kl} l_\lambda > 0.$$

With the perfect-foresight assumption, the equilibrium is saddle-point stable. Therefore, one of the two eigenvalues of the first matrix on the right-hand side of (28) is negative, and one is positive. Denote the positive eigenvalue as μ_2 and the negative one as μ_1. Hence, the determinant of the matrix is negative since it is equal to the product of the two eigenvalues.

The general form of the solution to (28) is given by

$$k = k^* + A_1 e^{\mu_1 t} + A_2 e^{\mu_2 t}$$

$$\lambda = \lambda^* - \frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_1} A_1 e^{\mu_1 t} - \frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_2} A_2 e^{\mu_2 t}, \tag{29}$$

with the constants A_1 and A_2 being determined by the initial condition and the transversality condition. With the saddle-point stability, the phase diagram is depicted in Figure 1.

Substituting the initial condition and TVC into equation (29), we have

$$k = k^* + (k_0 - k^*) e^{\mu_1 t},$$

$$\lambda = \lambda^* - \frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_1}(k_0 - k^*) e^{\mu_1 t}. \tag{30}$$

Now we get two paths. One is a stable path, denoted by xx in Figure 1:

$$\lambda - \lambda^* = -\frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_1}(k - k^*); \tag{31}$$

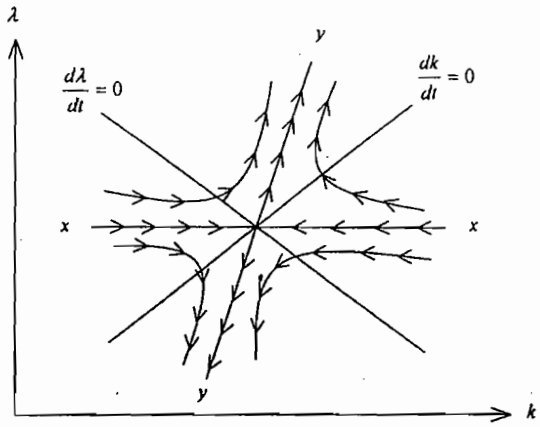

Figure 1. Saddle-Point Stability of the Steady State

Another one is the unstable path, denoted by *yy* in Figure 1:

$$\lambda - \lambda^* = \frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_2}(k - k^*). \tag{32}$$

Along the stable path, capital accumulation, $k(t)$, and the marginal utility of wealth, $\lambda(t)$, will converge to the steady state (k^*, λ^*).

3. Effects of a Permanent Rise in Foreign Aid

Long-Run Effects on Capital Accumulation, Consumption, and Foreign Debt

Obstfeld (1999) has introduced foreign aid into the standard Ramsey–Cass–Koopmans model and studied the dynamic behavior of consumption and investment. He finds that, in the long run, foreign aid has no effect on the capital stock, and that it only increases the long-run consumption level by the same amount. In our present model we find very different results.

Differentiating equations (26) and (27) yields

$$\begin{pmatrix} w_{11} & w_{22} \\ -\lambda^* w_{21} & -\lambda^* w_{22} \end{pmatrix}\begin{pmatrix} dk^* \\ d\lambda^* \end{pmatrix} = \begin{pmatrix} -\dfrac{1}{1-b_k} \\ 0 \end{pmatrix} da. \tag{33}$$

Hence:

$$\frac{d\lambda^*}{da} = \frac{-\lambda^* w_{21}}{D}\frac{1}{1-b_k} < 0,$$
$$\frac{dk^*}{da} = \frac{\lambda^* w_{22}}{D}\frac{1}{1-b_k} < 0, \tag{34}$$

because $D = -\lambda^* w_{22} w_{11} + w_{12}\lambda^* w_{21} < 0$, $w_{21} < 0$, and $w_{22} > 0$.

Equations (34) say that a permanent increase in foreign aid inflows will decrease the steady-state capital stock. This is because a rise in foreign aid raises the agent's per-

manent income. The agent reacts to this rising income by increasing consumption, cutting investment, and reducing his long-run accumulation of capital.

From equations (21) and (34) we get the long-run effects of foreign aid on foreign borrowing as follows:

$$\frac{db}{da} = b_\lambda \frac{d\lambda^*}{da} + b_k \frac{dk^*}{da},$$

which does not have a definite sign at a first look because the first term on the right-hand side is negative, whereas the second term on the right-hand side is positive. But some tedious calculations yield that

$$\frac{db}{da} = \frac{f_{kl}(u_{cc} + u_{cl})}{h''\Delta} \frac{-\lambda^* w_{21}}{D} \frac{1}{1-b_k} + \frac{f_{kk} + l_k f_{kl}}{h''} \frac{\lambda^* w_{22}}{D} \frac{1}{1-b_k} = 0.$$

Therefore, a permanent rise in foreign aid has no effects on long-run foreign borrowing. In this model, a permanent rise in foreign aid decreases the marginal utility of wealth and increases foreign borrowing; but at the same time, a permanent increase in foreign aid results in a lower capital stock, which in turn reduces foreign borrowing. These two effects exactly offset each other in our model, and leave long-run foreign borrowing unchanged. In Gong and Zou (2000) it is shown that, if the agent's time preference is a function of his utility as in Uzawa (1968), an increase in foreign aid will lead to more foreign borrowing.

Equations (20) and (34) lead to the following effect of foreign aid on the long-run consumption level:

$$\frac{dc}{da} = \frac{u_{cl}\lambda^2 f_{kl}^2 - (f_{kk} + f_{kl} l_k)(u_{ll} + \lambda f_{ll} + u_{cl} f_l)}{D\Delta} > 0. \tag{35}$$

Hence, from equation (35), we know that a permanent increase in foreign aid will increase the steady-state consumption level.

As for the effect of foreign aid on the long-run labor supply, from equations (19) and (34) we have

$$\frac{dl}{da} = \frac{l_\lambda \lambda(-\Delta w_{21} - u_{cc} f_{kl}\lambda)}{D\Delta} < 0, \tag{36}$$

because $D < 0, \Delta > 0, l_\lambda > 0, w_{21} < 0$, and $f_{kl} > 0$. Equation (36) asserts that a permanent rise in foreign aid will decrease the labor supply of the agent. This is because a higher level of foreign aid decreases the steady-state capital stock. A lower capital input must decrease the real return on labor (the real wage rate) because $f_{lk} > 0$. Therefore, the agent will reduce his labor supply. At the same time, a rise in foreign aid leads to more income for the agent, and he can afford to work less without reducing his consumption.

To sum up, a permanent rise in foreign aid reduces capital accumulation and labor supply, increases consumption, and generates no effect on foreign borrowing.

Initial Effects of a Permanent Rise in Foreign Aid

Suppose that the economy is initially in the steady state, and suppose that there is a permanent rise in foreign aid. Because the initial equilibrium capital stock $k(0)$ (the state variable) cannot jump, we have $\partial k(0)/\partial a = 0$. But for other variables, the resulting changes can be derived. Here we focus on how the permanent change in foreign

aid affects the initial consumption level, $c(0)$, the initial labor supply, $l(0)$, the initial foreign borrowing, $b(0)$, and the initial marginal utility of wealth, $\lambda(0)$.

First, from the short-run equilibrium conditions (16), (17), and (18), we have

$$\frac{\partial c(0)}{\partial a} = c_\lambda \frac{\partial \lambda(0)}{\partial a},$$
$$\frac{\partial l(0)}{\partial a} = l_\lambda \frac{\partial \lambda(0)}{\partial a},$$
$$\frac{\partial b(0)}{\partial a} = b_\lambda \frac{\partial \lambda(0)}{\partial a}. \tag{37}$$

Along the stable path xx, we get

$$\frac{\partial \lambda(0)}{\partial a} = \frac{\partial \lambda^*}{\partial a} + \frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_1} \frac{\partial k^*}{\partial a} < 0, \tag{38}$$

because $\partial\lambda^*/\partial a < 0$, $\partial k^*/\partial a < 0$, and $\lambda^* w_{21}/(\lambda^* w_{22} + \mu_1) > 0$.

From equations (37), we know that a permanent rise in foreign aid will decrease the initial marginal utility of wealth. In turn, from (37) we get

$$\frac{\partial c(0)}{\partial a} > 0, \quad \frac{\partial l(0)}{\partial a} < 0, \quad \frac{\partial b(0)}{\partial a} < 0. \tag{39}$$

Expressions (39) assert that a permanent increase in foreign aid will increase the initial consumption level, but decrease the initial labor supply and initial foreign borrowing. Furthermore, because a permanent increase in foreign aid increases the agent's total wealth, the marginal utility of wealth will be lower: $\partial\lambda(0)/\partial a < 0$ as shown in (38). At the same time, the decrease in the marginal utility of wealth will increase the initial consumption.

The dynamic adjustment is described in Figure 2. With a permanent rise in foreign aid, the marginal utility of wealth, $\lambda(0)$, will jump down from λ' to λ_1^*, while maintaining the initial capital stock, k'. Hence, the economy will initially move from A to P. After the initial jump, the economy will move along the new stable path $x'x'$ and converge to the new steady-state Q with a lower marginal utility of wealth, λ_1^*, and a lower capital stock, k_1^*.

Effects on Welfare

Recall that the instantaneous utility of the representative agent at time t is

$$Z(t) = u(c(t), l(t)),$$

and the welfare of the agent is

$$w = \int_0^\infty u(c(t), l(t)) e^{-\rho t} dt = \int_0^\infty Z(t) e^{-\rho t} dt. \tag{40}$$

Differentiating equation $Z(t)$ with respect to a, we have

$$\frac{dZ}{da} = u_c \frac{dc}{da} + u_l \frac{dl}{da} = u_c \left(\frac{dc}{da} - f_l \frac{dl}{da} \right), \tag{41}$$

where we have used the first-order condition (10).

From the equilibrium in the product market, we have

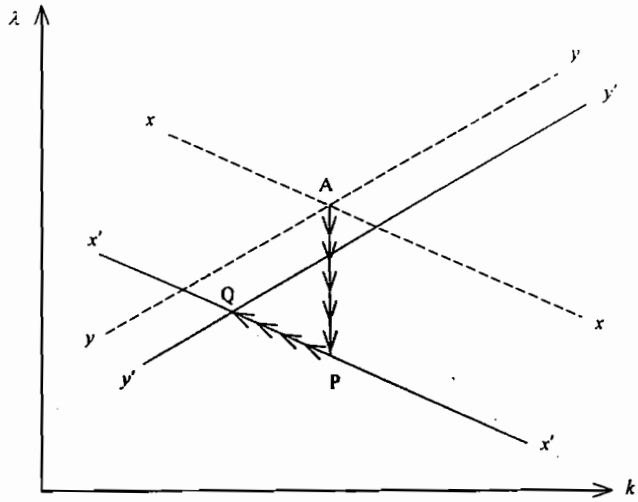

Figure 2. Dynamic Adjustment

$$f(k,l) = c + h(b) + \frac{dk}{dt} - a - \frac{db}{dt}. \tag{42}$$

Differentiating the above equation, we obtain

$$f_k \frac{dk}{da} + f_l \frac{dl}{da} = \frac{dc}{da} + \frac{d}{da}\left(\frac{dk}{dt}\right) - 1 + h' \frac{db}{da} - \frac{d}{da}\left(\frac{db}{dt}\right). \tag{43}$$

Substituting (43) into (41) yields

$$\frac{dZ}{da} = u_c + u_c\left[f_k \frac{dk}{da} - \frac{d}{da}\left(\frac{dk}{dt}\right) - h' \frac{db}{da} - b\lambda \frac{d}{da}\left(\frac{d\lambda}{dt}\right) - b_k \frac{d}{da}\left(\frac{dk}{dt}\right)\right]. \tag{44}$$

Using the dynamic path of the capital stock of equation (30) in (44), we arrive at

$$\begin{aligned}\frac{dZ}{da} &= u_c + u_c\left[f_k(1 - e^{\mu_1 t}) + \mu_1 e^{\mu_1 t} \frac{dk^*}{da} - h' \frac{db}{da}\right] \\ &\quad + u_1 u_c\left[b_\lambda \frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_1} - b_k\right] e^{\mu_1 t} \frac{dk^*}{da}.\end{aligned} \tag{45}$$

Now the effects of foreign aid on the initial instantaneous utility, $Z(0)$, and the steady-state utility, Z^*, are given as

$$\begin{aligned}\frac{dZ(0)}{da} &= u_c + u_c \mu_1\left[1 - b_k + b_\lambda \frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_1}\right] \frac{dk^*}{da} - h' \frac{db(0)}{da}, \\ \frac{dZ^*}{da} &= u_c + u_c f_k \frac{dk^*}{da}.\end{aligned} \tag{46}$$

Linearizing $Z(t)$ around the steady state, we have

$$Z(t) = Z^* + (Z(0) - Z^*)e^{\mu_1 t}. \tag{47}$$

Substituting equation (47) into (40), we get

$$w = \frac{Z^*}{\rho} + \frac{(Z(0) - Z^*)}{\rho - \mu_1}. \tag{48}$$

Hence we have

$$\frac{dw}{da} = \frac{1}{\rho}\left(u_c + u_c f_k \frac{dk^*}{da}\right) - u_c \frac{f_k - \mu_1}{\rho - \mu_1}\frac{dk^*}{da} - \frac{h'}{\rho - \mu_1}\frac{db(0)}{da} + \frac{1}{\rho - \mu_1}u_1 u_c\left[b_\lambda \frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_1} - b_k\right]\frac{dk^*}{da} \tag{49}$$

Noting the condition $f_k = \rho$, we rewrite (49) as

$$\frac{dw}{da} = \frac{u_c}{\rho} - \frac{h'}{\rho - \mu_1}\frac{db(0)}{da} + \frac{1}{\rho - \mu_1}\mu_1 u_c\left[b_\lambda \frac{\lambda^* w_{21}}{\lambda^* w_{22} + \mu_1} - b_k\right]\frac{dk^*}{da} > 0, \tag{50}$$

which is positive because $h'/(\rho - \mu_1) > 0$, $db(0)/da < 0$, $b_\lambda \lambda^* w_{21}/(\lambda^* w_{22} + \mu_1) - b_k > 0$, and $dk^*/da < 0$.

Equation (50) implies that a permanent increase in foreign aid will raise welfare. This is because foreign aid increases the consumption level and reduces labor supply (i.e., increases leisure), even though it reduces the long-run capital accumulation and output.

4. Effects of Temporary Foreign Aid

In this section we consider temporal foreign aid. Suppose that initially, at time $t = 0$, there is no foreign aid; and at time $t > 0$ the agent receives one unit of foreign aid; i.e.,

$$\begin{aligned} a &= 1, \quad t \in (0, T] \\ a &= 0, \quad \text{otherwise.} \end{aligned} \tag{51}$$

Because foreign aid is temporal, in the long run the economy will return to its initial steady state. We need to consider only the transitional adjustment path, which is illustrated in Figure 3. When there is a temporal increase in foreign aid, the stable path and the unstable path are $x'x'$ and $y'y'$. If foreign aid is permanent, the system initially jumps to point P from point A, and along the stable path goes to the new steady state Q. But if foreign aid is temporal, the fall in $\lambda(0)$ falls short of its response to the permanent increase in foreign aid. This leaves the economy at some intermediate point, such as L. When foreign aid lasts, the economy moves along the unstable path LM and reaches the original stable locus at point M. When foreign aid ends, the economy moves along the old stable path from point M to the original steady state A.

Following Turnovsky (1995), we can provide a quantitative evaluation of the effect of temporal foreign aid on the endogenous variables in our dynamic system. In fact, the dynamic adjustment is divided into two periods. First, at time $t = 0$, the economy is at steady state (k_0^*, λ_0^*) associated with the foreign aid level $a = 0$. For the inflows of temporal foreign aid at time period $[0,T]$, the steady state associated with foreign aid a is (k_1^*, λ_1^*), and we know that around the steady state the economy moves along the paths

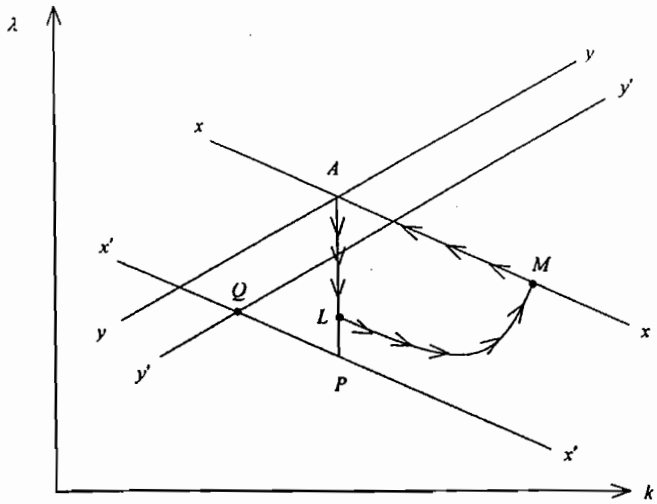

Figure 3. Adjustment to Temporal Foreign Aid

$$k = k_1^* + A_1 e^{\mu_1 t} + A_2 e^{\mu_2 t},$$
$$\lambda = \lambda_1^* - \frac{\lambda_1^* w_{21}}{\lambda_1^* w_{22} + \mu_1} A_1 e^{\mu_1 t} - \frac{\lambda_1^* w_{21}}{\lambda_1^* w_{22} + \mu_2} A_2 e^{\mu_2 t}. \tag{52}$$

After time T, we again have $a = 0$, and the economy goes back to the original steady state of (k_0^*, λ_0^*). Around the steady state, we have

$$k = k_0^* + A_1' e^{\mu_1 t} + A_2' e^{\mu_2 t},$$
$$\lambda = \lambda_0^* - \frac{\lambda_0^* w_{21}}{\lambda_0^* w_{22} + \mu_1} A_1' e^{\mu_1 t} - \frac{\lambda_0^* w_{21}}{\lambda_0^* w_{22} + \mu_2} A_2' e^{\mu_2 t}, \tag{53}$$

where the constants A_1, A_2, A_1', and A_2' will be determined by initial conditions and other conditions for k and λ. First, notice that the TVC gives $A_2' = 0$. The other constants will be determined by

$$k_0 = k_1^* + A_1 + A_2, \tag{54}$$

and the smooth conditions of the solutions. For the solutions to k and λ to be continuous for $t > 0$, and in particular for $t = T$, the solutions for (52) and (53) must coincide; namely:

$$k_1^* + A_1 e^{\mu_1 T} + A_2 e^{\mu_2 T} = k_0^* + A_1' e^{\mu T}, \tag{55}$$

$$\lambda_1^* - \frac{\lambda_1^* w_{21}}{\lambda_1^* w_{22} + \mu_1} A_1 e^{\mu_1 T} - \frac{\lambda_1^* w_{21}}{\lambda_1^* w_{22} + \mu_2} A_2 e^{\mu_2 T} = \lambda_0^* - \frac{\lambda_0^* w_{21}}{\lambda_0^* w_{22} + \mu_1} A_1' e^{\mu_1 T}. \tag{56}$$

From equations (54), (55), and (56), we get

$$A_1 = \frac{e^{\mu_1 T}}{H}[(k_0 - k_1^*)(c_3 - c_2)e^{\mu_2 T} - (\lambda_0^* - \lambda_1^*) - c_3(k_0^* - k_1^*)],$$

$$A_2 = \frac{e^{\mu_1 T}}{H}[(\lambda_0^* - \lambda_1^*) + c_3(k_0^* - k_1^*) - (k_0 - k_1^*)(c_3 - c_1)e^{\mu_2 T}],$$

$$A_1' = \frac{e^{\mu_2 T}}{H}[(\lambda_0^* - \lambda_1^*) + c_2(k_0^* - k_1^*)](1 - e^{(\mu_1 - \mu_2)T})$$
$$-(c_2 - c_1)e^{\mu_2 T}(k_0 - k_1^* - (k_0^* - k_1^*)e^{-\mu_2 T}),$$

where

$$c_1 = \frac{\lambda_1^* w_{21}}{\lambda_1^* w_{22} + \mu_1}, \quad c_2 = \frac{\lambda_1^* w_{21}}{\lambda_1^* w_{22} + \mu_2}, \quad c_3 = \frac{\lambda_0^* w_{21}}{\lambda_0^* w_{22} + \mu_1},$$

and $H = e^{\mu_1 T}((c_3 - c_2)e^{\mu_2 T} - (c_3 - c_1)e^{\mu_1 T})$.

To see the welfare change of a temporal foreign aid, we substitute A_1, A_2, and A_1' back into equations (52) and (53), and get the paths for capital accumulation and the marginal utility of wealth under temporal foreign aid. We approximate the utility function with its linear expansion at the steady state; namely:

$$\begin{aligned} Z(t) &= u(c(\lambda, k), l(\lambda, k)) \\ &= u(c(\lambda^*, k^*), l(\lambda^*, k^*)) + u_c c_\lambda(\lambda - \lambda^*) + u_c c_k(k - k^*) \\ &\quad + u_l l_\lambda(\lambda - \lambda^*) + u_l l_k(k - k^*). \end{aligned}$$

Hence:

$$\begin{aligned} Z(t) &= u(c(\lambda_1^*, k_1^*), l(\lambda_1^*, k_1^*)) + u_c c_\lambda(\lambda - \lambda_1^*) + u_c c_k(k - k_1^*) \\ &\quad + u_l l_\lambda(\lambda - \lambda_1^*) + u_l l_k(k - k_1^*) \end{aligned}$$

when $t \in [0, T]$, and

$$\begin{aligned} Z(t) &= u(c(\lambda_0^*, k_0^*), l(\lambda_0^*, k_0^*)) + u_c c_\lambda(\lambda - \lambda_0^*) + u_c c_k(k - k_0^*) \\ &\quad + u_l l_\lambda(\lambda - \lambda_0^*) + u_l l_k(k - k_0^*), \end{aligned}$$

when $t > T$.

Now, welfare is given by

$$\begin{aligned} w &= \int_0^T Z(t)e^{-\rho t}dt + \int_T^\infty Z(t)e^{-\rho t}dt \\ &= \frac{(1 - e^{-\rho T})u(c(\lambda_1^*, k_1^*), l(\lambda_1^*, k_1^*))}{\rho} \\ &\quad - (u_c c_\lambda + u_l l_\lambda)\left[c_1 A_1 \frac{e^{(\mu_1 - \rho)T} - 1}{\rho - \mu_1} + c_2 A_2 \frac{e^{(\mu_2 - \rho)T} - 1}{\rho - \mu_2}\right] \\ &\quad + (u_c c_k + u_l l_k)\left[A_1 \frac{e^{(\mu_1 - \rho)T} - 1}{\rho - \mu_1} + A_2 \frac{e^{(\mu_2 - \rho)T} - 1}{\rho - \mu_2}\right] \frac{u(c(\lambda_0^*, k_0^*), l(\lambda_0^*, k_0^*))}{\rho} e^{-\rho T} \\ &\quad + (u_c c_\lambda + u_l l_\lambda)c_3 A_1' \frac{-e^{(\mu_1 - \rho)T}}{\rho - \mu_1} + (u_c c_k + u_l l_k)A_1' \frac{-e^{(\mu_1 - \rho)T}}{\rho - \mu_1}. \end{aligned}$$

The expression above does not have a definite sign, and hence the welfare effect of a temporal foreign aid is ambiguous. This ambiguous welfare effect of a temporal foreign

aid shall be compared with a definite rise in welfare as a result of a permanent increase in foreign aid in section 3.

5. Conclusion

In an optimal growth model with foreign aid, foreign borrowing, and endogenous leisure-and-consumption choices, it has been shown that a permanent rise in foreign aid reduces long-run capital accumulation and labor supply, increases long-run consumption, and generates no effect on long-run foreign borrowing. Foreign aid does raise welfare as it increases utility through a rising consumption and a reduced labor supply (more leisure). Even though one of the main goals of foreign aid is to promote economic development and growth in poor developing countries, the result may turn out to be just the opposite in light of our theory.

Our theoretical findings are not purely intellectual exercises at all. In fact, they are strongly supported by the negative relationship between external finance and domestic savings and investment found in many empirical studies. For example, it is found that there exists a clear negative impact of foreign finance on domestic savings in earlier empirical studies covering the period from the 1950s to the 1970s, by Griffin (1970), Griffin and Enos (1970), Fry (1978, 1980), and Giovannini (1983, 1985). More recently, with a more comprehensive coverage of developing countries over a longer time period, Boone (1994a,b) has also found that foreign aid has been mainly channeled into consumption and it has no relationship with investment and growth in many developing countries.

In this context, the study by Taylor and Williamson (1994) deserves some special attention. In the late nineteenth century there was mass capital flow from the Old World (e.g., Britain) to the New World (e.g., Argentina, Australia, and Canada). Taylor and Williamson found that the financial flow from Britain to Argentina, Australia, and Canada significantly depressed savings rates in the three countries.

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附　　录

永恒的怀念

激情讲述与董辅礽、让-雅克·拉丰和杨小凯有关的故事*

邹恒甫

一代经济学大师董辅礽先生2004年7月30日在美国病逝后，人民网记者在武汉大学有幸见到了与董辅礽先生身前有过长期密切交往、目前在国内讲学、埋头办教育的著名经济学家邹恒甫教授。一向低调的邹恒甫教授这次并没有回避媒体，他欣然接受了记者专访。我们听他娓娓讲述董辅礽先生和与之相关的鲜为人知的故事，听他激情畅谈他们之间的深厚友谊，听他深情缅怀经济学界三颗巨星的先后陨落，听他慨叹人生的聚散离合与无常。

在这里，我们要简单地介绍一下著名经济学家邹恒甫教授。邹恒甫教授1962年出生于湖南华容县，恢复高考后，他顺利考取了武汉大学，入校那年他只有15岁。他在武汉大学读了四年经济学，毕业后进入哈佛大学攻读经济学博士学位。他成了新中国成立以来第一个进入哈佛大学经济系的中国学生，也是建国以来中国第一个哈佛经济学博士。他现为世界银行研究部终身高级经济学家，在那里研究发展中国家的储蓄和增长、收入分配和地方财政。他已经发表论文60余篇，其中40多篇发表在国外经济学杂志上。他在国际经济学领域的排名十分靠前。邹恒甫教授在中西方经济学界可谓一位传奇性人物。世界银行丰厚的年薪足以让他过上极为优越的生活，但他毅然游走于东西方文化和经济学与教育之间，在中国的诸多经历依然让他痴心不改，决然要为自己的祖国为母校武汉大学做点事情。

在世界经济学领域奋斗的邹恒甫教授，怀着一颗报国的赤子之心，投身中国的经济学教育领域。他在武汉大学、北京大学悄悄地进行着全新的经济学教育改革实验，全套引进西方最先进的教育模式，使这两所著名高校尤其是武汉大学的数理金融经济学教育为世界瞩目。十年来，仅在武汉大学，他就把那里的上百位优秀学生先后送往美国和欧洲的一流大学深

* 本文系2004年7月末人民网记者采访邹恒甫教授的访谈录。

造。他还在武汉大学办起了国学、历史、哲学等实验班，取得了累累硕果。有评论说，中国的经济学和与其相关的教育在邹恒甫教授的带动下，其历史必定重写。

邹恒甫教授现在是武汉大学高级研究中心主任，武汉大学 EMBA 和高级培训中心学术指导委员会主任，武汉大学经济学教授、博士生导师。北京大学一级教授、北京大学董辅礽经济学讲座教授；中山大学岭南学院学术委员会联合主席、中山大学岭南学院岭南讲座教授；浙江大学特聘顾问教授；《经济研究》杂志特约联合主编。他一个人就参与了两个国家一级重点学科。他与厉以宁教授同是北京大学国民经济管理学国家一级重点学科学术带头人，与谭崇台教授同是武汉大学西方经济学国家一级重点学科学术带头人。

一、在武汉大学浓厚的学术氛围里加深了解董辅礽先生

记者：邹教授，您和董辅礽先生的深厚友谊外界早有传闻，请问，您是什么时候认识董辅礽先生的？他最初给您留下了什么样的印象？

邹恒甫：1978 年，董老师到我就读的武汉大学作一场学术报告，我听了他的报告后，当时就有这么一种感觉：这个人与别的人不一样，有思想，很了不起。我在那个学术报告上第一次听董老师讲了许多新奇的理论观点。在当时的情况下，我们不能谈论社会主义的利润，不能谈社会主义的生产价格，而董老师给我们讲述如此离经叛道的学术观点是要冒巨大的政治和学术风险的。对于那个时代，那是多么伟大的思想！

他给我的印象是有雄辩的口才，有鲜明的思想，有学者的风度，是很征服人的教授。他当时对我们年轻人讲了三句深刻的话，令我至今不忘。他说："你们学经济学一定要学好三样东西，一是要学好数学，二是要学好形式逻辑和哲学，三是要学好英语。"

多年后，我对我的学生也说这同样的话，当然，我又加了一句，要学好中文。

记者：您后来对董辅礽先生又有一些什么新的了解呢？

邹恒甫：1978 年至 1983 年 8 月，我在武汉大学学习期间，正是中国经济学大变革的时期，当时的中国有两件事情让人无法忘记，一是对社会主义经济理论的大反思，第二是西方经济理论的大量引进。前者就是以董老师为首的，当然，中间还包括了于光远、薛暮桥等一批前辈人物，他们大胆深刻地反思社会主义经济理论和实践，勇敢尖锐地提出了自己的理论主张。那时的董老师还只有 50 多岁，但观点鲜明、锐气逼人。后者是以张培刚、陈岱孙、吴纪先、谭崇台、厉

以宁等为代表的一批人，他们大力引进西方主流派经济学理论。中西冲撞，真可谓文明的大冲撞。

当时中国经济学界的许多重量级人物都与我就读的武汉大学产生关联，我把他们称作“武大学派”。他们的学术理论走到了最前面。董老师是武大的校友，这不用说，他与我的老师曾启贤是挚友，他们都是在武大任教的张培刚的学生。因为曾启贤老师，我对董老师有了更多的了解。我这里要谈到我尊敬的老师曾启贤，他1989年过世了，可以说他是武汉大学经济学里最伟大的人，他懂西方经济学，也懂中国，还懂得尊重他人。董老师与曾老师交流很多。曾老师把董老师、于光远、薛暮桥等人的一些最新思想带到了武汉大学。还有从哈佛回国的以张培刚、谭崇台为首的研究西方经济学的教授，以及同是从哈佛回国的吴纪先老师、刘涤源老师，从耶鲁回国的李崇淮、周新民，从威斯康新回国的朱景尧等一大批了解西方经济学的人物。他们齐聚武大，真可谓群星灿烂，光华四溢。我就在这种良好的学术环境里成长。尤其是董老师，他能够把东欧社会主义改革的一些最前沿的理论及时带给我们，我们还能够亲眼目睹他提出一系列新思想的过程，这对我的启发很大。我认为我当时很好地把握了时代的脉搏，加上得到西方经济学的熏陶，使我在同辈人中有很强的优越感。

二、董辅礽先生是我从哈佛回来后交到的最好的师友

记者：邹教授，我们了解到，您从哈佛回来后，才真正开始了同董辅礽先生的学术交往，你们是如何成为朋友的？您能为我们回顾一下这段时期的一些经历吗？

邹恒甫：1987年我从哈佛回来，带着西方经济学回到武大，回到中国，我那时年轻癫狂，目中无人。我认为当时中国的一批经济学家的思想不新不旧，我走在他们的前面已经很远，他们在我的后面爬行。我甚至在董老师和曾启贤老师面前说些让他们难受的话。我提出对中国的现有经济学理论和实践进行全盘重新思考。董老师却以非常平易的态度对待我，认真听我高谈阔论，在老师看来，这些东西不是那么好评价的。他们还不断地鼓励我多思考，充分表现出了大学者的高风亮节。我后来才知道，老师的那种胸怀是一般人很难企及的。董老师那时才57岁，名声显赫，风光无限，能有那样谦和的胸怀是多么的不容易啊。越往前走，越令我感动不已。这个时期，谭崇台和张培刚老师也给了我很多关怀。

1989年，我的老师曾启贤去世。董老师先后写了一系列文章纪念曾老师，并阐释曾老师的一些理论主张和思想。1999年，在曾老师去世10年之际，董老

师又重新写文章纪念曾老师，写他的为人，写他的学术，表现出了一个学者的高尚情操，给我印象极深。曾老师作为我的最好的老师之一，我至今也没有为他写过一篇文章，这令我惭愧。我是1989年5月从哈佛毕业的，曾老师此前过世了。我曾答应过曾老师，我要以儿子的身份把曾老师接到美国，把他安排在一个十分舒适、幽静的地方，让他研究，让他思考。然而，这已成了一个巨大的遗憾，常常让我愧疚万分。1989年8月，在我进入世界银行研究部的前后，我在学术上与中国联系最多的是董老师、张培刚老师和谭崇台老师，许多学术交流都是在这三人之间进行的。

可以这样说，董老师是我回到中国后交到的最好的师友。1991年，是我人生的一个很大的转折点，董老师和厉以宁老师联合推荐我到北京大学就职，北京大学给我副教授职务，但我没有接受。从那个时候开始，我就动了一个很大的心愿，想在国内组建一个先进的经济科学高级研究中心。当时的政治环境还很紧张，直到1993年这个事情才有了眉目。1994年，武汉大学经济科学高级研究中心正式挂牌。董老师一开始就对我要做的事情全力支持并倾注了很多心血。中心的第一台空调就是董老师捐钱买的，那时的空调是很贵的，一台要8000多元人民币。董老师还号召他的学生们都来支持我，鼓动他所有能赚钱的学生给中心捐钱。董老师在有很多领导参加的中心揭牌仪式上说了这样的话："在武汉大学的历史上，经济学的革命有两次，一次是1947年张培刚先生从哈佛回到了武大，第二次就是现在，邹恒甫从哈佛回来了。"董老师的话在当时给了我巨大的鼓舞和鞭策，震撼心灵，终身难忘。

三、乐意助人、敢于直言，我觉得他更像我们湖南老乡

记者：您和董辅礽先生在不断的交往中产生了珍贵的友谊，他虚怀若谷，奖掖后学，乐意助人，您还能为我们讲述更多的关于他的故事吗？

邹恒甫：在那时，在人们的眼里，他是中国经济学的第一高手，但他从不以老师、专家自居。与他谈话很轻松，遇到什么问题，他总是说："恒甫，你怎么看待这个问题？"

由于我了解一些世界经济学前沿的知识，当时从国外带回了一些最新的经济学研究成果，还有很先进的教材，我把这些资料都送给董老师。董老师态度谦虚，总想着别人。这些书籍看过后，他希望通过我送给新一代的人，他总是说，这些好东西不能浪费了。他把那些国外最好的论文和教材都留给了后一代人。

我在国内创办了第一份全英文版的《经济金融年刊》，在一次记者招待会

上，董老师发表讲话："我在中国社会科学院任经济所所长的时候，想做的第一件事情，就是想办一份这样的刊物，我没有办成，邹恒甫现在办成了。"如此谦虚的胸怀，多年过去了，现在想起来，仍然令我汗颜。

这些年来，我一直在北京大学、武汉大学进行经济学的现代化教育的全面探索和改革，尤其在武汉大学，从始至终，董老师都在关注我实施的改革计划，他不停地鼓励我，尽全力支持我。

在一次有国家教育部和省教育厅有关领导参加的视察武汉大学高级研究中心的座谈会上，董老师直言不讳："当高级研究中心还是一棵幼苗时，国内有人想把她扼杀在摇篮中，现在有成绩了，许多人又来摘桃子。"董老师振聋发聩的话语，敢于直言的精神，令我无比钦佩。从许多方面看，我觉得他更像我们湖南老乡。

记者：由您组建的由董辅礽先生出任联合主任的武汉大学的 EMBA 中心在国内乃至世界上都有了很大的影响，董辅礽先生和您一起办 EMBA 教育，这中间一定有很多的故事？

邹恒甫：2002 年，我在武汉大学组建 EMBA 中心，董老师应我的邀请，欣然同意出任该中心的联合主任，另一个联合主任是前不久去世的法国著名经济学家让-雅克·拉丰。短短两年，我们共同见证、亲历了创办 EMBA 中心的全部艰辛。这中间的许多曲折故事是无法在短时间里讲完的。我，董老师还有前不久去世的法国著名经济学家任 EMBA 中心联合主任的拉丰，我们共同努力，从无到有，全部聘请世界一流大学的包括多名诺贝尔经济学奖得主在内的著名教授为学员授课，被业界和媒体认为是中国 EMBA 教育的奇迹。这中间，董老师付出了很多心血。

董老师是 2002 年 8 月就任中心联合主任的。上任后，他就和雅克·拉丰在北京、武汉、长沙、深圳、苏州等地为之奔走呼号。最令我感动的是 2003 年 8 月下旬的一天，下午 4 点，董老师从美国回到北京，一刻也没停留，便转飞苏州。由于飞机延误，他到苏州时已是凌晨 3 点。董老师休息了三个小时便匆匆奔赴苏州大学作学术报告。他的时差还没有调整过来就一口气作了两场报告。我记得他那次报告讲的是所有制问题。因为他是著名的"董所有"，他从马克思的德文版《共产党宣言》谈起，特别是说到书中关于消灭私有制的中文翻译，他强调那个"消灭"在德文里不是消灭，而是扬弃。

我们一起在艰难和快乐中创办、探索中国的 EMBA 教育，刚刚有了一个良好的开端，不幸的是两位 EMBA 的联合主任都先后患癌症离开了我们。拉丰是 2004 年 5 月 1 日去世的，董老师在拉丰去世后不到 3 个月的时间里也离开了我们。加上我的好朋友、著名经济学家杨小凯，2004 年 6 月在董老师之前也在国外患癌症去世了。

四、三星同陨，我深刻地感悟生命的脆弱和无常

记者：几乎在一个夏天里，与您相知甚深的三位著名经济学家让-雅克·拉丰、杨小凯和董辅礽先生都先后离开了这个世界。你在这三个人中间，目睹了什么？见证了什么？我们相信您一定有太多的人生感悟。

邹恒甫：是的，他们都离开了我们。这种人生的变故和损失，对中国、对欧洲乃至对世界的经济学的影响无疑都是巨大的。一个夏天，三星同陨，这使我在很短的时间里深刻地感悟到了生命的脆弱和无常。我与董辅礽老师、拉丰和杨小凯之间，仿佛只有小说和电影里才有的许多故事，但这些故事却真实地发生在我的生活中。

在董老师得病之前，拉丰已身患肺癌。拉丰才57岁，他是欧洲经济学会的主席，被公认为是诺贝尔经济学奖最有力的竞争者之一。最初，当我知道拉丰患有癌症的时候，拉丰在精神上正处于全面崩溃的边缘。我记得在电话里他这样对我说："恒甫，我再也不能帮助你了，我再也不能帮助武汉大学EMBA了，我再也不能帮助中国了。"这是一种何等绝望的心理啊！

在这种情况下，最先伸出援手的是杨小凯。杨小凯与肺癌斗争了将近三年，表现出了超人的勇气和信心。他认为癌症病人都是被吓死的。他还举了芝加哥大学经济学系主任谢尔文·罗松为例，谢尔文·罗松知道自己患了癌症后，精神很快就崩溃了，很快就死去了。杨小凯认为，癌症是可以征服的。杨小凯给我发来了无数封电子邮件，还打来了许多电话，他的那些与癌症斗争的经验和故事通过我转发给拉丰。我成了他们之间的传声筒。杨小凯与拉丰并不相识，我把这些邮件和电话里的故事转告给拉丰，拉丰得到了巨大的鼓舞。杨小凯非常坚强，那时，我们还真的以为杨小凯的病已经完全好了，其实，杨小凯离自己生命的尽头已近在咫尺。杨小凯在他生命的最后时刻，用自己全部的生命激情和对人类的无限关怀让拉丰产生了生活的希望和求生的勇气。

2004年4月18日，我到洛杉矶去看望拉丰，看见他70磅都没有了，他原来有190多磅啊。那个时候，杨小凯已经处于癌症晚期，他已经不会说话了，只能用手写字。杨小凯比拉丰晚了一个多月离开这个世界。杨小凯皈依了上帝，55岁的杨小凯带着期待和欣慰进了他的天堂。我相信他一定是进了天堂。57岁的拉丰在5月1日的那天离开了我们，拉丰是带着对法国经济学和中国经济学的关注与爱以及无尽的遗憾离开这个世界的。拉丰在患病期间曾对我说过这样的话："如果我能像董辅礽老师那样活到70多岁，那该多么好啊，哪怕就是70岁也很好，那样我就可以更多地照顾我的孩子和家人，我还可以为经济学事业

做更多的事情啊。”如今，每当我想起这些话，就禁不住潸然泪下。

早在2003年9月，董老师就被确诊为癌症，董老师得知这个消息后，我们通了电话，他在电话里几乎说了和当时拉丰对我所说的同样的话。他说：“恒甫，我不能再帮助你了。”

我在震惊的同时，马上给他鼓励。我同样用杨小凯和拉丰的例子鼓励他，他精神为之一振，我的话还真的发生了作用。董老师跟家里人说：“恒甫告诉我了，这是有希望的，癌症是可以战胜的。”董老师的女儿和女婿都是研究癌症和生物方面的专家，他们都在美国杜克大学任终身教授。他们也认为董老师再活三五年是没有问题的。

董老师非常关注拉丰和杨小凯的情况。我又把杨小凯的故事转述给董老师，他听了很高兴。他要与癌症作斗争，他对生命充满了希望和信心。2004年3月，我去美国杜克大学看望董老师，发现他像往常一样，他说，除了手心有点痒，其他都很正常。我回到华盛顿，我给拉丰打了电话，告诉他我所见到的关于董老师的一些事情。拉丰在电话里骂了一句，他抱怨地说：“我们的事业怎么这么艰难啊！我们怎么这么倒霉啊！”

他们患病的三人中董老师年岁最高，77岁了，是最乐观的人。5月1日，拉丰去世后，我没有告诉董老师。董老师喜欢上网，他不久就知道了这个消息。5月下旬，他对我说，拉丰是不是走了？我说：“我自欺欺人，我一直不敢把这个消息告诉您。”当时，我感到董老师的心情非常沉重。后来不久他开始发低烧，癌细胞可能又发作了，我也知道关于董老师的治疗不是很乐观，死亡阴影正悄悄地向他袭来。

又过了不久，我邀请诺贝尔经济学奖得主卢卡斯来武汉大学进行学术交流。7月17日，我给董老师打电话，他第一句话就问，杨小凯是不是也走了。他说，他在网上已经看到了。我如实地告诉了他，我先前没有告诉他的原因是怕这个坏消息对他的精神打击太大。他说，没有关系，他说自己的情况有所好转。我听了还非常高兴。

2004年7月30日下午3点零3分，董老师在美国的杜克大学医疗中心永远地离开了这个世界。我很快就和他的女儿通了电话。我当时在中国，董老师去世的时候，我没有在他的身边陪伴他，这是我终身的遗憾。我现在唯一能够做的事情是继续他的事业，为中国，为武汉大学，能够多做一些事情，以告慰他的在天之灵。

五、我相信历史一定会给董辅礽先生以恰当公正的评价

记者：我们发现，董辅礽先生去世后，网上有对董辅礽先生正反两方许多不

同的评价。对此您有何看法?

邹恒甫:董老师去世后,许多人向我提到网上有一些人对他有非议。我认为,在改革开放的中国,出现这样的现象很正常,也符合学术的发展规律。我相信历史一定会给董辅礽老师以恰当公正的评价。

记者:最后,您有什么话要向大家说吗?

邹恒甫:我的朋友董辅礽老师、拉丰和杨小凯,他们三个人都是对学术有着崇高追求并影响世界和中国经济学的巨人。这些年来,他们没有给我一点点癌症的迹象。我想对所有人说,我们不仅要锻炼身体,还要经常检查身体。我相信,这也是我的好朋友、我最尊敬的董辅礽老师、拉丰和杨小凯共同要向大家说的心里话。