经济与金融高级研究丛书

Advanced Studies in Economics and Finance

丛书主编　邹恒甫

Editor in Chief　Heng-fu Zou

财政、经济增长和动态经济分析

Public Finance, Growth, and Dynamic Economic Analysis

邹恒甫　著

Heng-fu Zou

北京大学出版社

Peking University Press

图书在版编目(CIP)数据

财政、经济增长和动态经济分析/邹恒甫著. -北京：北京大学出版社，2000.9
ISBN 7-301-04715-0

Ⅰ.财… Ⅱ.邹… Ⅲ.①财政-研究-文集 ②经济增长-研究-文集 ③动态经济学-研究-文集 Ⅳ.F-53

中国版本图书馆 CIP 数据核字(2000)第 70443 号

书　　名：财政、经济增长和动态经济分析
著作责任者：邹恒甫
责 任 编 辑：梁鸿飞
标 准 书 号：ISBN 7-301-04715-0/F·372
出　版　者：北京大学出版社
地　　址：北京市海淀区中关村北京大学校内　100871
网　　址：http://cbs.pku.edu.cn/cbs.htm
电　　话：出版部 62752015　发行部 62754140　编辑部 62753121
电 子 信 箱：zpup@pup.pku.edu.cn
排　版　者：兴盛达打字服务社 82614608
印　刷　者：北京大学印刷厂印刷
发　行　者：北京大学出版社
经　销　者：新华书店
787 毫米×1092 毫米　16 开本　22.125 印张 360 千字
2000 年 10 月第 1 版　2002年1月第2次印刷
定　　价：46.00 元

经济与金融高级研究丛书
出版前言

中国的经济学和金融学研究如何走向世界?这是一个值得探讨的问题。中国经济学者素以刻苦求知、真诚报国为荣。在国内,自改革开放以来经济学者的突出贡献已深得国人认同;在海外,中国的经济学者同样做出了可喜的成绩。但是,国内经济学者的学术成果得到国际上认可的为数寥寥,而海外中国经济学者所取得的学术成果在国内也鲜为人知。同时,国际经济学者的学术成果在国内的传播也很有限。凡此种种,原因当然是多方面的,其中之一是学术传播与交流上的障碍。这些障碍的存在造成彼不知我,我亦不知彼,国内经济学者的学术研究难以走向世界,国际经济学者和海外中国经济学者的学术研究难以走进中国这样一种尴尬的局面。不言而喻,在全球经济一体化趋势主导世界潮流的今天,这种状况不利于中国经济和中国经济学的发展。

随着改革开放的一步步深化,中国经济与世界经济日益接轨。世界各国经济学者对中国经济发展和中国经济研究的兴趣和热情有增无减。海内外中国经济学者的拳拳报国之心也日益高涨。科学无国界,学术交流也无国界。我们相信,学者们的热情与努力将冰释学术交流中的所有障碍。因此,在经济全球化的今天.在经济腾飞指日可待的中国,这套《经济与金融高级研究丛书》的出版是时代的要求,更是我们的历史使命。

本套丛书将尽可能全面地收录国际经济学者特别是中国经济学者在国际上已获得公认的学术成果。每部著作将基本保留其最初发表在国际刊物上的原貌(或其创作的原貌),由作者按研究专题编纂成书。此举一方面是为了让更多的国人了解这些学者的研究成果,或者至少感知一下国际经济学者和海内外中国经济学者在国际主流经济学发展进程中所迈出的坚实的步伐,从而激励更多的青年学子求知问道;另一方面也是为了使世界各国的经济学者对中国经济学者的研究成果有更多和更全面的了解,或者至少感知到中国的经济学研究并非固步自封置身世界之外,而是与世界同步与潮流并进的。知己知彼,互相交流,这对于繁荣学术是有百利而无一弊的。北京大学出版社真诚地希望更多的海内外学者向我们赐稿,并给我们批评、建议,以助于这项造福世人的学术文化传播事业。

北京大学出版社

经济和金融高级研究丛书
编者说明

本丛书收录世界各国经济学者特别是海内外中国经济学者从事当代经济学和金融学理论研究和实际研究的前沿成果。就某一专题或者多个专题，作者既可以把已经发表的论文收集成册，也可以修辑整理成一部或多部专著。收集成册的公开发表的论文一律保持其发表时的各刊物排版印制的原貌，以方便读者查寻援引；尚未公开发表的论文则一律保持其创作原貌，以供读者参考。

本丛书主编同时还与海内外众多学者合作主办英文学术刊物 *Annals of Economics and Finance*。此刊物出版尚未发表的至少具有一些原创性的经济学和金融学（英文）论文。如有兴趣借此刊物宣布自己学术思想的学人，敬请寄论文给：

北京大学光华管理学院 *Annals of Economics and Finance* 主编

——邮编 100871

或者

武汉大学高级研究中心 *Annals of Economics and Finance* 主编

——邮编 430072

但愿此丛书和杂志能促进中国经济学者与世界各国经济学者的学术交流，促进中国经济学和金融学研究走向世界主流。

邹恒甫

于北京大学

Contents

Acknowledgments

The Peking University Press wishes to thank the following who have kindly given permission for the use of copyright material.

Academic Press Inc. for articles: "Dynamic Effects of Federal Grants on Local Spending", *Journal of Urban Economics*, **36**: 98 – 115, 1994; "Taxes, Federal Grants, Local Public Spending, and Growth", *Journal of Urban Economics*, **39**: 303 – 317, 1996; "Fiscal Decentralization and Economic Growth in the United States", *Journal of Urban Economics*, **45**: 228 – 239, 1999; "Fiscal Decentralization and Economic Growth: A Cross-Country Study", *Journal of Urban Economics*, **43**: 244 – 257, 1998.

Blackwell Publishers Ltd. for articles: "Explaining International and Intertemporal Variations in Income Inequality", *The Economic Journal*, **108**: 26 – 43, 1998; "Income Inequality is not Harmful for Growth: Theory and Evidence", *Review of Development Economics*, **2**(3): 318 – 334, 1998; "Corruption, Income Distribution, and Growth", *Economics and Politics*, **12**(2): 155 – 182, 2000.

Elsevier Science Publishers for articles: "The Composition of Public Expenditure and Economic Growth", *Journal of Monetory Economics*, **37**: 313 – 344, 1996; "'The Spirit of Capitalism' and Long-Run Growth", *European Journal of Political Economy*, **10**: 279 – 293, 1994: "Fiscal Decentralization, Public Spending, and Economic Growth in China", *Journal of Public Economics*, **67**: 221 – 240, 1998; "Dollarization and Inflation in a Two-Country Optimization Model", *Journal of International Money and Finance*, **12**: 209 – 220, 1993; "Should Public Capital be Subsidized or Provided?", *Journal of Monetary Economics*, **41**: 319 – 331, 1998; "The Spirit of Capitalism and Savings Behavior", *Journal of Economic Behavior and Organization*, **28**: 131 – 143, 1995; "A Dynamic Model of Capital and Arms Accumulation", *Journal of Economic Dynamics and Control*, **19**: 371 – 393, 1995; "Dynamic Analysis in the Viner Model of Mercantilism", *Journal of International*

Money and Finance, **16**(4): 637 – 651, 1997; "A Note on the Bauer-Kornai Investment Cycle Theory", *China Economic Review*, **4**(1): 75 – 81, 1993; "Socialist Economic Growth and Political Investment Cycles", *European Journal of Political Economy*, **7**: 141 – 157, 1991; "On the Dynamics of Privatization", *China Economic Review*, **5**(2): 221 – 233, 1994.

Springer-Verlag for article: "The Spirit of Capitalism, Social Status, Money, and Accumulation", *Journal of Economics*, **68**(3): 219 – 233, 1998.

Louisiana State University Press for article: "Short-Run Analysis of Fiscal Policy and the Current Account in a Finite Horizon Model", *Journal of Macroeconomics*, **16**(2): 347 – 357, 1994.

前言

收集在这里的20篇论文已于1991年至2000年之间发表在国际上的经济学刊物，它们多少反映了我和我的一些合作者在经济学研究中的尝试。在此我把这些论文中在某些学术小范围里略微有些影响的实证发现和理论观点概括为以下五点：

第一，对43个发展中国家近20年的统计分析表明，政府部门的生产性公共支出在总支出中的比例对经济增长有负作用，而政府部门的非生产性公共支出在总支出中的比例则与经济增长正相关(见本书第1章)。也就是说，许多发展中国家的政府在基本建设上投资比例太大、忽视了经常性的公共支出(如行政管理、社会治安、文化教育和社会福利等方面的支出)。

第二，尽管理论上有许多理由可以推断，财政分权——把税收征收权和公共支出的职责由中央政府转交给地方政府——可以提高政府部门运作的效率，从而推进经济发展和增长。但对中国、美国等世界上四十六个国家的综合经验分析证明，财政分权往往对经济增长带来负作用(见本书第2、3、13章)。

第三，世界各国收入分配的不平等是一个非常稳定的现象。对每一个国家而言，刻画收入分配不平等的基尼系数往往在很长时间里不发生显著变化。但基尼系数的国际差别却非常大。收入分配不平等的变化主要由教育水平、财富分配、金融发展和社会民主自由的程度等因素决定(见本书第14章)。

第四，收入分配不平等的增加在理论上并不一定妨碍经济增长，在实际上甚至能促进经济增长(见本书第15章)。

第五，资本主义精神这种文化因素能帮助我们解释世界上人均国民收入、经济增长和国民储蓄等方面的差别(见本书第7、8、9章)。

虽然鲜为人知，但我自己却感到一丝欣慰的还有两点：本书第19章提供了第一个为重商主义辩护的数理模型，而本书第20章则第一次展开了对军事支出和资本积累的数理分析。经济学家们经常说，思想观点最要紧。人人都想标新立异，我

也不例外。但自己的思想能否得到学术界的承认，那就是另外一回事了。

本书和本丛书中的其他著作能在中国发行并同许多读者见面，我要感谢北京大学出版社彭松建先生和梁鸿飞先生。同时，我也借此机会感谢本书中的论文合作者：Hamid Davoodi、Shanta Devarajan、李宏毅、Lyn Squire、Vinaya Swaroop、谢丹阳和徐立新等先生。书中的错误望读者批判指正。

邹恒甫

2000年8月31日于北京大学

Part I

Public Finance, Fiscal Decentralization, and Economic Growth

ELSEVIER Journal of Monetary Economics 37 (1996) 313–344

JOURNAL OF Monetary ECONOMICS

The composition of public expenditure and economic growth

Shantayanan Devarajan, Vinaya Swaroop*, Heng-fu Zou

Policy Research Department, The World Bank, Washington, DC 20433, USA

(Received October 1993; final version received February 1996)

Abstract

Noting that the literature has focused on the link between the level of public expenditure and growth, we derive conditions under which a change in the composition of expenditure leads to a higher steady-state growth rate of the economy. The conditions depend not just on the physical productivity of the different components of public expenditure but also on the initial shares. Using data from 43 developing countries over 20 years we show that an increase in the share of current expenditure has positive and statistically significant growth effects. By contrast, the relationship between the capital component of public expenditure and per-capita growth is negative. Thus, seemingly productive expenditures, when used in excess, could become unproductive. These results imply that developing-country governments have been misallocating public expenditures in favor of capital expenditures at the expense of current expenditures.

Key words: Productive and unproductive government expenditures; Economic growth; Developing countries

JEL classification: E62; H50; O40

* Corresponding author.

We are indebted to Min Zhu for exceptionally able research assistance. We received helpful comments from Alberto Alesina, David Aschauer, Robert Barro, Gerry Helleiner, Manny Jimenez, Lant Pritchett, Mike Stevens, Michel Strawczynski, Mike Walton, and seminar participants at Georgetown University, Seoul National University (Seoul, South Korea), the National Institute of Public Finance and Policy (New Delhi, India), the World Bank, and at a conference on 'Africa: From Stabilization to Growth', held in Marstrand, Sweden. The comments from an anonymous referee and the editor were extremely useful in revising the paper. Devarajan and Swaroop acknowledge financial assistance from the World Bank's Research grant RPO #676-84. Zou is also affiliated with Wuhan University, China. The views expressed in this paper are not necessarily those of the World Bank.

1. Introduction

Governments in developing countries spend an average of 26 percent of GDP on goods and services, a figure which has risen by eight percentage points over the last fifteen years (World Bank, 1992). The magnitude and growth of this figure has prompted a fair amount of research on the relationship between the size of government and economic growth (for a survey, see Lindauer and Velenchik, 1992). Much less is known about how the composition of public expenditure affects a country's growth rate. Yet, this may be the central question. First, while the size of government is a public-choice issue, its composition is open to policy discussion. Several observers distinguish between 'productive' and 'unproductive' public expenditures, and show how a country can improve its economic performance by changing the mix between the two. Second, after a decade of fiscal adjustment, during which many of the 'white elephants' in government budgets were weeded out, some developing countries are faced with hard choices when undertaking further fiscal restraint. Which component of public expenditure should be cut? Health? Education? Infrastructure? Defense? The answer must depend on, inter alia, the contribution of these components to economic growth.

The purpose of this paper is to shed light on the relationship between the composition of public expenditure and economic growth. Before proceeding, we note that governments undertake expenditures to pursue a variety of goals, only one of which may be an increase in per-capita income. We focus on growth because (i) inasmuch as growth is one of the objectives of a government, it is useful to know the contribution of different components of expenditure to this objective as a means of assessing the cost of pursuing other goals, and (ii) per-capita income is easier to measure than some of the other objectives of government.

Neither economic theory nor empirical evidence provides clear-cut answers to the question of how the composition of public expenditure affects economic growth. The theory develops a rationale for government provision of goods and services based on the failure of markets to provide public goods, internalize externalities, and cover costs when there are significant economies of scale. Furthermore, when there is a failure in one market, government intervention in a related market can be justified. Sound as they are, these theoretical notions do not translate easily into operational rules about which component of public expenditure is to be cut.

On the empirical front, a few researchers have tried linking particular components of government expenditure to private-sector productivity and economic growth but most of these efforts lack a rigorous theoretical framework (Diamond, 1989). The recent revival of interest in the expenditure-composition issue (Aschauer, 1989; Morrison and Schwartz, 1991; Holtz-Eakin, 1991) has been based on theoretical models but the focus has been on the productivity of public expenditures in the United States.

In this paper, we develop in Section 2 an analytical framework which links the composition of public expenditure with economic growth. In Section 3 we attempt to determine which components of public expenditure – current or capital on the one hand, and health, education, transport and communications, or defense on the other – have been shown to be productive in developing countries. Our major finding is that developing-country governments have been misallocating public expenditures in favor of capital expenditures at the expense of current expenditures. In Section 4 we provide an interpretation of our results. Section 5 presents our concluding remarks.

2. The model

Since the 1960's, researchers have been looking at the relationship between fiscal policy and the economy's growth rate. The seminal contribution was by Arrow and Kurz (1970), who developed a model where consumers derive utility from private consumption as well as the public capital stock. In addition, private production benefits from the services of this capital stock. Arrow and Kurz assumed (implicitly) that all government investment was productive. Furthermore, their model was in the neoclassical tradition where public spending only affected the economy's transitional growth rate; the steady-state growth rate remained unaltered.

The recent explosion of work on endogenous growth has generated a number of models linking public spending with the economy's long-term growth rate. A particularly simple version is Barro's (1990), which takes government expenditure to be complementary with private production. Like Arrow and Kurz, Barro assumes that all government spending is productive in this sense.

Meanwhile, the empirical literature on the same topic has highlighted the distinction between productive and unproductive government spending (e.g., Landau, 1983; Aschauer, 1989; Barro, 1990, 1991). A major finding of these studies is that output growth is negatively correlated with the share of government consumption in GDP. Aschauer and Barro also find a positive relationship between public investment and output growth.

We combine the above empirical observation with the earlier theoretical framework by postulating a model in which there are two types of government expenditure, productive and unproductive. The model expresses the difference between productive and unproductive expenditures by how a shift in the mix between the two alters the economy's long-term growth rate. We assume the aggregate production function has three arguments:[1] private capital stock, k,

[1] As is typical of these models, we leave out labor as a separate argument in the production function. If the economy in question has surplus labor, then labor is not a binding constraint and can be left out of the production function. Alternatively, we can consider the capital factor, k, to reflect human as well as physical capital.

and two types of government spending, g_1 and g_2. After developing the model, we will define precisely what it means for, say, g_1 to be productive and g_2 to be unproductive. If the functional form is CES (constant elasticity of substitution), then the relationship can be expressed as

$$y = f(k, g_1, g_2) = [\alpha k^{-\zeta} + \beta g_1^{-\zeta} + \gamma g_2^{-\zeta}]^{-1/\zeta}, \tag{1}$$

where

$$\alpha > 0, \quad \beta \geq 0, \quad \gamma \geq 0, \quad \alpha + \beta + \gamma = 1, \quad \zeta \geq -1.$$

Following Barro (1990), we assume that the government finances its expenditure by levying a flat-rate income tax,[2] τ,

$$\tau y = g_1 + g_2. \tag{2}$$

The share, ϕ $(0 \leq \phi \leq 1)$, of total government expenditure which goes toward g_1 is given by

$$g_1 = \phi \tau y \quad \text{and} \quad g_2 = (1 - \phi)\tau y. \tag{3}$$

Taking the government's decisions on τ and ϕ as given,[3] the representative agent chooses consumption, c, and capital, k, to maximize his welfare

$$U = \int_0^\infty u(c) e^{-\rho t} \, dt, \tag{4}$$

subject to

$$\dot{k} = (1 - \tau) y - c, \tag{5}$$

where ρ is the rate of time preference.

In order to get analytical solutions, it is useful to specialize the utility function to the isoelastic form:

$$u(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma}. \tag{6}$$

[2]Our focus is on the *composition* of expenditure, we abstract from issues of the financing of government expenditures: (a) There is no deficit financing in the model as the government is constrained to run a balanced budget (for a lucid treatment of the deficit financing issue, see Easterly, 1989); and (b) the role of the structure of taxes is not analyzed in examining the effect of total government expenditure on per-capita growth (for a discussion of role of the structure of taxes in explaining growth variations, see Easterly and Rebelo, 1993, who experimented with 13 different tax measures and found only one variable – the marginal income tax rate – to be statistically significant).

[3]While we do not analyze the government's decision problem of choosing expenditure or the tax rate, we are implicitly assuming that the government chooses the tax rate (τ). Since the government is constrained to run a balanced budget in the model, this effectively means that the level of government expenditure, g, is determined by default. Doing a complete analysis of the choice of both g and τ would be a useful extension to our analysis. See Davoodi, Xie, and Zou (1995) for an attempt.

Substituting (6) into (4) and maximizing subject to (1), (2), (3), and (5) yields the equation for the growth rate of consumption:

$$\frac{\dot{c}}{c} = \frac{\alpha(1-\tau)\{\alpha + (g/k)^{-\zeta}[\beta\phi^{-\zeta} + \gamma(1-\phi)^{-\zeta}]\}^{-(1+\zeta)/\zeta} - \rho}{\sigma}. \tag{7}$$

Call the steady-state growth rate of consumption λ, and assume that along the steady-state growth path the tax rate τ (and hence g/y) is constant. It follows that g/k is a constant which, by simple manipulation of (1)–(3), is given by

$$g/k = \{[\tau^{\zeta} - \beta\phi^{-\zeta} - \gamma(1-\phi)^{-\zeta}]/\alpha\}^{1/\zeta}. \tag{8}$$

Substituting the value of g/k from (8) into (7) we obtain the steady-state growth rate of consumption as

$$\lambda = \frac{\alpha(1-\tau)\{\alpha\tau^{\zeta}/[\tau^{\zeta} - \beta\phi^{-\zeta} - \gamma(1-\phi)^{-\zeta}]\}^{-(1+\zeta)/\zeta} - \rho}{\sigma}. \tag{9}$$

From Eq. (9), we can derive a relationship between the steady-state growth rate, λ, and the share of government expenditure devoted to g_1:

$$\frac{d\lambda}{d\phi} = \frac{\alpha(1-\tau)(1+\zeta)[\alpha\tau^{\zeta}]^{-(1+\zeta)/\zeta}[\beta\phi^{-(1+\zeta)} - \gamma(1-\phi)^{-(1+\zeta)}}{\sigma[\tau^{\zeta} - \beta\phi^{-\zeta} - \gamma(1-\phi)^{-\zeta}]^{-1/\zeta}}. \tag{10}$$

We can now define productive expenditure: that component of public expenditure an increase in whose share will raise the steady-state growth rate of the economy. From Eq. (10), the component g_1 is productive if $d\lambda/d\phi > 0$.

What are the implications of this definition for the parameters of the model? Assuming λ [given by Eq. (9)] is positive, the right-hand side of (10) will be positive if

$$(1+\zeta)[\beta\phi^{-(1+\zeta)} - \gamma(1-\phi)^{-(1+\zeta)}] > 0. \tag{11}$$

Since $\zeta \geq -1$, (11) implies that $d\lambda/d\phi > 0$ if[4]

$$\frac{\phi}{1-\phi} < \left(\frac{\beta}{\gamma}\right)^{\theta}, \tag{12}$$

where $\theta = 1/(1+\zeta)$ is the elasticity of substitution. Note that the condition (12) – for a shift in the composition to increase the growth rate – depends not just on the productivity (β and γ) of the two components but also on the initial shares. Thus, a shift in favor of an 'objectively' more productive type of expenditure (e.g., $\beta > \gamma$) may not raise the growth rate if its initial share (ϕ) is 'too high'.

[4]When $\zeta = -1$, the production technology is linear, i.e., $y = \alpha k + \beta g_1 + \gamma g_2$, and the growth rate of consumption is $\lambda = [(1-\tau)\alpha - \rho]/\sigma$. In such a case, the composition of government expenditure plays no role in enhancing the rate of economic growth. This is intuitive, since if $\zeta = -1$, the two components of government expenditure are perfect substitutes.

To see the intuition behind this condition, consider the special case of Cobb–Douglas technology, for which $\zeta = 0$ and $\theta = 1$. Then condition (12) becomes

$$\frac{\phi}{1-\phi} < \frac{\beta}{\gamma}.$$

According to this condition, if the relative share of public expenditure devoted to the two goods g_1 and g_2 is below their relative output elasticities (β and γ are the output elasticities of g_1 and g_2, respectively), then a shift in the mix towards g_1 will increase the economy's long-run growth rate.[5] Both elasticities may be positive (i.e., both components of government expenditure are complementary with private production), yet if the above condition holds, transferring resources from g_2 to g_1 will raise the steady-state growth rate. Further, $\beta > \gamma$ is not sufficient to guarantee that a shift in favor of g_1 will increase the growth rate; it must be the case that the relative budget shares are below the relative output elasticities.

Now consider the more general case of a CES technology, where $\theta \neq 1$. Assume $\beta > \gamma$ and define ϕ^* as the critical value above which an increase in the share of expenditure going to g_1 will not increase the growth rate. That is,

$$\frac{\phi^*}{1-\phi^*} = \left(\frac{\beta}{\gamma}\right)^{\theta}.$$

How will the critical value of ϕ^* change as θ increases? Simple manipulation reveals that

$$\frac{\mathrm{d}\phi^*}{\mathrm{d}\theta} = (1-\phi^*)\left(\frac{\beta}{\gamma}\right)^{\theta} \ln\left(\frac{\beta}{\gamma}\right),$$

so that $\mathrm{d}\phi^*/\mathrm{d}\theta > 0$ since $\beta > \gamma$. As the two types of government expenditure become more and more substitutable, ϕ^* increases. The intuition is that the more substitutable are the two types of expenditure, the more likely it will be that an increase in the share going to the one with the higher coefficient will increase the growth rate. Conversely, when the substitution elasticity is low, increasing the amount going to g_1 may not increase the growth rate even if the

[5] As pointed out by an anonymous referee, ϕ, the budgetary share, cannot be equal to either 0 or 1 in the Cobb–Douglas specification because one of the g's then is zero and so is output. Even the case where ϕ is close to 0 or 1 is problematic because output then is arbitrarily small. While this is a restrictive assumption (especially when there are more than two public goods) in the sense that there is no reason to believe that societies cannot set components of government expenditure at any proportions (including zero) they like, the Cobb–Douglas case simplifies the algebra and provides valuable insights into the model. Furthermore, as shown above, the model results hold for the more general CES technology where $0 \leq \phi \leq 1$.

initial share is quite small. In the limiting case, when $\theta = 0$, the production function is of the Leontief form and increasing g_1's share over a certain amount will have no effect on the long-run growth rate.

Note that the increase in the growth rate achieved by shifting towards productive expenditure can be accomplished with no change in *total* government expenditure. In fact, the effect of an increase in the latter on the growth rate is ambiguous. To see this, consider the response of λ to an increase in τ (since $\tau = g/y$, this is equivalent to an increase in the share of government expenditure in GDP). Some tedious manipulation reveals that

$$\frac{d\lambda}{d\tau} \geq (<)\, 0 \quad \text{if} \quad \frac{\tau^{\zeta+1}}{B} + \tau\zeta \leq (>)\, 1 + \zeta,$$

where

$$B = \beta\phi^{-\zeta} + \gamma(1-\phi)^{-\zeta}.$$

Clearly, the relationship between τ and λ is ambiguous and can change sign depending upon the relationship between τ and B, where the latter can be thought of as a proxy for the total productivityof government expenditure. Some further intuition can be derived by considering the Cobb–Douglas technology, in which the above condition reduces to

$$\frac{d\lambda}{d\tau} > 0 \quad \text{when} \quad \tau < \beta + \gamma,$$

and conversely if $\tau > \beta + \gamma$. This is intuitive given our balanced-budget assumption: an increase in total government spending, since it has to be financed by taxes, will raise the steady-state growth rate only if the productivity of that government spending $(\beta + \gamma)$ exceeds the taxes required to pay for it.

The model can be extended in several ways. We now consider three. First, the number of components of government expenditure can be increased from just two. This extension only makes the algebra more cumbersome without improving our knowledge of the growth process. If there are N types of government expenditure, each with its own exponent, β_i, in the production function, and share ϕ_i in the budget, then the effect on growth of increasing the share of government expenditure going to the ith component depends on which component's share is being reduced. If the increase in i's share comes from a component j such that

$$\frac{\beta_i^\theta}{\phi_i} > \frac{\beta_j^\theta}{\phi_j},$$

then the shift in expenditure composition will increase the steady-state growth rate of the economy. Alternatively, if the above inequality were reversed, then a shift from j to i would lower the long-run growth rate.

Second, not all components of government expenditure affect the production function; some – such as transfers to households – are intended to affect

consumer welfare. In our model, this can be incorporated by including these components in the consumer's utility function, and allowing their coefficient in the production function to be zero. The rest of the analysis follows as before.

Finally, in this model, we take the government's decisions as given, rather than deriving them from some optimizing framework. Doing the latter requires specifying the government's objective function and the result will depend on this function. While we do not attempt such an exercise in this paper, our results – especially those in the next section – suggest that this may be a fruitful extension. See Davoodi, Xie, and Zou (1995) and Zhang and Zou (1996) for some preliminary results.

Despite its simplicity, the model described above yields an important insight into what makes particular components of government expenditure productive. In particular, it shows that the answer does not depend on the sign of the exponent in the production function; rather, it is a relationship between the coefficient (output elasticity in the Cobb–Douglas case) and the actual share in the budget which determines whether or not a component is productive. However, the formal framework begs the question of which government expenditures are productive and which are not. In the next section, we attempt to answer this question by examining empirically how the growth performance of developing countries over time was affected by the composition of their public expenditures. We ask the data to tell us which components of expenditure are productive.

3. Empirical analysis

Our empirical analysis focuses on the link between various components of government expenditure and economic growth in developing countries. Aschauer and Greenwood (1985), Barro (1990), and others emphasize the distinction between public goods and services that enter into the household's utility function and those that complement private sector production. The former, which they argue would include much of government consumption, are likely to have negative growth effects. While it provides utility to households, government consumption lowers economic growth because the higher taxes needed to finance the consumption expenditure reduce returns on investments and the incentive to invest. This is confirmed by Grier and Tullock (1987). Using pooled cross-section/time-series data (115 countries including 24 OECD countries in the post-World War II period), they find a significantly negative relationship between the growth rate of real GDP and government consumption's share of GDP. By contrast, government investment expenditure, such as the provision of infrastructure services, is thought to provide the enabling environment for growth. Aschauer (1989) finds that 'core infrastructure' – streets, highways, airports, mass transit, and other public capital – has the most explanatory power for private-sector productivity in the United States over the period

1949–85. Based on a set of cross-country regressions, Easterly and Rebelo (1993) find that public investment in transport and communications in developing countries leads to higher economic growth. For other categories of public spending, there appears to be some disagreement over whether they constitute 'productive' expenditure. While Kormendi and Meguire (1985), Grier and Tullock (1987), and Summers and Heston (1988) classify defense and education as government consumption and hence unproductive, Barro (1991) models them as productive. He considers spending on public education as investing in human capital. Similarly, defense spending helps protect property rights which increases the probability that an investor will receive the marginal product of capital. Based on data on 98 countries, Barro (1991) finds that an increase in resources devoted to nonproductive government consumption is associated with lower per-capita growth.

In our analysis, we refrain from an a priori classification of public expenditures into 'productive' and 'unproductive'. Instead, we allow the data to tell us which components conform to our definition of productive expenditure. Furthermore, since ours is a pooled, cross-section/time-series data set, we are able to capture some of the lags involved in translating productive public expenditures into economic growth. Our study is also unique inasmuch as it focuses exclusively on developing countries. Most of the other studies use a mixed sample of developed and developing countries, or examine developed countries only. As we will show, the results change dramatically when the sample is restricted to developing countries.

3.1. Data and choice of variables

The empirical analysis uses annual data on 43 countries (see Appendix B for the list of countries) from 1970 through 1990 to examine the link between components of government expenditure and economic growth. The pooled data include total central government expenditures (including current and capital), expenditures for defense, education, health, and transport and communication.[6] The latter expenditure variable is used as a proxy for expenditure in economic infrastructure.

The model in Section 2 developed links between the shares of government expenditure and the long-term growth rate of the economy. In the empirical analysis, we test whether the share allocated to different components of government expenditure is associated with higher growth. Thus, our key explanatory variable is the share of each component in total government expenditure. To control for level effects, we also include the share of government expenditure in

[6]As a check on our results, we repeat our analysis for the subsample of countries for which there are data on consolidated government expenditures (see below).

GDP. This also allows us to control for the effects of financing government expenditure (which is a function of the level) on growth. Given that the pattern of economic growth has been uneven across the continents, we include continent dummies to control for the continent-specific effect. In addition, we attempt to control for two other factors which determine a country's growth rate but are not necessarily linked to the composition of public expenditure: external shocks and other domestic policies. The latter is measured by the premium on the official rate in the black market for foreign exchange. Finally, the dependent variable is the five-year forward moving average of per-capita real GDP growth.[7] The forward lag is chosen to reflect the fact that public expenditures often take time before their effects on output growth can be registered. We use a five-year average to eliminate short-term fluctuations induced by shifts in public expenditure, and by choosing a moving average we are able to increase the number of time series observation in our panel data.

The choice of a five-year forward lag structure is aimed at addressing another problem which plagues most analyses of the link between public expenditure and growth: the joint endogeneity of the two variables and the possibility of reverse causality. For instance, if education expenditure is negatively associated with growth, it need not necessarily mean that education expenditure is unproductive; it could mean that slow-growing countries spend more on education in an attempt to grow faster. While this problem exists in principle in our paper as well, we attempt to minimize it by modeling expenditure in period t as affecting growth from period $t+1$ through $t+5$. Thus, for the reverse causality argument to hold in our model, governments would have to anticipate the decline in growth rates up to five years into the future and accelerate education spending today.[8]

3.2. Regression analysis

The method of ordinary least squares (OLS) is used to estimate the following equation:

$$GRPCGDP^i_{(t+1,t+5)} = \sum_{j=1}^{5} \alpha_j D_j + \alpha_6 (TE/GDP)^i_t + \alpha_7 BMP^i_t + \alpha_8 SHOCK^i_t + \sum_k \alpha_k (G_k/TE)^i_t + \mu^i_t, \tag{13}$$

[7]Whether the five-year average is long enough to capture the long-term growth is an issue of contention. In the econometric analysis we tried seven-year and ten-year averages but the results did not change significantly.

[8]If, however, the growth rate has a distributed lag structure, then the joint endogeneity problem may not have been reduced significantly.

where the variables are:

(i) $GRPCGDP^i_{(t+1,t+5)}$: Five-year forward moving average of per-capita real GDP growth for country i.

(ii) D_j: Continental dummy variables; $j = 1, 2, 3, 4$, and 5 correspond to East Asia, South Asia, sub-Saharan Africa, Latin America, and Europe, Middle East, and North Africa (EMENA), respectively.

(iii) $(TE/GDP)^i_t$: Share of total government expenditure in GDP for country i at time t.

(iv) BMP^i_t: Premium in the black market for foreign exchange in country i at time t, calculated as $BMER^i_t = [(BMER^i_t - OER^i_t)/OER^i_t]*100$, where $BMER^i_t$ = black market exchange rate and OER^i_t = official exchange rate.

(v) $SHOCK^i_t$: The shock variable is a weighted average of changes in the world real interest rate (R) and the export price index (PX) and import price index (PM) for each country. The export and import price indices are index numbers expressed in U.S. dollars converted at the annual average of the country's official exchange rate. The weights are the ratios to GDP of debt, exports (X), and imports (M), respectively. By 'changes' we mean the difference in the average value of these variables between $t-4$ to t and $t+1$ to $t+5$. In symbols it is defined as, $SHOCK_t = (R_{t+1,t+5} - R_{t-4,t})*(DEBT/GDP)_t - (PX_{t+1,t+5} - PX_{t-4,t})*(X/GDP)_t + PM_{t+1,t+5} - PM_{t-4,t})*(M/GDP)_t$.

(vi) $(G/TE)^i_t$: A vector of public expenditure ratios for country i at time t:[9]
Expenditure shares by economic classification: $Ncur/Te$ = ratio of current expenditure (net of interest payments) to total expenditure and Cap/Te = ratio of capital expenditure to total expenditure.
Expenditure shares by functional classification: Def/Te = ratio of defense expenditure to total expenditure, $Hlth/Te$ = ratio of health expenditure to total expenditure [the subcategories of health expenditure include expenditure on hospitals ($Hosp$), spending on clinics providing mainly outpatient

[9]We use the classification of government expenditure used in the International Monetary Fund's (IMF) *Government Financial Statistics*. The IMF classification follows two main lines: (1) the *economic classification* of expenditure which is based on the type or economic characteristics of expenditure, and (2) the *functional classification* of expenditure which is based on the purpose or function toward which the expenditure is directed. The former is grouped in terms of the type of outlay: (a) Capital Expenditure which covers payments for the purchase or production of new or existing durable goods (i.e., goods with a life of more than one year); and (b) Current or Recurrent Expenditure which in turn includes wages and salaries, other goods and services, interest payments, and subsidies. The latter includes expenditures on (a) economic services (transport and communication, electricity, agriculture, etc.), (b) social services (education, health, etc.), (c) general government services (general public administration, defense, public order and safety, etc.), and (d) other functions. For details, see International Monetary Fund (1986).

services (*Inhlth*), and other spending on health (*Othlth*)], Ed/Te = ratio of education expenditure to total expenditure [the subcategories of education expenditure include expenditure of spending on schools (*Schl*), spending on universities (*Univ*), and other spending on education (*Othed*)], Tac/Te = ratio of transportation and communication expenditure to total expenditure.

(vii) μ_t^i: Error term.

By constructing the dependent variable as a five-year forward moving average of per capita real GDP growth we introduce serial correlation in the error terms within a country sample. The standard errors of the OLS estimator are therefore incorrect although estimates are consistent. To correct the standard errors we extend the method of correlation correction outlined by Hansen and Hodrick (1980).[10]

Table 1 contains the estimates of Eq. (13). Eq. (1.1) shows a positive and statistically significant relationship between the five-year forward moving average of per-capita real GDP growth and the ratio of current (net of interest spending) to total expenditure. A unit increase in this ratio increases the per-capita real GDP growth rate by 0.05 percentage points. Clearly, this is an unusual finding. For example, Barro (1990, 1991) finds that consumption expenditure (current expenditure less education and defense expenditure) is associated with *lower* per-capita growth. Furthermore, our result cuts against the grain of policy advice received by developing countries, which prescribes cutting current, rather than capital, expenditures in order to foster long-term growth. In the next subsection, we report on various tests of the robustness of these results, which show that they are not just a statistical anomaly. In the final section, we offer some interpretations of these findings.

The relationship between the capital component of public expenditure and per-capita growth is negative and significant as illustrated in Eq. (1.2).[11] Once again this belies the standard hypothesis. Public expenditure on capital goods is supposed to add to the country's physical capital (mainly infrastructure – roads, bridges, dams, ports, power plants, etc.). Intuition suggests that the resulting

[10]Hansen and Hodrick (1980) introduced an econometric time-series technique to estimate the covariance matrix of the OLS estimator when errors are serially correlated due to the use of overlapping observations. By sampling more finely than the forest interval (i.e., by using overlapping observations) they were able to increase the size of the data in examining the 'efficient-markets hypothesis' for foreign exchange markets. We extend their time-series technique to estimate the covariance matrix of the OLS estimator when serial correlation is introduced by using overlapping observations over time in panel data (see Appendix A).

[11]The coefficient is not exactly the negative of current expenditure because the latter is net of interest payments (so that the two shares do not sum to one). When the budgetary share of total current expenditure (i.e., including interest spending) is used, the coefficient is positive, statistically significant, and exactly equal (in absolute value) to the coefficient of current spending.

Table 1
Composition of government expenditure and economic growth, with t-statistics in parentheses

Dependent variable = *GRPCGDP*, five-year forward moving average of per capita real GDP growth rate

	Eq. (1.1)	Eq. (1.2)	Eq. (1.3)	Eq. (1.4)	Eq. (1.5)	Eq. (1.6)
East Asia	0.06	4.58	7.29	3.70	6.66	8.21
	(0.03)	(3.50)	(3.72)	(0.82)	(2.74)	(1.32)
South Asia	0.30	4.65	5.89	2.61	7.46	7.86
	(0.14)	(3.20)	(3.85)	(0.51)	(2.75)	(1.21)
Sub-Saharan Africa	− 2.93	1.75	3.66	0.28	2.93	4.33
	(− 1.45)	(1.43)	(2.05)	(0.08)	(1.29)	(0.78)
Latin America	− 3.86	0.75	2.03	6.32	4.28	7.86
	(− 1.96)	(0.71)	(1.25)	(1.93)	(2.11)	(1.64)
EMENA	− 0.99	3.38	5.27	4.22	3.91	5.78
	(− 0.39)	(1.82)	(2.29)	(1.08)	(1.70)	(1.05)
Te/GDP	0.016	0.002	− 0.033			− 0.039
	(0.43)	(0.06)	(− 0.86)			(− 0.48)
Ncur/Te	0.046					
	(1.98)					
Cap/Te		− 0.045				
		(− 1.72)				
Def/Te			− 0.053	0.093	− 0.053	− 0.006
			(− 1.38)	(0.96)	(− 0.91)	(− 0.05)
Hlth/Te			− 0.024		− 0.50	
			(− 0.30)		(− 2.15)	
Ed/Te			− 0.021	0.017		
			(− 0.36)	(0.16)		
Tac/Te			− 0.145	− 0.33	− 0.22	− 0.30
			(− 3.16)	(− 5.54)	(− 3.71)	(− 3.41)
Schl/Te					0.075	0.02
					(0.65)	(0.07)
Univ/Te					0.38	0.39
					(1.18)	(0.85)
Othed/Te					0.63	− 0.56
					(2.64)	(− 1.02)
Hosp/Te				0.29		− 0.70
				(0.52)		(− 2.00)
Inhlth/Te				0.02		0.02
				(0.03)		(0.02)

Table 1 (continued)

	Eq. (1.1)	Eq. (1.2)	Eq. (1.3)	Eq. (1.4)	Eq. (1.5)	Eq. (1.6)
Othlth/Te				1.03		1.05
				(1.17)		(1.19)
HlthCap				−0.16		
				(−1.89)		
EdCap					−0.025	
					(−1.45)	
Black	−0.013	−0.014	−0.010	0.003	−0.010	−0.009
	(−2.50)	(−2.59)	(−1.96)	(0.09)	(−1.11)	(−0.31)
Shock	−0.05	−0.053	0.008	0.005	−0.01	−0.051
	(−0.75)	(−0.90)	(0.14)	(0.03)	(−0.10)	(−0.27)
Adj. *R*-sq.	0.33	0.30	0.37	0.81	0.53	0.79
Obs.	294	305	266	54	121	54
DW	0.56	0.55	0.66	0.92	0.84	0.83

stock of infrastructure capital would complement private-sector productivity and, hence, have favorable growth effects.

The level effect of total government expenditure[12] on per-capita growth is positive but statistically insignificant. This is consistent with our model's prediction: to finance a higher level of government spending higher distortionary taxes are needed and the steady-state growth rate will increase only if the productivity of that government spending exceeds the deadweight loss associated with the taxes required to pay for it.

Eq. (1.3) – which includes expenditure shares according to the functional classification – indicates that defense and economic infrastructure are negatively related to per-capita growth. Public spending in health and education also have negative coefficients though they are statistically insignificant. As economic infrastructure expenditures in general have a high proportion of capital expenditures, the finding that it has a negative correlation with per-capita real GDP growth is consistent with the negative correlation found between capital expenditures and per-capita growth in Eq. (1.2). The result is, however, in sharp contrast with the finding of Easterly and Rebelo (1993, p. 431), who report that public investments in transport and communication in developing countries 'seem to be consistently positively correlated with growth with a very high

[12]This variable in the regression controls for the level effect of public expenditure as we are primarily interested in examining the link between the composition of public expenditure and economic growth.

coefficient'.[13] There are at least two reasons why our finding is different from that of Easterly and Rebelo: First, consistent with our theoretical model, our result is on the *composition* effect of spending on growth; the *level* effect has been controlled for separately in the regression analysis by the variable *TE/GDP* (the share of total expenditure in GDP). In other words, a unit increase in the budgetary share of transport and communication spending has to be matched by a unit decrease in some other spending share(s), as the size of total spending remains fixed. On the other hand, Easterly and Rebelo find a positive and statistically significant coefficient on the share of transport and communication spending in GDP – a variable that mixes the level effect of spending with the composition effect. In their analysis, a unit increase in the share of transport and communication spending in GDP does not necessarily mean that other expenditure items – which could enhance the productivity of transport and communication spending – are decreasing. Second, Easterly and Rebelo use a new measure of public investment – one which incorporates public investment by all levels of government as well as investments by public enterprises – in transport and communication in developing countries. While we agree that such a consolidated public investment series is needed to examine the full impact of public expenditures and growth (the expenditure data used in our research are confined to the central government), the authors construct this series from a large collection of World Bank reports on public investment in individual developing countries. Unfortunately, such reports do not present data consistently. For instance, in one country report 'development expenditures' refers exclusively to capital expenditures while in others it contains some current expenditures as well. We are therefore skeptical that meaningful results can be obtained from data constructed in this manner.

In Eq. (1.4), public spending on health care is disaggregated into expenditure on (i) hospital affairs and services [*Hosp*], (ii) clinics providing mainly outpatient services [*Inhlth*], and (iii) public health affairs and services (mainly of a preventive nature), applied research, and experimental development related to the health and medical delivery system [*Othlth*]. Notwithstanding the reduced number of observations with this specification of the health expenditure variable, we find that the coefficient of the share of expenditure on public health affairs and services, etc. [*Othlth*] is weakly positive for per-capita growth. The other two components of health expenditures have statistically insignificant coefficients. A unit increase in per-capita health expenditure [*HlthCap*] is however associated with a decline in per-capita growth. Thus, the finding indicates that neither health expenditure per capita nor total public health expenditure as a share of total expenditure is positively related to the per-capita growth rate. It is the share of health expenditure on preventive care and research and development that has some growth effects.

[13]This is the only sectoral public spending variable that is statistically significant in their analysis.

In Eq. (1.5), we disaggregate the education variable into expenditure on (i) administration, management, inspection, operation of pre-primary, primary, and secondary education [*Schl*], (ii) of tertiary education [*Univ*], and (iii) other education [*Othed*]. As reported in Eq. (1.5), this last component of education expenditure is positively and significantly related to the per-capita growth rate. This category of spending on education includes subsidiary services to education (transportation, food, lodging, medical, and other such services to students), program units engaged in administering, supporting, or carrying out applied research into teaching methods and objectives, into learning theory and curriculum development, etc. A unit increase in the share of this category of education spending leads to an increase of 0.63 percentage points in per-capita real GDP. The level of education expenditure (measured by per-capita real education expenditure, *Edcap*) has negative growth effects.

As for the other variables in the regressions, note that the black-market premium is negative and statistically significant in almost all the equations. The sign is what would be expected: the higher the premium, the more distorted the economy, the worse its growth performance. Interestingly, the shock variable is not statistically significant. It is possible that most of the contribution of this variable is being picked up by the regional dummies, which are, for the most part, statistically significant.

3.3. Alternative specifications and samples

Given the surprising nature of these results, especially those having to do with current and capital expenditures, we now subject them to a series of tests, to ensure that they are not due to some statistical fluke. The tests are not formal ones. Rather, they are based on our views of possible factors which could be driving these results but were not connected with the productivity of public spending.

3.3.1. Developed vs. developing countries sample

Our use of panel data also distinguishes our study from Barro's (1991), which is based on cross-country regressions. It is worth investigating whether this difference, or some other variation between the two approaches, is responsible for the sharp contrast in results. To begin with Barro's study combines both developed and developing countries, whereas our sample is restricted to developing countries only. This appears to be important. Rerunning our regressions with a sample of 21 developed countries,[14] we find that our conclusions are reversed and the results conform to the standard hypothesis: The coefficient for

[14]All OECD countries except Greece, Portugal, and Turkey, which are not part of the 'high-income economies' as defined in World Bank (1994).

Table 2
Composition of government expenditure and economic growth, for developed countries, with t-statistics in parentheses

Dependent variable = *GRPCGDP*, five-year moving average per capita real GDP growth rate

	Eq. (2.1)	Eq. (2.2)	Eq. (2.3)	Eq. (2.4)	Eq. (2.5)	Eq. (2.6)
Intercept	8.55	1.12	1.18	1.35	0.77	0.97
	(6.21)	(3.53)	(2.34)	(2.59)	(1.3)	(1.41)
Te/GDP	0.01	0.01	0.015	0.023	0.019	0.025
	(1.37)	(1.38)	(1.79)	(2.39)	(1.66)	(2.12)
Cur/Te	− 0.074					
	(− 4.72)					
Cap/Te		0.072				
		(4.57)				
Def/Te			− 0.024	− 0.024	0.005	− 0.007
			(− 1.36)	(− 1.24)	(0.26)	(− 0.33)
Hlth/Te			0.019		0.048	
			(1.48)		(3.12)	
Ed/Te			− 0.029	− 0.071		
			(− 1.45)	(− 2.72)		
Tac/Te			0.089	0.09	0.002	0.036
			(3.50)	(3.02)	(0.05)	(1.02)
Schl/Te					− 0.03	− 0.07
					(1.03)	(− 2.12)
Univ/Te					− 0.17	− 0.14
					(− 2.47)	(− 1.88)
Othed/Te					0.41	0.24
					(3.52)	(1.93)
Hosp/Te				0.036		0.056
				(2.13)		(3.11)
Inhlth/Te				− 0.081		− 0.035
				(− 3.34)		(− 1.20)
Othlth/Te				0.10		0.11
				(2.53)		(2.68)
Adj. R-sq.	0.06	0.06	0.06	0.18	0.14	0.21
Obs.	319	319	285	199	211	194
DW	0.46	0.45	0.52	0.58	0.49	0.59

capital expenditure is positive and statistically significant; and the coefficient for current expenditure is negative and statistically significant.

Table 2 has the estimates of Eq. (13) for thc 21 developed countries; the external shock variable and the black market premium were dropped from the

regression specification. There is no black market for foreign exchange in these countries; and economic growth in developed economies is not affected by the kind of country-specific exogenous shocks captured by our shock variable. To make these results exactly comparable to Barro's, we would have to redefine current expenditure by subtracting total expenditures on education and defense. This is problematic, since current expenditure is part of the economic classification of public expenditure, whereas education and defense fall under the functional category. In other words, to recreate Barro's variables with our data, we would have to subtract apples from oranges. Nevertheless, the reversal of our results for developed countries is interesting in its own right. While the popular view is that developing countries lack infrastructure and other types of public capital, and that developed countries do not, there are several reasons why public capital expenditure could be more productive in developed countries. First, the optimal level of public goods in an economy is a function of the other distortions in the economy (see Hulten, 1994). If distortions in developing countries are such that the desired level of public goods is smaller, then additional expenditure on these public goods may in fact be unproductive. Second, as shown in our theoretical model, an increase in the share going to expenditures which are traditionally considered productive need not raise the growth rate: the initial shares could be such that there is already 'too much' of this kind of expenditure so an increase is counterproductive.

Finally, we investigate whether the difference between using cross-section and panel data is important. If we collapse our panel data set so that we have only one observation per country (taking period averages), our results do change. While the coefficients on current and capital expenditure do not change in signs, they are no longer statistically significant. However, if we lag the period averages (for example, let average public expenditure shares from 1970–1985 affect the average growth rate from 1975–1990), the results begin resembling our earlier ones in Table 1. Thus, allowing for a time lag in the effect of public expenditure on growth – not an unreasonable notion, given the gestation periods of most public projects – has a strong effect on the signs of the coefficients, and could very well be the reason our results differ from Barro's. As noted above, the five-year forward lag structure in our model addresses partially the problem of joint endogeneity. It is possible that the opposite results such as Barro's are due to reverse causality in his model.

3.3.2. *Fixed-effects model*

The regression results reported in Section 3.2 are based on panel data with the implicit assumption that there are no individual cross-sectional effects. It is likely, however, that there are country-specific characteristics which might influence per-capita growth. While such characteristics are generally difficult to measure (e.g., cultural factors), simply running pooled regression may bias the

coefficient estimates. We apply the fixed-effects method which takes into account country-specific characteristics and models them as fixed effects within the country. In such a case we estimate the following individual-mean corrected regression model:

$$GRPCGDP^{i}_{t+1,t+5} = \alpha_i + \beta_k X^{i}_{k,t} + \mu^{i}_{t},$$

where the variable X consists of all the independent variables of Eq. (13). The computational procedure (see Hsiao, 1992) for estimating the parameters requires transforming the observed variables by subtracting out the appropriate time-series means, and then applying the least-squares method to the transformed data.

Table 3 contains the estimates of the above equation. The issue of interest is: How do the results presented in Table 1 change with the fixed-effects method? Eq. (3.1) in Table 3 shows that the coefficient on the budgetary share of current expenditure (net of interest) continues to be weakly positive and statistically significant. Similarly, the coefficient on capital expenditure's share is negative and statistically significant. The most significant change is the statistical significance of the coefficient on the share of transport and communication. In all but one of four specifications, the negative relationship between transport and communications and per-capita growth is statistically insignificant. One reason for this could be the loss in degrees of freedom in going from continent dummies to the fixed-effects approach. Another interesting feature of this fixed-effects model is that the shock variable, which was previously insignificant, now becomes highly significant, and the black-market premium does the reverse. Evidently, the black-market premium was picking up country-specific characteristics (political instability, etc.). Once these characteristics were explicitly accounted for, the premium loses significance. By contrast, the external shock variable's role appears to have strengthened, since it now captures those determinants of growth not incorporated in the country-specific characteristics.

3.3.3. *Nonlinear specification and other variables*

In this subsection we discuss the regression results based on other specifications of the basic model reported in Eq. (13). In the first instance we attempt a nonlinear specification of the model. Both theory and intuition suggest that expenditure ratios and growth might have a nonlinear relationship. From the model in Section 2 we know that productive expenditures can be positively associated with growth when their shares in the budget are low but this relationship turns negative when the share gets large. The intuition is that as the share keeps rising, decreasing returns to scale set in and, eventually, the relationship between the two variables turns negative.

Table 4 reports the nonlinear regression model. In Eq. (4.1), the growth rate is an increasing function of the share of current expenditure (net of interest

Table 3
Composition of government expenditure and economic growth, for fixed-effects model, with t-statistics in parentheses

Dependent variable = *GRPCGDP*, five-year forward moving average of per capita real GDP growth rate

	Eq. (3.1)	Eq. (3.2)	Eq. (3.3)	Eq. (3.4)	Eq. (3.5)	Eq. (3.6)
Intercept	0.041	0.1	0.048	−0.11	−0.023	−0.15
	(0.42)	(1.04)	(0.46)	(−0.43)	(−0.14)	(−0.46)
Te/GDP	0.002	−0.003	−0.015			0.035
	(0.07)	(−0.13)	(−0.47)			(0.3)
Ncur/Te	0.035					
	(2.7)					
Cap/Te		−0.059				
		(−3.41)				
Def/Te			0.053	−0.13	0.016	−0.11
			(1.42)	(−1.23)	(0.27)	(−0.97)
Hlth/Te			−0.013		0.14	
			(−0.30)		(0.62)	
Ed/Te			0.006	−0.16		
			(0.14)	(−1.11)		
Tac/Te			−0.037	−0.14	−0.04	−0.13
			(−1.14)	(−1.24)	(−0.88)	(−1.00)
Schl/Te					0.16	−0.29
					(1.40)	(−1.37)
Univ/Te					0.09	0.23
					(0.45)	(0.58)
Othed/Te					0.16	−0.14
					(0.81)	(−0.24)
Hosp/Te				0.75		0.46
				(0.90)		(0.48)
Inhlth/Te				0.43		0.21
				(0.70)		(0.26)
Othlth/Te				2.26		2.14
				(2.48)		(2.06)
HlthCap				−0.39		
				(−3.24)		
EdCap					−0.091	
					(−3.88)	
Black	0.0004	0.0005	0.001	−0.009	0.001	−0.009
	(0.44)	(0.61)	(1.00)	(−0.36)	(0.18)	(−0.33)

Table 3 (continued)

	Eq. (3.1)	Eq. (3.2)	Eq. (3.3)	Eq. (3.4)	Eq. (3.5)	Eq. (3.6)
Shock	− 0.096	− 0.095	− 0.12	0.017	− 0.096	− 0.065
	(− 3.67)	(− 3.67)	(− 3.86)	(0.16)	(− 1.78)	(− 0.50)
Adj. *R*-sq.	0.06	0.08	0.05	0.26	0.15	0.06
Obs.	294	305	266	54	121	54
DW	0.96	1.05	1.04	0.84	1.03	1.01

Table 4
Composition of government expenditure and economic growth, for nonlinear specification, with *t*-statistics in parentheses

Dependent variable = *GRPCGDP*, five-year forward moving average of per capita real GDP growth rate

	Eq. (4.1)	Eq. (4.2)
East Asia	− 6.41	2.76
	(1.83)	(2.87)
South Asia	− 6.18	2.88
	(− 1.76)	(2.87)
Sub-Saharan Africa	− 9.37	0.04
	(− 2.69)	(0.05)
Latin America	− 10.26	− 1.06
	(− 2.96)	(− 1.2)
EMENA	− 7.55	1.35
	(− 2.09)	(1.09)
Te/GDP	0.02	0.008
	(0.97)	(0.41)
Ncur/Te	0.24	
	(2.39)	
(Ncur/Te)sq.	− 0.001	
	(− 1.95)	
Cap/Te		0.11
		(1.80)
(Cap/Te)sq.		− 0.003
		(− 2.62)
Black	− 0.013	− 0.014
	(− 4.0)	(− 4.58)
Shock	− 0.048	− 0.059
	(− 1.37)	(− 1.7)
Adj. *R*-sq.	0.33	0.32
Obs.	294	305
DW	0.57	0.59

spending) in the budget and a decreasing function of the square term. While the first variable is strongly significant (t-value = 2.39), the square term is insignificant at the conventional 5 percent level. There is one clear explanation of this result: Most of the data points are clustered around the positive and upward-sloping part of the functional relationship. Therefore, it is likely that the linear relationship gives a better fit. The nonlinear specification for the capital expenditure ratio is reported in Eq. (4.2). The function attains a maximum when the ratio is around 18 percent. While the coefficient on the square term is statistically significant, the coefficient on the other variable is not. Once again these results corroborate our earlier findings reported in Table 1. In this case most of the data points cluster around the downward sloping negative part of the functional relationship.

As a check on our results we also include each country's per-capita GDP in 1969 as a proxy for the initial level of development for that country. Previous students of the growth process (e.g., Chenery and Syrquin, 1975) have found this variable to be an important factor in determining the relationship between, say, openness and growth. When this variable is included, the results reported in Table 1 remain unchanged. The variable itself has a negative sign and is statistically insignificant. However, the variable becomes significant when we drop the continent dummies although, again there is no change in the other coefficients.[15]

3.3.4. General vs. central government spending

Our data set covers the operations of only the central government. Ideally, one would like to examine the impact of total government expenditures that includes the operations of state and local governments as well as expenditures of government-owned or -controlled enterprises, on economic growth. This may be particularly important in the case of health and education expenditures, where in some federal systems, the bulk of these expenditures are carried out by subnational governments. Such *comprehensive* and *consistent* expenditure series (across countries and over time) are not available. However, there are a few countries for which consolidated general government expenditures (i.e., operations of central, state, and local governments) are reported in the GFS.

In order to determine whether or not including state and local government expenditure data qualitatively and quantitatively affects our results, we do a few diagnostic tests. Of the 43 countries in our sample, there are nine (see Appendix B for the list) for which consolidated general government expenditure data are reported in the GFS. We use this sample of nine countries to ascertain whether

[15] For space considerations these results are not reported here. They are available from the authors.

Table 5
Sample statistics for central and general government expenditure shares, for nine countries, 1971–90

	Observations		Mean		Std. deviation		Maximum		Minimum	
	CC	CG	CC	CG	CC	CG	CC	CG	CC	CG
Cur/Te	184	135	79.46	76.99	12.64	14.16	98.05	97.73	47.15	45.44
Ncur/Te	184	135	70.70	68.85	12.90	14.28	91.86	93.07	35.12	32.11
Cap/Te	184	135	20.55	20.97	12.62	12.09	52.85	51.95	1.95	1.95
Def/Te	145	121	11.95	8.67	5.70	5.93	26.24	20.76	1.69	0.01
Hlth/Te	182	126	6.17	6.62	3.73	3.79	19.83	19.44	1.09	2.01
Edu/Te	182	126	11.82	13.43	5.94	3.53	24.00	24.31	1.46	6.52
Tac/Te	179	125	8.63	8.85	6.40	6.02	48.27	27.99	0.90	1.96

The nine countries are: Argentina, Chile, Ethiopia, Indonesia, India, Kenya, Malawi, Panama, Zimbabwe.

CC = consolidated central government and CG = consolidated general government.

the expenditure ratios used in our analysis are statistically different for general government from central government in these countries.

Table 5 presents the sample statistics for the expenditure ratios. In comparing the statistics for the two different levels of government, a couple of interesting facts emerge: as defense is primarily the responsibility of the central government, the ratio of defense to total expenditure decreases for general government; the share of education expenditure is larger for general government indicating that state and local government allocate a higher budgetary share for education. The expenditure ratios presented in Table 5 also seem to indicate that state and local governments spend more money on capital but less on current expenditure. Based on a paired *t*-test, we find that all expenditure ratios but transport and communication based on general government data are statistically different (significant at the 99% level) from the ratios based on central government data.[16]

To test whether or not the relationship between the composition of expenditure and economic growth is different when expenditure shares based on general government data are used, we run the same regression model based on each of the two data sets. The regression results are reported in Table 6.

While the signs and magnitudes of the coefficients are similar for both data sets, the coefficients are statistically insignificant. A paired *t*-test, however, indicates that the difference between the coefficients is statistically insignificant. Hence, the coefficient estimates of the growth equations based on general government expenditure and central government expenditure are statistically the same.

[16]For space considerations these results are not reported here. They are available from the authors.

Table 6

Composition of government expenditure and economic growth, with t-statistics in parentheses

Dependent variable = *GRPCGDP*, five-year moving average per capita real GDP growth rate

	Eq. (C.1)	Eq. (G.1)	t-test	Eq. (C.2)	Eq. (G.2)	t-test	Eq. (C.3)	Eq. (G.3)	t-test
East Asia	4.53 (2.25)	4.88 (2.52)	0.023	1.17 (0.53)	2.09 (0.88)	−0.286	−1.62 (−0.54)	1.41 (0.68)	−0.83
South Asia	4.92 (2.04)	5.14 (1.97)	0.086	2.54 (2.36)	2.48 (1.67)	0.035	1.695 (0.88)	0.84 (0.48)	0.33
Sub-Saharan Africa	2.92 (0.98)	2.52 (0.75)	0.11	0.28 (0.16)	−0.06 (−0.03)	0.132	−6.41 (−1.46)	−3.60 (−1.37)	−0.55
Latin America	4.68 (1.47	4.65 (1.35)	0.072	2.25 (1.18)	1.92 (0.97)	0.119	−2.78 (−0.83)	−2.01 (−0.75)	−0.18
EMENA	0	0	0	0	0	0	0	0	0
Te/GDP	−0.025 (−0.41)	−0.026 (−0.44)	−0.048	−0.023 (−0.39)	−0.02 (−0.35)	−0.036	−0.011 (−0.13)	−0.012 (−0.164)	0.0087
Nucr/Te	−0.024 (−0.91)	−0.027 (−0.98)	0.065						

Cap/Te				0.043	0.033	0.215			
				(1.35)	(0.92)				
Def/Te							0.016	− 0.086	0.89
							(0.194)	(− 1.11)	
Hlth/Te							0.066	0.149	− 0.32
							(0.336)	(0.91)	
Ed/Te							0.223	0.152	0.35
							(1.35)	(1.33)	
Tac/Te							0.175	0.062	1.15
							(2.17)	(1.14)	
Black	− 0.014	− 0.012	0.127	− 0.015	− 0.015	0.0	− 0.0079	− 0.00008	− 0.345
	(− 1.45)	(− 0.91)		(− 1.56)	(− 1.19)		(− 0.441)	(− 0.005)	
Shock	− 0.03	− 0.017	− 0.27	− 0.046	0.018	− 0.505	0.042	0.049	− 0.056
	(− 0.34)	(− 0.18)		(− 0.54)	(0.2)		(0.46)	(0.57)	
Adj. *R*-sq.	0.44	0.47		0.45	0.46		0.52	0.62	
Obs.	60	57		60	57		51	46	
DW	0.96	1.00		0.95	0.97		1.02	1.46	

In the equation numbers C stands for central and G for general government, and '*t*-test' indicates the *t*-test for the differences between β_{kc} and β_{kg}.

4. Interpreting the results

The empirical implementation of the model yielded what at first glance seem like surprising results. All of the standard candidates for productive expenditure – capital, transport and communication, health, and education – had either a negative or insignificant relationship with economic growth. The only broad category which was associated with higher economic growth was current expenditure.

But these results are not so surprising if we recall the theoretical model. Seemingly productive expenditures may be unproductive if there is an excessive amount of them. Our empirical results show that developing-country governments have been misallocating public expenditures in favor of capital expenditures at the expense of current expenditures, and the developed countries have been doing the reverse. If, as we suspect, these results stand up to further scrutiny, they have important implications for policy. The widespread recommendation to increase public investment's share of the budget in developing countries could be misleading. Several components of current expenditure, such as operations and maintenance, may have higher rates of return than capital expenditure.

This line of inquiry opens up several questions for further research. One is whether public expenditures on capital goods enhance public capital stocks which have been shown to be associated with economic growth (Canning and Fay, 1993; Levine and Renelt, 1992). If not, why not? A second issue is how governments choose the level and composition of expenditure. Some government objective functions would be consistent with our results; for instance, some capital expenditures ('white elephants') could be in the governments objective function. What then do our results say about government behavior in developing countries? These open questions notwithstanding, the basic message arising from this paper is that the traditional view of the link between the composition of public expenditures and economic growth is not borne out by the historical experience of developing countries.

5. Conclusion

This paper investigated the relationship between the composition of pubic expenditure and economic growth. Using a simple, analytical model, we derived conditions under which a change in the mix of public spending could lead to a higher steady-state growth rate for the economy. The conditions depended not just on the physical productivity of different components of public spending but also on the shares of government expenditure allocated to them. Based on the model, our empirical results suggest that expenditures which are normally considered productive could become unproductive if there is an excessive

amount of them. In particular, capital expenditures – often thought to be the mainstay of development – may have been excessive in developing countries, rendering them unproductive at the margin. Because they are squeezed by capital spending, current expenditures are actually productive at the margin. These results confirm that developing-country governments have been misallocating resources, but show that the direction of bias is quite different from the standard view.

Appendix A

Overlapping observations and serial correlation: Estimation of the covariance matrix of the OLS estimator

The Gauss–Markov assumptions for the method of ordinary least squares estimation are

$$\begin{aligned} E(\mu_t^i) &= 0 && \text{for all countries } i, \\ E(\mu_t^i \mu_{t+h}^j) &= 0 && \text{for } h \neq 0, \\ &= \sigma^2 && \text{for } i = j,\ h = 0. \end{aligned}$$

Proposition. If

$$Y_{(t+1,t+k)}^i = \beta X_t^i + \mu_{t,k}^i$$

is the regression equation to be estimated by the standard OLS technique where the dependent variable is a k-year forward moving average, then under the Gauss–Markov assumptions the error structure satisfies the following:

$$\begin{aligned} E(\mu_{t,k}^i \mu_{t+h,k}^j) &= 0 \quad \text{for} \quad i \neq j, \\ &= 0 \quad \text{for} \quad h \geq k, \\ &\neq 0 \quad \text{for} \quad i = j, \quad h < k. \end{aligned}$$

Proof. We will prove the proposition by contradiction. Suppose that all the standard Gauss–Markov assumptions are satisfied. Therefore:

$$E(\mu_{t,k}^i \mu_{t+h,k}^j) = 0, \qquad i = j, \quad h < k.$$

The above assumption implies

$$E[\{Y_{(t+1,t+k)}^i - \beta X_t^i\}\{Y_{(t+h+1,t+h+k)}^i - \beta X_{t+h}^i\}] = 0, \quad h < k.$$

Let

$$Y_{(t+1,t+k)} = Y_{t,k} \quad \text{and} \quad Y_{(t+h+1,t+h+k)} = Y_{t+h,k}.$$

Then

$$\mathrm{E}(Y^i_{t,k}\,Y^i_{t+h,k}) - \beta X^i_t\ \mathrm{E}(Y^i_{t+h,k}) - \beta X^i_{t+h}\ \mathrm{E}(Y^i_{t,k}) + \beta X^i_t\,\beta X^i_{t+h} = 0, \qquad h < k,$$

or

$$\mathrm{E}(Y^i_{t,k}\,Y^i_{t+h,k}) - \mathrm{E}(Y^i_{t,k})\mathrm{E}(Y^i_{t+h,k}) - \mathrm{E}(Y^i_{t+h,k})\mathrm{E}(Y^i_{t,k}) + \mathrm{E}(Y^i_{tk})\mathrm{E}(Y^i_{t+h,k}) = 0 \qquad h < k.$$

Further, this can be written as

$$\mathrm{E}(Y^i_{t,k}\,Y^i_{t+h,k}) = \mathrm{E}(Y^i_{t,k})\mathrm{E}(Y^i_{t+h,k}), \qquad h < k.$$

But this means that $Y^i_{t,k}$ and $Y^i_{t+h,k}$ for $h < k$ are uncorrelated. This is a contradiction because the dependent variable being a k-year forward moving average implies $Y^i_{t,k}$ and $Y^i_{t+h,k}$ are correlated for $h < k$. Hence, it must be the case that

$$\mathrm{E}(\mu^i_{t,k}\,\mu^j_{t+h,k}) \neq 0, \qquad i = j, \quad h < k. \qquad \text{Q.E.D.}$$

We have shown that, by using overlapping observations in panel data, serial correlation over time is introduced in the error structure in the simple OLS regression analysis. The errors are correlated as long as the sampling interval is less than the moving average lag. Given this correlation, the OLS procedure yields consistent estimates but the standard errors needed to apply tests of significance are incorrect.

To correct the standard errors of the least-squares estimators, we use a methodology first proposed by Hansen and Hodrick (1980) in examining restrictions on a k-step ahead forecasting equation. We extend the applicability of their technique from time-series to panel data (pooled cross-section/time-series data).

Hansen and Hodrick (1980) note that in testing hypotheses concerning the parameters of a k-step ahead linear forecasting equation

$$\mathrm{E}(y_{t+k}/\phi_t) = x_t\beta,$$

one way to ensure that the errors are serially uncorrelated is to define the sampling interval to be equal to the forecast interval. In the context of tests of exchange market efficiency, however, this procedure of using nonoverlapping observations to avoid serial correlation, does not make use of all available data. In testing the efficient-markets hypothesis for foreign exchange markets, Hansen and Hodrick use data sampled more finely than the forecast interval. They propose a modified OLS technique which allows the estimation of the covariance matrix of the OLS estimator.

Hansen and Hodrick (1980) show that $\sqrt{T}(\hat{\beta}_T - \beta)$ converges in distribution to a normally distributed random vector with mean zero and covariance matrix

Θ, where T is the sample size, $\hat{\beta}_T$ is the OLS estimator,

$$\Theta = R_x(0)^{-1}\Xi R_x(0)^{-1} \quad \text{and} \quad \Xi = \sum_{j=-k+1}^{k-1} R_u(j)R_x(j),$$

and

$$R_x(j) = \mathrm{E}(x_t' x_{t+j}) \quad \text{and} \quad R_u(j) = \mathrm{E}(u_{t,k}\, u_{t+j,k}).$$

Further, they show that

$$\hat{R}_x^T(j) = \frac{1}{T}\sum_{t=j+1}^{T} x_t' x_{t-j} \quad \text{and} \quad \hat{R}_u^T(j) = \frac{1}{T}\sum_{t=j+1}^{T} \hat{u}_{t,k}^T\, \hat{u}_{t-j,k}^T$$

are consistent estimators of $R_x(j)$ and $R_u(j)$, respectively. Thus, by estimating the covariance matrix they compute asymptotically justified confidence regions of the OLS estimator.

Using panel data we extend their analysis by noting that for country $i = 1, \dots, N$ with observations $t = 1, \dots, T$

$$\mathrm{E}(y_{t+k}^i) = x_t^i \beta.$$

Thus, along the lines of the Hansen–Hodrick methodology

$$\hat{\Theta}_{N\times T} = (X_{N*T}' X_{N*T})^{-1} X_{N*T}' \hat{\Omega}_{N\times T} X_{N*T} (X_{N*T}' X_{N*T})^{-1}$$

is a consistent estimator of the covariance matrix of the OLS estimator, $\hat{\beta}_{N*T}$; X_{N*T} is a column vector formed by stacking the $N*T$ observations on x_t; and $\hat{\Omega}$ is a symmetric $N*T \times N*T$ matrix whose lower triangular representation is

$$\begin{aligned} a_{t+n,t} &= \hat{R}_\mu(0), && n = 0, \quad t = 1, \dots, N*T, \\ &= \hat{R}_\mu(n), && n = 1, \dots, k-1, \quad t \neq \lambda T - j + 1, \\ & && \text{where } \lambda = 1, \dots, N-1, j = 1, \dots, n, \\ &= 0, && \text{otherwise,} \end{aligned}$$

where

$$\hat{R}_\mu(j) = \frac{1}{N*T}\sum_{i=1}^{N}\sum_{t=j+1}^{T} \hat{\mu}_{t,k}^i\, \hat{\mu}_{t-j,k}^i.$$

In extending the applicability of the Hansen–Hodrick technique to panel data one significant change is introduced in the structure of the covariance matrix. This is due to the following assumption:

$$\mathrm{E}(\mu_{t,k}^i\, \mu_{t+h,k}^j) = 0, \qquad i \neq j, \quad \text{for any } h \text{ and } k.$$

The implication is that by using overlapping observations for a country in panel data, serial correlation is introduced over time but not across country.

Appendix B

Data

Annual data on 43 developing countries (see the list below) from 1970 through 1990 were used for the empirical analysis. Several sources were used (see below the section on sources) to assemble the data base. At this point, we are still in the process of collecting additional data.

The primary source for data on government expenditure is *Government Finance Statistics* (*GFS*), an annual publication of the International Monetary Fund. Ideally, we would like to have consolidated general government (including the expenditures of public-sector enterprises) expenditure data to examine the full impact of public expenditures on economic growth. Unfortunately, such data do not exist in sufficient quantity for the majority of developing countries. GFS coverage is comprehensive for central government accounts but is quite restricted for the accounts of general government. For this reason, the main empirical results presented in data used in this paper are based on central government expenditures. The operations of state and local governments as well as expenditures of government owned or controlled public-sector enterprises are not accounted for. Regression results based on consolidated general government (includes central, provincial and municipal) expenditures are presented in Table 6. Within the main sample of 43 countries, expenditure data on 34 countries are on consolidated central government (includes central government account, social security, and extra budgetary account), and on the remaining nine countries, it only accounts for budgetary central government.

B.1. Data sources

(i) Government Finance Statistics (GFS), International Finance Statistics (IFS), and National Accounts (BESD – World Bank Economic and Social Database) – all from the International Monetary Fund.
(ii) International Currency Analysis, Inc., World Currency Yearbook, New York.
(iii) IECNA in BESD; World Development Report (WDR), 1991; World Debt Tables (WDT) – all from the World Bank.

B.2. Countries

Country groups: Regional classification

5 East Asia countries, 3 South Asia countries, 18 sub-Saharan Africa countries, 13 Latin American and Caribbean countries, and 4 Europe, Middle East, and North Africa (EMENA) countries.

Country groups: Income levels

19 Low-income countries, 22 middle-income (lower-level) countries, and 2 middle-income (upper-level) countries.

Country list

Argentina*, Bolivia, Brazil, Burkina Faso, Cameroon, Chile*, Colombia, Costa Rica, Egypt, Arab Republic of, El Salvador, Ethiopia*, Guatemala, India*, Indonesia*, Kenya*, Korea, Republic of Liberia, Malawi*, Malaysia, Mali, Mauritania, Mauritius, Mexico, Morocco, Nicaragua, Nigeria, Pakistan, Panama*, Peru, Philippines, Rwanda, Senegal, Sri Lanka, Sudan, Syrian Arab Republic, Tanzania, Thailand, Togo, Turkey, Venezuela, Zaire, Zambia, and Zimbabwe* (the asterisks indicate countries for which general government expenditure is also available in the GFS).

References

Arrow, K.J. and M. Kurz, 1970, Public investment, the rate of return and optimal fiscal policy (Johns Hopkins University, Baltimore, MD).

Aschauer, D., 1989, Is government spending productive?, Journal of Monetary Economics 23, 177–200.

Aschauer, D. and J. Greenwood, 1985, Macroeconomic effects of fiscal policy, Carnegie–Rochester Conference Series on Public Policy 23, 91–138.

Barro, R.J., 1990, Government spending in a simple model of endogenous growth, Journal of Political Economy 98, S103–S125.

Barro, R.J., 1991, Economic growth in a cross section of countries, Quarterly Journal of Economics 106, 407–444.

Canning, D. and M. Fay, 1993, The effect of transportation networks on economic growth, Discussion paper (Department of Economics, Columbia University, New York, NY).

Chenery, H.B. and M. Syrquin, 1975, Patterns of development: 1950–1970 (Oxford University Press, London).

Davoodi, H., D. Xie, and H. Zou, 1995, Fiscal decentralization and economic growth in the United States, Mimeo. (The World Bank, Washington, DC).

Diamond, J., 1989, Government expenditure and economic growth: An empirical investigation, Working paper no. 89/45 (International Monetary Fund, Washington, DC).

Easterly, W., 1989, Policy distortions, size of government and growth, NBER working paper no. 3214, Dec.

Easterly, W. and S. Rebelo, 1993, Fiscal policy and economic growth: An empirical investigation, Journal of Monetary Economics 32, 417–458.

Grier, K. and G. Tullock, 1989, An empirical analysis of cross-national economic growth, 1951–1980, Journal of Monetary Economics 24, 259–276.

Hansen, L.P. and R.J. Hodrick, 1980, Forward exchange rates as optimal predictors of future spot rates: An econometric analysis, Journal of Political Economy 88, 830–853.

Holtz-Eakin, D., 1991, Public-sector capital and the productivity puzzle, Mimeo. (Syracuse University, Syracuse, NY).

Hsiao, C., 1992, Analysis of panel data, Econometric Society monograph (Cambridge University Press, Cambridge).

Hulten, C., 1994, Optimal growth with infrastructure capital: Theory and implications for empirical modeling, Mimeo. (University of Maryland, Baltimore, MD).

International Monetary Fund, 1986, A manual on government finance statistics (International Monetary Fund, Washington, DC).
Kaufman, D., 1991, The forgotten rationale for policy reform: The productivity of Bank and IFC investment projects, Mimeo. (The World Bank, Washington, DC).
Kormendi, R.C. and P.G. Meguire, 1985, Macroeconomic determinants of growth: Cross-country evidence, Journal of Monetary Economics 16, 141–164.
Landau, D., 1983, Government expenditure and economic growth: A cross-country study, Southern Economic Journal 49, 783–792.
Levine, R. and D. Renelt, 1992, A sensitivity analysis of cross-country growth regressions, American Economic Review 82, 942–963.
Lindauer, D.L. and A.D. Velenchik, 1992, Government spending in developing countries: Trends, causes and determinants, World Bank Research Observer 7, 59–78.
Morrison, C. and A.E. Schwartz, 1991, State infrastructure and productive performance, Mimeo. (Tufts University, Medford, MA).
Summers, R. and A. Heston, 1988, A new set of international comparisons of real product and price levels: Estimates for 130 countries, Review of Income and Wealth 34, 1–25.
World Bank, 1992, World development report (The World Bank, Washington, DC).
World Bank, 1994, World development report (The World Bank, Washington, DC).
Zhang, T. and H. Zou, 1996, The growth impacts of intersectoral and intergovernmental allocation of public expenditures, Mimeo. (The World Bank, Washington, DC).

2

JOURNAL OF URBAN ECONOMICS 43, 244–257 (1998)
ARTICLE NO. UE972042

Fiscal Decentralization and Economic Growth: A Cross-Country Study*

Hamid Davoodi and Heng-fu Zou

Policy Research Department, The World Bank, N10-075, 1818 H St. NW, Washington, DC 20433; and Institute of Advanced Studies, Wuhan University, Wuhan, China 430072

Received May 14, 1996; revised January 31, 1997

We use a panel data set of 46 countries over the 1970–1989 period to investigate the relationship between fiscal decentralization and economic growth. We find a negative relationship between fiscal decentralization and growth in developing countries, but none in developed countries. Several explanations are offered for our findings.

1. INTRODUCTION

Out of the seventy-five developing and transitional economies with populations greater than five million, all but twelve claim to have embarked on some type of transfer of power to local governments (Dillinger [7]). Fiscal decentralization, or the devolution of fiscal power from the national government to subnational governments, is seen as part of a reform package to improve efficiency in the public sector, to increase competition among subnational governments in delivering public services, and to stimulate economic growth (Bahl and Linn [1], Bird and Wallich [4]).

The basic economic argument in favor of fiscal decentralization is based on two complementary assumptions: (1) decentralization will increase economic efficiency because local governments are better positioned than the national government to deliver public services as a result of information advantage; and (2) population mobility and competition among local governments for delivery of public services will ensure the matching of preferences of local communities and local governments (Tiebout [15];

*For criticisms, suggestions and help, we thank Richard Bird, Jan Brueckner, Shantayanan Devarajan, Andrew Feltenstein, Avner Greif, Bert Hofman, Gregory Ingram, Ronald McKinnon, Charles McLure, Wallace Oates, Yingyi Qian, Anwar Shah, Hedy Sladovich, Barry Weingast, Danyang Xie, Tao Zhang, and seminar participants at Stanford University, Wuhan University, and the World Bank. We are most grateful to two referees and Jan Brueckner for their detailed suggestions, which led to a substantial revision of this paper.

Oates [11]). These public-finance considerations suggest that policies aimed at the provision of public services such as infrastructure and education that are sensitive to regional and local conditions are likely to be more effective in encouraging growth than centrally-determined policies that ignore these geographical differences. Consequently, other things being equal, a decentralized fiscal system where local governments play a more important role than the federal or central government in public-service provision leads to more rapid economic growth (Oates [13]).

Although many policy discussions have favored decentralization, there is little empirical support to the hypotheses mentioned above. The objectives of our study are to supply an analytical framework and empirical methodology, and to use the methodology to test for the presence and size of efficiency gains from fiscal decentralization.

Fiscal decentralization is a complicated phenomenon with many dimensions. This paper will focus on one important dimension: economic growth. Section 2 provides a tractable theoretical and empirical framework linking fiscal decentralization to growth, and characterizes parameters that measure the efficiency gains from fiscal decentralization. The growth dimension of fiscal decentralization is emphasized for two reasons. First, economic growth is often cited as a major objective of fiscal decentralization (Bahl and Linn [1], Bird and Wallich [4], Oates [13]). Second, an often-stated objective of many governments is to adopt policies that lead to a sustained increase in per capita income. In that context, it is important to know which level of government (national or subnational) contributes more to economic growth.

Section 3 provides a detailed empirical examination of the relationship between fiscal decentralization and economic growth. Section 4 concludes and points to some limitations of the study.

2. ANALYTICAL FRAMEWORK

In this section, we outline a theoretical model of fiscal decentralization and economic growth. The model assumes, without loss of generality, three levels of government: federal, state, and local. The level of fiscal decentralization is defined as the spending by subnational governments 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.

Following Barro [3], the production function has two inputs: private capital and public spending. We depart from the Barro model by assuming that public spending is carried out by three levels of government: federal, state, and local. Let k be private capital stock, g total government spending, f federal government spending, s state government spending,

and l local government spending, all measured on a per capita basis:

$$f + s + l = g. \tag{2.1}$$

The production function is Cobb–Douglas[1]:

$$y = k^{\alpha} f^{\beta} s^{\gamma} l^{\omega}, \tag{2.2}$$

where y is per capita output, $1 > \alpha > 0, 1 > \beta > 0, 1 > \gamma > 0, 1 > \omega > 0$, and $\alpha + \beta + \gamma + \omega = 1$.

The allocation of consolidated or total government spending g among different levels of government takes the following form:

$$f = \theta_f g, \qquad s = \theta_s g, \qquad l = \theta_l g, \tag{2.3}$$

where $\theta_f + \theta_s + \theta_l = 1$ 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 the share of state government, and θ_l the share of local government. Consolidated government spending g is financed by a flat income tax at rate τ:

$$g = \tau y. \tag{2.4}$$

The representative agent's preferences are given by

$$U = \int_0^{\infty} \frac{c^{1-\sigma} - 1}{1 - \sigma} e^{-\rho t}\, dt, \tag{2.5}$$

where c is per capita private consumption, and ρ is the positive time discount rate.

The dynamic budget constraint of the representative agent is

$$\frac{dk}{dt} = (1 - \tau)y - c = (1 - \tau)k^{\alpha} f^{\beta} s^{\gamma} l^{\omega} - c. \tag{2.6}$$

We further assume a constant tax rate along the balanced growth path. Given total government spending g, a constant tax rate τ, and the shares of spending by different levels of governments (θ_i's, $i = f, s, l$), the representative agent's choice of consumption is determined by maximizing (2.5) subject to (2.6) and the government's budget allocation. Along the balanced growth path, the solution for the per capita growth rate of the

[1]The use of more general functional forms such as the CES would not alter our analysis qualitatively; see Davoodi, Xie, and Zou [5] and Devarajan, Swaroop, and Zou [6].

economy is given by

$$\frac{dy/dt}{y} = \frac{1}{\sigma}\left[(1-\tau)\tau^{1-\alpha/\alpha}\alpha\theta_f^{\beta/\alpha}\theta_s^{\gamma/\alpha}\theta_l^{\omega/\alpha} - \rho\right]. \tag{2.7}$$

Equation (2.7)[2] shows that the long-run growth rate of per capita output is a function of the tax rate and the shares of spending by different levels of government. It forms the basis for our empirical investigation of the relationship between fiscal decentralization and growth. Following the literature on fiscal federalism, we regard a country as more fiscally centralized if it has a higher value of the federal spending share θ_f.

It is important to note that, for a given share of total government spending in GDP, a reallocation of public spending among different levels of governments can lead to higher economic growth if the existing allocation is different from the growth-maximizing expenditure shares. To show this point, we maximize the growth rate in (2.7) by choosing θ_f, θ_s, and θ_l subject to the constraint $\theta_f + \theta_s + \theta_l = 1$. The growth-maximizing government budget shares are

$$\theta_f^* = \frac{\beta}{\beta+\gamma+\omega}, \qquad \theta_s^* = \frac{\gamma}{\beta+\gamma+\omega}, \qquad \theta_l^* = \frac{\omega}{\beta+\gamma+\omega}.$$

Therefore, as long as the actual government budget shares are different from growth-maximizing shares, the growth rate can always be increased without altering the total budget's share in GDP.

3. EMPIRICAL ANALYSIS

3.1. *Econometric Specification and Data Sources*

Equation (3.1) is the growth regression that will be estimated on a cross-country panel data using the ordinary least squares technique:

$$g_{it} = \delta_1 + \delta_2\theta_{it} + \delta_3\tau_{it} + \delta_4'D_i + \delta_5'N_t + \delta_6'X_{it} + \varepsilon_{it}, \tag{3.1}$$

where $i(=1,\ldots,I)$ and $t(=1,\ldots,N)$ refer to country i at time t; I denotes the number of countries and N the number of time periods; δ_1, δ_2, and δ_3 are scalar parameters while δ_4', δ_5' and δ_6' are vectors; g_{it} is the average growth rate; θ_{it} is the measure of fiscal decentralization; τ_{it} is the tax rate; D_i is a vector of $I-1$ country fixed-effects (i.e., country dummies); N_t is a vector of $N-1$ time fixed-effects (i.e., intercept time dummies). We work with time-averaged data since the benefits of fiscal

[2]See Davoodi, Xie, and Zou [5] for a more general expression of the balanced growth rate with the CES production technology.

decentralization are not expected to affect year-to-year fluctuations in growth. Because of our focus on long-run growth, the growth regression is estimated on data averaged over five- and ten-year periods.[3] Accordingly, the dependent variable is the average growth rate over these two periods; X_{it} is a vector of control variables; and ε_{it} is the disturbance term that is assumed to be serially uncorrelated and orthogonal to the explanatory variables. Our primary concern is the coefficient (δ_2) on the fiscal decentralization variable, which is expected to be positive and significant given the conventional arguments in favor of fiscal decentralization.

The average growth rate is the average growth of real per capita output over five- and ten-year periods. Real per capita output is the real per capita gross domestic product (GDP) at 1985 international prices and is taken from the Summers–Heston [14] data set (version 5.6a). The tax rate is the ratio of total tax revenues to GDP, both in nominal terms and in local currency; these variables are taken from the International Monetary Fund's Government Finance Statistics (GFS) and the World Bank Economic and Social Data (BESD) base, respectively.

The measure of fiscal decentralization is the subnational share of total government spending. The higher is this measure, the higher is the degree of fiscal decentralization. Such a measure has been constructed previously by, *inter alia*, Oates [12, 13]. The numerator of the fiscal decentralization variable is direct spending by subnational governments, i.e., their total spending net of intergovernmental transfers. The denominator is the sum of spending by the national government (i.e., the consolidated central government) and subnational governments (state and local) net of intergovernmental transfers. The GFS is the primary source for internationally comparable data on economic activities at all levels of government. To increase the sample size, for countries with three levels of government we have consolidated accounts of the two subnational governments (state and local governments) into one, thus enabling us to pool the fiscal decentralization measure for these countries with countries that have only one subnational government.

The vector X_{it} consists of a set of variables identified by Levine and Renelt [9] as the important control variables for cross-country growth regressions. These are (i) the average growth rate of population; (ii) initial human capital; (iii) initial per capita GDP; and (iv) the average real investment share of GDP. The first two variables are taken from the World Bank's BESD; the latter two are from the Summers–Heston data

[3]See Barro and Sala-i-Martin [2] for cross-country growth regressions on five- and ten-year average data.

base. The measure of human capital is the secondary school enrollment rate; real investment's share of GDP refers to investment in physical capital.

After combining the above variables from various data sources, we obtain an unbalanced panel data set of 46 countries over the 1970–89 period. The Data Appendix gives the list of countries included.

3.2. *Regression Results*

We estimate regression (3.1) using (i) three country groupings—the full sample (world), developing and developed country samples; (ii) five- and ten-year average data, and (iii) with and without the control variables. Our baseline regression includes the first five regressors in (3.1): a constant, average tax rate, fiscal decentralization, country fixed effects, and time fixed-effects. We then look at the sign and significance of the coefficient on the fiscal decentralization variable as we sequentially add the control variables across the three country groupings. These regressions, therefore, provide a rich set of sensitivity analyses regarding the possible relationship between fiscal decentralization and growth. We have summarized all these regressions in two tables.

Tables 1 and 2 show that there is a negative relationship between fiscal decentralization and economic growth for five- and ten-year intervals in the world and developing country samples; the point estimate is statistically significant in a one-tail test at the 5% and 10% level for the world and the developing country samples respectively. For the world sample, the t-ratios are -2.00 (Table 1; column 5) and -1.85 (Table 2; column 5) while the t-ratios for developing countries are -1.48 (Table 1; column 5) and -1.72 (Table 2; column 5). The one-tail test is a suitable one because the hypothesis that fiscal decentralization leads to higher growth predicts a positive relationship. Clearly a negative relation is a rejection of this hypothesis at the stated significance levels. However, if we were agnostic and maintained a hypothesis of no relation, then we should employ a two-tail test. In such a case we would not be able to reject the hypothesis of no relation at the same significance levels.

With either the one- or two-tail test, the point estimate of fiscal decentralization is similar for both samples in the two tables. For example, a 10 percentage point increase in fiscal decentralization (well within its standard deviation of 18%) in the world and developing country samples is associated with a reduction in the growth rate of 0.7–0.8 percentage points. As a benchmark comparison, consider another growth-reducing policy experiment: an equivalent reduction in the investment-GDP ratio of 10 percentage points will lead to a much larger decline in the growth rate (2.3–3.2 percentage points in the world and developing country samples, respectively).

TABLE 1
Five-Year Averages

Dep. Var: Per Capita GDP Growth

	World sample				
Indep. var.	(1)	(2)	(3)	(4)	(5)
Constant	1.53	4.41	5.53	48.78	51.95
	(0.69)	(1.55)	(1.80)	(3.60)	(3.98)
Average tax rate	−0.04	−0.06	−0.04	−0.06	−0.01
	(−0.58)	(−0.85)	(−0.49)	(−0.81)	(−0.14)
Fiscal decentralization	−0.07	−0.07	−0.06	−0.06	−0.08
	(−1.86)	(−1.85)	(−1.47)	(−1.56)	(−2.00)
Dummy for 1975–79	−1.09	−1.21	−1.01	−0.13	−0.17
	(−2.02)	(−2.24)	(−1.58)	(−0.20)	(−0.26)
Dummy for 1980–84	−2.34	−2.54	−2.45	−0.77	−0.60
	(−4.00)	(−4.28)	(−3.23)	(−0.87)	(−0.71)
Dummy for 1985–89	−1.19	−1.45	−0.98	0.99	1.39
	(−1.91)	(−2.26)	(−1.09)	(0.95)	(1.36)
Population growth		−1.14	−1.43	−1.93	−2.91
		(−1.61)	(−1.90)	(−2.63)	(−3.73)
Initial human capital			−0.04	−0.04	−0.06
			(−1.05)	(−1.25)	(−1.68)
Initial per capita GDP				−5.86	−6.17
				(−3.27)	(−3.58)
Investment share of GDP					0.23
					(2.95)
R-square	0.53	0.54	0.53	0.58	0.62
Obs	158	157	145	145	145
No. of countries	46	45	43	43	43
F value	2.40	2.48	2.22	2.61	2.94
Prob > *F*	0.0001	0.0001	0.0005	0.0001	0.0001

	Developed countries				
Indep. var.	(1)	(2)	(3)	(4)	(5)
Constant	3.42	3.55	2.91	104.59	97.73
	(1.07)	(1.01)	(0.69)	(4.89)	(4.57)
Average tax rate	−0.03	−0.03	−0.01	−0.01	−0.02
	(−0.54)	(−0.54)	(−0.20)	(−0.18)	(−0.38)
Fiscal decentralization	0.01	0.01	0.02	0.04	0.04
	(0.18)	(0.16)	(0.42)	(0.77)	(0.77)
Dummy for 1975–79	−1.16	−1.17	−1.46	0.25	0.46
	(−2.66)	(−2.54)	(−2.84)	(0.45)	(0.83)
Dummy for 1980–84	−1.81	−1.83	−2.29	0.95	1.37
	(−3.40)	(−3.23)	(−3.51)	(1.12)	(1.57)
Dummy for 1985–89	−0.28	−0.29	−0.64	3.44	3.86
	(−0.47)	(−0.47)	(−0.83)	(3.29)	(3.64)
Population growth		−0.06	−0.50	−0.13	−0.46
		(−0.09)	(−0.67)	(−0.21)	(−0.73)

TABLE 1
(*Continued*)

Indep. var.	(1)	(2)	(3)	(4)	(5)
Initial human Capital			−0.01 (−0.25)	−0.01 (−0.57)	−0.01 (−0.72)
Initial per capita GDP				−11.09 (−4.82)	−10.59 (−4.65)
Investment share of GDP					0.12 (1.62)
R-square	0.58	0.58	0.60	0.75	0.76
Obs	72	72	66	66	66
No. of countries	19	19	18	18	18
F value	2.93	2.75	2.58	4.75	4.85
Prob > *F*	0.0008	0.0002	0.0036	0.0001	0.0001
		Developing countries			
Indep. var.	(1)	(2)	(3)	(4)	(5)
Constant	3.46 (1.14)	8.40 (2.06)	9.75 (2.14)	63.76 (3.25)	69.64 (3.76)
Average tax rate	−0.17 (−1.28)	−0.19 (−1.51)	−0.17 (−1.19)	−0.25 (−1.79)	−0.14 (−1.04)
Fiscal decentralization	−0.08 (−1.46)	−0.07 (−1.36)	−0.06 (−1.11)	−0.06 (−1.18)	−0.07 (−1.48)
Dummy for 1975–79	−0.85 (−0.91)	−0.88 (−0.96)	−0.21 (−0.18)	0.91 (0.79)	0.40 (0.37)
Dummy for 1980–84	−2.46 (−2.55)	−2.69 (−2.81)	−1.94 (−1.42)	0.10 (0.07)	−0.34 (−0.25)
Dummy for 1985–89	−1.64 (−1.64)	−2.15 (−2.11)	−0.86 (−0.51)	1.13 (0.66)	1.22 (0.75)
Population growth		−2.00 (−1.77)	−2.17 (−1.82)	−3.33 (−2.81)	−4.81 (−3.89)
Initial human capital			−0.07 (−0.99)	−0.07 (−1.02)	−0.09 (−1.37)
Initial per capita GDP				−7.08 (−2.82)	−7.69 (−3.26)
Investment share of GDP					0.32 (2.71)
R-square	0.54	0.57	0.56	0.62	0.68
Obs	86	85	79	79	79
No. of countries	27	26	25	25	25
F value	2.04	2.23	1.91	2.37	2.84
Prob > *F*	0.0105	0.0051	0.0221	0.0036	0.0006

Note: *t*-statistics are in parentheses. All regressions include country-specific dummies.

TABLE 2
Ten-Year Averages

Dep. Var: Per Capita GDP Growth

	World sample				
Indep. var.	(1)	(2)	(3)	(4)	(5)
Constant	1.51	2.52	5.14	60.76	60.50
	(0.80)	(0.89)	(1.48)	(4.56)	(4.51)
Average tax rate	−0.04	−0.05	−0.07	−0.11	−0.08
	(−0.48)	(−0.54)	(−0.72)	(−1.36)	(−0.91)
Fiscal decentralization	−0.10	−0.10	−0.09	−0.07	−0.07
	(−2.18)	(−2.16)	(−1.75)	(−1.780)	(−1.85)
Dummy for 1980–89	−1.30	−1.34	−1.07	1.05	1.10
	(−2.84)	(−2.85)	(−1.66)	(1.46)	(1.51)
Population growth		−0.41	−1.14	−2.65	−2.74
		(−0.48)	(−1.16)	(−3.03)	(−3.08)
Initial human capital			−0.04	−0.05	−0.05
			(−1.05)	(−1.72)	(−1.75)
Initial per capita GDP				−7.09	−7.12
				(−4.27)	(−4.26)
Investment share of GDP					0.06
					(0.76)
R-square	0.75	0.75	0.75	0.84	0.85
Obs	87	86	82	82	82
No. of countries	46	45	44	44	44
F values	2.38	2.33	2.12	3.53	2.42
Prob > *F*	0.0033	0.0043	0.0128	0.0002	0.0002

	Developed countries				
Indep. var.	(1)	(2)	(3)	(4)	(5)
Constant	−0.27	−3.15	−2.13	80.21	78.15
	(−0.05)	(−0.56)	(−0.32)	(5.73)	(5.14)
Average tax rate	0.09	0.13	0.14	0.11	0.10
	(0.85)	(1.17)	(1.13)	(1.73)	(1.60)
Fiscal decentralization	−0.04	−0.02	−0.01	0.05	0.05
	(−0.52)	(−0.28)	(−0.16)	(1.37)	(1.33)
Dummy for 1980–89	−1.09	−1.07	−1.31	1.45	1.55
	(−1.77)	(−1.75)	(−1.87)	(2.52)	(2.44)
Population growth		1.14	−0.11	0.06	0.05
		(1.11)	(−0.07)	(0.08)	(0.06)
Initial human capital			−0.02	−0.02	−0.02
			(−0.46)	(−1.130)	(−1.08)
Initial per capita GDP				−9.07	−8.92
				(−6.05)	(−5.62)
Investment share of GDP					(0.03)
					(0.46)

TABLE 2
(*Continued*)

Indep. var.	(1)	(2)	(3)	(4)	(5)
R square	0.63	0.66	0.67	0.92	0.93
Obs	38	38	36	36	36
No. of countries	19	19	19	19	19
F value	1.31	1.323	1.083	5.647	5.04
Prob > *F*	0.2937	0.2922	0.4596	0.0024	0.0055
		Developing countries			
Indep. var.	(1)	(2)	(3)	(4)	(5)
Constant	3.79	5.27	10.50	58.38	58.60
	(1.58)	(1.47)	(2.35)	(3.53)	(3.46)
Average tax rate	−0.22	−0.22	−0.34	−0.33	−0.29
	(−1.64)	(−1.64)	(−2.35)	(−2.82)	(−2.17)
Fiscal decentralization	−0.11	−0.11	−0.09	−0.08	−0.08
	(−1.86)	(−1.79)	(−1.53)	(−1.71)	(−1.72)
Dummy for 1980–89	−1.56	−1.64	0.36	−1.36	1.34
	(−2.58)	(−2.59)	(−0.37)	(1.39)	(1.34)
Population growth		−0.64	−1.42	−2.89	−3.01
		(−0.57)	(−1.22)	(−2.69)	(−2.69)
Initial human capital			−0.11	−0.11	−0.11
			(−1.82)	(−2.19)	(−2.12)
Initial per capita GDP				−6.15	−6.26
				(−2.97)	(−2.94)
Investment share of GDP					0.06
					(0.57)
R-square	0.82	0.82	0.84	0.90	0.90
Obs	49	48	46	46	46
No. of countries	27	26	25	25	25
F value	2.92	2.83	2.99	4.60	4.26
Prob > *F*	0.0088	0.0121	0.0122	0.0015	0.003

Note: *t*-statistics are in parentheses. All regressions include country-specific dummies.

As for other explanatory variables in the regressions, the average tax rate is negatively related to growth and quantitatively more significant for developing countries. This finding perhaps reflects the differential effects of distortionary taxation between the two sets of countries. Of the four other control variables, only human capital has the wrong (negative) sign; growth is higher in countries with a higher investment rate, lower population growth and lower initial per capita GDP. The negative coefficient on

initial per capita GDP indicates the conditional convergence found in many previous studies, i.e., other things being equal, countries that start poorer tend to grow faster.

To sum up, regression results in Tables 1 and 2 show that (i) there is no relationship between fiscal decentralization and growth in developed countries, and (ii) the negative relationship between fiscal decentralization and growth is limited to the developing country sample, which seems to be driving the same results in the pooled world sample. To explain the difference, we note that in our panel data there is much more cross-country variation in growth and fiscal decentralization for developing countries than developed countries. The standard deviation of per capita output growth in developing countries is three times as high as that of developed countries; and the spread between the most and the least fiscally-decentralized developing country is 1.4 times as high as the spread in developed countries. Developed countries are simply too homogeneous vis-a-vis developing countries, leaving hardly any cross-country variation in fiscal decentralization to be linked systematically to cross-country differences in growth. Therefore, when the data for developing countries are pooled with developed countries, the variation in the former dominates that in the latter, producing a result for the world sample that closely resembles the developing country sample.

3.3. *Some Explanations of the Negative Effect of Fiscal Decentralization on Growth in Developing Countries*

How can one explain the negative impact of fiscal decentralization on economic growth for developing countries? We offer several explanations. First, the composition of government spending may explain the negative finding. The decentralization measure in this study does not tell us what a subnational government buys; it does not distinguish between current spending (e.g., wages and salaries) and capital spending; nor does it distinguish spending on welfare and social security from infrastructure spending. The conventional wisdom points towards positive growth effects of capital and infrastructure spending and negative growth effects of welfare and current spending. Excessive spending by subnational governments on the wrong expenditure items can lead to lower growth even if the expenditure assignment is optimal. Second, lower growth can result from the wrong revenue assignment among various levels of government. For example, subnational governments may be raising revenues using a tax instrument which should have been used by the central government. Third, the efficiency gains from fiscal decentralization, perhaps the strongest

argument in its favor, may not materialize for developing countries since revenue collection and expenditure decisions by local governments may still be constrained by the central government. Fourth, in practice local governments may not be responsive to local citizens' preferences and needs. This can occur when local officials are not elected by local citizens and when local citizens may be too poor to "vote with their feet."

4. CONCLUSIONS

In this paper we have provided a simple endogenous growth model showing how the degree of fiscal decentralization affects the growth rate of the economy. We used a cross-country panel data set of 46 developed and developing countries over the 1970–89 period to investigate whether fiscal decentralization has any growth impact. From our sample, developed countries are on average more decentralized than developing countries (33% vs. 20%) and tend to have a higher per capita GDP growth rate (2% vs. 1.6%). But can one conclude that there is a positive relationship between decentralization and growth? Given other determinants of growth, we find a negative relationship for developing countries and the world, and none for developed countries. The point estimate for the developing country sample is significant at the 10% level in a one-tail test, which is an appropriate test under the null hypothesis that fiscal decentralization leads to higher growth. Therefore, on the basis of this test and the significance level we clearly reject the hypothesis of a positive relationship between fiscal decentralization and growth.

Finally, we want to draw attention to one major limitation of this preliminary study. Our measure of fiscal decentralization, which is the subnational government share of total government expenditure, may not reflect the subnational governments' autonomy in expenditure decision-making. As Musgrave [10] has pointed out, subnational governments that act as administrative agents of national governments do not necessarily reflect true expenditure decentralization. Further work will look into other related issues of fiscal decentralization such as local autonomy, local revenue collection, the composition of local spending, and intergovernmental transfers.[4]

[4]Some analyses in a dynamic framework can be found in Zou [18, 19].

APPENDIX

List of the 46 Countries in the Sample

Argentina	Zimbabwe
Chile	Belgium
Czechoslovakia, Former	Denmark
Finland	France
Hungary	Ireland
Iceland	Luxembourg
India	Netherlands
Indonesia	Portugal
Iran, Islamic Republic of	United Kingdom
Israel	Poland
Italy	China
Kenya	Australia
Malawi	Austria
Malaysia	Bolivia
Mexico	Brazil
Netherlands Antilles	Canada
Norway	Colombia
Paraguay	South Africa
Philippines	Switzerland
Romania	United States
Sweden	Germany
Thailand	Spain
Uruguay	Yugoslavia, Former Fed. Rep.

REFERENCES

1. R. Bahl and J. F. Linn, "Urban Public Finance in Developing Countries," New York, Oxford Univer. Press (1992).
2. R. Barro and X. Sala-i-Martin, "Economic Growth," McGraw-Hill, New York (1995).
3. R. Barro, Government spending in a simple model of endogenous growth, *Journal of Political Economy*, **98**, S103–S125 (1990).
4. R. Bird and C. Wallich, "Fiscal decentralization and intergovernmental relations in transition economies: Towards a systematic framework of analysis," Country Economics Department Working Paper, World Bank, Washington D.C. (1993).
5. H. Davoodi, D. Xie, and H. Zou, "Fiscal Decentralization and Economic Growth in the United States," Mimeo, Policy Research Department, World Bank (1995).
6. S. Devarajan, V. Swaroop, and H. Zou, The composition of public expenditure and economic growth, *Journal of Monetary Economics*, 37, 313–344 (1996).
7. W. Dillinger, Decentralization and its implications for urban service delivery," Urban Management and Municipal Finance Discussion Paper No. 16, The World Bank, Washington D.C. (1994).

8. International Monetary Fund, "Government Finance Statistics," Washington, DC.
9. R. Levine and D. Renelt, A sensitivity analysis of cross-country growth regressions, *American Economic Review*, **82**, 942–963 (1992).
10. R. Musgrave, "The Theory of Public Finance, A Study in Public Economy," McGraw-Hill, New York (1959).
11. W. Oates, "Fiscal Federalism," Harcourt Brace Jovanovich, New York (1972).
12. W. Oates, Searching for Leviathan: An empirical analysis, *American Economic Review*, **75**, 748–757 (1985).
13. W. Oates, Fiscal decentralization and economic development, *National Tax Journal*, **XLVI**, 237–243 (1993).
14. R. Summers and A. Heston, Summers–Heston Database, version 5.6a (1995).
15. C. Tiebout, A pure theory of local expenditures, *Journal of Political Economy*, **64**, 416–424 (1956).
16. The World Bank, "World Bank Economic and Social Database," Washington, DC.
17. T. Zhang and H. Zou, "Fiscal Decentralization, Public Spending and Economic Growth in China," *Journal of Public Economics*, in press.
18. H. Zou, Dynamic effects of federal grants on local spending, *Journal of Urban Economics*, **36**, 98–115 (1994).
19. H. Zou, Taxes, federal grants, local public spending and growth, *Journal of Urban Economics*, **39**, 303–317 (1996).

3

Journal of Urban Economics 45, 228–239 (1999)
Article ID juec.1998.2095, available online at http://www.idealibrary.com on IDEAL®

Fiscal Decentralization and Economic Growth in the United States*

Danyang Xie

Hong Kong University of Science and Technology, Hong Kong

Heng-fu Zou†

Institute for Advanced Studies, Wuhan University, China and Development Research Group, World Bank, Washington, DC 20433

and

Hamid Davoodi

International Monetary Fund, Washington, DC 20431

Received May 16, 1997; revised February 13, 1998

In a simple model of endogenous growth with spending by different levels of government, we demonstrate how fiscal decentralization affects the long-run growth rate of the economy. Applying the model to the U.S. economy, we find that the existing spending shares for state and local governments have been consistent with growth maximization. In this sense, further decentralization in public spending may be harmful for growth.

1. INTRODUCTION

Fiscal decentralization, the devolution of fiscal responsibilities of the federal government to state and local governments, is seen as a means to enhance the efficiency of the government and promote economic development and growth. This argument is clearly stated by Oates [13]:

> The basic economic case for fiscal decentralization is the enhancement of economic efficiency: the provision of local outputs that are differentiated according

* We thank Amarcsh Bagchi, Richard Bird, Shantayanan Devarajan, Nan Li, Wallace Oates, Yingyi Qian, Barry Weingast, Shlomo Yitzhaki, Dingsheng Zhang, and especially two referees and Jan Brueckner for comments, criticism, and suggestions. Any errors remain ours.

†Mailing address: The World Bank, Room MC2-611, 1818 H Street, N.W. Washington, DC 20433.

to local tastes and circumstances results in higher levels of social welfare than centrally determined and more uniform levels of outputs across all jurisdictions. Although this proposition has been developed mainly in a static context (see my treatment of the Decentralization Theorem, Oates [11]), the thrust of the argument should also have some validity in a dynamic setting of economic growth. There surely are strong reasons, in principle, to believe that policies formulated for the provision of infrastructure and even human capital that are sensitive to regional or local conditions are likely to be more effective in encouraging economic development than centrally determined policies that ignore these geographical differences.

This argument has been supported by many experts on fiscal federalism and local government finance (Rivlin [15]; Bird [3]; Gramlich [8]; Sylla, Wallis, and Legler [16]). In practice, most developing countries have been decentralizing public spending and revenue collection from central governments to local governments (Dillinger [7]), whereas many developed economies such as the United States, the United Kingdom, and Canada are reviving debates on fiscal decentralization or devolution. The case is especially pertinent for the United States. In recent years, the U.S. Congress has been contemplating eliminating hundreds of federal programs, replacing some with block grants to state and local governments, and ending the so-called unfunded federal mandates.

However, it is surprising that the few existing empirical studies have been unsuccessful in their efforts to substantiate the potential contribution of fiscal decentralization to economic growth and development. Davoodi and Zou [5], and Zhang and Zou [17] have taken a first step toward quantifying the growth effects of fiscal decentralization and aggregate public spending by different levels of government. So far they have only found a negative association between output growth and fiscal decentralization in their cross-country study, as well as a country case study on China.

In this paper we set up a general analytical model linking fiscal decentralization to economic growth and then apply our analytical framework to the U.S. economy over the past four decades to test the significance of efficiency gains from fiscal decentralization.

2. A GROWTH MODEL WITH DIFFERENT LEVELS OF GOVERNMENT SPENDING

Following Barro [2], Devarajan, Swaroop, and Zou [6], and Davoodi and Zou [5], the endogenous growth model consists of a production function with two inputs: private capital and public spending, where the function exhibits constant returns to scale in the two inputs. We depart from Barro's model by assuming that public spending is carried out by three levels of government: federal, state, and local. Let k be private capital stock, g the consolidated government spending, f federal government spending, s state

government spending, and l local government spending:

$$f + s + l = g. \tag{1}$$

The production function is CES:

$$y = \left[\alpha k^{\phi} + \beta f^{\phi} + \gamma s^{\phi} + \omega l^{\phi}\right]^{1/\phi}, \qquad -\infty < \phi < 1, \tag{2}$$

where α, β, γ, and ω are all in $(0, 1)$ and $\alpha + \beta + \gamma + \omega = 1$. The CES production function includes the Cobb–Douglas specification in Davoodi and Zou [5] as a special case ($\phi = 0$). The introduction of public spending by different levels of government creates a potentially positive link between fiscal decentralization (i.e., differential effects of spending by three levels of government) and growth. As in Barro [2], when specifying the production function, we do not consider human capital and labor, but allow for these inputs in the empirical work.

The consolidated government spending g is financed by a flat output tax at rate τ:

$$g = \tau y. \tag{3}$$

To derive the long-run growth rate of the economy, we first analyze the decisions made by the private sector. We consider a long-lived representative individual who maximizes his discounted utility,

$$\max \int_0^{\infty} \left[\frac{c^{1-\sigma} - 1}{1 - \sigma}\right] e^{-\rho t}\, dt, \tag{4}$$

where c is consumption of a single good produced in this economy; σ is the inverse of the intertemporal elasticity of substitution; and ρ is the rate of time preference. An overlapping-generations model addressing similar issues is presented by Brueckner [4].

The dynamic budget constraint he faces is:

$$\dot{k} = (1 - \tau)\left[\alpha k^{\phi} + \beta f^{\phi} + \gamma s^{\phi} + \omega l^{\phi}\right]^{1/\phi} - c, \quad k_0 \text{ given.} \tag{5}$$

The representative individual takes as given the government's announcement of the fixed tax rate τ, and spending at different levels of governments, f, s, and l. He then chooses optimally the consumption path $\{c(t) : t \geq 0\}$ and the path of the capital stock $\{k(t) : t \geq 0\}$. To characterize the individual's optimal allocation of resources, we write down the Hamiltonian:

$$H = \left[\frac{c^{1-\sigma} - 1}{1 - \sigma}\right] + \lambda\left\{(1 - \tau)\left[\alpha k^{\phi} + \beta f^{\phi} + \gamma s^{\phi} + \omega l^{\phi}\right]^{1/\phi} - c\right\}. \tag{6}$$

The first-order conditions are given by

$$c^{-\sigma} = \lambda, \tag{7}$$

$$\dot{\lambda} = \rho\lambda - \lambda\alpha(1-\tau)\left[\alpha k^{\phi} + \beta f^{\phi} + \gamma s^{\phi} + \omega l^{\phi}\right]^{(1-\phi)/\phi} k^{\phi-1}. \tag{8}$$

The transversality condition is $k\lambda e^{-\rho t} \to 0$ as t approaches infinity.

Equations (5), (7), and (8) together with the initial condition and the transversality condition determine the representative individual's optimal responses. One immediate result from these equations is that the growth rate of consumption is given by

$$\frac{\dot{c}}{c} = \frac{r(\mathbf{x}) - \rho}{\sigma}, \tag{9}$$

where $\mathbf{x}$ denotes the vector (k, f, s, l, τ); $r(\mathbf{x})$ has the interpretation of the real interest rate and is defined by

$$r(\mathbf{x}) = \alpha(1-\tau)\left[\alpha k^{\phi} + \beta f^{\phi} + \gamma s^{\phi} + \omega l^{\phi}\right]^{(1-\phi)/\phi} k^{\phi-1}. \tag{10}$$

Let us define the spending shares for the federal, state, and local governments as φ_f, φ_s, and φ_l, respectively ($\varphi_f + \varphi_s + \varphi_l = 1$):

$$\varphi_f = \frac{f}{g}, \quad \varphi_s = \frac{s}{g}, \quad \varphi_l = \frac{l}{g}. \tag{11}$$

Then, substituting (10) and (11) into (9), we obtain the long-run growth rate, G, of the economy explicitly as a function of various spending shares, income tax, and other exogenous factors:

$$G = \frac{\alpha(1-\tau)}{\sigma}\left[\frac{\alpha\tau^{-\phi}}{\tau^{\phi} - \beta\varphi_f^{\phi} - \gamma\varphi_s^{\phi} - \omega\varphi_l^{\phi}}\right]^{1-\phi/\phi} - \frac{\rho}{\sigma}. \tag{12}$$

Thus the allocation of public spending among different levels of government can affect economic growth as seen from Eq. (12). To examine how the long-run growth rate responds to various spending shares and income tax rates, we assume that the government's objective is to maximize the growth rate in (12) by choosing τ, φ_f, φ_s, and φ_l. This is the same as maximizing the individual's consumption growth (which coincides with the rate of growth of output and capital) in (9) subject to the government budget constraint of (3). Hence the problem can be formulated as one of maximizing (12) subject to

$$f + s + l \le \tau\left[\alpha k^{\phi} + \beta f^{\phi} + \gamma s^{\phi} + \omega l^{\phi}\right]^{1/\phi}. \tag{13}$$

The growth-maximizing tax rate is given in the following equation:

$$\frac{\tau^{1-\phi}}{\phi\tau + (1-\phi)} = \Pi^{1-\phi}, \tag{14}$$

where $\Pi = \beta^{1/(1-\phi)} + \gamma^{1/(1-\phi)} + \omega^{1/(1-\phi)}$.

The growth-maximizing shares of federal, state, and local government spending are given by

$$\varphi_f^* = \frac{\beta^{1/(1-\phi)}}{\Pi}, \tag{15}$$

$$\varphi_s^* = \frac{\gamma^{1/(1-\phi)}}{\Pi}, \tag{16}$$

$$\varphi_l^* = \frac{\omega^{1/(1-\phi)}}{\Pi}. \tag{17}$$

Here we can interpret $\beta^{1/(1-\phi)}$, $\gamma^{1/(1-\phi)}$, and $\omega^{1/(1-\phi)}$ as measures of individual productivity of public spending by the federal, state, and local governments, respectively. In the same light, $\Pi = \beta^{1/(1-\phi)} + \gamma^{1/(1-\phi)} + \omega^{1/(1-\phi)}$ represents the aggregate productivity of all levels of government spending. From Eqs. (15) to (17), it is apparent that the growth-maximizing spending shares are equal to the ratios of individual productivity over the aggregate productivity. If the actual spending shares do not correspond to these growth-maximizing shares, some reallocation of resources among the three levels of government will be growth-enhancing.

This point can be made most clearly in the case of the Cobb–Douglas production function. With the Cobb–Douglas technology, $\phi = 0$. Then, the growth-maximizing tax rate given by Eq. (14) is very simple:

$$\tau^* = \beta + \gamma + \omega, \tag{18}$$

which is the same as the formula in Barro [2] after making the notation consistent. Π is simply equal to $(\beta + \gamma + \omega)$. The growth-maximizing shares of federal, state, and local government spending are also very simple as in Davoodi and Zou [5]:

$$\varphi_f^* = \frac{\beta}{\beta + \gamma + \omega}, \tag{19}$$

$$\varphi_s^* = \frac{\gamma}{\beta + \gamma + \omega}, \tag{20}$$

$$\varphi_l^* = \frac{\omega}{\beta + \gamma + \omega}. \tag{21}$$

It should be noted that we have focused on growth-maximizing spending shares and income taxation. Quite naturally, we may raise the issue that the government may maximize society's welfare. In general, growth maximization and welfare maximization lead to different tax rates and different spending shares for the three levels of government. However, if the production function is Cobb–Douglas, these two kinds of maximization yield the same solutions.[1]

[1]Technical details are available from the authors upon request.

3. EMPIRICAL ANALYSIS

To test the impact of fiscal decentralization on growth, we use annual historical time series for the U.S. economy from 1948 to 1994. Following the public finance literature (e.g., Oates [12]) we measure fiscal decentralization as the share of spending by each level of government in consolidated government spending across all levels. A ceteris paribus rise in, say, the share of the federal government, indicates a lower degree of fiscal decentralization whereas a ceteris paribus rise in local government's share indicates a higher degree of fiscal decentralization.

Figure 1 plots these shares for three levels of government over the 1948–94 period. The share of state spending rose steadily from 15 to 30% over the 47 years, whereas local spending share fluctuated between 20 and 30% during the same period. The federal spending share declined from 63% in the early 1950s to 43% in 1994. In calculating these spending shares, federal grants to lower levels of government are not counted as federal spending. At the same time, state spending includes the net grants received, which is defined as total grants received by state governments minus state transfers to local governments. Similarly, local spending includes all grants received.

In our theoretical analysis, the growth equation (12) expresses the growth rate of the economy as a function of the shares of government spending

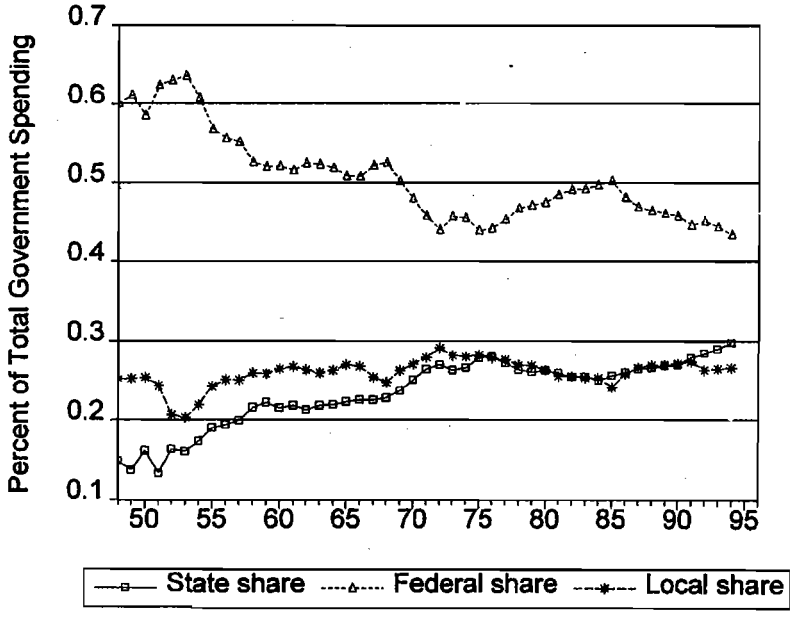


FIG. 1. Fiscal decentralization 1948–1994.

at different levels and the tax rate. Our estimated equation below can be thought of as a linear approximation of our nonlinear growth equation:

$$\Delta y_t = x_t'\delta + u_t \tag{22}$$

where Δ is the difference operator, i.e., $\Delta y_t = y_t - y_{t-1}$, y_t is the logarithm of per capita output; hence Δy_t represents per capita output growth rate; x_t consists of shares of government spending at different levels (measures of fiscal decentralization), the tax rate, and other determinants of growth; δ is the vector of parameters to be estimated; and u_t is a disturbance term which may be serially correlated and/or correlated with some elements of x_t.

The detailed specification of variables in Eq. (22) is as follows. Per capita output is measured by real per capita gross domestic product (GDP). We use our theoretical model as a guide to measure the tax rate and the shares of government spending at different levels. Accordingly, the tax rate τ is defined as the ratio of the total consolidated receipts of government (i.e., net of intergovernmental grants) to GDP. It is therefore a measure of the average tax rate. In the previous section we already explained the construction of shares of government spending by different levels of government. These shares correspond to φ_f, φ_s, and φ_l in our theoretical model. Please note that these shares may be a function of the rate of economic growth. But in this exploratory study we find it difficult to choose a good set of instruments to correct for this potential endogeneity of the spending shares. In reality, these spending shares are not only related to economic growth; they are also a product of political, institutional, and historical processes shaping the assignments of taxes and expenditures among the federal, state, and local governments. Hence, to offer a reasonable explanation for these spending shares amounts to studying how fiscal decentralization itself is determined, which shall be an important topic for further research.

In our empirical estimation, we also include a few other variables to test the robustness of our basic tax and spending share variables as the determinants of growth. These are the size of the labor force, the investment rate, a measure of external shock, two measures of the openness of the economy, the inflation rate, and a measure of income distribution (the Gini coefficient).

The *Bureau of Labor Statistics'* measure of the labor force, adjusted for different education levels of the working population, represents our candidate variable for labor quality or the stock of human capital. We refer to this variable as the labor quality index or labor. Gross private investment in fixed assets, as defined in the *National Income and Product Accounts of the United States (NIPA),* is used as a measure of private investment in physical capital.

A price index of energy products is used as a measure of external shocks. Energy price shocks have always been cited as causes of growth slowdown

in the United States and other industrialized countries; see, among others, Hamilton [9]. We use the average tariff rate as one measure of the openness of the economy. It is defined as the ratio of total customs duties to total imports for consumption. A higher tariff rate indicates a less open economy. Alternatively, we use the ratio of foreign trade volume over GDP as another measure of openness as in many empirical studies on economic growth; see Levine and Renelt [10]. In addition, we include the inflation rate and income distribution as two other control variables to test the robustness of our regression analysis; see Levine and Renelt [10]; Alesina and Rodrik [1]; and Persson and Tabellini [14].

We estimate the growth regression equation (22) using the technique of the ordinary least squares (OLS). The results are reported in Tables 1 and 2.

Table 1 shows our results for three levels of government. Since spending shares for three levels of government add up to unity, we only include two shares in the regression. For the three-level case, we include local and state spending shares, where the local level represents the lowest layer of the government. In Table 1 local spending share has a negative coefficient most of the time (six out of eight regressions), suggesting that higher fiscal decentralization may be associated with lower growth. But the t-statistics for the estimates are not very significant. In addition, the state spending share has a positive, but insignificant, coefficient for all eight regressions. On the basis of our theoretical, growth-maximizing model it is expected that a negative and significant coefficient on one of the government-share variables indicates that this level of government is relatively too large, whereas a positive and significant coefficient suggests that this level of government is relatively too small. Therefore, the insignificant coefficients on local and state spending shares may imply that the existing spending shares for local and state governments have been consistent with growth maximization.[2] In this sense, further decentralization in public spending may be harmful for growth.

For other control variables in Table 1, the estimated coefficients are broadly consistent with other empirical studies on economic growth: higher growth is associated with lower energy prices, income inequality, tariff rate, inflation rate, tax rate and a higher investment rate, and more foreign trade.

Table 2 reports the OLS estimations of the growth regression for two levels of government for the same set of conditioning variables as in

[2]We should also acknowledge the alternate possibility that our model is incorrect and that the effects of public spending by different levels of government in the production function of Eq. (2) are the same. That is to say, output depends only on aggregate government spending g and not on the separate spending levels: f, s, and l. In this case, the spending shares are irrelevant to growth and should have no effect.

TABLE 1
Dependent Variable: Per Capita Output Growth Rate (Three Levels of Government)

Estimation technique period	OLS(1) 1951–1992	OLS(2) 1951–1991	OLS(3) 1958–1994	OLS(4) 1958–1991	OLS(5) 1958–1992	OLS(6) 1958–1991	OLS(7) 1949–1994	OLS(8) 1949–1991
Constant	0.05	0.01	0.30	0.24	0.33	0.27	0.07	0.05
	(0.12)	(0.11)	(0.14)	(0.15)	(0.14)	(0.15)	(0.11)	(0.10)
	[0.41]	[0.10]	[2.09]	[1.59]	[2.23]	[1.80]	[0.65]	[0.54]
Average tax rate	−0.15	−0.03	−0.67	−0.53	−0.72	−0.60	−0.22	−0.18
	(0.40)	(0.39)	(0.41)	(0.45)	(0.43)	(0.45)	(0.38)	(0.37)
	[−0.37]	[−0.07]	[−1.64]	[−1.17]	[−1.65]	[−1.32]	[−0.58]	[−0.49]
State government spending share	0.04	0.07	0.44	0.37	0.54	0.47	0.15	0.25
	(0.41)	(0.41)	(0.42)	(0.52)	(0.49)	(0.52)	(0.34)	(0.36)
	[0.09]	[0.18]	[1.04]	[0.71]	[1.10]	[0.89]	[0.45]	[0.71]
Local government spending share	0.06	0.04	−0.77	−0.64	−0.91	−0.77	−0.06	−0.12
	(0.43)	(0.42)	(0.51)	(0.55)	(0.54)	(0.55)	(0.36)	(0.35)
	[0.14]	[0.10]	[−1.51]	[−1.16]	[−1.69]	[−1.38]	[−0.17]	[−0.34]
Labor growth rate	−0.07	0.07	0.55	0.74	0.52	0.65	−0.06	−0.06
	(0.58)	(0.56)	(0.65)	(0.69)	(0.67)	(0.67)	(0.53)	(0.53)
	[−0.12]	[0.13]	[0.84]	[1.07]	[0.77]	[0.96]	[−0.11]	[−0.12]
D(Log(Private physical capital investment))	0.12	0.11	0.11	0.10	0.09	0.09	0.13	0.12
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
	[3.74]	[3.61]	[3.25]	[2.94]	[2.90]	[2.86]	[4.74]	[4.72]
D(Openness)	0.52	0.15			0.99	0.59		
	(0.44)	(0.45)			(0.50)	(0.56)		
	[1.16]	[0.32]			[1.95]	[1.05]		
D(Average tariff rate)			−1.57	−0.61			−1.23	−0.68
			(1.14)	(1.26)			(0.96)	(0.96)
			[−1.37]	[−0.48]			[−1.27]	[−0.71]
Inflation rate	−0.49	−0.50					−0.44	−0.49
	(0.15)	(0.14)					(0.14)	(0.14)
	[−3.10]	[−3.41]					[−2.99]	[−3.42]
D(Log(Price of energy))			−0.12	−0.11	−0.14	−0.13		
			(0.05)	(0.05)	(0.05)	(0.05)		
			[−2.13]	[−2.07]	[−2.45]	[−2.30]		
D(Gini)		−0.01		−0.02		−0.01		−0.01
		(0.01)		(0.01)		(0.01)		(0.01)
		[−2.43]		[−1.89]		[−1.62]		[−2.75]
Adjusted *R*-squared	0.40	0.47	0.37	0.41	0.40	0.43	0.45	0.53
Number of observations	42	41	37	34	35	34	46	43

Notes: $Dx_t = x_t - x_{t-1}$. Standard errors and t-statistics are given in parentheses and brackets respectively. OLS = ordinary least squares.

TABLE 2
Dependent Variable: Per Capita Output Growth Rate (Two Levels of Government)

Estimation technique period	OLS(1) 1951–1992	OLS(2) 1951–1991	OLS(3) 1958–1994	OLS(4) 1958–1991	OLS(5) 1958–1992	OLS(6) 1958–1991	OLS(7) 1949–1994	OLS(8) 1949–1991
Constant	0.05	0.01	0.11	0.10	0.13	0.11	0.03	0.01
	(0.04)	(0.04)	(0.06)	(0.07)	(0.07)	(0.07)	(0.03)	(0.03)
	[1.32]	[0.18]	[1.72]	[1.36]	[1.77]	[1.44]	[1.15]	[0.04]
Average tax rate	−0.15	−0.01	−0.19	−0.13	−0.16	−0.12	−0.11	−0.01
	(0.21)	(0.21)	(0.24)	(0.24)	(0.25)	(0.247)	(0.19)	(0.19)
	[−0.74]	[−0.01]	[−0.79]	[−0.55]	[−0.64]	[−0.51]	[−0.58]	[−0.02]
State and local government spending share	0.05	0.06	−0.09	−0.11	−0.14	−0.12	0.04	0.06
	(0.12)	(0.11)	(0.20)	(0.21)	(0.21)	(0.21)	(0.12)	(0.11)
	[0.40]	[0.50]	[−0.48]	[−0.55]	[−0.67]	[−0.60]	[0.41]	[0.56]
Labor growth rate	−0.07	0.08	0.31	0.68	0.39	0.61	−0.05	−0.03
	(0.56)	(0.54)	(0.64)	(0.69)	(0.68)	(0.68)	(0.52)	(0.52)
	[−0.13]	[0.14]	[0.48]	[0.98]	[0.58]	[0.89]	[−0.11]	[−0.06]
D(Log(Private physical capital investment))	0.11	0.11	0.12	0.11	0.10	0.10	0.13	0.13
	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
	[3.86]	[3.75]	[3.59]	[3.26]	[3.30]	[3.29]	[5.14]	[5.15]
D(Openness)	0.52	0.14			0.83	0.40		
	(0.40)	(0.41)			(0.51)	(0.54)		
	[1.29]	[0.34]			[1.63]	[0.73]		
D(Average tariff rate)			−1.46	−0.43			−1.13	−0.51
	(1.16)	(1.25)			(0.91)	(0.90)		
			[−1.26]	[−0.35]			[−1.24]	[−0.57]
Inflation rate	−0.48	−0.50					−0.46	−0.51
	(0.15)	(0.14)					(0.14)	(0.14)
	[−3.20]	[−3.50]					[−3.25]	[−3.60]
D(Log(Price of energy))			−0.13	−0.12	−0.14	−0.13		
			(0.05)	(0.05)	(0.06)	(0.06)		
			[−2.33]	[−2.12]	[−2.43]	[−2.24]		
D(Gini)		−0.01		−0.02		−0.01		−0.01
		(0.01)		(0.01)		(0.01)		(0.01)
		[−2.47]		[−1.96]		[−1.78]		[−2.78]
Adjusted *R*-squared	0.41	0.49	0.34	0.41	0.37	0.42	0.46	0.54
Number of observations	42	41	37	34	35	34	46	43

Notes: $Dx_t = x_t - x_{t-1}$. Standard errors and *t*-statistics are given in parentheses and brackets, respectively. OLS = ordinary least squares.

Table 1. With two levels of government, federal and the combined state and local governments, only one spending share is included in the regression because of the adding-up property. We have included the spending share of the combined state and local governments as a measure of fiscal decentralization; a higher level of the combined share indicates a higher

degree of fiscal decentralization. Results in Table 2 show that the estimated coefficients for the combined state and local spending share have mixed signs and are highly insignificant, further indicating that the existing fiscal structure in public spending has been consistent with growth maximization. Other variables in Table 2 have the same signs as in Table 1.

4. CONCLUSION

The main objective of this paper has been to provide theory and evidence on the relationship between fiscal decentralization and growth. In a simple model of endogenous growth with public spending by different levels of government, we have demonstrated how fiscal decentralization affects the long-run growth rate of the economy. Applying the model to the U.S. economy, we find that the existing spending shares for local and state governments are consistent with growth maximization. This finding holds for two as well as three levels of government. Our empirical examination is highly relevant for current policy debates on the allocation of federal grants and the assignment of expenditure responsibilities among the three levels of government in the United States. If efficiency gains and growth are the main objectives for further fiscal decentralization in the United States, the empirical results of our study seem to suggest that this move may be harmful for growth.

DATA APPENDIX

The following data sources are used in this paper: Economic Report of the President (ERP), Historical Statistics of the United States, Colonial Times to 1970 (HSUS); Historical Abstract of the United States (HAUS); National Income and Product Accounts of the United States , Volumes I and II, 1929–1988 (NIPA); Survey of Current Business (SCB); Facts and Figures on Government Finance (FFGF); Bureau of Labor Statistics (BLS); Current Population Reports (CPR).

The variables as well as their sources used in this paper are civilian labor force (ERP; HSUS); population (ERP); imports and exports (ERP); gross domestic private investment (ERP); gross domestic product (ERP); consumer price index or inflation (ERP); total duties calculated and total imports for consumption (HSUS;HAUS); federal government expenditure, state and local government expenditure (NIPA;SCB); state government direct expenditure, local government direct expenditure (HAUS;FFGF); federal grants-in-aid to state and local governments, federal government receipts, state and local government receipts (NIPA;SCB); labor quality index or labor (BLS); price of energy (HSUS;HAUS;SCB); the Gini coefficient (CPR).

The data used in this study are available from the authors upon request.

REFERENCES

1. A. Alesina and D. Rodrik, Distributive politics and economic growth, *Quarterly Journal of Economics*, **109**, 465–490 (1994).
2. R. Barro, Government spending in a simple model of endogenous growth, *Journal of Political Economy*, **98**, S103–S125 (1990).
3. R. Bird, Threading the fiscal labyrinth: Some issues in fiscal decentralization, *National Tax Journal*, **XLVI**, 207–227 (1993).
4. J. Brueckner, Fiscal federalism and capital accumulation, mimeo, Department of Economics, University of Illinois at Urbana–Champaign (1996).
5. H. Davoodi and H. Zou, Fiscal decentralization and economic growth: A cross-country study, *Journal of Urban Economics* **43**, 244–257 (1998).
6. S. Devarajan, V. Swaroop, and H. Zou, Composition of public spending and economic growth, *Journal of Monetary Economics*, **37**, 313–344 (1996).
7. W. Dillinger, Decentralization and its implications for urban service delivery, working paper, The World Bank (1994).
8. E. Gramlich, A policy maker's guide to fiscal decentralization, *National Tax Journal*, **XLVI**, 229–235 (1993).
9. J. Hamilton, Oil prices and the macroeconomy since World War II, *Journal of Political Economy*, **91**, 228–248 (1982).
10. R. Levine and D. Renelt, A sensitivity analysis of cross-country growth regressions, *American Economic Review*, **82**, 942–963 (1992).
11. W. Oates, "Fiscal Federalism," Harcourt Brace Jovanovic, New York (1972).
12. W. Oates, Searching for Leviathan: An empirical study, *American Economic Review*, **75**, 748–757 (1985).
13. W. Oates, Fiscal decentralization and economic development, *National Tax Journal*, **XLVI**, 237–243 (1993).
14. T. Persson and G. Tabellini, Is inequality harmful for growth? Theory and evidence, *American Economic Review*, **84**, June: 600–621.
15. A. Rivlin, "Reviving the American Dream, The Economy, the States, and the Federal Government," Brookings Institution, Washington, D.C (1992).
16. R. Sylla, J. Wallis, and J. Legler, Historical economics: US state and local government, *NBER Reporter*, Spring, 14–16 (1995).
17. T. Zhang and H. Zou, Fiscal decentralization, public spending, and economic growth in China" *Journal of Public Economics*, **67**, 221–240 (1998).

4

ELSEVIER Journal of Monetary Economics 41 (1998) 319–331

JOURNAL OF Monetary ECONOMICS

Should public capital be subsidized or provided?

Shantayanan Devarajan[a], Danyang Xie[b], Heng-fu Zou[a,c,*]

[a] *Development Research Group, The World Bank, 1818 H Street, NW, Washington, DC 20433, USA*
[b] *Hong Kong University of Sciences and Technology, Hong Kong*
[c] *Wuhan University, Wuhan, P.R. China*

Received 5 June 1997; received in revised form 25 September 1997; accepted 8 October 1997

Abstract

In an endogenous-growth model, we consider alternative ways of providing public capital using distortionary taxes. We show that if the government provides the good, the resulting growth rate and welfare may or may not be higher than under laissez-faire. By contrast, if the government subsidizes private providers, not only are growth and welfare higher than under public provision, they are also unambiguously higher than under laissez-faire.

JEL classification: E62; H2; H4; H5; O4

Keywords: Public capital; Subsidy; Taxes; Public provision

1. Introduction

The early literature on endogenous-growth models (Romer, 1986; Lucas, 1988) showed that, when there are stocks that generate positive externalities (knowledge, human capital, infrastructure capital), the government can increase the economy's growth rate by intervening to internalize the externality. This literature assumed that the government had access to lump-sum taxes to finance the intervention. The more recent literature (Barro, 1990) has looked at situations where the government uses distortionary taxes. However, this literature

* Corresponding author. Tel.: + 1 202 473 7939; fax: + 1 202 522 1154; e-mail: hzou@worldbank.org.

does not model the underlying rationale for public intervention. Rather, they assume that government spending is productive by including it as an argument in the aggregate production function.

If the reason for public intervention is an externality, the solution need not be government provision of the good; it could be a subsidy to private providers. The purpose of this paper is to examine alternative forms of providing these so-called 'public capital' goods using distortionary taxes where the externality associated with public capital is explicitly taken into account. In Section 2, we set up a two-capital endogenous-growth model in which type 1 capital has no externality but type 2 has a positive externality. In Section 3, we analyze the laissez-faire equilibrium in a special version of the model, deriving the long-run rate of growth of output. By laissez-faire, we mean that all capital formation is done by private individuals and the government plays no role. In Section 4, we analyze the equilibrium under two popular kinds of government intervention, namely (1) the government's taking over type 2 capital formation; and (2) subsidizing private type 2 capital formation. In Section 5, we compare the welfare and growth rates of the various cases. We show that with public provision, welfare and the growth rate of output may or may not be higher than under laissez-faire, since the distortionary costs of taxation may outweigh the benefits of capturing the positive externality. With the subsidy, however, not only are welfare and the growth rate higher than with public provision (because the former requires less of the distortionary tax) but it is also unambiguously higher than under laissez-faire. Section 6 concludes.

2. The model

Consider an economy with an infinitely lived representative agent. His preferences are given by

$$\sum_{t=0}^{\infty} \rho^t u(c_t),$$

where ρ is the discount factor ($0 < \rho < 1$) and $u(c_t)$ is increasing and concave in c_t, and satisfies the Inada conditions.

The per-capita production function is given by

$$y_t = f(k_t^1, k_t^2)e(\hat{k}_t^2),$$

where k_t^1 is type 1 capital stock in a representative firm and k_t^2 is type 2 capital stock in the representative firm. The positive externality generated by type 2 capital is captured by an increasing function, $e(\hat{k}_t^2)$, where $\hat{k}_t^2$ is the *average* of type 2 capital stock in the economy. Accumulation of the two types of capital

goods is given by

$$k_{t+1}^1 = y_t + (1-\delta^1)k_t^1 - c_t - z_t,$$
$$k_{t+1}^2 = z_t + (1-\delta^2)k_t^2, \tag{1}$$

where δ^1 and δ^2 are the rates of depreciation in type 1 and type 2 capital goods, respectively, and z_t is investment in type 2 capital.

This completes the basic setup. In the next two sections, we characterize the benchmark case (laissez-faire) and the two scenarios outlined in the introduction by solving some dynamic optimization problems. We will use a special example which delivers an explicit solution and makes transparent the comparison of long-run growth rates and welfare.

3. The benchmark case: Laissez-faire

In this section, we analyze the laissez-faire equilibrium in a special version of the model. We adopt a utility function and production function that permit an explicit solution. Specifically, the pair consists of a log utility and the Cobb–Douglas production function, which is used by Long and Plosser (1983) and is a special case of the pairs studied in Benhabib and Rustichini (1994). For pairs of utility and production functions that allow for explicit dynamics in a *continuous* time framework, see Xie (1991), Xie (1994).

To fix ideas, we specify in detail the functional forms in this example:

$$u(c_t) = \ln(c_t),$$

$$f(k_t^1, k_t^2) = A(k_t^1)^\alpha (k_t^2)^\beta,$$

$$e(\hat{k}_t^2) = (\hat{k}_t^2)^{1-\alpha-\beta},$$

where $\alpha \in (0,1)$, $\beta \in (0,1)$ and $\alpha + \beta < 1$. The functional form for the externality term is specified in such a way that long-run growth is possible (see Lucas, 1988; Romer, 1990).

In order to have an explicit solution, we also need to impose that $\delta^1 = \delta^2 = 1$. The assumption of 100% depreciation of both capital goods is not realistic and should be abandoned when it comes to simulation. For the theoretical purpose here, the assumption helps us to draw qualitative conclusions.

Under laissez-faire, formation of both type 1 and type 2 capital is done by private individuals. The government plays no role. As explained in Kehoe et al. (1992), the competitive equilibrium allocation is the result of the following

optimization problem:

$$\text{maximize} \quad \sum_{t=0}^{\infty} \rho^t \ln(c_t)$$

$$\text{subject to } k_{t+1}^1 = A(k_t^1)^\alpha (k_t^2)^\beta (\hat{k}_t^2)^{1-\alpha-\beta} - c_t - z_t,$$

$$k_{t+1}^2 = z_t.$$

The first-order conditions to this problem are

$$1/c_t = \lambda_t, \tag{2}$$

$$\lambda_t = \mu_t, \tag{3}$$

$$\lambda_t = \rho\lambda_{t+1}\alpha y_{t+1}/k_{t+1}^1, \tag{4}$$

$$\mu_t = \rho\lambda_{t+1}\beta y_{t-1}/k_{t+1}^2, \tag{5}$$

$$k_{t+1}^1 = A(k_t^1)^\alpha (k_t^2)^{1-\alpha} - c_t - k_{t+1}^2, \tag{6}$$

where λ_t and μ_t are the Lagrangian multipliers corresponding to the two constraints. The transversality conditions are $\rho^t\lambda_t k_{t+1}^1 \to 0$ and $\rho^t\mu_t k_{t+1}^2 \to 0$ as $t \to \infty$. Note that in Eq. (6), the equilibrium condition $k_t^2 = \hat{k}_t^2$ has been substituted in.

We guess that the solution to the above equations has the following form:

$$k_{t+1}^1 = ay_t, \quad k_{t+1}^2 = by_t \quad \text{and}$$

$$c_t = (1-a-b)y_t \text{ with } a \text{ and } b \text{ constant.}$$

It is straightforward to verify that when $a = \rho\alpha, b = \rho\beta$, the guess above satisfies all the first-order conditions and the transversality conditions and therefore is the solution.[1] To find the rate of output growth, we calculate that

$$y_{t+1} = A(k_{t+1}^1)^\alpha (k_{t+1}^2)^{1-\alpha} = \rho A\alpha^\alpha \beta^{1-\alpha} y_t. \tag{7}$$

Thus, the rate of output growth in the benchmark case is

$$g_0 = \rho A\alpha^\alpha \beta^{1-\alpha} - 1. \tag{8}$$

Note that $k_{t+1}^1 = \rho\alpha y_t$ and $k_{t+1}^2 = \rho\beta y_t$. It is clear that an increase in α raises next period type 1 capital for any given current output; an increase in β raises next period type 2 capital for any given current output. However, from the growth rate formula Eq. (8), g_0 increases in β while the effect of an increase in α is ambiguous. The explanation for this is that β does not appear in the production function at the equilibrium whereas α has an ambiguous effect on output since

[1] We are only interested in non-degenerate symmetric equilibria. A degenerate one would involve $k^2 = 0$, and hence zero output.

$y_{t+1} = A(k^1_{t+1})^{\alpha}(k^2_{t+1})^{1-\alpha}$. Eq. (8) also says that the growth rate is increasing in ρ and A. This is intuitive because an increase in ρ means that individuals discount future utility to a lesser extent and thus would save more and the economy would grow faster; an increase in A means that productivity is higher and therefore the growth rate is higher.

Under laissez-faire, since the positive externality from type 2 capital stock is not internalized, private individuals will invest in this type of capital *less* than the socially optimal amount. This is one of the popular arguments for government action. In the next section, we study the costs and benefits of different types of government intervention to internalize the externality.

4. Costs and benefits of government intervention

In the last section, we reiterated the conventional wisdom that laissez-faire leads to under-investment in the presence of positive externality. The popular actions that the government takes in this circumstance are: (1) take over type 2 capital formation, providing it publicly; and (2) subsidize type 2 capital formation by the private sector. When lump-sum taxes are available to the government, actions (1) and (2) can both restore the social optimum. In this case, it is straightforward to derive that in equilibrium, $k^1_{t+1} = \rho\alpha y_t$, $k^2_{t+1} = \rho(1-\alpha)y_t$ and the rate of output growth is $\rho A\alpha^{\alpha}(1-\alpha)^{1-\alpha} - 1$.

But what if lump-sum taxes are not available and the government has to use *distortionary* taxes? Several issues arise. First, given the tax distortions, is it worthwhile for the government to take any action? Second, which of the two actions – public provision or a subsidy – is more desirable from the social-welfare point of view?

We now analyze the two actions. To simplify matters, we limit our analysis to constant tax/subsidy rates.

4.1. Action 1: Public capital formation by output tax

The setup is as follows. The government announces that a tax rate τ will be levied on output and all the tax proceeds spent on type 2 capital formation for public use. Private individuals then respond optimally to the announced government policy and decide how much to consume and how much to save for type 1 capital investment. Finally, the government takes the individuals' response as given to maximize the representative individual's welfare.

To proceed, let us write down the individual's optimization problem:

$$\text{maximize} \quad \sum_{t=0}^{\infty} \rho^t \ln(c_t)$$

$$\text{subject to } k^1_{t+1} = A(k^1_t)^{\alpha}(\tilde{k}^2_t)^{1-\alpha}(1-\tau) - c_t,$$

where $\tilde{k}_t^2$ and τ are controlled by the government and are taken as given by the individual. The Lagrangian in this case is

$$\mathscr{L} = \sum_{t=0}^{\infty} \rho^t\{\ln(c_t) + \gamma_t[A(k_t^1)^\alpha(\tilde{k}_t^2)^{1-\alpha}(1-\tau) - c_t - k_{t+1}^1]\}. \tag{9}$$

The first-order conditions are

$$1/c_t = \gamma_t, \tag{10}$$

$$\gamma_t = \rho\gamma_{t+1}\alpha(1-\tau)y_{t+1}/k_{t+1}^1. \tag{11}$$

The transversality condition is $\rho^t\gamma_t k_{t+1}^1 \to 0$ as $t \to \infty$. Note that all government tax revenue is assumed to be spent on type 2 capital formation. Thus we have $\tilde{k}_{t+1}^2 = \tau y_t$.

It is easy to verify that the individual's optimal response is the following:

$$k_{t+1}^1 = \rho\alpha(1-\tau)y_t, \tag{12}$$

$$c_t = [1 - \rho\alpha(1-\tau) - \tau]y_t. \tag{13}$$

The growth rate of output is thus

$$g(\tau) = A\rho^\alpha\alpha^\alpha(1-\tau)^\alpha\tau^{1-\alpha} - 1. \tag{14}$$

To find the optimal tax rate, we first calculate the individual's welfare as a function of $\tau, W(\tau)$. This can be done explicitly because Eq. (13) says that consumption starts from $c_0(\tau)$ and grows at a constant rate $g(\tau)$, where $c_0(\tau) = [1 - \rho\alpha(1-\tau) - \tau]y_0$. In fact, we have

$$W(\tau) = \Gamma + \frac{\ln c_0(\tau)}{1-\rho} + \frac{\rho}{(1-\rho)^2}[\alpha\ln(1-\tau) + (1-\alpha)\ln\tau], \tag{15}$$

where Γ is independent of τ. Setting $W'(\tau) = 0$, we get the optimal tax rate

$$\tau_1^* = \rho(1-\alpha) \tag{16}$$

and the resulting growth rate

$$g_1 = \rho A\alpha^\alpha(1-\alpha)^{1-\alpha}[1-\rho(1-\alpha)]^\alpha - 1. \tag{17}$$

It is worth noting that the optimal tax rate derived here is consistent with the one found in Glomm and Ravikumar (1994). Like Barro (1990), Glomm and Ravikumar (1994) *assume* that infrastructure is provided by the government and then ask what the optimal tax rate should be. We in this paper raise the question of whether infrastructure *should be* provided by the government. The answer to this question is deferred to Section 5 where we compare growth rates and welfare in various cases.

4.2. Action 2: Investment subsidy financed by output tax

This is the case in which the government intervenes indirectly through incentive schemes instead of directly taking over type 2 capital formation. We represent the government's action by two constant rates s and τ, where s is the subsidy rate to private type 2 capital formation and τ is the output tax rate. We assume that the government budget is balanced in each period. To ensure a balanced budget, the two rates must satisfy a simple relation: $\tau = \rho\beta s/(1 + \rho\beta s)$. This says that when the subsidy rate s is zero (the laissez-faire case), the tax rate needed to finance the subsidy is obviously zero; when s increases without bound, τ increases and approaches unity. We will verify later that this relation does guarantee a balanced budget.

The above discussion means that the government's action can be represented by the subsidy rate s alone. When s is given, the required τ is determined by $\rho\beta s/(1 + \rho\beta s)$. With this in mind, we raise two questions. First, will welfare increase when we move from $s = 0$ (the laissez-faire case) to a slightly positive s? In other words, does intervention pay? Second, what is the optimal subsidy rate s^* that leads to the highest welfare among all possible subsidy rates?

To answer these questions, we form and solve the representative individual's optimization problem. Each individual takes s and τ as given. He also takes other individuals' actions as given. Since we assume there are an infinite number of individuals, no individual has control over $\{\hat{k}_t^2\}_{t=0}^{t=\infty}$, the average of type 2 capital in the economy. The individual's optimization problem is as follows:

$$\text{maximize} \quad \sum_{t=0}^{\infty} \rho^t \ln(c_t)$$

$$\text{subject to } k_{t+1}^1 = A(k_t^1)^\alpha (k_t^2)^\beta (\hat{k}_t^2)^{1-\alpha-\beta}(1-\tau) - c_t - z_t,$$

$$k_{t+1}^2 = z_t(1+s),$$

where c_t and z_t (investment on type 2 capital) are the control variables; k_t^1 and k_t^2 are the state variables.

The optimal decision by the representative agent can be summarized by the following results:

$$k_{t+1}^1 = \rho\alpha(1-\tau)y_t,$$

$$k_{t+1}^2 = \rho\beta(1+s)(1-\tau)y_t,$$

$$z_t = \rho\beta(1-\tau)y_t.$$

It is straightforward to verify that for s and τ that satisfy $\tau = \rho\beta s/(1 + \rho\beta s)$, the government budget is always balanced:

$$sz_t - \tau y_t = s\rho\beta[1 - \rho\beta s/(1+\rho\beta s)]y_t - [\rho\beta s/(1+\rho\beta s)]y_t \equiv 0.$$

Given the optimal decision of the representative agent, we can easily calculate his welfare as a function of the subsidy rate s. To proceed, we note that

$$c_t = y_t - k_{t+1}^1 - k_{t+1}^2 = (1 - \rho\alpha - \rho\beta)y_t/(1 + \rho\beta s)$$

and

$$\begin{aligned} y_{t+1} &= A(k_{t+1}^1)^{\alpha}(k_{t+1}^2)^{1-\alpha} \\ &= \rho A\alpha^{\alpha}\beta^{1-\alpha}(1+s)^{1-\alpha}y_t/(1+\rho\beta s) \\ &\equiv [1 + g(s)]y_t, \end{aligned}$$

where we use the notation $g(s)$ to denote the growth rate of output when the subsidy rate is s. Since c_t is proportional to y_t, the growth rate of consumption is equal to $g(s)$. Hence, the consumption series starts with $c_0(s) = (1 - \rho\alpha - \rho\beta)y_0/(1 + \rho\beta s)$ and grows at the rate $g(s)$. As a result, welfare as a function of s can be calculated:

$$W(s) = J + \frac{\rho(1-\alpha)}{(1-\rho)^2}\ln(1+s) - \frac{1}{(1-\rho)^2}\ln(1+\rho\beta s), \tag{18}$$

where J is a constant and is independent of the subsidy rate. We now answer the questions raised above in two propositions.

Proposition 1. *Welfare increases when s increases from zero (the laissez-faire case) to a slightly positive rate, i.e. $W'(0) > 0$.*

Proof. From Eq. (18), we obtain

$$W'(s) = \frac{\rho(1-\alpha-\beta) - [1-\rho(1-\alpha)]\rho\beta s}{(1-\rho)^2(1+\rho\beta s)(1+s)}. \tag{19}$$

Thus, $W'(0) = \rho(1-\alpha-\beta)/(1-\rho)^2 > 0$. □

Proposition 2. *The optimal rate of subsidy is given by*

$$s^* = \frac{1-\alpha-\beta}{\beta\,[1-\rho(1-\alpha)]}. \tag{20}$$

Proof. From Eq. (19), we see that,

$$W'(s) = \begin{cases} +, & 0 \leqslant s < s^*, \\ 0, & s = s^*, \\ - & s > s^*, \end{cases}$$

where s^* is given in Eq. (20). Thus $W(s)$ is maximized at s^*. The corresponding output tax rate required to finance the subsidy is given by

$$\tau_2^* = \frac{\rho(1-\alpha-\beta)}{1-\rho\beta},$$

which is seen to lie in the open interval (0,1). □

Propositions 1 and 2 have two implications for policy based on welfare considerations. First, the government can improve upon laissez-faire by subsidizing public capital formation. Second, government intervention should not be overdone; when the subsidy rate is greater than s^*, welfare starts to decline.

When the government subsidizes type 2 capital formation at the rate s^* and finances it by an output tax at the rate τ_2^*, the equilibrium levels of capital formation are given by

$$k_{t+1}^1 = \rho\alpha\left[\frac{1-\rho(1-\alpha)}{1-\rho\beta}\right]y_t, \tag{21}$$

$$k_{t+1}^2 = \rho(1-\alpha)y_t \tag{22}$$

and the resulting growth rate of output is

$$g_2 = \rho A\alpha^\alpha(1-\alpha)^{1-\alpha}\left[\frac{1-\rho(1-\alpha)}{1-\rho\beta}\right]^\alpha - 1. \tag{23}$$

Eq. (23) will be used for comparison with other growth rates.

5. Comparison of growth rates and welfare

In this section, we provide two propositions. Proposition 3 compares growth rates and Proposition 4 compares welfare.

Proposition 3. Among the growth rates in the laissez-faire case and in the subsequent cases with government intervention, we have

$$g_1 < g_2, \qquad g_0 < g_2.$$

Proof. From Eqs. (17) and (23), we see that $g_1 < g_2$. To show that $g_0 < g_2$, let us look at the ratio of the two growth factors:

$$\frac{1+g_2}{1+g_0} = \left[\frac{1-\alpha}{\beta}\right]^{1-\alpha}\left[\frac{1-\rho(1-\alpha)}{1-\rho\beta}\right]^\alpha. \tag{24}$$

Define an auxiliary function $\Phi(x)$ by

$$\Phi(x) = x^{1-\alpha}[1-\rho x]^\alpha.$$

It is straightforward to show that $\Phi(x)$ is increasing in x when $0 < x < (1-\alpha)/\rho$. Note that $0 < \beta < 1-\alpha < (1-\alpha)/\rho$. It must be true that $\Phi(\beta) < \Phi(1-\alpha)$. In other words,

$$\frac{1+g_2}{1+g_0} = \frac{\Phi(1-\alpha)}{\Phi(\beta)} > 1. \qquad \square$$

The intuition behind this proposition is as follows. To begin with, it is natural that g_2 is greater than g_1 because in taking action 2, the government needs less of the distortionary tax to finance the investment subsidy than in taking action 1 where all of public capital formation has to be financed. The result that g_2 is always greater than g_0 says that the benefit from an investment subsidy to correct for the externality is always greater than the cost of financing the subsidy through an output tax. The reason for this stems from Proposition 1, which stated that starting from zero, a small subsidy will improve welfare (it will also increase the growth rate). But a subsidy of zero is the laissez-faire equilibrium. Thus, we can always improve welfare and the growth rate (relative to the laissez-faire case) by increasing the subsidy from zero to its optimal amount.

What Proposition 3 leaves out is the comparison between g_1 and g_0. We now tackle this problem. From Eqs. (8) and (17), we obtain

$$\frac{1+g_1}{1+g_0} = \left[\frac{1-\alpha}{\beta}\right]^{1-\alpha} [1-\rho(1-\alpha)]^{\alpha}. \tag{25}$$

The first term on the right-hand side, which is greater than 1, captures the benefit of internalizing the positive externality; the second term, which is less than 1, captures the cost of the distortionary output tax that is imposed in order to finance the public capital formation.

When α approaches zero, $(1+g_1)/(1+g_0)$ approaches $1/\beta$, which is greater than 1. The net effect of public capital formation is clearly favorable to long-run growth. This occurs because with a small α, type 1 capital is unimportant. The tax distortion on type 1 capital formation is thus not very costly. The benefit from internalizing the positive externality dominates the outcome.

When $(1-\alpha)$ is close to β, the first term is close to 1 and the second term is close to $[1-\rho\beta]^{1-\beta}$. Therefore, the cost dominates the benefit. When $(1-\alpha)$ is close to β, $1-\alpha-\beta$ is close to zero. The externality in the production function is hardly significant and hence not worth internalizing.

The greater ρ is, the less people discount the future. The accumulation of both types of capital, and type 2 capital in particular, will be faster. This requires a greater tax burden and the cost from tax distortion becomes more severe. Therefore, the net benefit from public capital formation tends to be lower with a greater ρ. This intuition is confirmed in Eq. (25).

Proposition 4. Among the representative individual's welfare achieved in the laissez-faire case and in the subsequent cases with government intervention, we have

$$W_0 < W_2, \qquad W_1 < W_2.$$

Proof. $W_0 < W_2$ was established in Propositions 1 and 2. As for W_1 and W_2, they can be calculated as follows. First, note that from Eqs. (13) and (16), we have

$$c_1(0) = \{1 - \rho\alpha[1 - \rho(1-\alpha)] - \rho(1-\alpha)\}y(0) \tag{26}$$

and from Eqs. (21) and (22), we have

$$c_2(0) = \left\{1 - \rho\alpha\left[\frac{1-\rho(1-\alpha)}{1-\rho\beta}\right] - \rho(1-\alpha)\right\}y(0). \tag{27}$$

Also, the growth rates are given explicitly in Eqs. (17) and (23). With this information, the computation of W_1 and W_2 is straightforward and we find

$$\operatorname{sgn}(W_2 - W_1) = \operatorname{sgn}\Psi(\beta),$$

where $\Psi(\beta) = (1-\rho)\ln(1-\rho\alpha-\rho\beta) - (1-\rho)\ln(1-\rho\alpha) - [1-\rho(1-\alpha)]\ln(1-\rho\beta)$. We now show that $\Psi(\beta) > 0$, recalling that $\beta \in (0, 1-\alpha)$. First, we see that $\lim \Psi(\beta) = 0$ as $\beta \to 0+$. Second, we calculate $\Psi'(\beta)$ and find

$$\operatorname{sgn}\Psi'(\beta) = \operatorname{sgn}(1-\alpha-\beta).$$

Thus, $\Psi'(\beta) > 0$ for any $\beta \in (0, 1-\alpha)$. □

While the intuition behind $W_1 < W_2$ is the same as that for the comparison of the two growth rates, note that the initial consumption under action 1 is *higher* than under action 2. Thus, it must be the case that the two consumption paths cross, and that the higher initial consumption under action 1 is dominated by the higher long-run consumption under action 2. As for the comparison between W_0 and W_1, we again have an ambiguous result. When the private return to type 2 capital is small (β close to zero), simple calculation shows that W_0 is less than W_1. Thus, direct provision of type 2 capital is better than laissez-faire. When β approaches $1-\alpha$, we find that

$$\operatorname{sgn}(W_1 - W_0) = \operatorname{sgn}[\Omega(\alpha,\rho)],$$

where,

$$\begin{aligned}\Omega(\alpha,\rho) &= \rho\ln[1-\rho(1-\alpha)]^{\alpha} + (1-\rho)\ln\frac{(1-\rho\alpha)[1-\rho(1-\alpha)]}{1-\rho}\\ &\leqslant \ln\{\rho[1-\rho(1-\alpha)]^{\alpha} + (1-\rho\alpha)[1-\rho(1-\alpha)]\}\\ &< \ln\{\rho[1-\alpha\rho(1-\alpha)] + (1-\rho\alpha)[1-\rho(1-\alpha)]\}\\ &= 0,\end{aligned}$$

in which the first inequality is due to the fact that $\ln(\cdot)$ is concave; the second inequality is because $(1-x)^{\alpha} < 1-\alpha x$ for $\alpha \in (0,1)$ and $x \in (0,1)$. Therefore, when β approaches $1-\alpha$, W_1 is less than W_0. This result is intuitive because in this case, the externality is so small that the benefit from internalizing the externality is negligible compared to the cost of the tax distortion.

6. Conclusions

In this paper, we attempted to combine two ideas arising from the literature on endogenous growth. One is that there are positive externalities associated with stocks, which if internalized can increase the economy's long-run growth rate. The other is that in order to intervene and internalize these externalities, governments have to resort to distortionary taxes. Using a simple model, we showed that the manner in which the government intervenes makes a big difference to whether the intervention is beneficial or not. Specifically, we showed that if the government provides the public capital stock, the resulting growth rate and welfare may not be superior to those when the government does nothing (laissez-faire). By contrast, if the government subsidizes private provision of public capital, the long-run growth rate and welfare will always dominate both the public-provision and laissez-faire cases.

While the model used to derive these results was highly simplified, the basic messages are quite robust. The normative lesson is that governments should always consider the option of subsidization before public provision when intervening to correct an externality. Even under the extreme assumption that the public sector is as efficient as the private sector, the costs of financing public programs through distortionary taxes may outweigh the benefits of internalizing the positive externality. The positive lesson is that government spending could be growth-enhancing in one country but growth-impeding in another, because of the relative importance of distortionary taxation and the externality being internalized. In fact, this idea may be part of the explanation of why empirical estimates of the Barro-type endogenous growth model have produced a wide range of results (see, for example, Aschauer, 1989; King and Rebelo, 1990; Easterly and Rebelo, 1993; Devarajan et al., 1996).

Needless to say, the model in this paper can be enriched in several ways. For instance, it could be extended to include congestion effects in the use of the public capital stock. A wider array of instruments could be considered. For example, if the public capital stock is knowledge, then the government could consider patent policy as another option. Finally, some of the assumptions about functional forms could be relaxed. Simulation analysis would then permit us to characterize not just the long-run growth rate, but the transitional dynamics as well.

Acknowledgements

We would like to thank Jess Benhabib, William Chan, Ross Levine, Chong Yip, Shlomo Yitzhaki, and a referee for useful comments.

References

Aschauer, D., 1989. Is public expenditure productive?. Journal of Monetary Economics 23, 177–200.

Barro, R., 1990. Government spending in a simple of model of endogenous growth. Journal of Political Economy 98, S103–S125.

Benhabib, J., Rustichini, A., 1994. A note on a new class of solutions to dynamic programming problems arising in economic growth. Journal of Economic Dynamics and Control 18, 807–813.

Devarajan, S., Swaroop, V., Zou, H.-f., 1996. The composition of public spending and economic growth. Journal of Monetary Economics 37, 313–344.

Easterly, W., Rebelo, S., 1993. Fiscal policy and economic growth: An empirical investigation. Journal of Monetary Economics 32, 417-458.

Glomm, G., Ravikumar, B., 1994. Public investment in infrastructure in a simple growth model. Journal of Economic Dynamics and Control 18, 1173–1187.

Kehoe, T., Levine, D., Romer, P., 1992. On characterizing equilibria of economies with externalities and taxes as solutions to optimization problems. Economic Theory 2, 43–68.

King, R., Rebelo, S., 1990. Public policy and economic growth. Journal of Political Economy 98, S126–S150.

Long, J., Plosser, G., 1983. Real business cycles. Journal of Political Economy 91, 39–69.

Lucas, R., 1988. On the mechanics of economic development. Journal of Monetary Economics 22, 3–42.

Romer, P., 1986. Increasing returns and long-run growth. Journal of Political Economy 94, 1002–1037.

Romer, P., 1990. Endogenous technological change. Journal of Political Economy 98, S71–S102.

Xie, D., 1991. Increasing returns and increasing rates of growth. Journal of Political Economy 99, 429–435.

Xie, D., 1994. Divergence in economic performance: transitional dynamics with multiple equilibria. Journal of Economic Theory 63, 97–112.

5

JOURNAL OF URBAN ECONOMICS 36, 98–115 (1994)

Dynamic Effects of Federal Grants on Local Spending

HENG-FU ZOU[1]

Public Economics Division, Policy Research Department, The World Bank, Washington, DC 20433

Received February 16, 1993; revised June 11, 1993

In a dynamic model of local government spending, this paper examines both long-run and short-run effects of permanent federal grant changes on local public investment and recurrent expenditures. It also utilizes the Judd approach to quantify the short-run effects of temporary (current and future) policy shocks. The interesting, perhaps surprising, findings are: (1) a permanent increase in the matching grants for investment and recurrent expenditures may accelerate or slow down public investment and (2) a current, temporary grant increase stimulates current public investment, but a temporary, future increase in the nonmatching grant reduces current investment and raises current recurrent expenditures.

I. INTRODUCTION

The effects of intergovernmental grants have been studied extensively in both the theoretical and the empirical literature; see Wilde [11, 12], Gramlich [3], Gramlich and Galper [4], Inman [5], Mieszkowski and Oakland [9], and Rosen [10], among many others. Most of the studies have modeled local (including state, metropolitan, county, and town) government behavior in a static, utility maximization framework. The responses of local spending to federal grants are typically divided into the income effect and the price (substitution) effect. While Gramlich and Galper [4] offered, to our knowledge, the first and the only dynamic analysis to include local capital services in a general equilibrium model, their model specification is limited to a quadratic utility function; the properties of their dynamic model such as stability and comparative statics are not worked out, and the short-run effects versus the long-run effects of changes in federal grants are not examined.

It goes without saying that a dynamic approach to the effects of intergovernmental grants is well justified. First of all, local government spending is readily divided into recurrent expenditures and local public

[1]I thank Richard Bird, Shantayanan Devarajan, Gunnar Eskeland, and especially Anwar Shah for discussions in writing this paper. In revising this paper, I am indebted to Jan Brueckener and two anonymous referees for their suggestions and help. All remaining errors are mine. The opinions expressed here are soley mine and not of the World Bank.

capital formation or investment. Local public investment often takes the tangible form of roads, buildings, streetlights, water supply, and highways; it also takes the intangible form of human capital development such as education financing, provision of health services, and maintenance of public security and order. Federal transfers to local governments are often provided through various grants tied to different items in recurrent expenditures and capital expenditures. In the United States, federal aid to state and local governments has been largely categorical grants designed to support closely specified programs in localities. Many of those categorical grants are related to local public investment. For example, in recent years, grants on highways accounted for about 11.6% of total federal aid to localities; grants on housing and education together accounted for about another 23.7%. How does one identify the effects of these grants on local public investment? Obviously, due to the time-to-build property of capital formation, the static framework used in most of the existing literature is not well suited to deal with this question. Only when studied in a dynamic model of local capital accumulation can the effects of federal grants on both local public investment and recurrent expenditures be identified.

This distinction is of empirical importance, too. A dynamic framework can shed light on the recent policy debate in the United States on the desirability of block grants versus categorical grants. Suppose that the federal government intends to stimulate local investment in response to the alarming deterioration in the nation's infrastructure. It is necessary for policymakers to have a clear idea about the dynamic effects of block or nonmatching grants and categorical or matching grants on local investment. As we will see later, while a matching grant for investment can lead to more local capital formation in the long run, it may even slow down local investment during the transitional period. On the other hand, a nonmatching grant unambiguously raises both the rate of investment in the short run and the capital stock in the long run.

While a dynamic model provides the necessary framework to study both long-run and short-run effects of federal grants on local recurrent expenditures and local investment, it also allows us to distinguish the effects of different grant changes, e.g., a permanent grant change versus a temporary grant change, a current grant change versus a future grant change. In this way, we can see more clearly how the effects of grants are closely related to the timing of grants. From this perspective, we can improve our empirical studies of the effects of intergovernmental grants by explicitly modeling the dynamic behavior of local public investment and by specifying the timing, duration, and expectation of the changes in federal grants.

Motivated by these considerations, this paper represents a formal attempt to model local government behavior within a dynamic framework. In Section II, a dynamic optimization model of a representative local

government is set up, the stability of the dynamic system is analyzed, and the dynamic paths of recurrent expenditures and public investment are characterized. In Section III, we focus on the long-run effects of permanent changes in federal grant policies on local recurrent expenditures and capital formation. We show in particular how different grants affect public investment in the transition to the long-run equilibrium. In Section IV, instead of using phase diagrams to obtain qualitative results, we utilize the Judd [6–8] approach to quantify the short-run effects of temporary grant policy changes on local spending and investment. In addition to summarizing our results in Section V, we also point out directions of further research.

II. THE MODEL

In this paper, local government expenditures are divided into two parts: recurrent expenditures, e, and public investment, I. The representative local government or community has continuously differentiable preferences defined on e and the local public capital stock, k,

$$U(e, k) = u(e) + v(k), \tag{1}$$

with $u'(e) > 0$, $v'(k) > 0$, $u''(e) < 0$, and $v''(k) < 0$. Here $u(e)$ represents the utiiity from the services cf recurrent expenditures and $v(k)$ the utility from the services of the public capital stock. This is the utility function used in Gramlich [3], Arrow and Kurz [1], Gramlich and Galper [4], and Barro [2] among others. The separability of the utility function is assumed for simplicity.

At each time period, the local government collects tax revenues T from its jurisdiction. It also receives the following grants from the federal government: a nonmatching grant g, a matching grant for local public investment αI $(1 > \alpha \geq 0)$, and a matching grant for local recurrent expenditures βe $(1 > \beta \geq 0)$. Thus the budget constraint for the local government is

$$e + I = T + g + \alpha I + \beta e. \tag{2}$$

The accumulation of local public capital is given as

$$\dot{k} = I - \delta k, \tag{3}$$

wherc δ is the depreciation rate of the local capital stock.

The local government tries to maximize a discounted stream of utility with a positive time discount rate ρ,

$$\int_0^\infty [u(e) + v(k)]\exp(-\rho t)dt, \tag{4}$$

subject to constraints (2) and (3). The initial public capital stock is given by k_0.

This is perhaps the simplest dynamic specification of intergovernmental grants and local spending. In this setup, three essential aspects of local government finance are not considered.[2] First, we have assumed away the externality of local public investment on private production as in the models by Arrow and Kurz [1] and Barro [2]. Including private capital accumulation and production in this model is straightforward, but it will make our dynamic analysis, especially the short-run analysis, either much more complicated or intractable. If we consider the dynamics of both local government and private sector independently, we must study this extended model as a differential game played by the local government on one side and the private sector on the other. If we follow the Barro [2] model and consider public investment as an externality to private production, we need to consider the private sector's optimization first and model the reaction function of the private sector as a constraint on the optimization problem of the local government in a dynamic Stackelberg game.

Second, due to the absence of private production in our model, we have taken the nongrant revenues or local own revenues for the typical local government as exogenous. This is another serious limitation of our model. It is clear that local government revenues are closely linked to local production. If public capital is an input to private production in the form of a positive externality, more public capital will attract more business and more business ultimately generates an expanded tax base for the local government. But, in our simple model, the effects of public investment on tax policies and revenues of the local government are ignored.

Third, it is a well-known fact that, at least in the United States, states consider federal grants to be in many cases a nuisance. In fact, the federal government typically decides the amount of the grant (α and β in the model) and the amount of recurrent expenditures and public investment through mandatory spending programs, thereby determining the size of the state's net spending on the whole project. This means that the state may have to settle for a nonoptimal spending level, one which in general will be above what the state would like to pursue. The implication is that

[2] I thank two anonymous referees for pointing out the limitations of the model and for suggesting possible extensions.

other spending projects may be crowded out by federal matching grants on mandatory projects. By treating matching grants very much like an "investment credit," our model is somewhat limited by the fact that the local government is assumed to have complete control over the amount of spending while in reality the decision is often of a second-best nature.

Returning to the analysis of the model, we substitute I from (2) into (3):

$$\dot{k} = (1-\alpha)^{-1}[T + g - (1-\beta)e] - \delta k. \tag{5}$$

Thus the model consisting of the objective function in (4) and the dynamic constraint in (5) is analogous to those with an infinitely lived representative agent who can consume now or invest. The expressions $(1-\alpha)$ and $(1-\beta)$ are simply "prices" for investment and consumption, and the nonmatching grant g is simply a change in income. From this perspective, our model is essentially an extension of the dynamic analysis of optimal consumption and investment from a representative consumer to a representative local government. Here the control variable is recurrent expenditures e, and the state variable is the stock of public capital k. The dynamic paths of local own revenues and federal grants are exogenously given.

To solve this optimization problem, we first define the current-value Hamiltonian function,

$$H(e,k,\lambda) = u(e) + v(k) + \lambda\{(1-\alpha)^{-1}[T + g - (1-\beta)e] - \delta k\}, \tag{6}$$

where λ is the current marginal utility of an extra unit of public capital.

The necessary conditions for an optimum are

$$u'(e)/\lambda = (1-\beta)/(1-\alpha), \tag{7}$$

$$v'(k) - \lambda(\delta + \rho) = -\dot{\lambda}, \tag{8}$$

$$\dot{k} = (1-\alpha)^{-1}[T + g - (1-\beta)e] - \delta k, \tag{5}$$

and the transversality condition is

$$\lim_{t\to\infty} \lambda(t)k(t)\exp(-\rho t) = 0. \tag{9}$$

We interpret these conditions as follows. Equation (7) says that the marginal rate of substitution between recurrent expenditures and public investment equals their price ratio. Equation (8) is the Euler equation trading off current and future public investment. Equation (5) again is the dynamic budget constraint for the local government.

Solving λ from Eq. (7) and substituting the solution into (8), we obtain a complete system of dynamic equations in terms of e and k:

$$\dot{e} = \left[-v'(k)(1-\beta)(1-\alpha)^{-1}/u''(e)\right] + \left[u'(e)(\delta+\rho)/u''(e)\right], \quad (10)$$

$$\dot{k} = (1-\alpha)^{-1}[T+g-(1-\beta)e] - \delta k \quad (5)$$

Now it can be shown that the dynamic system is saddle-point stable in the neighborhood of the steady-state values of e and k. Let e^* and k^* denote the steady-state values of e and k, respectively. Linearizing the system around e^* and k^*,

$$\begin{bmatrix} \dot{e} \\ \dot{k} \end{bmatrix} = \begin{bmatrix} (\delta+\rho) & -v''(k^*)(1-\beta)(1-\alpha)^{-1}/u''(e^*) \\ -(1-\beta)(1-\alpha)^{-1} & -\delta \end{bmatrix} \times \begin{bmatrix} e-e^* \\ k-k^* \end{bmatrix}. \quad (11)$$

Let J be the constant Jacobian matrix of the equilibrium equations in (11) and let Δ be the determinant of J. It is simple to see that Δ is negative from (11):

$$\Delta = -\delta(\delta+\rho) - \left\{v''(k^*)\left[(1-\beta)(1-\alpha)^{-1}\right]^2/u''(e^*)\right\} < 0. \quad (12)$$

Since the product of the two characteristic roots for (11) equals Δ, a negative Δ means that one root is negative and one root positive. Thus the dynamic system is saddle-point stable.

Let μ be the positive characteristic root and ω the negative root:

$$\mu = \left[\rho + (\rho^2 - 4\Delta)^{1/2}\right]/2, \quad \text{and} \quad \omega = \left[\rho - (\rho^2 - 4\Delta)^{1/2}\right]/2. \quad (13)$$

The perfect-foresight convergent path is given by

$$k(t) = k^* - (k^* - k_0)\exp(\omega t), \quad (14)$$

$$e(t) = e^* + (\omega - \delta)(1-\alpha)(1-\beta)^{-1}(k(t) - k^*). \quad (15)$$

In (14) and (15), the capital stock and recurrent expenditures converge to the steady state k^* and e^* in the long run, because $\exp(\omega t)$ approaches zero for sufficiently large time t.

III. PERMANENT POLICY SHOCKS AND LONG-RUN EFFECTS

To examine the long-run effects of different federal grants on local recurrent expenditures and the capital stock, it is necessary to assume that all policy shocks in this section are permanent in nature, for temporary policy shocks cannot affect the long-run equilibrium values of e and k. Let the state prior to the policy shock be a steady state. The steady-state equations are $\dot{e} = 0$ and $\dot{k} = 0$:

$$-v'(k^*)(1-\beta)(1-\alpha)^{-1} + u'(e^*)(\delta+\rho) = 0, \tag{16}$$

$$(1-\alpha)^{-1}[T+g-(1-\beta)e^*] - \delta k^* = 0. \tag{17}$$

If permanent policy changes happen to the three grant parameters α, β, and g, they will alter the equilibrium values and their effects on the equilibrium values of e and k can be derived from the total differentiation of Eqs. (16) and (17):

$$\begin{bmatrix} (\delta+\rho)u''(e^*) & -v''(k^*)(1-\beta)(1-\alpha)^{-1} \\ -(1-\beta)(1-\alpha)^{-1} & -\delta \end{bmatrix} \begin{bmatrix} de^* \\ dk^* \end{bmatrix} = \begin{bmatrix} -v'(k^*)(1-\alpha)^{-1}\,d\beta + v'(k^*)(1-\beta)(1-\alpha)^{-2}\,d\alpha \\ -(1-\alpha)^{-1}e^*d\beta - [T+g-(1-\beta)e^*] \\ \times(1-\alpha)^{-2}\,d\alpha - (1-\alpha)^{-1}\,dg \end{bmatrix}. \tag{18}$$

First, a permanent increase in the matching grant for public investment raises the long-run public capital stock but has an ambiguous effect on recurrent expenditures; furthermore, it may speed up or slow down investment along the unique perfect foresight path. To see the former, apply Cramer's rule to (18),

$$dk^*/d\alpha = \{-(\delta+\rho)[T+g-(1-\beta)e^*](1-\alpha)^{-2}u''(e^*) + (1-\beta)^2(1-\alpha)^3 v'(k^*)\}/\Delta u''(e^*),$$

which is positive, but

$$de^*/d\alpha = \{-v''(k^*)[T+g-(1-\beta)e^*](1-\beta)(1-\alpha)^3 - v'(k^*)\delta(1-\beta)(1-\alpha)^2\}/\Delta u''(e^*),$$

which has an ambiguous sign because the first term in parentheses is positive while the second term is negative. The intuition is the same as in the static model: an increase in the matching grant for investment lowers the relative price of investment $(1-\alpha)/(1-\beta)$. Hence, the local government tends to substitute investment for recurrent spending. At the same time, a higher α means more budget revenue for the local government, and the income effect works in the opposite direction.

For investment, take the time derivative of $k(t)$ in (14),

$$\dot{k}(t) = \omega(k - k^*), \tag{19}$$

while in (19) an increase in α raises k^*, which in turn accelerates investment if $k < k^*$ (since $\omega < 0$); a higher α may make ω less negative, which results in a slower capital accumulation. In fact,

$$d\omega/d\alpha = (\rho^2 - 4\Delta)^{-1/2}\, d\Delta/d\alpha.$$

So $d\Delta/d\alpha$ and $d\omega/d\alpha$ have the same sign. From (12),

$$\begin{aligned} d\Delta/d\alpha = &-(1-\beta)^2(1-\alpha)^{-2}(u''(e^*))^{-1}v'''(k^*)(dk^*/d\alpha) \\ &+(1-\beta)^2(1-\alpha)^{-2}(u''(e^*))^{-2}v''(k^*)u'''(e^*)(de^*/d\alpha) \\ &-\left[(1-\beta)^2(1-\alpha)^{-3}v''(k^*)/u''(e^*)\right]. \end{aligned}$$

It is easy to provide specific examples to illustrate that $d\Delta/d\alpha$ is positive. In this case, $d\omega/d\alpha$ will be positive, and an increase in the matching grant for investment may lead to slower investment, even though a higher investment matching grant will eventually raise the long-run public capital stock. It should be emphasized here that a less-negative eigenvalue ω has a significant impact on the rate of convergence from the initial capital stock k_0 to the steady-state capital k^* because $\exp(-\omega t)$ approaches zero much more slowly for a less-negative ω in Eq. (14):

$$k(t) = k^* - (k^* - k_0)\exp(\omega t).$$

With a less negative eigenvalue ω, the time it takes to get to the steady state may actually increase even though the matching grant for public investment eventually raises the long-run stock of public capital. This result also has implications for empirical studies on the stimulating effects of government grants on local spending. Take the highway construction as an example. If the long-run demand for the highway system in a certain state can be estimated as a function of various federal grants, especially the highway grant, in addition to other exogenous factors, it should not be

surprising to find that, while the steady-state stock of highways increases with highway grant, the annual highway construction may not show a significant upward jump because the construction may be spread over a longer time period.

Second, an increase in the matching grant for recurrent expenditures raises recurrent spending; its effect on the equilibrium stock of public capital is ambiguous. To see this, we apply Cramer's rule again in (18),

$$\begin{aligned} de^*/d\beta &= \Big[v'(k^*)\delta(1-\alpha)^{-1} \\ &\qquad -v''(k^*)(1-\beta)(1-\alpha)^{-2}e^*\Big]/u''(e^*)\Delta > 0, \\ dk^*/d\beta &= \Big[-(\delta+\rho)(1-\alpha)^{-1}u''(e^*)e^* \\ &\qquad -v'(k^*)(1-\beta)(1-\alpha)^{-2}\Big]/u''(e^*)\Delta, \end{aligned}$$

where $dk^*/d\beta$ does not have a definite sign.

The economic intuition is also similar to the static case. A rise in the matching grant for recurrent expenditures reduces the price for recurrent expenditures $(1-\beta)$ and raises the relative price for public investment $(1-\alpha)/(1-\beta)$. Therefore, the substitution effect of this matching grant gives rise to more recurrent spending and less public capital stock in the long run. But a higher matching grant of any kind always implies more income for the local government. Since both recurrent expenditures and local public capital are normal goods in our model, the income effect of the matching grant for recurrent expenditures will increase the long-run stock of public capital.

Third, an increase in the nonmatching grant results in more capital stock and more recurrent expenditures. In fact, from (18),

$$\begin{aligned} de^*/dg &= -v''(k^*)(1-\beta)(1+\alpha)^2(1-\alpha)^{-2}/\Delta u''(e^*) > 0, \\ dk^*/dg &= -(\delta+\rho)\delta/\Delta > 0. \end{aligned}$$

It can also be shown that the rise in the nonmatching grant accelerates the rate of public investment. Substituting $k(t)$ in (14) into (18), we have

$$\dot{k}(t) = -\omega\exp(\omega t)(k^* - k_0).$$

The response of public investment to the nonmatching grant is given by (note that $\omega < 0$)

$$d\dot{k}(t)/dg = -\omega\exp(\omega t)dk^*/dg > 0.$$

The effects of a nonmatching grant on public capital and recurrent spending are what we expect, for they are the results of a pure income

effect. However, the positive effect on the rate of public investment is a bit surprising when compared to the ambiguous effect of the matching grant for investment on the rate of public investment. Technically, the reason is that the negative characteristic root ω is independent of the nonmatching grant g. As usual in dynamic analysis, characteristic roots are often complicated functions of various parameters in a dynamic system. It is often misleading to make an assertion based only on intuition. Perhaps our analysis in this section provides another illustration of this kind of complexity.

IV. TEMPORARY POLICY SHOCKS AND SHORT-RUN EFFECTS

Many grant policies are temporary and even project-specific in their nature. During the course of time, grant policies also change frequently. While these temporary shocks cannot influence the long-run equilibrium values of recurrent expenditures and the stock of public capital, they are significant elements in shaping the short-run behavior of local government spending. Very often in dynamic economic analysis, the study of the short-run effect of a temporary shock uses phase diagrams to obtain some qualitative results. Here we will follow the approach developed in a series of papers by Judd [6–8] to quantify the short-run effects of temporary changes in federal government grants on local government spending.

Suppose that at time $t = 0$, the stock of public capital and recurrent spending are at the steady-state level corresponding to the grant parameters α, β, and $\bar{g}$. Also at time $t = 0$, federal grant policies change as

$$\alpha' = \alpha + \varepsilon h_\alpha(t), \tag{20a}$$

$$\beta' = \beta + \varepsilon h_\beta(t), \tag{20b}$$

$$g' = \bar{g} + \varepsilon g(t), \tag{20c}$$

where ε is a parameter. Functions $h_\alpha(t), h_\beta(t)$, and $g(t)$ describe the intertemporal policy changes in a magnitude-free fashion since ε can represent different magnitudes of changes. For example, a change in the matching grant for investment during time period $T_1 < t < T_2$ can be represented by setting $h_\alpha(t)$ to be one for $T_1 < t < T_2$ and zero otherwise.

Substituting α', β', and g' for α, β, and g in Eqs. (5) and (10), respectively;

$$\dot{e} = -v'(k)(1 - \beta - \varepsilon h_\beta)(1 - \alpha - \varepsilon h_\alpha(t))^{-1}/u''(e) + u'(e)(\delta + \rho)/u''(e), \tag{21a}$$

$$\dot{k} = (1 - \alpha - \varepsilon h_\alpha(t))^{-1}\left[T + \bar{g} + \varepsilon g(t) - (1 - \beta - \varepsilon h_\beta)e\right] - \delta k. \tag{21b}$$

The solutions for k and e depend on both t and ε. We write the solutions as $k(t, \varepsilon)$ and $e(t, \varepsilon)$. Since $\varepsilon = 0$ implies that the system remains at the initial position, the effects of a grant policy change can be seen from the impact on the paths of e and k as ε shifts from zero to a small positive or negative value. Formally, we define the initial impact of ε on e and k here:

$$e_\varepsilon(t) = \partial e(t,0)/\partial\varepsilon, \qquad k_\varepsilon(t) = \partial k(t,0)/\partial\varepsilon,$$
$$\dot{e}_\varepsilon(t) = \partial(\partial e(t,0)/\partial\varepsilon)/\partial t, \qquad \dot{k}_\varepsilon(t) = \partial(\partial k(t,0)/\partial\varepsilon)/\partial t.$$

Differentiation of Eqs. (21a) and (21b) evaluated at $\varepsilon = 0$ yields a linear differential equation in variables e_ε and k_ε,

$$\begin{bmatrix} \dot{e}_\varepsilon \\ \dot{k}_\varepsilon \end{bmatrix} = J \begin{bmatrix} e_\varepsilon \\ k_\varepsilon \end{bmatrix} + \begin{bmatrix} w_1(t) \\ w_2(t) \end{bmatrix}, \tag{22}$$

where

$$\begin{aligned} w_1(t) &= \left[-(1-\beta)(1-\alpha)^{-2} v'(k^*) h_\alpha(t)/u''(e^*)\right] \\ &\quad + \left[(1-\alpha)^{-1} v'(k^*) h_\beta(t)/u''(e^*)\right], \\ w_2(t) &= [T + \bar{g} - (1-\beta)e^*](1-\alpha)^{-2} h_\alpha(t) \\ &\quad + (1-\alpha)^{-1} e^* h_\beta(t) + (1-\alpha)^{-1} g(t), \end{aligned}$$

and J is the Jacobian matrix in (11).

As in Judd [8], the Laplace transform can be used to solve Eq. (22). For sufficiently large positive s, the Laplace transform of a function $f(t)$ $(t > 0)$ is another function $F(s)$, where

$$F(s) = \int_0^\infty f(t) \exp(-st)\, dt.$$

Naturally, let $E_\varepsilon(s), K_\varepsilon(s), H_\alpha(s), H_\beta(s), G(s)$, and $W(s)$ be the Laplace transforms of $e_\varepsilon(t), k_\varepsilon(t), h_\alpha(t), h_\beta(t), g(t)$, and $w(t)$, respectively. Then

$$\begin{bmatrix} E_\varepsilon \\ K_\varepsilon \end{bmatrix} = (s\Lambda - J)^{-1} \begin{bmatrix} W_1(s) + e_\varepsilon(0) \\ W_2(s) \end{bmatrix}, \tag{23a}$$

where Λ is the identity matrix. Write out $(s\Lambda - J)^{-1}$ explicitly in (23a):

$$\begin{bmatrix} E_\varepsilon \\ K_\varepsilon \end{bmatrix} = [(s-\mu)(s-\omega)]^{-1} \times \begin{bmatrix} s+\delta & -(1-\beta)(1-\alpha)^{-1} v''/u'' \\ -(1-\beta)(1-\alpha)^{-1} & s-\delta-\rho \end{bmatrix} \times \begin{bmatrix} W_1(s) + e_\varepsilon(0) \\ W_2(s) \end{bmatrix}. \tag{23b}$$

For a temporary shock at present or in the future, the steady-state values of recurrent expenditures and the capital stock remain the same. Therefore,

$$W_1(s) = -(1-\beta)(1-\alpha)^{-2} v'(k^*) H_\alpha(s)/u''(e^*) + (1-\alpha)^{-1} v'(k^*) H_\beta(s)/u''(e^*),$$

$$W_2(s) = [T + \bar{g} - (1-\beta)e^*](1-\alpha)^{-2} H_\alpha(s) + (1-\alpha)^{-1} e^* H_\beta(s) + (1-\alpha)^{-1} G(s).$$

In Eq. (23b), $e_\varepsilon(0)$ represents the initial jump in recurrent expenditures corresponding to grant policy changes. As usual in dynamic analysis, this jump is necessary to assure the convergence of the variables along the perfect foresight path. To determine $e_\varepsilon(0)$, we note that the existence of a saddle-point equilibrium in our model implies a bounded, steady-state capital stock for any ε. Therefore, $K_\varepsilon(s)$ must be finite for all $s > 0$, even for $s = \mu$ (the positive eigenvalue of the dynamic system). However, when $s = \mu$, the matrix $(s\Lambda - J)$ is singular and the denominator in the inverse matrix is zero. To have a bounded $K_\varepsilon(\mu)$, implicitly, the numerator on the right-hand side of (23b) must be zero (see the Appendix in Judd [8] for technical details). That is to say,

$$(\mu + \delta)[W_1(\mu) + e_\varepsilon(0)] - (1-\beta)(1-\alpha)^{-1} W_2(\mu) v''/u'' = 0,$$

or

$$
\begin{aligned}
e_\varepsilon(0) &= (1-\beta)(1-\alpha)^{-1}(\mu+\alpha)^{-1}W_2(\mu)v''/u'' - W_1(\mu) \\
&= \left.\begin{aligned}&\left[(1-\beta)(1-\alpha)^{-1}(\mu+\alpha)^{-1}v''/u''\right] \\ &\quad\times\left\{\left[T+\bar{g}-(1-\beta)e^*\right](1-\alpha)^{-2}\right. \\ &\qquad\left.+(1-\beta)(1-\alpha)^{-2}v'(k^*)/u''(e^*)\right\}H_\alpha(\mu)\end{aligned}\right\}\text{(effect of }\alpha) \\
&\quad+\left.\begin{aligned}&\left\{\left[-(1-\alpha)^{-2}v'(k^*)/u''(e^*)\right]\right. \\ &\qquad\left.+(1-\alpha)^{-2}(1-\beta)(\mu+\alpha)^{-1}v''/u''\right\}H_\beta(\mu)\end{aligned}\right\}\text{(effect of }\beta) \\
&\quad+\left[(1-\beta)(1-\alpha)^{-2}(\mu+\alpha)^{-1}v''/u''\right]G(\mu)\Big\}\text{(effect of }g).
\end{aligned}
\tag{24}
$$

Equation (24) presents that impact of temporary grant policy changes on the initial recurrent expenditures. First, any future increase in the matching grant for the recurrent expenditures ($H_\beta(\mu)$) will stimulate recurrent expenditures today. From (24),

$$
\begin{aligned}
de_\varepsilon(0)/dH_\beta(\mu) = \Big\{&\left[-(1-\alpha)^{-1}v'(k^*)/u''(e^*)\right] \\
&+\left[(1-\alpha)^{-2}(1-\beta)(\mu+\alpha)^{-1}v''/u''\right]\Big\} > 0.
\end{aligned}
$$

For example, let the change in the matching grant for recurrent expenditures take the time path

$$
h_\beta(t) = 0 \quad \text{for } t < A, \qquad h_\beta(t) = 1 \quad \text{for } A \le t \le A+i,
$$
$$
h_\beta(t) = 0 \quad \text{for } t > A+i.
$$

Then $H_\beta(\mu) = i\exp(-\mu A)$ and today's recurrent expenditures increase by (assuming that other grant policies remain the same)

$$
\begin{aligned}
e_\varepsilon(0) = \Big\{&\left[-(1-\alpha)^{-1}v'(k^*)/u''(e^*)\right] \\
&+\left[(1-\alpha)^{-2}(1-\beta)(\mu+\alpha)^{-1}v''/u''\right]\Big\}i\exp(-\mu A).
\end{aligned}
$$

We can explain this result as follows. Anticipating a temporary future increase in the matching grant for recurrent expenditures, the local government will have more income in the future than it has now. To

smooth its spending, the local government devotes more current resources to recurrent expenditures. This income effect is further reinforced by the substitution effect that recurrent expenditures will become less costly than public investment as a result of the rise in the matching grant for recurrent spending.

Next, the impact on today's recurrent expenditures of a future rise in the nonmatching grant ($G(\mu)$) is also positive:

$$de_\varepsilon(0)/dG(\mu) = \left[(1-\beta)(1-\alpha)^{-2}(\mu+\alpha)^{-1}v''/u''\right] > 0.$$

If the nonmatching grant follows the same time path given above for the matching grant on recurrent expenditures, then $g(t) = 0$ for $t < A$, $g(t) = 1$ for $A \le t \le A + i$, $g(t) = 0$ for $t > A + i$, and $G(\mu) = i \exp(-\mu A)$. Its effect on the initial recurrent expenditures is

$$c_\varepsilon(0) = \left[(1-\beta)(1-\alpha)^{-2}(\mu+\alpha)^{-1}v''/u''\right] i \exp(-\mu A).$$

The reason for this result is simple. A rise in a future nonmatching grant will increase future income relative to current income. Then an obvious response from the local government would be to increase its current expenditures.

But, from (24), a rise in the investment grant in the future ($H_\alpha(\mu)$) has an ambiguous effect on today's recurrent expenditures,

$$\begin{aligned} de_\varepsilon(0)/dH_\alpha(\mu) = {} & \left[(1-\beta)(1-\alpha)^{-1}(\mu+\alpha)^{-1}v''/u''\right] \\ & \times\Big\{\left[T+\bar{g}-(1-\beta)e^*\right](1-\alpha)^{-2} \\ & \quad +\left[(1-\beta)(1-\alpha)^{-2}v'(k^*)/u''(e^*)\right]\Big\}, \end{aligned}$$

which does not have a definite sign because the first term in parentheses is positive and the second term is negative. This is understandable because, while a future rise in the investment grant leads to more future income for the local government, the investment grant also increases the relative price of recurrent expenditures; the substitution effect tends to reduce current recurrent expenditures.

To find out the impact of grant policy changes on current public investment, we substitute (24) into (22) and set $t = 0$ (also note that $k_\varepsilon(0)$ is zero because the initial capital stock is given and cannot jump),

$$\dot{k}_\varepsilon(0) = -(1-\beta)(1-\alpha)^{-1}e_\varepsilon(0) + w_2(0), \qquad (25)$$

where

$$w_2(0) = [T + \bar{g} - (1-\beta)e^*](1-\alpha)^{-2} h_\alpha(0) + (1-\alpha)^{-1} e^* h_\beta(0) + (1-\alpha)^{-1} g(0).$$

From (25), we note that all extra grants today ($t = 0$), i.e., positive $h_\alpha(0)$, $h_\beta(0)$, and $g(0)$, always increase public investment today. These effects are given by the three positive terms of $w_2(0)$ in (25). When these three kinds of grants change at $t = 0$, namely, $h_\alpha(0) = h_\beta(0) = g(0) = 1$, and when there is no change in future grant policies, current public investment will go up by

$$\dot{k}_\varepsilon(0) = [T + \bar{g} - (1-\beta)e^*](1-\alpha)^{-2} + (1-\alpha)^{-1}(e^* + 1) > 0.$$

We can provide some economic intuition for this positive association between a current rise in all federal grants and a current increase in local public investment. As in the typical intertemporal model of consumption and investment, the representative local government in our model tries to smooth recurrent expenditures over time. Therefore, a momentary increase in current federal grants in any form, while future grants remain unchanged, will only increase current public investment.

The impact of future changes in federal grants on local public investment can also be seen from (25). As the coefficient for $e_\varepsilon(0)$, i.e., $[-(1-\beta)(1-\alpha)^{-1}]$, is negative in (25), the effects on current public investment of any future increase in federal grants are just the opposite of the effects on current recurrent expenditures. Thus, the combination of Eqs. (24) and (25) indicates a negative impact on current investment from any future increase in the nonmatching grant $G(\mu)$:

$$d\dot{k}_\varepsilon(0)/dG(\mu) = \left[-(1-\beta)^2(1-\alpha)^{-3}(\mu+\alpha)^{-1} v''/u''\right] < 0.$$

The effect of future matching grant for recurrent spending $H_\beta(\mu)$ on current investment is also negative:

$$d\dot{k}_\varepsilon(0)/dH_\beta(\mu) = \left[(1-\beta)(1-\alpha)^{-2} v'(k^*)/u''(e^*)\right] - \left[(1-\alpha)^{-3}(1-\beta)^2(\mu+\alpha)^{-1} v''/u''\right] < 0.$$

In addition, a change in a future investment grant ($H_\alpha(\mu)$) has an ambiguous effect on current investment:

$$d\dot{k}_\varepsilon(0)/dH_\varepsilon(\mu) = \left[-(1-\beta)^2(1-\alpha)^{-4}(\mu+\alpha)^{-1}v''/u''\right] \times\{[T+\bar{g}-(1-\beta)e^*] + [(1-\beta)v'(k^*)/u''(e^*)]\}.$$

These findings can be interpreted as follows. At time $t = 0$, the total revenue for the local government is given if there is no grant change today. When a higher nonmatching grant is expected in the future, today's recurrent expenditures will be increased by the local government as a way to smooth its consumption. With fixed local revenue today, initial public investment must be cut. Similarly, a future rise in the matching grant for recurrent expenditures favors recurrent spending over current public investment in terms of both the income effect and the substitution effect; therefore, current investment is sacrificed as a result of an expected increase in the matching grant for recurrent spending. Finally, anticipating a future rise in the matching grant for investment, local government may raise its recurrent expenditures since it is going to have more future income. But the investment grant also lowers the opportunity cost of investment and makes recurrent expenditures relatively more expensive. Furthermore, since it takes time to build the stock of public capital, the expectation of a higher investment grant may also stimulate current investment. Hence, with these two offsetting effects, a future rise in the investment grant gives rise to an ambiguous impact on current public investment.

V. CONCLUDING REMARKS

In a dynamic model of local government spending, this paper has examined both long-run and short-run effects of permanent federal grant changes on local public investment and recurrent expenditures. It has also utilized the Judd approach to quantify the short-run effects of temporary (current and future) policy shocks. We summarize our main findings here: (1) a permanent increase in the nonmatching grant leads to faster public investment, larger long-run capital stock, and greater long-run recurrent expenditures; (2) a permanent increase in the matching grants for investment and the recurrent expenditures may speed up or slow down local investment; (3) a temporary grant increase at present, no matter what form the federal grants take, stimulates current public investment; (4) a temporary, future increase in the nonmatching grant reduces current investment and raises current recurrent expenditures; (5) a temporary, future increase in the matching grant for recurrent expenditure leads to less current public investment and more current recurrent expenditures;

but (6) a temporary, future increase in the matching grant for investment has an ambiguous impact on current public investment.

Two interesting observations and comparisons regarding these findings should be emphasized. First, for a temporary change in a federal grant, whether it is present or future is crucial for predicting its effect on current local investment: while a current change does not have any effect on current recurrent expenditures and its full impact falls on current investment, an anticipated rise in both the nonmatching grant and the matching grant for recurrent expenditures reduces current investment. Also, the duration of a federal grant change is a significant factor in determining the responses of local governments. A permanent rise in the nonmatching grant leads to more public investment in the short run and more stock of public capital in the long run, but a temporary, future rise in the nonmatching grant reduces the short-run public investment.

Our theoretical findings also shed light on how to test the effects of intergovernmental grants in empirical studies. The distinction between public investment and recurrent spending is, of course, important in dealing with some general statistical tests on the effects of intergovernmental grants. In more specific areas such as highway construction, urban housing services, and community education, the dynamic behavior of local governments should be modeled explicitly in order to capture the time-to-build characteristic of local public investment. In addition, the timing of grants, the duration of grants, and the role of expectations should be considered as well. As our model has suggested, the effects of a current grant change on current investment are very different from the ones of a future grant change. It is not very difficult to test this difference empirically if we have the time series of grants. To give an example, we can test the following simultaneous equations about local public investment and local recurrent expenditures,

$$\dot{k}(t) = f(\alpha_t, \alpha_{t+1}, g_t, g_{t+1}, \beta_t, \beta_{t+1}, \theta),$$
$$e(t) = h(\alpha_t, \alpha_{t+1}, g_t, g_{t+1}, \beta_t, \beta_{t+1}, \theta),$$

where subscripts t and $(t + 1)$ refer to current grants and expected grants, respectively, and θ represents other exogenous factors.

Even though our dynamic approach to intergovernmental grants has extended the usual static approach in many ways, our model in this paper is still oversimplified and suffers from several limitations as we have already pointed out. Future research should expand this model to include the role of public capital in private production, to endogenize local own revenues, and to model the private sector, local governments, and the federal government in a full general-equilibrium framework.

REFERENCES

1. K. Arrow and M. Kurz, "Public Investment, the Rate of Returns, and Optimal Fiscal Policy," Johns Hopkins Univ. Press (for Resources for the Future), Baltimore, MD (1970).
2. R. Barro, Government spending in a simple model of endogenous growth, *Journal of Political Economy* **98**, S103–S125 (1990).
3. E. Gramlich, State and local governments and their budget constraint, *International Economic Review* **10**, 163–82 (1968).
4. E. Gramlich and H. Galper, State and local fiscal behavior and federal grant policy, *Brookings Papers on Economic Activity* **1** 15–65 (1973).
5. R. Inman, Toward an econometric model of local budgeting, *in* National Tax Association: Proceedings of the Sixty-Second Conference on Taxation" (1971).
6. K. Judd, An alternative to steady-state comparison in perfect foresight Models, *Economics Letters* **10**, 55–59 (1982).
7. K. Judd, Short-run analysis of fiscal policy in a simple perfect model, *Journal of Political Economy* **93**, 298–319 (1985).
8. K. Judd, Debt and distortionary taxation in a simple perfect foresight model, *Journal of Monetary Economics* **20** 51–72 (1987).
9. P. Mieszkowski and W. Oakland (Eds.), "Fiscal Federal and Grants-in-Aid," Urban Institute, Washington, DC (1979).
10. H. Rosen (Ed.), "Fiscal Federalism: Quantitative Studies," Univ. of Chicago Press, Chicago (1988).
11. J. Wilde, The expenditure effects of grant-in-aid programs, *National Tax Journal* **21**, 340–48 (1968).
12. J. Wilde, Grants-in-aid: The analytics of design and response, *National Tax Journal* **24**, 143–55 (1971).

6

JOURNAL OF URBAN ECONOMICS 39, 303–317 (1996)
ARTICLE NO. 0016

Taxes, Federal Grants, Local Public Spending, and Growth

HENG-FU ZOU[1]

Public Economics Division, Policy Research Department, The World Bank, Washington, DC 20433
and
Institute of Advanced Economic Studies, Wuhan University, Wuhan, China

Received August 3, 1994; revised February 9, 1995

In a dynamic model with both private and local public capital accumulation, this paper examines how federal and local income taxes, local consumption tax, and federal matching grants for local public consumption and local public investment affect the long-run equilibrium (equilibria) of private consumption, private capital accumulation, local public consumption, and local public capital stock.

I. INTRODUCTION

In a static and utility-maximizing framework, many existing studies have analyzed the effects of intergovernmental grants on local public spending by examining the implied price (substitution) and income effects.[2] While Zou [13] has examined some dynamic effects of federal grants on local public consumption and investment, tax revenues of the federal government and local governments are assumed to be constant and the effects of taxes, grants, and local public spending on private sector's consumption, production, and investment are totally ignored. To remedy these deficiencies, this paper first presents a model of local economic growth to include both public and private capital accumulation, spillovers between public and private sectors, and dynamic budget balance of federal and local governments. Then, by dividing local public expenditures into public consumption and public investment, it examines how federal income tax, local taxes, and intergovernmental grants (matching grants for local public

[1]The main ideas in this paper were suggested by two referees of this journal on my previous paper (H. Zou, *Journal of Urban Economics*, 36, 98–115 (1994)). Here I acknowledge their contributions to this paper. I also thank Richard Bird, Jan Brueckner, Hamid Davoodi, Shantayanan Devarajan, Gunnar Eskeland, Anwar Shah, Danyang Xie, and referees for their comments and help. All remaining errors are mine. The opinions expressed here are not necessarily those of the World Bank.

[2]See Gramlich [5]; Gramlich and Galper [6]; Inman [7]; Mieszkowski and Oakland [8]; Rosen [10]; and Wilde [11, 12]; among many others.

consumption and investment) affect local public investment, private capital formation, local public consumption, and private consumption.

This approach provides us with a convenient framework to study new areas of local and urban finance. First, the integration of both grants and taxes in a dynamic framework offers a different perspective to understand the interactions among taxes and grants and their general-equilibrium effects. In this integrated framework, for example, it can be seen more clearly how incentives for public investment may also become the incentives for private investment, and how budget constraints of the federal and local governments are consolidated to neutralize the effects of some federal grants. Second, while the role of public consumption and public investment in improving private welfare and private capital accumulation has been previously considered (Arrow and Kurz [1], Barro [2], and Devarajan *et al.* [4]), growth implications of local taxes and federal grants have not been explored in local and urban finance literature. This paper, built on those contributions, explicitly models the externalities of local public capital accumulation on private investment and analyzes how local economic growth responds to various taxes and grants. Thus the model here is broad and realistic enough to allow us to confront the data and make empirical assessments on the growth effects of taxes and grants.

I organize this paper as follows. In Section II, I set up a basic model in which a representative agent's utility function depends on private consumption and local public consumption, and private sector's production is defined on private capital stock and local capital stock. The role of the federal government is to collect an income tax from the private sector and to allocate the proceeds to localities through matching grants for local public consumption and local public investment. A representative local government collects local taxes and receives grants from the federal government and optimally chooses its spending on public consumption and investment; the private sector takes federal government's and local government's actions (taxes, grants, and public spending) as given and optimally decides how much to consume and invest. In Section III, I examine the stability and equilibrium of the resulting dynamic system and analyze the effects of various taxes and grants on the equilibrium values of private consumption, local public consumption, private investment, and local public investment. In Section IV I extend the basic model to a modified Arrow–Kurz utility function by defining the representative agent's utility function on both local public consumption and local public capital stock in addition to private consumption. Some significant differences between the basic model and the modified Arrow–Kurz model will be presented. I conclude this study in Section V by summarizing the main findings and pointing out some direction for future research.

II. THE BASIC MODEL

A representative agent in a typical locality has an increasing, concave, and continuously differentiable utility function defined on private consumption, c, and local public consumption E:

$$\int_0^\infty [u(c) + v(E)]e^{-\rho t}\,dt, \qquad 0 < \rho < 1. \tag{1}$$

The separability in the utility function greatly simplifies the analysis, but it is not essential for the results obtained in this paper.

The production function of the representative agent has two inputs: private capital stock k_p and local public capital stock k_s. Let y denote the output, and

$$y = y(k_p, k_s). \tag{2}$$

The production function has the properties $y_1 > 0$, $y_2 > 0$, $y_{11} < 0$, $y_{22} < 0$, $y_{12} = y_{21} > 0$, and $y_{11}y_{22} - y_{12}^2 > 0$; that is to say, the production function is increasing, concave, and continuously differentiable, and, in particular, local public capital stock is complementary to private capital stock in the production. The production function also satisfies the usual Inada conditions: $y_i \to \infty$ as k_i approaches zero, and $y_i \to 0$ as k_i approaches infinity, for i = p and s.

At each time period, the federal government collects an income tax from the private sector at the rate τ_f; its expenditures consist of two matching grants for local governments: a matching grant for local public investment at the rate α $(0 < \alpha < 1)$ and a matching grant for local public consumption at the rate β $(0 < \beta < 1)$. If the federal government's budget is always assumed to be balanced, then

$$\tau_f y = \alpha \dot{k}_s + \beta E, \tag{3}$$

where $\dot{k}_s$ is the public investment undertaken by a typical local government.

The representative local government collects an income tax at the rate τ_s on the private sector (the case of the United States) and a consumption tax τ_c on private consumption (a resemblance to the sales tax collected by local governments in the United States).[3] These tax rates are often set by the federal governments in many countries and cannot be chosen by local governments, or in the United States, they are chosen by local govern-

[3]All tax rates in this paper are exogenous parameters. The optimal choices of tax rates and grants will not be considered in this paper; see Zou [14] for a study on the optimal design of federal grants to localities.

ments and cannot be often changed by local governments. The total revenue of a typical local government consists of a local income tax, a consumption tax, and two matching grants from the federal government; its expenditures are public consumption, E, and public investment, $\dot{k}_s$. Therefore its budget constraint is

$$\tau_s y(k_p, k_s) + \tau_c c + \alpha \dot{k}_s + \beta E = \dot{k}_s + E, \tag{4}$$

or

$$\dot{k}_s = \left[\tau_s y(k_p, k_s) + \tau_c c - (1 - \beta)E\right](1 - \alpha)^{-1}. \tag{5}$$

The representative agent's budget constraint is given by the condition that the after-tax income is equal to the total spending on private consumption, $(1 + \tau_c)c$, and private investment, $\dot{k}_p$:

$$\dot{k}_p = (1 - \tau_f - \tau_s)y(k_p, k_s) - (1 + \tau_c)c. \tag{6}$$

I first look at the optimization in the private sector. Taking the time paths of local public consumption E, local public capital stock k_s, and taxes as given, the representative agent maximizes (1) by choosing private consumption c and private capital stock k_p

$$\underset{(c, k_p)}{\text{Max}} \int_0^\infty [u(c) + v(E)]e^{-\rho t}\, dt, \qquad 0 < \rho < 1. \tag{1}$$

subject to the budget constraint in (6).

The current-value Hamiltonian function for the representative agent is

$$H(c, k_p, \lambda_p) = u(c) + v(E) + \lambda_p\left[(1 - \tau_f - \tau_s)y(k_p, k_s) - (1 + \tau_c)c\right], \tag{7}$$

where λ_p is the costate variable.

The necessary conditions for the optimization are given by (6) and

$$\dot{c} = \frac{u'(c)}{-u''(c)}\left[(1 - \tau_f - \tau_s)y_1(k_p, k_s) - \rho\right], \tag{8}$$

plus the transversality condition

$$\lim_{t \to \infty} u'(c)(1 + \tau_c)k_p e^{-\rho t} = 0.$$

Similarly, the optimal conditions for the representative local government can be derived. The local government is assumed to maximize the repre-

sentative agent's welfare by choosing E and k_s while taking the time paths of c, k_p, grants, and taxes as given, or

$$\underset{(E,k_s)}{\text{Max}} \int_0^\infty [u(c) + v(E)]e^{-\rho t}\,dt, \qquad 0 < \rho < 1, \tag{1}$$

subject to the budget constraint (5).

The current-value Hamiltonian function for the local government is

$$H(E, k_s, \lambda_s) = [u(c) + v(E)] + \lambda_s[\tau_s y(k_p, k_s) + \tau_c c - (1-\beta)E] \\ (1-\alpha)^{-1}, \tag{9}$$

where λ_s is the costate variable.

The optimal conditions for the local government's optimization are (5)

$$\dot{E} = \frac{v'(E)}{-v''(E)}\left[\tau_s(1-\alpha)^{-1} y_2(k_p, k_s) - \rho\right], \tag{10}$$

and the transversality condition is

$$\lim_{t\to\infty} v'(E)(1-\beta)(1-\alpha)^{-1} k_s e^{-\rho t} = 0.$$

In this model, the federal government has been assigned the simple roles of a tax collector and a grantor, because nation-wide public consumption and public investment are excluded from the model. To include these federal expenditures into the model is straightforward, but it is analytically difficult to deal with six differential equations at the same time.

To complete the model setup, it is necessary to integrate the federal government's budget constraint (3) into the necessary conditions for optimization. That can be done easily. Substituting Eq. (3) for $\alpha\dot{k}_s$ in Eq. (4) leads to an integrated budget constraint for the federal and local governments

$$\dot{k}_s = (\tau_s + \tau_f)y(k_p, k_s) + \tau_c c - E, \tag{11}$$

which says that all tax revenues are allocated to local public investment $\dot{k}_s$ and local public consumption E.

Equations (8), (10), (6), and (11) compose a complete dynamic system in the four endogenous variables of the model: private consumption, public consumption, private capital, and public capital. This dynamic system is the focus of the analysis in the next section.

III. ANALYSIS

PROPOSITION 1. *The dynamic system in Eqs.* (8), (10), (6), *and* (11) *has a unique equilibrium.*

Proof. At any equilibrium, $\dot{c} = \dot{E} = \dot{k}_p = \dot{k}_s = 0$. Then, the dynamic system is reduced to

$$(1 - \tau_f - \tau_s)y_1(\bar{k}_p, \bar{k}_s) - \rho = 0, \tag{12}$$

$$\tau_s(1 - \alpha)^{-1}y_2(\bar{k}_p, \bar{k}_s) - \rho = 0, \tag{13}$$

$$(1 - \tau_f - \tau_s)y(\bar{k}_p, \bar{k}_s) - (1 + \tau_c)\bar{c} = 0, \tag{14}$$

$$(\tau_s + \tau_f)y(\bar{k}_p, \bar{k}_s) + \tau_c\bar{c} - \bar{E} = 0, \tag{15}$$

where $\bar{c}$, $\bar{E}$, $\bar{k}_p$, and $\bar{k}_s$ denote the steady-state values of private consumption, public consumption, private capital, and public capital, respectively.

In (12) and (13), since $y_{11}y_{22} - y_{12}^2 > 0$ (as a result of the concavity of the production function), the equilibrium values, $\bar{k}_p$ and $\bar{k}_s$, can be solved uniquely as the functions of parameters τ_s, τ_f, ρ, and α by the implicit function theorem. Then, with the uniqueness of $\bar{k}_p$ and $\bar{k}_s$, $\bar{c}$ is unique from Eq. (14). Similarly, with the uniqueness of $\bar{k}_p$, $\bar{k}_s$, and $\bar{c}$, the unique solution for $\bar{E}$ is given by Eq. (15). Q.E.D.

PROPOSITION 2. *There exists a unique perfect-foresight path in this dynamic system.*

Proof. See the Appendix.

With the uniqueness of the equilibrium and its stability, I proceed to study the comparative dynamics regarding the effects of various taxes and grants on the long-run accumulation of capital stocks. Totally differentiate the equilibrium conditions (12)–(15):

$$\begin{bmatrix} 0 & 0 & (1-\tau_f-\tau_s)y_{11} & (1-\tau_f-\tau_s)y_{12} \\ 0 & 0 & \tau_s(1-\alpha)^{-1}y_{21} & \tau_s(1-\alpha)^{-1}y_{22} \\ -(1+\tau_c) & 0 & (1-\tau_f-\tau_s)y_1 & (1-\tau_f-\tau_s)y_2 \\ \tau_c & -1 & (\tau_f+\tau_s)y_1 & (\tau_f+\tau_s)y_2 \end{bmatrix} \begin{bmatrix} dc \\ dE \\ dk_p \\ dk_s \end{bmatrix}$$

$$= \begin{bmatrix} y_1\,d\tau_f + y_1\,d\tau_s \\ -y_2\,d\tau_s - \tau_s(1-\alpha)^{-2}y_2\,d\alpha \\ y\,d\tau_f + y\,d\tau_s + \bar{c}\,d\tau_c \\ -y\,d\tau_f - y\,d\tau_s - \bar{c}\,d\tau_c \end{bmatrix}. \tag{16}$$

From (16), it is simple to note two implications:

First, a rise in the federal income tax rate τ_f reduces private capital stock, local public capital stock, and private consumption in the long run. Its effect on local public consumption is ambiguous. These results can be explained as follows: while a higher federal income tax reduces the after-tax returns on private investment and leads to a lower private capital accumulation, it also reduces local public investment because a smaller private capital stock lowers the productivity of public capital (note that $y_{12}(k_p, k_s) > 0$). Since private consumption is given by (14), a rise in τ_f reduces consumption both directly (through a reduced after-tax income) and indirectly (through a reduced before-tax income as a result of lower private and public capital stocks). The effect on public consumption is ambiguous because, while a higher federal income tax leads to a smaller consumption tax, $\tau_c c$, it may raise or lower the income tax $\tau_f y$. This ambiguity can be seen directly from Eq. (15), or

$$\bar{E} = \tau_f y\left(\bar{k}_p, \bar{k}_s\right) + \tau_s y\left(\bar{k}_p, \bar{k}_s\right) + \tau_c \bar{c}. \tag{17}$$

On the right-hand side of Eq. (17), the second and the third terms are reduced as a result of a higher federal income tax, but the first term may be higher or lower (the familiar property of the Laffer curve for income tax or inflation tax).

Second, a rise in the federal matching grant for local public investment leads to more local public capital stock, more private capital stock, and more private and public consumption in the long run. The reason for these results is simple. The federal matching grant for local public investment creates more incentive for the local government to undertake more investment and accumulate more public capital stock, which in turn improves the productivity of private investment. Thus, in the long run, both local public capital and private capital are increased as a result of a higher federal matching grant for local public investment. As both private and local public capital stocks increase after the rise in the federal matching grant for local public investment, more output is produced and more private consumption obtained. Local public consumption also increases because more income tax and more consumption tax are collected with the rise in private production and private consumption.

Now I turn to a few results which are not so obvious from the model.

PROPOSITION 3. *A rise in the local income tax rate τ_s has ambiguous effects on private capital stock, local public capital stock, private consumption, and local public consumption in the long run.*

This proposition can be verified by using Cramer's rule in (16),

$$\frac{dk_p}{d\tau_s} = \frac{\tau_s(1-\alpha)^{-1}y_{22}y_1 + (1-\tau_f-\tau_s)y_{12}}{(1-\tau_f-\tau_s)\tau_s(1-\alpha)^{-1}\left[y_{11}y_{22}-y_{12}^2\right]}, \tag{18}$$

$$\frac{dk_s}{d\tau_s} = \frac{-\tau_s(1-\alpha)^{-1}y_{12}y_1 - (1-\tau_f-\tau_s)y_2y_{11}}{(1-\tau_f-\tau_s)\tau_s(1-\alpha)^{-1}\left[y_{11}y_{22}-y_{12}^2\right]}, \tag{19}$$

which do not have definite signs because the numerators can be positive or negative while the common denominator is always positive. As for both private and public consumption, their ambiguities follow the ambiguities of the capital stock and output.

The economic intuition for this result is the following: the direct impact of a rise in the local income tax is a reduction in private investment and an increase in local public investment. But the rising public investment also stimulates private investment due to the fact that these two capital inputs are complementary in production. Thus, the net effect of a rise in the local income tax on output production is not clear. Proposition 3 leads to a similar issue regarding the optimal local income tax for financing local public investment as found in different contexts by Barro [2] and Devarajan *et al.* [4]. Essentially, due to the externality of local public capital on private production, a small income tax as a way of financing local public investment is always justified. But when the income tax rate is rising above a certain point, the corresponding disincentive for private production will outweigh the benefits of public capital formation. Naturally, the optimal choice of a local income tax schedule can be determined by the cost–benefit analysis in a dynamic growth model similar to that in this paper.

PROPOSITION 4. *In the long run, the federal matching grant for local public consumption has no effect on private capital stock, local public capital accumulation, private consumption, and local public consumption.*

To show this result, I first point out that both private and public capital stocks are independent of the federal matching grant for local public consumption in the long run as in the steady-state equations (12) and (13). Once the long-run public capital stock is determined, the spending on the long-run local public consumption is decided as a residual.

This result is quite counter-intuitive. In general, we expect that a rise in the federal matching grant for local public consumption would lead to locality to divert more local resources from public investment to consumption. This conclusion is a fact which can be derived from many static

models on local government spending. But what we usually expect does not hold in the long-run analysis based on a sound dynamic structure. In particular, I want to draw attention to the surprising conclusion that this matching grant does not even change local public consumption in the long run. To put it in a policy context, we may question the effectiveness of many federal incentive programs for local welfare and public consumption. In the long run, a matching grant for investment turns out to be more effective in providing more local public consumption than a matching grant for consumption.

PROPOSITION 5. *An increase in the local consumption tax has no effect on the long-run capital stocks, but it reduces private consumption and raises local public consumption.*

That local consumption tax has no effect on the long-run accumulation of both private and local public capital can be seen directly from the steady-state equations (12) and (13), because the local consumption tax does not appear in these two equations, which determine the long-run capital stocks. Then, from Eq. (14), as the after-tax income, $(1 - \tau_f - \tau_s)y(\bar{k}_p, \bar{k}_s)$, is fixed, consumption has to be reduced corresponding to a rise in the consumption tax. With a higher consumption tax, local public consumption will increase and its magnitude can be derived from Eq. (15): $dE/d\tau_c = \bar{c} > 0$. Therefore, a local consumption tax only reallocates a given amount of resources between the private sector and public sector and cannot stimulate either private or public capital accumulation in the long run.

IV. THE MODIFIED ARROW–KURZ UTILITY FUNCTION

It should be emphasized that many results derived in Sections II and III above depend on the commonly accepted utility function defined in (1). But if the utility function is defined on both local public consumption and local public capital in addition to private consumption (a suggestion from Arrow and Kurz [1]),1 then, in the long run, the federal matching grant for local public consumption and a local consumption tax do affect the long-run accumulation of both private and public capital. To make this point clear, let me first extend the model setup to include the Arrow–Kurz utility function

$$\int_0^\infty [u(c) + v(E) + w(k_s)]e^{-\rho t}\,dt, \qquad 0 < \rho < 1, \tag{20}$$

where $w(k_s)$ represents the utility from the services of local public capital stock. The dynamic budget constraints for the representative agent, the local government, and the federal government remain the same as Eqs. (6),

(5), and (3), respectively. The necessary conditions for optimization are modified to be Eqs. (8), (6), (11), and

$$\dot{E} = \frac{v'(E)}{-v''(E)}\left[\tau_s(1-\alpha)^{-1}y_2(k_p, k_s) - \rho\right] + \frac{w'(k_s)}{-v''(E)}(1-\beta)(1-\alpha)^{-1}. \tag{21}$$

Now, the dynamic system differs from that previous only in Eq. (21). It can be shown as in Arrow and Kurz [1] that, unlike the model in Sections II and III, there may exist multiple equilibria here, so that the nice properties of the unique equilibrium of the previous model disappear with the introduction of $w(k_s)$ into the utility function. That is to say, Propositions 1 and 2 do not hold any more in the new model. With multiple equilibria, it is necessary to choose a saddle-point equilibrium to linearize the dynamic system above, which amounts to assuming that, at some equilibrium state, $(\bar{c}, \bar{E}, \bar{k}_p, \bar{k}_s)$, out of the possible few, the 4×4 matrix, denoted as M', has a positive determinant Δ'. This is to guarantee that there exists a unique perfect foresight path in the neighborhood of this equilibrium. With this assumption, the comparative equilibrium analysis can proceed as usual.

In this selected saddle-point equilibrium, the equilibrium conditions of the new dynamic system are (12), (14), (15), and

$$\tau_s(1-\alpha)^{-1}y_2(\bar{k}_p, \bar{k}_s)v'(\bar{E}) - v'(\bar{E})\rho + w'(\bar{k}_s)(1-\beta)(1-\alpha)^{-1} = 0. \tag{22}$$

The difference between these equilibrium conditions and those previous is that Eq. (13) has been changed to Eq. (22) here, which implies that the marginal benefit of local public investment, $\tau_s(1-\alpha)^{-1}y_2(\bar{k}_p, \bar{k}_s)v'(\bar{E}) + w'(\bar{k}_s)(1-\beta)(1-\alpha)^{-1}$, equals the marginal cost of the foregone local public consumption, $v'(\bar{E})\rho$.

With the new utility function, Propositions 4 and 5 are not true any more. In fact:

PROPOSITION 6. *With the Arrow–Kurz utility function, an increase in the federal matching grant for local public consumption reduces local public capital, private capital, private consumption, and even (surprisingly) local public consumption in the long run.*

Proof. Totally differentiate (12), (22), (14), and (15):

$$\begin{bmatrix} 0 & 0 & (1-\tau_f-\tau_s)y_{11} & (1-\tau_f-\tau_s)y_{12} \\ 0 & \left[\tau_s(1-\alpha)^{-1}y_2-\rho\right]v'' & \tau_s(1-\alpha)^{-1}y_{21}v' & \tau_s(1-\alpha)^{-1}y_{22}v'+\dfrac{1-\beta}{1-\alpha}w'' \\ -(1+\tau_c) & 0 & (1-\tau_f-\tau_s)y_1 & (1-\tau_f-\tau_s)y_2 \\ \tau_c & -1 & (\tau_f+\tau_s)y_1 & (\tau_f+\tau_s)y_2 \end{bmatrix} \times \begin{bmatrix} dc \\ dE \\ dk_p \\ dk_s \end{bmatrix}$$

$$= \begin{bmatrix} y_1\,d\tau_f + y_1\,d\tau_s \\ -y_2(1-\alpha)^{-1}v'\,d\tau_s - \left[\tau_s(1-\alpha)^{-2}y_2v' + (1-\beta)w'(1-\alpha)^{-2}\right]d\alpha + (1-\alpha)^{-1}w'\,d\beta \\ y\,d\tau_f + y\,d\tau_s + \bar{c}\,d\tau_c \\ -y\,d\tau_f - y\,d\tau_s - \bar{c}\,d\tau_c \end{bmatrix} \tag{23}$$

Using Cramer's rule in (23) yields

$$\frac{dk_p}{d\beta} = -w'(\bar{k}_s)(1-\alpha)^{-1}(\Delta'')^{-1}(1+\tau_c)(1-\tau_f-\tau_s)y_{12}(\bar{k}_p,\bar{k}_s) < 0, \tag{24}$$

$$\frac{dk_s}{d\beta} = w'(\bar{k}_s)(1-\alpha)^{-1}(\Delta'')^{-1}(1+\tau_c)(1-\tau_f-\tau_s)y_{11}(\bar{k}_p,\bar{k}_s) < 0, \tag{25}$$

where Δ'' is positive by the assumption of a perfect-foresight equilibrium at $(\bar{c}, \bar{E}, \bar{k}_p, \bar{k}_s)$, because Δ'' is just the product of the four eigenvalues (two positive and two negative for perfect-foresight equilibrium) multiplied by a positive number.

Then, private consumption will be reduced as a result of lower capital stocks and a lower output from Eq. (14). Similarly, the long-run local public consumption is reduced because of a smaller output tax and a smaller consumption tax as in Eq. (15). Q.E.D.

Proposition 6 combined with Proposition 4 provides some strong indication about the effects of a matching grant for local public consumption. In the short run, a matching grant for local public consumption always stimulates public consumption and reduces public investment. In the long run, it either has no effect on the accumulation of private and public capital (when the utility function is independent of local public capital) or

reduces both private and public capital stocks with the Arrow–Kurz utility function. Furthermore, in the long run, a federal matching grant for local public consumption has either no effect or negative effect on the equilibrium level of local public consumption.

PROPOSITION 7. *With the modified Arrow–Kurz utility function, a rise in the consumption tax leads to more private capital and more local public capital.*

Proof. In (23),

$$\frac{dk_s}{d\tau_c} = -(\Delta'')^{-1}(1-\tau_f-\tau_s)y_{11}(\bar{k}_p,\bar{k}_s)\left[\tau_s(1-\alpha)^{-1}y_2-\rho\right]v''(E) > 0,$$

which is positive because the term $[\tau_s(1-\alpha)^{-1}y_2-\rho]$ has to be negative for the equilibrium condition in (22) to be maintained. The rise in private capital stock follows:

$$dk_p/d\tau_c = -y_{1:}y_{11}(dk_s/d\tau_c) > 0. \qquad \text{Q.E.D.}$$

Proposition 6 stands in sharp contrast to Proposition 5 in the previous section. Without the Arrow–Kurz utility function, Proposition 5 has shown that long-run capital stocks are independent of consumption tax. With the Arrow–Kurz utility function, the rising local government's revenue as a result of a higher consumption tax will be allocated to both local public consumption and local investment in both the short run and the long run. Unlike equilibrium condition (13) where long-run local public capital does not depend on the utility from local public consumption, the new equilibrium condition of (22) underlies the balance between local public investment and local public consumption. In particular, if a higher consumption tax only gives rise to a rise in local public consumption, the marginal utility from the unchanged local public capital stock will be higher as seen clearly from Eq. (22). To maintain this equilibrium condition, more local revenue will be invested in local public capital accumulation. As local public capital stock increases, the marginal productivity of private investment also rises. Therefore, all capital stocks and output in the long run will be higher as a result of a higher consumption tax.

V. SUMMARY

In a modified optimal growth model with both private and local public capital accumulation, this paper has made a preliminary attempt to examine how federal and local income taxes, local consumption tax, and federal matching grants for local public consumption and local public investment affect the long-run equilibrium (equilibria) of private consumption, private capital accumulation, local public consumption, and local public capital stock. The main findings are summarized in Table 1 according to the two

TABLE 1
Long-Run Effect of Taxes and Grants

Endogenous variables	Exogenous variables τ_f (i)	τ_f (ii)	τ_s (i)	τ_s (ii)	τ_c (i)	τ_c (ii)	α (i)	α (ii)	β (i)	β (ii)
$\bar{k}_p$	—	—	?	?	0	+	+	+	0	—
$\bar{k}_s$	—	—	?	?	0	+	+	+	0	—
$\bar{c}$	—	—	?	?	—	?	+	+	0	—
$\bar{E}$	?	?	?	?	+	+	+	+	0	—

definitions of the utility function, where columns (i) and (ii) report the results corresponding to the usual utility function and the Arrow–Kurz utility function, respectively.

Theoretically, both types of preferences are reasonable even though it is more often the case that the utility function is defined in private and public consumption. Since the implications of various policies are so different as a result of these two specifications of preferences, the issues can only be settled empirically in future studies.

APPENDIX: PROOF OF PROPOSITION 2

I need to show that there are two positive eigenvalues and two negative eignevalues corresponding to the two jumping variables, c and E, and the two state variables, k_p and k_s; see Buiter [3]. Linearizing the four differential equations of the dynamic system around the steady-state values,

$$\begin{bmatrix} \dot{c} \\ \dot{E} \\ \dot{k}_p \\ \dot{k}_s \end{bmatrix} = \begin{bmatrix} 0 & 0 & \frac{u'(\ )}{-u''(\ )}(1-\tau_f-\tau_s)y_{11} & \frac{u'(\ )}{-u''(\ )}(1-\tau_f-\tau_s)y_{12} \\ 0 & 0 & \frac{v'(\ )}{-v''(\ )}\tau_s(1-\alpha)^{-1}y_{21} & \frac{v'(\ )}{-v''(\ )}\tau_s(1-\alpha)^{-1}y_{22} \\ -(1+\tau_c) & 0 & (1-\tau_f-\tau_s)y_1 & (1-\tau_f-\tau_s)y_2 \\ \tau_c & -1 & (\tau_f+\tau_s)y_1 & (\tau_f+\tau_s)y_2 \end{bmatrix}$$

$$\times \begin{bmatrix} c-\bar{c} \\ E-\bar{E} \\ k_p-\bar{k}_p \\ k_s-\bar{k}_s \end{bmatrix}. \tag{A1}$$

Let M denote the 4×4 matrix in (A1) and let λ_1, λ_2, λ_3, and λ_4 denote the four eigenvalues of this dynamic system. It is well known that the

product of these four eigenvalues equals the determinant of matrix M (denoted as Δ)

$$\lambda_1\lambda_2\lambda_3\lambda_4 = \Delta = \frac{u'(\bar{c})}{u''(c)}\frac{v'(\bar{E})}{v''(\bar{E})}\tau_s(1+\tau_c)(1-\alpha)^{-1}(1-\tau_f-\tau_s)$$

$$\left[y_{11}y_{22} - y_{12}^2\right] > 0, \tag{A2}$$

which is to say, there are three possibilities: no negative eigenvalue, two negative eigenvalues, or four negative eigenvalues. But, the sum of the four eigenvalues is equal to the trace of matrix M, which turns out to be positive:

$$\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 = (1-\tau_f-\tau_s)y_1\left(\bar{k}_p, \bar{k}_s\right) + (\tau_f+\tau_s)y_2\left(\bar{k}_p, \bar{k}_s\right) > 0. \tag{A3}$$

Therefore, at least one eigenvalue is positive. Combining (A2) with (A3) narrows down the possibilities to two: either no negative eigenvalue (all four eigenvalues are positive) or two negative eigenvalues. To show that the latter is true, I need the condition that the product, $\lambda_1\lambda_2\lambda_3 + \lambda_1\lambda_2\lambda_4 + \lambda_1\lambda_3\lambda_4 + \lambda_2\lambda_3\lambda_4$, equals the sum of all principal minors of order three in matrix M. Some tedious calculation yields

$$\begin{aligned}
&\lambda_1\lambda_2\lambda_3 + \lambda_1\lambda_2\lambda_4 + \lambda_1\lambda_3\lambda_4 + \lambda_2\lambda_3\lambda_4 \\
&\quad = \frac{v'(\bar{E})}{v''(\bar{E})}\tau_s(1-\alpha)^{-1}(1-\tau_f-\tau_s)[y_{12}y_2 - y_{22}y_1] \\
&\qquad + \frac{u'(\bar{c})}{u''(\bar{c})}(1-\tau_f-\tau_s)[(1+\tau_c)(\tau_f+\tau_s)y_1y_{12} \\
&\qquad\qquad - \tau_c(1-\tau_f-\tau_s)(y_2y_{11} - y_1y_{12}) - (\tau_f+\tau_s)y_2y_{11}],
\end{aligned}$$

which is negative. Thus, at least one eigenvalue is negative. With the results regarding the determinant and the trace of matrix M, the only possibility is that there are two negative eigenvalues and two positive eigenvalues, or stated differently, there exists a unique perfect foresight equilibrium in this dynamic system. Q.E.D.

REFERENCES

1. K. Arrow and M. Kurz, "Public Investment, the Rate of Return, and Optimal Fiscal Poiicy," Johns Hopkins Univ. Press (for Resources for the Future), Baltimore (1970).
2. R. Barro, Government spending in a simple model of endogenous growth, *Journal of Political Economy*, **98**, S103–S125 (1990).

3. W. Buiter, Saddlepoint problems in continuous time rational expectation models: A general method and some macroeconomic examples, *Econometrica*, **52**, 665–680 (1984).
4. S. Devarajan, V. Swaroop, and H. Zou, The composition of public spending and economic growth, *Journal of Monetary Economics*, **37**, (1996).
5. E. Gramlich, State and local governments and their budget constraint, *International Economic Review*, **10**, 163–182 (1968).
6. E. Gramlich, and H. Galper, State and local fiscal behavior and federal grant policy, *Brookings Papers on Economic Activity*, **1**, 15–65 (1973).
7. R. Inman, Toward an econometric model of local budgeting, *in* "National Tax Association: Proceedings of the Sixty-Second Conference on Taxation" (1971).
8. P. Mieszkowski, and W. Oakland, (Eds.), "Fiscal Federalism and Grants-in-Aid," Urban Institute, Washington, DC (1979).
9. P. Romer, Increasing returns and long-run growth, *Journal of Political Economy*, **94**, 1002–1037 (1986).
10. H. Rosen, (Ed.), "Fiscal Federalism: Quantitative Studies," University of Chicago Press, Chicago (1988).
11. J. Wilde, The expenditure effects of grant-in-aid programs, *National Tax Journal*, **21**, 340–348 (1968).
12. J. Wilde, Grants-in-aid: The analytics of design and response, *National Tax Journal*, **24**, 143–155 (1971).
13. H. Zou, Dynamic effects of federal grants on local spending. *Journal of Urban Economics*, **36**, 98–115 (1994).
14. H. Zou, Optimal design of federal grants to localities, mimeo, Policy Research Department, World Bank (1993).

Part II

The Spirit of Capitalism, Saving, Money, and Growth

ELSEVIER

European Journal of Political Economy
Vol. 10 (1994) 279–293

European Journal of
POLITICAL
ECONOMY

'The spirit of capitalism' and long-run growth

Heng-fu Zou

Public Economics Division, Policy Research Department, The World Bank, Room N10-075, 1818 H St. N.W., Washington, DC 20433, USA

Accepted for Publication February 1993

Abstract

In this paper, we will show that the capitalist-spirit approach to economic growth has been developed by Adam Smith, Karl Marx, Max Weber and John Maynard Keynes and many others. It can be demonstrated that countries with different degree of the capitalist spirit will have different per capita consumption, per capita capital stock and different endogenous growth rates in the long run. This capitalist spirit model is also widely supported by many empirical and historical studies on cultural attributes and economic development.

Key words: Spirit of capitalism; Endogenous growth; Savings; Frugality; Culture
JEL classification: O10; O40; B10; B20; P10

1. Introduction

Traditional optimal growth models such as Phelps (1961), Cass (1965) and Koopmans (1965) have demonstrated that, with a typical neoclassical production function and an exogenously given time discount factor, the maximization of an additive utility function defined on per capita consumption by a representative agent or family leads to a unique steady state where the net marginal productivity of capital equals the time discount rate. If two countries have the same technology and the same discount rate, it is expected

*This paper is based in part on the first chapter of my Ph.D thesis submitted to Harvard University in May 1989. I am grateful to Jeffrey Sachs, Richard Caves, Dwight Perkins, Bela Balassa, Andrew Newman, Lawrence Summers, Philippe Weil, Danyang Xie, Xinsheng Zeng for helpful discussions and comments. I also thank an anonymous referee for the suggestions on revising this paper. Responsibility for the contents of the paper is solely mine and not of the World Bank.

that per capita consumption, per capita capital stock, the saving rate and returns on capital are all equalized in steady state.

This well-known convergence theorem of economic growth has been faced with a growing number of challenges in recent years. Empirically, the convergence theorem cannot explain several puzzling economic facts: (i) why the growth rates in some developing countries with Confucian culture, like four East Asian 'miracles' of South Korea, Taiwan, Hong Kong and Singapore are so high and the rates in some developing countries so low; (ii) why the relative income gap between developed countries and developing countries is getting wider rather than narrowing; (iii) why productivity levels have not converged; and (iv) why the nations with Protestant religious establishment in 1870 had 1979 per capita income more than one-third higher than the nations with Catholic religion (DeLong, 1987). To try to answer these problems, some new theories have emerged. A typical starting point for these new theories is to depart from the usual assumption of diminishing returns (Romer, 1986; Lucas, 1988). Romer (1986) has shown that, under increasing returns to scale, the level of per capita income in different countries need not converge.

We believe that culture differences among countries, in addition to technology, play an important role in the determination of economic growth, Here our alternative growth model is based on Max Weber's theory of 'the spirit of capitalism' and a mathematical model of Kurz (1968). In an unduly neglected paper of the economics profession, Kurz (1968) deviates from the conventional wisdom of economics and defines utility function on both consumption and capital which he calls wealth effects. As we will see in Section 2, this novel definition of preference function reflects the essence of the spirit of capitalism: the continual accumulation of wealth for its own sake, rather than for the material rewards that it can serve to bring. (We hasten to add that Kurz's original model is a purely technical one and he does not offer any explanation or justification for his inclusion of capital into the preference. We hope that our reasoning will not distort Kurz's original ideas.)

As a result of the presence of the so-called wealth effects in the preference function, the steady-state capital stock is larger than the modified golden rule level, and the forms of utility functions play a crucial role in determining equilibrium consumption and capital. Therefore, countries with the same technology and the same time discount rate may have different steady states depending on the difference in their wealth effects or their capitalist spirit.

In recent contributions to endogenous growth theory, the technology is often assumed to be constant or increasing returns in capital input. To generate growth, for all levels of capital stock, the net marginal product of capital is further assumed to be bounded below by the time discount rate. In Sections 3 and 4, we will demonstrate how the capitalist spirit can cause

endogenous growth even though the net marginal product of capital can be smaller than the time discount rate or can go to zero as capital increases without bound. Through a specific example, it is shown that the stronger the capitalist spirit, the higher the endogenous growth rate and the saving rate.

Section 5 discusses the empirical relevance of the capitalist-spirit model. By citing work of sociologists, historians and economists, we will see that the capitalist-spirit approach to economic growth and development has been widely used in many historical and empirical studies.

We conclude this paper in Section 6 with a few remarks.

2. 'The spirit of capitalism' and its mathematical representation

Here we first present a model essentially the same as in Kurz (1968). A representative agent maximizes a discounted utility over an infinite time horizon subject to a dynamic constraint of capital accumulation:

$$\max \int_0^\infty [u(c)+v(k)]e^{-\rho t}dt, \tag{1}$$

s.t.

$$\dot{k}=f(k)-c, \tag{2}$$

where c is consumption, k is capital stock, and ρ is the time discount rate and $0<\rho<1$. $f(k)$ is the net output function (=gross output−capital depreciation). A dot over a variable denotes time derivative. The utility function has the following standard properties:

$$u'(c)>0, \quad u''(c)<0, \quad u'(0)\to\infty \quad \text{and} \quad u'(\infty)\to 0;$$

$$v'(k)>0, \quad v''(k)<0, \quad v'(\infty)\to 0.$$

The net output function $f(k)$ is typically neoclassical:

$$f(0)=0, \quad f'(k)>0, \quad f''(k)<0, \quad f'(0)\to\infty, \quad f'(\infty)\to 0, \quad f(\infty)\to\infty,$$

so $f(k)$ is strictly concave; and when capital stock increases without bound, the net marginal product of capital goes to zero and the net output increases to infinity.

The optimal path of capital accumulation is described by the following two dynamic equations:

$$-u''(c)\dot{c}=v'(k)+u'(c)(f'(k)-\rho), \tag{3}$$

$$\dot{k}=f(k)-c. \tag{2}$$

Let the steady-state values be denoted as $\bar{k}$ and $\bar{c}$, then

$$v'(\bar{k})+u'(\bar{c})(f'(\bar{k})-\rho)=0, \tag{4}$$

$$f(\bar{k})-\bar{c}=0. \tag{5}$$

Two facts immediately follow from these two equations. First, the steady-state capital stock is higher than one at the modified golden rule level. To see this, we compare the steady-state condition (4) to the modified golden rule in Cass (1965),

$$f'(\bar{k})=\rho-\frac{v'(\bar{k})}{u'(\bar{c})}<\rho=f'(k^{mg})$$

where k^{mg} denotes the modified golden rule capital. Since $f''(k)<0$, $v'(k)$ and $u'(c)$ are positive for all k and c, $\bar{k}>k^{mg}$. Second, the steady-state capital is no longer independent of the preference functions as in the Cass model. In fact, even if different countries have the same time discount rate and technology, the difference in the utility functions can give rise to different per capita capital stock and per capita consumption across countries in the long run.

In the rest of this section, we are going to argue why the inclusion of capital or wealth into the preference reflects 'the spirit of capitalism' in Max Weber's sense and how some great economists in history have developed the same idea in their growth theories.

In '*The Protestant Ethic and the Spirit of Capitalism*', Weber (1958) defines capitalism as the rational organization of formally free labour (p. 21). The essence of the spirit of capitalism is the continual accumulation of wealth for its own sake, rather than only for the material rewards that it can serve to bring (p. 4).

> 'At all periods of history, wherever it was possible, there has been ruthless acquisition, bound to no ethical norms whatever'. But only in a capitalist economy, '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 his material needs.* This reversal of what we should call the natural relationship, so irrational from a naive point of view, is evidently a *leading principle of capitalism* as it is foreign to all people not under capitalist influence' (p. 53, italic added.).

Weber's idea is clear: capital accumulation in a capitalist economy is motivated not only by the maximization of the long-run consumption, but also by the enjoyment (utility) from enhancing wealth itself. This capitalist spirit approach to long-run growth has been also taken by Adam Smith (1937), Karl Marx (1977) and John Maynard Keynes (1971), among many others.

In the '*Wealth of Nations*', Adam Smith (1937) makes the following description of a capitalist society's savings behavior:

> 'The principle which prompts to save, is the desire of bettering our condition, a desire which though generally calm and dispassionate, comes with us from the womb, and never leaves us till we go into the grave ... . An augmentation of fortune is the means by which the greater part of men propose and wish to better their condition. It is the means of the most vulgar and the most obvious; and the most likely way of augmenting their fortune, is to save and accumulate some part of what they acquire, either regularly and annually, or upon some extraordinary occasions. Though the principle of expense, therefore, prevails in almost all men upon some occasions, and in some men upon almost all occasions, yet in the greater part of men, taking the whole course of their life at an average, the principle of frugality seems not only to predominate, but to predominate very greatly' (*The Wealth of Nations*, pp. 324–325).

Adam Smith is so occupied by the moral of savings, he declares that 'every prodigal appears to be a public enemy, and every frugal man a public benefactor' (p. 324).

Karl Marx (1977) also shares this view with many so-called classical economists. He regards the instinctive nature of accumulation by capitalists as an essential part of capitalism:

> "Accumulate, accumulate! That is Moses and the prophets! 'Industry furnishes the material which saving accumulates!' Therefore save, save, i.e., reconvert the greatest possible portion of surplus-value into capital! Accumulation for the sake of accumulation, production for the sake of production: this is the formula in which classical economists expressed the historical mission of the bourgeoisie in the period of its domination" (*Capital*, Vol. 1, p. 742).

John Maynard Keynes (1971) develops the same idea in his statement of the 'psychology' of capitalist society.[1] He says that

> 'Europe was so organised socially and economically as to secure the maximum accumulation of capital. While there was some continuous improvement in the daily conditions of life of the mass of the population, society was so framed as to throw a great part of the increased income into the control of the *class least likely to consume it*. The new rich of the nineteenth century were not brought up to large expenditures, and *preferred the power which investment gave them to the pleasures of immediate consumption* .... Herein lay, in fact, the main justification of the capitalist system. If the rich had spent their new wealth on their own enjoyments, the world would long ago have found such a regime intolerable. But like bees they saved and accumulated, not less to the advantage of the whole community because they themselves held narrow ends in prospect' (*The Economic Consequences of the Peace*, p. 11, italic added).

[1] I thank Jeffrey Sachs for directing my attention to Keynes' work 'The Economic Consequences of the Peace'.

Keynes continues to describe the saving behavior of the capitalist class:

> They "were allowed to call the best part of the cake theirs and were theoretically free to consume it, on the tacit underlying condition that they consumed very little of it in practice. *The duty of 'saving' became nine-tenths of virtue and the growth of the cake the object of true religion* .... And so the cake increased; but to what end was not clearly contemplated. Individuals would be exhorted not so much to abstain as to defer, and to cultivate the pleasures of security and anticipation. Saving was for old age or for your children; but this was only in theory – the virtue of the cake was that it was never to be consumed, neither by you nor by your children after you" (p. 12, italic added).

Therefore, defining utility on both consumption and capital is a way to model the nature of capitalism mathematically. In this respect, for space limitation, we add only one more excellent passage from Gustav Cassel (1924):

> 'There is a formation of capital for which it is hardly possible to assign any concern about the future as motive. It cannot be said of the leading capitalists who satisfy all their wants of any consequence, and have a capital the returns on which guarantees this satisfaction of wants for all time to them and their families, yet constantly set aside large sum to increase their wealth, that they save out of the concern about the future. In these cases there must be some other motive. It is the economic interest of the capitalist to increase his wealth, and this in time becomes an end in itself. The motives that are at work are numerous. The senseless cupidity that in times finds its sole pleasure in contemplating the growth of its wealth, and may very well be described as an abnormal sluggishness of spirit and a pathological impoverishment of the emotional life, is certainly not the sole explanation. The desire of splendor and of the higher position in the society which the possession of great wealth assures, the stimulation of jealousy of other men, the healthy joy of the strong man in successful work as such, in ruling large masses, in influence especially – these are all factors that have to be taken into account' (*The Theory of Social Economy*, pp. 228–229).

To define the utility function on both consumption and capital or wealth is also a way to model man not only as an economic animal, but also a political animal. Ever since Aristotle, we are taught that 'man is by nature an animal of intended to live in a polis' (see Aristotle, 1958). Wealth or property provides man not only consumption means but also political power and social prestige. Possession of wealth is, to a considerable degree, a measure and standard of a person's success in a society. Thus capital and wealth directly enter to the utility function of the representative agent of the capitalist economy. In a recent book on power, Galbraith (1984), following the long tradition of sociology and political science, classifies wealth as one of three resources of political power. 'In past time, so great was the prestige of property that ... it accorded power to its possessor. What the man of wealth said or believed attracted the belief of others as a matter of course' (p.

49). To this day, 'wealth per se no longer gives automatic access to conditional power. The rich man who now seeks such influence hires a public relations firm to win others to his beliefs. Or he contributes to a politician or a political action committee that reflects his views. Or he goes into politics himself and uses his property not to purchase votes but to persuade voters' (p. 50).

This analysis agrees with Lord Acton's (1988) contention that: 'Power goes with property' (p. 572). In a *laisser-faire* capitalist economy, 'freedom of accumulation not only carries with it the possibility of cumulative increase in the inequality of economic power, ... in addition, economic power confers power in other forms, including the political' (Knight, 1942, p. 82). Seeking high social position and power has been long recognized as one of the most important motivation in capital accumulation. In the discussion related to the spirit of capitalism, Weber (1958) explicitly states that 'the desire for the power and recognition which the mere fact of wealth brings plays its part' (p. 70) in capital accumulation.

So much is the justification why we should define a representative agent's utility function on both consumption and capital (or wealth). We turn next to the relation between the capitalist spirit and endogenous growth.

3. 'The spirit of capitalism' and endogenous growth

Recent contributions to endogenous growth theory have shown that long-run growth rate can be endogenously determined by preference and technology. A common starting point of many models is to assume that the production technology is increasing or constant returns to scale instead of diminishing returns: e.g., Romer (1986), Lucas (1988), Barro (1990) and Rebelo (1991). In a convex model of endogenous growth, while allowing decreasing returns to scale, Jones and Manuelli (1990) assume that the net marginal product of capital does not go to zero as the stock of capital increases without bound. In fact, in all these models, in order to generate endogenous growth, it is required that the net marginal product of capital is always greater than the time discount rate. This is the so-called lower boundary condition on technology.

We are going to show that the inclusion of the capitalist spirit into the model can generate endogenous growth without this lower boundary condition. In this section we will retain all the assumptions regarding the utility functions in the last section. In the following, unless otherwise noted, the net production function is strictly concave and, when capital stock increases to infinity, the net output also increases to infinity, *but the net marginal product of capital can be less than the time discount rate, ρ*:

$$f''(k)<0, \quad \text{and} \quad f(\infty)\to\infty, \text{ and } f'(\infty)<\rho.$$

From the last section, the optimal conditions regarding the time path of consumption and capital accumulation can also be written as

$$\dot{c}=\{v'(k)/u'(c)+[f'(k)-\rho]\}\sigma(c)^{-1}, \tag{6}$$

$$\dot{k}=f(k)-c, \tag{2}$$

where $\sigma(c)$ is the coefficient of the absolute risk aversion:

$$\sigma(c)=-u''(c)/u'(c).$$

It is immediate from (6) that, if there is no capitalist spirit and $v(k)$ and $v'(k)$ are zero, we go back to the standard Cass model: in the long run, as the net marginal product of capital is less than the time discount rate, ρ, consumption growth will stop when the net marginal product equals the time discount rate, i.e., $f'(k)=\rho$. All the new endogenous growth models have tried to 'escape' from this rule by modifying the technology such that the net marginal product of capital is always larger than the time discount rate (the lower boundary condition). With this lower boundary condition, capital and consumption will grow for ever.

Due to the existence of capitalist spirit in our model, the lower boundary condition is not necessary for unbounded growth of capital and consumption:

Proposition 1. Suppose that $f'(k)+v'(k)/u'(f(k))$ is larger than the time discount rate ρ and k is any value satisfying the inequality: $f'(k)<\rho$. Then consumption and capital will rise for ever.

Proof. In Eq. (6), if $f'(k)\geqslant\rho$, the right-hand side will be positive and consumption will rise: $\dot{c}>0$. If $f'(k)<\rho$, and suppose that there exists a stationary steady state, then, from $\dot{k}=0$, $f(k)=c$, and from $\dot{c}=0$,

$$v'(k)/u'(f(k))+[f'(k)-\rho]=0. \tag{7}$$

But Eq. (7) cannot hold because by assumption, $f'(k)+v'(k)/u'(f(k))>\rho$ for any k satisfying $f'(k)<\rho$. So $\dot{c}$ cannot be zero. The case that $\dot{c}$ is negative can be ruled out. This is because a negative $\dot{c}$ can happen only if $c<f(k)$ for any value of k that is higher than the modified golden rule level. In this case, $[v'(k)/u'(c)]$ is less than $[v'(k)/u'(f(k))]$ for $u'(c)>u'(f(k))$. But then, $\dot{k}$ in (2) will be positive for $f(k)>c$ and capital will increase to infinity at the same time when consumption keep decreasing. Sooner or later, the marginal utility of consumption will be significantly higher than the marginal utility of

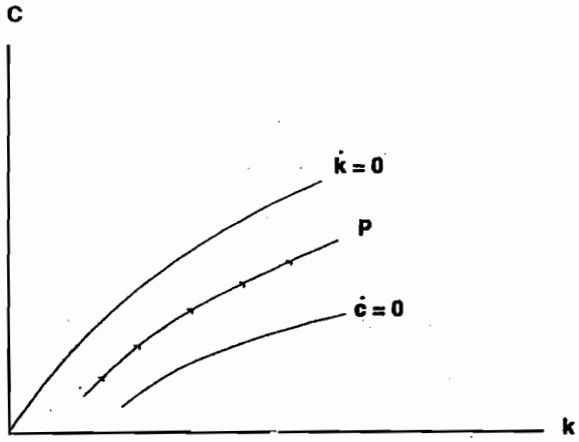


Fig. 1. P is the optimal path

capital (for $v'(\infty)\to 0$) and the representative agent's utility can be raised by reversing this process. Therefore, the only optimal path is to have consumption increase for ever: $\dot{c}>0$. But without an ever increasing capital stock, this ever growing consumption is not sustainable, so $\dot{k}>0$ always. Q.E.D.

Proposition 1 implies that, to have unbounded growth, it is essential to require that, as both consumption and capital increase to infinity, the sum of the net marginal productivity of capital and the marginal rate of substitution between capital and consumption is larger than the time discount factor. *In particular, if the marginal rate of substitution between capital and consumption, $v'(k)/u'(f(k))$, is larger than the time discount rate for all k such that $f'(k)<\rho$, consumption and capital will keep growing even though the net marginal product of capital can go to zero when capital increases without bound.*

The optimal dynamic path is depicted the phase diagram in Fig. 1. In Fig. 1, both curves are upward sloping because the slope for $\dot{c}=0$ and $\dot{k}=0$ are positive and are given by $[v''(k^*)+u'(c^*)f''(k^*)]/u''(c^*)[\rho-f'(k^*)]$ and $f'(k^{**})$, respectively. Here c^* and k^* denote the values of consumption and capital satisfying the equation $\dot{c}=0$, and c^{**} and k^{**} denotes the value for $\dot{k}=0$, or $f(k^{**})-c^{**}=0$. Given the condition in Proposition 1, there is no intersection (i.e., no stationary steady state) for these two curves. Since both consumption and capital are increasing, the optimal path, P, is bounded in the region between $\dot{k}=0$ and $\dot{c}=0$. Below the curve $\dot{k}=0$, c is smaller than $f(k)$ and $\dot{k}$ is positive; above the curve $\dot{c}=0$, for given k^*, c is larger than the value of consumption, c^*, which satisfies that $\dot{c}=0$, so $\dot{c}$ will be positive as $u'(c)$ is deceasing in c, $c>c^*$, and $v'(k^*)/u'(c)$ is larger than $v'(k^*)/u'(c^*)$.

4. Two examples

We first present an example by assuming that the net output is constant returns to capital as in Barro (1990) and Rebelo (1991):

$$f(k)=Ak.$$

Just for simplicity, we let the utility functions be

$$u(c)=\log c, \quad v(k)=\beta \log k.$$

Here the parameter β is positive and it measures the capitalist spirit.

To generate endogenous growth in the Barro–Rebelo model, it is essential to have the net marginal product of capital be greater than the time discount rate: $A>\rho$. This condition can be easily relaxed in our capitalist spirit model. In fact, let $A<\rho$ and so $f'(k)(=A)<\rho$. Furthermore, for $u(c)=\log c$ and $v(k)=\beta \log k$, $v'(k)/u'(f(k))=\beta A$. If $\beta A>\rho$ though $A<\rho$, by Proposition 1, there will be endogenous growth. But since $f'(k)$ equals to A $(A>0)$ for all k, we have:

Proposition 2. Let $f(k)=Ak$ and $A<\rho$, then there will be endogenous growth if $(1+\beta)A$ is larger than the time discount rate ρ; and the balanced growth rate, denoted as γ, is given by:

$$\gamma=A-\rho/(1+\beta).$$

Proof. The current value Hamiltonian is

$$H=\log c+\beta \log k+\lambda(Ak-c).$$

Here λ is the costate variable. The optimal conditions are:

$$c^{-1}=\lambda, \tag{8}$$

$$(\beta/k\lambda)+A-\rho=-\dot{\lambda}/\lambda, \tag{9}$$

$$(A-1/k\lambda)=\dot{k}/k. \tag{10}$$

Differentiate condition (8) with respect to time and denote the constant growth rate of consumption as γ:

$$-\dot{\lambda}/\lambda=\dot{c}/c=\gamma.$$

Substitute γ into (9):

$$k\lambda=\beta/(\gamma+\rho-A). \tag{11}$$

Differentiate (11) with respect to time on both sides:

$$\dot{k}/k = -\dot{\lambda}/\lambda = \gamma.$$

That is to say, the growth rate of capital on the balanced growth path is the same as the growth rate of consumption. Substitute $\dot{k}/k = \gamma$ into (10):

$$k\lambda = (A-\gamma)^{-1}. \tag{12}$$

Then use (11) and (12) to solve for the balanced growth rate γ:

$$\beta/(\gamma+\rho-A) = (A-\gamma)^{-1}$$

and

$$\gamma = A - \rho/(1+\beta). \tag{13}$$

To have positive growth rate in (13), $A-\rho/(1+\beta)$ needs to be positive, namely, $(1+\beta)A > \rho$. From Eq. (13), the growth rate is higher if the spirit of capitalism is stronger:

$$\mathrm{d}\gamma/\mathrm{d}\beta = \rho/(1+\beta)^2 > 0.$$

Even if technology and the time discount rate are the same across countries, the growth rates will be different if the capitalist spirit is different.

On the balanced growth path, the saving rate, s, is:

$$s = \dot{k}/f(k) = (\dot{k}/k)(k/Ak) = \gamma/A = 1 - \rho/(1+\beta)A. \tag{14}$$

So the saving rate is an increasing function of the capitalist spirit:

$$\mathrm{d}s/\mathrm{d}\beta = \rho/A(1+\beta)^2 > 0.$$

As a second example, we let

$$f(k) = k^{(1-\alpha)} \quad \text{and} \quad 0 < \alpha < 1, \tag{15}$$

so $f'(k) \to 0$ as $k \to \infty$. Let $u(c) = \log c$ and $v(k) = \beta k^{\alpha}$, then, if $\beta\alpha > \rho$, $\dot{c}$ and $\dot{k}$ will be positive all the time. To see this, we only need to check that the condition in Proposition 1 is satisfied:

$$v'(k)/u'(f(k)) = \beta\alpha k^{(\alpha-1)} k^{(1-\alpha)} = \beta\alpha.$$

Thus there exists no stationary steady state if $\beta\alpha > \rho$, and consumption and capital stock will keep rising.

5. The empirical relevance of the capitalist-spirit model

It is interesting to observe that we economists tend to explain growth and development by dealing with capital, labor and technology, while historians, political scientists and sociologists pay much more attention to the cultural and other institutional background of growth and development. That might be the division of labor among intellectuals. Our model is an attempt to reconcile in part both stories told by economists and other social scientists.

Since Max Weber published his famous study, '*The Protestant Ethic and the Spirit of Capitalism*', there has been tremendous accumulation of literature on capitalist spirit and its relation to religions and wealth creation. Though sociologists and historians (Weber, 1958; Sombart, 1913, 1915; Tawney, 1926) often argue more about which religious belief leads to capitalist spirit, the positive link between capitalist spirit and wealth accumulation has been taken for granted. Recently there are even studies to provide theological justifications for the capitalist spirit. For interested readers, a good collection is Berger's (1990) '*The Capitalist Spirit: Toward a Religious Ethic of Wealth Creation*'.

Empirically, recent examples of capitalist-spirit approach to growth and development are numerous. To cite a few, there are Harrison's (1985) study '*Underdevelopment Is a State of Mind*', Wiener's (1981) work on the decline of British industries: *English Culture and the Decline of the Industrial Spirit*: 1850–1980, and MacFarquhar's (1985) study on the four Asian 'miracles' of South Korea, Taiwan, Hong Kong and Singapore: *The Post-Confucian Challenge.*

Our economics profession is not immune from this capitalist-spirit approach. I quote two studies here. The first one is DeLong (1988). Contrary to the claim made by Baumol (1986), DeLong finds that the productivity levels among once-rich twenty-two countries in 1870 did not converge in 1979. In fact, 'holding constant 1870 per capita income, nations that had Protestant religious establishments in 1870 had 1979 per capita income more than one-third higher than do nations that had Catholic establishments'. And he shows that 'there is one striking ex-ante association between growth over 1870–1979 and an exogenous variable: a nation's dominant religious establishment .... A religious establishment variable that is one for Protestant, one-half for mixed, and zero for Catholic nations is significantly correlated with growth as long as measurement error variance is not too high'. Indeed, 'it does serve as an example of how culture may be associated with substantial divergence in growth performance'. DeLong is not the first economist to put forward such an argument. Boulding (1973) entitles one of his interesting papers as 'religious foundations of economic progress', in which he argues that Protestant ethic has not only influenced the development of capitalism, but 'the Protestant ethic has contributed to the *success* of

capitalist institutions, particularly in regard to their fostering a high rate of economic progress' (p. 45).

The second colorful example is Morishima (1982): *Why Has Japan 'Succeeded'?*. Under this sensational title, Morishima attributes the economic success of Japan to Western technology and Japanese Confucianism. His approach is typical Weberian and his comparison between the protestant ethic and the Japanese ethos is illuminating. For modern capitalism to be established, a religious revolution had to come first. In the Western, 'Puritanism's worldly frugality meant opposition to enjoyment and consumption, and luxury consumption especially was completely squeezed out. In this way the formation of capital was carried out through frugality; new capital was then used productively and became a new source of profit. Thus the religious revolution resulting from Protestantism created the modern entrepreneur and capitalism – a new type of person who was the possessor of an earnest faith, and who controlled huge wealth, but nevertheless contended himself with a life of extreme simplicity, striving to accumulate capital' (pp. 83–84).

> 'If the Japanese had not adopted the belief of frugality, which was another of the prerequisites of capitalism, then modern capitalism could certainly not have been achieved in Japan. In Japan in those days Buddhism and Shinto, the traditional religions, did not have that great influence on the everyday life of the Japanese people. However, ... as a result of the Tokugawa Bakufu's cultural policy, Confucianism had spread widely and deeply among the Japanese people. Confucianism was understood in Japan as an ethical system rather than a religion, and it directly taught the Japanese people that frugal behavior was noble behavior. Therefore Japan, at the end of the Meiji Revolution, had already fulfilled the second prerequisite for capitalism' (p. 86).

Japan's story is not exceptional. Now South Korea, Taiwan, Singapore and Hong Kong are following the Japanese example. As observed by MacFarquhar (1985), for all these countries, 'the significant coincidence is culture, the shared heritage of centuries of inculcation with Confucianism. That ideology is as important to the rise of the east Asian hyper-growth economies as the conjunction of Protestantism and the rise of capitalism in the west'. 'Post-Confucian economic man works hard and plays hard, buys much, but saves more'.

As another example to illustrate how change in the capitalist spirit may affect industrial growth, we quote from Wiener (1982): *English Culture and the Decline of the Industrial Spirit*, 1850–1980: For Britain, Wiener argues that, after the Great Exhibition of 1851, 'social and psychological currents began to flow in a different direction' (p. 157). 'The emerging culture of industrialism ... was itself transformed. The thrust of new values borne along by the revolution in industry was contained in the later nineteenth century; the social and intellectual revolution implicit in industrialism was muted,

perhaps even aborted' (p. 157). 'For a century and a half the industrialist was an essential part of English society, yet he was never quite sure of his place. The educated public's suspicions of business and industry inevitably colored the self-image and goals of the business community. Industrialists responded to their mental environment, sometimes by seeking to leave the world of production for more acceptable realms of gentility, and sometimes by striving to adapt their way of life to the canons of gentility .... As a rule, leaders of commerce and industry in England over the past century have accommodated themselves to an elite culture blended of preindustrial aristocratic and religious values and more recent bureaucratic values that inhibited their quest for expansion, productivity, and profit' (p. 127). The gentrification of the industrialists discouraged 'commitment to a wholehearted pursuit of economic growth' (p. 127) and led to 'the waning of the industrial spirit' (p. 159) or the capitalist spirit.

6. Concluding remarks

This paper has shown that a strong capitalist spirit can lead to unbounded growth of consumption and capital even though the net marginal product of capital is less than the time discount rate or goes to zero when capital stock increases to infinity. In doing this we have relaxed the technology condition required in many endogenous growth models and at the same time integrated two approaches to economic growth and development – the production-technology approach and the cultural approach – into a single model.

While we have mainly focused on the role of capitalist spirit in generating long-run growth, we want to emphasize that our model is strictly complementary to many existing models which have more or less concentrated on technology and productivity progress. In fact, as the capitalist-spirit model just adds a cultural element to the existing models, it can embody all the contributions by both the traditional growth theory and the new growth theory. It is a mistake to totally ignore the cultural elements in economic growth and development, but it is a blunder to just talk about culture without putting technology in its right place. This is why Morishima (1982) explains the successful story of Japan by two factors: Western technology and Japanese Confucianism. The balance between culture and technology should be always maintained.

References

Lord Acton, 1988, in: J.R. Fears, ed., Essays in religion, politics, and morality (Liberty Classics, Indianapolis, IN).

Aristotle, 1958, The politics of Aristotle (Edited and translated by E. Barker) (Oxford University, Oxford).

Barro, R., 1990, Government spending in a simple model of endogenous growth, Journal of Political Economy 98, Oct., S103–125.

Berger, P., ed., 1990, The capitalist spirit: Toward a religious ethic of wealth creation (Institue for Contemporary Studies, San Francisco, CA).

Boulding, K., 1973, Religious foundations of economic progress, in: Collected papers of Kenneth Boulding, Vol. 3 (Colorado Associated University Press, Boulder, CO) 43–51,

Cass, D., 1965, Optimum growth in an aggregate model of capital accumulation, Review of Economic Studies 32, 229–243.

Cassel, G., 1924, The theory of social economy (Harcourt-Brace and Company, London).

DeLong, B., 1988, Productivity growth, convergence, and welfare: Comment, American Economic Review 78, 1138–1154.

Galbraith, J.K., 1983, The anatomy of power (Houghton-Mifflin, Boston, MA).

Harrison, L., 1985, Underdevelopment is a state of mind – The Latin American case (Harvard University, Cambridge MA, and University Press of America).

Jones, L. and R. Manuelli, 1990, A convex model of equilibrium growth: Theory and policy implications, Journal of Political Economy 98, Oct., 1008–1038.

Keynes, J.M., 1971, The economic consequences of the peace (Macmillan, St Martin's Prese, New York).

Knight, F.H., 1947, Freedom and reform (Liberty Press, Indianapolis, IN).

Koopmans, T.C., 1965, On the concept of optimal economic growth, in: The econometric approach to development planning (North-Holland, Amsterdam).

Kurz, M., 1968, Optimal economic growth and wealth effects, International Economic Review 9, Oct., 348–357.

Lucas, R.E., 1988, On the mechanics of economic development, Journal of Monetary Economics 22, 3–42.

MacFarquhar, R., 1985, The post-Confucian challenge, in: Korea: Past, present and future (Aspen Institute for Humanistic Studies, Queenstown, MD).

Marx, K., 1977, Capital, Vol. I (Vintage Books, New York).

Mill, J.S., 1909, Principles of political economy (Edited by W.J. Ashley) (Longman. Green, and Co., Harlow).

Morishima, M., 1982, Why has Japan 'succeeded'? (Cambridge University Press, Cambridge).

Phelps, E.S., 1961, The golden rule of accumulation: A fable for growth men, American Economic Review 51, 638–643.

Ramsey, F., 1928, A mathematical theory of saving, Economic Journal 38, Dec., 543–559.

Rebelo, S., 1991, Long run policy analysis and long run growth, Journal of Political Economy 99, 500–521.

Romer, P., 1986, Increasing returns and long-run growth, Journal of Political Economy 94, 1002–1037.

Sombart, W., 1913, The Jews and modern capitalism (T.F. Unwin, London).

Sombart, W., 1915, The quintessence of capitalism (Translated and edited by M. Epstein (Dutton, New York).

Tawney, R.H., 1926, Religion and the rise of capitalism (Penguin Books, 1961).

Weber, M., 1958, The Protestant ethic and the spirit of capitalism (Charles Scribner's Sons, New York).

Wiener, M., 1981, English culture and the decline of the industrial spirit, 1850–1980 (Cambridge University Press, Cambridge).

Zou, Heng-fu, 1991, The spirit of capitalism and long-run growth, Working paper WPS 630 (The World Bank, Washington, DC).

Zou, Heng-fu, 1993, The spirit of capitalism and savings behavior, Journal of Economic Behavior and Organization, forthcoming.

8

ELSEVIER

Journal of Economic Behavior and Organization
Vol. 28 (1995) 131–143

JOURNAL OF
Economic Behavior
& Organization

The spirit of capitalism and savings behavior

Heng-fu Zou

Policy Research Department, The World Bank, Room N10-075, 1818 H Street, NW, Washington DC 20433, USA
Institute of Advanced Economic Studies, Wuhan University, Wuhan 430072, China

Received 6 October 1993; revised 11 January 1994

Abstract

This paper presents a capitalist-spirit model of savings by including wealth in the intertemporal utility function. While this model includes the life-cycle model and bequest model as two special cases, it sheds light on why wealth holding has tended to increase with age, why decumulation of wealth after retirement has not happened, and why households with and without children have not shown significant differences in their savings behavior. The capitalist-spirit approach is especially useful for understanding savings by the rich and savings across countries and over time (JEL E21, B10).

JEL classification: E21; B10

Keywords: Savings puzzle; Capitalist spirit; Wealth accumulation

1. Introduction

Many empirical studies suggest that the life-cycle theory of consumption cannot explain the "savings puzzle": why wealth does not decumulate after retirement, and why wealth holdings tend to increase with age (Atkinson (1971); Atkinson and Harrison (1978); Mirer (1979); Thurow (1976); Danziger et al. (1983). Moreover, Kotlikoff and Summers (1981) demonstrate that the pure life-cycle component of aggregate US savings has been very small and that most capital accumulation in the US occurs through intergenerational transfers. Like the life-cycle model, however, the theory of intergenerational transfer cannot fully

explain why there exists no significant difference in the rate of asset decumulation between the elderly who have children and those who do not, which is shown by Hurd (1986); nor can it explain why there exists a positive relation between transfers and recipient's income as demonstrated in Cox (1987).

This paper proposes a possible solution to these anomalies by recalling the role of the "capitalist spirit" in the sense of Max Weber (1905), which motivates the continual accumulation of wealth not only for the material reward that it brings, but also for its own sake.

Even before Weber, Adam Smith, Nassau Senior, and Karl Marx expressed similar views, and subsequently Werner Sombart, Joseph Schumpeter, John Maynard Keynes and Gustav Cassel argued essentially the same hypothesis (Zou (1993b)). For example, Adam Smith (1776) states the following principle of savings in a capitalist society: "The principle which prompts to save... comes with us from the womb, and never leaves us till we go into the grave. ... In the greater part of men, taking the whole course of their life at an average, the principle of frugality seems not only to predominate, but to predominate very greatly" over the principle of expense or consumption (pp. 324–325).

If I express this statement by Adam Smith on the nature of the economic man in the form of a utility function, it is obvious that the utility function not only includes the expense or consumption part, but also frugality or wealth. That is, the utility function of a typical capitalist should be defined as u(c, w), where c is consumption and w denotes wealth.

In the remainder of this paper I show how this hypothesis can be captured in the standard neoclassical savings theory as in Kurz (1968) but using an explicit generational framework. This makes it possible to incorporate the standard intertemporal savings and bequest motives as special cases. I then consider the empirical evidence already reported in the literature which can be reinterpreted from this more general point of view. Finally, I comment on the measurement of the capitalist spirit in some related studies. The present approach is strictly complementary to the existing life-cycle theory and the theory of bequest. My contribution is to explain the part of savings which cannot be explained when the capitalist spirit is not incorporated. In other words, there are three motives for savings: for retirement, for bequest, and accumulation for its own sake.

2. The capitalist spirit in an overlapping-generations model of savings

Consider a typical agent of the i-th generation who lives for two periods. He consumes $c_{i,1}$ in period 1 and $c_{i,2}$ in period 2, saves $w_{i,1}$ in period 1 and $w_{i,2}$ in period 2, and derives a discounted utility over the two periods:

$$u(c_{i,1}) + \beta v(w_{i,1}) + \frac{u(c_{i,2}) + \beta v(w_{i,2})}{1+\delta}, \tag{1}$$

where $(1+\delta)^{-1}$ is the positive time discount factor; $\beta v(.)$ is the utility derived from wealth accumulation itself and the parameter β is used to measure the capitalist spirit, and can take any value from zero to positive infinity. [I exclude negative values of β or Wittgenstein's view that money is a nuisance (Russell (1968), p. 144).] When β equals zero, this is the standard utility function as in Diamond (1965); when the term $\beta v(w_{i,1})$ is dropped for the first period but retained for the second, this is the standard bequest models like Blinder's [Blinder (1973)]. It is further assumed that both functions $u(.)$ and $v(.)$ are increasing, concave and differentiable in their arguments: $u'(.)>0$, $v'(.)>0$, $u''(.)<0$, and $v''(.)<0$.

For simplicity, population growth is assumed to be zero. I normalize the number of individuals in each cohort to be one. Thus generation i or agent i receives an amount of wealth $w_{i-1,2}$ from the generation $(i-1)$. This wealth is left behind by agent $(i-1)$, while the old generation has already derived the discounted utility $(1+\delta)^{-1}\beta v(w_{i-1,2})$ from the holding of wealth $w_{i-1,2}$. In addition to the wealth left over by the old generation, individual i receives an income y when he is young. Again for simplicity, this income is assumed to be the same for all generations and the interest rate on savings is also fixed at a constant r for all generations. Therefore, we can write the budget constraint for the typical generation i as follows:

$$w_{i,1}=y+(1+r)w_{i-1,2}-c_{i,1}, \tag{2}$$

$$w_{i,2}=(1+r)w_{i,1}-c_{i,2}. \tag{3}$$

Here Eq. (2) says that generation i's total income $[y+(1+r)w_{i-1,2}]$ is allocated between first-period consumption $c_{i,1}$ and first-period savings $w_{i,1}$. Eq. (3) says that the total first-period savings plus the interest income is used for the second-period consumption $c_{i,2}$ and the second-period savings $w_{i,2}$.Maximizing (1) subject to (2) and (3) yields the first-order conditions:

$$\beta v'(w_{i,2})=u'(c_{i,2}), \tag{4}$$

$$\beta v'(w_{i,1})+\frac{(1+r)}{(1+\delta)}u'(c_{i,2})=u'(c_{i,1}). \tag{5}$$

Combining (2)-(5), savings in periods 1 and 2 can be expressed as:

$$\beta v'(w_{i,2})=u'((1+r)w_{i,1}-w_{i,2}), \tag{6}$$

$$\beta v'(w_{i,1})+\frac{(1+r)}{(1+\delta)}\beta v'(w_{i,2})=u'(y+(1+r)w_{i-1,2}-w_{i,1}). \tag{7}$$

Differentiating w_{ij}, $j=1,2$, with respect to β, I obtain:

Proposition 1. The higher the capitalist spirit, the higher the savings in both periods 1 and 2.

Rearranging optimal conditions (4) and (5), I have:

$$\frac{v'(w_{i,1})}{v'(w_{i,2})} = \frac{u'(c_{i,1})}{u'(c_{i,2})} - \frac{(1+r)}{(1+\delta)}. \tag{8}$$

From which, the movement of the wealth ratio $(w_{i,1}/w_{i,2})$ can be seen:

Proposition 2. Savings increase (decrease) with age, that is, $w_{i,1}/w_{i,2} < 1$ $(w_{i,1}/w_{i,2} > 1)$, if the marginal rate of substitution between consumption in period 1 and consumption in period 2 is larger (smaller) than $(2 + r + \delta)(1 + \delta)^{-1}$.

The proof comes directly from expression (8). Suppose that $w_{i,1}/w_{i,2}$ is less than one, that is to say, savings in the second period are higher than in the first period. Then the left-hand side of Eq. (8) is larger than one since the function $v(.)$ is concave. To maintain equality, the right-hand side has to be bigger than one, which means that the marginal rate of substitution between consumption in period 1 and consumption in period 2 minus $(1 + r)(1 + \delta)^{-1}$ is larger than one, or the marginal rate of substitution is larger than $(2 + r + \delta)(1 + \delta)^{-1}$. The proof of the other case is similar.

From proposition 2, we can see the movement of consumption in the two periods corresponding to changes in savings. If the wealth ratio $w_{i,1}/w_{i,2}$ is less than, or equal to, one, the marginal rate of substitution $u'(c_{i,1})/u'(c_{i,2})$ is greater than, or equal to, $(2 + r + \delta)(1 + \delta)^{-1}$, which is greater than one. Then, by concavity of $u(.)$, the ratio of the consumption in period 1 over that in period 2, $c_{i,1}/c_{i,2}$, is less than one, or $c_{i,1} < c_{i,2}$. This observation leads to:

Proposition 3. If second-period savings are larger than, or equal to, first-period savings: $w_{i,2} \geq w_{i,1}$, then second-period consumption is no less than first-period consumption: $c_{i,2} \geq c_{i,1}$.

In order to see the effect of the capitalist spirit on the wealth ratio clearly, let $u(c) = \log c$ and $v(w) = \log w$. Then, the first-order conditions become:

$$\frac{\beta}{w_{i,2}} = \frac{1}{c_{i,2}}, \tag{9}$$

$$\frac{\beta}{w_{i,1}} + \frac{(1+r)}{(1+\delta)c_{i,2}} = \frac{1}{c_{i,1}}. \tag{10}$$

Substituting (9) into the budget constraint (3):

$$\frac{w_{i,2}}{w_{i,1}} = \frac{(1+r)\beta}{1+\beta}. \tag{11}$$

This gives:

Proposition 4. Second-period savings are higher (less) than first-period savings if $r\beta > (<) 1$ or if the capitalist spirit β is larger (smaller) than $(1/r)$.

In this special case, Proposition 2 can be strengthened:

Proposition 5. The ratio of savings over the two periods, $(w_{i,2}/w_{i,1})$, increases in the capitalist spirit β.

That is,

$$\frac{d\left[\frac{w_{i,2}}{w_{i,1}}\right]}{d\beta} = \frac{1+r}{1+\beta^2} > 0. \tag{12}$$

I continue to use the special case to illustrate the path of wealth accumulation or savings over time and from one generation to another generation. Using the budget constraints (2) and (3) and the first-order conditions (9) and (10), I obtain the following relation between second-period savings of the i-th generation and second-period savings of the $(i-1)$-th generation:

$$w_{i,2} = \frac{(1+r)(2+\delta)\beta^2 + \beta(1+r)}{(1+\beta)^2(2+\delta)}\left[y + (1+r)w_{i-1,2}\right] \tag{13}$$

From this, it follows that:

Proposition 6. When the capitalist spirit is strong, each generation will bestow more and more wealth to the next generation.

That is,

$$\frac{dw_{i,2}}{dw_{i-1,2}} \to (1+r)^2 > 1 \text{ for the large values of } \beta. \tag{14}$$

3. Empirical evidence

3.1. Savings behavior of the old in empirical studies

According to the standard life-cycle theory of savings, old people are supposed to decumulate their wealth after retirement. But from the perspective of the capitalist-spirit model, savings in old age can be higher than in young age as

suggested by propositions 4 and 5. This theoretical result has strong support in empirical studies on the savings behavior of the old since the 1970s.

Atkinson (1971) and Atkinson and Harrison (1978) show that average wealth accumulation in Britain increases in old age. Brittain (1978) finds a positive relationship between age and wealth holdings in the United States. Mirer (1979) examines wealth holding patterns among aged married couples from the 1968 survey of the Demographic and Economic Characteristics of the Aged and finds that wealth (not including the capital value of pensions, social security, etc) declines modestly, or perhaps not at all, with age. This observation not only applies to the very rich, but also holds for all other levels of wealth. Furthermore, after correcting for intercohort differences in wealth at retirement, he shows that wealth increases with age. Menchik and David (1983) also fail to show individuals decumulating wealth in old age, and, on the contrary, the opposite result seems to hold in their study. As for the saving rate, Thurow (1976) finds positive saving rates for all age groups. Danziger et al. (1983) show that the elderly not only do not dissave to finance their consumption during retirement, they spend less on consumption goods and services (save significantly more) than the non-elderly at all levels of income. Moreover, the oldest of the elderly save the most at given levels of income.

Intergenerational transfers have been used to explain this increasing relationship between wealth and age. But empirical studies have cast some doubt on this motive. According to the bequest theory, children with low income should receive more transfer income from their parents than the children with high income from the same family. But statistical studies have shown the opposite. For example, Sussman et al. (1970), Brittain (1978) and Menchik (1980) all have found that wealth bequeathed to children is shared equally, while Cox (1987) finds a positive relation between the transfers and the recipient's income.

All these facts are consistent with the capitalist-spirit model of savings. Since savings themselves also generate utility, the old keep saving even though the life-cycle motive tends to reduce savings. Furthermore, as strong capitalist-spirit-minded parents may encourage their children to have the same spirit, they will give equal or more money to those children with a strong capitalist spirit and high income than to their children with low income. This positive association between recipients' income and bequest also points out that the parents have tried to encourage industriousness and savings of their children.

3.2. Savings behavior of households with and without children

Perhaps the most important challenge to the bequest theory of savings, and a more significant piece of supporting evidence for the capitalist-spirit theory of savings, comes from Hurd (1986). One may expect that the bequest motive depends on whether the old have children. But, with the data from the Longitudinal Retirement History Survey (RHS), Hurd finds that households with children

and without children do not show any significant difference in their dissavings. In fact the opposite is true: "the households with children have less bequeathable wealth than households without children. If the observed rates of decumulation continue beyond the ages of the RHS households, the households with children will always have less wealth than households without children" (p. 32–33). Hurd also finds that the saving rates of households without children are always higher than the saving rates of households with children. While Hurd's finding challenges the bequest motive of savings, it implies that savings can be undertaken for the sake of savings regardless of whether a household has children or not. Hurd hints that the existing methods cannot be used to study the savings behavior of the very wealthy: "If one wants to understand how the capital stock is accumulated, one would probably want to study the very wealthy. However, the standard consumption models may not apply: time constraints prevent the very wealthy from consuming even the interest from their wealth" (p. 35). The capitalist-spirit theory of savings seems to offer an alternative to the existing models of savings.

3.3. Savings psychology of the rich

The rich have most of the wealth in most countries. For example, in Britain, the top 1 percent of the adult population own about a third of the total personal wealth and the top 10 percent as much as three-quarters (Atkinson (1971), p. 239). Empirical studies have demonstrated some different patterns of savings for the rich. Burbridge and Robb (1985) show that, among Canadian households, there exists a significant difference in accumulation behavior among the rich and the poor; on average, "blue-collar" households decumulate after retirement and "white-collar" do not.

While it is difficult to offer a regression analysis about the savings behavior of the very rich and the "captains of industry", their savings habit and their "spirit of accumulation" can be seen from their confessions and many case studies. The first example is taken from Weber (1958):

"When Jacob Fugger, in speaking to a business associate who had retired and who wanted to persuade him to do the same, since he had made enough money and should let others have a chance, (*they are the followers of the life-cycle theory*, added), rejected that as pusillanimity and answered that 'he (Fugger) thought otherwise, he wanted to make money as long as he could.'" (p. 51).

Many examples are presented in Sombart's (1915) book. For example, Sombart cites Andrew Carnegie's *Autobiography*: "We were always hoping ... that there would come a time when extension of business would no longer be necessary; but we invariably found that to put off expanding would mean retrogression". (p. 174) He also quotes Rockefeller: "The more the business grew the more capital we put into it, the object being always the same: to extend our business". (p. 174)

Having studied the money-making careers of many "captains of industry", Sombart offers the following observation on their savings psychology: "It fre-

quently happens that he really does not want to expand further, but he must. Many a captain of industry has confessed as much... Most capitalist undertakers think nothing else but this desire for extension and expansion, which to the outside observer appears so meaningless" (pp. 174–175). This expansion psychology leads to ever-increasing savings. If you interpret their behavior as saving and investing for the future or for the next generation, captains of industry will quickly dismiss this intention and "regard you with a kind of mild surprise" (p. 175).

Wicksteed (1933) has the following description of the savings psychology of the rich: "A millionaire is not only able to save but unable not to save, because he cannot spend all his accumulation at once, and he is always able to transmute present into future command of wealth". (p. 294). "Indeed to the rich man the problem often is how he can avoid saving too much. The exigencies of his business may drain him of his income. It is always demanding to be extended, till he no longer controls it, but it controls him. It has become a kind of Frankenstein's monster that dominates his life. It must grow or die. And he cannot let it die, partly because he is dependent upon it, and partly because it has become a kind of entity to him, and, independently of all the things in the circle of exchange that it represents to him, has acquired a kind of independent claim upon his affection and his imagination, and is bound up with all manner of personal relations and obligations". (p. 298).

3.4. The connection between the capitalist spirit and savings over time

The role of the capitalist spirit in the economic take-off from a traditional society to a modern capitalist economy has manifested in two aspects: first, the capitalist spirit contributes to a higher saving rate; and second, the capitalist spirit cannot be separated from entrepreneurship in the sense of Joseph Schumpeter as I have argued in Zou (1993b). As observed by Rostow (1960), the economic take-off from a traditional society to an industrialized society requires a significant increase in the saving or investment rate from about 5 percent of national income to about 10 percent. How does one explain this phenomenon? According to Weber and Sombart, the attitudes towards acquisition, savings and wealth accumulation are very different between a traditional society on one hand and a capitalist society on the other. While in the traditional society the normal situation for mankind is that rationally acquisitive activities are oriented to a traditionally fixed standard of living and the saving rate is rather low, in the capitalist era, the traditional practice is broken down and acquisition has become an endless process. From the historical perspective, the Protestant ethic is the psychological origin of this capitalist spirit because the Protestant ethic – hard work, thrift, austerity – "must have been the most powerful conceivable lever for the expansion of that attitude toward life which we have called the spirit of capitalism". These ethos also have a direct implication for the rising saving rates: "when the limitation of consumption is combined with this release of acquisitive activity, the inevitable practical result is

obvious: *accumulation of capital through ascetic compulsion to save*''. (Weber (1905), p. 172, italics added.)

Mill (1848) also takes the capitalist-spirit approach to study economic growth in the 17th to the 19th-century Europe. In England as well as other prosperous countries of Europe, ''in a very numerous portion of the community, the professional, manufacturing, and trading classes, being those who, generally speaking, unite more of the means with more of the motives for saving than any other class, *the spirit of accumulation is so strong, that the signs of rapidly increasing wealth meet every eye*''. (p. 173, italics added). What are the causes of this accumulation phenomenon? After citing numerous economic, political, institution factors, Mill adds the following: ''These causes have, in England, been greatly aided by what extreme incapacity of the people for personal enjoyment, which is a characteristic of countries over which puritanism has passed''. (p. 174) According to Mill, the spirit of accumulation is even higher in Holland where ''the mercantile classes...remained frugal and unostentatious'' (p. 175).

Mill paid particular attention to the puzzle between low returns and rapid accumulation in his time. His explanation emphasizes the spirit of accumulation. As long as the spirit of accumulation is strong, high returns are not needed to stimulate savings: ''In England and Holland, then, for a long time past, and now in most other countries in Europe... *the desire of accumulation does not require, to make it effective, the copious returns which it requires in Asia, but is sufficiently called into action by a rate of profit so low, that instead of slackening, accumulation seems now to proceed more rapidly than ever*''. (p. 175, italics added.)

Keynes (1920) also emphasizes the role of ''the saving for the sake of savings'' in the vast accumulation of capital in the 19th-century Europe: ''Europe was so organized socially and economically as to secure the maximum accumulation of capital. While there was some continuous improvement in the daily conditions of life of the mass of the population, *society was so framed as to throw a great part of increased income into the control of the class least likely to consume it. The new rich of the nineteenth century were not brought up to larger expenditures, and preferred the power which investment gave them to the pleasure of immediate consumption*''. (pp. 18–19, italics added.)

While a strong capitalist spirit has led to rapid capital accumulation and fast economic growth, the waning of the capitalist spirit has been the main cause of the ''British disease'' as diagnosed by Sombart (1915), Henry Rosovsky [in Harrison (1992)], and Wiener (1982). Once the ''captains of industry'' have lost their wholehearted pursuit of money and profits, and once people have developed their contempt for the capitalist spirit, then a declining trend of savings and economic growth is inevitable. While blaming large government deficits and borrowing as the main cause of very low saving rates in the US, Harrison (1992) is very careful to point out the fundamental change in the American cultural values. According to Harrison, the traditional American values such as hard work, frugality and austerity, namely, the strong capitalist spirit of America, have been eroded

gradually, "disrespect for thrift and austerity, driven by increased focus on the present and reduced focus on the future, has a lot to do with our low national levels of savings and investment". (p. 230)

3.5. The Confucianist ethic of frugality and high saving rates of East Asia

Many studies on high saving rates in East Asian countries and regions like Japan, Taiwan, South Korea, Singapore and Hong Kong have taken the capitalist-spirit approach modified to the Confucianist ethic of frugality. In explaining the economic success of Japan, Morishima (1982) places the Confucianist ethic of frugality on equal footing with the Protestant ethic: while the Protestant ethic is the origin of the capitalist spirit in the West, the Confucianist ethic of frugality is the origin of the capitalist spirit in Japan. Since Morishima does not explain the Confucianist moral of frugality, I present some idea of the Confucianist teaching on frugality here; more details appear in Zou (1993a).

The Confucianist ethic of frugality is expressed in the doctrine of Confucius (born 552 B.C.), the founder of the Confucianist school. Since the early Han Dynasty (B.C. 206–220 A.D.) until the early 20th century, Confucianism was the official ideology of China. The adoption of Confucianism in Korea and Japan resulted in the Korean Confucianism and the Japanese Confucianism. Even today, the moral teachings in these countries and other countries like Taiwan, Singapore and Hong Kong all have their origin directly from Confucianism. In the most famous Chinese classic *The Analects* (Confucius (1986), English edition), Confucius states the following moral codes on frugality:

"The Master (Confucius) said, 'In guiding a state of a thousand chariots, approach your duties with reverence and be trustworthy in what you say; be frugal in spending and love your fellow men'" (Book I, 5).

"Lin Fang asked about the basis of the rites. The Master said, 'A noble question indeed! With the rites, it is better to err on the side of frugality than on the side of extravagance'" (Book III. 4).

"The Master said, 'Extravagance means ostentation, frugality means shabbiness. I would rather shabby than ostentatious'" (Book VII. 36).

The Confucianist ethic of frugality plays a very important role in promoting high savings in China. It is absolutely right to attribute fast economic growth in the past 15 years to economic reforms initiated by Deng Xiaoping. But why have the Chinese people with a low per capita income kept an average saving rate of 34%? Perhaps this is the reason why most experts on China and East Asia have advocated so much the role of the Confucianist values in generating high saving rates and fast economic growth in those countries; see Harrison (1992) and many references in Harrison's book.

When Hayashi (1986) makes a detailed examination "Why is Japan's saving rate so apparently high?", he lists cultural factors as one of the explanatory factors (p. 167). The paper by Hirioka (1985) has also shown some mixed evidence on the

relation between the culture and high saving rates in Japan. There is also an interesting observation made by Lawrence Summers and one of his students appeared in Hayashi (1986): "Summers suggested cultural difference between Japanese and Americans as a possible explanation of the high saving rate in Japan. He cited a work based on survey data for Japanese-Americans by one of his students. The research showed that Japanese-Americans' saving rate is 5 percent higher than that of the other group". (p. 234)

4. Conclusion

Our theoretical model which includes the life-cycle motive and bequest motive captures the essence of wealth accumulation in a capitalist economy: accumulation for the sake of accumulation. It indicates that, with a strong capitalist spirit, people may not decumulate their wealth in retirement, but continue to accumulate generation after generation. The empirical evidence strongly supports the role of the accumulation motive. First, the old do not generally decumulate wealth during retirement. On the contrary, they tend to keep saving until they die. Second, households with and without children do not have significant differences in their savings behavior. Moreover, the capitalist-spirit model of savings realistically characterizes the savings behavior of the very wealthy, and explains why there is a significant upward jump in the saving rates when a traditional society becomes a modern capitalist economy. It implies that saving rates will be different across countries if the intensity of the capitalist spirit is different. In particular, the model sheds light on high saving rates in East Asian countries endowed with the Confucianist ethic of frugality.

Naturally, the measurement of the capitalist spirit is a problem. This is exactly the issue discussed by Lucas (1988) in this theory of human capital and endogenous growth. Lucas admits that, even though human capital accumulation is the engine of growth in his model, "we can no more directly measure the amount of human capital a society has, or the rate it is growing, than we can measure the degree to which a society is umbued with the Protestant ethic" (p. 35). Lucas regards the concept of human capital equivalent to "the Protestant ethic, or the spirit of history or just 'factor X'", or the capitalist spirit because these concepts all have the same measurement problem. An approximation to measuring the capitalist spirit has been done by DeLong (1988). He takes the dominant religious establishment in a nation as a dummy variable with value one for a country with dominant Protestants, value zero for a country with dominant Catholics, and one-half for a country with half Catholics and half Protestants. He finds that the GDP per capita from 1870 to 1979 for once rich twenty-two countries in 1870 was significantly positively correlated with this religious dummy variable. In fact, the measurement of the capitalist spirit is no more difficult than the measurement of the desire for intergenerational transfers in the standard savings models; it is no

more difficult than the measurement of time preference and the elasticity of the intertemporal substitution in almost all dynamic models. As usual, the capitalist-spirit model can be calibrated to stimulate the savings patterns in a country and across countries; or one can follow the Lucas-DeLong approximation to the capitalist spirit by choosing a dummy variable of dominant religious establishments across countries; or, for East Asia countries, one can follow Morishima's suggestion to take the degree of exposure to the Confucianist ethic of frugality as another possible candidate. In the end, it should be noted that this so-called latent variable problem discussed here is very common in economics and other social sciences. [For the interested reader, see Aigner and Goldberger (1977).]

5. For further reading

Zou (1994), Zou (1995), and Bakshi and Chen (1995).

Acknowledgements

I thank John Campbell, Richard Caves, Shantayanan Devarajan, Dwight Perkins and Jeffrey Sachs for discussions, criticism and suggestions. I am especially indebted to Richard Day for detailed suggestions, editorial help and encouragement, which led to a total revision of this paper. All remaining errors are my own. The views expressed here do not necessarily reflect those of the World Bank.

References

Aigner D. and A. Goldberger, 1977, (eds.) Latent variable in socio-economic models. North-Holland, Amsterdam.

Atkinson, Anthony. 1971, The distribution of wealth and the individual life-cycle, Oxford Economic Papers 23, 239–254.

Atkinson, Anthony and A.J. Harrison, 1978, The distribution of wealth in Britain (Cambridge University Press).

Bakshi, Gurdip, and Zhiwu Chen, 1995, The spirit of capitalism and stock market prices, forthcoming, American Economic Review.

Blinder, Alan, 1973, A model of inherited wealth, Quarterly Journal of Economics 87, 608–626.

Brittain, John, 1978, Inheritance and the inequality of material wealth (The Brookings Institution, Washington, D.C.).

Burbridge, J.B. and A.L. Robb, 1985, Evidence on wealth-age profiles in Canadian cross section data, Canadian Journal of Economics 18, 854–875.

Confucius, 1986, The analects, translated by D.C. Lau (Dorset Press, New York).

Cox, Donald, 1987, Motives for private income transfers, Journal of Political Economy 95, 508–546.

Danziger, Sheldon, Jacques van der Graag, Eugene Smolensky and Michael Taussig, 1983, The life-cycle hypothesis and the consumption behavior of the elderly, Journal of Post Keynesian Economics 5 (2), 208–227.

DeLong, B., 1988, Productivity growth, convergence and welfare: comment, American Economic Review.

Diamond, Peter, 1965, National debt in a neoclassical growth model, American Economic Review 55, 1126–1150.

Hayashi, Fumio, 1986, Why is Japan's saving rate so apparently high?, Stanley Fischer, (ed.) NBER Macroeconomics Annual 1986 (The MIT Press), 147–234.

Harrison, Lawrence, 1992, Who prospers? How cultural values shape economic and political success (Basic Books).

Hirioka, C., 1985, A survey on the literature on household saving in Japan: why is the household saving rate so high in Japan?, Mimeo (Kyoto University).

Hurd, M.D., 1986, Savings and bequests, NBER working paper 1826 (Cambridge, MA).

Keynes, J.M., 1920, The economic consequences of the peace (Harcourt, Brace and Howe).

Kotlikoff, Laurence and Lawrence Summers, 1981, The role of intergenerational transfers in aggregate capital formation, Journal of Political Economy 89, 706–732.

Kurz, M., 1968, Optimal economic growth and wealth effects, International Economic Review 9, 348–57.

Lucas, R.E., 1988, On the mechanics of economic development, Journal of Monetary Economics 22, 3–42.

Menchik, P.L., 1980, Primogeniture, equal sharing and the US distribution of wealth, Quarterly Journal of Economics 94 (2), 229–316.

Menchik, Paul and Martin David, 1983, Income distribution, lifetime savings and bequests, American Economic Review 73, 672–690.

Mill, J.S., 1848, (1st edition), Principles of political economy, Edited by W.A. Ashley, Longman, Green and Co (1909).

Mirer, Thad W., 1979, The wealth-age relation among the aged, American Economic Review 69, 435–443.

Morishima, M., 1982, Why has Japan "succeeded"? (Cambridge University Press).

Rostow, W., 1960, Stages of economic growth (Cambridge University Press).

Russell, Bertrand, 1968, The autobiography of Bertrand Russel: 1914–1944 (Little, Brown and Company, Boston).

Smith, Adam, 1776, The wealth of nations, (Modern Library, New York, 1930).

Sombart, W., 1915, The quintessence of capitalism (New York: Dutton), translated and edited by M. Epstein.

Sussman, M.B., J.N. Cates and O.T. Smith, 1970, Inheritance and the family (Sage, New York).

Thurow, L., 1976, Generating inequality (Basic Books, New York).

Weber, M., 1905, The protestant ethic and the spirit of capitalism (Charles Scribner's Sons, New York, 1958).

Wicksteed, Philip H., 1933, The common sense of political economy, 2 volumes (Routledge & Kegan Paul).

Wiener, M., 1982, English culture and the decline of the industrial spirit, 1850–1980 (Cambridge University Press).

Zou, Heng-fu, 1993a, Economic growth, the capitalist spirit and thrift, Journal of Economic Research, February, 56–64 (Chinese Academy of Social Sciences, Beijing).

Zou, Heng-fu, 1993b, The capitalist-spirit approach to growth: A perspective from the history of economic analysis. Revised for History of Political Economy.

Zou, Heng-fu, 1994, The spirit of capitalism and long-run growth, European Journal of Political Economy 10, No. 2, 279–293.

Zou, Heng-fu, 1995, The spirit of capitalism, savings, asset prices and growth, forthcoming, The World Bank and Wuhan University.

Vol. 68 (1998), No. 3, pp. 219–233

Journal of Economics
Zeitschrift für Nationalökonomie

The Spirit of Capitalism, Social Status, Money, and Accumulation

Heng-fu Zou

Received March 20, 1998; revised version received August 8, 1998

This paper demonstrates the unambiguous existence of the Tobin portfolio-shift effect in the wealth-is-status and the spirit-of-capitalism models of growth. Namely, higher inflation leads to higher capital stock in the long run, and inflation increases the endogenous-growth rate of the economy.

Keywords: spirit of capitalism, social status, money, growth.

JEL classification: E1, E31, O42.

1 Introduction

Recently, Cole et al. (1992, 1995), Robson (1992), Fershtman and Weiss (1993), Bakshi and Chen (1996), and Zou (1994, 1995) have developed the wealth-is-status and the spirit-of-capitalism models of savings, growth, and asset pricing. The salient feature of these models is to define social status and wealth directly or indirectly in the representative agent's utility function. Including wealth in the preferences is an explicit way to model people's quest for social status as in Rae (1964), Veblen (1973), Duesenberry (1949), Spence (1974) and Frank (1985); it also reflects the spirit of capitalism in the sense of Max Weber (1958): individuals accumulate wealth not only for consumption, but also for its own sake.[1]

All these studies have considered the effects of social status and the spirit of capitalism on savings and growth in a real economy. This paper extends this new approach to a monetary economy and examines the effect of inflation on capital accumulation and growth. It is found that there exists unambiguously the Tobin (1965) portfolio-shift effect.

1 For detailed justifications, see Cole et al. (1992, 1995) and Zou (1994, 1995).

Specifically, in Sect. 2, we demonstrate that, for a perfect-foresight equilibrium and even with a separable utility function on consumption and real balances, higher inflation leads to a higher capital stock in the long run. In Sect. 3, still with a simple, separable utility function and with the same assumption on the production technology as in Rebelo (1987) and Barro (1990), we show that inflation increases the long-run balanced-growth rate. If the desire for social status and the spirit of capitalism are dropped from the model, the balanced-growth rate is independent of the growth rate of money. These findings stand in sharp contrast to the superneutrality result in the Sidrauski model, the negative effect of inflation on growth in the Stockman (1981) model, and many ambiguities regarding the connection between inflation and growth in other related studies.

2 The Model and Analysis

Here we first present the monetary extension of the wealth-is-status and the spirit-of-capitalism models. A representative agent maximizes a discounted utility defined on both consumption and wealth over an infinite time horizon subject to a dynamic constraint of wealth accumulation[2]:

$$\int_0^\infty (U(c,m) + \beta v(a))\mathrm{e}^{-\rho t}\,\mathrm{d}t\ , \tag{1}$$

where c is consumption, m is real balances, β is a nonnegative parameter, which measures the desire for social status and the intensity of the spirit of capitalism, ρ is the time discount rate ($0 < \rho < 1$), $U(c,m)$ is the utility from consumption and liquidity services as in the Sidrauski model, a is total wealth, namely, the sum of capital, k, and real balances:

$$a = k + m\ , \tag{2}$$

and $\beta v(a)$ is the utility[3] derived from wealth accumulation (the spirit of capitalism). It also represents the idea that absolute wealth is status as in Kurz (1968), Bakshi and Chen (1996), and Zou (1994, 1995).

2 Defining the utility function on both consumption and wealth or asset has also been done in Bardhan (1967), Kurz (1968), and Blanchard (1983) in modeling growth and foreign borrowing.

3 We need to point out that all the results obtained in this paper also apply to the alternative definition of the utility function $U(c,m) + \beta v(k)$ instead of $U(c,m) + \beta v(a)$.

A more sophisticated approach will consider the ratio of one's own wealth to the social-wealth index as the determinant of social status; see Duesenberry (1949), Spence (1974), Robson (1992), Bakshi and Chen (1996), and Rauscher (1997), among many others. That would be an interesting extension of the model considered here.

The dynamic constraint is given by:

$$\dot{a} = f(k) + x - c - \pi m - g \ , \tag{3}$$

and

$$\dot{a} = \dot{k} + \dot{m} \ , \tag{4}$$

where x is the lump-sum transfer from the government, π is the expected inflation rate, g is government spending, and $f(k)$ is the net output (equal to gross output minus capital depreciation). A dot over a variable denotes a time derivative. The utility function is increasing, concave, and differentiable in c, m, and a. The production function is neoclassical.

A representative agent maximizes (1) subject to the constraints (2) and (3). Following Calvo (1979), let λ_1 be the costate variable associated with the budget constraint (3) and λ_2 be the multiplier associated with the wealth definition (2). The Hamiltonian is given as follows:

$$\begin{aligned} H = \{&U(c, m) + \beta v(a) + \lambda_1[f(k) + x - c - \pi m - g] \\ &+ \lambda_2(a - k - m)\}e^{-\rho t} \ . \end{aligned} \tag{5}$$

It is well-known that in the Sidrauski model, a separable utility function in consumption and real balances results in not only short-run, but also long-run superneutrality. To show how the wealth-is-status model differs from the Sidrauski model, we assume that $U(c, m)$ is separable in c and m:

$$U(c, m) = u(c) + l(m) \ . \tag{6}$$

The conditions necessary for a maximum are

$$u'(c) = \lambda_1 \ , \tag{7}$$

$$l'(m) = u'(c)(f'(k) + \pi) \ , \tag{8}$$

$$\beta v'(a) + u'(c)(f'(k) - \rho) = -u''(c)\dot{c} \ , \tag{9}$$

$$\lim a\lambda_1 e^{-\rho t} = 0, \quad t \to \infty \ , \tag{10}$$

plus the dynamic budget constraint:

$$\dot{k} + \dot{m} = f(k) + x - c - \pi m - g \ . \tag{3'}$$

By definition,

$$\dot{m} = (\theta - \dot{p}/p)m \ , \tag{11}$$

where θ is the constant rate of money growth, and p is the price level. On the perfect-foresight path, the expected inflation rate is equal to the actual one:

$$\dot{p}/p = \pi \ . \tag{12}$$

We also note that government transfer, x, is equal to the net increase in money supply:

$$x = \theta m \ . \tag{13}$$

Substituting (11), (12), and (13) into conditions (8) and (3′), and rewriting condition (9), we have:

$$\beta v'(a) + u'(c)(f'(k) - \rho) = -u''(c)\dot{c} \ , \tag{9}$$

$$[f'(k) + \theta - l'(m)/u'(c)]m = \dot{m} \ , \tag{14}$$

$$f(k) - c - g = \dot{k} \ . \tag{15}$$

In the steady state $\dot{c} = \dot{k} = \dot{m} = 0$. Two points about the steady-state equation (9) are worth noting here. First, as $\beta v'(\cdot)$ is positive, $(f'(k) - \rho)$ has to be negative in the steady state, namely, the steady-state capital is larger than the modified-golden-rule level of capital. Second, if β is zero in (9), we are back to the Sidrauski model, and capital accumulation is independent of monetary growth in both the short run and long run; because β is positive in our model, capital accumulation will in general depend on inflation.

As in the real-sector Kurz (1968) model, there often exist multiple equilibria in our monetary model. That is to say, depending on the initial conditions, different economies can have very different long-run steady states. Thus the convergence theorem in the standard neoclassical growth model such as Cass (1965) does not hold in our monetary growth model with social status and the spirit of capitalism. But in this paper we focus on an equilibrium with only one negative characteristic root; or stated differently, we focus on a perfect-foresight equilibrium. Denoting the steady-state capital, consumption, and real balances as k^*,

c^*, and m^*, and linearizing the dynamic system around them, we have:

$$\begin{bmatrix} \dot{c} \\ \dot{m} \\ \dot{k} \end{bmatrix} = \begin{bmatrix} -(f'(k^*)-\rho) & \dfrac{\beta v''(\cdot)}{-u''(c^*)} & \dfrac{\beta v''(\cdot)+u'(c^*)f''(k^*)}{-u''(c^*)} \\ \dfrac{l'(m^*)u''(c^*)m^*}{u'(c^*)^2} & \dfrac{l''(m^*)m^*}{-u'(c^*)} & f''(k^*)m^* \\ -1 & 0 & f'(k^*) \end{bmatrix} \cdot \begin{bmatrix} c-c^* \\ m-m^* \\ k-k^* \end{bmatrix} . \tag{16}$$

Call the 3×3 matrix in (16) as T. The trace of matrix T is positive:

$$\operatorname{tr} T = \rho - \frac{l''(m^*)m^*}{u'(c^*)} > 0 . \tag{17}$$

Since the trace is the sum of the three characteristic roots in our dynamic system, a positive trace implies that at least one characteristic root is positive. The determinant of matrix T, which we denote as Δ, does not possess a definite sign,

$$\begin{aligned} \Delta = {} & (f'(k^*)-\rho)f'(k^*)\frac{l''(m^*)m^*}{u'(c^*)} + f''(k^*)\frac{\beta v''(a^*)m^*}{u''(c^*)} \\ & + \frac{\beta v''(\cdot)+u'(c^*)f''(k^*)}{u''(c^*)}\frac{l''(m^*)m^*}{u'(c^*)} \\ & + \frac{\beta v''(\cdot)}{u''(c^*)}\frac{l'(m^*)u''(c^*)m^*}{u'(c^*)^2}f'(k^*) , \end{aligned}$$

where the second, third, and fourth terms are always negative, but the first term is positive.

As noted by Brock (1974), Calvo (1979), and Fischer (1979), a unique perfect-foresight path is crucial for the assumption of rational expectation in a monetary economy. In our model, this assumption amounts to a negative Δ. To see this point, we know that Δ is equal to the product of the three characteristic roots. Hence, a negative Δ implies that there are either one or three negative roots. Since the trace of matrix T is positive as shown in (17), at least one of the roots is positive. Therefore the dynamic system has one negative root and two positive roots. Since we have one state variable (capital stock) and two

jumping variables (consumption and price) in our model, there exists a unique perfect-foresight path converging to the steady state.[4]

Proposition 1: Along the unique perfect-foresight path, a higher growth rate of money leads to more capital accumulation in the long run.

Totally differentiating Eqs. (9), (14), and (15) yields:

$$T\begin{bmatrix} \mathrm{d}c \\ \mathrm{d}m \\ \mathrm{d}k \end{bmatrix} = \begin{bmatrix} v'(\cdot)/u''(c^*)\,\mathrm{d}\beta \\ -m^*\,\mathrm{d}\theta \\ \mathrm{d}g \end{bmatrix} . \tag{18}$$

By Cramer's rule (and note that the determinant of T, Δ, is negative),

$$\frac{\mathrm{d}k}{\mathrm{d}\theta} = \frac{-\beta v''(\cdot)m^*}{\Delta u''(c^*)} > 0 . \tag{19}$$

We can offer some intuitions for this result. As the growth rate of money rises, inflation goes up and the cost of money holdings increases. In terms of utility from wealth accumulation, it is relatively cheaper to save more in the form of capital accumulation than real-balance holdings. Thus, the representative agent reduces his money stock. This is similar to the explanation of the Tobin portfolio-shift effect in an ad hoc monetary-growth model (see Tobin, 1965; also Sidrauski, 1967b). Of course, the result here is derived from an infinite-horizon model with the optimal choice of the representative agent instead of with some ad hoc equations of money demand and asset accumulation.

Consumption also increases as a result of higher inflation:

$$\mathrm{d}c/\mathrm{d}\theta = f'(k^*)\,\mathrm{d}k/\mathrm{d}\theta > 0 . \tag{20}$$

The effects of inflation on money demand are not clear-cut. To see this, use Cramer's rule in linear system (18),

$$\frac{\mathrm{d}m}{\mathrm{d}\theta} = \frac{1}{\Delta}(f'(k^*) - \rho)m^* f'(k^*) + \frac{\beta v''(\cdot) + u'(c^*)f''(k^*)m^*}{\Delta u''(c^*)} , \tag{21}$$

4 If Δ is positive, the dynamic system will have either three positive eigenvalues or two negative eigenvalues. The former case is a critical equilibrium point in the situation of multiple equilibria. The latter case gives rise to multiple converging paths, which are not admissible by the definition of the perfect-foresight equilibrium.

where the second term on the right-hand side is always negative, which represents the substitution effect of money demand, but the first term is positive, which represents the income effect of money demand since inflation leads to more capital accumulation, more output, and more consumption.

Proposition 2: The stronger the desire for social status and the capitalist spirit, the higher the steady-state capital. The higher the government spending, the lower the steady-state consumption and real balances. The effect of government spending on the steady-state capital is ambiguous.

Recall that in our model parameter β measures the desire for social status and the intensity of the spirit of capitalism. From (18), it is easy to show the positive effect of the capitalist spirit on long-run capital accumulation:

$$\frac{\mathrm{d}k}{\mathrm{d}\beta} = \frac{-l''(m^*)m^*v'(\cdot)}{\Delta u'(c^*)u''(c^*)} > 0 . \tag{22}$$

Zou (1994, 1995) offers both theoretical and empirical discussions of the spirit of capitalism for economic growth over time and across countries in a real-sector model. The rich implications of this proposition are also derived by Cole et al. (1992, 1995), Fershtman and Weiss (1993), and Bakshi and Chen (1996). In particular, this proposition provides a potential explanation for the divergent growth performance across countries. We refer interested readers to the above papers and evidence therein.

As for the effect of government spending on various variables in our model, we can show that, again from (18),

$$\frac{\mathrm{d}k}{\mathrm{d}g} = \frac{(f'(k^*) - \rho)l''(m^*)m^*}{\Delta u'(c^*)} + \frac{\beta v''(\cdot)l'(m^*)m^*u''(c^*)}{\Delta u''(c^*)u'(c^*)^2} \gtrless 0 , \tag{23}$$

$$\frac{\mathrm{d}m}{\mathrm{d}g} = \frac{-l'(m^*)u''(c^*)m^*[\beta v''(\cdot) + u'(c^*)f''(k^*)]}{\Delta u''(c^*)u'(c^*)^2} + \frac{1}{\Delta}(f'(k^*) - \rho)f''(k^*)m^* < 0 , \tag{24}$$

$$\frac{\mathrm{d}c}{\mathrm{d}g} = -\left\{\frac{\beta v''(\cdot)f''(k^*)m^*}{u''(c^*)} + \frac{[\beta v''(\cdot) + u'(c^*)f''(k^*)]l''(m^*)m^*}{u'(c^*)u''(c^*)}\right\}\frac{1}{\Delta} < 0 . \tag{25}$$

Therefore, an increase in government spending crowds out private consumption and real-balance holdings. To see the effect of government spending on capital accumulation, we look to the magnitude of its effect on consumption. From Eq. (25), the two terms in the parentheses are two of the three negative terms in Δ. But Δ also has one positive term. Hence, we do not know whether these two negative terms in (25) are larger or smaller than Δ (note that Δ is also negative by assumption). Differentiate equilibrium condition (15) with respect to g,

$$\mathrm{d}k/\mathrm{d}g = (1 + \mathrm{d}c/\mathrm{d}g)/f'(k^*) \ . \tag{26}$$

$\mathrm{d}k/\mathrm{d}g$ will be positive if $\mathrm{d}c/\mathrm{d}g$ is larger than minus one and negative if $\mathrm{d}c/\mathrm{d}g$ is smaller than minus one. That is to say, if government spending crowds out private consumption by more than a one-to-one ratio, then government spending can increase long-run capital accumulation. This result is also interesting when compared to the Sidrauski model, where government spending fully crowds out private consumption and exerts no effect on capital accumulation in the long run.

3 Inflation and Endogenous Growth

Even though recent studies on endogenous growth have reformulated many growth models, e.g., Romer's (1986) and Lucas' (1988) revisions of the traditional real-sector optimal-growth model and Barro's (1990) extension of the new model to include government spending, the monetary model, e.g., the Sidrauski model, has received little attention thus far. This is not strange considering we will show that in the Sidrauski model the balanced rate of growth is independent of the rate of monetary growth.

To derive an explicit solution to the endogenous-growth rate, we follow Barro (1990) and use a linear production function defined on the stock of capital:

$$f(k) = Ak \ , \tag{27}$$

where $A > 0$ is the constant net marginal product of capital.

The utility function is assumed to be of the simple form:

$$u(c) = \log c, \quad l(m) = \log m, \quad \beta v(a) = \beta \log a \ . \tag{28}$$

The equation of motion for asset accumulation is modified to be:

$$\dot{a} = Ak + x - c - \pi m \ , \tag{29}$$

$$a = k + m \ . \tag{30}$$

In writing Eq. (29), we have set government spending, g, equal to zero.

The representative agent maximizes a discounted logarithmic utility function defined in (28) subject to constraints (29) and (30). The optimal conditions are (λ is the costate variable):

$$\lambda = c^{-1} \ , \tag{31}$$

$$\lambda(A + \pi) = m^{-1} \ , \tag{32}$$

$$\beta(k + m)^{-1} + \lambda(A - \rho) = -\dot{\lambda} \ , \tag{33}$$

$$Ak + x - c - \pi m = \dot{k} + \dot{m} \ . \tag{34}$$

Again, by definition,

$$\dot{m} = (\theta - \dot{p}/p)m \ . \tag{11}$$

On the perfect-foresight path, the expected inflation rate equals the actual one:

$$\pi = \dot{p}/p \ . \tag{12}$$

In addition, government transfer, x, is just the revenue from inflation in our model without any other taxes:

$$x = \theta m \ . \tag{13}$$

Substituting (11), (12), and (13) into (32), (33), and (34), we obtain:

$$\lambda = c^{-1} \ , \tag{31}$$

$$m/c = (A + \theta - \dot{m}/m)^{-1} \ , \tag{35}$$

$$(m + k)/c = \beta(\rho - A - \dot{\lambda}/\lambda)^{-1} \ , \tag{36}$$

$$\dot{k} = Ak - c \ . \tag{37}$$

In the rest of this section, we focus on a particular solution to the dynamic system: the balanced-growth path. Along this path, all real variables grow at a constant rate. Let γ be the growth rate of consumption, $\gamma = \dot{c}/c = \dot{\lambda}/\lambda$. Differentiate (35) on both sides with respect to time and note that $\dot{m}/m$ is a constant: $\dot{m}/m = \dot{c}/c = \gamma$. Similarly from (37), $\dot{k}/k = \dot{c}/c = \gamma$. Therefore, on the balanced-growth path, consumption, real balances, and capital stock all grow at the same rate, γ.

Next we want to solve the balanced-growth rate, γ, in terms of the technology, the parameters of the preference, and the money growth rate. In (35), (36), and (37), substitute all the growth rates with the common variable λ:

$$m/c = (A + \theta - \gamma)^{-1} , \tag{38}$$

$$k/c = (A - \gamma)^{-1} , \tag{39}$$

$$(m + k)/c = \beta[\rho - (A - \gamma)]^{-1} . \tag{40}$$

Equation (38) plus (39) equals (40), $(A + \theta - \gamma)^{-1} + (A - \gamma)^{-1} = \beta[\rho - (A - \gamma)]^{-1}$. Simple algebra leads to

$$A - \gamma = \frac{-[(\beta + 1)\theta - 2\rho] \pm \sqrt{[(\beta + 1)\theta - 2\rho]^2 + 4(2 + \beta)\theta\rho}}{2(2 + \beta)} .$$

From (39), $(A - \gamma)$ has to be positive. Thus, the endogenous-growth rate is given by:

$$\gamma = A + \frac{[(\beta + 1)\theta - 2\rho] - \sqrt{[(\beta + 1)\theta - 2\rho]^2 + 4(2 + \beta)\theta\rho}}{2(2 + \beta)} . \tag{41}$$

In passing we note that, if the spirit of capitalism is not present in the model, in other words, if $\beta = 0$, the utility function is $(\log c + \log m)$ and the unique balanced-growth rate is directly given by Eqs. (31) and (33): $\gamma = A - \rho$, which is exactly the same as the case of the real economy and is independent of inflation. In this case, to generate positive growth, the net marginal product of capital has to be larger than the time discount rate.

In (41), we can show:

Proposition 3: The higher the monetary growth rate, the higher the endogenous-growth rate.

Proof: Differentiate γ with respect to θ in (41):

$$\frac{d\gamma}{d\theta} = \frac{1}{2(2 + \beta)} \left\{ (\beta + 1) - \frac{[(\beta + 1)\theta - 2\rho](\beta + 1) + 2(2 + \beta)\rho}{\sqrt{[(\beta + 1)\theta - 2\rho]^2 + 4(2 + \beta)\theta\rho}} \right\} , \tag{42}$$

which is shown to be positive in the appendix. □

The intuition for this result is as follows: with a higher rate of money supply and higher inflation, the representative agent tends to substitute real-balance holdings with capital. This stimulates the rate of investment and capital accumulation, which in turn raises the balanced-growth rate of the economy. In the end, as the balanced-growth rate goes up, the rise in the growth rate of money does not bring about a proportional rise in the inflation rate. To see this, just look at the following identity: $\dot{m}/m = \theta - \pi$. On the balanced-growth paths, $\gamma = \theta - \pi$. Differentiate this equation with respect to the growth rate of money: $\mathrm{d}\pi/\mathrm{d}\theta = 1 - \mathrm{d}\gamma/\mathrm{d}\theta < 1$. Therefore, inflation falls short of the growth rate of money.

Proposition 3 is a very strong result. It says that inflation not only stimulates long-run capital accumulation, but also increases the long-run economic growth rate. Accordingly, this result significantly extends the Tobin portfolio-shift effect in the context of endogenous growth.

Proposition 4: The stronger the desire for social status, the higher the balanced-growth rate.

Proof: In (41), differentiate γ with respect to parameter β, and rearrange terms,

$$\frac{\mathrm{d}\gamma}{\mathrm{d}\beta} = \frac{1}{2(2+\beta)^2}\left\{(\theta + 2\rho) + \sqrt{[(\beta+1)\theta - 2\rho]^2 + 4(2+\beta)\theta\rho} - \frac{(2+\beta)(\beta+1)\theta^2}{\sqrt{[(\beta+1)\theta - 2\rho]^2 + 4(2+\beta)\theta\rho}}\right\}, \tag{43}$$

which is shown to be positive in the appendix. □

As in the case of Proposition 2, Proposition 4 illustrates another implication of the cultural-economic approach in examining capital accumulation and economic growth. For a similar result in an economy without money, see Rauscher (1997).

4 Conclusion

In an infinite-horizon model of economic growth with social status and the spirit of capitalism, we have demonstrated that the Tobin portfolio-shift effect holds unambiguously: in the long run, inflation stimulates capital accumulation and increases the endogenous-growth rate. Our

results overturn the superneutrality result in the Sidrauski model and the negative association between inflation and growth in the money-in-production model and the cash-in-advance model (Stockman, 1981). It also avoids the ambiguity in the leisure-in-utility model (Brock, 1974).

Appendix

Here we prove Propositions 3 and 4.

For Proposition 3, we only need to show that the terms in the parentheses of Eq. (42) are positive. Suppose not, then:

$$(\beta+1) < \frac{[(\beta+1)\theta-2\rho](\beta+1)+2(2+\beta)\rho}{\sqrt{[(\beta+1)\theta-2\rho]^2+4(2+\beta)\theta\rho}} . \tag{A.1}$$

For $\theta > 0$, the numerator on the right-hand side of (A.1) is positive, so both sides are positive. Take the square on both sides and cross multiply:

$$\begin{aligned}&(\beta+1)^2\{[(\beta+1)\theta-2\rho]^2+4(2+\beta)\theta\rho\}\\&<\{[(\beta+1)\theta-2\rho](\beta+1)+2(2+\beta)\rho\}^2 .\end{aligned} \tag{A.2}$$

Expand the expression:

$$\begin{aligned}&(\beta+1)^2[(\beta+1)\theta-2\rho]^2+(\beta+1)^2(2+\beta)4\theta\rho\\&<(\beta+1)^2[(\beta+1)\theta-2\rho]^2+(\beta+1)^2(2+\beta)4\theta\rho\\&\quad-8\rho^2(\beta+1)(2+\beta)+4\rho^2(2+\beta)^2 ,\end{aligned} \tag{A.3}$$

namely,

$$0 < -8\rho^2(\beta+1)(2+\beta)+4\rho^2(2+\beta)^2 , \tag{A.4}$$

or,

$$0 < 4\rho^2(2+\beta)(2+\beta-2\beta-2) , \tag{A.5}$$

$$0 < -4\beta\rho^2(2+\beta) , \tag{A.6}$$

which is a contradiction, for both β and ρ are positive, and the right-hand side is negative. Hence the right-hand side of Eq. (42) is positive.

Next we show that the terms in the parentheses of Eq. (43) are positive, which is the same as:

$$(\theta + 2\rho) + \sqrt{[(\beta + 1)\theta - 2\rho]^2 + 4(2 + \beta)\theta\rho} > \frac{(2 + \beta)(\beta + 1)\theta^2}{\sqrt{[(\beta + 1)\theta - 2\rho]^2 + 4(2 + \beta)\theta\rho}} . \tag{A.7}$$

Multiply both sides by the positive number $([(\beta+1)\theta-2\rho]^2+4(2+\beta)\cdot\theta\rho)^{1/2}$, and simplify:

$$(\theta + 2\rho)\sqrt{[(\beta + 1)\theta - 2\rho]^2 + 4(2 + \beta)\theta\rho} + 4\rho^2 + 4\theta\rho > (\beta + 1)\theta^2 . \tag{A.8}$$

But the left-hand side of inequality (A.8) is the same as:

$$\begin{aligned}&(\theta + 2\rho)\sqrt{(\beta + 1)^2\theta^2 + 4\rho^2 + 4\theta\rho} + 4\rho^2 + 4\theta\rho \\ &> (\theta + 2\rho)(\beta + 1)\theta + 4\rho^2 + 4\theta\rho \\ &> (\beta + 1)\theta^2 ,\end{aligned} \tag{A.9}$$

which is just what we need to prove.

Acknowledgements

I thank two referees for their constructive suggestions in revising this paper. Of course, all remaining errors are mine.

References

Bakshi, G., and Chen, Z. (1996): "The Spirit of Capitalism and Stock-Market Prices." *American Economic Review* 86: 133–157.

Bardhan, P. (1967): "Optimum Foreign Borrowing." In *Essays on the Theory of Optimal Economic Growth*, edited by K. Shell. Cambridge, Mass.: MIT Press.

Barro, R. (1990): "Government Spending in a Simple Model of Endogenous Growth." *Journal of Political Economy* 98: S103–125.

Blanchard, O. (1983): "Debt and Current Account Deficit in Brazil." In *Financial Policies and the World Capital Market*, edited by A. Armella, R. Dornbusch, and M. Obstfeld. Chicago: University of Chicago Press.

Brock, W. A. (1974): "Money and Growth: the Case of Long Run Perfect Foresight." *International Economic Review* 15: 750–777.

Calvo, G. (1979): "On Model of Money and Perfect Foresight." *International Economic Review* 20: 83–104.

Cass, D. (1965): "Optimum Growth in an Aggregate Model of Capital Accumulation." *Review of Economic Studies* 32: 229–243.

Cole, H., Mailath, G., and Postlewaite, A. (1992): "Social Norms, Savings Behavior, and Growth." *Journal of Political Economy* 100: 1092–1125.

—— (1995): "Incorporating Concern for Relative Wealth into Economic Models." *Federal Reserve Bank of Minneapolis Quarterly Review* summer issue: 12–21.

Duesenberry, J. (1949): *Income, Saving, and the Theory of Consumer Behavior*. Cambridge, Mass.: Harvard University Press.

Fershtman, C., and Weiss, Y. (1993): "Social Status, Culture and Economic Performance." *Economic Journal* 103: 946–959.

Fischer, S. (1979): "Capital Accumulation on the Transition Path in a Monetary Optimization Model." *Econometrica* 47: 1433–1439.

Frank, R. H. (1985): *Choosing the Right Pond: Human Behavior and the Quest for Status*. Oxford: Oxford University Press.

Kurz, M. (1968): "Optimal Economic Growth and Wealth Effects." *International Economic Review* 9: 348–357.

Lucas, R. E. (1988): "On the Mechanics of Economic Development." *Journal of Monetary Economics* 22: 3–42.

Rae, J. (1964): *New Principles of Political Economy*. New York: Augustus M. Kelley.

Rauscher, M. (1997): "Protestant Ethic, Status Seeking, and Economic Growth." Working Paper nr. 9, Thünen-Series of Applied Economic Theory, University of Rostock, Rostock, Germany.

Rebelo, S. (1987): "Long Run Policy Analysis and Long Run Growth." NBER Working Paper, National Bureau of Economic Research, Cambridge, Mass.

Robson, A. J. (1992): "Status, the Distribution of Wealth, Private and Social Attitudes to Risk." *Econometrica* 60: 837–857.

Romer, P. (1986): "The Increasing Returns and Long-Run Growth." *Journal of Political Economy* 94: 1002–1037.

Sidrauski, M. (1967a): "Rational Choice and Pattern of Growth in a Monetary Economy." *American Economic Review, Papers and Proceedings* 57: 534–544.

—— (1967b): "Inflation and Economic Growth." *Journal of Political Economy* 75: 796–810.

Spence, A. M. (1974): *Market Signaling: Information Transfer in Hiring and Related Screening Processes*. Cambridge, Mass.: Harvard University Press.

Stockman, A. (1981): "Anticipated Inflation and the Capital Stock in a Cash-in-Advance Economy." *Journal of Monetary Economics* 8: 387–393.

Tobin, J. (1965): "Money and Economic Growth." *Econometrica* 33: 671–684.

Veblen, T. (1973): *The Theory of the Leisure Class*. Boston: Houghton Mifflin.

Weber, M. (1958): *The Protestant Ethic and The Spirit of Capitalism*. New York: Charles Scribner's Sons.

Zou, H. (1994): "The Spirit of Capitalism and Long-Run Growth." *European Journal of Political Economy* 10: 279–293.
—— (1995): "The Spirit of Capitalism and Savings Behavior." *Journal of Economic Behavior and Organization* 28: 131–143.

Address of author: Heng-fu Zou, Room MC2-611, The World Bank, 1818 H St. N.W., Washington, DC 20433, USA.

Part III
Socialist Economies

10

European Journal of Political Economy 7 (1991) 141–157. North-Holland

Socialist economic growth and political investment cycles*

Heng-fu Zou

Public Economics Division, The World Bank, Washington, D.C. 20433, USA

Accepted for publication October 1990

Treating social planners as self-interested bureaucrats, this paper offers a positive growth model to understand (i) why rapid capital accumulation is directly towards the social planners' own interest; (ii) why investment hunger is an inevitable consequence of social planners' rational choice; and (iii) how investment cycles are related to political changes in the centrally planned economy. Preliminary empirical work on China has provided strong support for this modeling.

1. Introduction

In traditional optimal growth models for a centrally planned economy, see, e.g., Cass (1965) and Koopmans (1965), social planners maximize an intertemporal social welfare function defined on per capita consumption, subject to the dynamic constraint of capital accumulation. The results from these models have become the folklore of modern economics: there exists a unique optimum path converging asymptotically to the unique equilibrium; the optimum capital stock in the long run is determined by the famous modified golden rule, i.e., marginal productivity of capital is equal to the natural growth rate of population plus the time discount rate of social planners. In these models, social planners all act in the interest of the society. They do not have any objective function other than the welfare of the people, and their personal images are only reflected in the time discount rate. Cass (1965) provides a typical picture of the central planners:

> 'The central planning authority's concept of social welfare is related to the ability of the economy to provide consumption goods over time. In

*I am grateful to Bela Balassa, Richard Caves, Janos Kornai, Andrew Newman, Dwight Perkins, Yingyi Qian, Jeffrey Sachs and Xinsheng Zeng for very helpful discussion and comments. The first version of this paper was presented in Janos Kornai's workshop at Harvard. I thank the seminar participants for their suggestions. Responsibility for the contents of the paper is solely mine and not of the World Bank.

> particular, welfare at any point of time is measured by a utility index of current consumption per capita .... The central planning authority recognizes that consumption tomorrow is not the same thing as consumption today. For this reason, it takes the politically pragmatic view that its planning obligation is stronger to present and near future generations than to far removed future generations. This view is implemented in practice by discounting future welfare at a positive rate.'

This approach to socialist growth suffers from serious limitations when compared to socialist reality. First of all, traditional optimal growth models are based on an insufficient understanding or indeed, a misunderstanding of the nature of the social planners. This point has been emphasized by Janos Kornai in his various studies [Kornai (1982, 1986, 1988)]. With both political power and economic resources in their control, social planners are not constrained or directed to choose the optimum feasible growth path with respect to the only criterion, which is to maximize social welfare.

> 'Such an unworldly bureaucracy never existed in the past and will never exist in the future. Political bureaucracies have inner conflicts reflecting the divisions of society and the diverse pressures of various social groups. They pursue their own individual and group interests, including the interests of the particular specialized agency to which they belong. Power creates an irresistable temptation to make use of it. A bureaucrat must be interventionist because that is his role in the society; it is dictated by his situation.' [Kornai (1986, pp. 1726–1727)]

In practice, social planners are often investment growth rate maximizers [Grosfeld (1987)], and their personal interests are more connected to the persistent expansion of their organizations than to the increase in people's consumption. In their investment strategies,

> 'the highest priority is placed on industry, and within industry on heavy industry, and within heavy industry on the part related to the military .... Among the neglected, non-priority sectors, one typically finds agriculture, and even more so all the branches of the tertiary or service sector, such as transport and telecommunication, housing, other communal services, domestic trade, and health. This diversion of resources from consumption to investment takes place not provisionally for two or three years, but for decades, for twenty, thirty, or forty years.' [Kornai (1988, p. 244)]

In this paper, we intend to offer a simple alternative model to capture certain essential aspects of socialist economic growth. The most important

feature of the model is in defining the social planners' objective function in both per capita consumption and *per capita capital stock*. The model is justified and set up in section 2. In its abstract form, this modelling was presented by Mordecai Kurz in 1968. That paper has long been neglected in the economics profession partly because, we guess, Kurz has not offered any justification for the so-called wealth effects model. In this paper, we are able to find a realistic setting for the Kurz model in socialist economic growth.

In section 3, we demonstrate that this simple model provides good framework for the understanding of 'investment hunger' and 'expansion-drive' studied by Kornai (1980). Section 4 derives a theory of political investment cycle from our basic model. It is shown that the investment rates (or accumulation rates in the terminology of socialist economics) are related to different political regimes in socialist countries. In section 5 we will look at the empirical data on investment rates from 1952 to 1985 in China. The variations on investment rates throughout those years can be substantially explained by the change of political power at the top level of government, evidence supporting the theory of political investment cycle.

2. The model and its justification

We define the instantaneous utility function of social planners at a given time t as the summation of two parts: $u(c_t)+\pi v(k_t)$, where c_t is consumption per capita, and k_t is capital stock per capita at time t. Social planners derive positive utility from both consumption enjoyed by the people and capital stock owned by the state, so the first-order derivatives of functions $u(\cdot)$ and $v(\cdot)$ are positive. The Greek letter π is a positive constant that measures the importance of capital accumulation from the point of view of the social planners. In later sections, we will allow π to take different values, and its effects on capital accumulation, the investment rate and consumption will be studied. Furthermore, for technical reason, we assume that the second-order derivatives of $u(\cdot)$ and $v(\cdot)$ are negative, and that:

$$\lim_{c_t \to 0} u'(c_t) = \infty,$$

which guarantee the sufficiency of the first-order conditions for optimization, and exclude the corner solution of zero consumption.

In modelling the social planners' preference, we maintain that social planners do care about people's consumption, and the improvement in the living standard of the people seems to justify their manipulation of political power and economic resources in a socialist economy. But it is more important to note that social planners' own interest lies more directly in the expansion of the firm and public organization of which they are in charge.

Social planners are not just a group of persons in the central planning bureau, they consist of all persons involved in formulating the plan, from the managers at the bottom to the ministers at the top. According to Kornai (1981, 1986, 1988), the first and most important motivation for accelerated capital accumulation is the identification of social planners with their own jobs. An expansion of the firm or organization under their direct control is always a source of satisfaction. The second motivation is prestige. 'A larger organization brings more prestige, and also more power' [Kornai (1981)]. 'The simple urge to exert power over people, and to exercise some discretion over the allocation of physical resources can also make managers strive for higher investment levels for their firm' [Kornai (1988, p. 264)]. So

> 'it is important to note that investment hunger and expansion drive characterize not only the behavior of the top manager and his subordinates in a particular firm, but also *the attitude of economic agents at all levels of the bureaucratic hierarchy in a socialist system . . . the general ideology of the system favors expansion, and no claimant's application for funds is ever regarded as unreasonable or unethical by anyone in the hierarchy. On the contrary, everyone considers such a request as the natural and normal behavior within the system.*' [Kornai (1988, pp. 264–265, emphasis added)]

This assessment of socialist planners is essentially the same as the one used in the analysis of bureaucrats in western democracies. For example, Orzechowski (1977) defines the bureaucrat's utility function directly on the output produced by his bureau and the capital stock or labor in his control. And the striving for more budget revenue in western public sectors resembles the investment hunger and expansion drive in socialist economies.

With these discussions, we might call π, which appeared in the social planners' utility function, the measure of the degree of expansion drive. A large value of π means that the social planners are highly expansion oriented; and a zero value of π brings us back to Ramsay–Cass–Koopman's mathematical utopia of socialism. [Phelps (1961) presents the golden rule of capital accumulation in 'a fable for growthmen'. In reality, where can we find the King of the Kingdom of Solovia?].

To proceed with our model, we assume that the social planners maximize the following intertemporal utility with discounting (for notation convenience, we omit the time subscript t of all variables from now on):

$$\int_0^\infty [u(c)+\pi v(k)]\,e^{-\rho t}\,dt, \quad \rho>0, \tag{1}$$

where ρ is the social planners' subjective rate of discount.

There is a standard neoclassical production function $f(k)$ in the economy with $f'(k)>0$, and $f''(k)<0$. Capital is subject to a depreciation rate δ. The population growth rate is exogenously given as n. So capital accumulation in per capita term follows the dynamic equation:

$$\dot{k}=f(k)-c-(n+\delta)k. \tag{2}$$

Social planners maximize (1) subject to the dynamic constraint (2). The current value Hamiltonian H is defined by

$$H=u(c)+\pi v(k)+\lambda[f(k)-c-(n+\delta)k]. \tag{3}$$

The optimal paths for consumption and investment are

$$\dot{c}=\frac{1}{-u''(c)}[\pi v'(k)+u'(c)(f'(k)-n-\delta-\rho)], \tag{4}$$

$$\dot{k}=f(k)-c-(n+\delta)k, \tag{5}$$

$$\lim_{t\to\infty} e^{-\rho t}\lambda k=0. \tag{6}$$

We are going to make a detailed analysis of above dynamics in the next section.

3. The dynamics of the model and the properties of the equilibrium

As noted by Kurz (1968), the dynamic systems (4) and (5) may easily result in multiple equilibria, and some equilibrium points are saddle-point stable, while some are totally unstable. To see this, denote the equilibrium values of consumption and capital as c^* and k^*, and linearize the systems around these values:

$$\begin{bmatrix}\dot{c}\\ \dot{k}\end{bmatrix}=\begin{bmatrix}(n+\delta+\rho)-f'(k^*) & \dfrac{\pi v''(k^*)+u'(c^*)f''(k^*)}{-u''(c^*)}\\ -1 & f'(k^*)-n-\delta\end{bmatrix}\begin{bmatrix}c-c^*\\ k-k^*\end{bmatrix}. \tag{7}$$

Denote the 2×2 matrix as M. The trace of the matrix is

$$\mathrm{tr}(M)=\rho>0. \tag{8}$$

As the trace is the sum of the two characteristic roots of the systems, at least

one of the roots is positive. Therefore we cannot have a stable equilibrium point.

Next, the determinant of the matrix is

$$\Delta=[n+\delta+\rho-f'(k^*)][f'(k^*)-n-\delta]-\frac{\pi v''(k^*)+u'(c^*)f''(k^*)}{u''(c^*)}. \tag{9}$$

The second term on the right-hand side of (9) is negative; the first term is positive or negative depending on whether the capital stock is smaller or larger than the golden rule capital as pointed out by Kurz (1968). If the steady-state capital stock is equal to or larger than the golden rule capital, $f'(k)$ is equal to or less than $n+\delta$; the first term on the right-hand side of (9) is also negative because $[n+\delta+\rho-f'(k^*)]$ is positive as shown below in proposition one. In this case, Δ is negative. For Δ is the product of two characteristic roots, negative Δ implies that one root is positive and one negative. If Δ is positive, then both roots will be positive as the existence of two negative roots contradicts (8). For this section, we will focus on the case that Δ is negative, that is to say, there exists a unique optimal path in the neighborhood of the equilibrium. Furthermore, we assume that there exists only one equilibrium for the systems. A numerical example is presented in the next section before we go on to discuss the political investment cycle. Of course, if the time discount rate is very small, the first term on the right-hand side of (9) is negative; so is Δ.

The properties of the unique saddle-point equilibrium follow in order:

Property 1. The equilibrium capital stock is larger than the modified golden rule one.

To show this, note that, in a steady state, we have

$$\frac{1}{-u''(c^*)}\{\pi v'(k^*)+u'(c^*)[f'(k^*)-n-\delta-\rho]\}=0, \tag{10}$$

$$f(k^*)-c^*-(n+\delta)k^*=0. \tag{11}$$

From (10):

$$f'(k^*)=n+\delta+\rho-\frac{\pi v'(k^*)}{u'(c^*)}<n+\delta+\rho=f'(k^{mg}), \tag{12}$$

where k^{mg} denotes the modified golden rule amount of capital. From (12), it is clear that $k^*>k^{mg}$ as $f''(\cdot)$ is negative. The explanation is simple. Since

social planners benefit directly from the expansion of the economic organization and since the welfare of consumers over the infinite horizon is not the only criterion for planning, the short-run consumption will be partly sacrificed for the expansion drive. It is quite possible that, as shown in the next numerical example, consumption is permanently sacrificed in this kind of models: equilibrium consumption is lower than the golden rule one and capital is over-accumulated.

Property 2. The higher the value of π, the higher the steady-state capital.

Totally differentiating eqs. (10) and (11), we have

$$\begin{bmatrix} \mathrm{d}c \\ \\ \mathrm{d}k \end{bmatrix} = M \begin{bmatrix} \dfrac{v'(k^*)}{u''(c^*)}\mathrm{d}\pi \\ \\ 0 \end{bmatrix} \tag{13}$$

It is simple to show that

$$\frac{\mathrm{d}k}{\mathrm{d}\pi} = \frac{1}{\Delta}\frac{v'(k^*)}{u''(c^*)}, \tag{14}$$

which is positive as the economy is on the unique optimal convergent path. As for the steady-state consumption, the sign is ambiguous depending on whether the equilibrium capital is higher or lower than the golden rule capital.

The effects of π on investment and consumption on the unique optimal path can also be analyzed. From (7), the solutions of the linearized systems for the behavior of the capital stock and consumption are

$$k_t = k^* - (k^* - k_0)\,\mathrm{e}^{\theta t}, \tag{15}$$

$$\dot{k}_t = -\theta(k^* - k_t), \tag{16}$$

$$c_t = c^* + (f'(k^*) - n - \delta - \theta)(k_t - k^*), \tag{17}$$

where θ is the negative root of the dynamic system:

$$\theta = \tfrac{1}{2}[\rho - \sqrt{\rho^2 - 4\Delta}]. \tag{18}$$

From (16) and (17), it is clear that, through its positive effect on steady-state capital, k^*, the high value of π leads to high investment and low

consumption on the optimal path for all k_t less than k^*. But we should note that π may also affect θ and c^*. If the increase in π tends to lower θ, in other words, θ becomes more negative, then the investment will be unambiguously high as a result of π being high.

Property 3. The higher the value of π, the higher the steady-state investment rate (or saving rate).

In the steady state, investment is just $(n+\delta)k^*$. Let the investment rate (or saving rate) be s, then

$$s=\frac{(n+\delta)k^*}{f(k^*)}, \tag{19}$$

$$\frac{\mathrm{d}s}{\mathrm{d}\pi}=\frac{(n+\delta)}{(f(k^*)^2}[f(k^*)-f'(k^*)k^*]\frac{\mathrm{d}k}{\mathrm{d}\pi}, \tag{20}$$

which is positive since $\mathrm{d}k/\mathrm{d}\pi$ is positive and $[f(k^*)-f'(k^*)k^*]$ is also positive for any concave function.

The three properties stated above reveal how social planners' preferences affect the growth pattern in socialist economies. In the Cass model, we know that the form of social welfare functions does not enter into the determination of equilibrium capital stock. Even if we interpret the social welfare function as the social planners' own preference, the equilibrium capital and consumption are still independent of the social planners' preference as long as their preference is defined only on consumption. Recall from Cass (1965), that in equilibrium:

$$f'(k^{mg})=n+\delta+\rho, \tag{21}$$

$$f(k^{mg})-c-(n+\delta)k^{mg}=0, \tag{22}$$

so the social welfare function itself plays no role in the determination of k^{mg} in Cass model. [Please compare (21) and (22) with equilibrium conditions (10) and (11).] The invention by Kurz (1968) provides us a rich picture for the link between preference and economic growth. Of course, as a positive approach, the Kurz model with proper justification is much more realistic than the Cass model when applied to a socialist economy.

4. A numerical example and an illustration of political investment cycle

Even though the modified Kurz model gives us interesting results, the existence of multiple equilibria brings about complicated dynamics even with simple preferences and technology. Here we show that, if preference is the popular logarithm functions of consumption and capital and if technology is standard Cobb–Douglas, there exists a unique equilibrium and a unique optimal path.

Now the social planners maximize

$$\int_0^\infty [\log c + \pi \log k] e^{-\rho t} dt, \tag{23}$$

subject to

$$\dot{k} = k^\alpha - c - nk, \tag{24}$$

where $0<\alpha<1$, and we have set δ equal to zero for simplicity. The corresponding optimal conditions are:

$$\dot{c} = \frac{c}{k}[\pi c - \alpha k^\alpha - (n+\rho)k], \tag{25}$$

$$\dot{k} = k^\alpha - nk - c. \tag{26}$$

Set the time derivatives of c and k equal to zero in (25) and (26), the unique optimal equilibrium point is:

$$k^* = \left[\frac{\pi+\alpha}{n\pi+n+\rho}\right]^{1/(1-\alpha)}, \tag{27}$$

$$c^* = k^{*\alpha} - nk^*. \tag{28}$$

The determinant of the corresponding matrix M is

$$\Delta = \frac{c^*}{k^*}\{\pi[\alpha k^{*\alpha-1} - n] + [\alpha^2 k^{*\alpha-1} - (n+\rho)]\}. \tag{29}$$

Upon substitution:

$$\Delta=\frac{(n+\rho-n\alpha)(\pi n+n+\rho)[\pi(\alpha-1)-\alpha(1-\alpha)]}{(\pi+\alpha)^2}<0 \tag{30}$$

as $0<\alpha<1$. So there is one negative characteristic root and one positive root: the equilibrium is saddle-point stable.

It is straightforward to check that

$$\frac{dk}{d\pi}=(1-\alpha)k^{*\alpha}\frac{\rho+(1-\alpha)n}{(\pi n+n+\rho)^2}>0, \tag{31}$$

$$\frac{ds}{d\pi}=n(1-\alpha)k^{*(-\alpha)}\frac{dk}{d\pi}>0. \tag{32}$$

Next, we are going to see under which circumstances a high degree of expansion drive leads to dynamic inefficiency. In Phelps (1961), the golden rule capital stock at which consumption is maximized is given as (for Cobb–Douglas technology):

$$k^g=[\alpha/n]^{1/(1-\alpha)}. \tag{33}$$

For k^* is larger than k^g, it is required that

$$\frac{\pi+\alpha}{n\pi+n+\rho}>\frac{\alpha}{n}, \tag{34}$$

which is the same as to require that

$$\pi>\alpha\rho/(1-\alpha n). \tag{35}$$

For $\alpha=0.25$, $\rho=0.05$, and $n=0.01$, π should be larger than 0.0125, which is not a strict requirement. So, in this case, the people's consumption is not only sacrificed on the dynamic path converging to the steady state, but is also sacrificed in the steady state.

Suppose there are two groups of social planners in the economy. Following the convention, we may call one group 'softliners' or the 'right', and the other group 'hardliners' or the 'left'. They alternatively control the process of making the plan. It is known that in socialist countries such as Hungary,

shifts of resources towards consumption rather than investment always come about as a result of 'softline' rule; the 'hardliners' or the 'left' are always more expansion oriented [see Kornai (1988, pp. 283–284)]. In our model, if we denote π_ℓ as the expansion desire of the 'left' and π_r as the expansion desire of the 'right' and let $\pi_\ell > \pi_r > \alpha\rho/(1-\alpha n)$, then the 'left' maximizes:

$$\int_0^\infty [\log c_\ell + \pi_\ell \log k_\ell] e^{-\rho t} dt \tag{36}$$

subject to

$$\dot{k}_\ell = k_\ell^\alpha - c_\ell - nk_\ell. \tag{24}$$

The 'right' maximizes:

$$\int_0^\infty [\log c_r + \pi_r \log k_r] e^{-\rho t} dt \tag{37}$$

subject to

$$\dot{k}_r = k_r^\alpha - c_r - nk_r. \tag{24}$$

The initial capital stock is the same for both groups: $k_0 = \bar{k}$. To avoid the problem of time inconsistency, we assume that the 'left' and the 'right' both commit to the optimal programs they calculate at time zero, and make no changes later on.

From the calculations above, it is easy to obtain that in steady state

$$k_\ell^* > k_r^*, \qquad c_\ell^* < c_r^*. \tag{38}$$

From (32), the steady-state investment rate for the 'left' is always larger than the one for the 'right'. If the 'left' is in power, the economy experiences higher investment and lower consumption; if the 'right' is in power, consumption is relatively high and investment relatively lower. The cyclical change in consumption, investment and the investment rate is shown diagramatically in fig. 1, where E_ℓ and E_r are equilibrium points for the 'left' and the 'right' respectively. If the economy is currently in E_ℓ, the power shift from the 'left' to the 'right' results in an immediate upward jump in consumption and in a reduction of investment; the new long-run equilibrium is E_r where capital stock is lower than, but consumption is higher than, the equilibrium levels at E_ℓ. The investment rates fluctuate following the political power shifts. This is a demonstration of political investment cycles at steady states. Investment cycles can also happen on the paths converging to the steady states. In fig. 2, P_r and P_ℓ are the optimal convergent paths for the

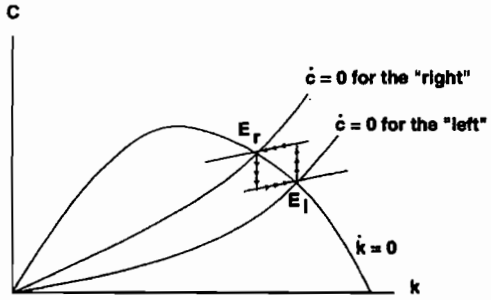


Fig. 1

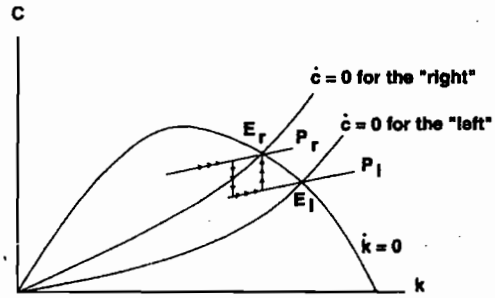


Fig. 2

'right' and the 'left' respectively. If the economy is initially on the path for the 'right' P_r, a change in political regime from the 'right' to the 'left' leads to an immediate downward jump from the path P_r to the path P_ℓ. Throughout time, the economy follows a zigzag path, and investment rates fluctuate accordingly on the path.

5. Historical evidence

In this section, we present a preliminary empirical study of the effects of political change on the investment rate in China. The labels for different wings of the communist party, the 'right' and the 'left', are well known in China. The 'left' consists of strong, dogmatic adherents of socialism; they advocate the centralization of economic activities, the rapid abolishment of private ownership in the industrial sector, and the rapid transition of the agricultural sector from private ownership to collective ownership and then to state ownership. Chairman Mao is the symbol of the 'left'. Those on the 'right' are more often associated with economic policies with a capitalist flavor, such as relying on market mechanisms and material incentives in the

planned sectors and allowing private plots and contract systems in agricultural production. The prominent members of this group are Liu Shaoqi and Deng Xiaoping. They were known as the capitalist representatives in the communist party during the Cultural Revolution. The power struggles between the 'left' and the 'right' have shaped the history of China in the past four decades, and their effects can be seen in every aspect of Chinese society. Our present focus is on the effects of these struggles on the investment rates.

Table 1 contains relevant data for our analysis; the power over economic planning is represented by a dummy variable; a value of zero means that the 'right' controls the planning board, while a value of one means that the 'left' controls the planning. The term 'productive investment' is special to Marxist and socialist economics, and needs some explanation. It refers to investment that directly serves material production or meets the needs of material production. Its counterpart is non-productive investment, which includes investment on public utilities, housing, public health, social welfare and education. Since non-productive investment is more or less related to people's consumption, especially durable and public consumption, the percentage of productive investment in total investment outlay is a more accurate measure of accumulation. The fluctuations in investment rate and in productive investment rate are depicted in fig. 3.

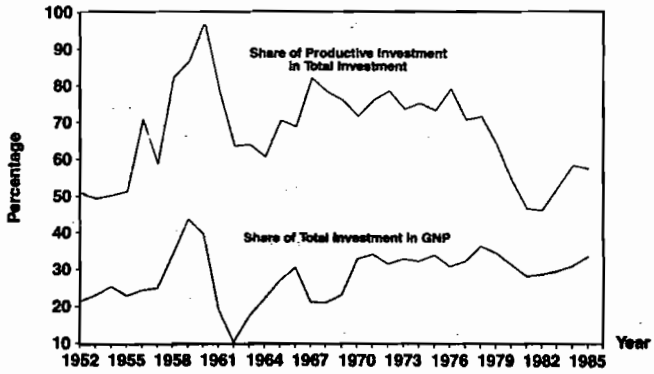


Fig. 3

During the period 1952–1957, economic decision making was more under the control of the 'right' as Mao did not totally dominate the planning processes and political life was more democratic in the communist party than it subsequently became. The investment rates were in the range of 21.4% and 25.5%. The average share of productive investment in total investment was 55.3%. Both production and consumption went up rapidly in those six years, and those investment rates were later regarded as the optimal or normal ones.

Table 1

The data.

Year	Investment rate as % of GNP	Consumption rate as % of GNP	Productive investment as % of total investment	Power regimes as a dummy variable
1952	21.4	78.6	50.8	0
1953	23.1	76.9	49.4	0
1954	25.5	74.5	50.3	0
1955	22.9	77.1	51.4	0
1956	24.4	75.6	71.0	0
1957	24.9	75.1	58.8	0
1958	33.9	66.1	82.3	1
1959	43.8	56.2	86.9	1
1960	39.6	60.4	97.4	1
1961	19.2	80.8	78.5	0
1962	10.4	89.6	63.6	0
1963	17.5	82.5	63.9	0
1964	22.2	77.8	60.8	0
1965	27.1	72.9	70.7	0
1966	30.6	69.4	68.9	1
1967	21.3	78.7	82.2	1
1968	21.1	78.9	78.5	1
1969	23.2	76.8	76.2	1
1970	32.9	67.1	71.8	1
1971	34.1	65.9	76.2	1
1972	31.6	68.4	78.7	1
1973	32.9	67.1	73.7	1
1974	32.3	67.7	75.4	1
1975	33.9	66.1	73.4	1
1976	30.9	69.1	79.3	1
1977	32.3	67.7	70.9	1
1978	36.5	63.5	71.8	1
1979	34.6	65.4	64.1	0
1980	31.5	68.5	54.5	0
1981	28.3	71.7	46.8	0
1982	28.8	71.2	46.4	0
1983	29.7	70.3	52.5	0
1984	31.2	68.8	58.6	0
1985	33.7	66.3	57.7	0

Source: Statistical Year Book of China, 1986.

The year 1957 was a turning point in the political climate of China. The anti-'rightist' movement launched by Mao had a fundamental effect on the political and economic life of China. With the beginning of the 'Great Leap Forward' in 1958 and of the movement of people's communes some time later, economic planning was dominated by the ideology of the 'left'. The investment rate jumped up to 33.9%, 43.8% and 39.6% in 1958, 1959 and 1960 respectively. The average share of the productive investment for those three years was up to 88.3%. High investment rates and natural calamities during this period caused poverty, hunger and death all over China. Facing economic disaster, Mao retreated from economic planning and even admitted to having made a mistake in 1962. The power over planning shifted back into the hands of the 'right', and the Chinese economy entered a period of adjustments.

From 1963 to 1965, the average investment rate was set at 22.7% and productive investment only accounted for 64% of total investment. President Liu Shaoqi even introduced many programs in agricultural production which later under Deng Xiaoping became important ingredients of economic reforms.

The reign of the 'right' was short-lived. The next 10 years, 1966–1976, were those of the 'Great Cultural Revolution', and Mao and the 'left' were in absolute control of economic planning. Except for the years 1967–1969 when the economy was almost paralyzed by destructive political turmoil, the investment rate on the average was above 31%, and 75% of which was for productive purposes. After Mao's death, his chosen successor, Hua Guofang, continued the expansion drive of the 'left', and even started a 'Foreign Leap Forward' from 1977 to 1979, importing large amounts of foreign technology. The average investment rate was above 34%.

In 1979, political power began to shift back to the 'right', and Deng Xiaoping and the 'reformers' came to the forefront, though the ideology of the 'left' still deeply affected planning and the effects of the 'Foreign Leap Forward' still kept the investment rate at a high level of 34.6%. But in that year, the proportion of productive investment in the total investment began to decrease. From 1981 to 1985, the average investment rate went down to 30.3%, and the average share of productive investment was at an historical low level – 52.4%. That is to say, a large proportion of investment was diverted to the improvement of residential conditions, service sectors, public health and education.

So we can see that the investment rates and political changes are closely related in China. It is convenient to test how much fluctuations in investment rates and productive investment rates can be explained by the political changes in China's socialist history. Here we report results of a few regression equations:

$$I_t = \underset{(2.84)}{11.23} + \underset{(2.05)}{4.06}D_t + \underset{(3.36)}{0.55}I_{t-1}, \quad R^2 = 0.50, \ \mathrm{DW} = 1.13, \tag{39}$$

$$PI_t = \underset{(4.47)}{31.25} + \underset{(5.17)}{12.36}D_t + \underset{(4.35)}{0.45}PI_{t-1}, \quad R^2 = 0.73, \ \mathrm{DW} = 1.93, \tag{40}$$

where I_t is the investment rate at time t, D_t is the dummy variable of political change (a value of one refers to the 'left' regime and a value of zero the 'right' regime), and PI_t is the share of productive investment in total investment.

Eqs. (39) and (40) both show that political changes have substantial effects on the investment rate and the productive investment rate. The positive

coefficients say that a 'left' regime causes high rates, and a 'right' regime leads to low rates. As investment projects often last for a few years, the lagged variables also help to explain the rates.

If we exclude the politically abnormal years 1967–1969, then political changes alone can explain about half of the variations in the investment rates:

$$I_t = \underset{(18.17)}{25.36} + \underset{(5.19)}{8.9} D_t, \quad R^2 = 0.43, \quad \mathrm{DW} = 0.74, \tag{41}$$

$$PI_t = \underset{(28.14)}{58.32} + \underset{(6.51)}{19.12} D_t, \quad R^2 = 0.57, \ \mathrm{DW} = 0.93. \tag{42}$$

Two points should be added to our analysis of political investment cycles in China. First, the 'right' and the 'left' are both expansionists by definition because they are both social planners, the difference being only a matter of degree. Throughout time, there is a tendency for social planners to increase the investment rates; this can be seen from regressing the investment rates against a time variable:

$$I_t = \underset{(1.02)}{5.07} + \underset{(2.21)}{4.22} D_t + \underset{(2.56)}{0.48} I_{t-1} + \underset{(1.135)}{0.114} \mathrm{TIME}, \tag{43}$$

$$R^2 = 0.52, \ \mathrm{DW} = 1.13.$$

Second, political factors as an exogenous variable cannot fully explain all fluctuations in investment rates; a theory espoused by Bauer (1978) and Kornai (1980, 1988), which we may call a model of endogenous investment cycles, has developed to explain investment cycles under the same political regime. The focus of this theory is to relate the investment rate to the intensity of shortage in the economy. Social planners will reduce the investment rate when shortage intensity is high, and raise the investment rate when shortage intensity is low. For a model developed in this line, see Zou (1990). These two theories of investment cycles should be taken as complementary, and

> 'they can be usefully and effectively placed side by side and, taken together, they do a good job not only of explaining the regular pattern of the cycle, but also of explaining its irregularities'. [Kornai (1988, p. 284)]

6. Summary

In this paper, we have offered a positive growth model that sheds considerable light on the 'norms' of socialist growth, such as investment

hunger, expansion drive, chronic shortage and investment cycles. This model also provides an analytical framework within which to study the relationship between investment fluctuations and political changes in socialist countries. Preliminary empirical work on China has provided strong support for this approach.

References

Alesina, A., 1988, Macroeconomics and politics, in: S. Fischer, ed., NBER Macroeconomics Annual 1988 (MIT Press, Cambridge, MA).

Alesina, A. and J. Sachs, 1988, Political parties and the business cycle in the United States, 1948–1984, Journal of Money, Credit and Banking 20, 63–82.

Bajt, A., 1971, Investment cycles in European socialist economies: A review article, Journal of Economic Literature 9, 53–63.

Bauer, T., 1978, Investment cycles in planned economies, Acta Oeconomica, 243–260.

Cass, D., 1965. Optimum growth in an aggregate model of capital accumulation, Review of Economic Studies 32, 229–243.

Grosfeld, I., 1986, Endogenous planners and the investment cycle in the centrally planned economies, Comparative Economic Studies, 42–53.

Grosfeld, I., 1987, Modelling planners' investment behavior: Poland, 1956–1981, Journal of Comparative Economics 11, 180–191.

Ickes, B., 1986, Cyclical fluctuations in centrally planned economies: A critique of the literature, Soviet Studies 38, 36–52.

Koopmans, I., 1965, On the concept of optimal economic growth, in: The econometric approach to development planning (North-Holland, Amsterdam).

Kornai, J., 1972, Rush versus harmonic growth (North-Holland, Amsterdam).

Kornai, J., 1980, Economics of shortage (North-Holland, Amsterdam).

Kornai, J., 1981, Some properties of the Eastern European growth pattern, World Development 9, 965–970.

Kornai, J., 1982, Growth, shortage and efficiency (University of California Press).

Kornai, J., 1986, The Hungarian reform process: Visions, hopes and reality, Journal of Economic Literature 26, 1687–1743.

Kornai, J., 1987, 1988, Lecture notes on socialist political economy (Harvard University, unpublished).

Kurz, M., 1968, Optimal economic growth and wealth effects, International Economic Review 9, 348–357.

Orzechowski, W., 1977, Economic models of bureaucracy: Survey, extension, and evidence, in: T.E. Borcherding, ed., Budgets and bureaucrats (Duke University Press, Durham).

Phelps, E., 1961, The golden rule of accumulation: A fable for growthmen, American Economic Review 51, 638–643.

Roland, G., 1987, Investment growth fluctuations in the Soviet Union: An econometric analysis, Journal of Comparative Economics 11, 192–206.

Statistical Year Book of China, 1986 (State Statistics Bureau, Beijing, China).

Zou, Heng-fu, 1990, A model of Bauer–Kornai investment cycle theory, Mimeo. (The World Bank).

11

A NOTE ON THE BAUER-KORNAI INVESTMENT CYCLE THEORY

Heng-fu Zou

ABSTRACT: This short paper has formulated the Bauer–Kornai investment cycle theory in a dynamic system of shortage and the investment rate: when the actual investment rate is higher (lower) than the normal one, the shortage intensity tends to intensify (decrease); when the shortage intensity is above (below) the norm, social planners react to lower (raise) the investment rate. This approach of adjustment by norm has been widely applied to empirical work on investment fluctuations in socialist countries, though the rationality of the investment cycles has been ignored by many. Here it has been shown that this cycle model can be explicitly derived from the rational choice of social planners. JEL Classification numbers: E22, E32, P26, P24.

INTRODUCTION

The economic explanation of investment cycles has been offered by Bauer (1978) and Kornai (1980, 1986). Many empirical studies have followed the same reasoning, e.g., Grosfeld (1987) and Roland (1987). The main idea of the Bauer–Kornai approach is the following: social planners adjust the investment rate according to the shortage intensity in the economy; when shortage is below or around the normal state, social planners approve and initiate large numbers of projects. The high investment rate will soon overheat the economy, and shortage intensity will exceed the normal level and become intolerable. Social planners will react to halt all new investment and cut or stop quite a few existing investment projects. After this slowdown process lasts for a while, shortage intensity is reduced and more slack is revealed. There comes a new wave of optimism, and a new cycle starts again.

In this paper, I intend to deal with the following questions: If social planners can perceive the effects of their action, which is possible from repeated practices, why do they not follow a smoother pattern of investment? Is the cycle itself an optimal choice of the social planners? I answer these questions in two sections. In Section II, I will focus on the dynamic relation between the shortage intensity and the investment rate. With some over-simplification, but without sacrifice of the essence, I reformulate the Bauer–Kornai cycle theory in the familiar Volterra–Lotka equations of cycles. I begin Section III by defining social planners' preference. It will be justified that social planners derive positive utility from high investment rate and negative utility or disutility from high shortage intensity in the economy. If social planners' preference is defined in a special way, investment cycles can be shown to be the rational choice of social planners.

Direct all correspondence to: Heng-fu Zou, Public Economics Division, World Bank, Washington, D. C. 20433.

China Economic Review, Volume 4, Number 1, 1993, pages 75–81

ISSN: 1043–951X.

THE BAUER–KORNAI INVESTMENT CYCLE THEORY

I first present a stylized description of the Bauer–Kornai investment cycle theory.

In the upswing of investment cycle, the economy is in a state of *run–up* and *rush*. An increasing number of investment projects is approved, and many new investments are initiated, and the existing projects are accelerated and expanded. This process continues until the economy hits the "tolerance limits":

1. high rate of investment leads to serious shortage of consumption goods that various forms of protest by consumers take place;
2. large number of investment projects compete with each other in investment inputs, and shortage of certain materials, late deliveries, bottlenecks and many other shortage phenomena become intolerable;
3. continued high rate of investment brings about large foreign trade deficit and debt accumulation.

All these send alarm signals to social planners, and they react to suddenly halt all new investment projects and cut or stop many existing projects. The economy enters into a state of *slowdown* and the investment rate is often substantially reduced.

After some time, the shortage intensity is reduced considerably; producers find a relatively small volume of unfilled orders, consumers are more often in a short queue. So "there is too much slack" in the economy, "more could be squeezed out of investment sphere. This increasingly optimistic spirit suddenly becomes a strong determination and a new impetus is given to investment activity. The cycle starts again" (Kornai, 1980, pp. 213–14).

It seems to me that the essential parts of this cycle theory can be summarized in two dynamic equations. The first equation governs the dynamics of the shortage intensity: if the investment rate exceeds some normal rate, shortage tends to intensify; if the investment rate is below the normal level, the shortage intensity mitigates. The second equation describes the behavior of social planners: facing high and intolerable shortage phenomena, social planners lower the investment rate; and when the shortage intensity is well below certain critical or normal level, they raise the investment rate. Let me denote the investment rate as k and the shortage intensity as z. Also denote the normal investment rate as k^* and the normal shortage intensity as z^*. Rates k^* and z^* are assumed to be constant here. The concept of normality has been well studied by Kornai (1971, 1980, 1982) and plays a central role in the understanding of the centrally planned economies. For elaboration, I refer readers to Kornai's original works.

Mathematically we write the change in the shortage intensity as a positive and linear function of the difference between the actual investment rate and the normal investment rate:

$$\frac{\dot{z}}{z} = A(k - k^*) \qquad A > 0 \tag{1}$$

The equation regarding social Planners' behavior takes the following form:

$$\frac{\dot{k}}{k} = B(z^* - z) \qquad B > 0 \tag{2}$$

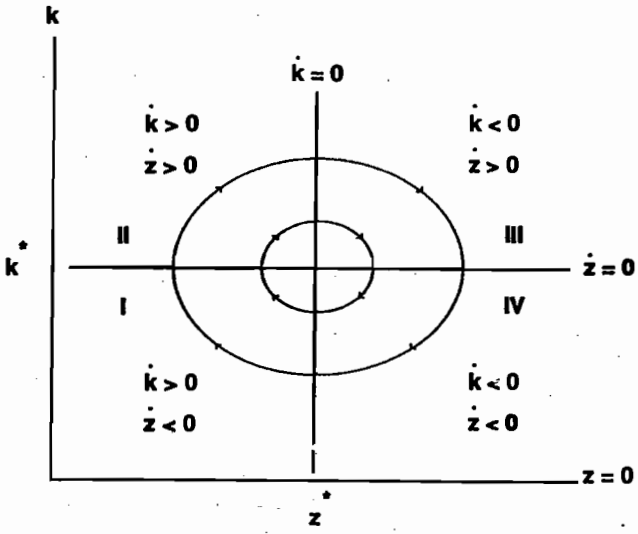


Figure 1.

For simplicity, I set constants A and B to unity. Equations (1) and (2) are just the Volterra–Lotka model in terms of the shortage intensity and the investment rate, and their application can be found in the predator–prey model in biology and the Goodwin–cycle in economics (Goodwin, 1967). Following the discussion in Hirsch and Smale (1974), I depict the phase diagram in figure 1.

The equilibrium points are given by (z^*, k^*) and (0, 0). The interesting equilibrium is the normal levels of shortage and investment. It is proved that (z^*, k^*) is a stable equilibrium, and there exists no limit cycle in the model, and every trajectory of these two equations is a closed orbit except the two equilibria, see Hirsh and Smale (1974). Therefore, for any given initial shortage intensity and investment rate other than (z^*, k^*), shortage and investment will oscillate cyclically.

In region I, as z is less than z^*, and k less than k^*, the investment rate goes up and shortage is expected to go down. This region is more or less like the period of *run–up* called by Tamas Bauer. Region II is Bauer's *rush* period, where the investment rate exceeds the normal rate and the shortage level increases; sooner or later, the tolerance limit will be hit and the social planners begin to "pull the brake." So in region III, investment rate is reduced and shortage continues to rise for a while. This *slowdown* process is typically manifested in region IV where both the investment rate and the shortage intensity begin to decrease.

Now the questions. Does equation (2) really reflect the optimal choice of the social planners? Why should social planners stick to the cyclical path instead of some smooth one? We take up these questions in the next section.

THE RATIONAL INVESTMENT CYCLE

To derive social planners' optimal decision rule from explicit rational choice, we first define social planners' objective function. Social planners are a large group of people who are in charge of all economic organizations and management in a socialist economy. With both political power and economic resources in their control, "they pursue their own individual and group interests, including the interests of the particular specialized agency to which they belong. Power creates an irresistible temptation to make use of it" (Kornai, 1986). It is a common phenomenon that social planners in all socialist economies have placed the highest priority on capital accumulation, and "investment hunger" and "expansion–drive" are the most important characteristics of socialist economic growth. According to Kornai (1981, 1986, 1988), it is in their own interests for social planners to accelerate investment and capital accumulation, because the expansion of the organization or firms is a way for social planners to identify themselves with their own jobs; "a larger organization brings more prestige, and also more power" (Kornai, 1981).

Of course, social planners do care about the shortage intensity caused by the high rate of investment. Chronic and excessive shortage often brings about consumers' dissatisfaction with social planners' manipulation of power, and the overextended investment policy may lead to complaints, wild strikes or demonstration, or open revolt.

Taking these two aspects into account, social planners enjoy positive utility from the investment rate and derive disutility from shortage if its intensity is very high. Using the notations in the last section, I write their instantaneous utility function as $u(k) - v(z)$. I further assume that functions $u(k)$ and $v(z)$ are twice continuously differentiable, with the property $u'(k) \geq 0$, and $v''(z) > 0$. As for the first order derivative of function $v(z)$, it is reasonable to assume that $v'(z) > 0$ for large value of the shortage intensity; if z is below certain level, $v'(z)$ may well be negative. Since $v'(z)$ is continuous by assumption, there exists at least one value z^* such that:

$$v'(z^*) = 0 \tag{3}$$

For $v''(z)$ is strictly larger than zero for all z, z^* satisfying (3) is unique.

Social planners maximize their utility over a finite horizon [0, T]:

$$\int_0^T [u(k) - v(z)]dt \tag{4}$$

subject to the dynamic equation (2) in the last section:

$$\frac{\dot{z}}{z} = (k - k^*) \tag{5}$$

where k is the control variable and z is the state variable. The Hamiltonian function is:

$$H(\dot{k}, z, \lambda) = u(k) - v(z) + \lambda z(k - k^*) \tag{6}$$

The first–order conditions for maximization are:

$$-\frac{u'(k)}{z}=\lambda \tag{7}$$

$$-v'(z)+\lambda(k-k^*)=-\dot{\lambda} \tag{8}$$

$$z(k-k^*)=\dot{z} \tag{9}$$

where λ is the costate variable. At time T, the boundary condition requires that $\lambda(T)=0$.

Now I will focus on the dynamics of equations (7), (8) and (9). Substituting λ into (8), and manipulating some algebra, I obtain

$$\dot{k}=-\frac{v'(z)z}{u''(k)} \tag{10}$$

$$\dot{z}=z(k-k^*) \tag{9}$$

To get an exact Volterra–Lotka cycle of investment, I assume that social planners' utility function takes the following form:

$$u(k)-v(z)=k\log k-z+z^*\log z. \tag{11}$$

Also if the actual shortage is higher than the normal one, the marginal utility of shortage is negative; if the actual shortage is lower than the normal, the marginal utility of shortage is positive. Now the social planners' objective function is to maximize:

$$W=\int_0^T[k\log k-z+z^*\log z]\,dt \tag{12}$$

subject to

$$\dot{z}=z(k-k^*) \tag{9}$$

I will first show that social planners never take a smooth pattern of shortage and investment as their optimal choice in this case. If social planners set the investment rate at $k_1>k^*$ after some time t_1, then

$$z(t)=e^{(k_1-k^*)t} \tag{13}$$

The integral (13) is equal to

$$W=k_1\log k(T-t_1)-\frac{e^{(k_1-k^*)T}-e^{(k_1-k^*)t_1}}{(k_1-k^*)}$$

$$+z^*(k_1-k^*)(T^2-t_1^2)+\text{some constant}. \tag{14}$$

This will be a large negative number for large T because $(k_1 - k^*)$ is positive and the second term on the right hand side of (14) dominates all other terms.

Similarly, if social planners choose an investment rate k_1 less then k^*, the third term on the right hand side will become very negative and the second term approaches zero for a large value of T. Also note that the third term will dominate the first term as square of T is greater than T when T is large. Therefore, W goes negative for large T.

To find the optimal adjustment function for social planners, we let $u(k) = k \log k$, and $v(z) = z - z^* \log z$ in (9) and (10). The optimal conditions for this case upon substitution are:

$$\dot{k} = -\frac{(1 - z^*/z)z}{1/k}$$

and

$$\dot{z} = (k - k^*)z.$$

Namely:

$$\frac{\dot{k}}{k} = (z^* - z) \tag{15}$$

$$\frac{\dot{z}}{z} = (k - k^*) \tag{16}$$

which are exactly the Volterra–Lotka equations discussed in Section II. If the initial shortage intensity and investment rate are different from the equilibrium state (z^*, k^*), the economy will oscillate throughout the time. In particular, the cycle is proved to be the rational choice of social planners.

CONCLUSION

In this short note, I have formulated the Bauer–Kornai investment cycle theory in a dynamic system of shortage and the investment rate: when the actual investment rate is higher (lower) than the normal one, the shortage intensity tends to intensify (decrease); when the shortage intensity is above (below) the normal, social planners react to lower (raise) the investment rate. This approach of adjustment by norm has been widely applied to empirical work on investment fluctuations in socialist countries, though the rationality of the investment cycles has been ignored by many. Here, relying on some special example, I have shown that this cycle model can be explicitly derived from the optimal choice of social planners. In this limited sense we can say that investment cycles are chosen by social planners to maximize their utility.

ACKNOWLEDGMENTS

I thank Richard Caves, Janos Kornai, Dwight Perkins, and Jeffrey Sachs for their help in writing this paper. Any remaining errors are mine. Responsibility for the contents of this paper is solely mine and not that of the World Bank.

REFERENCES

Bauer, T. 1978. Investment cycles in planned economies. *Acta Oeconomica*, 243–60.

Goodwin, R. 1967. A growth cycle. In C. H. Feinstein, ed., *Socialism, capitalism and economic growth: Essays presented to Maurice Dobb*. Cambridge: Cambridge University Press.

Grosfeld, I. 1986. Endogenous planners and the investment cycle in the centrally planned economies, *Comparative Economic Studies* (pp. 42–53). (Spring).

———. 1987. Modelling planners' investment behavior: Poland, 1956–1981. *Journal of Comparative Economics, 11*, 180–191.

Hirsh, M., and S. Smale. 1974. *Differential equations, dynamic system, and linear algebra*. Academic Press.

Kornai, J. 1971. *Anti–equilibrium*. Amsterdam: North-Holland.

———. 1980. *Economics of shortage*. Amsterdam: North-Holland.

———. 1981. Some properties of the eastern European growth pattern, *World Development*, 9.

———. 1982. *Growth, shortage, and efficiency*. Berkeley: University of California Press.

———. 1986. The Hungarian reform process: visions, hopes, and reality. *Journal of Economic Literatures, 26*, 1687–1743.

Roland, G. 1987. Investment growth fluctuations in the Soviet Union: An econometric analysis. *Journal of Comparative Economics, 11*, 192–206.

Zou, Heng-fu. 1991. Socialist economic growth and political investment cycles. *European Journal of Political Economy, 7*, 141–157.

12

ON THE DYNAMICS OF PRIVATIZATION

Heng-fu Zou

ABSTRACT: In this paper, we answer two questions about how privatization should proceed. First, we assume an exogenously given time span of privatization and study how the rate of privatization is related to the initial total state capital, the adjustment cost of privatization, the efficiency difference between the private sector and the state sector, the income discount rate and the exogenous terminal time for privatization. Second, from the perspective of income maximization and adjustment cost minimization, we endogenize the choice of the time span of privatization and offer a solution to the optimal terminal time for the completion of the privatization process. *JEL Classification Numbers: E2, O2, P2, P5.*

INTRODUCTION

It is generally agreed that the most difficult task in transforming Central and Eastern European economies into market economies is the privatization of the state sector. While price libralization and currency convertibility may be achieved through the "shock therapy" or "big bang," the process of privatization may last for years (Lipton & Sachs, 1990a, b) or even decades (Kornai, 1990). The experience of privatization up to date in East Europe has shown a mix of the one-by-one (the gradualist or British-style privatization) approach and the systemic (the mass privatization) approach (Sachs, 1992), and, for most countries, the privatization processes seem to continue for many years to come.

It goes without saying that, in any former socialist state, the speed of privatization and the time span of privatization are determined by many factors other than purely economic considerations because privatization is not only necessary for economic efficiency, it is also a precondition for fundamental social and political changes. In this paper, we will limit our attention to the economic rationals for privatization and answer two questions about how privatization should proceed. First, we assume an exogenously given time span of privatization and study how the rate of privatization is related to the initial total state capital, the adjustment cost of privatization, the efficiency difference between the private sector and the state sector, the income discount rate and the exogenous terminal time for privatization. Second, from the perspective of income maximization and adjustment cost minimization, we endogenize the choice of the time span of privatization and offer a solution to the optimal terminal time for the completion of the privatization process. We will deal with the first problem in the second section and the second problem in the third section. Conclusions and extensions will be presented in the fourth section.

Direct all correspondence to: Heng-fu Zou, Public Economics Division, Policy Research Department, The World Bank, Washington, D.C. 20433; Institute of Advanced Economic Studies, Wuhan University.

China Economic Review, Volume 5, Number 2, 1994, pages 221-233 ISSN: 1043-951X.

THE BASIC DYNAMICS

We consider a typical socialist economy at the beginning of transition. The aggregate capital stock in this economy is given by $\bar{k}$, which consists of two parts: a dominant state sector k_s and a relatively small share of private capital k_p:

$$\bar{k} = k_s + k_p. \tag{1}$$

The income generated in the state sector is:

$$y_s = f(k_s), \tag{3}$$

and the income generated in the private sector is:

$$y_p = g(k_p). \tag{4}$$

In general, the private sector in a competitive environment is more efficient than the state sector. This is the most important reason why there should be privatization in this economy. The efficiency discrepancy between the private and state ownership can be most easily characterized by two simple, linear versions of the income functions:

$$y_s = \theta_s k_s \tag{3'}$$

$$y_p = \theta_p k_p \tag{4'}$$

where θ_i's (i, $= s$ and p) are all positive, but

$$\theta_p > \theta_s > 0. \tag{5}$$

This formulation of a linear technology in the capital stock has been quite popular in recent theory of endogenous growth, in particular, see Barro (1990) and Rebelo (1991). It can be justified in two ways. First, the capital stock can be understood to include both physical and human capital. In our case, the privatization process not only transforms the state capital stock to the private sector, it also involves the reallocation of workers (human capital) through firing, unemployment, retraining, and rehiring. With this broad definition of capital, the usual neoclassical production function with capital and labor as separate inputs can be approximated by the linear technologies in (3') and (4'). Second, following Barro (1990), we can also think that capital and labor enter the production process in certain fixed proportion as in the Leontief technology. Then a Cobb-Douglas production function can be simplified to be a linear function of the capital stock.

The transformation of state capital into private capital involves the cost of adjustment such as the overhaul and reorganization of the existing production method and manage-

ment system. If we interpret the capital stock in the broad sense above, the privatization process involves reallocation of both physical capital and human capital. In this way, the adjustment cost or the privatization cost also includes the cost of unemployment, social safety net, and retraining. Following the usual assumption in the text-version investment theory such as Blanchard and Fischer (1989), the adjustment cost for investment is assumed to be increasing and convex in the new investment in the private sector. Let $h(\dot{k}_p)$ denote the adjustment cost. The function $h(.)$is assumed to be quadratic:

$$h(\dot{k}_p) = (\gamma \dot{k}_p^2/2), \gamma > 0, \tag{7}$$

where $\dot{k}_p$ is the incremental investment in the private sector or the rate of privatization. By equation (1), given the total capital in this economy, an increase in private capital comes from an equal amount of reduction in the state sector:

$$\dot{k}_p = -\dot{k}_s. \tag{8}$$

This economy intends to maximizes its net discounted income. In this section, we first consider the case where the time span of privatization, from now (time zero) to a future time T, is determined exogenously. That is to say, the choice of time span of privatization $[0, T]$ is not our concern and, by time T, $k_p(T)$ will account for all existing capital stock $\bar{k}$.

$$k_p(T) = \bar{k}. \tag{9}$$

If part of the existing capital stock is still owned by the state at time T, we can just write $k_p(T) = \alpha\bar{k}$ and $0 < \alpha < 1$. But in this paper, for notational simplicity, we will assume a total privatization of the state sector, namely, $\alpha = 1$ by time T.

Since our focus is the privatization of the state sector, we ignore the part of private capital formation through new investment other than the privatized state capital. With this simplification, the net income during the period of privatization is:

$$y = \theta_p k_p + \theta_s k_s - h(\dot{k}_p) \text{ for } 0 < t \leq T,$$

and the net income after the completion of privatization is produced, by our assumption, only in the private sector:

$$y = \theta_p \bar{k} \text{ for } t > T.$$

Then, the economy's objective function can be formulated as to:

$$\text{Maximize} \int_0^T \left[\theta_p k_p + \theta_s k_s - (\gamma \dot{k}_p^2/2)\right] e^{-rt} dt + \theta_p \bar{k} e^{-rT}/r, \tag{10}$$

subject to:

$$\bar{k} = k_s + k_p \tag{1}$$

$$\dot{k}_p = -\dot{k}_s \tag{8}$$

$$k_p(T) = \bar{k} \tag{9}$$

$$k_p(0) = k_{p0}. \tag{11}$$

here r (> 0) is the income discount rate and T is given. The term $(\theta_p k e^{-rT}/r)$ represents a kind of "salvage value" because it is the discounted income generated in the private sector from time T on. Since we exclude the possibility of new private investment other than the privatization of the existing state capital stock, we have to maintain the condition that $k_p(t) \le \bar{k}$ for all t in the interval $[0, T]$. In addition, we might as well impose the assumption of irreversibility in the investment process of the private sector, namely, $\dot{k}_p(t) \ge 0$.

Substituting equations (1), (2) and (8) into (10), we have:

$$\text{Maximize} \int_0^T \left[(\theta_p - \theta_s) k_p + \theta_s \bar{k} - (\gamma \dot{k}_p^2/2) e^{-rt} \right] dt + \theta_p \bar{k} e^{-rT}/r, \tag{12}$$

subject to:

$$k_p(T) = \bar{k} \tag{9}$$

$$k_p(0) = k_{p0} \tag{11}$$

and T is given.

The Euler equation for this problem is:

$$\partial y e^{-rt}/\partial k_p(t) = d[\partial y e^{-rt}/\partial \dot{k}_p(t)]\, dt,$$

namely,

$$\ddot{k}_p - r\dot{k}_p + (\theta_p - \theta_s)/\gamma = 0. \tag{13}$$

In equation (13), we make the change of variable $\dot{k}_p = z$, so that $\ddot{k}_p = \dot{z}$. Then equation (13) can be written as a first-order differential equation:

$$\dot{z} - rz + (\theta_p - \theta_s)/\gamma = 0.$$

Its solution is:

$$z = \dot{k}_p = (\theta_p - \theta_s)/r + c_1 e^{rt},$$

where c_1 is a constant of integration. Integration again yields:

$$k_p = (\theta_p - \theta_s)\gamma/r + c_1 e^{rt}/r + c_2, \tag{14}$$

where c_2 is another constant of integration. The boundary conditions:

$$k_p(0) = c_1/r + c_2 = k_{p0}, \text{ and}$$

$$k_p(T) = (\theta_p - \theta_s)T/\gamma r + c_1 e^{rt}/r + c_2 = \bar{k},$$

yield values for the constants of integration:

$$c_2 = k_{p0} - \{[(\bar{k} - k_{p0})r/(e^{rT} - 1)] - [(\theta_p - \theta_s)T/(e^{rT} - 1)\gamma]\}/r,$$

$$c_1 = [(\bar{k} - k_{p0})r/(e^{rT} - 1)] - [(\theta_p - \theta_s)T/(e^{rT} - 1)\gamma].$$

Therefore the optimal time path for capital formation in the private sector is:

$$k_p(t) = (\theta_p - \theta_s)t/r\gamma + k_{p0} + \{[(\bar{k} - k_{p0})r/(e^{rT} - 1)] - [(\theta_p - \theta_s)T/(e^{rT} - 1)\gamma]\}(e^{rT} - 1)/r. \tag{15}$$

Since $k_p(t) = \bar{k} - k_s(t)$, equation (15) also describes the divestiture of the state sector. Differentiating $k_p(t)$ with respect to time t in equation (15):

$$\dot{k}_p(t) = (\theta_p - \theta_s)/r\gamma + \{[(\bar{k} - k_{p0})r/(e^{rT} - 1)] - [(\theta_p - \theta_s)T/((e^{rT} - 1)\gamma)]\}e^{rt}. \tag{16}$$

Equation (16) is the optimal dynamic path for the private sector investment or the rate of privatization, which has the following properties:

Proposition 1: If $(rT) > (rT)^2$ for $0 < t < T$, the privatization rate is positively related to the efficiency difference between the private-sector capital and the state-sector capital; if $(rT) < (rT)^2$ for $0 < t < T$, the privatization rate is negatively related to the efficiency difference.

Proof:

$$dk_p(t)/d(\theta_p - \theta_s) = 1/(r\gamma) - Te^{rt}/(e^{rT} - 1)\gamma$$
$$= (e^{rT} - 1 - rTe^{rt})/(e^{rT} - 1)r\gamma.$$

The denominator is always positive as e^{rt} is always larger than one and $rT > 0$. But the sign of the numerator is ambiguous. To see this, note that $e^{rT} = 1 + rT + (rT)^2/2! + ...$, $e^{rT} = 1 + rt + (rt)^2/2! + ...$; thus $e^{rT} - 1 - rTe^{rt} = (rT)^2/2! - rT(rT)^2/2! + (rT)^3/3! - r(rT)^3/3! + ...$ This expression is positive if $(rT) > (rT)^2$, and it is negative if $(rT < (rt)^2$. Let us illustrate this proposition with the following example. Suppose that the income discount rate, r, is 12 percent. If the privatization process is required to finish in 15 years or $T = 15$, then rT is 1.5. Then, when t is less than 10.351 years, the privatization rate is positively related to the efficiency difference $\theta_p - \theta_s$; but when $t > 10.351$, $(rt)^2$ is greater than 1.5 and the privatization rate changes its direction with respect to the efficiency difference $(\theta_p - \theta_s)$.

From intuition, it seems that, if the private sector is much more efficient than the state sector, the privatization should proceed faster during the period of [0, T]. But Proposition 1 only partly confirms this conjecture. In particular, if the time discount rate is large and the period of privatization lasts long (namely, a large T), it is likely that the pace of privatization will slow down as t gradually approaches T. Thus Proposition 1 provides some useful information on the time path of the privatization rate during the period [0, T]. At the beginning of the privatization process, as t is much smaller than T and the privatization rate is positively linked to the efficiency deference between the private sector and the state sector. With time going, t is increasing and, after t reaches certain value, $(rt)^2$ can be greater than the value rT, the privatization rate will be inversely related to the efficiency difference $(\theta_p - \theta_s)$.

Proposition 2: If $(rT) > (rT)^2$ for $0 < t < T$, the privatization rate is a decreasing function of the adjustment cost γ, if $(rT) < (rT)^2$ for $0 < t < T$, the privatization rate is an increasing function of the adjustment cost.

The proof follows Proposition 1 because we have:

$$d\dot{k}_p(t)/d\gamma = -(\theta_p - \theta_s)(e^{rT} - 1 - rTe^{rT})/(e^{rT} - 1)r\gamma^2.$$

In the expression above, since $(\theta p - \theta s)$ is positive, the numerator will be negative if $(rT) > (rT)^2$ for $0 < t < T$. In this case, a high adjustment cost will lower the privatization rate. Since this case fits more to the initial stage of the transformation process, this proposition seems to suggest that the initial privatization should proceed slowly if the adjustment cost or the privatization cost is very high. But, when $(rT) < (rT)^2$ for $0 < t < T$, privatization will have progressed for a time and the adjustment cost, discounted at the rate r, will become small and, accordingly, the pace of privatization will be speeded up.

Proposition 3: The larger the initial state capital stock $k_{s0}(= \bar{k} - k_{p0})$, the faster the privatization rate:

$$d\dot{k}_p(t)/d(\bar{k} - k_{p0}) = re^{rt}/(e^{rT} - 1) > 0.$$

This proposition is what we have expected. If most of the capital is in the hand of the state, the time limit set exogenously will exert pressure upon the privatization process and

the privatization rate will be increasing. At the same time, the discounted efficiency gain is also large when the inefficiency of the state ownership is got rid of quickly. On the other hand, when the existing private sector in the economy is already very significant, the time horizon of privatization, [0, T], does not demand fast speed of privatization and it is better for the economy to get privatized slowly. This proposition applies quite well to the case of Hungary and China, where, at the initial stage of transformation, private ownership and market elements are significant compared to countries like Poland and Russia, and, thus, the privatization process has taken place at a relatively slower pace.

Proposition 4: An increase in the the time span of privatization is likely to reduce the privatization rate.

Proof:

$$dk_p(t)/dT = -[(k-k_{p0})re^{r(t+T)}/(e^{rT}-1)]^2\gamma$$
$$-(\theta_p-\theta_s)e^{rt}(e^{rt}-1-rTe^{rT})/r(e^{rT}-1)^2.$$

In the expression above, the first term on the right hand side is always negative as $(k - k_{p0})$ is positive; the second term is negative or positive depending on the condition whether (rT) is greater or smaller than $(rT)^2$ for $0 < t < T$. But we should note the value of $e^{r(t+T)}$ in the first term will be much larger than the value of e^{rt} in the second term, and the negative effect of an increase in T seems to dominate. That is to say, a lengthening of the time span of privatization is likely to slow down the privatization rate. The intuition also supports this conclusion. For a given amount of state capital stock, more time available for the privatization process can only reduce or at most does not affect the rate of privatization.

Proposition 5: If $(\bar{k}-k_p^0)r\gamma > (\theta_p - \theta_s)T$, the privatization rate accelerates during the time span [0, T]; on the other hand, if $(\bar{k}-k_p^0)r\gamma < (\theta_p - \theta_s)T$, the privatization rate decelerates from time zero to T.

Proof:

$$d\dot{k}_p(t)/dt = \{[(\bar{k}-k_{p0})r/(e^{rT}-1)] - [(\theta_p-\theta_s)T/(e^{rT}-1)\gamma]\}re^{rt}.$$

The term in the braces is positive if $(\bar{k}-k_{p0})r\gamma > (\theta_p-\theta_s)T$, and it is negative if $(\bar{k}-k_{p0})r\gamma < (\theta_p-\theta_s)T$. If the term in the braces is positive, the privatization rate will rise with time. If the term is negative, the private investment rate or the rate of privatization will keep decreasing.

The condition whether $(\bar{k}-k_{p0})r\gamma > (\theta_p-\theta_s)T$ or $(\bar{k}-k_{p0})r\gamma < (\theta_p-\theta_s)T$ leads us to study the requirements for an accelerating privatization process and a decelerating privatization process. If the initial state capital stock, $k_{s0} = (k-k_{p0})$, is large, if the income discount rate, r, is large, and if the adjustment cost, γ, is also large, then privatization will become faster and faster during [0, T]. On the other hand, if the efficiency difference $(\theta_p-\theta_s)$ is very significant and the terminal time T is remote from today, the privatization rate will be decreasing from the present to T.

To understand this proposition, we offer some economic intuition here. For the accelerating case, the driving forces are high adjustment cost, high income discount rate, and very small initial private capital stock compared to the total capital stock or a large initial state capital stock. Since the income discount rate and the adjustment cost are high, it is advantageous to privatize at a small scale initially and then to gradually increase the scale. This is reasonable because a high income discount rate often leads to the preference of the status quo over the future while the discounted future income and cost appear to be worth much less than the present ones. So with a high income discount rate, the privatization will be accelerated throughout the time span [0. T]. In addition, the accelerating process is likely to happen if the efficiency difference between the private sector and the state sector is small. This is well justified because rapid privatization at the beginning brings about small efficiency gain but large adjustment cost; thus it is worthwhile to postpone the large scale privatization and the discounted adjustment cost will become small. On the contrary, if the efficiency difference is great and if the gain from privatization outweighs the adjustment cost today, the economy should privatize at large scale today and in the near future. For the role of the terminal time for privatization, T, a small T naturally speeds up theprivatization process while a large T provides plenty of time for gradualist approach to privatization.

THE CHOICE OF THE TIME SPAN OF PRIVATIZATION

Should privatization be proceeded gradually or in a "big-bang"? Our model in the last section totally avoided this problem by assuming an exogenously determined terminal time for privatization, T. But, by focusing on the problem of income maximization or adjustment cost minimization, our model can shed light on this problem. Of course, what has happened in practice is far more complex than our model specified in this paper. Political and social adjustments are often closely linked to privatization, and they often demand rapid privatization to facilitate political and social transitions from communist dictatorship to democracy because state ownership is the economic foundation of communist dictatorship. Furthermore, the success of economic transition as a whole depends on the speed of privatization. Therefore, conclusions derived from our model have to be viewed together with social, political and other economic factors.

Recall our optimization problem in the last section:

$$\text{Maximize} \int_0^T \left[(\theta_p - \theta_s) k_p + \theta_s \bar{k} - \gamma (\dot{k}_p^2/2) \right] e^{-rt} dt + \theta_p \bar{k} e^{-rT}/r,$$

subject to:

$$k_p(T) = \bar{k} \tag{9}$$

$$k_p(0) = k_{p0}. \tag{11}$$

In the last section, the terminal time T is exogenously given. Now we hope to choose the privatization rate as well as the terminal time T optimally. This modification does not

change the Euler condition for the optimal choice of privatization rate $\dot{k}_p$ and we still have the first-order condition:

$$\ddot{k}_p - r\dot{k}_p + (\theta_p - \theta_s)/\gamma = 0.$$

But the boundary condition for the optimal terminal time T requires that, at time $t = T$,

$$\theta_p \bar{k} - \gamma(\dot{k}_p(T))^2/2 + \gamma(\dot{k}_p(T))^2 - \theta_p \bar{k} = 0; \tag{18}$$

which is the same as requiring that the optimal terminal time should be chosen such that the amount of investment in the private sector is zero at time $t = T$:

$$\dot{k}_p(T) = 0. \tag{19}$$

Given the initial and the terminal conditions (9) and (11), we can solve for the optimal rate of privatization as before:

$$\begin{aligned} k_p(t) = {} & (\theta_p - \theta_s)t/r\gamma + k_{p0} + \{[(\bar{k} - k_{p0})r/(e^{rT} - 1)] \\ & - [(\theta_p - \theta_s)T/(e^{rT} - 1)\gamma]\} e^{rt}, \end{aligned} \tag{15}$$

and

$$\begin{aligned} \dot{k}_p(t) = {} & (\theta_p - \theta_s)/r\gamma + \{[\bar{k}(-k_{p0})r/(e^{rT} - 1)] \\ & - [(\theta_p - \theta_s)T/(e^{rT} - 1)\gamma]\} e^{rt}. \end{aligned} \tag{16}$$

With the optimal rate of privatization given by equation (16), the optimal terminal time in equation (19) can be determined by setting time t to T in equation (16) and letting the whole expression equal zero:

$$\begin{aligned} \dot{k}_p(T) = {} & (\theta_p - \theta_s)/r\gamma + \{[(\bar{k} - k_{p0})r/(e^{rT} - 1)] \\ & - [(\theta_p - \theta_s)T/(e^{rT} - 1)\gamma]\} e^{rT} = 0. \end{aligned} \tag{20}$$

Rearranging equation (20), we have:

Proposition 6: The optimal terminal time T is given implicitly in the following equation:

$$e^{rT}[(\theta_p - \theta_s)(1 - rT) + (\bar{k} - k_{p0})r^2\gamma] = (\theta_p - \theta_s). \tag{21}$$

It is obvious that, for equation (21) to hold, the term, $[(\theta_p - \theta_s)(1 - rT) + (\bar{k} - k_{p0})r^2\gamma]$, has to be positive:

$$[(\theta_p - \theta_s)(1 - rT) + (\bar{k} - k_{p0})r^2\gamma] > 0. \tag{22}$$

Also, for equation (20) to hold, it needs:

$$(\bar{k} - k_{p0})r\gamma - (\theta_p - \theta_s)T < 0. \tag{23}$$

From now on, in our model, we will choose the proper unit for the capital stock and make condition (23) satisfied. In passing, we note that we already used both inequality (23) and its opposite in Proposition 5 of the last section. There we took the terminal time as exogenously given, but, here, the determination of the optimal terminal time is precisely our task.

With the help of condition (23), we can analyze the responses of optimal terminal time T with respect to various parameters in our model. A total differentiation of equation (21) yields:

$$\begin{aligned} re^{rT}[(\bar{k} - k_{p0})r^2\gamma - (\theta_p - \theta_s)rT]\,dT = {} & [rTe^{rT} - e^{rT} + 1]\,d(\theta_p - \theta_s) \\ & - e^{rT}r^2\gamma d(\bar{k} - k_{p0}) - e^{rT}(\bar{k} - k_{p0})r^2 d\gamma \\ & - [e^{rT}(\theta_p - \theta_s)rT^2 + (\bar{k} - k_{p0})(r^2\gamma Te^{rT} + 2e^{rT}r\gamma)]\,dr. \end{aligned} \tag{24}$$

Condition (23) implies that the coefficient for dT on the left side of equation (24) is negative. Therefore,

Proposition 7: The larger the initial state capital stock, the longer the optimal time span for the privatization process.

This proposition can be easily shown from equation (24) (note $k_{s0} = (\bar{k} - k_{p0})$):

$$dT/d(\bar{k} - k_{p0}) = -r^2\gamma/[(\bar{k} - k_{p0})r^2\gamma - (\theta_p - \theta_s)rT] > 0. \tag{25}$$

In other words, if the initial private capital stock is large, the optimal time for privatization will be short; and vice versa:

$$dT/dk_{p0} = r^2\gamma/[(\bar{k} - k_{p0})r^2\gamma - (\theta_p - \theta_s)rT] < 0.$$

This proposition implies that, other things equal, the economy with a large state sector needs more time to privatize than the economy with a small state sector. From the consideration of long-run income maximization, it also suggests that the exogenously determined time span, which we considered in the last section, cannot achieve long-run income maximization at least from the perspective of narrowly defined cost and benefit of privatization

in our model. The adoption of the time span for privatization to country specifics is further required by the next proposition.

Proposition 8: Both a high privatization cost and a high income discount rate increase the optimal terminal time of privatization.

This can be seen from equation (24):

$$dT/d\gamma = -r^2/[(\bar{k}-k_{p0})r^2\gamma-(\theta_p-\theta_s)rT] > 0.$$

$$dT/dr = -[e^{rT}(\theta_p-\theta_s)rT^2+(\bar{k}-k_{p0})(r^2\gamma Te^{rT}+2e^{rT}r\gamma)]/$$
$$[(\bar{k}-k_{p0})r^2\gamma-(\theta_p-\theta_s)rT] > 0. \quad (26)$$

Thus with different adjustment costs and income discount rates, different economies should choose different time horizons of privatization. The adjustment cost not only slows down the pace of privatization directly as we argued in the last section, it reinforces this effect indirectly through a longer time for privatization. The role of the income discount rate can be interpreted in two senses. For the case of a small economy, if we take the income discount rate as the interest rate of the world capital market, then a high world interest rate will increase the time span for privatization. If we take the income discount rate as the subjective time discount rate,then an economy with a high time preference will privatize longer than an economy with a low time preference.

Proposition 9: If $(rT) > (rT)^2$ for $0 < t < T$, the larger the efficiency difference between the private sector and the state sector, the shorter the time span for privatization; if $(rT) < (rt)^2$ for $0 < t < T$, the larger the efficiency difference, the longer the time span for privatization.

To show this proposition, note that, from equation (24),

$$dT/d(\theta_p-\theta_s) = ([rTe^{rT}-e^{rT}+1]/[(k-k_{p0})r^2\gamma-(\theta_p-\theta_s)rT]). \quad (27)$$

As shown in Proposition 1, the term $[rTe^{rT}-e^{rT}+1]$ is positive or negative depending on whether $(rT) < (rt)^2$ or $(rT) > (rt)^2$ for $0 < t < T$. This proposition indicates that the efficiency difference between the private and the state sectors can have two effects on the optimal terminal time. On one hand, when the efficiency difference is large, income maximization demands rapid privatization in a short time span. But, on the other hand, fast privatization incurs more adjustment cost. Hence the optimal terminal time will be determined by balancing the efficiency gain and adjustment loss at the margin.

After we have qualitatively analyzed the effects of various parameters on the optimal terminal time T in our model, we need to go back to the optimal investment equation (16). Now since the terminal time is endogenously determined, some of our results obtained in the last section cannot apply here quantitatively. In particular, Propositions 1 to 3 should be

re-examined because all parameters in our model not only affect the optimal rate of investment or privatization directly, they also impact on the optimal terminal time T, which in turn influences the optimal rate of privatization in equation (16). As the preparations for these re-examinations, we note that Proposition 4 still holds if we change the derivative $d\dot{k}_p(t)\,dT$ into $\partial k_p(t)/\partial T$. The reason for this is the same as before: more time available for the completion of the privatization process does not affect, or, at most, slows down, the rate of privatization; that is to say,

$$\partial \dot{k}_p(t)/\partial T \leq 0. \tag{28}$$

In the following, we can see that Propositions 1 to 3 can be extended qualitatively from the case of exogenous terminal time to the case of endogenous terminal time. We present them here without detailed arguments.

First, with Proposition 7 and condition (28), we have

Proposition 3': The optimal rate of privatization is always increasing in the initial proportion of the state capital stock.

$$\begin{aligned} d\dot{k}_p(t)/d(\bar{k}-k_{p0}) &= \partial k_p(t)/\partial(\bar{k}-k_{p0}) + [\partial k_p(t)/\partial T]\,dT/d(\bar{k}-k_{p0}) \\ &= [(re^{rt}/(e^{rT})-1)] - [\partial \dot{k}_p(t)/\partial T]\,r^2\gamma/[(\bar{k}-k_{p0})r^2\gamma-(\theta_p-\theta_s)rT] > 0. \end{aligned}$$

Second, Proposition 8 and condition (28) together give rise to:

Proposition 2': While the direct adjustment cost may increase or decrease the rate of privatization, it always lengthens the optimal time span of privatization, which in turn slows down the privatization rate.

$$d\dot{k}_p(t)/d\gamma = \partial \dot{k}_p(t)/\partial\gamma + [\partial \dot{k}_p(t)/\partial T]\,dT/d\gamma.$$

Here $\partial \dot{k}_p(t)/\partial\gamma$ has an ambiguous sign as shown in Proposition 2, but the second term on the right is always negative. Thus, in general, $d\dot{k}_p(t)/d\gamma$ does not have a definite sign.

Finally, with Proposition 8 and condition (28),

Proposition 1': The efficiency difference between the private sector and the public sector has an ambiguous effect on the rate of privatization.

$$d\dot{k}_p(t)/d(\theta_p-\theta_s) = \partial \dot{k}_p(t)/\partial(\theta_p-\theta_s) + [\partial \dot{k}_p(t)/\partial T]\,dT/d(\theta_p-\theta_s),$$

which has an ambiguous sign because both terms on the right side can be negative or positive.

CONCLUDING REMARKS

In this paper, we have considered the time path of privatization and the optimal time span of privatization from the perspective of adjustment cost minimization or income maximization. We have found that:

1. the rate of privatization is negatively related to the amount of the initial private capital stock and positively related to the total existing capital stock. That is to say, the rate is positively related to the existing state capital stock. In addition, the optimal terminal time is positively related to the existing state capital stock;
2. the efficiency difference between the private sector and state sector has ambiguous effects on the rate of privatization and the optimal terminal time of privatization;
3. the adjustment cost may speed up or slow down the rate of privatization and, it unambiguously increases the optimal terminal time of privatization;
4. the rate of privatization is time-dependent. For certain parameters of the initial state capital, efficiency difference, adjustment cost and the time discount rate, the rate of privatization can be accelerating and decelerating.

We can take a more general approach to the dynamics of privatization instead of specializing our case to the linear technology and quadratic adjustment cost. As our results from the simple model have suggested, the complicated relations between the rate and time span of privatization on the one hand and various parameters on the other can be seen most clearly through an explicit analytical solution to our problem.

The adjustment in the labor market cannot be seen directly in our model. But we want to re-emphasize that it can be modeled if the capital stock is broadly defined as the combination of physical and human capital. In this way, the reallocation cost of labor force from the state sector to the private sector can be easily included into the adjustment cost of investment in our model.

ACKNOWLEDGMENTS

I thank Shantayanan Devarajan, Delfin Go, and Bruce Reynolds for their comments and suggestions. All remaining errors are mine. The opinions expressed here are not necessarily those of the World Bank.

REFERENCES

Barro, R. (1990). Government spending in a simple model of endogenous growth. *Journal of Political Economy, 98*, S103-S125.

Blanchard, O. J., & Fischer, S. (1989). *Lectures on macroeconomics*. MIT Press.

Kornai, J. (1990). *The road to a free economy: Shifting from a socialist system—The example of Hungary*. New York, Norton.

Lipton, D., & Sachs, J. (1990a). Creating a market economy in Eastern Europe: The case of Poland. *Brookings Papers on Economic Activity, 11*, 75-147.

_____. (1990b). Privatization in Eastern Europe: the case of Poland. *Brookings Papers on Economic Activity, 2*, 293-334.

Rebelo, S. (1990). Long-run policy analysis and long-run growth. *Journal of Political Economy, 99*, 500-521.

Sachs, J. (1992). Privatization in Russia: Some lessons from Eastern Europe. *American Economic Review* (May), 43-48.

13

ELSEVIER

Journal of Public Economics 67 (1998) 221–240

JOURNAL OF PUBLIC ECONOMICS

Fiscal decentralization, public spending, and economic growth in China

Tao Zhang[a,b], Heng-fu Zou[a,b,*]

[a]*Institute of Advanced Studies, Wuhan University, Wuhan, 430072 China.*
[b]*Policy Research Department, World Bank, Washington, DC 20433, USA*

Received 1 October 1995; received in revised form 1 April 1997; accepted 1 May 1997

Abstract

This study of China demonstrates how the allocation of fiscal resources between the central and local governments has affected economic growth since reforms began in the late 1970s. We find that a higher degree of fiscal decentralization of government spending is associated with lower provincial economic growth over the past fifteen years. This consistently significant and robust result in our empirical examinations is surprising in light of the argument that fiscal decentralization usually makes a positive contribution to local economic growth. © 1998 Elsevier Science S.A.

Keywords: Fiscal decentralization; Public spending; Growth; Chinese economy

JEL classification: E62; H2; H4; H5; O4; R5

1. Introduction

Many developing countries and transition economies have a mandate to decentralize aspects of their public finance. At the same time, many developed economies such as the United States, the United Kingdom, and Canada are reviving debates on devolution. Decentralizing revenue raising and spending decisions is seen as a way to improve the efficiency of the public sector, cut the budget deficit, and promote economic growth (Bird, 1993; Bird, Wallich, 1993;

*Corresponding author. Room N 10-075, the World Bank, 1818 H St. NW, Washington, DC 20433, USA. Fax: 001 202 522 1154; e-mail HZOU@Worldbank.Org

Bahl, Linn, 1992; Gramlich, 1993 and Oates, 1993). The argument is that decentralization will increase economic efficiency because local governments are better positioned than the national government (Oates, 1972) to deliver public services that match local preferences and needs, and that over time, efficiency gains will lead to faster local as well as national economic growth.

Such conventional wisdom is reflected in numerous studies on intergovernmental fiscal relations in China (Bahl, Wallich, 1992; World Bank, 1990, 1992). Many proposals favor assigning more revenue and expenditure responsibilities to local governments. However, in China there is concern that decentralization has been implemented too fast and has gone too far, and that this is threatening macroeconomic control and stability (Wang, Hu, 1993; World Bank, 1995, 1996). It seems that national priorities in public spending have often been crowded out by local public projects.

Despite the mounting concern, there have been very few empirical studies of the relationship between fiscal decentralization and economic growth for developing countries in general, and for China in particular. This paper explores how the allocation of fiscal resources between the central and local governments has been associated with economic growth in China since the reforms of the late 1970s.[1]

First, we will summarize the trend in fiscal allocation between the central and local governments in Section 2 and then empirically test the impact on economic growth of spending by different levels of government using provincial panel data during the period 1978–1992 in Section 3. Section 4 concludes the paper.

2. 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 (World Bank, 1990; Wong et al., 1993; 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.

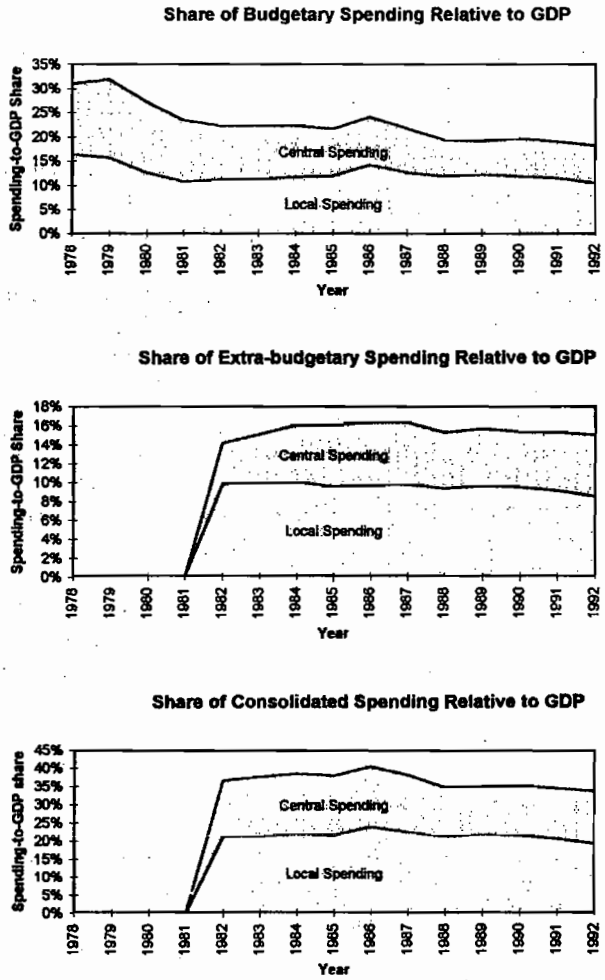
2.1. Overall fiscal status

In China, official government spending appears in three ways: budgetary spending, extra-budgetary spending, and consolidated spending, which is the sum of budgetary and extra-budgetary spending.

Fig. 1 shows that 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,

[1]Local governments include all subnational governments in this paper.

[2]The data used in our calculation are described in the data appendix A.



Source: See the data appendix.

Fig. 1. Shares of spending.

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 extra-budgetary 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 1982–86 from

[3]The central and provincial aggregate data on extra-budgetary spending became available in 1982.

36.4% in 1982 to 40.4% in 1986 (except for a small decline in 1985), and then declined during 1986–92 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.

2.2. 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.

Fig. 1 shows spending by local governments, including the spending financed by transfers from the central government, was 16.4% of GDP in 1978. 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

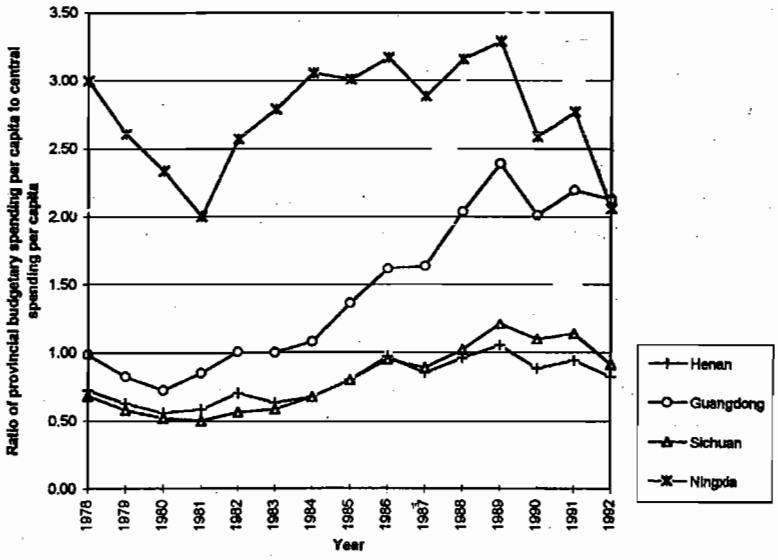


Fig. 2. Fiscal decentralization in selected provinces.

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 extra-budgetary spending demonstrated a trend of fiscal centralization over the entire post-reform period. As Fig. 1 shows, local governments spent 9.8% of GDP as extra-budgetary expenditures in 1978, and 8.4% in 1992; the share of local extra-budgetary spending in total extra-budgetary spending declined from 69.1% in 1982 to 56.4% in 1992. If we combined budgetary and extra-budgetary 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.

2.3. 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 under-developed 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. As Table 1 shows, during the period 1978–92, 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 extra-budgetary spending during 1986–92, the average province-to-center ratio in *Ningxia* was only 5% of that in *Liaoning*, one of China's heavy industrial centers. Since extra-budgetary 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 extra-budgetary spending to central extra-budgetary 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

[4]Of the total thirty provincial areas in China, two provincial areas, Tibet and Hainan, are excluded due to their special status. For a complete list of the twenty-eight provincial areas used in this study, see the data Appendix A.

[5]The central per capita spending is the central spending divided by the total population of China.

Table 1
China: Income growth and provincial fiscal decentralization, 1978–1992

Provincial areas	Real growth rate of provincial income Average (1978–1992)	The ratio of provincial budgetary spending to central Average (1978–1992)	The ratio of provincial extra-budgetary spending to central Average (1986–1992)	The ratio of per capital provincial budgetary spending to per capita central (DC_{bc}) Average (1978–1992)	The ratio of provincial extra-budgetary spending to central, expressed relative to income (DC_{ebc}) Average (1986–1992)	The ratio of per capita provincial consolidated spending to central (DC_{cbc}) Average (1986–1992)
Three metropolitan cities	8.57%	0.04	0.07	4.15	2.38	5.94
Beijing	9.07%	0.04	0.07	4.31	2.84	6.45
Tianjin	8.18%	0.03	0.04	3.91	2.20	4.71
Shanghai	8.45%	0.05	0.10	4.24	2.11	6.67
Coastal areas	11.74%	0.06	0.08	1.29	1.37	1.70
Liaoning	11.24%	0.07	0.12	2.03	2.14	3.00
Hebei	8.89%	0.06	0.07	1.02	1.42	1.20
Jiangsu	12.75%	0.06	0.10	1.01	1.24	1.44
Zhejiang	13.67%	0.05	0.07	1.17	1.27	1.64
Fujian	12.62%	0.04	0.04	1.41	1.34	1.61
Shandong	10.83%	0.07	0.09	0.92	1.12	1.18
Guangdong	12.19%	0.09	0.09	1.45	1.10	1.81
Inland areas	8.68%	0.05	0.05	1.19	1.34	1.36

Shanxi	8.32%	0.04	0.04	1.51	2.06	1.65
Jilin	8.98%	0.04	0.05	1.89	2.24	2.47
Heilongjiang	6.46%	0.06	0.06	1.82	1.50	2.07
Anhui	8.75%	0.04	0.04	0.79	1.17	0.90
Jiangxi	9.15%	0.03	0.03	1.00	1.40	1.09
Henan	9.49%	0.06	0.05	0.78	0.99	0.82
Hubei	9.19%	0.05	0.06	1.14	1.20	1.27
Hunan	8.08%	0.05	0.06	0.92	1.34	1.07
Sichuan	9.21%	0.08	0.09	0.81	1.38	1.00
Shaanxi	8.55%	0.03	0.03	1.21	0.09	1.30
Minority areas	8.54%	0.03	0.02	1.91	1.80	1.78
Inner Mongolia	8.33%	0.04	0.03	2.09	2.10	2.12
Guangxi	8.25%	0.03	0.04	1.06	1.67	1.17
Guizhou	9.47%	0.02	0.02	1.05	1.18	0.96
Yunnan	9.99%	0.05	0.04	1.48	1.77	1.60
Gansu	7.91%	0.03	0.02	1.45	2.42	1.44
Qinghai	6.22%	0.01	0.01	3.02	2.44	2.61
Ningxia	7.88%	0.01	0.01	2.75	2.34	2.28
Xinjiang	10.23%	0.03	0.02	2.43	0.46	2.10
Minimum	6.22%	0.01	0.01	0.78	0.09	0.82
Maximum	13.67%	0.09	0.12	4.31	2.84	6.67
Average	9.39%	0.04	0.05	1.74	1.59	2.06
Coefficient of Variation	0.192	0.426	0.568	0.605	0.400	0.745

Source: See the data Appendix A.

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, as shown in Fig. 2. *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 1978–92. 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.

2.4. Summary

The above discussion suggests that fiscal reform in China does not yield a clear pattern of fiscal decentralization on the spending side: (1) budgetary spending became more decentralized since 1978; (2) extra-budgetary spending, however, showed a decreasing local share during the entire reform period; (3) the share of local consolidated spending rose and fell; (4) fiscal decentralization varied across provinces and over time. In the following section, we will quantify the impact of fiscal decentralization measures on provincial economic growth.

3. Empirical estimations with provincial-level data

3.1. Variables and estimations

Our empirical estimations are based on annual data from 1980 to 1992 for 28 provinces. The dependent variable is the provincial income growth rate in real terms.[6] The explanatory variables fall into four categories:

1. Production inputs, including investment and labor.
2. Measures of fiscal decentralization of spending.

[6]Provincial income is defined as the provincial equivalent of national income (*Guomin Shouru*), which measures net provincial output according to Chinese statistics.

3. Measures of the composition of central and provincial budgetary expenditures.
4. Other variables, such as the tax rate, foreign trade, and the inflation rate.

We define the following variables in our estimations:

- Y = the real growth rate of provincial income.
- L = the growth rate of the provincial labor force.
- I = the provincial investment rate, measured by the ratio of investment (accumulation in fixed assets and circulating funds) to provincial income.
- F = the degree of openness of the provincial economy, measured by the share of total volume of foreign trade (the sum of exports and imports) in provincial income.
- TAX = the degree of distortion in the provincial economy, measured by
  CT: the ratio of central budgetary revenue to national GDP, which is the same to all provinces,
  PT: the ratio of provincial revenue (collection) to provincial income.
- R = the inflation rate, measured by the overall retail price index in each province.
- DC = the degree of fiscal decentralization, measured by the following three indicators:
  DC_{cbe} = the ratio of consolidated provincial spending to consolidated central spending, expressed in per capita terms
  DC_{be} = the ratio of provincial budgetary spending to central budgetary spending, expressed in per capita terms,
  DC_{ebe} = the ratio of provincial extra-budgetary to central extra-budgetary spending, expressed relative to income.

We fit our growth model to these provincial-level data as follows:[7]

$$Y_{st} = \beta_m M_{st} + \beta_n N_{st} + \beta_{dc} DC_{st} + u_{st}, \tag{1}$$

where s and t indicate province and year, respectively. M_{st} is a set of variables always included in the regression, N_{st} is a subset of variables identified by the literature as potentially important explanatory variables of growth, DC_{st} denotes variables of interest, and finally, u_{st} denotes the error term.

The M-variables consist of the growth rate in total labor force (L) and the tax rates (CT and PT). The tax rates are our aggregate measure of distortion introduced by governments to finance their spending.[8] Other potentially important

[7]This specification follows from Barro (1990); Davoodi et al. (1995); Devarajan et al. (1996) and Davoodi, Zou (1997).

[8]To better capture the effect of tax distortions on provincial economic growth, we choose CT, the central tax rate as some measure of the overall tax rate, in addition to PT, the provincial tax rate.

explanatory variables of growth used in many studies on economic growth are included as N-variables: the degree of openness (F), the inflation rate (R), and the investment rate (I). The usual argument for including the degree of openness as a determinant of growth states that more exports lead to more efficient resource allocation as a result of external competition in the world market, whereas imports are the means to import advanced technology from developed economies (see Feder, 1983). Inflation can generate a positive effect on growth because higher inflation leads people to invest more in physical capital and cut their real-balance holdings (the Tobin portfolio-shift effect). But at the same time, inflation raises the transaction cost of economic activities (consumption and investment) and may reduce the rate of economic growth. The investment rate appears as a "must-include" variable in traditional specifications of growth estimation. But in the recent literature on economic growth, it is endogenous. In order to make sure that our results are robust across different specifications of regression equations, we also include the investment rate as one explanatory variable in our sensitivity analysis. To capture the impact of the pattern of budgetary expenditure by the central and provincial governments on economic growth, the composition of public expenditure by both is also included as N-variables.

In this study, our primary concern is with the third set of variables, DC_{st} in Eq. (1): the three indicators of fiscal decentralization, DC_{be}, DC_{ebe}, and DC_{cbe}, which adjust for population size and income level.

3.2. Regression results

3.2.1. Base case

As our base case, we first choose the M-variables and one of the three indicators of fiscal decentralization, DC_{be}, the ratio of per capita provincial budgetary spending to per capita central budgetary spending, while ignoring the potentially important N-variables. The results of the LSDV (least squares dummy variables) regression of the base case are:

$$\begin{aligned} Y_{st} &= 0.341L_{st} - 0.058CT_t - 0.329PT_{st} - 0.054DC_{be\,st} \\ &\quad (1.501) \quad (-1.364) \quad (-1.818) \quad (-3.617). \end{aligned} \tag{2}$$

(Adjusted $R^2 = 0.173$, number of observations $= 196$, and values of t-statistics appear in parentheses.) Labor growth has a positive but insignificant effect on growth. Both the central tax and provincial tax have negative, relatively insignificant, effects on growth. Our primary concern is the sign and magnitude of the coefficient for fiscal decentralization, which is -0.054 and significantly different from zero at the 1% significance level. This is surprising in light of the conventional expectation that fiscal decentralization is usually associated with positive economic growth.

3.2.2. Structural changes and their sensitivities

To see whether our result is robust to changes in the conditioning information set, we conduct sensitivity tests against the three fiscal decentralization indicators in various estimations.[9] In doing so, eight estimations are made along with different selections of the three N-variables (F, R, and I). In estimating the impact of fiscal decentralization of extra-budgetary spending on growth, we use both DC_{bc} and DC_{ebc} to jointly measure the degree of decentralization.

Table 2 shows the sensitivity results for each of the M-variables and the indicators of fiscal decentralization. For budgetary spending, the coefficients of labor growth are positive but not significantly different from zero at the conventional 5% significance level, and the non-significance result is consistent between the lower bound and the upper bound of the labor coefficient. Similar results are observed with the coefficients of the tax rates. But the coefficient of decentralization measure, DC_{bc}, is consistently negative and significant. At the upper bound, the decentralization coefficient is -0.047 with a t-value of -3.413, whereas it becomes -0.070 with a t-value of -4.704 at the lower bound.

Similar results are obtained for extra-budgetary spending, DC_{ebc}, and for consolidated spending, DC_{cbc}. The negative association between decentralization and growth prevails in 32 estimations although the negative significance for DC_{bc} appears relatively weak in two estimations at the 5% significance level. The magnitude of the negative association between decentralization in extra-budgetary spending and the growth rate ranges from 0.088 to 0.101. Moreover, the coefficients for openness and the investment rate in these estimations are positive and significant.

3.2.3. Alternative specifications

To further investigate the negative association between fiscal decentralization and provincial economic growth, three alternative specifications are introduced with respect to the base case: (1) different sample periods, (2) cross-province estimations based on provincial average values during 1986–92, and (3) the random-effect estimation with the generalized-least-squares (GLS) regression.

Table 3 contains the results of the above alternative specifications. First, the negative correlation between fiscal decentralization and growth remains for both additional sample periods of 1980–92 and 1985–89. The first sample period extends the base sample period (1986–92) to the beginning of the reforms. The second is selected to focus on the period of extensive fiscal decentralization. As columns (1) and (2) show, the decentralization coefficients are consistently negative and significantly different from zero at the 5% level of significance. The magnitude of the negative effect of decentralization on growth, however, varies: in the sample covering the entire reform period, the negative effect of decentraliza-

[9] Following Levine, Renelt (1992), we say that the result is robust if the regression coefficient remains significant and has the same sign at the extreme (lower and upper) bounds.

Table 2
Sensitivity results for fiscal decentralization indicators. Dependent variable: real growth rate (Y), 1986–1992

Variable		Coefficient	Standard error	t	R-Square	Adjusted R-Square	S.E. regression	Other variables
L (Labor)	high	0.484	0.322	1.501	0.353	0.220	0.005	I, R
	base	0.341	0.324	1.053	0.305	0.173	0.045	
	low	0.180	0.320	0.562	0.367	0.244	0.043	F
CT (Central Tax Rate)	high	0.377	0.448	0.842	0.390	0.264	0.043	R, F
	base	−0.058	0.424	−1.364	0.305	0.173	0.045	
	low	−0.060	0.412	−1.696	0.350	0.222	0.045	I
PT (Provincial Tax Rate)	high	−0.124	0.171	−0.727	0.425	0.303	0.042	I, R, F
	base	−0.329	0.181	−1.818	0.305	0.173	0.045	
	low	−0.329	0.181	−1.818	0.305	0.173	0.046	
DC_{be}	high	−0.047	0.014	−3.413	0.367	0.244	0.043	F
	base	−0.054	0.015	−3.617	0.305	0.173	0.045	
	low	−0.070	0.015	−4.704	0.425	0.303	0.042	I, R, F
L (Labor)	high	0.462	0.320	1.443	0.349	0.212	0.040	I, R
	base	0.328	0.321	1.019	0.302	0.166	0.045	
	low	0.153	0.319	0.479	0.338	0.204	0.044	F
CT (Central Tax Rate)	high	0.798	0.453	1.761	0.375	0.243	0.041	R, F
	base	−0.128	0.417	−0.306	0.302	0.166	0.045	
	low	−0.209	0.405	−0.052	0.347	0.215	0.044	I
PT (Provincial Tax Rate	high-	0.032	0.186	−0.170	0.411	0.283	0.042	I, R, F
	base	−0.251	0.195	−1.288	0.302	0.166	0.045	
	low	−0.251	0.195	−1.288	0.302	0.166	0.045	
DC_{ebe}	high	−0.316	0.144	−2.193	0.338	0.204	0.044	F
	base	−0.387	0.145	−2.660	0.302	0.166	0.045	
	low	−0.517	0.152	−3.392	0.349	0.212	0.044	I, R
L (Labor)	high	0.494	0.305	1.622	0.426	0.303	0.042	I, R
	base	0.349	0.309	1.131	0.373	0.250	0.044	
	low	0.205	0.306	0.669	0.405	0.283	0.043	F
CT (Central Tax Rate)	high	0.263	0.430	0.613	0.444	0.326	0.041	R, F
	base	−0.620	0.404	−1.536	0.373	0.250	0.044	
	low	−0.750	0.390	−1.923	0.423	0.305	0.042	I
PT (Provincial Tax Rate)	high	−0.062	0.163	−0.383	0.485	0.371	0.040	I, R, F
	base	−0.250	0.174	−1.440	0.373	0.250	0.044	
	low	−0.250	0.174	−1.440	0.373	0.250	0.044	
DC_{be}	high	−0.025	0.154	−1.603	0.405	0.283	0.043	F
	base	−0.027	0.016	−1.725	0.373	0.250	0.044	
	low	−0.044	0.015	−2.856	0.485	0.371	0.040	I, R, F
	high	−0.088	0.022	−3.972	0.444	0.326	0.041	R, F
DC_{ebe}	base	−0.097	0.023	−4.193	0.373	0.250	0.044	
	low	−0.101	0.022	−4.512	0.423	0.305	0.042	I

Note:
1. All estimations have considered provincial fixed effects, but the results are not reported here.
2. DC_{ebe} = decentralization measured by the ratio of consolidated provincial spending to consolidated central spending, expressed in per capita terms.
3. DC_{be} = decentralization measured by the ratio of provincial budgetary spending to central budgetary spending, expressed in per capita terms.
4. DC_{ebe} = decentralization measured by the ratio of provincial extra-budgetary to central extra-budgetary spending, expressed relative to the income size.
Source: See the data Appendix A.

Table 3
Estimates of alternative specifications. Dependent variable: real growth rate

Variable	(1) (1980–1992)	(2) (1985–1989)	(3) Base, average (1986–1992)	(4) Augmented base, average (1986–1992)	(5) GLS (consolidated) (1986–1992)	(6) GLS (budgetary) (1986–1992)	(7) GLS (extra-budgetary) (1986–1992)
Constant			0.104	0.01	0.163	0.203	0.298
			(4.130)	(0.195)	(4.992)	(5.446)	(7.188)
L (Labor)	0.088	0.863	−0.225	0.530	0.262	0.239	0.278
	(0.221)	(2.448)	(−0.406)	(1.300)	(0.865)	(0.798)	(0.977)
CT	0.38	−0.262			−0.331	−0.533	−0.606
(Central Tax Rate)	(0.841)	(3.147)			(−0.839)	(−1.342)	(−1.603)
PT	−0.204	−0.054	−0.076	−0.004	−0.315	−0.300	−0.232
(Provincial Tax Rate)	(−1.525)	(−0.285)	(−0.523)	(−0.037)	(−1.898)	(1.946)	(−1.566)
DC_{cbc}					−0.095		
					(−1.056)		
DC_{bc}	−0.011	−0.066	−0.003	−0.020		−0.022	0.001
	(−2.743)	(−3.147)	(−0.519)	(−2.85)		(−2.164)	(0.071)
DC_{ebc}							−0.090
							(−4.501)
R (Inflation Rate)				0.194			
				(0.324)			
F (Openness)				0.153			
				(5.21)			
I (Investment)				0.140			
				(2.33)			
Number of observations	308	134	28	28	196	196	196
Provincial fixed effect	Not included	Not included	Not included	Not included	Included	Included	Included
Adjusted *R*-square	0.039	0.182	−0.051	0.512			
Residual SS					0.349	0.341	0.306
S.E. Regression	0.090	0.043	0.022	0.015	0.043	0.043	0.040

Note:
1. Values of *t*-statistics appear in parentheses.
2. DC_{cbc} = decentralization measured by the ratio of consolidated provincial spending to consolidated central spending, expressed in per capita terms.
3. DC_{bc} = decentralization measured by the ratio of provincial budgetary spending to central budgetary spending, expressed in per capita terms.
4. DC_{ebc} = decentralization measured by the ratio of provincial extra-budgetary to central extra-budgetary spending, expressed relative to the income size.
Source: See the data Appendix A.

tion on growth appears weaker than in the base case, whereas in the sample of extensive decentralization, the negative effect becomes even stronger.

To introduce the second alternative specification, we estimate the base equation and the augmented base equation (including all the *M*- and *N*-variables) with average provincial data during 1986–92. The estimation of the base equation is shown in Column (3): the growth impact of decentralization is still negative, but not significant. The estimation of the augmented base equation is reported in Column (4), which presents a negative and significant coefficient for fiscal decentralization. In this column, we also note that the inflation rate has a positive and non-significant effect on growth, the effect of provincial openness is positive and statistically very significant, and the estimated coefficient of the investment rate is positive and significant.

The robustness of our results is further examined with random-effect estimations. Negative and significant coefficients for fiscal decentralization are found in two indicators for budgetary and extra-budgetary spending respectively as shown in columns (6) and (7). Column (5) shows a negative and insignificant sign for DC_{cbe}. The overall results from the random-effect estimations show their consistency with the fixed-effect estimations.

3.2.4. Impact of intersectoral allocation of central and provincial government spending on growth

Next we examine the expenditure pattern of central and provincial governments and its impact on growth in the context of fiscal decentralization. As an alternative, we measure the overall distortion in the economy by using the national tax rate, *NT*, defined as the ratio of national budgetary revenue to national GDP.[10] For fiscal decentralization, we use *DC*, measured by the ratio of provincial budgetary spending to central budgetary spending.[11] To measure the intersectoral allocation of government spending, we use the following variables:

- *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[12].

[10]Our results also hold qualitatively for the two measures of distortions, *CT* and *PT*, in our previous estimations.

[11]Since the data on functional distribution of extra-budgetary spending are not available, we limit our intersectoral analysis to budgetary spending only.

[12]Including expenses on capital construction, enterprise upgrading, technical R and 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[13].
- *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[14].
- *PHUM* = the share of provincial budgetary spending on human capital out of total provincial budgetary spending in each province.

The regression results are shown in Table 4.[15] The first column shows the estimates when only *DC*, spending variables, and the constant term are included. We find that fiscal decentralization is again negatively associated with real output growth; the coefficient is −1.79 and significant at the conventional 5% level.

In terms of the growth impact of government expenditures, the results for central and local government spending yield different pictures. Central spending on administration and development has a positive and significant impact on growth. For local expenditures, the growth impact of spending on administration and development is negative and significant. Both central and local government spending on human capital are positively but insignificantly associated with growth. Central government spending for defense gives an estimated coefficient that is negative and significant. Local government spending on urban maintenance and development gives an estimated coefficient that is positive but insignificant.

The second column shows estimates when provincial fixed effects are included. The estimate for fiscal decentralization, *DC*, is still negative and significant. The relationship between growth and government spending found in the first column remains unchanged.

Columns 3, 4, and 5 report estimation results when variables such as the investment rate, the share of foreign trade, and the inflation rate are included. The results show that the negative correlation between fiscal decentralization and growth is consistently stable under various control scenarios. The estimation results of government-spending variables reported in Column (1) do not change significantly.

[13]Including expenses on culture, education, health care, and science.
[14]Including urban maintenance and urban youth employment.
[15]The sample period here is 1987 to 1993.

Table 4
Effect of intersectoral and intergovernmental allocation of budgetary expenditure: national perspective, 1987–1993. Dependent variable: real growth of provincial GDP

Independent variables	(1)	(2)	(3)	(4)	(5)
Constant	3.123				
	4.018				
NT (National tax rate)	−10.055	−10.634	−10.792	−10.872	−14.699
	(−3.311)	(−3.801)	(−3.836)	(−4.064)	(−2.514)
L (Labor)	0.296	0.289	0.245	0.274	0.295
	(0.902)	(0.697)	(0.585)	(0.640)	(0.685)
DC	−1.788	−1.996	−1.959	−1.993	−2.504
	(−2.723)	(−3.291)	(−3.229)	(−3.428)	(−2.765)
CADM	6.932	7.481	7.867	7.548	9.216
	(4.094)	(4.626)	(4.595)	(4.562)	(3.283)
CDEV	1.074	1.118	1.149	1.205	1.681
	(2.833)	(3.207)	(3.298)	(3.614)	(2.311)
CDFN	−6.226	−6.134	−6.519	−6.367	−7.795
	(−6.138)	(−6.492)	(−6.173)	(−6.011)	(−3.526)
CHUM	0.469	0.033	0.153	−0.040	−0.377
	(0.609)	(0.044)	(0.206)	(−0.056)	(−0.442)
PADM	−0.443	−0.393	−0.404	−0.334	−0.332
	(−4.176)	(−2.175)	(−2.201)	(−1.833)	(−1.813)
PDEV	−0.142	−0.177	−0.201	−0.246	−0.254
	(−1.446)	(−1.373)	(−1.520)	(−1.952)	(−2.006)
PHUM	0.505	0.179	0.294	0.338	0.304
	(3.911)	(1.044)	(1.581)	(1.899)	(1.65)
PURB	0.074	0.330	0.293	0.149	0.155
	(0.358)	(0.935)	(0.810)	(0.400)	(0.413)
I (investment)			−0.045	0.043	0.055
			(−0.536)	(0.462)	(0.581)
F (foreign trade)				0.094	0.068
				(1.115)	(0.750)
R (interest rate)					−0.120
					(−0.737)
Number of observations	136	136	135	125	125
Provincial fixed effect	Not included	included	included	included	included
R-Square	0.634	0.774	0.780	0.792	0.793
Adjusted *R*-Square	0.601	0.682	0.686	0.689	0.688
S.E. of regression	0.037	0.033	0.033	0.030	0.030

Note: *t*-statistics are in parentheses.
Source: See the data Appendix A.

4. Conclusions

The negative association between fiscal decentralization and provincial economic growth has been found to be consistently significant and robust in China. This finding is surprising in light of the conventional wisdom that fiscal decentralization usually makes a positive contribution to local economic growth.

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 results shown in Table 4, 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.

This finding also has some implications for other developing countries and transition economies pursuing fiscal decentralization. The merits of fiscal decentralization have to be measured relative to the existing revenue and expenditure assignments and the stage of economic development. The central government may be in a much better position to undertake public investment with nation-wide externalities in the early stages of economic development. More importantly, if local shares in total fiscal revenue and expenditure are already high, further decentralization may result in slower overall economic growth. In this connection, the dangers of decentralization put forward by Prud'homme (1995) seem to be empirically relevant.

Acknowledgements

For comments and suggestions, we thank Hamid Davoodi, Martha de Melo, Shantayanan Devarajan, Gang Fan, Bert Hofman, John H. Jia, Hongyi Li, Stephen McGurk, Ronald McKinnon, Charles McLure, Richard Newfarmer, Yingyi Qian, Terry Sicular, Hedy Sladovich, Berry Weingast, Christine Wong, Danyang Xie, and seminar participants at Stanford University and the World Bank. We are most grateful to two referees of this journal for their detailed and constructive suggestions, which led to a substantial revision of this paper. We also acknowledge financial assistance from the Washington Center of China Studies, the Ford Foundation, and the World Bank (research grant RPO 680-02). The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the World Bank, its Executive Directors, or the countries they represent.

Appendix A

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 1984–1994/95.
TAX = the degree of distortion in provincial economy, measured by NT, the national tax rate, CT, the central tax rate, and PT, the ratio of provincial revenue collection in provincial income.
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.
DC_{cbe} = decentralization measured by the ratio of per capita provincial spending to per capita 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.
DC_{be} = decentralization measured by the ratio of per capita provincial budgetary spending to per capita central budgetary spending.
Source: See sources of budgetary spending and of population.
DC_{ebe} = decentralization measured by the ratio of provincial extra-budgetary spending to central extra-budgetary spending, expressed relative to income.
Source: See sources for provincial income and of extra-budgetary spending.
DC = the ratio of local budgetary spending relative to central budgetary spending.
Source: See sources for budgetary spending.

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 and 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.

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.

References

Bahl, R.W., Linn, J., 1992. Urban public finance in developing countries. Oxford University Press, New York.

Bahl, R.W., Wallich, C., 1992. Intergovernmental fiscal relations in China. Working Papers, Policy Research Department, World Bank, Washington D.C.

Barro, R., 1990. Government spending in a simple model of endogenous growth. Journal of Political Economy 98, S103–S125.

Bird, R.M., Wallich, C., 1993. Fiscal decentralization and intergovernmental relations in transition economies: Towards a systematic framework of analysis. Country Economics Department Working Paper, World Bank, Washington D.C.

Bird, R.M., 1993. Threading the fiscal labyrinth: Some issues in fiscal decentralization. National Tax Journal XLVI (2), 207–227.

Davoodi, H., Zou, H., 1997. Fiscal decentralization and economic growth: A cross-county study. forthcoming, Journal of Urban Economics.

Davoodi, H., Xie, D., Zou, H.-f., 1995. Fiscal decentralization and economic growth in the United States. Policy Research Department, World Bank, Washington, D.C.

Devarajan, S., Vinaya, S., Zou, H., 1996. The composition of public spending and economic growth. Journal of Monetary Economics 37, 313–344.

Feder, G., 1983. On exports and economic growth. Journal of Development Economics 12, 59–73.

Gramlich, E.M., 1993. A policy-maker's guide to fiscal decentralization. National Tax Journal XLVI (2), 229–235.

Levine, R., Renelt, D., 1992. A sensitivity analysis of cross-country growth regressions. American Economic Review 82 (4), 942–963.

Oates, W.E., 1972. Fiscal federalism. Harcourt Brace Jovanovich, New York.

Oates, W.E., 1993. Fiscal decentralization and economic development. National Tax Journal XLVI (2), 237–243.

Prud'homme, R., 1995. The dangers of decentralization. The World Bank Research Observer, World Bank, Washington D.C.

Wang, S., A. Hu, 1993. Report on China's state capacity (Zhongguo guojia nengli baogao). Shengyang, China: Liaoning People's Press.

Wong, C.P.W., Heady, C., Woo, W.T., 1993. Economic reform and fiscal management in China: Report of technical assistance project. Asian Development Bank and Ministry of Finance of China.

World Bank, 1990. Revenue mobilization and tax policy. A World Bank Country Study, World Bank, Washington D.C.

World Bank, 1992. China: Reforming intergovernmental fiscal relations. World Bank Discussion Papers, China and Mongolia Department, Washington D.C.

World Bank, 1995. Macroeconomic stability in a decentralized economy. China and Mongolia Department, World Bank, Washington D.C.

World Bank, 1996. The Chinese economy: Fighting inflation, deepening reforms. China and Mongolia Department, World Bank, Washington D.C.

Zhou, X., Yang, Z., 1992. Fiscal management and tax system in China: Problems and solutions (Zhongguo caishui tizhi de wenti yu chulu). Tianjin People's Press, Tianjin, China.

Part IV

Income Distribution and Growth

14

The Economic Journal, 108 (*January*), 26–43. © Royal Economic Society 1998. Published by Blackwell Publishers, 108 Cowley Road, Oxford OX4 1JF, UK and 350 Main Street, Malden, MA 02148, USA.

EXPLAINING INTERNATIONAL AND INTERTEMPORAL VARIATIONS IN INCOME INEQUALITY*

Hongyi Li, Lyn Squire and Heng-fu Zou

This paper explores the propositions that, income inequality is relatively stable within countries; and that it varies significantly among countries. A new and expanded data set provides broad support for both propositions. Drawing on a political economy and capital market imperfection arguments to explain the intertemporal and international variation in inequality, the empirical analysis shows that the predicted variables associated with the first argument (a measure of civil liberties and the initial level of secondary schooling) and the second argument (a measure of financial depth and the initial distribution of land) are indeed important determinants of inequality.

This paper explores two propositions regarding income inequality. They are: first, income inequality is relatively stable within countries; and second, it varies significantly across countries.[1] To illustrate, note that the Gini coefficient in India remained almost constant for forty years (1951–92) with mean 32.6 and standard deviation 2.0.[2] In contrast, the variation in Gini coefficients across countries is large: 61.9 in Honduras in 1968 compared with 17.8 in Bulgaria in 1976. If substantiated, these propositions have potentially significant implications for poverty. The significance of the first is obvious – barring any fundamental socio-political change, poverty reduction will depend crucially on the rate of economic growth. Given this, the significance of the second is that in inegalitarian economies the poor will enjoy a smaller share of any national increment in income than in more egalitarian ones.

Drawing on a new and expanded data set on inequality (Deininger and Squire, 1996*a*), the first of the paper's three sections conducts standard statistical tests of the two propositions. The sample comprises 573 observations on the most common measure of inequality – the Gini coefficient – for 49 developed and developing countries covering the period 1947–94. The results broadly confirm our two propositions. Specifically, analysis of variance (ANOVA) shows that about 90% of the total variance in the Gini coefficients

* The authors wish to thank Paul Armington, Francois Bourguignon, Klaus Deininger, Shanta Devarajan, Bill Easterly, Sebastian Edwards, Gary Fields, Emmanuel Jimenez, Ross Levine, Branko Milanovic, Vikram Nehru, Lant Pritchett, Martin Ravallion, Mary Shirley, Holger Wolf, Chi-wa Yuen and participants at a World Bank workshop for very helpful comments on an earlier version of this paper. We are very grateful to the two referees and Timothy Beasley (the editor) for their detailed suggestions, which led to a substantial revision of the paper. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the World Bank, its Executive Directors, or the countries they represent. The paper should not be cited without the authors' permission.

[1] We also explore a weaker, combined version of these two propositions – namely, that intertemporal shifts in inequality are modest compared with international differences.

[2] The mean Gini coefficient for India reported in Table 2 is 39.15. This is after the data have been adjusted for difference in definitions. The mean for the unadjusted data is 32.55.

can be explained by variation across countries, while only a small percentage of the total variance is due to variation over time. Similarly, regression analysis reveals significant differences across countries, and fails to detect any significant time trend in 32 countries. Moreover, in 10 of the 17 cases where the data reveal a significant trend, it is quantitatively small – an annual change of less than 1.0% of the country's average Gini coefficient. To take a typical example, Jamaica shows a statistically significant and negative time trend but the change in its Gini coefficient from its 1980 value of 49.9 would be only 0.2 points a year. At this rate, it would take Jamaica 70 years to bring its Gini index in line with the average index for all countries in our sample – 36.2. In this sense, the observed intertemporal changes are small relative to the observed differences across countries. On the other hand, seven of the countries in the sample have annual changes in excess of 1.0% indicating that in certain circumstances inequality as measured by the Gini index can change more quickly – in China the index was increasing during our sample period at a rate of 3% a year, the largest rate of change that we observed. What actually happened in these seven countries is an interesting issue for future research.

In general, our results suggest that inequality is determined by factors which differ substantially across countries but tend to be relatively stable within countries. The second section of the paper explores some possible determinants of inequality. To do so, it draws on two ideas that have recently received attention in the literature on inequality and growth. The first posits a link from income or wealth inequality to policy via a political economy argument. In its simplest form, the rich are assumed to have the resources to lobby for policies which are beneficial to them but may be harmful to the rest of the economy and to growth (see Bertola, 1993). The second idea has to do with imperfections in the market for credit. By preventing the poor from making productive investments (such as education), credit constraints arising from asymmetric information perpetuate a low and inequitable growth process (see, for example, Banerjee and Newman, 1991). Taken together, the two ideas suggest that an initial state of inequality may be expected to continue because the rich have the capacity to protect their wealth while the poor are unable to augment theirs.

We find considerable support for both these ideas. In particular, the key variables associated with the political economy argument (a measure of political freedom and initial secondary schooling) and those associated with the capital market imperfection (the initial degree of inequality in the distribution of assets as measured by the distribution of land and a measure of financial market development) are all shown to be significant determinants of current inequality. This suggests that the rich are indeed able to exercise sufficient control over economic policy at least to maintain their wealth while the non-rich encounter capital market imperfections that limit their capacity to accumulate capital, again reinforcing the tendency for unequal distributions of income to remain so. To check the robustness of our main findings, we conduct sensitivity analysis by controlling for various other factors identified in both theoretical and empirical work on inequality and growth. The results

suggest that our findings are quite robust. Section 3 concludes by linking our results to previous work on the relationship between growth and inequality.

1. Testing the Two Propositions

This paper uses a new data set on Gini coefficients.[3] Starting with a total of 2,480 observations on Gini coefficients covering 112 developed and developing countries for the years 1947–94, several criteria were used to 'cleanse' 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; and third, all sources of income and uses of expenditure had to be accounted for, including own-consumption. In addition, for the purpose of this paper, all observations had to be from countries with at least four observations covering a reasonable part of the 47 year period. These procedures resulted in a sample of 573 observations covering 49 countries. This is the data set used in this study. Before presenting the sample descriptive statistics, we note two points.

First, the definition of 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. The distribution of our sample by definitional differences is shown in Table 1. Because variation in definition can undermine the international and intertemporal comparability of the data, we include controls for different definitions throughout Section 1. The results indicate that differences between coefficients defined on net and gross income and between household-based and individual-based coefficients are not significant. Differences between expenditure-based and income-based coefficients, however, are significant. In subsequent analysis, therefore, we have adjusted the data following the procedure recommended by Deininger and Squire (1996*a*). Specifically, we adjust for differences between income-based and expenditure-based coefficients by systematically increasing the latter by 6.6 points, this being the average difference observed by Deininger and Squire (1996*a*).

Table 1

Distribution of Gini Coefficients by Different Definitions

	Income			
Unit of observation	Gross	Net	Expenditure	Total
Household	240	73	19	332
Individual	102	78	61	241
Total	342	151	80	573

[3] For further details see Deininger and Squire (1996*a*).

Second, the method used to calculate the Gini coefficients also varies across different sources. To minimise this problem we have recalculated the coefficients using a standard technique for as many observations as possible.[4]

With these points in mind, basic descriptive statistics for the adjusted data are reported in Table 2. Here we simply note that the overall sample mean is 36.2 and the standard deviation is 9.2. The number of observations per country is as follows: 28 countries have between 4 and 9 observations; 14 countries have between 10 and 19 observations; and 7 countries have 20 or more. In general, the developed countries have longer series and better coverage than the developing ones. As a preliminary test of our two propositions, note that the standard deviation of the means of the 49 countries (9.3) is substantially greater than any of the standard deviations of the within-country Gini coefficients for each country (see Table 2).

We begin with an analysis of the variance components of the Gini coefficients using the raw data. Table 3 reports the ANOVA results. Allowing for the fact that we have an unbalanced data set, we find that for the entire sample (Data set 1), 91.8% of the variance is cross-country variance, while only 0.85% is over-time variance. A total of 0.4% is due to the differences in definitions. Based on the F-values, only the country variation and variation due to income/expenditure definition are significant. After adjusting for the income/expenditure definition differences as described above (Data set 2), the ANOVA results show that the variance due to income/expenditure drops from 0.34% to 0.04% and is statistically no longer significant. This provides statistical evidence that the adjustment is necessary and useful.

Disaggregating the data (unadjusted) by income level according to the classification in the World Development Report, we obtain similar results. For high-income countries (Data set 3), the cross-country variance is 82.5% and the over time variance is only 1.9%. The corresponding figures for lower- and middle-income countries (Data set 4) are 93.1% and 1.4%. In this case, the variation due to income/expenditure definition is significant since most of the differences in income/expenditure occurs in this group. But, with the adjusted data, remaining variations due to definition are small and insignificant. We also repeated the ANOVA exercise for three subsamples in which we progressively increased the consistency of definitions: a subsample containing Gini coefficients based only on income (493 observations); a subsample containing only income-based and household-based Gini coefficients (313 observations); and a subsample containing coefficients defined on gross income per household (239 observations). In each case, the results (not reported) indicate that about 90% of the variation can be explained by country variation, while variation over time is small (1.1 to 1.7%).

We now turn to a least squares dummy variable regression which allows us to study individual country specific effects and perform explicit hypothesis testing

[4] The computational tool (POVCAL) we used for recalculating the Gini coefficients is discussed in detail in Datt (1992).

Table 2

Summary Statistics of Gini Coefficients (Adjusted for differences in definitions)

Code	Nob	Mean	St. dev.	Max	Min	Max–min	Coverage
AUS	9	37.88	2.91	41.72	32.02	9.70	69 ~ 90
BEL	4	27.00	0.76	28.25	26.22	2.03	79 ~ 92
BGD	10	35.83	1.55	39.00	33.34	5.66	63 ~ 92
BGR	28	23.30	3.34	34.42	17.83	16.59	63 ~ 93
BHS	11	45.77	3.91	54.09	40.64	13.45	70 ~ 93
BRA	14	57.84	2.82	61.94	53.00	8.94	60 ~ 89
CAN	23	31.27	1.64	32.97	27.41	5.56	51 ~ 91
CHL	5	51.84	5.15	57.88	45.64	12.24	68 ~ 94
CHN	12	32.68	3.62	37.80	25.70	12.10	80 ~ 92
COL	7	51.51	2.48	54.50	46.00	8.50	70 ~ 91
CRI	9	46.00	2.80	50.00	42.00	8.00	61 ~ 89
CSK	12	22.25	2.29	27.19	19.37	7.82	58 ~ 92
DEU	7	31.22	1.58	33.57	28.13	5.44	63 ~ 84
DNK	4	32.08	1.09	33.20	30.99	2.21	76 ~ 92
DOM	4	46.94	2.90	50.46	43.29	7.17	76 ~ 92
ESP	8	32.85	1.73	37.11	31.02	6.09	65 ~ 89
FIN	12	29.93	2.08	32.04	26.11	5.93	66 ~ 91
FRA	7	43.11	5.62	49.00	34.85	14.15	56 ~ 84
GBR	31	25.98	2.56	32.40	22.90	9.50	61 ~ 91
HKG	7	41.58	2.60	45.18	37.30	7.88	71 ~ 91
HND	7	54.49	3.36	61.88	50.00	11.88	68 ~ 93
HUN	9	24.65	3.36	32.24	20.97	11.27	62 ~ 93
IDN	11	40.09	2.07	45.19	37.30	7.89	64 ~ 93
IND	31	39.15	2.03	43.65	35.77	7.88	51 ~ 92
IRN	5	49.83	1.26	52.05	48.48	3.57	69 ~ 84
ITA	15	34.93	2.52	41.00	32.02	8.98	74 ~ 91
JAM	9	48.77	2.84	54.31	44.52	9.79	58 ~ 93
JPN	23	34.82	1.32	37.60	32.50	5.10	62 ~ 90
KOR	14	34.19	2.54	39.10	29.82	9.28	53 ~ 88
LKA	9	42.45	4.52	47.80	35.30	12.50	53 ~ 90
MEX	9	54.59	2.76	57.90	50.00	7.90	50 ~ 92
MYS	6	50.36	1.79	53.00	48.00	5.00	70 ~ 89
NLD	12	28.59	0.91	29.68	26.66	3.02	75 ~ 91
NOR	9	34.21	2.73	37.52	30.57	6.95	62 ~ 91
NZL	12	34.36	2.78	40.21	30.04	10.17	73 ~ 90
PAK	9	38.10	0.81	39.04	36.51	2.53	69 ~ 91
PAN	4	52.42	4.34	57.00	47.47	9.53	70 ~ 89
PHL	7	47.62	2.27	51.32	45.00	6.32	57 ~ 91
POL	17	25.69	2.44	33.06	20.88	12.18	76 ~ 93
PRT	4	36.60	0.59	37.23	35.63	1.60	73 ~ 91
SGP	6	40.12	1.65	42.00	37.00	5.00	73 ~ 89
SWE	14	31.74	1.42	33.41	27.31	6.10	67 ~ 92
THA	8	45.48	3.54	51.50	41.28	10.22	62 ~ 92
TTO	4	46.21	3.28	51.00	41.72	9.28	58 ~ 81
TUN	5	49.11	1.26	50.60	46.84	3.76	65 ~ 90
TWN	26	29.62	1.50	33.60	27.70	5.90	64 ~ 93
USA	45	35.28	1.27	38.16	33.50	4.66	47 ~ 91
VEN	9	44.42	4.02	53.84	39.42	14.42	71 ~ 90
YUG	10	32.62	0.95	34.73	31.18	3.55	63 ~ 90
Overall	573	36.23	9.15	61.94	17.83	44.11	47 ~ 94

Note: Nob – Number of observations.

Table 3

Analysis of Variance of Gini Coefficients

Data set (Nob)	Source	DF	Sum of Squares	F-Value	Source	DF	Sum of Squares	F-Value	% of Total
1	Model	98	42,837.71	64.84	Country	48	42,262.78	130.61	91.81
(573)	Error	474	3,195.24		Time	47	389.10	1.23	0.85
	Total	572	46,032.95		Income	1	157.00	23.29	0.34
					Hhld.	1	27.91	4.14	0.06
					Gross	1	0.93	0.14	0.00
2	Model	98	44,716.93	67.69	Country	48	44,280.97	136.85	92.42
(573)	Error	474	3,195.24		Time	47	389.22	1.23	0.81
	Total	572	47,912.17		Income	1	17.90	2.66	0.04
					Hhld.	1	27.91	4.14	0.06
					Gross	1	0.93	0.14	0.00
3	Model	68	6,627.54	17.52	Country	19	6,449.03	61.00	82.49
(283)	Error	214	1,190.81		Time	46	149.67	0.58	1.91
	Total	282	7,818.35		Income	1	19.98	3.59	0.26
					Hhld.	1	2.99	0.54	0.04
					Gross	1	5.88	1.06	0.08
4	Model	75	33,320.84	55.98	Country	28	32,618.22	146.80	93.14
(290)	Error	214	1,698.23		Time	44	492.43	1.41	1.41
	Total	289	35,019.07		Income	1	164.73	20.76	0.47
					Hhld.	1	34.14	4.30	0.10
					Gross	1	11.32	1.43	0.03

Notes: 1: DF – Degrees of freedom
2: Descriptions for different data sets:
Data set 1: The whole sample, including all definitions.
Data set 2: The whole sample, adjusted for difference in income or expenditure definitions.
Data set 3: Subsample, high-income countries, including all definitions.
Data set 4: Subsample, low- and middle-income countries, including all definitions.

concerning the two propositions. Because we have seen that standard deviation of within-country Gini coefficients is small and because a plot of the Gini coefficients by country revealed trends for some countries, we consider a simple linear trend model:

$$g_{it} = \phi_i D_i + \theta_i t_i + \delta_1 d_1 + \delta_2 d_2 + \delta_3 d_3 + \omega_{it} \tag{1}$$

where g_{it} is the Gini coefficient, $i = 1, 2, \ldots, N$ (number of countries), $D_i = 1$ for country i and 0 otherwise, $t_i = 1, 2, \ldots, T_i$, and $\omega_{it} \sim \text{iid}(0, \sigma_\omega^2)$. The panel data are unbalanced since in general $T_i \neq T_j$ for $i \neq j$. In light of the ANOVA results, we use the adjusted data but include definitional dummies to test for any remaining effect. d_1 is the control dummy for income $(=1)$/expenditure $(=0)$; d_2 is the control dummy for households $(=1)$/individual $(=0)$; d_3 is the control dummy for gross income $(=1)$/net income $(=0)$.

We would like to know whether, after controlling for the differences in definitions, the difference between the country specific effects $\phi_1, \phi_2, \ldots$, and ϕ_N is statistically significant or not and we want to test for the existence of a

significant, within-country time trend, $\theta_1, \theta_2, \ldots, \theta_N$. Accordingly, we test the following two hypotheses:

(a) $H_0^a: \phi_1 = \phi_2 = \ldots = \phi_N$,
(b) $H_0^b: \theta_i = 0$, for $i = 1, 2, \ldots, N$.

Based on the F-statistic in Table 4, hypothesis (a) is rejected at a 5% significance level. This confirms our first proposition – Gini coefficients differ significantly across countries. For individual time trends, we find statistical support for our second proposition in 32 of the 49 countries or 65% of the

Table 4

LSDV Estimation Results (Unrestricted Regression)

Dep var.: GINI

Control Dummy			Income		Households			Gross	
Estimate			4.00		−0.35			−0.80	
t-value			1.70		−0.61			−1.13	
Country Code	Country-specific	t-value	Trend Estimate	t-value	Country Code	Country-specific	t-value	Trend Estimate	t-value
AUS	34.18	13.90	0.35	3.04*	ITA	31.48	12.96	−0.37	−3.31*
BEL	23.62	8.03	−0.10	−0.44	JAM	49.77	59.58	−0.20	−2.77*
BGD	32.71	13.21	0.01	0.12	JPN	31.49	13.07	−0.02	−0.40
BGR	20.58	8.05	0.20	4.04*	KOR	31.89	12.89	0.10	1.68
BHS	43.47	17.77	−0.30	−3.65*	LKA	39.21	18.59	−0.09	−1.22
BRA	54.76	22.20	0.05	0.61	MEX	51.60	20.11	0.01	0.25
CAN	27.89	11.66	−0.06	−1.35	MYS	46.96	18.45	−0.17	−1.19
CHL	48.65	18.51	0.51	5.04*	NLD	24.20	9.74	0.11	0.83
CHN	24.72	8.70	0.80	4.54*	NOR	29.79	12.05	−0.22	−2.73*
COL	48.40	19.03	0.00	0.00	NZL	30.14	12.36	0.49	4.15*
CRI	42.71	17.01	−0.16	−1.74	PAK	38.10	52.02	0.06	0.71
CSK	18.65	7.12	−0.04	−0.60	PAN	49.48	18.25	−0.01	−0.08
DEU	28.34	11.23	0.13	1.10	PHL	43.83	17.24	−0.11	−1.66
DNK	27.85	10.44	0.21	1.13	POL	21.12	8.14	0.31	2.95*
DOM	42.31	14.51	0.34	1.88	PRT	34.96	18.67	−0.31	−1.62
ESP	33.26	40.47	−0.13	−1.24	SGP	36.89	14.61	0.01	0.09
FIN	25.98	10.54	−0.14	−1.35	SWE	27.71	11.34	0.01	0.13
FRA	34.22	12.97	−0.58	−6.40*	THA	42.16	17.09	0.31	4.10*
GBR	23.07	8.87	0.18	4.21*	TTO	41.76	14.90	−0.15	−1.15
HKG	38.44	15.47	0.21	1.71	TUN	49.57	43.57	−0.04	−0.37
HND	54.17	20.29	−0.37	−3.50*	TWN	25.97	9.99	−0.02	−0.43
HUN	21.04	8.02	0.14	1.92	USA	32.76	13.75	0.06	2.48*
IDN	40.69	45.87	−0.04	−0.50	VEN	41.16	16.23	0.27	2.26*
IND	38.41	50.02	−0.10	−3.29*	YUG	29.60	11.53	0.06	0.61
IRN	49.96	30.19	−0.03	−0.18					
NOB	573		R^2	0.95					
DF	472		F–Test	126.03					
Groups	49								

Notes: 1. Standard errors of individual country specific effects: 9.89.
2. For hypothesis (a), the F-statistic is 126.03. This leads to the rejection of hypothesis (a).
3. For hypothesis (b), 7 countries have significant negative trend, 10 countries have significant positive trend. (There is a total of 17 countries with significant trends (indicated by (*).)
4. The country-specific terms are equivalent to the 1980 predicted Gini coefficients.

sample.[5] For 7 countries, however, we find significant negative trends, while 10 countries have significant positive trends when we apply the 5% t-test. But of the 17 countries with a significant trend, 10 of them have time trends that are quantitatively small – defined here as an annual change of less than 1.0% of the country's 1980 predicted Gini coefficient, the estimated country-specific term in the regression reported in Table 4. This is, of course, an arbitrary cut-off point. We note, however, that applying the mean absolute rate of change (0.6% a year) for these 10 countries to the average Gini coefficient (36.2) for our entire sample, it would take more than 20 years for the index to move 5 points. This compares with a difference between the maximum and minimum 1980 predicted values for each country of 36.1 points. Thus, whether or not one considers movements of 0.6% a year quantitatively large, it is clear that intertemporal changes are very modest compared with international differences.

For seven countries (Australia, Chile, China, France, Italy, New Zealand, and Poland), however, we observe a statistically large and quantitatively important time trend, thus establishing that countries can change the degree of inequality as measured by the Gini coefficient relatively quickly. For example, the results for New Zealand indicate an annual change of 1.6% implying that a change of 5 points in the Gini index could be achieved in only 10 years. The factors affecting changes of this magnitude in these 'non-conforming' countries present an interesting opportunity for future research. Here we simply note that four of the countries – Australia, France, Italy, and New Zealand – are OECD countries where the fiscal system in general and the welfare system in particular are well developed so that, given the political will, it should be feasible to influence inequality. And in the remaining countries, China and Poland have of course been experiencing major structural changes during the period covered by our sample.

Because we have less than 10 observations for 28 countries, the test for a significant trend may not be accurate. Reducing the sample to only those countries with 10 or more observations, however, yields broadly similar results. For the 21 countries with at least 10 observations, the time trend is insignificant for 12 countries, and in the 9 countries where the time trend is significant it is quantitatively important (an annual change of more than 1% of the mean) in only four countries – China, Italy, New Zealand, and Poland. For the group of 21 countries, the average absolute trend is 0.16, or an average absolute percentage change of 0.52% per year. For the 7 countries with at least 20 observations, the results are even stronger. Three countries have an insignificant time trend, and of the other 4 none have a quantitatively important trend.

[5] Since most of the countries do not have enough observations to allow for suitable unit root tests, we have not pursued this approach. For the United States and United Kingdom, there are observable positive time trends since late 1970's and early 1980's. Since 1970, inequality in the United States has increased at a rate of 0.62% a year, while in the United Kingdom, the increase has been 1.37% a year. For the US data which have the longest time series, the simple Augmented Dickey-Fuller test suggests the presence of a unit root. However, in Raj and Slottje (1994), they found that the US Gini is stationary around a broken trend.

In fact, the average absolute trend for this group is only 0.1, while the average absolute percentage change is only 0.32% per year. Thus, for the countries where we have the most complete and reliable data, inequality appears to be quite stable over relatively long periods of time.

Recall that the results reported in Table 4 use the adjusted data for the Gini coefficient. With these data, we see that the definitional dummies are not significant. We also obtain broadly similar results for our two propositions (not reported) for the unadjusted data and in the subsample of observations with the same definition.

We have also estimated a random-effects model (with or without a time trend and using the adjusted data) to account for the loss of degrees of freedom in the LSDV regression. We assume that the country-specific effects are drawn from a random distribution, while at the same time controlling for the definition differences. The results are presented in Table 5. The only significant explanatory variable is the constant term with an estimated value of 37.7, close to the sample average. As a result of the large variation in Gini coefficients across countries, the constant has a standard error between 9.71 (without the time trend) and 9.82 (with the time trend) that is very close to the standard error of the country-specific effects (9.89) in the LSDV regression. Thus, the constant term in the random-effects model plays the same role as the country-specific terms in the LSDV regression, lending support to our assertion that the variations in inequality arise mainly from cross-country differences. Note also that the random-effects model provides no support for a general time trend: the mean value of the time trend is not significant with a 95% confidence interval of (−0.015, 0.035).

Taken together, these results provide substantial support for our two propositions. Thus, Gini coefficients are clearly different across countries (propo-

Table 5

Random-effects Regression of Gini Coefficients

Dep var.: GINI

	Model I		Model II	
	Estimate	t-value	Estimate	t-value
Constant	37.67	17.31	37.74	17.23
Income	1.07	0.57	1.03	0.55
Households	−0.43	−0.84	−0.52	−1.00
Gross	0.77	1.20	0.78	1.21
Trend			0.01	0.80
Nob	573		573	
DF	569		568	
Groups	49		49	

Notes: Standard errors of error terms: Individual constant terms: 9.71 (Model I), 9.82 (Model II).
Standard errors of error terms: White noise error: 2.63 (Model I), 2.63 (Model II).

sition one) and there is no evidence of a time trend in 32 countries or 65% of our sample (proposition two). In addition, the absolute magnitude of the time trends for the whole sample are quantitatively small (the biggest being 0.79 and the absolute average 0.18) compared with the cross-country variation. Moreover, for 10 (20% of the sample) of the 17 countries where we do identify a significant time trend, the data still support a weaker version of our two propositions – namely, that within-country intertemporal variation in the Gini coefficient is small relative to the variation across countries. At the same time, our data provide support for larger and faster changes in inequality in seven countries (14% of the sample). Thus, for the majority of countries – 42 out of 49 – inequality changes at best very slowly, suggesting that structural factors – economic, social, political, and demographic – play a crucial role in determining the level of inequality in a country and its evolution over time.

2. The Determinants of Inequality

In this section, we draw on two ideas that have received attention in the recent literature; see Benabou (1996) for a survey and further extensions. The first embeds the determination of policy in a political economy framework. This serves two functions: it renders policies endogenous, thus allowing us to focus on structural variables; and it gives those who wield political power the capacity to protect their wealth. And the second introduces private investment and a credit market imperfection that effects the accumulation of capital. This also serves two functions: it makes investment endogenous, again allowing us to focus on structural variables; and it makes it difficult for those without access to formal credit to accumulate capital. Thus, these two ideas fit well with our initial empirical conclusions – they point to the importance of structural variables which can differ markedly across countries but change only slowly within countries, and they introduce political forces and market imperfections that would tend to preserve an existing uneven distribution of wealth.

For simplicity, we focus on the behaviour of the richest segment of society, here called the 'rich minority', and the interaction between them on one side and the rest of society – the middle class and the poor termed here the 'poor majority' – on the other. Unlike the majority-rule models in Alesina and Rodrik (1994) and Persson and Tabellini (1994), we assume that the top group (the minority) can influence economic policy, not through the voting mechanism, but through its economic power (bribes) or through direct political control (most of the political leadership will be members of this group). The ability of the top group to influence power is, however, constrained by the degree of democratisation or political liberty and by the extent of education.

This approach reflects two considerations. First, the median-voter theory has not been well supported empirically. According to this theory, the median voter's distance from the average capital endowment in the economy will increase with wealth inequality, thus leading him or her to approve a tax rate that is higher the more unequal the distribution of wealth, which in turn reduces investment and economic growth. Thus in a democracy we would

expect higher inequality to be associated with lower growth. This is not substantiated by recent empirical work (Deininger and Squire, 1996*b*). On the contrary, they find that initial inequality is associated with lower growth in non-democratic countries, a conclusion that is consistent with the political economy mechanism modelled here. And second, for many of the countries and periods covered by our data the political setting cannot be characterised as democratic. Thus, we assume that, if sufficiently powerful, the rich minority can capture allocations of foreign exchange and credit, it can protect its own enterprises from foreign or domestic competition, it can influence public spending in favour of higher education and tertiary health care, and so on. While the interventions can take a multitude of forms, they basically amount to a tax on the rest of society. Such a characterisation may be appropriate for many of the developing countries included in our sample. For the more developed countries, the scope for exerting influence over policy would be much more constrained.

Both groups – the rich minority and the poor majority – can invest in capital. But, the presence of credit constraints arising from information asymmetries limits the ability of individuals to make productive investments in lumpy capital (Galor and Zeira, 1993, Banerjee and Newman, 1991, Greenwood and Jovanovic, 1990). In these circumstances, ownership of a collaterable asset can provide access to formal credit markets and cheaper credit. Since the rich are more likely to own collaterable assets, the cost of investing to the poor typically exceeds that to the rich. Thus, the poor have less incentive to invest in capital (because of the 'tax' imposed by the rich) and face higher costs of financing investment (through the credit market imperfection).

2.1. *Data and Estimation Methodology*

From the political economy argument, we experiment with two variables: a measure of civil liberties that can be expected to constrain the capacity of the rich to influence policy; and the initial level of secondary schooling on the assumption that a more educated population is able to exert a restraining influence on policy. For the poor's access to the financial market, we explore two variables – the depth of the financial sector and the initial distribution of land taken to be a collaterable asset. We expect that a more developed financial sector and a more equal distribution of land will ease the access of the poor to credit.

We use the adjusted data averaged over 5 year-periods in our empirical analysis for two reasons. First, although for most of the variables we have yearly observations, our data on Gini coefficients is more limited. Recall from Section 2 that for most of our 49 countries there are only a limited number of observations on income inequality – 28 countries have 4 to 9 observations each, while only 7 countries have more than 20 observations. By using 5-year averages we achieve a more balanced panel data set. Second, because our aggregate measures of inequality are relatively stable over time, using 5-year averages will not result in much loss of information. However, for other

variables use of 5-year averages will reduce short-run fluctuations and allow us to focus on the structural relationships of most interest to us.

2.2. *Base Regression*

Based on the above considerations we test a parsimonious base regression of the form:

$$g_{it} = \alpha + \beta_1 MYSC60_i + \beta_2 CIVLIB_{it} + \beta_3 LDGINI_i + \beta_4 FNDP_{it} + u_{it} \qquad (2)$$

where $i = 1, 2, \ldots, N$ (country index), $t = 1, 2, \ldots, T$ (time index) and u_{it} is independent and identically distributed regression error. g_{it} is the Gini coefficient.[6] *MYSC60* is the initial mean years of secondary schooling (1960 data), *CIVLIB* is the civil liberty index, *LDGINI* is the initial Gini coefficient for the distribution of land, and *FNDP* is a measure of financial development (defined as $M2/GDP$).[7] We expect *MYSC60*, *CIVLIB*, *LDGINI*, and *FNDP* to have a negative, positive, positive, and negative effect respectively on income inequality. Table 6 summarises the results. According to the OLS results, all four variables have the right sign and are significant.

We conducted a standard test of serial correlation for the base regression residuals. The DW statistic indicates serial correlation and so we reestimated the regression with an AR(1) error specification. The coefficient estimates and their significance remain largely unchanged after correction of serial correlation. The base regression may, however, suffer from an endogeneity problem. Financial depth as measured by the ratio of $M2$ to GDP – may be subject to policy influence and may therefore be endogenous. That is, the very factors that allow the rich to control certain economic policies may also allow them to control various policies influencing the development of the financial market. For this reason, we reestimate the base regression using the instrumental variables method (IV) with lagged variables for the instruments. The IV estimates are in general similar to the OLS or the AR(1) estimates (see Table 6).

To provide a quantitative appreciation of these results, we also show in Table 6 the standardised coefficient estimates (based on the IV method) for each of the independent variables. The key result to emerge is that the variables associated with the financial market imperfection argument have a much greater influence on inequality than those associated with the political economy argument. Thus, the joint effect of a one-standard-deviation increase in financial depth and a one-standard-deviation reduction in the inequality of land distribution results in a reduction of 5.05 points in inequality. On the

[6] We have also estimated the base regression using the ratio of the top quintile's income share to that of the bottom 80% of the population as the dependent variable with little change in the results.

[7] Data description and sources: *MYSC60* – Human capital stocks, Nehru *et al.* (1995). *CIVLIB* – There are two indices in Gastil (various issues) measuring civil liberties and political rights. Since the two are highly correlated, we only use one of them – the civil liberty index – but interpret it broadly to capture both civil liberties and political rights. We use the five year average index for the period 1972–89 as reported in Barro and Lee (1994). The index is defined from 1 to 7, with 1 assigned to countries with the largest degree of civil liberties. *LDGINI* – World Bank. *FNDP* – Based on M2 and GDP data, IFS (IMF).

Table 6

Base Regression Estimation Results

Dep var.: GINI

	OLS		AR(1)		IV		
Variable	Estimate	t-value	Estimate	t-value	Estimate	t-value	Std. Est.
Constant	32.81	13.79	33.47	12.59	34.20	14.17	—
MYSC60	−4.55	−5.80	−5.29	−5.47	−4.36	−5.60	−0.32
CIVLIB	1.61	5.47	1.13	3.65	1.54	5.27	0.30
LDGINI	0.16	6.64	0.16	5.70	0.15	6.54	0.32
FNDP	−7.73	−3.17	−6.42	−2.49	−10.07	−3.90	−0.23
Nob:	166		166		166		
$\bar{R}^2$:	0.62		0.77				

Notes: The DW–statistics for OLS is 0.743.
The errors in AR(1) is specified as an AR(1) process. The estimated AR(1) coefficient is 0.65.
Instruments for *FNDP* in IV: lagged value *FNDP*.
Std. Est.: Standardised estimates. Same for Table 7 below.

other hand, the impact of a one-standard-deviation increase in civil liberties and a one-standard-deviation increase in secondary schooling yields only a reduction of 2.75 points in inequality.

2.3. *Regressions for the Poor and the Rich*

Our data set also allows us to run separate regressions for the incomes of the rich minority and the poor majority. We use the real income of the top quintile of the population to represent the income of the rich minority, and the real income of the bottom 80% to represent that of the poor majority. Using the real income variable from Summers and Heston (1995) and the share data from Deininger and Squire (1996*a*) we can easily obtain the income of the poor and the rich. We run the following regression for both the poor and the rich:

$$y_{it} = \alpha + \beta_1 MYSC60_i + \beta_2 CIVLIB_{it} + \beta_3 LDGINI_i + \beta_4 FNDP_{it} + v_{it} \quad (3)$$

where y_{it} is the income of the poor or the rich. Table 7 reports the results. As before we use the AR(1) specification for serial correlation and the instrumental variables method to deal with endogeneity.

The results for the income of the poor provide strong support for both the political economy argument and the capital market imperfection argument. The OLS results are robust to AR(1) specification or instrumental variables method. All coefficients are highly significant and have the right signs. The results for the rich show that coefficients on financial depth, the civil liberties index and secondary schooling are significant. The results are highly plausible. Development of the financial sector should benefit the rich as well as the poor, as should the degree of secondary education. The result with respect to civil liberties could be argued either way for the rich – political freedom and civil liberties could foster overall growth as well as constraining the ability of the

Table 7

Estimation Results for the Poor's and the Rich's Income Regressions

Dep var.:The Poor's Income ($000 dollars)

	OLS		AR(1)		IV		
Variable	Estimate	t-value	Estimate	t-value	Estimate	t-value	Std. Est.
Constant	5.02	6.17	4.17	5.28	4.68	5.62	—
MYSC60	1.44	5.73	1.37	5.10	1.41	5.68	0.32
CIVLIB	−0.77	−7.15	−0.51	−4.88	−0.75	−6.99	−0.40
LDGINI	−0.03	−3.58	−0.03	−4.05	−0.03	−3.50	−0.18
FNDP	3.59	4.16	5.09	6.81	4.13	4.50	0.27
Nob:	144		144		144		
$\bar{R}^2$:	0.66		0.84				

Notes: The DW-statistics for OLS is 0.59.
The errors in AR(1) is specified as an AR(1) process. The estimated AR(1) coefficient is 0.74.
Instruments for *FNDP* in IV: lagged value *FNDP*.

Dep var.: The Rich's Income ($000)

	OLS		AR(1)		IV		
Variable	Estimate	t-value	Estimate	t-value	Estimate	t-value	Std. Est.
Constant	2.48	4.52	1.82	3.38	2.39	4.27	—
MYSC60	0.85	4.99	0.84	4.59	0.84	5.01	0.32
CIVLIB	−0.40	−5.47	−0.19	−2.74	−0.39	−5.44	−0.36
LDGINI	0.002	−0.40	−0.08	−1.44	0.002	−0.36	−0.02
FNDP	2.12	3.66	3.47	6.91	2.26	3.66	0.26
Nob:	144		144		144		
$\bar{R}^2$:	0.54		0.78				

Notes: The DW−statistics for OLS is 0.61.
The errors in AR(1) is specified as an AR(1) process. The estimated AR(1) coefficient is 0.75.
Instruments for *FNDP* in IV: lagged *FNDP*.

rich to influence policy in their favour. Of interest is that the coefficient on the distribution of land is not significant for the rich. Because all of the rich would be expected to have access to credit markets, it would be reasonable to suppose that holdings of collateral assets would not be a significant determinant of the incomes of the rich.

Finally, we note that this disaggregation allows us a clearer understanding of the results that were obtained with inequality as the dependent variable. Taken together, the results for the base regression and the current regression suggest that a more egalitarian distribution of land benefits the poor but not the rich thus leading to improvements in inequality. And the results show that expansion of political liberties and secondary education and greater financial depth affect income growth for both the rich and the poor in the same direction, but in a way that also reduces inequality. Thus, from Table 7, we note that the joint impact of a one-standard-deviation decrease in the civil liberty index and a one standard-deviation increase in both initial secondary schooling and financial

depth results in an increase of $3,000 dollars in the incomes of the poor but only an increase of $1,600 dollars in the incomes of the rich.

Consistent with our overall approach, the independent variables behave like structural variables in the sense that they are different across countries but relatively stable within countries. For example, the Gini coefficient for the distribution of land in Thailand is 45.4 compared with 92.4 in Venezuela. Increasing Thailand's coefficient to that of Venezuela would increase the Gini coefficient from its fitted value of 41.8 to 49.6, an increase of about 7.8. On the other hand, substituting the final-period value of the variable for financial depth for its initial-period value, the Gini coefficient in Korea falls by only 0.2 (from 38.9 to 38.7), in Sri Lanka by 0.5 (from 42.6 to 42.1), and in Indonesia by 1.0 (from 47.2 to 46.2).

2.4. *Sensitivity Analysis of the Base Regression*

To complete our tests of robustness, we undertake a sensitivity analysis. We conduct a stepwise regression analysis by adding other variables discussed in the literature to the base regression. The results are summarised in Table 8.[8] We consider the following variables: initial real per capita GDP (*INIGDP*), gross domestic investment ratio (*INVSHR*), urbanisation ratio (*URB*), black market premium (*BMP*), terms of trade shocks (*TOTSK*), openness (*XGDP*) and per capita arable area (*AAREA*).[9] Two results emerge. First, throughout the sensitivity test, our four key variables keep the right sign, remain significant, and have values for the estimated coefficient similar to those in the base regression. Our results appear to be quite robust. Second, initial per capita income is the only additional variable which turns out to be significant in all the sensitivity regressions. The results indicate that higher-income countries tend to have more equal distributions of income. Given the relative constancy of inequality over time despite in some cases significant increases in income, this result suggests that initial income is proxying for a range of cross-country structural differences at the start of the sample period. All other variables are consistently insignificant.

The stepwise regressions may be subject to change according to the order in which the variables are added. We therefore conduct a sensitivity analysis similar to that of Levine and Renelt (1992). We select three variables from the pool of seven variables each time, add these three variables to our base regression, and see whether the parameters in our base regression are stable or not. This procedure gives a total of 36 regressions. The summary results are presented in Table 9.

[8] Since the AR(1) results and the IV results are quite similar to the OLS results, they are therefore not presented to conserve space.

[9] Data description and sources: *INIGDP* – Initial real per capita GDP, Summers and Heston (1994). *INVSHR* – Gross domestic investment to GDP ratio, National Accounts (World Bank). *URB* – Urbanisation ratio, World Tables (World Bank). *BMP* – Black market premium, Barro and Lee, (1994). *TOTSK* – Terms of trade shocks, defined as Δ ln (Export price) – Δ ln (Import price), IFS (IMF) and Trade Statistics (World Bank). *XGDP* – Export to GDP ratio, IFS (IMF). *AAREA* – Per capita arable area, World Bank.

Table 8

Sensitivity Analysis(I)

Dep var.: GINI

	Base Reg.	1	2	3	4	5	6	7
Constant	32.81	35.62	33.54	33.54	33.55	33.62	35.84	34.72
	(13.787)	(13.318)	(10.303)	(10.187)	(10.030)	(10.026)	(9.541)	(9.251)
MYSC60	−4.55	−3.51	−3.48	−3.48	−3.46	−3.51	−3.98	−3.96
	(−5.803)	(−3.874)	(−3.835)	(−3.820)	(−3.791)	(−3.823)	(−4.058)	(−4.087)
CIVLIB	1.62	1.15	1.14	1.14	1.21	1.20	1.15	1.11
	(5.472)	(3.236)	(3.208)	(3.197)	(3.321)	(3.304)	(3.168)	(3.073)
LDGINI	0.16	0.16	0.17	0.17	0.17	0.17	0.15	0.15
	(6.636)	(6.543)	(6.488)	(6.266)	(6.262)	(6.263)	(5.158)	(4.993)
FNDP	−7.74	−7.64	−8.61	−8.61	−8.64	−8.67	−7.56	−8.45
	(−3.171)	(−3.126)	(−3.322)	(−3.306)	(−3.283)	(−3.287)	(−2.826)	(−3.099)
INIGDP		− 0.54	−0.60	−0.60	0.62	−0.62	−0.80	−0.82
		(−2.225)	(−2.418)	(−1.967)	(−2.010)	(−2.008)	(−2.531)	(−2.344)
INVSHR			0.10	0.10	0.08	0.08	0.05	0.04
			(1.118)	(1.082)	(0.902)	(0.837)	(0.583)	(0.374)
URB				0.00	0.01	0.01	0.03	0.05
				(0.008)	(0.148)	(0.181)	(0.921)	(1.444)
BMP					−1.09	−1.15	−1.19	−1.39
					(−0.851)	(−0.896)	(−0.939)	(−1.106)
TOTSK						−1.33	−1.10	−1.22
						(−0.629)	(−0.522)	(−0.583)
XGDP							−0.06	−0.01
							(−1.551)	(−0.249)
AAREA								−0.02
								(−0.278)
Nob	166	163	163	163	162	162	159	155
$\bar{R}^2$:	0.62	0.61	0.61	0.61	0.61	0.60	0.62	0.62

Note: The t-statistics are reported in parentheses.

Table 9

Sensitivity Analysis (II)

Dep var.: GINI

		Estimate	t−value	$\bar{R}^2$	Extra variables		
Constant	Minimum	31.76	9.736	0.60	*INIGDP*	*BMP*	*TOTSK*
	Base Reg.	32.81	13.787	0.61			
	Maximum	37.54	11.963	0.62	*INIGDP*	*URB*	*BMP*
MYSC60	Minimum	−4.97	−5.756	0.60	*INIGDP*	*BMP*	*AAREA*
	Base Reg.	−4.55	−5.803	0.61			
	Maximum	−3.46	−3.800	0.61	*INIGDP*	*INVSHR*	*URB*
CIVLIB	Minimum	1.05	2.962	0.62	*INIGDP*	*INVSHR*	*AAREA*
	Base Reg.	1.62	5.472	0.61			
	Maximum	1.64	5.241	0.60	*INIGDP*	*BMP*	*TOTSK*
LDGINI	Minimum	0.14	5.336	0.62	*INIGDP*	*INVSHR*	*XGDP*
	Base Reg.	0.16	6.636	0.61			
	Maximum	0.17	6.457	0.60	*INIGDP*	*URB*	*XGDP*
FNDP	Minimum	−9.23	−3.445	0.61	*INIGDP*	*BMP*	*XDGP*
	Base Reg.	−7.74	−3.171	0.61			
	Maximum	−6.70	−2.693	0.62	*INIGDP*	*URB*	*TOTSK*

Table 9 shows the maximum and minimum values of the estimates (based on OLS), together with the base regression estimates. Again, all the coefficients for the base regression variables are consistent with those in the base regression and statistically significant. For secondary schooling, the civil liberty index, land distribution and financial depth the ranges are (−4.97, −3.46), (1.05, 1.64), (0.14, 0.17) and (−9.32, −6.7), respectively. In short, the coefficient estimates for our four variables are fairly stable and insensitive to various extra regressors. Note that the range for the coefficients of initial income is (−0.81, −0.47) and significant in most of the regressions.

3. Conclusion

To conclude, we briefly link our results to other work on inequality. The first result of this paper – the relative stability of inequality over time – runs counter to one of the most famous conjectures in economics – Kuznets' hypothesis asserting an inverted U-shaped relationship between inequality and income. Although the analysis performed here does not constitute a direct test of the Kuznets hypothesis, the very fact that inequality has been shown to be relatively stable while incomes have almost certainly increased significantly during the 40-year period under study suggests that there is unlikely to be much support in the data for the systematic relationship between inequality and income suggested by Kuznets. Indeed, a more formal test of the Kuznets Hypothesis using the data employed in this paper finds little support for the conjecture (Deininger and Squire, 1996*b*). Rather than treating the inverted-U as a 'stylised fact' of development (Adelman and Robinson, 1989), the data presented here suggest instead that relative stability through time is a much more accurate representation.

Given this, our other result – that inequality differs significantly across countries – assumes importance in the light of recent research suggesting a relationship between initial inequality and subsequent growth (Alesina and Rodrik, 1994, Persson and Tabellini, 1994, Clarke, 1995). If the negative relationship between initial inequality and subsequent growth is indeed supported by the data, then inequitable economies will be condemned to lower growth rates far into the future because inequality is relatively stable. To illustrate, Clarke (1995) notes that a reduction in inequality from one standard deviation above the mean to one standard deviation below the mean would increase the long-term growth rate by approximately 1.3% per annum. This is not an insignificant increase in the growth rate. Even so, our results suggest that on average such a shift in inequality could take almost 70 or even 150 years when evaluated at the average absolute trends based on countries with at least 10 or 20 observations, respectively. Thus, while differences in inequality may explain a part of the difference in growth rates across countries, reducing inequality does not emerge as a simple remedy for increasing growth.

That said, the paper does identify the variables that influence inequality. Our results suggest that inequality is largely determined by factors that change only slowly within countries but are quite different across countries. The two

channels identified in the recent literature – the political economy argument and the capital market imperfection channel – received strong support from the empirical analysis with the latter appearing to have the greater influence.

Chinese University of Hong Kong

The World Bank

The World Bank and Wuhan University

Date of receipt of first submission: July 1996
Date of receipt of final typescript: March 1997

References

Adelman, I. and Robinson, S. (1989). 'Income distribution and development.' In *Handbook of Development Economics*, vol. II (ed. H. Chenery and T. N. Srinivasan), pp. 949–1003. Amsterdam: North-Holland.

Alesina, A. and Rodrik, D. (1994). 'Distributive politics and economic growth.' *Quarterly Journal of Economics*, vol. 109, no. 2 (May), pp. 465–90.

Banerjee, A. V. and Newman, A. F. (1991). 'Risk-bearing and the theory of income distribution.' *Review of Economic Studies*, vol. 58, no. 2 (April), pp. 211–35.

Barro, R. J. and Lee, J.-W. (1994). 'Data set for a panel of 138 countries.'

Benabou, R. (1996). 'Inequality and Growth.' Forthcoming, NBER *Macroeconomics Annual*.

Bertola, G. (1993). 'Factor shares and savings in endogenous growth.' *American Economic Review*, vol. 83, no. 5 (December), pp. 1184–201.

Clarke, G. R. G. (1995). 'More evidence on income distribution and growth.' *Journal of Development Economics*, vol. 47, no. 2 (August), pp. 403–27.

Datt, G. (1992). 'Computational tools for poverty measurement and analysis.' Policy Research Department, The World Bank.

Deininger, K. and Squire, L. (1996*a*). 'Measuring income inequality: a new data base.' *The World Bank Economic Review*, vol. 10, pp. 565–91.

Deininger, K. and Squire, L. (1996*b*). 'Inequality and growth: results from a new data set.' Policy Research Department, The World Bank.

Galor, O. and Zeira, J. (1993). 'Income distribution and macroeconomics.' *Review of Economic Studies*, vol. 60, no. 1 (January), pp. 35–52.

Gastil, R. *Freedom in the World*. Westport: Greenwood, various issues.

Greenwood, J. and Jovanovic, B. (1990). 'Financial development, growth, and the distribution of income.' *Journal of Political Economy*, vol. 98, no. 5 (October), pp. 1076–107.

IMF *International Financial Statistics*, various issues.

Levine, R. and Renelt, D. (1992). 'A sensitivity analysis of cross-country growth regressions.' *American Economic Review*, vol. 82, no. 4 (September), pp. 942–63.

Nehru, V., Swanson, E. and Debey, A. (1995). 'A new database on human capital stock in developing and industrial countries: sources, methodology, and results.' *Journal of Development Economics*, vol. 46, no. 2 (April), pp. 379–401.

Persson, T. and Tabellini, G. (1994). 'Is inequality harmful for growth?' *American Economic Review*, vol. 84, no. 3 (June), pp. 600–21.

Raj, B. and Slottje, D. J. (1994). 'The trend behavior of alternative income inequality measures in the United States from 1947–1990 and the structural break.' *Journal of Business and Economic Statistics*, vol. 12, no. 4 (October), pp. 479–87.

Summers, R. and Heston, A. (1994). 'Penn world table (Mark 5.6)'.

World Bank *World Tables*, various issues.

15

Review of Development Economics, 2(3), 318–334, 1998

Income Inequality is not Harmful for Growth: Theory and Evidence

*Hongyi Li and Heng-fu Zou**

Abstract

The paper shows that income inequality may theoretically lead to higher economic growth if public consumption enters the utility function. Empirically, baseline estimations and a sensitivity analysis show that income inequality is positively, and most of the time significantly, associated with economic growth. These findings stand in sharp contrast to the negative association between inequality and growth propounded by Alesina and Rodrik and by Persson and Tabellini.

1. Introduction

This paper reexamines the relationship between income distribution and economic growth. We consider a more general theoretical framework than Alesina and Rodrik (1994) by dividing government spending into production services and consumption services—the former enter the production function while the latter enter the utility function. With this extension it is found that, within a typical political-economy mechanism (the majority rule) on income taxation, more equal income distribution can lead to higher income taxation and lower economic growth; and in general, income inequality has an ambiguous effect on economic growth. This stands in sharp contrast to the theoretical result obtained by Alesina and Rodrik,[1] who focused on the productive services of government spending and found a definite negative link between them.

On the empirical side, we present an extensive statistical analysis to test the relationship between income inequality and economic growth on the basis of a much improved and expanded dataset on income distribution compiled recently by Deininger and Squire (1996). When regressing the GDP growth rate on the Gini coefficients and other typical explanatory variables, the estimated regression coefficients for the Gini coefficients are positive in all cases and even significant in many cases considered here. This empirical finding supports the more general theoretical result of our model.

In section 2 we present a simple model that may give rise to a positive relationship between income inequality and economic growth. Section 3 presents the empirical analysis in which we explain the data and methodology, summarize the results of the base regression, and conduct some sensitivity analysis. Section 4 concludes.

2. A Simple Model on the Positive Relationship between Income Inequality and Economic Growth

In this section, we focus on a model that can generate a positive relationship between inequality and growth. Whereas Alesina and Rodrik (1994) follow Barro (1990) to

* Li: Faculty of Business Administration, Chinese University of Hong Kong, Hong Kong. Tel: (852) 2609-7796; Fax: (852) 2643-5561; E-mail: hongyi@baf.msmail.cuhk.edu.hk. Zou: Institute for Advanced Studies, Wuhan University, Wuhan, China 430072; and Development Research Group, World Bank, Room MC2-611, 1818 H St. NW, Washington, DC 20433, USA. Tel. (202)473-7939; Fax: (202) 522-1154; E-mail: zou@worldbank.org.

define all government spending as an input in production, we divide government spending into production services and consumption services. This division has already been made by other authors since the seminal contribution by Arrow and Kurz (1970), and explicitly by Barro (see Barro, 1990, section V). In the special case presented here, government spending enters only the utility function.

An individual i has the following CES utility function:

$$U^i = \int_0^\infty \left[\frac{(c_i)^{1-\theta} - 1}{1-\theta} + \ln g \right] e^{-\rho t} dt, \tag{1}$$

where c_i is the ith individual's consumption at time t, $i = 1, \ldots, N$; N is the total number of individuals in this economy; g is total government spending on public services; $0 < \theta < \infty$, and $\rho > 0$. Empirically, θ usually takes values from the interval [1,10] as reported by Hall (1988) and also used by King and Rebelo (1990). When $\theta = 1$, we have the logarithmic utility function $\ln c^i$.

Instead of using the familiar Barro-type production function for this economy, $y = Ak^\alpha g^{1-\alpha}$, we assume $\alpha = 1$ and let the production function take the most popular form in the endogenous-growth literature:

$$y = Ak. \tag{2}$$

Here y is the total output, $A > 0$, and $k = \Sigma_{i=1}^N k_i$, where k_i is the capital stock held by individual i. As in Barro (1990), k can be interpreted as a combination of both physical and human capital. We will argue later that the Barro-type production function combined with the utility function in (1) generates ambiguous results regarding income distribution and economic growth. Thus by using the special case here we can see clearly how income inequality can lead to faster economic growth when government spending is wholly driven by public consumption. The Alesina–Rodrik result is another special case where government spending generates only production services. Of course, the reality is somewhere between these two extremes, expressed as the ambiguity between income distribution and economic growth.

Given a positive tax rate τ on capital income, individual i's after-tax income is $(1 - \tau)Ak_i$. Government spending with an imposed balanced budget at each period t is

$$g = \tau A \sum_{i=1}^N k_i = \tau A k. \tag{3}$$

Individual i accumulates capital as follows:

$$\frac{dk_i}{dt} = (1-\tau)Ak_i - c_i \tag{4}$$

with initial capital stock given by $k_i(0)$.

The income share for individual i is:

$$\sigma_i = \frac{Ak_i}{A\sum_{i=1}^N k_i} = \frac{k_i}{k}, \tag{5}$$

which is the same as individual i's wealth (capital) share in the total. An individual with a high σ is capital-rich or income-rich, while one with a low σ is capital-poor or income-poor. Note that our definition of σ is the inverse of the one in Alesina and

Rodrik (1994) when labor input is assumed to be the same for everyone in the economy.

Individual i maximizes (1) subject to the dynamic constraint in (4). The optimal rates of income growth, consumption growth and capital accumulation are the same on the balanced path:

$$\gamma_i \equiv \gamma \equiv \frac{dc_i/dt}{c_i} = \frac{dk_i/dt}{k_i} = \frac{dy_i/dt}{y_i} = \frac{(1-\tau)A-\rho}{\theta}. \tag{6}$$

Because all individuals are alike except for their initial capital holdings, the growth rate will be the same for the N individuals. Therefore, for individual i:

$$k_i(t) = k_i(0)e^{\frac{(1-\tau)A-\rho}{\theta}t}, \tag{7}$$

$$c_i(t) = \frac{\rho-(1-\tau)(1-\theta)A}{\theta}k_i(0)e^{\frac{(1-\tau)A-\rho}{\theta}t}, \tag{8}$$

$$\sigma_i(t) = \frac{k_i(0)}{k(0)}. \tag{9}$$

Because everything is growing at the same rate for all individuals, their income shares remain the same over time and equal their initial capital shares.

To determine the rate of capital income tax, we follow Alesina and Rodrik. First, we solve for the optimal choice of tax rate τ_i if the government intends to maximize individual i's well-being. With relevant substitutions, the objective function of individual i is:

$$U^i = \frac{[\sigma_i k(0)]^{1-\theta}}{(1-\theta)}\left[\frac{\rho-(1-\tau_i)(1-\theta)A}{\theta}\right]^{-\theta} + \frac{\ln\tau_i}{\rho} + \frac{A(1-\tau_i)-\rho}{\theta\rho^2} + \text{constant}. \tag{10}$$

Here, the term in the large square brackets is greater than zero for the discounted utility to be bounded.

Its maximization with respect to τ_i yields the following condition:

$$-A[\sigma_i k(0)]^{1-\theta}\left[\frac{\rho-(1-\tau_i)(1-\theta)A}{\theta}\right]^{-\theta-1} + \frac{1}{\tau_i\rho} - \frac{A}{\theta\rho^2} = 0. \tag{11}$$

Then:

$$\left\{-\frac{1-\theta^2}{\theta}A^2[\sigma_i k(0)]^{1-\theta}\left[\frac{\rho-(1-\tau_i)(1-\theta)A}{\theta}\right]^{-\theta-2} - \frac{1}{\tau_i^2\rho}\right\}d\tau_i = A[\sigma_i k(0)]^{-\theta}\left[\frac{\rho-(1-\tau_i)(1-\theta)A}{\theta}\right]^{-\theta-1}\frac{1-\theta}{\theta}k(0)d\sigma_i. \tag{12}$$

In (12), the right-hand side is positive (negative) if $\theta < (>) 1$. The first term on the left-hand side is positive (negative) if $\theta < (>) 1$, while the second term on the left-hand side is always negative. Thus:

$$d\tau_i / d\sigma_i > 0, \quad \text{if } \theta > 1 \tag{13}$$

$$d\tau_i / d\sigma_i = 0, \quad \text{if } \theta = 1 \tag{14}$$

Since $\theta \in [1, 10]$ for empirically relevant analysis as in Hall (1988), we can conclude that empirically τ_i is monotonically increasing in the income share σ_i. Therefore, altering the specific role of government spending overturns the negative relationship between income inequality and the income tax rate in Alesina and Rodrik. But for $0 < \theta < 1$, the first term on the left-hand side is positive while the second term is negative. Therefore the sign for $d\tau_i/d\sigma_i$ is ambiguous.

With the choice of income taxation by majority voting, the median-voter theorem applies here because the preferences are single-peaked. Therefore, the tax rate chosen by the majority rule is just the median voter's preferred choice τ_m with τ_m defined implicitly in

$$-A\left[\sigma_m k(0)\right]^{1-\theta}\left[\frac{\rho-(1-\tau_m)(1-\theta)A}{\theta}\right]^{-\theta-1}+\frac{1}{\tau_m \rho}-\frac{A}{\theta \rho^2}=0. \tag{15}$$

Therefore, for $\theta > 1$, when income distribution for the economy is more equal (i.e., when σ_m is higher) the income tax rate is higher, and the growth rate γ as in (6) is lower.

This result is intuitive. Because government spending is all for consumption, individuals in a democracy will try to allocate resources between public consumption and private consumption by comparing their marginal utility. Since individuals cannot provide public consumption services directly, government taxation and public provision come into play. With more income available to the median voter as a result of more equal distribution of income, people will vote for a higher income tax in order to allocate more resources to public consumption in their effort to equalize the marginal utility between private and public consumption.

Obviously enough, if all government spending is used for production, then government spending does not appear in the utility function, and the Barro-type production function will deliver a negative impact of income inequality on economic growth, the result given in Alesina and Rodrik (1994). The more realistic case is where government spending is partly for public consumption and partly for production, so the impact of income inequality on economic growth is ambiguous. Thus an effective empirical test of this more general theoretical result is an insignificant regression coefficient of income inequality on growth. We turn to this task in the next section.

3. Empirical Analysis

This section provides an extensive analysis of the relationship between growth and income inequality. As the baseline regression, we reexamine the regression analysis in Alesina and Rodrik (1994) using a much expanded dataset by Deininger and Squire (1996); then, we extend the Alesina–Rodrik regressions to include more variables in recent growth empirics (see Levine and Renelt, 1992) and conduct the sensitivity analysis.

Data and Methodology

Empirical studies in income distribution are often limited by the available data. In the case of Gini coefficients, the quality of the available data has been poor. The income inequality data we use here are based on a newly developed high-quality dataset of Gini coefficients by Deininger and Squire (1996). Starting with a total of 2,480 observations on Gini coefficients covering 112 developed and developing countries for the years 1947–94, several criteria were used to "cleanse" the data. First, all observations had to come from national household surveys for expenditure or income; second, the coverage had to be representative of the national population; and third, all sources of income and uses of expenditure had to be accounted for, including own-consumption. In addition, all observations had to be from countries with observations covering a reasonable time span in order to construct a panel dataset. Nevertheless, this panel data is highly unbalanced.

Note two points. First, the definition of 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 definition can undermine the international and intertemporal comparability of the data, proper adjustment is necessary. Therefore, we have adjusted the data following the 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 100-point scale), this being the average difference observed by Deininger and Squire (1996).

The data are averaged over five-year period as in Li et al. (1998). For most variables yearly observations are available, but the data on Gini coefficients are more limited—many countries have fewer than ten observations, while only a few countries have more than 20 observations. Therefore, the five-year averages provide a more balanced panel dataset. For other variables the five-year averages reduce the short-run fluctuations and allow us to focus on the structural relationships we are most interested in.

These procedures, together with the data availability of other variables, resulted in a sample of 217 observations covering 46 countries.[2] With this panel dataset, various panel-data approaches can be applied. This makes our empirical analysis quite different from other recent studies, which are mostly based on cross-section regressions without paying much attention to the quality of the Gini data (see Benabou, 1996, for an exception) and with fewer observations.

Following recent empirics on economic growth, we also consider many other control variables in our regression analysis; e.g. the initial or lagged GDP level, the urbanization ratio, the population growth rate, financial development (defined as M2/GDP), openness (defined as export over GDP), domestic investment shares of GDP, black market premium and primary school enrollment ratio. These data are mostly obtained through the World Bank national accounts and Summers and Heston (1995). The black market premium and primary school enrollment ratio data are from Barro and Lee (1994). The primary years of schooling data are from Nehru et al. (1995).

As in Alesina and Rodrik (1994), the democracy dummy variable is used to control for the difference between democratic and nondemocratic countries. A country is classified as democratic if its civil liberty index is less or equal to two.[3]

Baseline Regression Results

Following Alesina and Rodrik, we examine the following base regression in its linear form.

$$G_{it} = f\left(GINI_{i,t-1}, GDP_{i,t-1}, MYPR_{i,t-1}\right) + u_{it}, \tag{16}$$

where $i = 1, 2, \ldots, N$ (number of countries) and $t = 1, 2, \ldots, T$ (five-year time period). G_{it} is the real GDP growth rate; $GINI_{i,t-1}$ is the lagged (for a five-year period) Gini coefficient; $GDP_{i,t-1}$ is the lagged per capita real GDP level; and $MYPR_{i,t-1}$ is the lagged primary school enrollment ratio. The baseline regression in Alesina and Rodrik is a cross-sectional regression. The right-hand side variables are all initial values in the 1960s. With panel data we use the lagged values in (16) instead.

Our focus is to investigate the relationship between growth and income inequality, while controlling the effects of GDP and education level as emphasized in many recent growth literature. The (lagged) GDP level will account for the issues related to convergence; and the (lagged) education level is a proxy for the initial level of human capital. The problem of endogeneity can usually be corrected using the instrumental variables method. However, since all the right-hand side variables in our baseline regression are lagged for a five-year period, this does not seem to cause serious estimation problems.[4]

This dataset allows us to consider various specifications for panel data models. We have estimated the base regression using both the fixed-effects and the random-effects models. Time-specific effects are also considered, as well as time-period dummy variables. By construction there are a total of nine five-year periods denoted as *YDM1* to *YDM9*. Because the first four have only a few observations together, the time-specific effects for these time periods are not evaluated. Note that in the random-effects model the time-specific dummy variables are the same as in the fixed-effects model.

Now we turn to the discussion of the baseline estimation. We have considered four variations: (1) the base regression, (2) the base regression with time-specific dummy variables, (3) the base regression with democratic dummy variables, and (4) the base regression with democratic dummy and time-specific dummy variables. As Table 1 shows, the regression coefficients of the Gini coefficient for both models are positive in all the four cases. In all cases the fixed-effects model yields significant estimates, whereas in two cases the random-effects model also yields significant estimates. This is very distinct from the findings in earlier studies by Alesina and Rodrik (1994) and Persson and Tabellini (1994), who find a significant and negative relationship between growth and income inequality. Our finding is consistent with the general theoretical prediction that income inequality and economics growth relates to each other ambiguously, in general, and positively, sometimes. As stated in the theoretical section, when government revenues collected through income taxation are used to finance public consumption instead of production, a more equal income distribution (measured by a lower Gini coefficient) may lead to a higher income tax rate and accordingly lower economic growth. Other theoretical studies have also pointed out possible positive associations between inequality and growth through different channels. For example, in a nonoverlapping generations model with voting, Perroti (1993) finds that a very egalitarian but poor economy will not be able to start the growth process. By contrast, an economy with a very unequal income distribution is in the best position to achieve a high initial rate of growth. Much earlier theoretical studies by Lewis (1954), Kaldor (1957), and Pasinetti (1962) have also predicted this positive association. According to Lewis, entrepreneurs save a larger fraction of their profit income than the other groups in the economy, and income inequality can lead to more savings for the rich and faster growth for the economy. Of course, Kaldor takes the saving rate of the working class to be zero. Thus income inequality can generate high savings rates and growth rates if

Table 1. Base Regression Results (using Barro–Lee education data)

Independent variable[a]		Reg. 1 Fixed-effects	Reg. 1 Random-effects	Reg. 2 Fixed-effects	Reg. 2 Random-effects	Reg. 3 Fixed-effects	Reg. 3 Random-effects	Reg. 4 Fixed-effects	Reg. 4 Random-effects
CONSTANT	Coefficient	—	2.829	—	3.619	—	2.720	—	3.482
	t-statistic	—	1.174	—	1.181	—	1.105	—	1.129
GDP(-1)	Coefficient	−0.559	−0.460	−1.048	−0.689	−0.559	−0.463	−1.051	−0.702
	Std. coefficient	−0.413	−0.402	−0.774	−0.531	−0.413	−0.403	−0.776	−0.541
	t-statistic	−5.590	−5.367	−6.072	−5.277	−5.566	−5.333	−6.068	−5.324
MYPR(-1)	Coefficient	−0.112	0.266	−1.139	−0.293	−0.112	0.259	−1.142	−0.317
	Std. coefficient	−0.027	0.084	−0.279	−0.077	−0.027	0.081	−0.279	−0.083
	t-statistic	−0.373	1.143	−2.817	−0.970	−0.370	1.105	−2.817	−1.041
GINI(-1)	Coefficient	0.149	0.031	0.154	0.102	0.150	0.034	0.156	0.105
	Std. coefficient	0.180	0.048	0.187	0.132	0.181	0.052	0.189	0.137
	t-statistic	2.436	0.675	2.666	1.981	2.421	0.718	2.685	2.044
DEM	Coefficient					0.045	0.104	0.260	0.376
	t-statistic					0.073	0.187	0.437	0.679
YDM5	Coefficient			0.699	0.336			0.656	0.282
	t-statistic			1.240	0.645			1.144	0.534
YDM6	Coefficient			1.112	0.377			1.075	0.341
	t-statistic			1.815	0.695			1.734	0.623
YDM7	Coefficient			0.777	−0.361			0.737	−0.394
	t-statistic			1.091	−0.603			1.023	−0.653
YDM8	Coefficient			2.675	1.180			2.638	1.161
	t-statistic			3.287	1.799			3.217	1.761
YDM9	Coefficient			3.112	1.249			3.106	1.282
	t-statistic			3.245	1.662			3.229	1.700
NOB		185	185	185	185	185	185	185	185
COUNTRY		37	37	37	37	37	37	37	37
F (dummy)		4.212		5.089		3.769		4.593	
LM test			40.841		46.696		22.414		25.569
F (model)		13.717	13.408	9.064	7.903	10.218	10.631	8.032	7.150
$\bar{R}^2$		0.575		0.640		0.575		0.641	

Note: The estimated country specific dummy variables are not reported. Same for the following tables.
[a]The dependent variable is *G*, the growth rate of real per capita GDP.

the rich have a larger share of income, or if income is more unequally distributed in the economy.

We can also notice some simple empirical facts. In our sample, the developed countries have a more equal income distribution than the developing ones (with the mean values of the Gini coefficients for the two groups being 33.51 and 40.65, respectively), but developed countries have much higher income tax rates and not very high income growth rates (with the mean value 2.25%) compared with developing countries in our sample. The difference in growth rates between the developed countries and many East Asian developing countries is even larger in recent years. The experience in developed countries seems to suggest that more equal income distribution leads to higher income taxation and perhaps relatively lower economic growth.

In Table 1, standardized regression coefficients are abbreviated as "Std. coefficients." For the fixed-effects model, the standardized regression coefficients for the Gini coefficient range from 0.18 to 0.19. This means that, for one-standard-deviation increase in the Gini coefficient, there will be an increase of 0.45–0.48% in the rate of economic growth. For the random-effects model (two significant cases) the standardized regression coefficients range from 0.13 to 0.14. Correspondingly, for one-standard-deviation increase in the Gini coefficient, there will be an increase of 0.33–0.35% in the rate of economic growth.

For the other explanatory variables, the regression coefficients of initial or lagged GDP are negative and highly significant in all cases, which is consistent with the results of Alesina and Rodrik (1994). In particular, the mean standardized coefficients of the lagged GDP are –0.60 for the fixed-effects model and –0.47 for the random-effects model. Thus for one-standard-deviation increase in the real *GDP* level, the decrease in the rate of economic growth will be 1.5% for the fixed-effects model and 1.2% for the random-effects model. Thus the lagged real *GDP* level has a much stronger standardized effect (more than three times) than that of the *GINI* coefficients. As in Alesina and Rodrik, the democratic dummy variable does not have a significant coefficient.

For the primary school enrollment ratio, the regression coefficients are negative and significant in two cases (both in the fixed-effects model). In other cases, they are mostly negative and insignificant. This finding is different from Alesina and Rodrik, which shows positive and significant coefficients for this variable. Other studies also report a negative association between education and economic growth. For example, Pritchett (1996) finds that the estimated impact of growth of human capital on economic growth is large, strongly significant and negative. Furthermore, period 8 (1985–89) and period 9 (1990–94) time-specific dummy variables are significant in two cases. For other time periods they are not significant. It is interesting to find that the magnitude of the regression coefficients of the time-specific dummy variables increases over time. This result seems to suggest that economic growth has been relatively faster in recent years.

The above baseline regressions use the Barro–Lee primary school enrollment ratio data, the same variable used in Alesina and Rodrik (1994), which makes our results comparable. Note that only 37 of the 46 countries have data on this variable, and nine countries are excluded from the sample. Nehru et al. (1995) have constructed a dataset on human capital stock in developing and industrial countries. Using the primary years of schooling variable in Nehru et al. (1995), we are able to estimate the full sample baseline regression. The consequent results are summarized in Table 2.[5] The results are similar to those discussed in Table 1. In particular, lagged real *GDP* has negative and significant regression coefficients whereas *GINI* positive and significant regression coefficients. The standardized coefficients of the two variables are similar in magnitude

Table 2. Base Regression Results (using Nehru education data)

Independent variable		*(1)*	*(2)*	*(3)*	*(4)*
GDP(-1)	Coefficient	–0.640	–0.834	–0.642	–0.836
	Std. coefficient	–0.428	–0.558	–0.429	–0.559
	t-statistic	–6.091	–5.554	–6.079	–5.541
PYR(-1)	Coefficient	–0.153	–0.420	–0.155	–0.421
	Std. coefficient	–0.038	–0.105	–0.039	–0.105
	t-statistic	–0.546	–1.378	–0.548	–1.378
GINI(-1)	Coefficient	0.165	0.182	0.167	0.183
	Std. coefficient	0.177	0.195	0.179	0.196
	t-statistic	2.588	2.897	2.595	2.897
DEM	Coefficient			0.179	0.140
	t-statistic			0.276	0.213
YDM5	Coefficient		0.591		0.563
	t-statistic		0.978		0.908
YDM6	Coefficient		0.849		0.825
	t-statistic		1.360		1.295
YDM7	Coefficient		0.197		0.171
	t-statistic		0.285		0.243
YDM8	Coefficient		1.888		1.864
	t-statistic		2.506		2.440
YDM9	Coefficient		1.376		1.366
	t-statistic		1.618		1.599
NOB		217	217	217	217
COUNTRY		46	46	46	46
F (dummy)		4.755	4.859	4.669	4.692
F (model)		17.736	9.091	13.248	8.039
$\bar{R}^2$		0.582	0.620	0.583	0.620

Note: See Table 1 note.

to those of the regressions reported in Table 1. For example, the average standardized coefficient for lagged real *GDP* is 0.49, whereas for *GINI* it is 0.19. The primary years of schooling do not seem to significantly affect growth, however, the regression coefficients are all negative. Other dummy variables are insignificant most of the time. Thus the base regression results are fairly consistent for both the subsample and the full sample estimation results.

It is important to point out that we use panel data models, whereas Alesina and Rodrik used a cross-sectional dataset to discuss the relationship between growth and income distribution. They found that income inequality had a significant negative effect on growth. The basic implication of their model is that the more unequal the initial income distribution, the lower the rate of subsequent economic growth. The theoretical link between income inequality and growth emerges from redistributive policies. In their model the distribution of income is predetermined and remains constant over time. However, a more realistic assumption is that both growth and distribution change over time. For example, as emphasized by Atkinson (1997), in the United States, the Gini coefficient of inequality for household income sometimes increased and some-

times decreased by three and one half percentage points from 1950 to 1992. According to the estimates by Goodman and Webb (1994), between 1977 and 1991, the UK Gini coefficients rose by 10 percentage points. These large changes in income distribution and their impact on economic growth will not be fully recovered if we take a 30-year average value. Using a panel data model with a five-year lag in income inequality has the advantage of revealing the dynamic interaction between distribution and growth. Given this consideration, it is not surprising to see that our empirical results have shown a positive, and often significant, relationship between growth and income inequality.

It will be important to examine whether we can duplicate the Alesina–Rodrik and Persson–Tabellini results if we estimate a similar cross-sectional regression on the basis of our new dataset. The cross-sectional regression we consider is as follows:

$$G(60-90)_i = f(GINI60_i, GDP60_i, MYPR60_i, LDGINI60_i) + u_i, \qquad (17)$$

where i ($i = 1, 2, \ldots, N$) is the country index; $G(60–90)$ is the average growth rate between 1960 and 1990; and *GINI*60, *GDP*60, *MYPR*60 and *LDGINI*60 (*GINI* coefficient on land distribution) are initial values over five years between 1960 and 1964. Note that for some of the initial *GINI*, we use the five-year average between 1965 and 1969 or between 1970 and 1964 if there are no data for the period 1960–64. The time span is long enough for the growth rate, so the endogeneity problem of initial *GINI* seems to be a minor issue and the application of 2SLS or instrumental variables estimation suggested by Alesina and Rodrik (1994) is not considered here. We summarize the OLS results for the baseline regression using the cross-sectional data in Table 3. The first set of regressions (1 to 4) are based on the Barro–Lee primary school enrollment ratio, whereas the second set (5 to 8) are based on Nehru et al. (1995) primary schooling years to allow for a larger sample. The results are similar to those discussed by Alesina and Rodrik (1994). In particular, both the income distribution *GINI* and the land distribution *GINI* have negative and significant coefficients with their standardized coefficients approximately of the same magnitude. Note that, while all other variables remain to have the same signs in both the panel data models and the cross-sectional data regressions, the *GINI* has completely different signs. Thus by allowing the dynamic interaction between distribution and growth and also the difference between individual countries, we are able to extend the results in Alesina and Rodrik (1994), and Persson and Tabellini (1994), and present some supporting evidence for an ambiguous or even a positive relationship between income distribution and growth. In passing, we also note that in a cross-section study, Deininger and Squire (1997) have produced a negative but insignificant relationship between income inequality and economic growth for 1960–92 by including more explanatory variables in addition to the ones in the Alesina–Rodrik estimations. But our finding of a significant, positive association stands in sharp contrast to the findings of all the aforementioned empirical studies.

Overall, the relationship between income distribution and growth is a complicated theoretical and empirical issue. On a theoretical basis the relationship can be of any sign. On an empirical basis the relationship can be both positive and negative, depending on whether we allow enough variations in income inequality over time. When we extend the discussion in Alesina and Rodrik (1994) by considering the dynamic relationship between growth and income distribution, we can even find a very strong positive relationship between the two.

Table 3. Base Regression Results: Cross-Sectional Data

Independent variable[a]		*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
CONSTANT	Coefficient	7.280	8.479	7.240	8.582	5.785	7.150	6.525	7.886
	t-statistic	5.409	6.790	5.597	7.479	4.077	6.360	5.225	8.005
GDP64	Coefficient	−0.367	−0.276	−0.254	−0.167	−0.286	−0.227	−0.246	−0.168
	Std. coefficient	−0.693	−0.578	−0.479	−0.348	−0.524	−0.491	−0.483	−0.362
	t-statistic	−2.449	−2.186	−1.634	−1.344	−2.874	−3.112	−1.993	−1.808
MYPR64	Coefficient	0.160	0.033	0.249	0.110				
	Std. coefficient	0.249	0.056	0.389	0.187				
	t-statistic	0.933	0.227	1.459	0.809				
PYR64	Coefficient					0.192	0.091	0.299	0.173
	Std. coefficient					0.245	0.135	0.401	0.250
	t-statistic					1.421	0.903	2.488	1.887
GINI64	Coefficient	−0.089	−0.066	−0.092	−0.071	−0.060	−0.038	−0.081	−0.059
	Std. Coefficient	−0.568	−0.473	−0.590	−0.506	−0.375	−0.282	−0.525	−0.425
	t-statistic	−3.318	−2.590	−3.577	−3.007	−2.216	−1.774	−3.324	−2.967
LDGINI64	Coefficient		−0.030		−0.030		−0.034		−0.031
	Std. coefficient		−0.432		−0.439		−0.489		−0.452
	t-statistic		−2.769		−3.059		−3.593		−3.718
DEM	Coefficient			−1.321	−1.287			−0.919	−1.061
	t-statistic			−1.933	−2.527			−1.536	−2.391
NOB		37	34	37	34	42	39	40	38
F (model)		4.485	7.351	4.577	8.250	3.490	7.707	5.798	11.099
$\bar{R}^2$		0.225	0.435	0.284	0.523	0.154	0.414	0.330	0.577

[a]The dependent variable is *G*, the average growth rate of real per capita GDP between 1960 and 1990.

Sensitivity Analysis

To examine the robustness of our baseline regression results, we extend the base regression by adding more variables commonly used in growth empirics; see Levine and Renelt (1992), among many others. These variables, which we call sensitivity variables, include the population growth rate (*PGRW*), urbanization ratio (*URB*), openness (*XGDP*), investment share (*INVSHR*), black market premium (*BMP*), and financial development (*FNDP*). Obviously enough, some of these variables such as investment share and openness are endogenous. However, even using lagged values of these variables as instruments does not change the results significantly. Four groups of regressions were estimated based on the fixed-effects model. Since the baseline regression results suggest that adding democratic and time-specific dummy variables does not seem to change the results significantly, these dummy variables are not considered here. The regressions in the first two sets are backward stepwise regressions. The sensitivity variables are first all added and then the least insignificant one is deleted in a backward way. See the results in Table 4 where regressions 1 to 4 are based on the Barro–Lee education data (the subsample) and regressions 5 to 8 are based on the education data (the full sample) from Nehru et al. (1995). In the third group of sensitivity regressions each regression is obtained by adding only one sensitivity variable to the base regression each time. The results are reported in Table 5 (based on the Barro–Lee education data). Then we use the Nehru et al. (1995) education data to check the sensitivity of regression results for the full sample. The sensitivity analysis results for the last group are reported in Table 6.

Table 4. Sensitivity Analysis I: Stepwise Regressions

Independent variable[a]		*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
GDP(-1)	Coefficient	−0.690	−0.655	−0.626	−0.730	−0.573	−0.587	−0.570	−0.600
	Std. coefficient	−0.546	−0.519	−0.463	−0.539	−0.428	−0.455	−0.441	−0.401
	t-statistic	−4.872	−5.173	−5.176	−6.638	−4.821	−5.542	−5.420	−5.217
MYPR(-1)	Coefficient	−1.128	−1.073	−0.586	−1.103				
	Std. coefficient	−0.249	−0.237	−0.143	−0.270				
	t-statistic	−2.302	−2.234	−1.353	−3.166				
PYR(-1)	Coefficient					−0.326	−0.316	−0.314	−0.095
	Std. coefficient					−0.091	−0.088	−0.088	−0.024
	t-statistic					−1.268	−1.232	−1.222	−0.325
GINI(-1)	Coefficient	0.081	0.080	0.080	0.091	0.108	0.107	0.120	0.103
	Std. coefficient	0.101	0.099	0.097	0.110	0.127	0.126	0.142	0.110
	t-statistic	1.347	1.320	1.374	1.543	1.771	1.766	2.006	1.635
PGRW	Coefficient	−1.811	−1.837	−1.623	−1.268	−0.188	−0.145	−0.136	−0.118
	Std. coefficient	−0.268	−0.273	−0.239	−0.186	−0.343	−0.266	−0.249	−0.222
	t-statistic	−2.831	−2.872	−2.586	−2.088	−3.519	−3.027	−2.869	−2.488
XGDP	Coefficient	0.063	0.058	0.111	0.097	−1.741	−1.589	−1.858	−1.646
	Std. coefficient	0.146	0.136	0.283	0.247	−0.243	−0.239	−0.280	−0.224
	t-statistic	1.552	1.487	3.326	2.939	−2.810	−2.634	−3.316	−2.661
INVSHR	Coefficient	0.137	0.137	0.137	0.135	0.109	0.115	0.117	0.174
	Std. coefficient	0.236	0.237	0.235	0.232	0.172	0.183	0.187	0.258
	t-statistic	3.000	3.014	3.246	3.173	2.356	2.539	2.585	3.803
URB	Coefficient	−0.086	−0.080	−0.114		−0.585	−0.579	−0.628	
	Std. coefficient	−0.166	−0.154	−0.249		−0.108	−0.108	−0.117	
	t-statistic	−1.264	−1.192	−1.972		−1.598	−1.614	−1.758	
BMP	Coefficient	−0.479	−0.460			0.075	0.035		
	Std. coefficient	−0.086	−0.083			0.166	0.100		
	t-statistic	−1.177	−1.129			1.923	1.189		
FNDP	Coefficient	1.246				0.583			
	Std. coefficient	0.062				0.028			
	t-statistic	0.730				0.364			
NOB		165	166	185	185	183	187	187	217
COUNTRY		37	37	37	37	43	43	43	46
F (dummy)		3.059	3.029	2.916	2.757	3.363	3.526	3.630	4.028
F (model)		9.578	10.483	11.751	12.802	11.204	12.358	13.879	13.47
$\bar{R}^2$		0.696	0.692	0.655	0.646	0.702	0.697	0.694	0.631

[a]The dependent variable is *G*, the growth rate of real per capita GDP.

First we discuss the stepwise regressions in Table 4. For the base regression variables, the regression coefficients of *GDP* are still negative and significant in all the four cases. Primary education enrollment ratio has negative coefficients, which are significant in three out of the four cases. The regression coefficients of the *GINI* coefficient are still positive but insignificant. Note that they are significant in the base regressions (the fixed-effects model). These insignificant, positive coefficients further support the ambiguity between growth and income inequality derived from our general theoretical model.

For the sensitivity variables, the estimates for the growth effects of financial development (with positive coefficients) and black market premium (with negative coefficients) have the same signs as in King and Levine (1993a,b), but they are not statistically significant. Therefore, they are deleted (see cases 1 and 2). The remaining

Table 5. Sensitivity Analysis II: Based on the Barro–Lee Education Data

Independent variable[a]		*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
GDP(-1)	Coefficient	−0.699	−0.690	−0.512	−0.547	−0.588	−0.628
	Std. coefficient	−0.516	−0.510	−0.378	−0.404	−0.466	−0.480
	t-statistic	−6.252	−6.697	−5.249	−4.327	−6.107	−5.561
MYPR(-1)	Coefficient	−0.568	−0.681	−0.317	−0.056	−0.580	−0.105
	Std. coefficient	−0.139	−0.167	−0.077	−0.014	−0.128	−0.026
	t-statistic	−1.656	−2.059	−1.069	−0.120	−1.681	−0.340
GINI(-1)	Coefficient	0.158	0.130	0.093	0.148	0.131	0.150
	Std. coefficient	0.192	0.157	0.113	0.179	0.161	0.188
	t-statistic	2.636	2.192	1.522	2.407	2.104	2.545
PGRW	Coefficient	−1.656					
	Std. coefficient	−0.244					
	t-statistic	−2.607					
XGDP	Coefficient		0.120				
	Std. coefficient		0.305				
	t-statistic		3.557				
INVSHR	Coefficient			0.151			
	Std. coefficient			0.260			
	t-statistic			3.423			
URB	Coefficient				−0.009		
	Std. coefficient				−0.020		
	t-statistic				−0.159		
BMP	Coefficient					−0.791	
	Std. coefficient					−0.142	
	t-statistic					−1.873	
FNDP	Coefficient						2.653
	Std. coefficient						0.134
	t-statistic						1.505
NOB		185	185	185	185	166	183
COUNTRY		37	37	37	37	37	37
F (dummy)		4.398	4.493	2.153	4.032	3.825	4.147
F (model)		12.398	14.277	13.976	10.225	12.740	11.155
$\bar{R}^2$		0.594	0.609	0.607	0.575	0.629	0.598

[a]The dependent variable is *G*, the growth rate of real per capita GDP.

sensitivity variables in cases 3 and 4 are all significant. Population growth and urbanization have negative effects on growth, while openness and investment have positive effects. All of these follow the conventional wisdom.

Even though the positive association between inequality and growth has been produced in our two testing scenarios above, the change from significant coefficients for the Gini coefficients in our base regressions to nonsignificant ones in the sensitivity tests leads us to another step in our empirical examinations. One possible reason for this change is the correlation between the *GINI* coefficient and the sensitivity variables or the correlation between the sensitivity variables (the multicollinearity problem), or the correlation between growth and other sensitivity variables since pop-

Table 6. Sensitivity Analysis III: Based on the Nehru et al. (1995) Education Data

Independent variable[a]		*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
GDP(-1)	Coefficient	−0.728	−0.738	−0.598	−0.601	−0.600	−0.725
	Std. coefficient	−0.486	−0.505	−0.400	−0.402	−0.465	−0.481
	t-statistic	−6.344	−6.858	−5.830	−5.192	−6.474	−5.906
MYPR(-1)	Coefficient	−0.312	−0.298	−0.170	−0.057	−0.357	−0.158
	Std. coefficient	−0.078	−0.076	−0.042	−0.014	−0.100	−0.040
	t-statistic	−1.067	−1.086	−0.624	−0.186	−1.385	−0.569
GINI(-1)	Coefficient	0.168	0.133	0.108	0.164	0.156	0.160
	Std. coefficient	0.179	0.146	0.115	0.175	0.184	0.176
	t-statistic	2.645	2.155	1.686	2.568	2.583	2.538
PGRW	Coefficient	−1.069					
	Std. coefficient	−0.146					
	t-statistic	−1.837					
XGDP	Coefficient		0.071				
	Std. coefficient		0.194				
	t-statistic		2.628				
INVSHR	Coefficient			0.159			
	Std. coefficient			0.236			
	t-statistic			3.453			
URB	Coefficient				−0.036		
	Std. coefficient				−0.067		
	t-statistic				−0.802		
BMP	Coefficient					−0.792	
	Std. coefficient					−0.147	
	t-statistic					−2.109	
FNDP	Coefficient						2.581
	Std. coefficient						0.115
	t-statistic						1.443
NOB		217	216	217	217	187	212
COUNTRY		46	46	46	46	43	46
F (dummy)		4.871	5.067	3.693	4.712	4.151	4.093
F (model)		14.334	15.888	17.148	13.434	16.799	13.568
$\bar{R}^2$		0.591	0.62	0.610	0.584	0.647	0.601

[a]The dependent variable is *G*, the growth rate of real per capita GDP.

ulation growth, openness and the investment share can explain growth very well. For this reason, we have further estimated another two sets of sensitivity regressions by adding only one sensitivity variable into the base regression each time. See the results in Table 5 and Table 6. The lagged *GDP* has a strong negative effect on growth in the presence of other sensitivity variables. Education has a negative but insignificant effect. Except for one regression (regression (3) in both Table 5 and Table 6) when the investment share is added, the regression coefficients of the *GINI* coefficient are all positive and significant. These two sets of estimations seem to confirm that the positive, significant association between inequality and growth in our baseline regression is robust.

4. Concluding Remarks

In this paper, we have shown theoretically that income inequality may lead to higher economic growth if public consumption enters the utility function. Empirically, our baseline estimations and the sensitivity analysis have shown that income inequality is positively, and very often even significantly, associated with economic growth. These findings stand in sharp contrast to the significant negative association between inequality and growth found by Alesina and Rodrik (1994) and by Persson and Tabellini (1994).

In light of both theoretical models and empirical findings, we shall admit that the association between income inequality and economic growth is a very complicated matter (see much more on this point in Benabou (1996) and Perotti (1996a, b)). The positive effects of inequality on savings and growth in Lewis (1954) and Kaldor (1957) are intuitively appealing. The negative effects of inequality on growth in the Alesina–Rodrik and Persson–Tabellini models are also plausible. On the basis of simple empirical observations, neither positive nor negative association between inequality and growth shall be interpreted as causality from inequality to growth. To illustrate this point, we have a significant rising trend in the Gini coefficients for China in our dataset. In 1984, China had a relatively low Gini coefficient of household income at 25.7 on a scale of 100. By 1992, China reached a relatively high Gini coefficient of income at 37.8. This rapid increase in income inequality (12-point rise in 8 years) is associated with the spectacular growth performance of 9.8% average growth in real GDP. But for the UK, the 10-point rise in the Gini coefficient of income inequality was associated with moderate (2–3%) or even negative episodes of economic growth from 1977 to 1991 (Goodman and Webb, 1994). It would be of great interest to explore the dynamic interaction between inequality and growth for those countries with significant time trends in their income distribution.[6]

References

Alesina, A. and D. Rodrik, "Distributive Politics and Economic Growth," *Quarterly Journal of Economics* 109 (1994):465–90.

Arrow, K. and M. Kurz, *Public Investment, the Rate of Return and Optimal Fiscal Policy*, Baltimore, MD: Johns Hopkins University, 1970.

Atkinson, T., "Bring Income Distribution in from the Cold," *Economic Journal* 107 (1997): 297–321.

Banerjee, A. and A. Newman, "Occupational Choice and the Process of Development," *Journal of Political Economy* 101 (1993):274–98.

Barro, R., "Government Spending in a Simple Model of Endogenous Growth," *Journal of Political Economy* 98 (1990):S103–25.

Barro, R. and J. Lee, *Data Set for a Panel of 138 Countries*, 1994.

Benabou, R., "Inequality and Growth," in *NBER Macroeconomics Annual*, Cambridge, MA: MIT Press, 1996.

Deininger, K. and L. Squire, "Measuring Income Inequality: A New Data Base," *World Bank Economic Review* 10 (1996):565–91.

Deininger, K. and L. Squire, "Economic Growth and Income Inequality: Reexamining the Links," *Finance and Development* 34 (1997):38–41.

Galor, O. and J. Zeira, "Income Distribution and Macroeconomics," *Review of Economic Studies* 60 (1993):35–52.

Gastil, R., *Freedom in the World*, Westport, Greenwood, various issues.

Goodman, A. and S. Webb, "For Richer, For Poorer," Institute for Fiscal Studies Commentary No. 42, London, 1994.

Greenwood, J. and B. Jovanovic. "Financial Development, Growth, and the Distribution of Income," *Journal of Political Economy* 98 (1990):1076–107.
Hall, R., "Intertemporal Substitution in Consumption," *Journal of Political Economy* 96 (1988): 339–57.
Kaldor, N., "A Model of Economic Growth," *Economic Journal* 57 (1957):591–624.
King, R. and R. Levine, "Finance and Growth: Schumpeter Might Be Right," *Quarterly Journal of Economics* 108 (1993a):717–38.
King, R. and R. Levine, "Finance, Entrepreneurship, and Growth: Theory and Evidence," *Journal of Monetary Economics* 32 (1993b):513–42.
King, R. and S. Rebelo, "Public Policy, and Economic Growth: Developing Neoclassical Implications," *Journal of Political Economy* 98 (1990):S126–50.
Levine, R. and D. Renelt, "A Sensitivity Analysis of Cross-Country Growth Regressions," *American Economic Review* 82 (1992):942–63.
Lewis, W. A., "Economic Development with Unlimited Supplies of Labor," *The Manchester School* 22 (1954):139–91.
Li, H., L. Squire and H. Zou, "Explaining International and Intertemporal Variations in Income Inequality," *Economic Journal* 108 (1998):26–43.
Nehru, V., E. Swanson, and A. Debey, "A New Database on Human Capital Stock in Developing and Industrial Countries: Sources, Methodology, and Results," *Journal of Development Economics* 46 (1995):379–401.
Pasinetti, L., "Rate of Profit and Income Distribution in Relation to the Rate of Economic Growth," *Review of Economic Studies* 29 (1962):267–79.
Perotti, R., "Political Equilibrium, Income Distribution, and Growth," *Review of Economic Studies* 60 (1993):755–76.
Perotti, R.,"Growth, Income Distribution, and Democracy: What the Data Say," *Journal of Economic Growth* 1 (1996a):149–87.
Perotti, R., "Comment on Inequality and Growth," in *NBER Macroeconomics Annual*, Cambridge, MA: MIT Press, 1996b.
Persson, T. and G. Tabellini, "Is Inequality Harmful for Growth? Theory and Evidence," *American Economic Review* 84 (1994):600–21.
Pritchett, L., "Where Has all the Education Gone?" Policy Research Working Paper No. 1581, World Bank, 1996.
Summers, R. and A. Heston, "Penn World Table (Mark 5.6)," 1995.
Xu, L. C. and H. Zou, "The Changes of Income Inequality in China," Policy Research Department, World Bank, Washington, DC, 1997.

Notes

1. Persson and Tabellini (1994) have shown a similar negative relationship between income inequality and economic growth in a two-period model. A variety of theoretical approaches can be found in Greenwood and Jovanovic (1990), Banerjee and Newman (1993), Galor and Zeira (1993), and Perroti (1993).
2. These countries are (by the World Bank and IMF three-letter country code): 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.
3. There are two indices in Gastil (various issues) measuring civil liberties and political rights. Since the two are highly correlated, we only use one of them—the civil liberty index—in our base regression but interpret it broadly to capture both civil liberties and political rights. We use the average index for the period 1972–89 as reported in Barro and Lee (1994). The index is defined from 1 to 7, with 1 assigned to countries with the largest degree of civil liberties.
4. Since the growth rate is calculated based on the current and lagged period *GDP* and the lagged *GDP* also appears on the right-hand side, we have reestimated regression (16) by replacing the lagged *GDP* with *GDP* lagged for two time periods (ten years). The estimation results

did not seem to change. We have also estimated the baseline regression using the instrumental variables method, with the instrumental variables being the right-hand side variables lagged one additional time period. The change in the magnitudes and significance levels of the regression coefficients are small.

5. To conserve space, we report only the fixed-effects model results from now on. However, the random-effects model results are available from the authors.

6. Alesina and Rodrik (1994, p. 485) have also emphasized this point. See Atkinson (1997), and Xu and Zou (1997) for explorations of the rising inequality in the UK and China, respectively.

16

ECONOMICS AND POLITICS 0954-1985
Volume 12 July 2000 No. 2

CORRUPTION, INCOME DISTRIBUTION, AND GROWTH

HONGYI LI, LIXIN COLIN XU, AND HENG-FU ZOU*

This paper uses an encompassing framework developed by Murphy et al. (1991, 1993) to study corruption and how it affects income distribution and growth. We find that (1) corruption affects income distribution in an inverted U-shaped way, (2) corruption alone also explains a large proportion of the Gini differential across developing and industrial countries, and (3) after correcting for measurement errors, corruption seems to retard economic growth. But the effect is far less pronounced than the one found in Mauro (1995). Moreover, corruption alone explains little of the continental growth differentials. In countries where the asset distribution is less equal, corruption is associated with a smaller increase in income inequality and a larger drop in growth rates.

1. INTRODUCTION

THE LITERATURE defines corruption as an illegal payment to a public agent to obtain a benefit that may or may not be deserved, or the abuse of public offices for private gains (Rose-Ackerman, 1978, 1996; Klitgaard, 1988; Shleifer and Vishny, 1993). In the real world, corruption probably amounts to a large share of the gross national product in countries like Zaire and Kenya (Shleifer and Vishny, 1993). Corruption worries policy-makers and international organizations, who remain adamant about the adverse effects of corruption; the academic literature is less definite about how corruption influences growth and inequality.[1]

Many scholars are not overly concerned about corruption. Leff (1964), for example, views corruption as "grease money" to lubricate the squeaky wheels of a rigid administration. Francis T. Lui (1985) shows how bribes minimize the waiting costs associated with queuing, therefore reducing the inefficiency in public administration in a Nash equilibrium. Both of these models equate bribes as allocating the true worth of the underlying favor, licenses, or permit to the most worthy bidder. Forbidding bribes then amounts to prohibiting the use of a price mechanism in the public sector. It is perhaps this view that prompted the

*Hongyi Li is at the Chinese University of Hong Kong; Lixin Colin Xu is at the World Bank; and Heng-fu Zou is affiliated with the World Bank, Peking University, and Wuhan University. We thank Robert Cull and Raymond Fisman for comments. We are also grateful for the comments of two referees, which led to a substantial revision of the paper. The views expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the World Bank. Mailing address: Dr. Heng-fu Zou, The World Bank, MC2-611, 1818 H St., NW, Washington, DC 20433, USA. E-mail: hzou@worldbank.org. Tel. +202-473-7939.

[1] For a comprehensive review of issues related to corruption, see Bardhan (1995).

famous political scientist, Huntington (1968, p. 386), to write: "In terms of economic growth, the only thing worse than a society with a rigid, over-centralized, dishonest bureaucracy is one with a rigid, over-centralized, honest bureaucracy."

Much of the recent literature, however, views corruption as much more than a price mechanism. Corruption, after all, imposes an extortionary tax (Murphy et al., 1991; Mauro, 1995). Furthermore, the need for secrecy may distort investment projects toward those offering better opportunities for corruption, such as defense and infrastructure, for which it is harder to measure performance and quality (Shleifer and Vishny, 1993). In addition, once corruption becomes endogenized in the general equilibrium setup, bribing may no longer be akin to bidding for scarce resources. Corrupt officials may intentionally delay the queuing process to extract more bribes (Myrdal, 1968), perhaps partly because corruption contracts are not enforceable in courts (Shleifer and Vishny, 1993). Corruption may also cause misallocation of talents. Because corruption represents a higher return to rent-seekers, talent flows out of the innovation sector to the rent-seeking sector. In so far as the pace of technological progress is determined by the talent pool of the innovation sector, growth rates drop in societies in which corruption is widespread (Murphy et al., 1991). Finally, innovators or entrepreneurs are hit hardest by corruption as they must obtain government-supplied goods such as licenses and permits to start, whereas established producers do not (Murphy et al., 1993).

The empirical literature on corruption gradually emerging in this decade suggests a negative relationship between corruption and growth. Mauro (1995), the first to look at how corruption affects growth in a cross-country sample, concludes that corruption *causes* slower growth. The main instrument for corruption in the growth equation, the ethnolinguistic fracturization, however, has been shown to be a significant determinant of growth, both directly and indirectly (through other policy variables) (Easterly and Levine, 1997). Thus it no longer serves as a valid instrument for corruption in the growth regression. Using a cross-country sample, Murphy et al. (1991) find that a larger rent-seeking sector, as proxied by the ratio of college enrollments in law to total college enrollments, is associated with a lower growth rate. Knack and Keefer (1995) find that the quality of government institutions, including the degree of corruption, affects investment and growth as much as other political economy variables (e.g., political freedom, civil liberties, and political violence). Kaufman and Wei (1998) find that firms that pay more bribes also spend more time with bureaucrats in more corrupt countries and have a higher cost of capital, thus countering the view of corruption as "grease money." Finally, transitional countries are likely to have a smaller unofficial economy where taxes are fairer and regulation is less (Johnson et al., 1997).

Even so, many questions about the impact of corruption remain unanswered. For example, how does corruption affect income inequality? Since Mauro (1995) does not correct for measurement error, one wonders whether corruption will

still affect growth adversely if more policy controls are added. In addition, capital market imperfection and government spending have been suggested as two channels for corruption to affect inequality and growth. Is this assertion empirically valid? Finally, to what extent can corruption explain the differences in inequality and growth, say, between continents?

We examine these issues by looking at how corruption affects the Gini coefficient and growth rates in a sample of countries, using the recently compiled income distribution data by Deininger and Squire (1996) and a corruption index published by Political Risk Services. Using the theoretical framework developed by Murphy et al. (1991, 1993), we derive testable implications about how corruption affects inequality and growth. Most of these implications are found to be empirically valid. In particular, we find that corruption affects the Gini coefficient in an inverted U-shaped way; that is, inequality is low when levels of corruption are high or low, but inequality is high when corruption is intermediate. Corruption alone also explains a large proportion of the Gini differential across continents.[2] After correcting for measurement errors and imposing a rich conditional information set, corruption seems to retard economic growth. But its effect is not very significant. Moreover, corruption does not explain much of the growth differentials across continents. In countries where asset distribution is less equal, corruption is associated with a smaller increase in income inequality and a larger drop in growth rates. Finally, corruption raises income inequality to a lesser extent in countries with higher government spending.

This paper contributes to the empirical literature of corruption in five ways. First, we modify the framework of Murphy et al. (1991, 1993) to derive a rich set of empirical implications about the effects of corruption on growth and income distribution. Second, we examine, for the first time, the relationship between corruption and income inequality. Third, we check the robustness of the relationship between growth and corruption while dealing with measurement errors. Fourth, we allow the effects of corruption to depend on government spending and measures of capital market imperfection. And, finally, we investigate the potential role of corruption in explaining the differences in income inequality and growth rates across continents.

Section 2 presents a theoretical framework for examining how corruption affects growth and inequality. Section 3 discusses our data and then presents evidence on the effects of corruption. Section 4 concludes.

2. CORRUPTION, INCOME DISTRIBUTION, AND GROWTH: AN ANALYTICAL FRAMEWORK

Murphy et al. (1991, 1993) offer an encompassing framework to discuss how corruption affects both inequality and growth. In this section we modify their

[2] Here we use "continent" in a loose way. We mean the comparison of Asia, Latin America, and OECD countries.

models, especially the model in the second paper, to make the effects of corruption on inequality and growth more transparent.

A resident in a country can produce in either the traditional or the modern sector. In the traditional sector she produces γ, and in the modern sector she produces α, with $\alpha > \gamma$. The technological progress in the traditional sector is assumed to be slower than the modern sector. To simplify, we normalize the growth rate of the traditional sector as zero, and that of the modern sector as g, with $g > 0$. We assume that g decreases as the tax rate goes up in the modern sector. The advantage of the traditional sector is that it is not subject to expropriation, while the modern sector is. The reason is that entrepreneurs in the modern sector must obtain permits, licenses, and import quota from the government and are vulnerable to effects of corruption and rent-seeking behavior.

When not in productive sectors, one can also be a rent-seeker. Rent-seeking is characterized by a constant-return-to-scale technology of appropriating: the maximum amount one can appropriate is β. Let the ratio of people in the rent-seeking sector to the modern sector be n. Then the return to the modern sector will be $(\alpha - n\beta)$. Assuming that people maximize income, the allocation of labor across sectors will depend on α, γ, and β. The allocation in turn affects the average income level, income distribution, and growth rates. We analyze three cases.

1. $\beta < \gamma$. This corresponds to a non-corrupt society that protects property rights. With a low return on rent-seeking, everybody specializes in the modern sector. As a consequence, the average income at time t is αe^{gt}, the highest amount possible, and the growth rate is g. The Gini coefficient is zero.

2. $\beta > \alpha$. This is an extremely corrupt society that does not protect property rights. Since the return to rent-seeking is higher than any alternative activity, many people choose to be rent-seekers. Eventually, as the number of rent-seekers rises, the productivity of the modern sector falls to that of the traditional sector, i.e., $\alpha - n\beta = \gamma$. Call this threshold n', then $n' = (\alpha - \gamma)/\beta$. Since $\beta = \gamma$ at n', which is the interception for the return curves of the modern sector, the traditional sector, and the rent-seeking activity, $n' = \alpha/\gamma - 1$. In this economy, then, the average income level is γ, the lower bound of individual earning in the population. The Gini coefficient is zero. The growth rate is between 0 and g because some people are in the modern sector.[3]

3. $\gamma < \beta < \alpha$. This corresponds to an intermediate level of corruption. There are three equilibria: (i) the good equilibrium as in case 1 where everybody is in the modern sector; (ii) the bad equilibrium as in case 2, where people work in the modern, traditional, and rent-seeking sector, with equilibrium $n = \alpha/\gamma - 1$; and (iii) people work only in the modern and the rent-seeking sectors, and the return

[3] The exact *number* of people in the traditional and the modern sector is indeterminate here, only the ratio n is determinate. The indeterminacy could be eliminated if there are decreasing returns to scale to production, which is an unnecessary complication here.

to the modern sector is equated to that of rent-seeking, i.e., $\alpha - \beta n'' = \beta$, where n'' is the equilibrium ratio of rent-seekers to workers in the modern sector. Then $n'' = \alpha/\beta - 1 < n'$. Therefore, fewer people specialize in rent-seeking than in the equilibrium in case 2.[4] The income level is β, higher than that in case 2 but lower than that in case 1. Since fewer people choose to be rent-seekers and more people opt to work in the modern sector than in case 2, the growth rate g is larger. Similarly, the growth rate is lower than that in case 1, the good equilibrium.

It is conceivable that all three types of equilibria coexist in countries with an intermediate level of corruption. The variation in incomes (as measured by the coefficient of variation of incomes) in these countries, then, is higher than in countries with either high or low corruption (cases 1 and 2) – in cases 1 and 2, the equilibrium incomes are more likely to be similar. Moreover, the average income level and growth rate should be bounded by those of cases 1 and 2.

Now we summarize the main empirical implications from the model and, when appropriate, discuss further implications from the literature about how corruption affects inequality and growth:

- Corruption affects inequality in an inverted U-shaped way: inequality in countries with an intermediate level of corruption is higher than that in countries with little or rampant corruption.
- Corruption should be negatively correlated with the income level.
- Corruption should also be negatively correlated with growth. This conclusion is reinforced by elements not considered in the model. In Murphy et al. (1991), for instance, corruption is viewed as a tax on the profits from the productive sector. According to this logic, an increase in corruption amounts to a tax hike, which pulls talented entrepreneurs toward the rent-seeking sector; growth rates, in turn, drop. In addition, bureaucrats may distort investment toward projects offering better opportunities for secret corruption, such as defense and infrastructure (Shleifer and Vishny, 1993). The distortion in the composition of the modern sector raises the relative return to rent-seeking activity and, as a result, growth rates and income levels drop.
- There are further implications based on the above framework that are not modelled explicitly:

  (i) Since corruption pulls labor to the traditional sector – which needs low-skilled workers – the demand for unskilled relative to skilled workers increases. As a result, population growth in more corrupt countries will be higher.

[4] Implicitly we assume that the higher the ratio of rent-seekers to modern-sector workers, the higher the *number* of rent-seekers. This may not be true because, as pointed out in footnote 3, only the *ratio* is determined in the equilibrium, not the numbers. However, once we introduce decreasing returns to scale to production, the allocation of labor between the modern and the traditional sector will become determinant, and our implicit assumption holds.

(ii) In so far as the modern sector is likely to be concentrated in cities, and corruption discourages the modern sector, countries with more corruption are likely to be less urbanized.

(iii) Corruption affects reliance on banks or other financial intermediaries for business transaction. Johnson et al. (1997), for instance, note that fairer taxation and fewer regulations are associated with smaller unofficial economies in transitional economies of Eastern Europe and the former Soviet Union. We thus expect a more corrupt country to experience a lower level of financial deepening.

- An important variable related to corruption is the share of government spending. A larger share of government spending, financed by higher taxes on the modern sector, reduces investment rates, discourages talented people from becoming entrepreneurs, and thus reduces growth rates (Murphy et al., 1991). We therefore expect corruption in countries with higher government spending to have slower growth. Furthermore, a heavier tax for the modern/entrepreneur sector reduces the income differential between the modern and the traditional sector. We thus expect the effects of corruption in raising income inequality to be smaller in countries with more government spending.
- Assume that a high land Gini coefficient implies credit constraints for entry into the modern sector or becoming an entrepreneur (Li et al., 1998) – without assets as collateral, one has difficulties obtaining startup capital. A high land Gini coefficient then should be associated with a larger traditional sector. Since corruption mainly taxes the modern sector, corruption affects a smaller segment of the population in a country with a larger traditional sector, and thus has a smaller impact on inequality. We thus expect corruption to raise inequality to a lesser extent in countries with a higher initial land Gini coefficient.[5] Meanwhile, since a high land Gini coefficient implies a large traditional sector and less talent pouring into the modern sector, this results in a lower growth rate.

3. CORRUPTION, INCOME DISTRIBUTION, AND GROWTH: EVIDENCE

3.1 Data

The corruption index and other institutional variables – available for 1982–1994 – are based on the data published by Political Risk Services/IRIS (see Knack and Keefer, 1995). The data set contains five related variables: corruption (*CR*), government repudiation of contract (*GRC*), risk of expropriation (*RSKE*), rule of law (*ROLAW*), and bureaucratic quality (*BQ*). For the summary statistics of the corruption index, see Table 1. Since the five indices are highly correlated to each other (see Table 2), our regression analysis focuses on the

[5] This claim is demonstrated heuristically in Appendix A.

TABLE 1 SUMMARY STATISTICS OF CORRUPTION INDEX, GINI COEFFICIENT, AND GROWTH RATE

	Mean	Std. dev.	Maximum	Minimum
	Corruption index			
Full sample	2.080	1.580	6.000	0.00
OECD sample	0.593	0.762	2.830	0.00
Asian sample	2.956	1.555	6.000	0.00
Latin American sample	3.179	1.000	6.000	1.00
	Gini coefficient			
Full sample	38.115	9.302	58.015	19.965
OECD sample	32.745	4.010	41.720	25.400
Asian sample	39.898	5.847	50.150	28.376
Latin American sample	50.196	5.094	58.015	41.720
	Growth rate			
Full sample	1.702	3.322	13.734	−9.149
OECD sample	1.741	2.523	13.733	−5.448
Asian sample	3.703	2.804	9.090	−4.342
Latin American sample	0.454	2.828	6.272	−4.719

TABLE 2 CORRELATION MATRIX OF CORRUPTION INDEX AND OTHER INSTITUTIONAL VARIABLES

	CR	*BQ*	*ROLAW*	*RSKE*
BQ	0.8327			
ROLAW	0.8453	0.8266		
RSKE	0.7409	0.7890	0.8218	
GRC	0.7157	0.8298	0.8021	0.9071

corruption index, which ranks between 0 (most corrupted) and 6 (least corrupted). To make interpretation easier, the corruption index is transformed to (6−the index); still ranking between 0 and 6, a larger index now means a higher degree of corruption.[6]

The income inequality data are based on a new data set on the Gini coefficient developed by Deininger and Squire (1996), which is widely regarded as having the best inequality measure. Three criteria are used to compile the data. First, all observations are based on national household surveys for expenditure or income. Second, coverage represents the national population. Third, all sources of income and uses of expenditure are accounted for, including own-consumption. Since the definition of the Gini coefficient varies across countries in our sample – inequality can be measured by gross income, net income, or

[6] Our measure of corruption is more updated and extensive than Mauro (1995). We cover the period 1982–1994; Mauro covers only 1980–1983. After deleting observations without good Gini data, we cover 47 countries; Mauro (1995) covers 37.

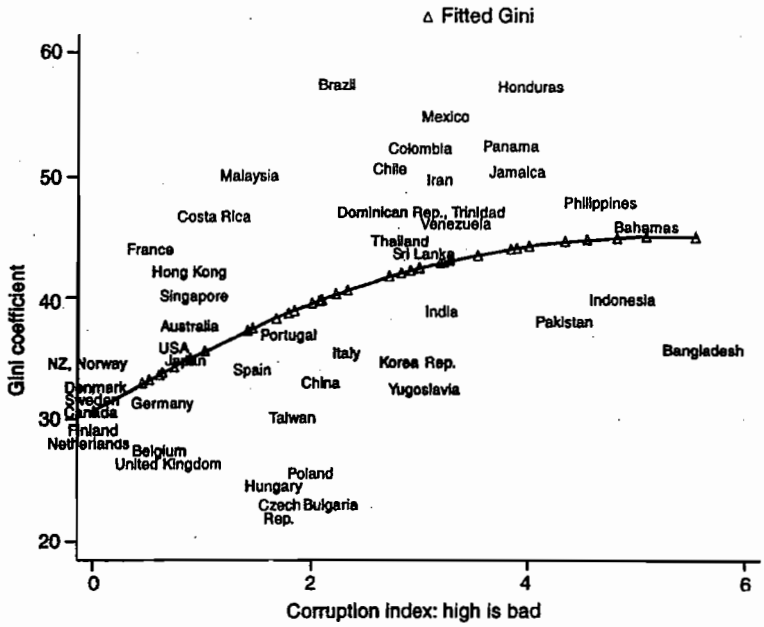


Figure 1. Correlation between corruption and income inequality.

expenditure, and it can be based on per capita or per household figures – proper adjustment is necessary. We have adjusted the data following the procedure recommended by Deininger and Squire (1996).[7]

The growth rate is calculated using the real per capita GDP (PPP adjusted) as in Summers and Heston (1994). The countries included in the analysis are Australia, Bangladesh, Belgium, Brazil, Bulgaria, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Dominican Republic, Finland, France, Germany, Honduras, Hong Kong, Hungary, India, Indonesia, Iran, Italy, Jamaica, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Panama, the Philippines, Poland, Portugal, Singapore, South Korea, Spain, Sri Lanka, Sweden, Thailand, Trinidad/Tobago, Tunisia, United Kingdom, United States, Venezuela, and Yugoslavia. The time period covered is 1980 to 1992.[8]

Figure 1 plots the average Gini against the average corruption index for the 47 countries. The Gini coefficient is positively correlated with corruption: the correlation coefficient is 0.462 and statistically significant (p-value of 0.000).

[7] Specifically, we adjust for differences between income-based and expenditure-based coefficients by increasing the latter by 6.6 points (based on a 100-point scale), the average difference observed by Deininger and Squire (1996).

[8] Although the corruption data are available up to 1995, the rest of the variables are available only up to 1992.

Note the inverted U-shaped line representing the simple regression of the Gini coefficient onto corruption and its square. Figure 2 plots the average growth rate against the average corruption index. The correlation coefficient is −0.048 (*p*-value of 0.574). Although insignificant, this correlation is in line with the empirical finding of Mauro (1995) that corruption is negatively associated with growth rates.

In our empirical analysis the variables are, as in many other empirical studies, averaged over five-year periods (see, for instance, Deininger and Squire, 1997; Li et al., 1998; Li and Zou, 1998; Li et al., 2000). The use of five-year averages reduces short-run fluctuations and allows us to focus on the structural relationships of interest. Most variables are complete, but the Gini coefficient is often missing in more than one year of each of the five-year periods; the five-year average then is computed based on non-missing observations. This should not represent a problem because the Gini coefficient is found to be relatively stable over time (Li et al., 1998).

Following recent empirics on economic growth (Barro, 1991; Levine and Renelt, 1992; King and Levine, 1993; Alesina and Rodrick, 1994), we also consider a list of other control variables in our regression analysis: (i) the initial GDP level (*INIGDP*), (ii) primary years of schooling (*SCHOOL*), (iii) financial

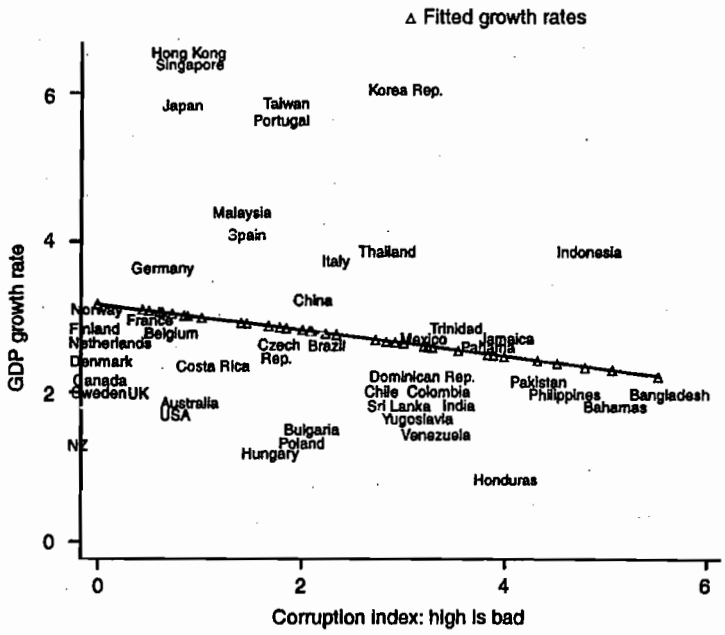


Figure 2. Correlation between corruption and growth.

development (*FINANCE*), defined as the money supply M2 over GDP, (iv) openness (*OPEN*), defined as imports over GDP, (v) terms-of-trade shocks (*TOTSHOCK*), defined as the difference of the change in export price and the change in import price, (vi) black market premium (*BMP*), (vii) government spending (*GOVSPEND*), defined as government spending over GDP, (viii) average arable land (*AREA*), (ix) the urbanization ratio (*URB*), (x) the population growth rate (*POPGROWTH*), and (xi) following Atkinson (1997), initial distribution of asset as measured by the initial land Gini coefficient (*INILANDGINI*). Most of these variables are obtained through the World Bank national accounts and Summers and Heston (1994). The black market premium data are from the Barro and Lee (1994) data set. The primary years of schooling data are from Nehru et al. (1995). Table 3 provides the correlation coefficients of the institutional variables and other regression variables based on the five-year average data for the whole sample.

Next we investigate the relationship between income inequality and corruption as well as the relationship between growth and corruption, while controlling for the effects of initial GDP (for convergence effects), education (human capital investment), financial development, and initial wealth distribution. Following Mauro (1995), Edwards (1997), and Li et al. (1998), we estimate the following equations:

$$\begin{aligned} GINI_{it} &= \alpha_0 + \alpha_1 CR_{it} + \alpha_2 INIGDP + \alpha_3 SCHOOL_{i,t-1} \\ &\quad + \alpha_4 FINANCE_{i,t-1} + \alpha_5 INILANDGINI_i + u_{it} \\ GROWTH_{it} &= \beta_0 + \beta_1 CR_{it} + \beta_2 INIGDP + \beta_3 SCHOOL_{i,t-1} \\ &\quad + \beta_4 FINANCE_{i,t-1} + \beta_5 INILANDGINI_i + v_{it}. \end{aligned} \tag{1}$$

TABLE 3 CORRELATION MATRIX OF INSTITUTIONAL VARIABLES AND OTHER REGRESSION VARIABLES

	CR	*BQ*	*ROLAW*	*RSKE*	*GRC*
GINI	−0.468	−0.400	−0.546	−0.547	−0.425
GROWTH	0.011	0.060	−0.013	0.165	0.187
INIGDP	0.690	0.759	0.747	0.615	0.634
$SCHOOL_{t-1}$	0.639	0.563	0.682	0.592	0.531
$FINANCE_{t-1}$	0.407	0.451	0.440	0.449	0.540
INILANDGINI	−0.307	−0.310	−0.260	−0.256	−0.330
TOTSHOCK	0.201	0.180	0.244	0.215	0.169
BMP	−0.214	−0.330	−0.253	−0.438	−0.423
OPEN	0.143	0.103	0.159	0.135	0.194
AREA	0.261	0.297	0.309	0.182	0.136
POPGROWTH	−0.581	−0.585	−0.676	−0.711	−0.638
URB	0.595	0.642	0.676	0.564	0.608
GOVSPEND	−0.204	−0.247	−0.247	−0.230	−0.238

Note: For some variables the lagged values are used in the regressions, hence their correlation coefficients are also based on lagged values.

Here *GINI* is the Gini coefficient, *GROWTH* is the real per capita GDP growth, *CR* is the corruption index. The country index is *i*, and the time index is *t* (*t* being 1, 2, and 3, the time interval for 1980–1984, 1985–1989, and 1990–1992). The lagged value of years of primary schooling and the financial development index are used to account for possible endogeneity.[9] The initial GDP and the initial land Gini are, of course, time-invariant.

Since corruption is a subjective measure, it is likely to be badly measured. So for each specification we correct for measurement errors. In particular, we use the average of the corruption measure for each country in Mauro (1995) – which is time-invariant – and its polynomials as instruments for our corruption measure. Since the Mauro measure comes from different sources and covers an earlier period (1980–1983), we do not expect the measurement errors of the two proxies to be correlated. Since they are closely correlated, the Mauro measure serves as a good instrument for our corruption measure (Greene, 1997, p. 443).

3.2 *Corruption and Income Distribution*

In the baseline regressions for the Gini coefficient (columns 1 and 2, Table 4), corruption raises the Gini in an inverted U-shaped way. This is consistent with the predictions of the model. The OLS results suggest that corruption begins to reduce the Gini when the index exceeds 2.91. Although the 2SLS results do not preserve the quadratic pattern of the OLS, as we shall see later, this pattern is robust to most other specifications. Thus, consistent with our model, high or low levels of corruption are associated with low income inequality, while an intermediate level of corruption is associated with high income inequality.

To examine the effects of corruption on income inequality across continents, we experimented with alternative coefficients for each continent (columns 3 and 4, Table 4). It turned out that only Latin American countries differ. Corruption affects the Gini coefficient, again in a quadratic way, both in the OLS and the 2SLS specification. Relative to elsewhere, corruption in Latin American countries increases inequality to a larger extent at low levels of corruption, and the implied marginal effects of corruption on inequality drop faster as corruption increases.

What happens when the square of the corruption index is dropped? Corruption in the OLS specification is no longer significant (columns 5 and 6 in Table 4). Taking measurement errors into account, the 2SLS results – using an alternative measure of corruption (the Mauro measure) and its polynomials as instruments – indicate that corruption increases income inequality significantly. A one-standard-deviation increase in corruption raises the Gini by roughly five points, a quite large effect.

[9] Similar results are obtained when we lag one or two more time periods, or when the instrumental variable method is applied. We thus do not report these results.

TABLE 4 INCOME DISTRIBUTION AND CORRUPTION
Dependent variable: the Gini coefficient

	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS	(5) OLS	(6) 2SLS	(7) OLS	(8) 2SLS	(9) OLS	(10) 2SLS
No. obs.	101	90	101	90	101	90	111	98	111	90
R^2	0.622	0.512	0.716	0.664	0.609	0.554	0.463	0.429	0.659	0.662
CR	3.119*	1.333	1.813	7.683**	0.440	2.995**	4.986**	5.425**	0.957	8.037**
	(1.652)	(4.957)	(1.469)	(3.212)	(0.662)	(1.380)	(1.389)	(2.659)	(1.238)	(2.453)
CR^2	−0.525*	0.349	−0.237	−1.021*			−0.923**	−0.583	−0.158	−1.079**
	(0.297)	(0.996)	(0.269)	(0.603)			(0.239)	(0.547)	(0.218)	(0.500)
CR × LATIN			8.098**	4.038					9.719**	4.468
			(2.575)	(6.861)					(2.388)	(6.368)
$CR^2 \times LATIN$			−1.489**	−0.476					−1.758**	−0.598
			(0.678)	(1.988)					(0.645)	(1.851)
INIGDP	0.138	−0.450	0.087	0.083	−0.137	−0.322	0.151	−0.315	−0.274	0.140
	(0.381)	(0.685)	(0.342)	(0.538)	(0.352)	(0.550)	(0.368)	(0.452)	(0.305)	(0.421)
$SCHOOL_{t-1}$	−1.740**	0.629	−1.325**	0.782	−1.727**	0.631	−1.896**	0.346	−1.106**	0.774
	(0.506)	(0.771)	(0.452)	(0.657)	(0.512)	(0.732)	(0.539)	(0.741)	(0.449)	(0.654)
$FINANCE_{t-1}$	−17.915**	−5.737	−9.300**	−4.972	−16.439**	−6.727	−11.436**	−3.877	−1.998	−4.968
	(3.319)	(5.182)	(3.426)	(5.162)	(3.247)	(4.129)	(3.017)	(3.924)	(2.809)	(5.147)
INILANDGINI	0.095**	0.179**	0.003	0.009	0.131**	0.157**				
	(0.040)	(0.075)	(0.039)	(0.053)	(0.035)	(0.040)				

*, ** Statistical significance at the 10 and 5 percent levels, respectively.
Note: Standard errors in parentheses. For all the 2SLS results, the instruments for corruption and its interaction term(s) are the Mauro corruption measure, its polynomials, and this measure's corresponding interaction term(s).

Some may argue that the initial land Gini may account for too much of the variation of the Gini, thus leaving too little room for other explanatory variables. It should be noted that the initial land Gini captures the distribution of assets instead of income, thus controlling for the initial land Gini does not imply controlling for the initial Gini. Moreover, Atkinson (1997) and Alesina and Rodrick (1994) also argue for the inclusion of this variable. Nonetheless, we still experiment with dropping it (columns 7 to 10, Table 4); doing so may highlight the link between corruption and the Gini coefficient as long as the initial land Gini partly reflects an initial cumulative effect of corruption, and corruption tends to persist over time. It turns out that the results do not change much – corruption still affects inequality in an inverted U-shaped way. Moreover, as expected, the effects of corruption on the Gini become even more pronounced, and the quadratic pattern is still preserved (columns 7 and 8). The threshold for corruption to reduce inequality becomes 2.7 for the OLS specification, and 4.7 for the 2SLS specification.

Adding more control variables does not change the quadratic pattern of corruption effects on the Gini coefficient (Table 5). Columns 1 to 4 include more variables that are conventionally thought to be important indicators of policies in cross-country studies (Barro, 1991; Levine and Renelt, 1992) – black market premium, the share of government spending, openness, and the terms-of-trade shock. The quadratic effects of corruption on the Gini coefficient remain intact in three out of the four specifications. The effect of corruption in Latin America is higher than the rest of the world – later we will show that it may be because government spending in Latin America has an especially harmful effect on inequality. Columns 5 to 8 further control for urbanization, arable land, and population growth rate. The quadratic pattern of corruption remains intact. Of the new variables, population growth significantly raises the Gini. Corruption continues to affect Latin America in a more adverse way.

Since corruption affects income distribution via government spending, as discussed earlier, we link corruption to government spending (columns 1 and 2, Table 6). The interaction term of corruption and government spending share is negative and significant in our preferred 2SLS specification; this is consistent with our hypothesis that corruption raises inequality less where government spending is higher. Government spending by itself does not affect the Gini in the 2SLS specification, but it raises the Gini in Latin America.[10]

The effect of corruption on inequality may also hinge on, as mentioned earlier, the initial land Gini coefficient – here the premise is that a more unequal distribution of assets reduces the access to credit markets for the poor and prevents them from migrating to the modern high-wage sector. Columns 3 and 4 of Table 6 indicate that the inequality-raising effects of corruption become

[10] The reason for a worse income inequality effect of government spending is beyond the scope of this paper.

TABLE 5 INCOME DISTRIBUTION AND CORRUPTION: SENSITIVITY ANALYSIS
Dependent variable: the Gini coefficient

	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS	(5) OLS	(6) 2SLS	(7) OLS	(8) 2SLS
No. obs	84	78	84	78	80	75	80	75
R^2	0.653	0.505	0.750	0.662	0.734	0.706	0.811	0.797
CR	3.231*	−1.671	2.082	8.870**	4.354**	2.252	2.686*	6.585**
	(1.664)	(5.585)	(1.471)	(3.195)	(1.544)	(3.631)	(1.391)	(2.122)
CR^2	−0.577**	0.702	−0.330	−1.367**	−0.751**	−0.270	−0.414*	−1.062**
	(0.294)	(1.081)	(0.259)	(0.562)	(0.271)	(0.714)	(0.241)	(0.386)
CR × LATIN			7.983**	5.447			10.790**	15.765**
			(2.964)	(6.743)			(3.050)	(6.071)
CR^2 × *LATIN*			−1.372*	−0.838			−2.113**	−3.608**
			(0.768)	(1.893)			(0.761)	(1.642)
INIGDP	−0.773*	−1.063	−0.708*	−0.035	−0.575	−0.877	−0.056	0.449
	(0.421)	(0.773)	(0.388)	(0.592)	(0.451)	(0.593)	(0.424)	(0.530)
$SCHOOL_{t-1}$	−0.366	0.323	−0.224	0.531	0.304	0.652	0.572	1.201**
	(0.629)	(0.840)	(0.543)	(0.690)	(0.598)	(0.656)	(0.515)	(0.575)
$FINANCE_{t-1}$	−14.931**	−6.160	−8.275**	−7.935	−7.567**	−3.841	−1.618	0.622
	(3.676)	(5.940)	(3.583)	(5.189)	(3.851)	(5.050)	(3.585)	(4.560)
INILANDGINI	0.107**	0.173**	0.032	−0.013	0.084**	0.118**	0.020	0.005
	(0.041)	(0.076)	(0.038)	(0.050)	(0.037)	(0.052)	(0.034)	(0.038)

BMP	1.772	2.767	−4.340	−4.740	−1.874	−1.356	−5.238*	−6.706**
	(3.370)	(4.394)	(3.154)	(3.981)	(3.215)	(3.682)	(2.833)	(3.152)
GOVSPEND	0.050	0.040	0.057	0.098	0.027	0.066	−0.067	−0.024
	(0.136)	(0.165)	(0.118)	(0.145)	(0.133)	(0.146)	(0.116)	(0.120)
OPEN	−0.049	−0.065	−0.066	−0.055	0.050	0.043	0.025	0.103
	(0.046)	(0.056)	(0.043)	(0.062)	(0.051)	(0.057)	(0.049)	(0.065)
TOTSHOCK	2.829	4.014	2.195	0.317	4.759	5.763	3.270	2.202
	(4.501)	(5.627)	(3.888)	(4.697)	(4.093)	(4.411)	(3.522)	(3.721)
URB					0.053	0.059	−0.083*	−0.103*
					(0.047)	(0.057)	(0.049)	(0.058)
AREA					−0.049	−0.034	0.047	−0.008
					(0.116)	(0.131)	(0.102)	(0.107)
POPGROWTH					4.289**	4.505**	2.993**	3.877**
					(1.060)	(1.336)	(0.942)	(1.089)

*, ** Statistical significance at the 10 and 5 percent levels, respectively.
Note: Standard errors in parentheses. For all the 2SLS results, the instruments for corruption and its interaction term(s) are the Mauro corruption measure, its polynomials, and this measure's corresponding interaction term(s).

TABLE 6 INCOME DISTRIBUTION AND CORRUPTION: FURTHER RESULTS
Dependent variable: the Gini coefficient

	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS
No. obs.	101	90	101	90
R^2	0.731	0.69	0.723	0.663
CR	0.18	4.401**	3.719**	6.827**
	(1.32)	(1.794)	(1.588)	(2.439)
INIGDP	−0.211	−0.627	−0.184	−1.257
	(0.309)	(0.459)	(0.305)	(3.602)
$SCHOOL_{t-1}$	−1.336**	0.403	−1.712**	−0.003
	(0.438)	(0.632)	(0.458)	(0.803)
$FINANCE_{t-1}$	−11.019*	−3.303	−9.080**	−1.257
	(2.928)	(3.629)	(3.058)	(3.602)
INILANDGINI	0.039	0.095**	0.119**	0.160**
	(0.033)	(0.039)	(0.049)	(0.072)
GOVSPEND	−0.334*	0.256		
	(0.193)	(0.245)		
CR × *GOVSPEND*	0.009	−0.168*		
	(0.075)	(0.09)		
GOVSPEND × *LATIN*	0.55**	0.512**		
	(0.091)	(0.106)		
CR × *INILANDGINI*			−0.068**	−0.090*
			(0.027)	(0.052)
CR × *INILANDGINI* × *LATIN*			0.048**	0.054**
			(0.08)	(0.014)

*, ** Statistical significance at the 10 and 5 percent levels, respectively.
Note: Standard errors in parentheses. For all the 2SLS results, the instruments for corruption and its interaction term(s) are the Mauro corruption measure, its polynomials, and this measure's corresponding interaction term(s).

smaller where the initial land Gini is larger, which is consistent with the theory. This change in magnitude is smaller in Latin America.

3.3 *Corruption and Growth*

Corruption reduces the growth rate (Table 7). Columns 1 and 2 in Table 7 present the baseline specification (following Barro, 1991; Levine and Renelt, 1992; and Alesina and Rodrik, 1994) in which we control for initial GDP (for convergence effects), $SCHOOL_{t-1}$, $FINANCE_{t-1}$, and *INILANDGINI*. We do not control for the investment rate because it is endogenous and is likely to reflect the outcome of our included variables. According to the OLS results, the direct effects of a one-standard-deviation increase of corruption on the growth

TABLE 7 GROWTH RATES AND CORRUPTION
Dependent variable: the growth rate

	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS	(5) OLS	(6) 2SLS	(7) OLS	(8) 2SLS	(9) OLS	(10) 2SLS
No. obs.	114	102	102	114	91	85	87	82	87	82
R^2	0.126	0.196	0.231	0.189	0.241	0.287	0.334	0.350	0.376	0.373
CR	−0.523*	−0.203	−0.744	−0.957**	−0.442	−0.582	−0.439	−0.454	−0.777**	−0.667
	(0.301)	(0.586)	(0.625)	(0.327)	(0.300)	(0.607)	(0.302)	(0.726)	(0.331)	(0.674)
INIGDP	−0.282*	−0.544**	−0.549**	−0.263*	−0.410**	−0.584**	−0.543**	−0.584**	−0.588**	−0.603**
	(0.163)	(0.233)	(0.220)	(0.158)	(0.183)	(0.251)	(0.216)	(0.249)	(0.211)	(0.241)
$SCHOOL_{t-1}$	−0.382	0.193	0.188	−0.309	−0.296	−0.164	−0.361	−0.216	−0.371	−0.236
	(0.239)	(0.298)	(0.289)	(0.233)	(0.279)	(0.298)	(0.293)	(0.303)	(0.286)	(0.299)
$FINANCE_{t-1}$	0.965	3.195*	3.512**	1.802	0.720	1.062	−1.256	−0.509	−0.236	0.650
	(1.479)	(1.676)	(1.612)	(1.460)	(1.586)	(1.778)	(1.841)	(1.953)	(1.851)	(1.963)
INILANDGINI	−0.034**	−0.019	0.010	0.000	−0.018	−0.009	−0.013	−0.008	0.011	0.017
	(0.016)	(0.017)	(0.023)	(0.020)	(0.017)	(0.018)	(0.017)	(0.019)	(0.020)	(0.023)
BMP					−3.660**	−3.003*	−1.939	−1.601	−1.344	−1.172
					(1.572)	(1.659)	(1.641)	(1.786)	(1.621)	(1.773)
GOVSPEND					−0.013	0.004	−0.021	−0.017	−0.003	0.010
					(0.063)	(0.062)	(0.068)	(0.070)	(0.066)	(0.069)
OPEN					−0.001	0.003	−0.011	−0.003	0.003	0.011
					(0.022)	(0.021)	(0.026)	(0.027)	(0.026)	(0.027)
TOTSHOCK					0.759	0.902	−0.256	0.421	−0.084	0.509
					(1.967)	(1.959)	(1.962)	(1.972)	(1.913)	(1.949)

(Continued)

TABLE 7 *Continued*

	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS	(5) OLS	(6) 2SLS	(7) OLS	(8) 2SLS	(9) OLS	(10) 2SLS
URB							−0.021	−0.026	0.000	0.004
							(0.024)	(0.027)	(0.026)	(0.029)
AREA							0.074	0.074	0.078	0.082
							(0.059)	(0.063)	(0.058)	(0.061)
POPGROWTH							−1.607**	−1.335**	−1.600**	−1.515**
							(0.541)	(0.654)	(0.527)	(0.638)
CR × ASIA			0.657**	0.800**					0.712**	0.827**
			(0.323)	(0.276)					(0.320)	(0.391)

*, ** Statistical significance at the 10 and 5 percent levels, respectively.
Note: Standard errors in parentheses. For all the 2SLS results, the instruments for corruption and its interaction term(s) are the Mauro corruption measure, its polynomials, and this measure's corresponding interaction term(s).

rate is a reduction of 0.83 percent; the 2SLS results suggest a smaller figure of 0.32 percent. Other baseline results suggest that *FINANCE* is associated with higher growth, initial land Gini is associated with lower growth, and schooling is insignificantly associated with growth.[11] When interacting corruption with the Asia dummy – the Latin America interaction proved to be insignificant – corruption has a far less deleterious effect on growth in Asia than elsewhere (though on net, corruption still had a negative effect on growth in Asia). Using the smaller figures of OLS, the direct effect of a one-standard-deviation increase of corruption (1.58) is a reduction of growth rate by 1.18 percent elsewhere, but only 0.14 in Asia. It is interesting to note that crony capitalism has been suggested as a culprit in the recent Asia crisis. While not constituting direct evidence for the claim, our findings suggest that during 1980–1994 Asia did not pay the price paid elsewhere for corruption; in other words, corruption may indeed have acted as grease money in Asia during this period. Therefore, corruption eventually extracted a higher price in Asia and may have contributed to the financial crises via the cumulative effects of investing in the wrong type of capital.[12]

The addition of more control variables in the empirical growth literature reduces the statistical significance of corruption, though the sign remains negative. This may raise doubts about whether corruption indeed reduces growth (Mauro, 1995).

Since corruption may be more harmful where government plays a larger role, columns 1 and 2 of Table 8 link the corruption effects to government spending. In most countries in our sample there is little evidence that corruption has a more adverse effect on growth when government spending is higher. Government spending by itself does not appear to affect the growth rate; though government spending appears to have adversely affected growth rates in Latin America.

The effect of corruption on growth appears to depend also on the initial land Gini (columns 3 and 4 of Table 8). Consistent with the implications of our analytical framework, corruption reduces growth rates more in countries where the distribution of land is more unequal. To gauge the magnitude, evaluated at the mean corruption level of 2.08, a one-standard-deviation increase of *INILANDGINI* (18.4) reduces growth rate by 1.1 percent, a fairly large effect. From another angle, at the mean level of *INILANDGINI*, a one-standard-deviation increase of corruption (1.58) reduces the growth rate by 0.6 percent, a large effect. (Note that we have taken into account the positive direct effect of corruption on growth, i.e., 1.455×1.58.)

[11] The insignificance and wrong sign of *SCHOOL* are probably due to the short panel of our analysis and the limited variation of the variable.

[12] In an interesting paper, Fisman (1998) provides complementary evidence that corruption may have a lot to do with the crisis in Indonesia. Using the Jakarta Stock Exchange's reaction to news about former President Suharto's health to estimate the proportion of a firm's value derived from political connections, he finds that as much as a quarter of a firm's share price in Indonesia may be accounted for by political connections.

TABLE 8 GROWTH RATES AND CORRUPTION: FURTHER RESULTS
Dependent variable: the growth rate

	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS
No. obs.	114	102	114	102
R^2	0.153	0.226	0.178	0.256
CR	−0.959	0.237	1.134	1.455*
	(0.747)	(0.943)	(0.699)	(0.796)
INIGDP	−0.311*	−0.628**	−0.213	−0.468**
	(0.168)	(0.226)	(0.161)	(0.212)
$SCHOOL_{t-1}$	−0.387	0.253	−0.531**	0.003
	(0.242)	(0.304)	(0.240)	(0.310)
$FINANCE_{t-1}$	0.012	2.864*	0.730	2.815*
	(1.576)	(1.722)	(1.443)	(1.641)
INILANDGINI	−0.02	0.001	0.015	0.032
	(0.018)	(0.019)	(0.025)	(0.032)
GOVSPEND	−0.075	0.097		
	(0.11)	(0.128)		
CR × *GOVSPEND*	0.027	−0.03		
	(0.042)	(0.047)		
LATIN × *GOVSPEND*	−0.082*	−0.082		
	(0.049)	(0.052)		
CR × *INILANDGINI*			−0.028**	−0.029*
			(0.011)	(0.014)

*, ** Statistical significance at the 10 and 5 percent levels, respectively.
Note: Standard errors in parentheses. For all the 2SLS results, the instruments for corruption and its interaction term(s) are the Mauro corruption measure, its polynomials, and this measure's corresponding interaction term(s).

3.4 *Can Corruption Explain Inequality and Growth?*

Since the regressions reported so far are not structural, we cannot interpret the coefficients of corruption as total effects; corruption may be correlated with other right-hand-side variables. To gauge the total effect of corruption and to put the numbers in perspective, we now analyze how corruption accounts for the differences in the Gini coefficient and in growth rates among pairs of continents: Latin America and Asia, Latin America and the OECD, and Asia and the OECD. (Africa is excluded because it has too few observations.)

The effects of corruption can be both direct and indirect. To be precise, suppose that the outcome equation is $y = X(C)\beta + C\delta + \varepsilon$, where y is the outcome (the Gini or per capita growth rate), X is a vector of other controls, and C is corruption. Since other explanatory variables also depend on C, X can be written as $X(C)$. Thus let $X(C) = X_0 + C\alpha + e$, where e is the error term. Denote the intercontinental difference (between continents i and j) in

corruption as ΔC_{ij}, then the direct effect of corruption is $\delta \Delta C_{ij}$, and the indirect effect is $\alpha\beta \Delta C_{ij}$.

To set the stage, Table 9 shows how all the channel variables are affected by corruption. The results confirm many of the notions discussed in the theoretical framework.[13] More corrupt countries share the following characteristics:

- Schooling attainment is lower, perhaps because the traditional sector does not need a high level of schooling.
- Population growth is higher, perhaps because the demand for unskilled labor (in the form of more children) is higher when corruption discourages the development of the modern sector.
- Urbanization is lower, most likely because residents choose to live in the countryside to avoid expropriation.
- Financial depth is thinner, presumably because firms and households rely more on an unofficial economy.
- Black market premiums are higher, another indication that corruption spurs the unofficial economy.
- Land distribution is more unequal, perhaps reflecting the cumulative effects of corruption.
- Government spending is higher, perhaps because big government spawns corruption via bureaucrats manipulating spending in order to collect more bribes.
- The extent of foreign trade is smaller, perhaps highlighting the presence of a traditional sector in these countries and the deleterious effects of corruption in discouraging potential exports (licenses would be more costly, for instance).
- The average income (*INIGDP*) is lower.[14]

The relationship between corruption and income levels needs further empirical illustration. One of our hypotheses is that countries with low or high corruption levels will have lower variability in income *level* than countries with intermediate corruption levels. This is borne out by our data (Figure 3). The coefficient of variations for *INIGDP* is much lower for the low- or high-corruption countries than that for the middle-ranged countries: the former all have values below 0.40, while the latter is between 0.55 and 0.80.

The accounting results for the Gini coefficient are reported in Table 10. We only report the results based on the specification that includes all the sensitivity variables (i.e., columns 5 and 6 in Table 5). The qualitative results from the baseline specification remain similar but less interesting because fewer channels

[13] Note that we exclude *TOTSHOCK* and *AREA* in the accounting exercise. It strains the imagination to see how corruption affects these two variables.

[14] Initial GDP may be affected by corruption because of the working assumption that corruption between periods is highly correlated over time, thus, the corruption index at time t is quite close in value to the initial time of our sample. Then the regression of initial GDP to corruption may reflect the influence of corruption on income level.

TABLE 9 LINKS BETWEEN INTERMEDIATE CHANNELS AND CORRUPTION

	$SCHOOL_{t-1}$	$FINANCE_{t-1}$	*INILANDGINI*	*BMP*	*GOVSPEND*	*OPEN*	*URB*	*POPGROWTH*	*INIGDP*
No. obs.	138	141	126	108	142	137	143	143	129
R^2	0.404	0.167	0.095	0.047	0.040	0.022	0.351	0.333	0.471
Corruption	−0.730**	−0.065**	3.757**	0.163**	0.791**	−2.702*	−8.470**	0.352**	−1.196**
	(0.076)	(0.012)	(1.043)	(0.071)	(0.329)	(1.542)	(0.969)	(0.042)	(0.112)

*, ** Statistical significance at the 10 and 5 percent levels, respectively.

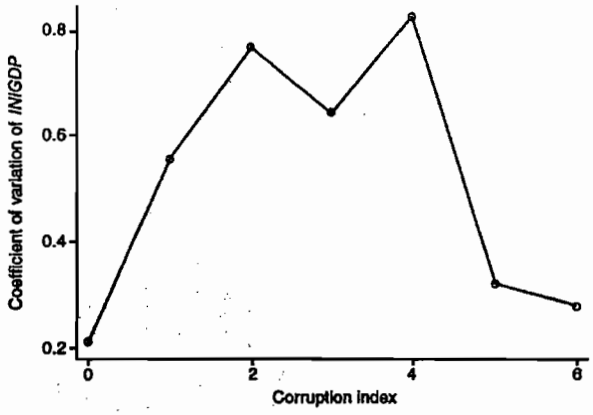


Figure 3. Coefficient of variation of *INIGDP* by corruption index. Note: The coefficient of variation of *INIGDP* is based on the collapsed sample mean of all countries with the same *integer* value of corruption index. For instance, a value of 4 represents all countries whose values are 4 up to 4.99.

are used.[15] Corruption accounts for a substantial portion of the Gini differential between industrial and developing countries. Corruption alone explains roughly half of the Latin America–OECD Gini differential, and all of the Asia–OECD Gini differential. In contrast, corruption only accounts for roughly 10 percent of the Latin America–Asia Gini differential. As Table 6 shows, corruption affects the Gini in Asia and Latin America through somewhat different routes: in Latin America the inequality-raising effects of corruption increase with government spending and initial inequaiity in asset distribution. The most important indirect effects include population growth, financial depth, and income level.

Corruption, in contrast, cannot explain much of the continental differentials in growth (Table 11).[16] While the Latin America–Asia growth differential is −3.3 percent, the direct and total effects of corruption are −0.10 and −0.04 percent, respectively. Similarly, the Asia–OECD growth differential is 1.96 percent, and the direct and total effects of corruption are negative by most estimates – higher corruption contributed to lower growth in Asia. The only pair where corruption helps to explain the differential is the Latin America vis-à-vis the OECD case: The growth rate differential is −1.3 percent, which can be almost entirely explained by the direct effects of corruption. The total effects

[15] They are available upon request.

[16] Again, we only report the results based on the specification that includes all the sensitivity variables (i.e., columns 7 and 8 in Table 7). The qualitative results from the baseline specification remain similar but less interesting because fewer channels are restricted to be used. The results are available upon request.

TABLE 10 ACCOUNTING FOR DIFFERENCES IN THE GINI COEFFICIENTS IN LATIN AMERICA, ASIA, AND THE OECD

	OLS			2SLS		
	Latin Am. vs. Asia	Latin Am. vs. OECD	Asia vs. OECD	Latin Am. vs. Asia	Latin Am. vs. OECD	Asia vs. OECD
Difference in the Gini coefficient	10.30	17.45	7.15	10.30	17.45	7.15
Difference in corruption	0.22	2.59	2.36	0.22	2.59	2.36
Total effects attributable to corruption	1.41	8.57	7.16	0.97	8.42	7.45
Direct effects of corruption	0.99	3.63	2.65	0.51	3.08	2.57
Indirect effects of corruption through:						
INIGDP	0.15	1.78	1.62	0.23	2.71	2.47
$SCHOOL_{t-1}$	−0.05	−0.57	−0.53	−0.11	−1.23	−1.12
$FINANCE_{t-1}$	0.11	1.27	1.16	0.06	0.65	0.59
INILANDGINI	0.07	0.81	0.74	0.10	1.15	1.05
BMP	−0.07	−0.79	−0.72	−0.05	−0.57	−0.52
GOVSPEND	0.005	0.06	0.05	0.01	0.13	0.12
OPEN	−0.03	−0.35	−0.22	−0.03	−0.30	−0.28
URB	−0.10	−1.17	−1.07	−0.11	−1.29	−1.18
POPGROWTH	0.34	3.90	3.56	0.35	4.10	3.74

Note: The specifications behind the first and second sets of three columns are columns 5 and 6 of Table 5, respectively.

TABLE 11 ACCOUNTING FOR DIFFERENCES IN GROWTH RATES IN LATIN AMERICA, ASIA, AND THE OECD

	OLS			2SLS		
	Latin Am. vs. Asia	Latin Am. vs. OECD	Asia vs. OECD	Latin Am. vs. Asia	Latin Am. vs. OECD	Asia vs. OECD
Difference in growth rates	−3.25	−1.29	1.96	−3.25	−1.29	1.96
Difference in corruption	0.22	2.59	2.36	0.22	2.59	2.36
Total effects attributable to corruption	−0.04	−0.47	−0.43	−0.02	−0.29	−0.26
Direct effects of corruption	−0.10	−1.14	−1.04	−0.10	−1.17	−1.07
Indirect effects of corruption through:						
INIGDP	0.15	1.68	1.53	0.16	1.81	1.65
$SCHOOL_{t-1}$	0.06	0.68	0.62	0.04	0.41	0.37
$FINANCE_{t-1}$	0.02	0.21	0.19	0.01	0.09	0.08
INILANDGINI	−0.01	−0.12	−0.11	−0.01	−0.08	−0.07
BMP	−0.07	−0.82	−0.75	−0.06	−0.67	−0.62
GOVSPEND	−0.003	−0.04	−0.04	−0.003	−0.03	−0.03
OPEN	0.01	0.08	0.07	0.002	0.02	0.52
URB	0.04	0.46	0.42	0.05	0.57	−1.11
POPGROWTH	−0.13	−1.46	−1.34	−0.10	−1.21	−1.299

Note. The specifications behind the first and second sets of three columns are columns 7 and 8 of Table 7, respectively.

explain less – largely because corruption leads to lower GDP, which contributes to a higher growth rate via convergence effects.

4. CONCLUSION

Based on the theoretical framework of Murphy et al. (1991, 1993), we find that the relationship between corruption and inequality is not a monotonic one; rather, an inverted U-shape is observed.[17] The theoretical framework suggests that high-corruption countries also have low inequality, and our empirical results confirm it. Our empirical findings also show that corruption tends to have a negative impact on growth, but its effect is not very significant. Furthermore, corruption alone explains little of the continental growth differentials. In addition, we find that corruption in countries with more inequality in asset allocation raises inequality to a lesser extent and reduces growth to a larger extent. In Latin America corruption has distinct effects: it has a greater impact on inequality relative to other continents. In particular, when government spending is higher corruption is more harmful for growth. It remains to find out what factors account for the Latin America effects.

Much work remains to be done. For instance, how does corruption affect the sectoral structure of the economy? What determines corruption? If, as Murphy et al. (1993) assert, the equilibrium associated with a particular level of corruption is relatively stable, then what explains the evolution of corruption and rent-seeking activity over time? Finally, in light of the weak link between corruption and growth, maybe we should re-examine Mauro's (1995) findings regarding the negative association between corruption and growth.

APPENDIX A

Consider a two-sector economy with a traditional and a modern sector. Let s be the share of the traditional sector, and ω the ratio of income between the modern and the traditional sector. It can be easily proven that

$$Gini = s - \frac{1}{1+\omega(1/s-1)} \approx s + (s-s^2)(\omega-1). \tag{2}$$

The approximation is based on a linear Taylor expansion at $\omega = 1$.

Let C represent corruption, then

$$\frac{\partial Gini}{\partial C} = \frac{\partial s}{\partial C}[1+(\omega-1)(1-2s)] + (s-s^2)\frac{\partial \omega}{\partial C} \tag{3}$$

$$\frac{\partial^2 Gini}{\partial C \partial s} = -2(\omega-1)\frac{\partial s}{\partial C} + (1-2s)\frac{\partial \omega}{\partial C}. \tag{4}$$

[17] The two papers by Murphy et al. are theoretical. Our paper differs from theirs in our empirical implementation.

It is useful to have some idea of how large ω is before we judge the sign of the second derivative. A value for ω of something like 1.5 or larger is likely to be appropriate, since the wage differential between the modern and the traditional sector should be larger than the wage differential between the urban and the rural, which is about 41 percent (Squire, 1981, table 30, p. 102). In another context, the real urban–rural wage gap for relatively homogeneous unskilled male labor in England at the end of the First Industrial Revolution was about 33 percent (Williamson, 1986).

Now we attempt to infer the sign of $(\partial^2 Gini/\partial C\partial s)$. Since $(\partial s/\partial C) > 0$ (as the model implies), and $(\partial\omega/\partial C) < 0$ (because corruption reduces the income level in the modern sector, but not the traditional sector), we can infer the following:

- If $s < 0.5$, the second term is negative, and $(\partial^2 Gini/\partial C\partial s)$ is then negative.
- If $s > 0.5$, but the marginal impact of corruption on the pay differential is smaller than on the share of employment in the traditional sector, $(\partial^2 Gini/\partial C\partial s)$ is still negative.
- Only when s approaches 1, and the sectoral wage differential is relatively small, and the marginal effects of corruption on sectoral wage differential are larger than its effects on the employment share of the traditional sector, is $(\partial^2 Gini/\partial C\partial s)$ positive.

Thus, $(\partial^2 Gini/\partial C\partial s)$ is most likely negative. Since a larger land Gini implies a larger s, as is assumed, a larger land Gini should be associated with smaller corruption effects on the Gini.

HONGYI LI
Chinese University of Hong Kong
LIXIN COLIN XU
The World Bank, Washington, DC
HENG-FU ZOU
The World Bank, Washington, DC, Peking University and Wuhan University

REFERENCES

Alam, M. S., 1991, Some economic costs of corruption in LDCs. *Journal of Development Studies* 27, 89–97.

Alesina, A. and D. Rodrik, 1994, Distribution politics and economic growth. *Quarterly Journal of Economics* 109, 465–490.

Atkinson, A. B., 1997, Bringing income distribution in from the cold. *Economic Journal* 35, 1320–1346.

Bardhan, P., 1995, The economics of corruption in less developed countries: a review of issues. Mimeo, University of California, Berkeley.

Barro, R., 1991, Economic growth in a cross-section of countries. *Quarterly Journal of Economics* 106, 407–443.

——— and J. Lee, 1994, Data set for a panel of 138 countries. NBER Working Paper.

Deininger, K. and L. Squire, 1996, A new data set measuring income inequality. *The World Bank Economic Review* 10, 565–591.

——— and ———, 1998, New ways of looking at old issues: inequality and growth. *Journal of Development Economics* 57, 259–287.

Easterly, W. and R. Levine, 1997, Africa's growth tragedy: policies and ethnic divisions. *Quarterly Journal of Economics* 111, 1203–1250.

Edwards, S. 1997, Trade policy, growth, and income distribution. *American Economic Review* 82, 205–210.

Fisman, R., 1998, It's not what you know . . . estimating the value of political connections. Mimeo, Columbia University and the World Bank.

Greene, W. H., 1997, *Econometric Analysis*, 3rd edn. (Prentice-Hall, Englewood Cliffs, NJ).

Huntington, S., 1968, *Political Order in Changing Societies* (Yale University Press, New Haven, CT).

Johnson, S., D. Kaufman, and A. Shleifer, 1997, The unofficial economy in transition. *Brookings Papers on Economic Activity* 2, 159–239.

Kaufman, D. and S. Wei, 1998, Does 'grease money' speed up the wheels of commerce? Mimeo, The World Bank.

King, R. G. and R. Levine, 1993, Finance and growth: Schumpeter might be right. *Quarterly Journal of Economics* 108, 717–738.

Klitgaard, R., 1988, *Controlling Corruption* (University of California Press, Berkeley, CA).

Knack, S. and P. Keefer, 1995, Institutions and economic performance: cross-country tests using alternative institutional measures. *Economics and Politics* 3, 207–227.

Leff, N., 1964, Economic development through bureaucratic corruption. *American Behavioral Scientist* 8, 6–14.

Levine, R. and D. Renelt, 1992, A sensitivity analysis of cross-country growth regression. *American Economic Review* 82, 942–963.

Li, H. and H. Zou, 1998, Income inequality is not harmful for growth: theory and evidence. *Review of Development Economics* 2. 318–334.

———, L. Squire, and H. Zou, 1998, Explaining international and intertemporal variations in income inequality. *Economic Journal* 108, 26–43.

———, D. Xie, and H. Zou, 2000, Dynamics of income distribution. Forthcoming in *Canadian Journal of Economics*.

Lui, F. T., 1985, An equilibrium queuing model of bribery. *Journal of Political Economy* 93, 760–781.

Mauro, P., 1995, Corruption and growth. *Quarterly Journal of Economics* 110, 681–712.

Murphy, K., A. Shleifer, and R. Vishney, 1991, The allocation of talent: implication for growth. *Quarterly Journal of Economics* 105, 503–530.

———, ———, and ———, 1993, Why is rent-seeking so costly to growth? *American Economic Review*, May, 409–414.

Myrdal, G., 1968, *Asian Drama*, Vol. II (Random House, New York).

Nehru, V., E. Swanson, and A. Dubey, 1995, A new database on human capital stock in developing and industrial countries: sources, methodology, and results. *Journal of Development Economics* 46, 379–401.

Rose-Ackerman, S., 1978, *Corruption: A Study in Political Economy* (Academic Press, New York).

Shleifer, A. and R. Vishney, 1993, Corruption. *Quarterly Journal of Economics* 108, 599–617.

Squire, L., 1981, *Employment Policy in Developing Countries* (Oxford University Press, Oxford).

Summers, R. and A. Heston, 1994, The Penn World Table (Mark 5.6): an international panel, 1950–1992. NBER Working Paper.

Williamson, J., 1986, Did British labor markets fail during the Industrial Revolution? Harvard Institute of Economic Research Paper No. 1209, Harvard University.

Part V

Other Essays on Dynamic Analysis

17

Journal of International Money and Finance (1993), 12, 209–220

Dollarization and inflation in a two-country optimization model

HENG-FU ZOU*

Policy Research Department, The World Bank, Washington DC 20433, USA

In a two-country, two-currency model, this paper examines the conditions of dollarization, analyzes the effect of government inflation finance and studies the strategic interdependence of different-currency inflation. (JEL F30).

As in Ortiz (1983), dollarization here measures the degree of shift from using domestic currency toward foreign money as a legal tender. For obvious reasons, we take foreign money as the dollar. Many existing studies such as Fischer (1982, 1983) and Lamdany and Dorlhiac (1987) have focused on the country experiencing dollarization. In our study, we assume that there are two countries in the world: the USA and LA (which stands for Latin America); the dollar is the currency of the USA and the peso is the currency of LA; and dollarization is going on only in LA. In Section I we will set up a two-country optimization model for the representative families in the USA and LA and discuss the conditions for dollarization in LA under the assumption that the government in LA distributes its inflation tax to the public through lump-sum transfers. In Section II, we introduce government inflation finance in LA into the model and present a coherent, general equilibrium model for the determination of both peso and dollar inflation rates. The conditions for dollarization and the strategic choices of the peso and dollar inflation rates by the governments will be analyzed in detail. We summarize our main findings in Section III.

I. Currency substitution in LA and dollarization

We assume that there is free trade between the USA and LA and there is one homogeneous good with price p. A representative family in LA derives instantaneous utility from consumption and the liquidity services of real balances. With currency substitution in LA, both LA's peso and the US dollar provide liquidity services. Following Stockman (1978) and Liviatan (1981), we assume

* I am grateful to Jeffrey Sachs for encouraging me to write this paper and for helpful discussion. I thank an anonymous referee, Maxim Engers, and especially Michael Melvin for many suggestions and help on revising this paper. Responsibility for the contents of this paper is solely mine and not that of the World Bank.

that the preference of the representative family in LA is functionally separable in per capita consumption and the real balances:

$$U(c^*, m^*, m_f) = U(c^*) + V(m^*, Em_f),$$

where all variables are in real terms, and c^* is per capita consumption, m^* is per capita peso holdings, m_f is per capita dollar holdings, and E is the exchange rate; $U(.)$ and $V(.)$ are increasing and concave in c^*, m^*, and m_f.

Free trade between the USA and LA and one homogeneous good in the whole world market make it plausible to assume purchasing power parity:

$$p^* = Ep,$$

where p^* is the price of consumption goods denominated in pesos.

With two kinds of currencies in the portfolio of the representative family in LA, the per capita real asset in terms of pesos is the sum of these two currencies divided by the peso price:

$$a^* = (M^*/p^*N^*) + (M/p^*N^*) = m^* + EM/pN^* = m^* + Em_f,$$

where N^* is the population in LA. For simplicity we let the population growth rates in both the USA and LA equal zero.

We might as well assume that the initial exchange rate E is equal to one, then

$$a^* = m^* + m_f.$$

The typical family in LA maximizes a discounted utility over an infinite horizon subject to the budget constraint:

$$\text{Max} \int_0^\infty [U(c^*) + V(m^*, m_f)]e^{-\rho^* t}dt$$

$$\text{s.t. } a^* = y^* + x^* - c^* - \pi m_f - \pi^* m^*,$$

$$a^* = m_f + m^*,$$

where ρ^* is the time discount rate, y^* is per capita real income, x^* is the LA government's transfer to its citizens, π is the expected dollar inflation rate, π^* is the expected inflation rate for the peso, and a dot over a variable denotes the time derivative.

The optimal conditions are

$$\langle 1 \rangle \qquad V_1/V_2 = (\pi^* + \rho^*)/(\pi + \rho^*),$$

$$\langle 2 \rangle \qquad V_1 - U'(c^*)(\pi^* + \rho^*) + U''(c^*)\dot{c}^* = 0,$$

$$\langle 3 \rangle \qquad y^* + x^* - c^* - \pi^* m^* - \pi m_f - \dot{m}_f - \dot{m}^* = 0.$$

The corresponding optimization program for a representative family in the USA is:

$$\text{Max} \int_0^\infty u(c, m_u)e^{-\rho t}dt$$

$$\text{s.t. } \dot{m}_u = y + x - c - \pi m_u,$$

where y, c, and m_u are per capita output, consumption, and real balances in the

representative family of the USA, ρ is the time discount rate, and x is the government transfer to each family member.

The necessary conditions for optimization are

$$u_2 - u_1(\pi + \rho^*) + u_{11}\dot{c} + u_{12}\dot{m}_u = 0, \tag{4}$$

$$y + x - c - \pi m_u - \dot{m}_u = 0. \tag{5}$$

Now we turn to the LA and the US governments' money supplies and their transfer to their citizens. For simplicity, we further assume that the population sizes in these two countries are the same: $N = N^*$ and N and N^* are total population in the USA and LA respectively. Thus the real dollar supply per US citizen is

$$m = M/pN = (M_u/pN) + (M_f/pN) = m_u + (M_f/pN^*)(N^*/N) = m_u + m_f.$$

By definition,

$$\dot{m}^* = [\theta^* - (\dot{p}^*/p^*)]m^*, \tag{6}$$

$$\dot{m}_u = [\theta_u - (\dot{p}/p)]m_u, \tag{7}$$

$$\dot{m}_f = [\theta_f - (\dot{p}/p)]m_f, \tag{8}$$

where θ^* is the peso growth rate in LA, θ_u and θ_f are the dollar growth rates in the USA and LA respectively. With perfect foresight,

$$\dot{p}^*/p^* = \pi^*, \tag{9}$$

$$\dot{p}/p = \pi. \tag{10}$$

Substituting ⟨9⟩ and ⟨10⟩ into ⟨6⟩, ⟨7⟩, and ⟨8⟩:

$$\dot{m}^* = (\theta^* - \pi^*)m^*, \tag{11}$$

$$\dot{m}_u = (\theta_u - \pi)m_u, \tag{12}$$

$$\dot{m}_f = (\theta_f - \pi)m_f. \tag{13}$$

The transfer from LA's government to its citizens is

$$x^* = \theta^* m^*. \tag{14}$$

The US government transfer is

$$x = \theta_u m_u + \theta_f m_f. \tag{15}$$

Substituting ⟨11⟩, ⟨12⟩, ⟨13⟩, ⟨14⟩, and ⟨15⟩ into the dynamic equations ⟨1⟩, ⟨2⟩, ⟨3⟩, ⟨4⟩, and ⟨5⟩ and assuming the steady state (in the steady state, $\dot{c} = \dot{c}^* = \dot{m}_u = \dot{m}_f = \dot{m}^* = 0$), we get:

$$V_1/V_2 = (\theta^* + \rho^*)/(\theta + \rho^*), \tag{16}$$

$$V_1 - U'(c^*)(\theta^* + \rho^*) = 0, \tag{17}$$

$$V_2 - U'(c^*)(\theta + \rho^*) = 0, \tag{18}$$

$$y^* - c^* - \theta m_f = 0, \tag{19}$$

$$u_2 - u_1(\theta + \rho) = 0, \tag{20}$$

$$y - c + \theta m_f = 0. \tag{21}$$

One equation out of ⟨16⟩, ⟨17⟩, and ⟨18⟩ is redundant, but we present all here for the convenience of analysis. Equations ⟨17⟩ and ⟨18⟩ are optimal conditions regarding consumption and real balances holdings in LA and equation ⟨20⟩ is the corresponding optimal condition for the USA. These three equations imply that the marginal rates of substitution between real balances and consumption equal the opportunity cost of real balance holdings.

Condition ⟨16⟩ is the optimal condition for currency substitution in LA. It says that the marginal rate of substitution of the two currencies equals the ratio of their costs (the money growth rate plus the time discount rate). This optimal condition suggests that any currency with a high growth rate will be substituted away by the currency with a low inflation rate (suprisingly this is not true as shown in Proposition 1 below), and, in particular, complete dollarization is just a special case when the peso and dollar are perfect substitutes in generating liquidity services, *i.e.*, if $V(m^*, m_f) = V(m^* + m_f)$. In this case, $V_1 = V_2$ and complete dollarization will happen in LA so long as the peso inflation rate is higher than the dollar inflation rate. But this kind of perfect substitutability does not exist in the real world and both the peso and dollar are used as a medium of transaction in the countries experiencing dollarization, though the peso has a much higher inflation rate than the dollar. For this reason we will focus on the situation where the peso and dollar are imperfect substitutes.

The steady state budget constraint ⟨19⟩ says that the income in LA is divided between consumption and the cost of dollar holdings. From now on, the cost of dollar holdings, θm_f, will be denoted as s, where

$$s = \theta m_f;$$

it is the seigniorage collected by the USA. From the steady state budget constraint for the USA—equation ⟨21⟩, it is clear that the seigniorage has been redistributed among US citizens in the form of lump-sum transfers.

We now turn to the condition for dollarization under a flexible exchange rate. Throughout this section, it is assumed that consumption goods are normal and that an increase in income will lead to more consumption in the steady state:

$$dc^*/dy^* > 0,$$

which is the same as requiring that

$$\langle 22\rangle \quad \Delta = V_{12}^2 - V_{11}V_{22} + U''(c^*)\theta\{(\theta^* + \rho^*)V_{12} - (\theta + \rho^*)V_{11}\} < 0,$$

because $dc^*/dy^* = [V_{12}^2 - V_{11}V_{22}]/\Delta$ and the numerator is negative as $V(.)$ is concave.

As for the cross partial derivative, V_{12}, it can be positive (cooperant) or negative (noncooperant) as in Liviatan (1981). Calvo and Rodriguez (1977) and Liviatan (1981) have studied monetary expansion and real exchange rate determination under the assumption that the peso and dollar are cooperant. From Proposition 1 below, it is clear that dollarization will not take place when these two currencies are cooperant.

Proposition 1: If the dollar and peso are cooperant, $V_{12} > 0$, and then a high peso inflation reduces both peso and dollar holdings in LA; if the dollar and peso are noncooperant, $V_{12} < 0$, and a high peso inflation reduces peso holdings and raises dollar holdings in LA.

Proof: Totally differentiate the steady state optimal conditions ⟨17⟩, ⟨18⟩, and ⟨19⟩:

$$\langle 23\rangle \quad \begin{bmatrix} -U''(c^*)(\theta^*+\rho^*) & V_{11} & V_{12} \\ -U''(c^*)(\theta+\rho^*) & V_{12} & V_{22} \\ -1 & 0 & -\theta \end{bmatrix} \begin{bmatrix} dc^* \\ dm^* \\ dm_f \end{bmatrix} = \begin{bmatrix} U'(c^*)(d\theta^*+d\rho^*) \\ U'(c^*)(d\theta+d\rho^*) \\ m_f d\theta - dy^* \end{bmatrix}.$$

The determinant of the 3 × 3 matrix is given by Δ in ⟨22⟩, which is negative when consumption is normal goods. From ⟨23⟩,

$$\langle 24\rangle \quad \frac{dm^*}{d\theta^*} = \frac{-U'(c^*)}{\Delta}[V_{22} + U''(c^*)\theta(\theta+\rho^*)] < 0,$$

$$\langle 25\rangle \quad \frac{dm_f}{d\theta^*} = \frac{U'(c^*)V_{12}}{\Delta} > 0\ (<0), \qquad \text{if } V_{12} < 0\ (V_{12} > 0),$$

$$\langle 26\rangle \quad \frac{dc^*}{d\theta^*} = \frac{-U'(c^*)\theta V_{12}}{\Delta} < 0\ (>0) \qquad \text{if } V_{12} < 0\ (V_{12} > 0).$$

The result ⟨24⟩ is true because a higher peso inflation raises the cost of liquidity services from the peso and people will economize their peso holdings. If the dollar and peso are cooperant, $V_{12} > 0$, and the reduction of peso holdings following a higher peso inflation will reduce the marginal utility of the liquidity services from the dollar. Hence, dollar holdings will be reduced in this case. From the steady state budget constraint, lower dollar holdings mean lower seigniorage collected by the USA so that people in LA have more income for consumption. This is why consumption in LA will rise following higher peso inflation if the peso and dollar are cooperant.

On the other hand, if the peso and dollar are noncooperant, $V_{12} < 0$, and a smaller amount of peso holdings leads to a large marginal utility of liquidity services from the dollar. Thus a higher peso inflation induces people to substitute dollars for pesos. For a given dollar inflation rate, more dollar holdings give rise to a greater inflation tax paid to the USA and less income available for consumption in LA. This explains the signs of changes in dollar holdings and consumption in ⟨25⟩ and ⟨26⟩ when $V_{12} < 0$.

Another special case of Proposition 1 is when the peso and dollar are separable in utility: $V_{12} = 0$. In this case, equation ⟨24⟩ still holds and the reason for it is the same as before. But higher peso inflation will not alter the steady state dollar holdings and consumption in LA:

$$dm_f/d\theta^* = dc^*/d\theta^* = 0 \qquad \text{if } V_{12} = 0.$$

Peso inflation also affects welfare in the USA. If the peso and dollar are cooperant, a higher peso inflation reduces both peso and dollar holdings in LA and thus lowers the seigniorage collected by the USA. As less income is available for the USA, consumption and real balance holdings will be smaller in the USA. The case of cooperancy between the peso and the dollar leads to just the opposite: higher peso inflation increases dollar holdings and seigniorage collected by the USA; therefore consumption and real balances rise in the USA.

Proposition 2: An increase in the dollar inflation rate always reduces dollar

holdings in LA; its effects on peso holdings and consumption in LA are ambiguous.

The proof is straightforward by applying Cramer's rule in ⟨23⟩ and obtaining $dm_f/d\theta < 0$. The effects on consumption and peso holdings in LA are ambiguous because the seigniorage collected by the USA can increase or decrease when dollar inflation is higher. For example, if higher dollar inflation results in more seigniorage collected by the USA, consumption in LA will decrease. As for the peso holdings, the noncooperancy (cooperancy) between the dollar and peso tends to raise (lower) peso holdings, but a lower income tends to reduce them.

The asymmetry between peso inflation and dollar inflation lies in the fact that, for the representative family in LA, the government's seigniorage from peso inflation is transferred to consumers while the dollar represents a real cost from LA's national standpoint. The steady state budget constraint makes this point very clear.

Next we turn to the discussion of seigniorage collected by the USA. We first extend the usual properties of seigniorage to the case of currency substitution. For the USA, the seigniorage is given by:

$$s(\theta, \theta^*) = \theta m_f(\theta, \theta^*),$$

which is a function of both the dollar inflation rate and the peso inflation rate. We will assume that the seigniorage can be represented by a Laffer curve, namely, that there exists a positive inflation rate $\bar{\theta}$ such that $\partial s/\partial\theta$ is positive for $\theta < \bar{\theta}$ and negative for $\theta > \bar{\theta}$; and $\partial^2 s/\partial\theta^2 < 0$.

With currency substitution, we know that, from Proposition 1, $\partial s/\partial\theta^*$ is positive if the two currencies are noncooperant and it is negative if the two currencies are cooperant. Furthermore it is reasonable to have

Assumption 1: $\partial^2 s/\partial\theta^* \partial\theta > 0$ if the peso and the dollar are noncooperant and $\partial^2 s/\partial\theta^* \partial\theta < 0$ if the peso and the dollar are cooperant.

For the case of noncooperancy, a small increase in dollar inflation following a higher peso inflation should not reduce dollar holdings too much in LA, stated in terms of the following expression,

$$\partial^2 s/\partial\theta^* \partial\theta = \theta(\partial^2 m_f/\partial\theta\, \partial\theta^*) + (\partial m_f/\partial\theta^*),$$

the first term (cross effect) should not be so negative as to dominate the second term (direct effect), which is positive for the noncooperant case. For the case of cooperancy, the second term is negative. We will expect this direct effect to dominate the cross effect no matter whether the cross effect is positive or negative.

With the Laffer curve assumption and assumption 1, it is simple to see how the dollar inflation rate should respond to peso inflation if the USA attempts to maximize the inflation tax from LA. The first-order condition is the familiar one:

$$\partial s/\partial\theta = m_f + \theta(\partial m_f/\partial\theta) = 0.$$

Totally differentiating this equation yields:

$$\frac{d\theta}{d\theta^*} = \frac{-(\partial^2 s/\partial\theta\, \partial\theta^*)}{\partial^2 s/\partial\theta^2}.$$

Therefore, if the two currencies are noncooperant,

$$d\theta/d\theta^* > 0.$$

But if the dollar and peso are cooperant,

$$d\theta/d\theta^* < 0.$$

That is to say, if the peso and dollar are noncooperant, an increase in peso inflation leads people in LA to switch to more dollar holdings, and the USA can collect more seigniorage by raising dollar inflation. If these two currencies are cooperant, high peso inflation reduces both peso and dollar holdings and, hence, when peso inflation is high, the dollar inflation rate should be reduced in order to avoid more loss of seigniorage income from LA.

II. Government inflation finance in LA and the determination of the peso and dollar inflation rates

In the real world, dollarization is often observed in those countries in which inflation finance is the main instrument used to raise revenue for government spending. When inflation finance by LA's government is taken into consideration in the representative family model, the budget constraint becomes

$$\dot{a}^* = y^* - c^* - \pi m_f - \pi^* m^*,$$

$$a^* = m_f + m^*.$$

So the government transfer, x^*, is set to be zero.

The new steady state equilibrium conditions are

$$V_1 - U'(c^*)(\theta^* + \rho^*) = 0, \quad \langle 17 \rangle$$

$$V_2 - U'(c^*)(\theta + \rho^*) = 0, \quad \langle 18 \rangle$$

$$y^* - c^* - \theta^* m^* - \theta m_f = 0. \quad \langle 27 \rangle$$

If we denote the peso inflation tax by $s^*(\theta^*, \theta)$, then from $\langle 27 \rangle$,

$$s^*(\theta^*, \theta) = \theta^* m^*(\theta^*, \theta).$$

In this new setting, both dollar and peso inflation are real tax burdens on the representative family in LA and the asymmetric roles of dollar and peso inflation in Section III disappear here. As we have seen from Proposition 1, the case of cooperancy between the dollar and peso does not impose a serious constraint on LA's government inflation finance because a high peso inflation tends to reduce both peso and dollar holdings, and dollarization may not necessarily happen in LA even though the peso inflation is high. Therefore, we will focus on the case in which the peso and dollar are noncooperant and, unless otherwise noted, it will be assumed throughout this section that $V_{12} < 0$.

To understand the connection between the LA government's inflation finance and dollarization, we first note that, if the stream of liquidity services from peso holdings is a normal consumption good, peso holdings will be reduced following high peso inflation: $\partial m^*/\partial\theta^* < 0$. But the seigniorage $s^* = \theta^* m^*$ may go up or

down. If s^* goes down for a higher peso inflation rate, we have the following strong result:

Proposition 3: If the peso inflation tax is given by a Laffer curve, then, for a given dollar inflation rate θ, there exists a critical peso inflation rate $\bar{\theta}^*$ such that dollarization will always take place for $\theta^* > \bar{\theta}^*$; and $\bar{\theta}^*$ is determined by the equation $\partial s^*/\partial\theta^* = 0$.

Proof: Since $s^*(\theta^*, \theta)$ is a Laffer curve, we have, for a given θ, a unique $\bar{\theta}^*$ satisfying the equation $\partial s^*(\bar{\theta}^*, \theta)/\partial\theta^* = 0$ and $\partial s^*/\partial\theta^* > 0$ for $\theta^* < \bar{\theta}^*$ and $\partial s^*/\partial\theta^* < 0$ for $\theta^* > \bar{\theta}^*$.

Now consider the case: $\theta^* > \bar{\theta}^*$ and $\partial s^*/\partial\theta^* < 0$. Differentiating the steady state budget constraint ⟨27⟩ with respect to the peso inflation rate θ^*:

$$\langle 28 \rangle \qquad \partial c^*/\partial\theta^* + \theta\, \partial m_f/\partial\theta^* = -\partial s^*/\partial\theta^*.$$

The right-hand side of ⟨28⟩ is positive as $\partial s^*/\partial\theta^*$ is negative for $\theta^* > \bar{\theta}^*$. The left-hand side can be written as (via conditions ⟨18⟩):

$$\langle 29 \rangle \qquad \left\{\frac{V_{22}}{(\theta+\rho)U''(c^*)} + \theta\right\} \partial m_f/\partial\theta^* + \frac{V_{12}}{(\theta+\rho)U''(c^*)}\, \partial m^*/\partial\theta^*.$$

In ⟨29⟩, the second term is negative for $V_{12} < 0$, $\partial m^*/\partial\theta^* < 0$ and $U'' < 0$. The coefficient of $\partial m_f/\partial\theta^*$ is positive. Therefore, to have equation ⟨28⟩, $\partial m_f/\partial\theta^*$ has to be positive; that is to say, when $\theta^* > \bar{\theta}^*$, dollarization definitely takes place. Q.E.D.

The economic explanation for this result is the following: If the peso inflation rate is higher than the seigniorage maximizing rate $\bar{\theta}^*$, seigniorage income from further peso inflation will be reduced and the public will have more income available for both consumption and dollar holdings. This income effect of dollar holdings will be further reinforced by the substitution effect—high peso inflation directly reduces peso demand and increases the attractiveness of the dollar when the peso and dollar are noncooperant. Therefore, dollarization will definitely happen on the wrong side of the Laffer curve and LA's government in this situation can reduce its national loss and, at the same time, raise more inflation tax by lowering the peso inflation rate.

What will happen if the peso inflation is below the critical level $\bar{\theta}^*$? As we have pointed out, s^* is rising for $\theta^* < \bar{\theta}^*$ and people in LA will end up with less income for a higher peso inflation. Though a high peso inflation rate induces people in LA to substitute the dollar for peso holdings, the income effect may dominate the substitution effect and dollar holdings may also be reduced. If the substitution effect dominates the income effect, dollarization will take place for $\theta^* < \bar{\theta}^*$. It is often stated that the LA government can do better without causing dollarization. For LA's national interest, this is absolutely right. But for LA's government, keeping a very low peso inflation and avoiding dollarization may result in a significant loss of government revenue. This is especially true here because dollarization happens at the same time that the peso inflation tax collected by LA's government is rising.

Our model also provides us with a coherent general equilibrium framework that we can use to study inflation determination for different currencies. The endogenization of both peso and dollar inflation is an improvement over the

models studying only the country experiencing dollarization. In the following, we will show how seigniorage maximization by LA's government and how welfare or seigniorage maximization by the US government lead to the equilibrium peso and dollar inflation rates. We begin with LA.

Suppose that LA's government intends to maximize its seigniorage from its citizens given the possibility that its people can substitute the dollar for the peso. Obviously its choice of proper peso inflation θ^* depends on the dollar inflation rate θ. In the special case where the peso and dollar are perfect substitutes in generating liquidity services, *i.e.*, $V(m^*, m_f) = V(m^* + m_f)$, people in LA will be indifferent between holding pesos or dollars if they have the same inflation rate. If the peso inflation rate is higher than the dollar inflation rate, as we mentioned earlier, there will be complete dollarization and LA government's seigniorage from peso inflation will be zero. Therefore, in this case, the optimal strategy for LA's government is to set the peso inflation rate such that it is less than or equal to the dollar inflation rate.

In the more general case in which the peso and dollar are imperfect substitutions, it is quite reasonable to assume as in Proposition 3 that the peso inflation tax collected by LA's government is given by the usual Laffer curve and that higher peso inflation accompanied by higher dollar inflation should not reduce seigniorage collected by LA's government:

Assumption 2: $\partial^2 s/\partial\theta^* \partial\theta > 0$.

Again, due to the Laffer curve properties of $s^*(\theta^*, \theta)$, the necessary and sufficient condition for maximizing $s^*(\theta^*, \theta)$ by choosing θ^* (given θ) is

$$\langle 30 \rangle \qquad \partial s^*(\theta^*, \theta)/\partial\theta^* = m^* + \theta^*(\partial m^*/\partial\theta^*) = 0.$$

With assumption 2, it is simple to see

$$\langle 31 \rangle \qquad d\theta^*/d\theta = -(\partial^2 s^*/\partial\theta^* \partial\theta)/(\partial^2 s^*/\partial\theta^{*2}) > 0.$$

Hence lower peso inflation should follow lower dollar inflation and the dollar inflation rate sets a constraint on how much the government in LA can collect from the public through peso inflation. It is simple to see that the seigniorage maximizing peso inflation rate with dollarization should be smaller than the one without dollarization in LA. This can be easily seen. Imagine that there is a hyperinflation in the USA. For this extreme case, dollarization will not take place in LA. By ⟨31⟩, LA's government can choose a much higher peso inflation rate in this situation than in the case of a moderate or small dollar inflation. But, in practice, governments in the dollarized countries may not pay enough attention to the dollar inflation rate when choosing their national currencies' inflation rates. The consequences of their actions are further dollarization and less inflation tax.

To determine dollar inflation and its relation to peso inflation, we continue to assume as in the last section that $s(\theta, \theta^*)$ is a Laffer curve and assumption 1 still holds. Given peso inflation θ^*, two options are available for the USA to determine the dollar inflation rate. The first is welfare maximization:

$$\begin{aligned} \partial u/\partial\theta &= u_1\, \partial c/\partial\theta + u_2\, \partial m_u/\partial\theta \\ &= u_1\, \partial s/\partial\theta + u_2\, \partial m_u/\partial\theta = 0. \end{aligned}$$

This is the same as requiring that, by solving $\partial m_u/\partial\theta$ from ⟨20⟩ and ⟨21⟩,

$$\langle 32\rangle \qquad [u_{11}(\theta+\rho)-u_{12}+(\theta+\rho)b](\partial s/\partial\theta)=-u_1,$$

here

$$b=u_{22}-u_{12}(\theta+\rho)<0.$$

The term in the bracket on the left side of ⟨32⟩ is negative, and the term on the right side is also negative, so at the optimum,

$$\partial s/\partial\theta>0.$$

Therefore, the welfare maximizing dollar inflation rate chosen by the US government lies at the increasing part of the Laffer curve and, for a given peso inflation rate, it is smaller than the seigniorage maximizing one. This is because dollar inflation has two effects: it directly reduces consumer welfare in the USA and it may increase or decrease the seigniorage collected from LA. At the optimum, the direct welfare loss due to dollar inflation has to be compensated by the additional income raised by the dollar inflation.

The second option for the USA is to maximize its seigniorage collected from LA:

$$\langle 33\rangle \qquad \partial s(\theta,\theta^*)/\partial\theta=m_f+\theta(\partial m_f/\partial\theta)=0.$$

Now ⟨30⟩ and ⟨33⟩ will jointly determine the peso and dollar inflation rates. Since the seigniorage maximizing dollar inflation rate is higher than the welfare maximizing one and a higher dollar inflation leads to a higher peso inflation rate by ⟨31⟩, seigniorage maximization by both governments leads to both higher peso and dollar inflation.

So far our discussion of peso and dollar inflation has been limited to the Nash equilibria. What does our model tell us about the USA as a leader and LA as a follower in a Stackelberg game of seigniorage maximization? Using ⟨30⟩, the peso inflation rate can be written as an increasing function of the dollar inflation rate: $\theta^*=\theta^*(\theta)$ and $d\theta^*/d\theta>0$. The USA maximizes $s(\theta,\theta^*(\theta))$ by choosing θ. The first-order condition is

$$\langle 34\rangle \qquad \partial s/\partial\theta+(\partial s/\partial\theta^*)(d\theta^*/\partial\theta)=0.$$

The first term on the left-hand side of ⟨34⟩ is the direct gain or loss in seigniorage through an increase in the dollar inflation rate and the second term is the indirect gain or loss in seigniorage through the effect of dollar inflation on peso inflation. These two effects offset each other when the seigniorage is maximized.

Comparing equilibrium condition ⟨34⟩ to ⟨33⟩, we have

Proposition 4: The Stackelberg equilibrium rates of the peso and dollar inflation are higher than the Nash equilibrium rates if peso inflation leads to more dollar holdings in LA.

Proof: The conditions for both Nash and Stackelberg equilibrium are:

$$\langle 33'\rangle \qquad \partial s(\theta^n,\theta^*(\theta^n))/\partial\theta=0,$$

$$\langle 34'\rangle \qquad \partial s(\theta^s,\theta^*(\theta^s))/\partial\theta+(\partial s(\theta^s,\theta^*(\theta^s))/\partial\theta^*))(d\theta^*/d\theta)=0,$$

where θ^n and θ^s denote the dollar inflation rates for Nash and Stackelberg equilibria respectively, and $\theta^*(\theta)$ is LA's government reaction function solved

from the condition ⟨30⟩ and again $d\theta^*/d\theta$ is positive (namely, high dollar inflation leads to high peso inflation).

If peso inflation results in more dollar holdings, there will be more seigniorage income for the USA and $\partial s/\partial\theta^*$ in ⟨34′⟩ will be positive. Hence, $\partial s/\partial\theta$ on the left-hand side of ⟨34′⟩ (the Stackelberg equilibrium condition) has to be negative. But from the condition for the Nash equilibrium ⟨33′⟩, $\partial s/\partial\theta = 0$. We must show that θ^s is larger than θ^n in this case.

Taking a Taylor expansion of $\partial s(\theta^s, \theta^*(\theta^s))/\partial\theta$ at the Nash equilibrium value yields:

⟨35⟩

$$\begin{aligned}0 > \partial s(\theta^s, \theta^*(\theta^s))/\partial\theta &= \partial s(\theta^n, \theta^*(\theta^n))/\partial\theta + (\theta^s - \theta^n)\,\partial^2 s(\phi^\varphi, \theta^*(\theta^\varphi))/\partial\theta^2 \\ &\quad + (\theta^s - \theta^n)(\partial^2 s(\theta^\varphi, \theta^*(\theta^\varphi))/\partial\theta\,\partial\theta^*)d\theta^*(\theta^\varphi)/d\theta \\ &= (\theta^s - \theta^n)\partial^2 s(\theta^\varphi, \theta^*(\theta^\varphi))/\partial\theta^2 \\ &\quad + (\theta^s - \theta^n)(\partial^2 s(\theta^\varphi, \theta^*(\theta^\varphi))/\partial\theta\,\partial\theta^*)\,d\theta^*(\theta^\varphi)/d\theta,\end{aligned}$$

where θ^φ is between θ^s and θ^n. Suppose that $\theta^s < \theta^n$. The stability condition for Nash equilibrium is

$$d\theta^*(\theta^\varphi)/d\theta = -\frac{\partial^2 s^*/\partial\theta\,\partial\theta^*}{\partial^2 s^*/\partial\theta^{*2}} < -\frac{\partial^2 s/\partial\theta^2}{\partial^2 s/\partial\theta\,\partial\theta^*}.$$

Substitute $d\theta^*/d\theta$ into ⟨35⟩ and note that $\theta^s < \theta^n$ and $\partial^2 s/\partial\theta/\partial\theta^* > 0$ by assumption:

$$\begin{aligned}0 &> \partial s(\theta^s, \theta^*(\theta^s))/\partial\theta \\ &= (\theta^s - \theta^n)\,\partial^2 s(\theta^\varphi, \theta^*(\theta^\varphi))/\partial\theta^2 + (\theta^s - \theta^n)(\partial^2 s(\theta^\varphi, \theta^*(\theta^\varphi))/\partial\theta\,\partial\theta^*)d\theta^*(\theta^\varphi)/d\theta \\ &> (\theta^s - \theta^n)\,\partial^2 s(\theta^\varphi, \theta^*(\theta^\varphi))/\partial\theta^2 \\ &\quad + (\theta^s - \theta^n)(\partial^2 s(\theta^\varphi, \theta^*(\theta^\varphi))/\partial\theta\,\partial\theta^*)\left(-\frac{\partial^2 s/\partial\theta^2}{\partial^2 s/\partial\theta\,\partial\theta^*}\right) \\ &= 0.\end{aligned}$$

This is a contradiction because $\partial s/\partial\theta$ cannot be less than zero and larger than zero at the same time. Therefore, if peso inflation leads to more dollar holdings, the dollar inflation for Stackelberg equilibrium will be higher than the one for Nash equilibrium: $\theta^s > \theta^n$. Since $d\theta^*/d\theta$ is positive, the peso inflation rate is also higher.

The economic intuition for this proposition is quite clear. As higher dollar inflation induces higher peso inflation and higher peso inflation forces people in LA to hold more dollars, the USA can collect a higher inflation tax from LA by recognizing its leading position in the Stackelberg game and setting a higher dollar inflation rate than in the Nash equilibrium.

III. Summary

In a two-country model, this paper has provided insight into two aspects of dollarization.

First, if the government in LA transfers its inflation tax to the public, dollarization will only happen when two currencies are noncooperant in generating liquidity service (Proposition 1); if the government finances its spending by inflation tax, dollarization will definitely occur on the wrong side of the Laffer curve (Proposition 3).

Second, if seigniorage maximization is the objective of LA's government, unintended dollarization may be an inevitable consequence of government policy because under certain circumstances more seigniorage income and further dollarization can occur at the same time. Nevertheless, the choice of proper peso inflation rates by LA's government crucially depends on the strategic choices of the dollar inflation. In particular, if the US government maximizes its citizens' welfare, the expected dollar inflation will be moderate and so is the seigniorage maximizing peso inflation rate. If both governments maximize their inflation tax independently, the resulting peso and dollar inflation rate are likely to be high. When there exists strategic interdependence, the seigniorage maximizing peso and dollar inflation rates for the Stackelberg equilibrium are higher than the ones for the Nash equilibrium (Proposition 4).

References

CALVO, G., AND C. RODRIGUEZ, 'A Model of Exchange Rate Determination under Currency Substitution and Rational Expectations,' *Journal of Political Economy*, June 1977, **85**: 617–625.

FISCHER, S., 'Seigniorage and the Case for a National Money,' *Journal of Political Economy*, April 1982, **90**: 295–313.

FISCHER, S., 'Seigniorage and Fixed Exchange Rates: An Optimal Inflation Tax Analysis,' in Aspe Armella *et al.*, eds, *Financial Policies and the World Capital Markets: The Problem of Latin American Countries*, University of Chicago Press, 1983.

LAMDANY, R., AND JORGE DORLHIAC, 'The Dollarization of a Small Economy,' *Scandinavian Journal of Economics*, March 1987, **89**: 91–102.

LIVIATAN, N., 'Monetary Expansion and Real Exchange Rate Dynamics,' *Journal of Political Economy*, December 1981, **89**: 1218–1227.

ORTIZ, G., 'Dollarization in Mexico: Causes and Consequences,' in Aspe Armella *et al.*, eds, *Financial Policies and the World Capital Markets: The Problem of Latin American Countries*, University of Chicago Press, 1983.

STOCKMAN, A., 'Risk, Information, and Forward Exchange Rates,' in J. Frenkel and H. Johnson, eds, *The Economics of Exchange Rates*, Reading, Mass.: Addison-Wesley, 1978.

18

HENG-FU ZOU
The World Bank
Washington, D.C.

*Short-Run Analysis of Fiscal Policy and the Current Account in a Finite Horizon Model**

This paper utilizes a technique developed by Judd to quantify the short-run effects of fiscal policies and income shocks on the current account in a small open economy. It is found that: (1) a future increase in government spending improves the short-run current account; (2) a future tax increase worsens the short-run current account; (3) a present increase in the government spending worsens the short-run current account dollar by dollar, while a present increase in the income improves the current account dollar by dollar; (4) when government budget is balanced in the long run, a tax cut accompanied by an equal government spending cut in the future always leads to a deterioration in the short-run current account.

1. Introduction

This paper examines the short-run effects of fiscal policies and income shocks on the current account in a small open economy. It differs from most of the existing studies by utilizing the approach developed by Judd (1982, 1985, 1987) to quantify the short-run impact on the current account of intertemporal policy and income changes. While many studies have relied on phase diagrams or long-run equilibrium to derive certain qualitative, short-run results (see Obstfeld 1981, 1982; Matsuyama 1987; Pitchford 1989; Sen and Turnovsky 1989, among many others), the Judd approach, with the help of the Laplace transform, can provide an exact quantitative expression for the short-run effects on the current account of different (temporary or permanent, present or future) shocks. New insights derived from this approach have been seen in various studies on taxation and debt in Judd's own studies, and Dixit's (1990) study on the traditional Solow model and the q-theory of investment.

In this paper, I apply the Judd approach to the Yaari-Blanchard model and consider a small open economy where the representative agent maximizes a discounted utility over a finite horizon by choosing consumption and two-asset (foreign bond and domestic government bond) holdings. The Yaari-Blanchard model not only offers a very simple structure to study the current account and fiscal policies, it also guarantees the existence of the short-run

*I thank an anonymous referee for comments and suggestions in revising this paper. Some details of technical calculations are available from me upon request. Responsibility for the contents of the paper is solely mine and not of the World Bank.

dynamics of consumption even when the time preference differs from the world interest rate. If I use the typical intertemporal model, an equilibrium can be achieved in this model when the time preference equals the world interest rate. But in this case consumption will always be a constant. If the time preference is not equal to the world interest rate, then consumption either keeps increasing or keeps decreasing. To introduce more interesting, short-run dynamics in this typical model, it is necessary to complicate the matter by assuming an imperfect world credit market as in Pitchford (1989) or by adding capital accumulation with adjustment cost to the model.

The Judd approach delivers many interesting findings regarding the short-run impacts of different shocks on the current account in the Yaari-Blanchard model: (1) a future increase in government spending improves the short-run current account; (2) a future tax increase worsens the short-run current account; (3) a present increase in the government spending worsens the short-run current account dollar by dollar while a present increase in the income improves the current account dollar by dollar. Thus the short-run consumption does not adjust to the present exogenous shocks and all impacts of present shocks fall upon the current account; (4) when government budget is balanced in the long run, a tax cut accompanied by an equal government spending cut in the future always leads to a deterioration in the short-run current account.

The paper is organized as follows. In Section 2 the Yaari-Blanchard model for a small open economy is briefly introduced. In Section 3 I focus on the short-run impacts of income and policy shocks on consumption and the current account. In Section 4 the effect on the current account of a balanced, long-run government budget constraint is studied. I conclude the paper in Section 5.

2. The Yaari-Blanchard Model

The set-up of the model is essentially taken from Blanchard (1985). I consider a small open economy in a world with perfect capital mobility. Assets available to the residents of the small open economy are foreign bonds and domestic government bonds. The returns on these two kinds of bonds are given by a constant world interest rate, r. Each representative agent in this economy faces a constant probability of death, p, throughout his life. It is further assumed that the population growth is zero, and at any instant of time a new cohort of size p (by proper normalization) is born. The expected remaining life for an agent of any age is $\int_0^\infty tpe^{-pt}dt = p^{-1}$, which is also taken as the time horizon. Finally, the size of the total population at any time t is $\int_{-\infty}^{0} pe^{-p(t-s)}dt = 1$.

Short-Run Analysis of Fiscal Policy

At any time t, let $c(s,t)$, $y(s,t)$, $a(s,t)$ and $h(s,t)$ denote consumption, noninterest income, nonhuman wealth and human wealth of a consumer born at time s. Here $a(s,t) = b(s,t) + b^*(s,t)$, and b is the government bonds and b^* is the foreign bonds. Also denote the lump-sum tax on the agent at time t as $T(t)$. Since the interest rate for nonhuman wealth is r, the dynamic budget constraint of the agent born at time s is

$$da(s,t)/dt = ra(s,t) + pa(s,t) + y(s,t) - T(t) - c(s,t), \tag{1}$$

where $pa(s,t)$ is the payment from the life insurance company as a result of the assumed existence of perfect annuity market in the Yaari-Blanchard model.

Let the instantaneous utility be logarithmic and let the time preference rate be θ. The agent maximizes the expected utility:

$$E_t\left[\int_0^\infty \log c(s,t)e^{\theta(t-\upsilon)}d\upsilon\right], \qquad \theta > 0 .$$

Since the only uncertainty is about the time of death, the maximization is equivalent to maximizing

$$\int_0^\infty \log c(s,\upsilon)e^{(\theta+p)(t-\upsilon)}d\upsilon . \tag{2}$$

The combination of (1) and (2) yields the following equation of motion for consumption:

$$c(s,t) = (p + \theta)\,[a(s,t) + h(s,t)] , \tag{3}$$

where $h(s,t) = \int_t^\infty [y(s,\upsilon) - T(\upsilon)]e^{(\theta+p)(t-\upsilon)}d\upsilon$.

Taking aggregation over the whole population at time t and denoting the aggregate variables by uppercase letters,

$$X(t) = \int_{-\infty}^{t} x(s,t)pe^{p(s-t)}ds, \text{ for } x(s,t) = c(s,t),\ a(s,t) \text{ and } h(s,t) .$$

Thus $C(t)$ is aggregate consumption, $A(t)$ aggregate assets, and $H(t)$ aggregate human wealth. The dynamic equations of these aggregate variables are given by

$$C = (\theta + p)(A + H) , \tag{4}$$

$$\dot{H} = (r + p)H - y + T , \tag{5}$$

$$\dot{A} = rA + y - T - C . \tag{6}$$

Integration of (5) while taking y and T constant becomes

$$\int_t^{\infty} d[He^{-(r+p)s}] = \int_t^{\infty} (T - y)e^{-(r+p)s} ds \; ;$$

that is,

$$H = (y - T)/(r+p) \; , \tag{5'}$$

which is the present discounted value of the after-tax noninterest income. With (5′), we can write (4) as

$$C = (\theta+p)[A + (y-T)/(r+p)] \; , \tag{4'}$$

which is the consumption function that appeared in Blanchard (1985, 241).

Let $g(t)$, $T(t)$ and $B(t)$ be government spending, tax revenue, and accumulated government borrowing at time t, respectively. Then the government budget constraint is given by:

$$\dot{B} = g + rB - T \, . \tag{7}$$

Since $A = B + B^*$, the substitution of (7) into (6) yields the dynamic equation for the foreign bond holdings or the current account:

$$\dot{B}^* = rB^* + y - C - g \, . \tag{8}$$

Differentiating Equation (4′) and using (7) and (8), I have the equation of motion for aggregate consumption:

$$\dot{C} = (r - p - \theta)C + p(p + \theta)(y - T)/(r + p) \, . \tag{9}$$

Equations (7), (8) and (9) consist of a full dynamic system in C, B and B^*. We also note that Equations (8) and (9) are two dynamic equations independent of the government budget constraint (7). In the following analysis, I will first study the subsystem of (8) and (9) and then proceed to consider the government budget constraint.

3. Short-Run Impacts of Exogenous Shocks

Blanchard (1985) has studied the effects of permanent shocks on consumption and the foreign bond holding by dealing with the steady-state equations of (4′), (8) and (9). My study here focuses on the short-run effects on consumption and the current account of different shocks, which can be permanent or temporary, present or future. As I said earlier, in dynamic economic analysis, many existing studies have utilized phase diagrams to derive certain qualitative results regarding the short-run effects; see Able (1982), Obstfeld (1981), and Sen and Turnovsky (1989), among others. To quantify the short-run effects of different shocks, I follow the Judd approach.

Short-Run Analysis of Fiscal Policy

Suppose that at time $t = 0$ or today the foreign bond holdings and consumption are at the steady-state level corresponding to exogenous variables y, g and T. In addition, the government budget is assumed to be balanced. At time $t = 0$, let the exogenous variables change as follows:

$$y'(t) = y + \varepsilon h_y(t)\,, \tag{10a}$$

$$g'(t) = g + \varepsilon h_g(t)\,, \tag{10b}$$

$$T'(t) = T + \varepsilon h_T(t)\,, \tag{10c}$$

where ε is a parameter. Functions $h_y(t)$, $h_g(t)$ and $h_T(t)$ are the intertemporal changes of the noninterest income, government spending and taxation, respectively. To give an example, let the government spending increase by ε for the time interval $t_1 < t < t_2$. Then $h_g(t) = 1$ for $t_1 < t < t_2$ and $h_g(t) = 0$ otherwise; $g'(t) = g + \varepsilon$ for $t_1 < t < t_2$ and $g'(t) = g$ otherwise.

Substituting $y'(t)$, $g'(t)$ and $T'(t)$ for the constants y, g and T in Equations (8) and (9), I have

$$\dot{C} = (r - p - \theta)C + p(p + \theta)(y + \varepsilon h_y(t) - T - \varepsilon h_T(t))/(r + p)\,, \tag{11a}$$

$$\dot{B}^* = rB^* + y + \varepsilon h_y(t) - C - g - \varepsilon h_g(t)\,, \tag{11b}$$

with boundary conditions $|\lim_{t\to n} B^*(t)| < \infty$, $B^*(0) = B_0^*$. The solutions to (11) will depend on both time, t, and exogenous parameter, ε. I write the solutions as $C(t, \varepsilon)$ and $B^*(t, \varepsilon)$. These two functions are differentiable with respect to ε because (11a) and (11b) are two linear differential equations. For $\varepsilon = 0$, the system stays at the initial steady state. As ε changes from zero to nonzero values, namely, as exogenous shocks occur, the impact on consumption and foreign asset accumulation at any time t can be seen from the partial differentiation of C and B^* with respect to ε. To this end, I use the following notations:

$$\partial C(t,0)/\partial\varepsilon = C_\varepsilon(t)\,, \qquad \partial B^*(t,0)/\partial\varepsilon = B_\varepsilon^*(t)\,,$$

$$\partial[\partial C(t,0)/\partial t)]/\partial\varepsilon = \dot{C}_\varepsilon(t)\,, \qquad \partial[\partial B^*(t,0)/\partial t)]/\partial\varepsilon = \dot{B}_\varepsilon^*(t)\,.$$

Differentiating Equations (11a) and (11b) with respect to ε and evaluating the results at $\varepsilon = 0$, I have

$$\begin{bmatrix} \dot{C}_\varepsilon \\ \dot{B}_\varepsilon^* \end{bmatrix} = \begin{bmatrix} (r - p - \theta) & 0 \\ -1 & r \end{bmatrix} \begin{bmatrix} C_\varepsilon \\ B_\varepsilon^* \end{bmatrix} + \begin{bmatrix} p(p + \theta)(r + p)^{-1}[h_y(t) - h_T(t)] \\ h_y(t) - h_g(t) \end{bmatrix}. \tag{12}$$

Denote the 2×2 matrix in (12) as J. J is the constant Jocobian matrix of the dynamic system. As it is clear from J, the initial equilibrium is saddle-point stable if $(r-p-\theta)$ is negative, which is a stability condition assumed in

Blanchard (1985) and Matsuyama (1987). With this assumption, one eigenvalue of the system is positive and one is negative:

$$\mu = r$$

and

$$\omega = r - p - \theta\,, \tag{13}$$

here μ (= r) is the positive eigenvalue and ω (= $r - p - \theta$) is the negative eigenvalue.

As in Judd (1985), the Laplace transform can be utilized to solve (12), a linear system with constant coefficients. The Laplace transform of a function, $f(t)$ ($t > 0$), is another function, $F(s)$, defined for sufficiently large s:

$$F(s) = \int_0^\infty f(t)e^{-st}dt\,.$$

Let $HC_\varepsilon(s)$, $HB_\varepsilon^*(s)$, $H_y(s)$, $H_g(s)$ and $H_T(s)$ be the Laplace transforms of $C_\varepsilon(t)$, $B_\varepsilon^*(t)$, $h_y(t)$, $h_g(t)$ and $h_T(t)$, respectively. Then apply the Laplace transform to (12):

$$\begin{bmatrix} sHC_\varepsilon(s) \\ sHB_\varepsilon^*(s) \end{bmatrix} = J \begin{bmatrix} HC_\varepsilon(s) \\ HB_\varepsilon^*(s) \end{bmatrix} \begin{bmatrix} p(p+\theta)(r+p)^{-1}[H_y(s) - H_T(s)] + C_\varepsilon(0) \\ H_y(s) - H_g(s) \end{bmatrix}.$$

Or,

$$\begin{bmatrix} HC_\varepsilon(s) \\ HB_\varepsilon^*(s) \end{bmatrix} = \begin{bmatrix} (s - r + p + \theta) & 0 \\ 1 & s - r \end{bmatrix} \begin{bmatrix} p(p+\theta)(r+p)^{-1}[H_y(s) - H_T(s)] + C_\varepsilon(0) \\ H_y(s) - H_g(s) \end{bmatrix}.$$

Solving the inverse matrix yields

$$\begin{bmatrix} HC_\varepsilon(s) \\ HB_\varepsilon^*(s) \end{bmatrix} = (s - r + p + \theta)^{-1}(s - r)^{-1} \begin{bmatrix} (s - r) & 0 \\ -1 & s - r + p + \theta \end{bmatrix} \begin{bmatrix} p(p+\theta)(r+p)^{-1}[H_y(s) - H_T(s)] + C_\varepsilon(0) \\ H_y(s) - H_g(s) \end{bmatrix}. \tag{14}$$

In (14), $C_\varepsilon(0)$ is the initial change or jump in consumption corresponding to exogenous shocks. This jump is necessary for the system to converge to the steady state along the unique perfect foresight path. To determine $C_\varepsilon(0)$, note that the existence of a saddle-point equilibrium in this model implies a bounded steady-state foreign asset accumulation for any ε. Therefore $HB_\varepsilon^*(s)$ must be finite for any $s > 0$; in particular, it is true for $s = \mu = r$ (the positive eigenvalue of the dynamic system). However, when $s = r$, the inverse matrix in (14) is singular. To remove this singularity, the numerator on the right-hand side of (14) has to be zero (see Judd 1987 for details):

$$-p(p + \theta)(r + p)^{-1}\,[H_y(r) - H_T(r)] - C_\varepsilon(0) + (p + \theta)[H_y(r) - H_g(r)] = 0\,,$$

which is the same as

$$C_\varepsilon(0) = r(p+\theta)(r+p)^{-1}H_y(r) - (p+\theta)H_g(r) + p(p+\theta)(r+p)^{-1}H_T(r) \ . \quad (15)$$

Equation (15) gives the impact on the initial or today's consumption from future shocks in the noninterest income, government spending and tax. Since the Laplace transform can be regarded as the present discount value of future shocks, the effects of different shocks in the remote future will be much smaller than the ones in the near future. Also, the discount factor here is the world interest rate, r, which is not true in general. Usually, the discount rate is the positive eigenvalue of the dynamic system, but they coincide in our model here.

From (15), it is clear, any future increase in the noninterest income will increase today's consumption. Instead of just providing this qualitative information, expression (15) presents the exact magnitude of this effect. For example, let the increase in noninterest income happen in the future time t: $t_1 < t < t_1 + \Delta t$ and Δt is very small. Then

$$H_y(r) = \int_0^\infty h_y(t)e^{-rt}dt = \int_{t_1}^{t_1+\Delta t} e^{-rt}dt \cong \Delta t e^{-rt_1} ,$$

and the initial consumption will increase by $r(p+\theta)(r+p)^{-1}\Delta t e^{-rt_1}$.

Next, a tax rise in the future will also increase the initial consumption. In fact, if future tax follows the time path of the noninterest income, namely $H_T(r) = \Delta t e^{-rt_1}$, today's consumption will go up by $p(p+\theta)(r+p)^{-1}\Delta t e^{-rt_1}$. This is an interesting result because people act to consume more today instead of saving more to smooth their consumption in view of a future tax hike. To provide some economic intuition for this result, we note that, for a fixed government spending, g, over time, an increase in the future tax will lower government bond finance over time as indicated by the integration of the government budget constraint (7). To gradually reduce their government bond holdings, people react to this anticipated tax increase by converting part of their government bond holdings to consumption today. This is why there will be an increase in consumption at $t = 0$ when the tax rises in the future.

Equation (15) also implies that an increase in future government spending will reduce today's consumption. The exact magnitude of this reduction is given by $(p+\theta)H_g(r)$. The economic intuition of this result is the following. From the integration of the government budget constraint (7), an increase in g in the future without raising the tax will lead to more government borrowing over time. Expecting an increase in government bonds, people reduce their consumption today and save more to purchase government bonds. Therefore, current consumption is lowered as a result of a future increase in government spending. A similar result has been obtained in Judd

(1985). In a framework of a neoclassical growth model with income taxation and government borrowing, Judd shows that an increase in future government spending reduces consumption today and consequently encourages investment today; see Judd (1985, 311). I will show that in the finite horizon model the reduced consumption today improves today's current account.

Substituting (15) into (12), we can solve the initial impact of different shocks on the current account:

$$\dot{B}^*_\varepsilon(0) = -C_\varepsilon(0) + h_y(0) - h_g(0),$$

or

$$\dot{B}^*_\varepsilon(0) = -r(p+\theta)(r+p)^{-1}H_y(r) + (p+\theta)H_g(r) - p(p+\theta)(r+p)^{-1}H_T(r) + h_y(0) - h_g(0). \quad (16)$$

In deriving (16), I have used the fact that the initial foreign bond holding is given ($B^*(0) = B^*_0$) and $B^*_\varepsilon(0) \equiv 0$ irrespective of ε; for this point, see Dixit (1990).

From (16), a few interesting points can be shown:

First, an increase in today's noninterest income will improve the current account dollar by dollar. This is given by the term $h_y(0)$ in (16). If the noninterest income rises today, that is, $h_y(0) = 1$, the foreign bond holdings will also rise by one. On the contrary, an increase in government spending today worsens the current account dollar by dollar. Combining (15) and (16), I can show that, as exogenous shocks happen today, there is no adjustment on today's consumption and all impact of today's shocks falls upon the initial current account.

These results can also be seen directly from Equation (8) combined with Equation (14). Since, from (14), today's consumption does not react to any of today's exogenous shocks, and since the wealth stock—foreign bond holdings, B^*—cannot change initially, Equation (8) indicates that a rise in y at time $t = 0$ increases savings and the current account surplus, and a rise in g at time $t = 0$ reduces savings and the current account surplus.

Second, any increase in future income reduces the initial current account balances, and its magnitude is just the opposite of the increase in the initial consumption, $-r(p + \theta)(r + p)^{-1}H_y(r)$. This is true because an anticipated future increase in y raises wealth, stimulates consumption, decreases savings and worsens the current account today.

Third, a future increase in government spending improves the initial current account by $(p + \theta)H_g(r)$. The explanation for this result is closely related to our explanation about the negative effect of future government spending on today's consumption. Since more government spending in the future without raising the tax requires an increase in government bond issue over time, people respond today by lowering their consumption and saving

more in the form of bond holdings. As today's consumption is reduced, some of this additional saving takes the form of more foreign asset holdings, and, thus, improves the current account today. As I said earlier, this stimulating effect of a future increase in government spending on the current account is very similar to the stimulating effect of government spending on investment in Judd (1985).

Finally, since a future increase in tax stimulates today's consumption as I have argued earlier, the economy will respond to a higher future tax by decumulating its foreign asset holdings and converting part of its foreign bonds to consumption today. The negative impact of a future tax increase on the initial current account is given by $-p(p+\theta)(r+p)^{-1}H_T(r)$ in (16).

4. The Balanced Budget Condition

I now return to the government budget constraint. When shocks are introduced into the government budget (7) in the form of Equations (10b) and (10c), the new budget constraint becomes

$$\dot{B} = g + \varepsilon h_g(t) + rB - T - \varepsilon h_T(t) . \tag{17}$$

Differentiating this equation with respect to ε and assuming that the stock of B at the initial steady state is zero, I find that, for a balanced budget, the following relation holds:

$$H_g(r) - H_T(r) = 0 ; \tag{18}$$

that is, the present value of government spending has to equal the present value of tax, discounted at the world interest rate r. For example, if the tax is cut at time $t = 0$, and later on the spending is also cut to balance the budget at time $t \geq \tau$, then $h_T(0) = -1$ today and the government spending has to be cut in the future by $h_g(t) = -\gamma$ for $t \geq \tau$. Equation (18) requires that

$$1 = \gamma \int_{\tau}^{\infty} e^{-rt} dt ;$$

namely,

$$\gamma = re^{r\tau}.$$

Substituting the relation (18) into (15) and (16), we have

$$C_\varepsilon(0) = r(p+\theta)(r+p)^{-1}H_y(r) + (p+\theta)[p(r+p)^{-1} - 1]H_T(r) . \tag{19}$$

$$\dot{B}^*_\varepsilon(0) = -r(p+\theta)(r+p)^{-1}H_y(r) + (p+\theta)[1 - p(r+p)^{-1}]H_T(r) + h_y(0) - h_g(0). \tag{20}$$

Therefore, an increase in tax balanced by an increase in government spending in the future always leads to improvement in the initial current account

because the term $[1 - p(r + p)^{-1}]$ in (20) is positive. Or put it in another way, a cut in tax balanced by a future cut in government spending always worsens the initial current account.

This finding can be explained as follows. In the finite horizon model, people have a nonzero probability to die at any time. With a future rise in tax, its effects on people born at different times are different, and a typical agent may not be taxed because he may die by the time more tax is actually collected. Similarly, the burden of more government spending may not be shared by a person due to the probability of his death. In this way, to a typical agent born at time t, the one to one correspondence between the discounted tax and discounted government spending in the infinite horizon model does not hold here. In fact, in this model, a future rise in government spending causes a greater reduction in today's consumption than the increase of today's consumption caused by an equal rise in future tax. Therefore, when the effect of tax is dominated by the effect of government spending, an equal amount of increase in future tax and government spending brings about a decline in the initial consumption and an improvement in the initial current account.

5. Summary

This paper has applied the Judd approach to study the effects of fiscal policies and income shocks on the short-run current account. Among the many interesting results found here, I should emphasize the following three observations: First, the present shocks in income and fiscal policies only alter the short-run current account, while future shocks have an effect on both the short-run current account and short-run consumption. Second, there exists an asymmetry between the effect of tax and the effect of government spending on the current account. A tax rise in the future worsens the short-run current account, but an increase in future government spending improves the short-run current account. The Judd approach allows me to conclude that the effect of government spending dominates the effect of an equal tax rise. Therefore, finally, when the balanced government budget constraint is imposed, a future increase in government spending and tax leads to a current account surplus in the short run and a future cut in government spending and tax results in a current account deficit in the short run.

Received: November 1992
Final version: June 1993

References

Abel, Andrew B. "Dynamic Effect of Permanent and Temporary Tax Policies in a q Model of Investment." *Journal of Monetary Economics* 9 (May 1982): 353–73.

Blanchard, Olivier J. "Debt, Deficits and Finite Horizon." *Journal of Political Economy* 93 (April 1985): 223–47.

Dixit, A. "Growth Theory after Thirty Years." In *Growth/Productivity/Unemployment*, edited by Peter Diamond, 3–22. Cambridge, MA: MIT Press, 1990.

Judd, Kenneth. "An Alternative to Steady State Comparison in Perfect Foresight Models." *Economics Letters* 10 (January 1982): 55–59.

———. "Short-Run Analysis of Fiscal Policy in a Simple Perfect Foresight Model." *Journal of Political Economy* 93 (April 1985): 298–319.

———. "Debt and Distortionary Taxation in a Simple Perfect Foresight Model." *Journal of Monetary Economics* 20 (July 1987): 51–72.

Matsuyama, Kiminori. "Current Account Dynamics in a Finite Horizon Model." *Journal of International Economics* 23 (November 1987): 299–313.

Obstfeld, Maurice. "Macroeconomic Policy, Exchange-Rate Dynamics, and Optimal Asset Accumulation." *Journal of Political Economy* 89 (December 1981): 1142–161.

———. "Aggregate Spending and the Terms of Trade: Is There A Laursen-Metzler Effect?" *Quarterly Journal of Economics* 97 (May 1982): 251–70.

Pitchford, J. D. "Optimum Borrowing and the Current Account When There Are Fluctuations in Income." *Journal of International Economics* 26 (May 1989): 345–58.

Sen, Partha, and Stephen Turnovsky. "Deterioration of the Terms of Trade and Capital Accumulation: A Re-examination of the Laursen-Metzler Effect." *Journal of International Economics* 26 (May 1989): 227–50.

Solow, R. "Reactions to Conference Papers." In *Growth/Productivity/Unemployment*, edited by Peter Diamond, 221–29. Cambridge, MA: MIT Press, 1990.

Yaari, Menahem. "Uncertain Lifetime, Life Insurance, and the Theory of Consumer." *Review of Economic Studies* 32 (April 1965): 137–50.

Pergamon

Journal of International Money and Finance, Vol. 16, No.4, pp.637-651.1997

PII: S0261-5606(97)00007-7

Dynamic analysis in the Viner model of mercantilism

HENG-FU ZOU*

Institute of Advanced Studies, Wuhan University, China and The World Bank, Washington, DC, USA

This paper models the central theme of mercantilism in Jacob Viner's interpretation—power vs plenty—in a framework of modern theory of international finance. It is shown that, in the Viner model of mercantilism, a nation with strong mercantilist sentiment ends up with large foreign asset accumulation and high consumption in the long run; an import tariff leads to more foreign asset holding and more total consumption; furthermore, in the Viner model, the Harberger–Laursen–Metzler effect exists unambiguously: a permanent terms-of-trade deterioration causes a current account deficit in the short run. (JEL F1, F3, BO).

This paper offers a mathematical model of mercantilism according to the interpretation by Jacob Viner (1937, 1948, 1968, 1991) while including the interpretations of mercantilism by Schmoller (1897), Cunningham (1907, 1968), and Heckscher (1935, 1955) as special cases of the Viner model. Even though mercantilism has been examined, criticized, or even ridiculed since Adam Smith, only recently has a formal model of mercantilism been presented by Irwin (1991) in a framework of the strategic trade theory. To address the central theme of mercantilism, I develop the Viner model of mercantilism in an extended framework of international finance and organize the study as follows.

In section I, I define the utility function of a representative nation on both consumption and foreign asset accumulation to capture 'power vs plenty as objectives' of mercantilism (Viner, 1948, 1991). In this way, a nation derives its power in the international community directly from its possession of wealth.

In section II, I first look at how the mercantilist mentality affects long-run

*Corresponding address: The World Bank, Room N10-075, 1818 H St., N.W. Washington, DC 20433, USA.
I thank Richard Caves, Kala Krishna, Arvind Panagariya, Jeffrey Sachs, and T.N. Srinivasan for their help in various stages of this study. For the revision of this paper, I am most grateful to the two referees for their constructive comments.

consumption and foreign asset accumulation and show that a nation with strong mercantilist sentiment will have high long-run consumption and foreign asset holdings. Furthermore, an import tariff advocated by mercantilists as a result of their 'fear of goods' (Heckscher, 1955) will lead to more foreign asset accumulation and more total consumption (the sum of domestic goods and foreign goods). Finally, using the Viner model of mercantilism, I show the unambiguous existence of the Harberger–Laursen–Metzler (H–L–M) effect: a permanent terms-of-trade deterioration causes a current account deficit in the short run. This finding is significant because so many existing studies have either produced ambiguous results without fully confirming the H–L–M effect or overturned the H–L–M effect.

In section III, I utilize a technique developed by Judd (1985, 1987) to analyze the effects of various exogenous shocks on consumption and foreign asset accumulation at the initial equilibrium. In section IV, I summarize the main findings and point out directions for future research.

I. The Viner model of mercantilism

This section presents the argument that a direct way to formulate the objective function of the mercantilist economic thinking is to define a nation's utility function on per capita consumption and per capita foreign asset holdings (the accumulated current account surplus):

$$\langle 1 \rangle \qquad \int_0^\infty U(c_h, c_f, b)e^{-\rho t}\,dt = \int_0^\infty \left[u(c_h, c_f) + \beta w(b)\right]e^{-\rho t}\,dt,$$

where c_h is per capita consumption of domestic goods, c_f is per capita consumption of foreign goods, b is per capita foreign asset holdings (a negative b is foreign borrowing), and $\beta(\beta > 0)$ measures the mercantilist sentiment in the words of Cunningham (1907) or the mercantilist mentality in the words of Heckscher (1955). The variable b can also be broadly defined as 'wealth', 'treasure' and 'riches'. Even in mercantilist heyday, these terms 'were used with considerable ambiguity, sometimes in broad sense to cover stocks of valuable goods of any kind which could command a price, but more often in a narrow sense to signify only the precious metals. The narrow usage was occasionally extended to commodities (other than the precious metals) which had great durability and high value per unit of bulk, such as precious stone, and even tin and copper' (Viner, 1991, p. 263). In the absence of domestic gold or silver mines, mercantilists advocated the attainment of the 'wealth' and 'treasure' through the excess of exports over imports or a current account surplus. The function $\beta w(b)$ can be regarded as the power a nation possesses and enjoys, which is an increasing function of a nation's wealth and asset holdings; the function $u(c_h, c_f)$ can be understood as the utility from consumption or as a measure of opulence and plenty in the words of Viner (1948). In its abstract form, the utility function in ⟨1⟩ has been used by Bardhan (1967), Kurz (1968), Blanchard (1983), Zou (1991, 1994b, 1995b) in studying foreign borrowing, capital accumulation, savings and economic growth.

For a small open economy, the dynamic equation of foreign asset accumulation or the current account is given by:

$$\langle 2 \rangle \qquad \dot{b} = \frac{y}{p} + rb - \frac{c_h}{p} - (1+\tau)c_f + \frac{x}{p},$$

where y is per capita endowment income, r is the exogneous interest returns on foreign asset holdings, p is the exogenous world relative price of the domestic good in terms of the foreign good, τ is the tariff on the imported consumption good, x is per capita government transfer. For simplicity, population is assumed to be a constant.

In the existing studies on mercantilism, the objective function of mercantilism has been a controversial topic. Cunningham (1907) has formulated mercantilism mainly as a system of power. In this system, the objective function is the maximisation of the national power, which in turn depends on the wealth and asset holdings possessed by a nation: 'The mercantile system is concerned with man solely as a being who pursue national power' (Heckscher, 1955, vol. 1, p. 29). According to this interpretation, mercantilism has an objective function as maximizing $\int_0^\infty \beta w(b) e^{-\rho t} dt$ subject to the dynamic constraint given by equation ⟨2⟩. This school does not directly define the utility on consumption because in its interpretation of mercantilism, 'economic well-being and betterment were not defined in terms of or measured by the satisfying of revealed community consumption preferences' (Allen, 1987). In the seventeenth century, 'accumulated wealth was vital, as well as the result of, power. And wealth was intimately associated with specie.... Wealth and specie were closely associated, however, and rising accumulation of gold and silver was taken as reflection of, even if it did not literally constitute, increasing wealth'. Indeed, 'money is the sinews of war' (Allen, 1987).

In this formulation of mercantilism, wealth accumulation through continued trade surplus is only the means to achieve the supreme goal — national power. Heckscher (1955) explicitly states 'Mercantilism as a System of Power' in his study. He has provided some detailed examination why mercantilism subordinates wealth and asset accumulation to power.

Viner (1948, 1991) holds a different point of view. His definition of the mercantilist objective can be modeled as exactly in functional form ⟨1⟩: the mercantilists seek both 'power and plenty (or opulence)'. This is clear from the title of his famous study: 'Power vs Plenty as Objectives of Foreign Policy in the Seventeenth and Eighteenth Centuries'. In addition to seeking plenty or opulence as represented by $u(c_h, c_f)$ in the objective function ⟨1⟩, the gain in wealth accumulation also appears explicitly as the term, rb, in the dynamic equation of the current account ⟨2⟩. Of course, like Cunningham and Heckscher, Viner also emphasize the role of wealth as the foundation of power, which is represented by the function $\beta w(b)$ in equation ⟨1⟩. In Viner's own words: 'I believe that practically all mercantilists, whatever the period, country, or status of the particular individual, would have subscribed to all the following propositions: (1) wealth is an absolutely essential means to power, whether for security or for aggression; (2) power is essential or valuable as a means to the acquisition or retention of wealth; (3) wealth and power are each

proper ultimate ends of national policy; (4) there is long-run harmony between these ends' (Viner, 1948, 1991, p. 136).

Therefore, our model specified in equations ⟨1⟩ and ⟨2⟩ can be regarded as a synthesis and combination of all these different interpretations of mercantilists' objective functions; in particular, it closely reflects Viner's interpretation of mercantilism.

II. Some long-run analysis of the model

Following Bardhan (1967), Kurz (1968), Calvo (1980), Blanchard (1983), and Cole, Mailath and Postlewaite (1992), the function $w(b)$ is assumed to have the following properties: $w' > 0$, $w'' \leq 0$. In addition, $u(c_h, c_f)$ is increasing, concave, and continuously differentiable in c_h and c_f, and $\partial^2 u/\partial c_h \partial c_f > 0$.

The model specified in this paper is an ancient one if it is interpreted with the mercantilist mentality, it is also a modern one if it is viewed as a reflection of today's protectionism, nationalism and international politics and the balance of power. Furthermore, it is a contemporary one because in its mathematical form it is a variation of the standard asset accumulation model in international finance such as Obstfeld (1981, 1982) and Turnovsky (1985, 1987).

Now I turn to the analysis of the model itself. The home country maximizes ⟨1⟩ subject to ⟨2⟩. The specification of asset accumulation equation ⟨2⟩ is identical to the one in Obstfeld (1982). The objective function differs from that of Obstfeld's paper in two aspects: first, the time discount rate here is constant instead of being an increasing function of the utility; second, the utility function is defined not only on consumption but also on foreign asset accumulation.

To derive the optimal conditions for the home country, I define the present-value Hamiltonian as

⟨3⟩ $$H = u(c_h, c_f) + \beta w(b) + \lambda\left[(y/p) + rb - (c_h/p) - (1+\tau)c_f + x/p\right].$$

where λ is the costate variable.

The first order conditions for maximization are

⟨4⟩ $$\partial u/\partial c_f = \lambda(1+\tau),$$

⟨5⟩ $$\partial u/\partial c_h = \lambda/p,$$

⟨6⟩ $$\dot{\lambda} = (\rho - r)\lambda - \beta w'(b),$$

⟨2⟩ $$\dot{b} = (y/p) + rb - (c_h/p) - (1+\tau)c_f + (x/p).$$

From ⟨4⟩ and ⟨5⟩, we can solve c_h and c_f as functions of λ, p and τ

⟨7⟩ $$c_h = c_h(\lambda, p, \tau), \qquad c_f = c_f(\lambda, p, \tau).$$

It is easy to show that

⟨8⟩ $$\partial c_h/\partial\lambda < 0, \quad \partial c_f/\partial\lambda < 0, \quad \partial c_h/\partial p > 0, \quad \partial c_f/\partial p > 0,$$
$$\partial c_h/\partial\tau < 0, \quad \partial c_f/\partial\tau < 0.$$

Substitute $c_h = c_h(\lambda, p, \tau)$ and $c_f = c_f(\lambda, p, \tau)$ into ⟨2⟩, and rewrite ⟨6⟩:

$$\langle 9 \rangle \qquad \dot{b} = (y/p) + rb - [c_h(\lambda, p, \tau)/p] - (1+\tau)c_f(\lambda, p, \tau) + x/p,$$

$$\langle 6 \rangle \qquad \dot{\lambda} = (\rho - r)\lambda - \beta w'(b).$$

Upon introducing a balanced government budget in each period, government transfer (x/p) in our model is exactly equal to its tariff revenue τc_f.

Therefore, equation ⟨9⟩ can be written as

$$\langle 9' \rangle \qquad \dot{b} = (y/p) + rb - [c_h(\lambda, p, \tau)/p] - c_f(\lambda, p, \tau).$$

Equations ⟨6⟩ and ⟨9′⟩ are the focus of our analysis. The necessary condition for the existence of a steady state is that in ⟨6⟩ the time discount rate needs to be greater than the interest rate

$$\langle 10 \rangle \qquad \rho > r.$$

This condition is also required for the finite horizon model in Blanchard (1985). Note that the introduction of the mercantilist instinct $\beta w(b)$ into our model avoids the knife-edge problem that, for an equilibrium to exist, the time discount rate has to equal the interest rate. In our model, the requirement ⟨10⟩ makes sense because asset accumulation not only bring about interest income r and 'opulence', it also directly gives rise to utility $\beta w'(b)$ and 'power', to use the terms used by Eli Heckscher and Jacob Viner. Thus in equilibrium the time discount rate should be larger than the interest rate but equal to the sum of the interest rate and the marginal utility of the power. One attractive feature about our formulation is that it enables us to get away from imposing the equality $\rho = r$, which is so common in much of international macroeconomics. Another way to break this link is to introduce quadratic costs of holding foreign bonds as in Turnovsky (1985). We also note that equation ⟨6⟩ is quite similar to the corresponding dynamic equation in Turnovsky (1985).

Denoting the steady-state values of λ and b as λ^* and b^*, and linearizing ⟨6⟩ and ⟨9′⟩ around λ^* and b^*, we obtain

$$\langle 10 \rangle \qquad \begin{bmatrix} \dot{\lambda} \\ \dot{b} \end{bmatrix} = \begin{bmatrix} \rho - r & -\beta w''(b^*) \\ -[(\partial c_h/\partial\lambda)/p] + \partial c_f/\partial\lambda & r \end{bmatrix} \begin{bmatrix} \lambda - \lambda^* \\ b - b^* \end{bmatrix}.$$

Let M denote the 2×2 matrix, and Δ' its determinant,

$$\langle 11 \rangle \qquad \Delta' = \det(M) = (\rho - r)r - \beta w''(b^*)\{[(\partial c_h/\partial\lambda)/p] + (\partial c_f/\partial\lambda)\}.$$

The equilibrium is saddle-point stable if the determinant is negative, namely,

$$\langle 12 \rangle \qquad \Delta' < 0.$$

In this case, there exists a unique perfect-foresight path converging to the equilibrium because one eigenvalue of the dynamic system is negative and one eigenvalue positive. These eigenvalues correspond to one state variable b and one jumping variable c in the model. If Δ' is positive, there will be two positive eigenvalues since the trace of the matrix M, which is the sum of the two

eigenvalues, is also positive and equals the time discount rate ρ; that is to say, at least one eigenvalue is positive. But a positive determinant of the matrix M implies that the dynamic system either has two positive eigenvalues or two negative eigenvalues. Thus a positive trace plus a positive determinant of matrix M will result in two positive eigenvalues and a totally unstable system, which will not be considered in this paper.

With the assumption in ⟨12⟩, we draw the phase diagram in Figure 1.

In Figure 1, both curves are downward sloping. Condition ⟨12⟩ is exactly the same as requiring that the slope of the curve $\dot{\lambda} = 0$ be steeper than the curve $\dot{b} = 0$ in order to have a unique saddle point path converging to the equilibrium A where $b = b^*$, and $\lambda = \lambda^*$.

II. A. The effect of the mercantilist mentality

To see how the mercantilist mentality β, affects asset accumulation and consumption in the long run, I set $\dot{\lambda}$ and $\dot{b}$ equal to zero in equation ⟨9′⟩ and ⟨6⟩, and totally differentiate the two steady-state equations

$$\langle 13\rangle \quad M\begin{bmatrix} d\lambda \\ \\ db \end{bmatrix} = \begin{bmatrix} w'(b^*)d\beta \\ \{[(\partial c_h/\partial\tau)/p] + (\partial c_f/\partial\tau)\}d\tau + \{[(y-c_h)/p^2] \\ +[(\partial c_h/\partial p)/p] + \partial c_f/\partial p\}dp \end{bmatrix},$$

where M is the same 2×2 matrix in ⟨10⟩.

Proposition 1: The stronger the mercantilist sentiment, the larger the long-run consumption and asset accumulation.

From ⟨13⟩ and ⟨12⟩

$$\langle 14\rangle \quad d\lambda/d\beta < 0, \quad db/d\beta > 0, \quad dc_h/d\beta > 0, \quad dc_f/d\beta > 0,$$

where we have used the fact that both $\partial c_h/\partial\lambda$ and $\partial c_f/\partial\lambda$ are negative as in ⟨8⟩.

The reason for this proposition is quite clear. As a nation highly values its wealth and power in the world, it saves more and consumes less in the short run in order to run a current account surplus and accumulate more foreign assets. More foreign asset holdings means more interest income, which in turn leads to more consumption in the long run. Proposition 1 is a very strong argument for mercantilism if a nation intends to maximize its citizens' long-run consumption.

II.B. The effect of the tariff

The effect of the tariff can be seen by Cramer's rule in ⟨13⟩

$$\langle 14\rangle \quad d\lambda/d\tau = \beta w''(b^*)\{[(\partial c_h/\partial\tau)/p] + (\partial c_f/\partial\tau)\}/\Delta' < 0,$$

$$\langle 15\rangle \quad db/d\tau = (\rho - r)\{[(\partial c_h/\partial\tau)/p] + (\partial c_f/\partial\tau)\}/\Delta' > 0.$$

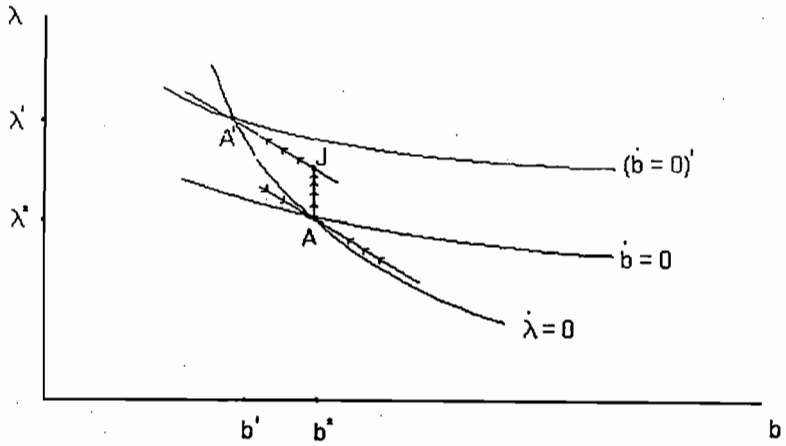


FIGURE 1. The phase diagram and the effect of a permanent terms-of-trade deterioration.

Proposition 2: A permanent increase in the tariff rate raises the total long-run consumption and asset accumulation.

The positive effect of the tariff on asset accumulation is in ⟨15⟩. To see its effect on long-run consumption, we note that a tariff directly reduces the consumption of both domestic and imported goods, but it also leads to a lower shadow price λ, which increases consumption. The net effect is positive because, from the steady state equation, $\dot{b} = 0$, namely,

$$(y/p) + rb^* - [c_h^*(\lambda^*, \tau)/p] - c_f^*(\lambda^*, \tau) = 0,$$

a higher tariff increases b^* and total interest income. Therefore, to maintain the equilibrium condition in the goods market, total consumption will have to rise in the long run, even though the impact on the consumption of the foreign good is ambiguous.

Proposition 2 provides support for the mercantilist protection policy, namely, the 'fear of goods' (Heckscher, 1955), if attainment of a higher long-run consumption is the national objective. Both proposition 1 and proposition 2 indicate the long-run harmony between wealth and power. Indeed, from the mercantilist perspective, 'there is long-run harmony between these two ends, although in particular circumstances it may be necessary for a time to make economic sacrifices in the interest of ...'long-run prosperity' (Viner, 1991, p. 136). Following an increase in the tariff, short-run consumption will be cut because people invest more in foreign asset. But in the long run, the increased foreign asset accumulation gives rise to more consumption and more power for the nation.

We should emphasize that proposition 2 is derived in a pure endowment economy without market imperfection and increasing returns to scale in production. In the strategic trade theory, protectionist economic policies are often justified with the presence of product differentiation on the demand side

and externalities on the production side. In the mercantilist model, protectionist economic policy such as a tariff leads to a higher long-run asset accumulation and consumption in a world without any imperfection on either the demand side or the supply side. Proposition 2 therefore sheds some insight on the protectionist economic policies in addition to the ones offered by the strategic trade theory.

II.C. The effect of a terms-of-trade shock

Since Obstfeld (1982) raised the doubt about the existence of the Harberger–Laursen–Metzler (H–L–M) effect in an infinite horizon model with an endogneous time preference, many contributions over the past decade have explored this issue. But perhaps it is a surprise that, while Obstfeld overturned the H–L–M effect, all other models have only produced ambiguous results on the existence of the H–L–M effect under various assumptions and model strategies. For example, Svensson and Razin (1983) have examined the effect of terms-of-trade changes on a small country's consumption and current account in an intertemporal model. They demonstrate that a temporary (future) terms-of-trade deterioration implies a deterioration (improvement) of the trade balance, whereas a permanent terms-of-trade deterioration has an ambiguous effect, depending on the rate of time preference. In another contribution by Persson and Svensson (1985), it is shown that the classic H–L–M effect can have any sign for plausible parameter values, both for temporary and permanent disturbance. Ambiguities have also been shown in various models by Matsuyama (1987), Sen and Turnovsky (1989), and Mansoorian (1993).

Here it can be shown that, in the Viner model of mercantilism, there exists a full confirmation of the H–L–M effect: an unanticipated permanent deterioration in the terms of trade always leads to a current account deficit in the short run. Suppose that the economy is in the steady state A of Figure 1, and the terms of trade worsen permanently, i.e. p goes up forever. Then, in Figure 1, the curve $\dot{\lambda} = 0$ does not change, but the curve $\dot{b} = 0$ shifts upward to $(\dot{b})' = 0$. Immediately following the shock, λ jumps up from the initial equilibrium point A to point J. Since foreign asset holdings are the state variable, b cannot jump. Therefore, at the time when this permanent shock happens, consumption will be cut immediately and the current account goes to surplus (we will provide a quantitative estimate for this initial change in consumption and the current account in the next section). But after the initial shock, along the convergent path from point J to the new equilibrium A', foreign asset holding b decreases and the current account goes to a deficit in the short run or during the adjustment period. At the same time, λ continues to increase, and, from ⟨8⟩, the consumption of both the home good and imported good is decreasing. In the new steady state A', the economy has smaller foreign asset holdings than before: $b' < b^*$.

Analytically, by Cramer's rule in ⟨13⟩,

⟨16⟩

$$d\lambda/dp = [\beta w''(b^*)/\Delta'] \left\{ [(y - c_h)/p^2] + \partial c_f/\partial p + (\partial c_h/\partial p)/p \right\} > 0,$$

which is positive because $w'' < 0$, $\Delta' < 0$, $(y - c_h) \geq 0$ (as the endowment of the home goods is no less than the consumption of the home goods), and, from ⟨8⟩, $\partial c_h/\partial p > 0$, and $\partial c_f/\partial p > 0$. Almost by the same reason,

⟨17⟩

$$db/dp = [(\rho - r)/\Delta']\left\{\left[(y - c_h)/p^2\right] + \partial c_f/\partial p + (\partial c_h/\partial p)/p\right\} < 0,$$

and note that $\rho > r$ in order to have a steady state as we stated earlier in condition ⟨12⟩. Therefore,

Proposition 3: The H–L–M effect always holds in the Viner model of mercantilism.

The economic explanation for proposition 3 is as follows: a permanent deterioration of the terms of trade reduces the small economy's income, the home country responds to this permanent shock by lowering its consumption immediately following the shock. Since the preference is directly defined on both consumption and foreign asset holdings, a lower consumption with unchanged foreign asset holdings upsets the initial equilibrium condition between consumption and foreign asset holdings. Therefore, the home country will convert part of its foreign asset holdings into consumption because consumption is now more valuable than foreign asset. In the short run, the current account goes to a deficit, and, in the long run, foreign asset accumulation is reduced. Thus in the Viner model of mercantilism, the H–L–M effect always holds. This confirmation of the H–L–M effect as a result of a permanent terms-of-trade deterioration stands in sharp contrast to the Obstfeld model; it is also a clear-cut result without the ambiguities presented in so many existing studies. In passing, we shall note that the ambiguities may continue when the mercantilist model is extended to include capital accumulation and variable rate of time preference.

III. The impacts of various shocks at the initial equilibrium

In this section, it is assumed that the home country is in an equilibrium at time $t = 0$. In order to examine the effects of various shocks on consumption and the current account at this initial equilibrium, I follow a technique developed by Judd (1985, 1987). A different analysis of the current account in a finite horizon model is presented in Zou (1994a).

Suppose that at time $t = 0$, i.e. today, the economy is in the steady state b^* and λ^* corresponding to the initial terms of trade p^*, the initial tariff rate τ^*, the initial interest rate r^*, and the initial mercantilist sentiment β^*. Also at time $t = 0$, the terms of trade, the tariff rate, the interest rate, and the mercantilist sentiment change as follows

⟨18⟩ $$p' = p^* + \varepsilon p(t), \qquad \tau' = \tau^* + \varepsilon\tau(t), \qquad r' = r^* + \varepsilon r(t),$$
$$\beta' = \beta^* + \varepsilon\beta(t),$$

where ε is a parameter and functions $p(t)$, $\tau(t)$, $r(t)$ and $\beta(t)$ represent the intertemporal changes of various parameters in a magnitude-free fashion since

ε can represent different magnitude of change. For example, a change in the terms of trade during a future time $T_1 < t < T_2$ can be represented by setting $p(t)$ to be one for $T_1 < t < T_2$ and zero otherwise. In this way, $p(t)$ can be regarded as a step function.

Substituting p', τ', r' and β' into equations ⟨6⟩ and ⟨9′⟩ yields

⟨19⟩ $$\dot{\lambda} = (\rho - r^* - \varepsilon r(t))\lambda - (\beta^* + \varepsilon\beta(t))w'(b),$$

⟨20⟩
$$\dot{b} = [y/(p^* + \varepsilon p(t))] - c_f(\lambda, p^* + \varepsilon p(t), \tau^* + \varepsilon\tau(t)) - [c_h(\lambda, p^* + \varepsilon p(t), \tau^* + \varepsilon\tau(t))/(p^* + \varepsilon p(t))] + (r^* + \varepsilon r(t))b.$$

The solutions for b and λ will depend on both t and ε. I write the solutions as $b(t, \varepsilon)$ and $\lambda(t, \varepsilon)$. Since $\varepsilon = 0$ implies that the system remains at the initial steady state, the effects of a terms-of-trade change can be seen from the impact on the paths of b and λ as ε varies from zero to a small positive or negative value. Formally, I define the initial impacts of ε on b and λ here:

$$b_\varepsilon(t) = \partial b(t,0)/\partial\varepsilon, \qquad \lambda_\varepsilon(t) = \partial\lambda(t,0)/\partial\varepsilon,$$
$$\dot{b}_\varepsilon(t) = \partial[\partial b(t,0)/\partial\varepsilon]/\partial t, \quad \dot{\lambda}_\varepsilon(t) = \partial[\partial\lambda(t,0)/\partial\varepsilon]/\partial t.$$

Differentiating equation ⟨19⟩ and ⟨20⟩ with respect to ε and evaluating the derivatives at $\varepsilon = 0$ yield a pair of differential equations in the variables b_ε and λ_ε

⟨21⟩
$$\begin{bmatrix} \dot{\lambda}_\varepsilon \\ \dot{b}_\varepsilon \end{bmatrix} = \begin{bmatrix} \rho - r & -\beta w''(b^*) \\ -[\partial c_f/\partial\lambda + (\partial c_h/\partial\lambda)/p^*] & r \end{bmatrix} \begin{bmatrix} \lambda_\varepsilon \\ b_\varepsilon \end{bmatrix} + \begin{bmatrix} v_1(t) \\ v_2(t) \end{bmatrix},$$

where

⟨22⟩ $$v_1(t) = -\lambda^* r(t) - w'(b^*)\beta(t),$$

⟨23⟩ $$v_2(t) = b^* r(t) - \{(\partial c_f/\partial\tau) + [(\partial c_h/\partial\tau)(1/p^*)]\}\tau(t) - \{[(y - c_h)/p^{*2}] + (\partial c_f/\partial p) + [(\partial c_h/\partial p)(1/p^*)]\}p(t).$$

the coefficient for $p(t)$ is always negative because $(y - c_h)$ is positive as the home goods endowment is no less than the home goods consumption, $\partial c_f/\partial p$ and $\partial c_h/\partial p$ are both positive from ⟨8⟩.

Let me continue to denote the determinant of the Jacobian matrix in ⟨21⟩ as Δ'. Then, for a saddle-point equilibrium, the positive and negative eigenvalues for the Jacobian matrix are given by μ and ω, respectively

⟨24⟩ $$\mu = \left[\rho + \sqrt{\rho^2 - 4\Delta'}\right]/2 > 0,$$

⟨25⟩ $$\omega = \left[\rho - \sqrt{\rho^2 - 4\Delta'}\right]/2 < 0.$$

As in Judd (1985, 1987), the Laplace transform can be utilized to solve equation ⟨21⟩. For sufficiently large positive s, the Laplace transform of a

function $f(t)(t>0)$ is another function $F(s)$, where

$$F(s)=\int_0^{\infty} f(t)e^{-st}\,\mathrm{d}t.$$

Let $\Lambda_\varepsilon(s)$, $B_\varepsilon(s)$, $R(s)$, $T(s)$, $P(s)$ and $H(s)$ be the Laplace transforms of $\lambda_\varepsilon(t)$, $b_\varepsilon(t)$, $r(t)$, $\tau(t)$, $p(t)$ and $\beta(t)$, respectively. Then

⟨26⟩

$$s\begin{bmatrix}\Lambda_\varepsilon\\ B_\varepsilon\end{bmatrix}=\begin{bmatrix}\rho-r & -\beta w''(b^*)\\ -\left[\partial c_f/\partial\lambda+(\partial c_h/\partial\lambda)/p^*\right] & r\end{bmatrix}\begin{bmatrix}\Lambda_\varepsilon\\ B_\varepsilon\end{bmatrix}+\begin{bmatrix}V_1(s)+\lambda_\varepsilon(0)\\ V_2(s)+b_\varepsilon(0)\end{bmatrix},$$

where

$$V_1(s)=-\lambda^*R(s)-w'(b^*)H(s),$$

$$V_2(s)=b^*R(s)-\left\{(\partial c_f/\partial\tau)+[(\partial c_h/\partial\tau)(1/p^*)]\right\}T(s)$$
$$-\left\{\left[(y-c_h)/p^{*2}\right]+(\partial c_f/\partial p)+[(\partial c_h/\partial p)(1/p^*)\right\}P(s).$$

Solving for $\Lambda_\varepsilon(s)$ and $B_\varepsilon(s)$ in ⟨26⟩

⟨27⟩

$$\begin{bmatrix}\Lambda_\varepsilon\\ B_\varepsilon\end{bmatrix}=\begin{bmatrix}s-\rho+r & \beta w''(b^*)\\ \left[\partial c_f/\partial\lambda+(\partial c_h/\partial\lambda)/p^*\right] & s-r\end{bmatrix}^{-1}\begin{bmatrix}V_1(s)+\lambda_\varepsilon(0)\\ V_2(s)\end{bmatrix}.$$

I have dropped $b_\varepsilon(0)$ in equation ⟨27⟩ because b is the state variable and the initial foreign asset $b(0)$ cannot be altered immediately. But the costate variable λ can jump and the jump is necessary to assure the convergence of the two variables on the perfect foresight path. To pin down the initial jump in λ, namely, $\lambda_\varepsilon(0)$, it is noted that the existence of a saddle-point equilibrium implies a bounded steady state foreign asset accumulation for any ε. Therefore, $B_\varepsilon(s)$ must be finite for all $s>0$, even for $s=\mu$ (the positive eigenvalue of the dynamic system). However, when $s=\mu$, the 2×2 matrix in ⟨27⟩ is singular and its inverse does not exist. To remove this singularity, implicitly the numerators on the right hand side have to be zero because the denominator is equal to $(s-\mu)(s-\omega)$, which is zero when $s=\mu$. That is to say

⟨28⟩ $$(\mu-r)[V_1(\mu)+\lambda_\varepsilon(0)]-\beta w''(b^*)V_2(\mu)=0.$$

From ⟨28⟩, I have

⟨29⟩

$$\lambda_\varepsilon(0)=-V_1(\mu)+\beta w''(b^*)V_2(\mu)(\mu-r)^{-1}$$
$$=-\lambda^*R(\mu)-w'(b^*)H(\mu)+\beta w''(b^*)(\mu-r)^{-1}\Big\{b^*R(\mu)-\big\{(\partial c_f/\partial\tau)$$
$$+[(\partial c_h/\partial\tau)(1/p^*)]\big\}T(\mu)-\left\{\left[(y-c_h)/p^{*2}\right]+(\partial c_f/\partial p)\right.$$
$$\left.+[(\partial c_h/\partial p)(1/p^*)\right\}P(\mu)\Big\}.$$

Since $P(\mu)$ is just the present value of future terms-of-trade shock discounted at the positive eigenvalue: $P(\mu)=\int_0^\infty p(t)e^{-\mu t}\,dt$, the initial jump in the shadow

price of the foreign asset is always positively related to the discounted, future terms-of-trade shock because the coefficient of $P(\mu)$ in ⟨29⟩ is always positive.

With the information of $\lambda_\varepsilon(0)$, I can substitute both $\lambda_\varepsilon(0)$ and $b_\varepsilon(0)$ (the latter is always zero) into equation ⟨21⟩ and find out the responses of the initial current account to various shocks

⟨30⟩

$$\begin{aligned}\dot{b}_\varepsilon(0) &= -\{(\partial c_f/\partial\lambda) + [(\partial c_h/\partial\lambda)(1/p^*)]\}\lambda_\varepsilon(0) + V_2(0)\\ &= -\{(\partial c_f/\partial\lambda) + [(\partial c_h/\partial\lambda)(1/p^*)]\}\{-\lambda^* R(\mu) - w'(b^*)H(\mu)\\ &\quad + \beta w''(b^*)(\mu - r)^{-1}\{b^* R(\mu) - \{(\partial c_f/\partial\tau) + [(\partial c_h/\partial\tau)(1/p^*)]\}T(\mu)\\ &\quad - \{[(y - c_h)/p^{*2}] + (\partial c_f/\partial p) + [(\partial c_h/\partial p)(1/p^*)]P(\mu)\}\}\\ &\quad + b^* r(0) - \{(\partial c_f/\partial\tau) + [(\partial c_h/\partial\tau)(1/p^*)]\}\tau(0)\\ &\quad - \{[(y - c_h)/p^{*2}] + (\partial c_f/\partial p) + [(\partial c_h/\partial p)(1/p^*)\}p(0).\end{aligned}$$

From ⟨30⟩, a few observations can be derived.

First, if the initial equilibrium asset holdings are positive, then any future increase in the interest rate results in a current account deficit today

$$\begin{aligned}d\dot{b}_\varepsilon(0)/dR(\mu) = &-\{(\partial c_f/\partial\lambda) + [(\partial c_h/\partial\lambda)(1/p^*)]\}\\ &\times\{-\lambda^* + \beta w''(b^*)(\mu - r)^{-1} b^*\} < 0,\end{aligned}$$

which is negative if the steady-state asset accumulation b^* is positive. This is true because any future rise in the interest rate leads to more future income for the home country. To smooth its consumption, the home country spends more today by cutting its current asset holding. Thus, the current account deteriorates today.

Second, a rise in the mercantilist mentality β in the future drives today's current account to a deficit

$$d\dot{b}_\varepsilon(0)/dH(\mu) = \{(\partial c_f/\partial\lambda) + [(\partial c_h/\partial\lambda)(1/p^*)]\}w'(b^*)H(\mu) < 0.$$

This result makes sense because a rise in β in the future will increase asset holdings and raises future income. Therefore, to smooth consumption, the home country increases its consumption today. The rising consumption without a corresponding increase in current income worsens the trade balance and the current account today.

Third, a higher tariff in the futue has a negative impact on the current account today (note that $(\mu - r) > 0$ in equation ⟨30⟩). This result holds because a future rise in the tariff leads to more asset accumulation and more income in the future (see proposition 2). Thus, to smooth consumption, the home country converts part of its current asset holdings to current consumption. In this way, today's current account goes to a deficit.

Fourth, any future deterioration (improvement) in the terms of trade improves (worsens) the current account today. (To see this, note that the

coefficient for $P(\mu)$ in ⟨30⟩ is always positive.) The economic intuition behind this observation is as follows: a future deterioration in the terms of trade reduces future income. The home country reacts to this anticipated future shock by cutting its consumption today. As shown in proposition 3, the long-run foreign asset holdings will also be reduced if the shock is permanent. But in the very short run, the foreign asset holding is a state variable, which cannot jump down immediately. Thus only consumption will be reduced. This is shown as the jump from point A to point J in Figure 1. In the transition from point J to point A' in Figure 1, both consumption and foreign asset holdings are reduced as a result of a permanent terms-of-trade shock.

Fifth, a current rise in the interest rate and the tariff rate improves today's current account while a current deterioration in the terms of trade worsens the current account today. Thus, the effects of all these current shocks on today's current account are just the opposite of the ones of future shocks. A current rise in the interest rate leads to more income today and improves today's current account; a current rise in the tariff reduces consumption and increases trade surplus; finally, a deterioration in the terms of trade today, i.e. $p(0)$ increases, lowers the home country's income today and worsens its current account because a momentary income reduction as a result of the terms-of-trade shock will not affect current consumption of both home goods and imported goods.

IV. Conclusions

This paper has formulated Jacob Viner's interpretation of mercantilism by defining both consumption and foreign asset accumulation in the utility function to reflect power vs plenty as objectives of a mercantilist nation. This model also has various applications and interpretations: nationalism in the sense of Bardhan (1967); the psychological benefit (costs) of foreign asset holdings (foreign borrowing) in the sense of Blanchard (1983); the wealth-is-status model in Frank (1985), Cole et al. (1992), and Fershtman and Weiss (1993); and the capitalist-spirit model as in Zou (1994b, 1995b) and Bakshi and Chen (1996).

The most interesting, and perhaps surprising fact about this Viner model of mercantilism is its theoretical predictions. We have shown that in the Viner model a nation with strong mercantilist sentiment has high consumption and large foreign asset accumulation in the long run; a permanent rise in the tariff rate leads to more foreign asset accumulation and more total consumption in the long run; a permanent terms-of-trade shock worsens the current account in the short run, which provides a full confirmation of the existence of the H–L–M effect in an infinite horizon model.

In future research, it is desirable to extent the endowment-economy and small-economy model in this paper into a big-country model with both capital accumulation and foreign asset holdings. It should also be interesting to study fiscal policy, monetary policy and the exchange-rate theory in the Viner model of mercantilism. Furthermore, the mercantilist model can be extended to consider the relative wealth or relative power status in a many-country world as

in Bakshi and Chen (1996), where the utility function from wealth and power is modified to be $\beta w(b(t)/B(t))$ with $B(t)$ as the average wealth level in the rest of the world.

References

Allen, W. (1987) Mercantilism. In *The New Palgrave: A Dictionary of Economics*. Macmillan, London.

Bakshi G. and Chen, Z. (1996) The spirit of capitalism and stock market prices. *American Economic Review* **86**, 133–157.

Bardhan, P. (1967) Optimum foreign borrowing. In: *Essays on the Theory of Optimal Economic Growth*, ed K. Shell. MIT Press.

Blanchard, O. (1983) Debt and current account deficit in Brazil. In: *Financial Policies and the World Capital Market*, eds A. Armella et al. University of Chicago Press, Chicago.

Blanchard, O. (1995) Debt, deficits and finite horizons. *Journal of Political Economy* **93**, 223–247.

Calvo, G. (1980) Financial Opening, Crawling Peg and the Real Exchange Rate, mimeo.

Cole, H., Mailath, G. and Postlewaite, A. (1992) Social norms, savings behavior, and growth. *Journal of Political Economy* **100**, 1092–1125.

Cunningham, W. (1968) *The Growth of English Industry and Commerce and Modern Times: The Mercantile System*, 4th edn., 1907; reprinted by A. M. Kelley Publishers, New York.

Fershtman, C. and Weiss, Y. (1993) Social status, culture and economic performance. *Economic Journal* **103**, 946–959.

Frank, R. (1985) *Choosing the Right Pond: Human Behavior and the Quest for Status*. Oxford University Press.

Heckscher, E., (1934, 1955) *Mercantilism*, Vol. 2. Allen & Unwin (2nd edn).

Irwin, D. (1991) Mercantilism as strategic trade policy: the Anglo-Dutch rivalry for the East India trade. *Journal of Political Economy* **99**, 1296–1314.

Judd, K. (1985) Short-run analysis of fiscal policy in a simple perfect foresight model. *Journal of Political Economy* **93**, 298–319.

Judd, K. (1987) Debt and distortionary taxation in a simple perfect foresight model. *Journal of Monetary Economics* **20**, 51–72.

Kurz, M. (1968) Optimal economic growth and wealth effects. *International Economic Review* **9**, 348–357.

Matsuyama, K. (1987) Current account dynamics in a finite horizon model. *Journal of International Economics* **23**, 299–313.

Manscorian, A. (1993) Habit persistence and the Harberger–Laursen–Metzler effect in an infinite horizon model. *Journal of International Economics* **34**, 153–166.

Obstfeld, M. (1981) Macroeconomic policy, exchange-rate dynamics, and optimal asset accumulation. *Journal of Political Economy* **89**, 1142–1161.

Obstfeld, M. (1982) Aggregate spending and the terms of trade: is there a Laursen–Metzler effect? *Quarterly Journal of Economics* **97**, 251–270.

Persson, T. and Svensson, L.E.O. (1985) Current account dynamics and the terms of trade. *Journal of Political Economy* **93**, 43–65.

Schmoller, G. (1897) *The Mercantile System and its Historical Significance, Illustrated Chiefly from Prussian History*, Macmillan, New York.

Schumpeter, J. (1954) *History of Economic Analysis*. Oxford University Press.

Sen, P. and Turnovsky, S. J. (1989) Deterioration of the terms of trade and capital accumulation. *Journal of International Economics* **26**, 227–250.

Svensson, L.E.O. and Razin, A. (1983) The terms of trade and the current account. *Journal of Political Economy* **91**, 97–125.

Turnovsky, S. (1985) Domestic and foreign disturbances in an optimizing model of exchange-rate determination. *Journal of International Money and Finance*, **4**, 151–171.

Turnovsky, S. (1987) Optimal monetary growth with accommodation fiscal policies in a small open economy. *Journal of International Money and Finance* 6, 179–193.

Viner, J. (1937) *Studies in the Theory of International Trade*. Harper, New York.

Viner, J. (1948) Power versus plenty as objectives of foreign policy in the seventeenth and eighteenth centuries. *World Politics* **1**, 1–29. Reprinted in *Essays on the Intellectual History of Economics*, by J. Viner; edited by D.A. Irwin, Princeton University Press, 1991.

Viner, J. (1968) Mercantilist thought. In: *The International Encyclopedia of the Social Sciences*, ed D. Sills, Vol. 4. pp. 435–443, Macmillan and the Free Press, New York. Reprinted in *Essays on the Intellectural History of Economics*, by J. Viner; edited by D.A. Irwin, Princeton University Press, 1991.

Zou, H. (1991) Socialist economic growth and political investment cycles, *European Journal of Political Economy* **7**, 141–157.

Zou, H. (1994a) Short-run analysis of fiscal policies and the current account in a finite horizon model. *Journal of Macroeconomics* **16**, 347–357.

Zou, H. (1994b) The spirit of capitalism and long-run growth. *European Journal of Political Economy* **10**, 279–293.

Zou, H. (1995a) A dynamic model of capital and arms accumulation. *Journal of Economic Dynamics and Control* **19**, 371–393.

Zou, H. (1995b) The spirit of capitalism and savings behavior. *Journal of Economic Behavior and Organization* **28**, 131–143.

ELSEVIER

Journal of Economic Dynamics and Control
19 (1995) 371–393

JOURNAL OF Economic Dynamics & Control

A dynamic model of capital and arms accumulation

Heng-fu Zou

Policy Research Department, The World Bank, Washington, DC 20433, USA

(Received November 1992; final version received August 1993)

Abstract

How does competitive arms accumulation affect investment and capital accumulation? In a dynamic optimization framework including both investment and military spending, we find 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 when the utility function is nonseparable between consumption and the weapon stocks, a current military threat may not decrease the short-run investment. In the long run, capital accumulation is independent of the military conflicts among countries regardless of the form of the utility function.

Key words: Capital accumulation; Military spending; Economic growth; Arms race
JEL classification: E20; E22; H56; O10; O40

1. Introduction

This paper examines both long-run and short-run responses of military spending and investment to competitive arms accumulation in a dynamic optimization model over an infinite horizon.

This approach is well justified for two reasons. First, the relation between military spending and capital accumulation has recently received considerable attention in policy discussions and empirical studies; see Deger and Sen (1983, 1992), Deger (1986), Hewitt (1991), McNamara (1992), Landau (1992), among

I thank two anonymous referees for very constructive suggestions and comments that lead to a substantial revision of this paper. All remaining errors are mine. The opinions expressed here are solely mine and not of the World Bank.

others. Even though there are strong arguments for the existence of a negative impact of military tension on productive investment and output growth, empirical analysis often indicates some ambiguous effects or even a weak but positive effect; see Deger and Sen (1983) and Landau (1992). In addition, cross-country examination also shows that defense spending definitely reduces national saving ratios; see Deger (1986). Up till now, a well-grounded theoretical interpretation for these empirical findings is still lacking. Overall, empirical studies in this field have not explicitly modeled the dynamic relation among investment, consumption, and military spending. And very often some simple regression equations are estimated by putting military spending either as a dependent variable in Hewitt (1991) or as an explanatory variable in Landau (1992). If we derive the dynamics of investment and military spending from explicit dynamic optimization based on exogenously given preference, technology, military tension, and other factors, then not only can we verify whether empirical findings are consistent with theoretical predictions, but we can also provide insights on how to test the relation between military spending and investment in econometric studies.

Second, numerous theoretical studies on military spending often take output as given or ignore capital accumulation while focusing on the competitive arms accumulation in the dynamic games played by two countries in a state of confrontation. This long tradition begins with Richardson (1960) and continues with Saaty (1968), Brito (1972), Simaan and Cruz (1975), Intriligator (1975), and Intriligator and Brito (1976). For more recent studies along this line, see Deger and Sen (1984) and van der Ploeg and Zeeuw (1990).

In this paper we set up a dynamic optimization model including both capital and arms accumulation. We consider a typical country, say the home country, which is in a state of actual or potential military confrontation with a foreign country. The home country derives positive utility from its consumption and military defense services but disutility from the potential threat or invasion by the foreign country. When the foreign military threat rises, how should the home country respond? Intuitively, there exist two alternatives. One way is for the home country to cut both investment and consumption in the short run and devote more resource to arms accumulation; thus, investment is reduced as a result of rising military tension. But the home country can take another approach by reducing current consumption and increasing both investment and military spending in the short run. That will lead to a higher capital stock and a higher weapon stock in the home country. The expanding capital stock means a growing output, which in turn makes more consumption and military spending possible in the home country. In this way, the rising military tension accelerates the short-run investment and capital accumulation in the home country.

Which approach should the home country take? In this paper, we find that the answer crucially depends on the occurring time of the military threat and the assumption about the utility function. When the utility function is separable

between consumption and the weapon stocks, we find that an unanticipated rise in current military threat reduces current investment and an anticipated rise in future military threat stimulates current investment. But when the utility function is nonseparable between consumption and the weapon stocks, a current military threat may not decrease the short-run investment. In the long run, no matter whether the utility function is separable or nonseparable, capital accumulation is determined by the famous modified golden rule, which is independent of the military conflicts among countries.

We organize this paper as follows. In Section 2, we set up the basic model with the utility function separable between consumption and the weapon stocks. In Section 3, we discuss the stability and the long-run equilibrium of the basic model. In Section 4, we demonstrate the short-run responses of both investment and military spending to different military shocks for the separable utility function. We consider the model with the nonseparable utility function in Section 5 and conclude this paper in Section 6.

2. The model

There are two countries in this model: the home country and the foreign country, and they are in a state of military confrontation. The preference of the home country is defined on consumption c, the home country's weapon stock m, and the foreign weapon stock m^*: $U(c, m, m^*)$. Furthermore $U(c, m, m^*)$ is concave and continuously differentiable in its arguments. As in Brito (1972), Deger and Sen (1983, 1984), and van der Ploeg and Zeeuw (1990), the following assumptions are imposed on the preference of the home country:

$$U_1 > 0, \quad U_2 > 0, \quad U_3 < 0, \quad U_{11} < 0, \quad U_{22} < 0, \tag{1}$$

$$U_{12} = U_{21} \geq 0, \quad U_{13} = U_{31} \leq 0, \quad U_{23} = U_{32} > 0. \tag{2}$$

All assumptions in (1) are self-evident. The assumption that $U_{23} > 0$ in (2) implies that an increase in the foreign weapon stock will increase the marginal utility of the home weapon stock and defense; see Deger and Sen (1984) for this reasoning. But the other two assumptions in (2) might not be accepted without some doubts because they raise the question why the utility from consumption relates to the weapon stocks. People may argue that the utility from consumption is independent of the weapon stocks. To take this consideration also into our model, we use the signs '≥ 0' and '≤ 0' and make it possible that the utility from consumption is independent of the weapon stocks.

The weapon accumulation in the home country is

$$\dot{m} = g - \delta m, \tag{3}$$

where g is military spending and δ is the depreciation rate of the weapon stock.

At any time, the resource available to the home country is the output $f(k)$, which is increasing and concave in the capital input k. If capital also depreciates at the rate δ, then the equation of motion for capital formation is given by

$$\dot{k} = f(k) - c - g - \delta k. \tag{4}$$

The production function used in (4) does not depend on the security represented by m in our model. Some may say that military spending enhances security and hence makes capital more productive. In this case, the positive effect of the military spending on capital accumulation is so obvious that we do not need further proof. To us, the more interesting and, in some sense, the more difficult case, is the independence of the production function from security and defense.

To make our dynamic system more tractable, we assume that the weapon stock and capital are essentially the same good and they can be added. In addition, we have already assumed that they have the same depreciation rate δ as in Eqs. (3) and (4).

Due to this assumption, we can define the total asset in the home country as w:

$$w = k + m. \tag{5}$$

Differentiate (5) with respect to time and use (3) and (4):

$$\dot{w} = f(k) - c - \delta w. \tag{6}$$

The home country's objective is to maximize a discounted stream of utility over an infinite horizon with a positive time discount rate ρ:

$$\max \int_0^\infty U(c, m, m^*) e^{-\rho t} dt,$$

subject to constraints (3) and (4) or, equivalently, constraints (5) and (6). The initial total asset is given: $w(0) = k(0) + m(0)$.

For most part of this paper, we follow van der Ploeg and Zeeuw (1990) and assume that the utility function is separable in consumption and the weapon stocks:

$$U(c, m, m^*) = u(c) + v(m, m^*). \tag{7}$$

Then, assumptions (1) and (2) are modified to be

$$u' > 0, \quad u'' < 0, \quad v_1 > 0, \quad v_{11} < 0, \quad v_{12} > 0. \tag{8}$$

That is to say, the utility from consumption does not depend on the weapon stocks. In assuming this separability between consumption and defense, we have the following advantages. First, we can avoid the problem of negative and positive effects of the weapon stocks on consumption just as we have done in the case of the production function. Second, this separability makes it very easy to compare our model to the standard neoclassical growth model without arms accumulation if we assume the same utility function of consumption, $u(c)$. Third, while the long-run analysis in our paper always holds with and without the separability in the utility function, a separable utility function allows us to obtain clear-cut results in our short-run analysis in Section 4. We will point out how some ambiguous results will appear in the case of the nonseparable utility function in Section 5.

To solve the optimization problem, we formulate the corresponding Hamiltonian:

$$H = u(c) + v(m, m^*) + \lambda(f(k) - c - \delta w) + \gamma(w - k - m),$$

where λ is the marginal utility of one extra unit of the asset, or the shadow price of the total asset, in the home country and γ is the multiplier for the add-up condition or the identity of the total asset.

The first-order conditions necessary for the optimization are

$$u'(c) = \lambda, \tag{9}$$

$$v_1(m, m^*) = \lambda f'(k), \tag{10}$$

$$w = k + m, \tag{11}$$

$$\dot{\lambda}/\lambda = \delta + \rho - f'(k), \tag{12}$$

$$\dot{w} = f(k) - c - \delta w, \tag{13}$$

$$\lim_{t\to\infty} \lambda w e^{-\rho t} = 0. \tag{14}$$

The explanations for these necessary conditions are straightforward. Eq. (9) implies the equality between the marginal utility of one extra unit of asset and the marginal utility of consumption. Eq. (10) says that the marginal rate of substitution between consumption and arms equals the opportunity cost of arms, namely, the marginal productivity of capital. Eq. (11) repeats the asset add-up condition (5). The familiar Euler condition is given by Eq. (12), which governs the optimal choice between consumption and capital accumulation. Again, Eq. (13) is the dynamic budget constraint (6). The usual transversality condition is given by (14).

Instead of working with three differential equations in c, m, and k, we can solve c, m, and k in terms of λ, w, and m^*, and substitute them into Eqs. (12) and (13). Denote the solutions as $c(\lambda, w, m^*)$, $m(\lambda, w, m^*)$, and $k(\lambda, w, m^*)$ (see Appendix 1 for the properties of these functions) and denote

$$h(\lambda, w, m^*) = \delta + \rho - f'(k(\lambda, w, m^*)),$$

$$g(\lambda, w, m^*) = f(k(\lambda, w, m^*)) - c(\lambda, w, m^*) - \delta w,$$

then, we have

$$\dot{\lambda} = \lambda h(\lambda, w, m^*), \tag{15a}$$

$$\dot{w} = g(\lambda, w, m^*). \tag{15b}$$

In Appendix 1, it is established that $h_\lambda > 0$, $h_w > 0$, $h_{m^*} < 0$, $g_\lambda > 0$, $g_{m^*} < 0$, and g_w does not possess a definite sign. We will focus on Eqs. (15a) and (15b) in Sections 3 and 4 of this paper.

3. The long-run effects of the foreign military threat

Let $\bar{\lambda}$, $\bar{w}$, $\bar{c}$, $\bar{m}$, and $\bar{k}$ be the long-run equilibrium values of the corresponding variables. Upon linearizing (15) around the steady state values $\bar{\lambda}$ and $\bar{w}$, we obtain

$$\dot{\lambda} = \bar{\lambda} h_\lambda(\lambda - \bar{\lambda}) + \bar{\lambda} h_w(w - \bar{w}), \tag{16a}$$

$$\dot{w} = g_\lambda(\lambda - \bar{\lambda}) + g_w(w - \bar{w}), \tag{16b}$$

here all the partial derivatives are evaluated at the steady state values $\bar{\lambda}$ and $\bar{w}$. In the steady state, $\dot{\lambda} = 0$ and $\dot{w} = 0$ in (15). The phase diagram is presented in Fig. 1. The $\dot{\lambda} = 0$ locus is downward-sloping because the slope $\mathrm{d}\lambda/\mathrm{d}w = -(h_w/h_\lambda)$ is less than zero. The $\dot{w} = 0$ locus has an ambiguous sign because g_λ is positive but g_w does not have a definite sign from Eq. (A.4e) of Appendix 1. In Fig. 1, we draw the $w = 0$ locus as a downward-sloping line; the dynamics are the same whether it is upward- or downward-sloping. For the existence of a perfect foresight equilibrium in our mode, it is required that

$$\Delta' \equiv \bar{\lambda}(h_\lambda g_w - h_w g_\lambda) < 0. \tag{17}$$

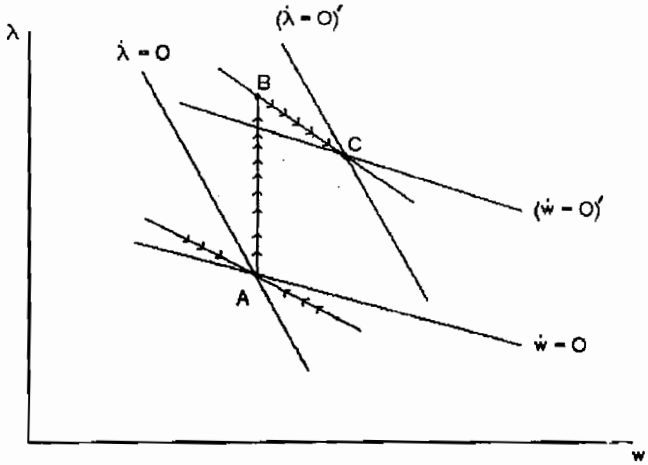


Fig. 1. The phase diagram and the effect of a permanent rise in the foreign military threat.

The geometry of the intuition for (17) is that the $\dot{\lambda} = 0$ locus is steeper than the $\dot{w} = 0$ locus. With condition (17), it is easy to check that the positive eigenvalue of the dynamic system is given by

$$\mu_1 \equiv [(\bar{\lambda} h_\lambda + g_w) + \sqrt{(\bar{\lambda} h_\lambda + g_w)^2 - 4\Delta'}]/2 > 0, \tag{18a}$$

and the negative eigenvalue is

$$\mu_2 \equiv [(\bar{\lambda} h_\lambda + g_w) - \sqrt{(\bar{\lambda} h_\lambda + g_w)^2 - 4\Delta'}]/2 < 0. \tag{18b}$$

As there is one negative eigenvalue μ_2 corresponding to one state variable w and one positive eigenvalue μ_1 corresponding to one jumping variable λ, the dynamic system (15) has a unique perfect foresight path converging to the steady state. It is important to note that, without (17), we will have either a totally unstable dynamic system (i.e., two positive eigenvalues) or a totally stable dynamic system (i.e., two negative eigenvalues). In the former, we cannot do too much analysis on effects of exogenous shocks because any perturbation to the dynamic system will lead to either an explosive or a corner solution. In the latter, a unique perfect foresight equilibrium does not exist because any initial point in the neighborhood of the equilibrium will converge to the steady state and it does not matter how the dynamic paths are moving in the short run. In fact, the dynamic path can be increasing, or decreasing, or any continuous function of time and, therefore, in a totally stable dynamic system, it is meaningless to talk about the short-run effects of any shock. This is why we will only examine the dynamic system (15) when condition (17) holds.

Now suppose that there is a permanent increase in the foreign weapon stock. We want to know how the long-run equilibrium values of the endogenous variables are affected.

Proposition 1. In the long run, a permanent increase in the foreign threat leads to less consumption and more arms accumulation in the home country, but it does not alter the long-run capital stock in the home country.

To show this proposition, we differentiate the two steady state equations, $h(\bar{\lambda}, \bar{w}, m^*) = 0$ and $g(\bar{\lambda}, \bar{w}, m^*) = 0$, with respect to the foreign weapon stock m^*, and solve for $\mathrm{d}\lambda/\mathrm{d}m^*$ and $\mathrm{d}w/\mathrm{d}m^*$:

$$\mathrm{d}\lambda/\mathrm{d}m^* = \bar{\lambda}(g_{m^*}h_w - h_{m^*}g_w)/\Delta',$$

$$\mathrm{d}w/\mathrm{d}m^* = \bar{\lambda}(h_{m^*}g_\lambda - g_{m^*}h_\lambda)/\Delta'.$$

Upon substituting all these partial derivatives from Appendix 1:

$$\mathrm{d}\lambda/\mathrm{d}m^* = -\bar{\lambda}\delta f''(\bar{k})(\mathrm{d}k/\mathrm{d}m^*)/\Delta' > 0, \tag{19}$$

$$\mathrm{d}w/\mathrm{d}m^* = \bar{\lambda} f''(\bar{k})(\mathrm{d}k/\mathrm{d}m^*)(\mathrm{d}c/\mathrm{d}\lambda)/\Delta' > 0, \tag{20}$$

which are positive because $\mathrm{d}k/\mathrm{d}m^* < 0$ and $\mathrm{d}c/\mathrm{d}\lambda < 0$ from Appendix 1 and $\Delta' < 0$ from (17). Thus a permanent increase in the foreign weapon stock raises the total asset and the shadow price of the total asset in the home country.

As $u'(\bar{c}) = \bar{\lambda}$ and $\mathrm{d}c/\mathrm{d}\lambda = 1/u''(\bar{c}) < 0$, the foreign military threat reduces the long-run consumption: $\mathrm{d}c/\mathrm{d}m^* = (\mathrm{d}c/\mathrm{d}\lambda)(\mathrm{d}\lambda/\mathrm{d}m^*) < 0$.

To see that the long-run capital stock is not affected, just observe the steady state condition $\dot{\lambda} = 0$, which is the same as

$$f'(\bar{k}) = \delta + \rho.$$

Thus the long-run capital stock is determined by the equality of the marginal productivity of capital and the time discount rate plus the capital depreciation rate. It needs to be pointed out that, as shown in Section 5 later, this result always holds no matter whether the utility function is separable or nonseparable in consumption and the weapon stocks.

Since the long-run capital stock is not changed, the long-run equilibrium value of arms in the home country is higher as a result of a higher total asset in the home country [see expression (20)]. In fact, $\mathrm{d}w/\mathrm{d}m^* = \mathrm{d}m/\mathrm{d}m^*$: the long-run increase in the total asset due to a permanent shock of the foreign military threat only reflects the long-run increase in arms accumulation in the home country.

The driving force for Proposition 1 is the modified golden rule of the long-run capital accumulation. Since the optimal capital stock in the long run is determined by the time preference and the depreciation rate of capital in our model, the total resource available in the home country is fixed in the long run if the time preference and the capital depreciation rate remain the same. Facing more foreign military threat, the home country has to choose 'less butter and more guns'.

This analytical result is also depicted in Fig. 1. As a result of a permanent increase in the foreign weapon stock, both the $\dot{w} = 0$ locus and the $\dot{\lambda} = 0$ locus shift upward to the right. The unique perfect foresight path is from the initial equilibrium point A to point B and, then, from point B to point C – the new equilibrium. At the new equilibrium point C, the home country has more weapon accumulation and less consumption (note that consumption is a decreasing function of the shadow price λ).

4. The short-run effects of the foreign military threat

While the long-run 'superneutrality' of the foreign military threat holds, an equally, if not more, interesting question is how the short-run investment and military spending are affected by the military threat. It is natural to ask whether the foreign military threat accelerates capital formation in the home country or decelerates it. The scenario here resembles the classical case of inflation and growth. As shown by Sidrauski (1967), inflation is superneutral because the long-run capital stock is independent from inflation. But in the short run, Fischer (1979) demonstrates that inflation often stimulates investment along the transitional path towards the long-run equilibrium. If we follow Fischer's approach here, we need to examine the impact of the foreign military threat on the negative eigenvalue μ_2 given in Eq. (18b). It is obvious that the foreign threat does affect the negative eigenvalue in (18b), but the differentiation of μ_2 with respect to the military threat parameter m^* does not yield a definite sign. However there exists another approach developed by Kenneth Judd (1983, 1985, 1987) which is especially helpful in tracing the short-run impacts of exogenous shocks on endogenous variables. See also Dixit (1990) for a lucid presentation of the Judd approach.

Following Judd (1987) and Dixit (1990), we suppose that initially, i.e., at time $t = 0$, the home country is in the steady state corresponding to the foreign military threat m^*. Now let the foreign military threat change as follows:

$$x^*(t) = m^* + \varepsilon z(t), \tag{21}$$

where $z(t)$ is the intertemporal change in the foreign weapon stock and ε is a small perturbation of the military threat. In this paper, we might take $z(t)$ as

a step function of time and then a *temporary* change in the foreign weapon stock during time $t \subseteq [t_1, t_2]$ can be represented by $z(t) = 1$ for $t \subseteq [t_1, t_2]$ and $z(t) = 0$ otherwise. From this example, we can see that the temporary shocks can be easily handled with this technique. Of course, $z(t)$ can take other function forms such a ramp function and an impulse function. Eventually $z(t)$ is assumed to be constant.

Substitute $x^*(t)$ for m^* into (15):

$$\dot{\lambda} = \lambda h(\lambda, w, m^* + \varepsilon z(t)), \tag{22a}$$

$$\dot{w} = g(\lambda, w, m^* + \varepsilon z(t)). \tag{22b}$$

The solution to the dynamic system (22) will be smooth in both t and ε as the preference and technology are continuously differentiable. We write the solution as $\lambda(t, \varepsilon)$ and $w(t, \varepsilon)$. Differentiating (22) with respect to ε and linearizing:

$$\begin{bmatrix} \dot{\lambda}_\varepsilon \\ \dot{w}_\varepsilon \end{bmatrix} = \begin{bmatrix} \bar{\lambda} h_\lambda & \bar{\lambda} h_w \\ g_\lambda & g_w \end{bmatrix} \begin{bmatrix} \lambda_\varepsilon \\ w_\varepsilon \end{bmatrix} + \begin{bmatrix} \bar{\lambda} h_{m^*} z(t) \\ g_{m^*} z(t) \end{bmatrix}, \tag{23}$$

where all partial derivatives of h and g are evaluated at the initial steady state values $\bar{\lambda}$, $\bar{w}$, and $\varepsilon = 0$. In the last section we already studied the Jacobian matrix in (23) and found its two eigenvalues [see Eqs. (18a) and (18b)]. Next, to solve (23), we take the Laplace transforms of $\lambda(t)$, $w(t)$, and $z(t)$ and denote them $\Lambda(s)$, $W(s)$, and $Z(s)$ for $s > 0$, respectively,

$$\Lambda(s) = \int_0^\infty \lambda(t) e^{-st} dt,$$

$$W(s) = \int_0^\infty w(t) e^{-st} dt,$$

$$Z(s) = \int_0^\infty z(t) e^{-st} dt,$$

With these Laplace transforms, (23) is converted to

$$s \begin{bmatrix} \Lambda_\varepsilon(s) \\ W_\varepsilon(s) \end{bmatrix} = \begin{bmatrix} \bar{\lambda} h_\lambda & \bar{\lambda} h_w \\ g_\lambda & g_w \end{bmatrix} \begin{bmatrix} \Lambda_\varepsilon(s) \\ W_\varepsilon(s) \end{bmatrix} + \begin{bmatrix} \bar{\lambda} h_{m^*} Z(s) + \lambda_\varepsilon(0) \\ g_{m^*} Z(s) + w_\varepsilon(0) \end{bmatrix}$$

or

$$\begin{bmatrix} \Lambda_\varepsilon(s) \\ W_\varepsilon(s) \end{bmatrix} = \begin{bmatrix} s - \bar{\lambda} h_\lambda & -\bar{\lambda} h_w \\ -g_\lambda & s - g_w \end{bmatrix}^{-1} + \begin{bmatrix} \bar{\lambda} h_{m^*} Z(s) + \lambda_\varepsilon(0) \\ g_{m^*} Z(s) \end{bmatrix}. \tag{24}$$

In deriving (24), we have used the fact that the initial total asset $w(0)$ is given and cannot change, i.e., $w_\varepsilon(0) = 0$, but the shadow price of the total asset λ can jump. Thus we have dropped $w_\varepsilon(0)$ and retained $\lambda_\varepsilon(0)$ in (24).

To determine $\lambda_\varepsilon(0)$ in (24), we note that the existence of a saddle-point equilibrium in our model implies a finite total asset in the home country: a bounded capital stock and a bounded weapon stock. In addition, $z(t)$ is constant for sufficiently large time t. Therefore $W_\varepsilon(s)$ is finite for all $s > 0$. In particular, $W_\varepsilon(s)$ is finite when s equals the positive eigenvalue μ_1. But when $s = \mu_1$, the inverse matrix in (24) is singular. To remove this singularity, the only possibility is to set implicitly the numerators in (24) to zero:

$$(\mu_1 - g_w)[\bar{\lambda} h_{m^*} Z(\mu_1) + \lambda_\varepsilon(0)] + \bar{\lambda} h_w g_{m^*} Z(\mu_1) = 0 \tag{25a}$$

and

$$g_\lambda[\bar{\lambda} h_{m^*} Z(\mu_1) + \lambda_\varepsilon(0)] + (\mu_1 - \bar{\lambda} h_\lambda) g_{m^*} Z(\mu_1) = 0. \tag{25b}$$

Solving (25a) for $\lambda_\varepsilon(0)$:

$$\lambda_\varepsilon(0) = \{[\bar{\lambda} g_w h_{m^*} - \bar{\lambda} h_w g_{m^*}] - \bar{\lambda} \mu_1 h_{m^*}\}(\mu_1 - g_w)^{-1} Z(\mu_1). \tag{26}$$

In (26), the coefficient for $Z(\mu_1)$ is positive because $[\bar{\lambda} g_w h_{m^*} - \bar{\lambda} h_w g_{m^*}]$ is positive upon substituting the relevant terms from Appendix 1 [which is equal to $\bar{\lambda}\delta f''(\bar{k})\mathrm{d}k/\mathrm{d}m^* > 0$], $-\bar{\lambda}\mu_1 h_{m^*}$ is also positive for $h_{m^*} < 0$ from Appendix 1, and $(\mu_1 - g_w)$ is positive for μ_1 is larger than $(\bar{\lambda} h_\lambda + g_w)$ and $h_\lambda > 0$ from both Eq. (18a) and Appendix 1. Therefore we have established:

Proposition 2. When the utility function is separable between consumption and the weapon stocks, any perfectly anticipated increase in the future military threat from the foreign country raises the shadow price of the total asset today in the home country.

This interpretation of expression (26) is true because $Z(\mu_1)$ can be regarded as the present value of future military threat from the foreign country discounted at the positive eigenvalue:

$$Z(\mu_1) = \int_0^\infty z(t)\mathrm{e}^{-\mu_1 t}\mathrm{d}t.$$

For example, if the foreign weapon stock rises by one unit from time $t = T$ on, then, $z(t) = 0$ for $t \subseteq [0, T)$ and $z(t) = 1$ for $t \subseteq [T, \infty)$, and

$$Z(\mu_1) = \int_0^\infty \mathrm{e}^{-\mu_1 t}\mathrm{d}t = \mathrm{e}^{-\mu_1 T}/\mu_1.$$

In this case, the initial shadow price of the total asset will jump up by

$$\lambda_\varepsilon(0) = \{[\bar{\lambda} g_w h_{m^*} - \bar{\lambda} h_w g_{m^*}] - \bar{\lambda}\mu_1 h_{m^*}\}(\mu_1 - g_w)^{-1}\mathrm{e}^{-\mu_1 T}/\mu_1.$$

Since $\lambda = u'(c)$, we can derive the initial response of consumption from the initial response of the shadow price. In fact,

$$\begin{aligned} c_\varepsilon(0) &= \lambda_\varepsilon(0)/u''(c^*) \\ &= \{[\bar{\lambda} g_w h_{m^*} - \bar{\lambda} h_w g_{m^*}] - \bar{\lambda}\mu_1 h_{m^*}\}(\mu_1 - g_w)^{-1} Z(\mu_1)/u''(c^*). \end{aligned}$$

Hence, when the utility function is separable, any perfectly anticipated future military threat reduces current consumption in the home country.

With the knowledge of $\lambda_\varepsilon(0)$ and $w_\varepsilon(0)$ (the latter always equals zero), we can follow Judd (1987) and substitute these two values back into (23) while setting $t = 0$:

$$\begin{aligned} \dot{\lambda}_\varepsilon(0) &= \bar{\lambda} h_\lambda \lambda_\varepsilon(0) + \bar{\lambda} h_{m^*} z(0) \\ &= \bar{\lambda} h_\lambda\{[\bar{\lambda} g_w h_{m^*} - \bar{\lambda} h_w g_{m^*}] - \bar{\lambda}\mu_1 h_{m^*}\}(\mu_1 - g_w)^{-1} Z(\mu_1) + \bar{\lambda} h_{m^*} z(0), \end{aligned} \tag{27}$$

$$\begin{aligned} \dot{w}_\varepsilon(0) &= g_\lambda \lambda_\varepsilon(0) + g_{m^*} z(0) \\ &= g_\lambda\{[\bar{\lambda} g_w h_{m^*} - \bar{\lambda} h_w g_{m^*}] - \bar{\lambda}\mu_1 h_{m^*}\}(\mu_1 - g_w)^{-1} Z(\mu_1) + g_{m^*} z(0). \end{aligned} \tag{28}$$

In (27), $h_\lambda > 0$ and $h_{m^*} < 0$ from Appendix 1. Therefore, when the utility function is separable, a perfectly anticipated rise in the foreign arms accumulation speeds up the change in the initial shadow price while an unanticipated rise in the current foreign weapon stock lowers the speed of the initial change in the shadow price.

Eq. (28) is the most important equation we have tried to derive so far. It tells us how the short-run or the current asset accumulation, i.e., the sum of current investment and military spending, responds to military shocks. As $g_\lambda > 0$ and $g_{m^*} < 0$ from Appendix 1, we have:

Proposition 3. When the utility function is separable, an unanticipated rise in current foreign military threat reduces current asset accumulation, and a perfectly anticipated rise in future foreign military threat accelerates the current asset accumulation.

With Proposition 3 and the optimal condition between capital and arms accumulation for the case of a separable utility function in consumption and the weapon stocks, namely, $v_1(m, m^*) = \lambda f'(k)$, we can show how current investment and military spending are affected by the foreign military shocks.

Proposition 4. When the utility function is separable, an unanticipated rise in current foreign military threat reduces current investment, and a perfectly anticipated rise in future foreign military threat stimulates current investment.

To prove this proposition, we first note from Proposition 3 that, with an unanticipated rise in current foreign weapon stock, there will be an asset decumulation in the home country; since

$$\dot{w}_\varepsilon(0) = \dot{k}_\varepsilon(0) + \dot{m}_\varepsilon(0),$$

either current investment or current military spending or both will be reduced. In addition, from (27), the current shadow price of the asset is likely to be reduced, which is to say, for $u'(c) = \lambda$ with a separable utility function, current consumption is not going to be reduced as a result of an unanticipated rise in the current foreign military shock. Then go back to the optimal condition for the case of a separable utility function:

$$v_1(m, m^*) = \lambda f'(k). \tag{10}$$

Suppose that military spending remains the same or is reduced. The left-hand side is larger because m^* is higher and m is lower or remains the same [note $v_{12}(m, m^*) > 0$]. On the right-hand side, λ is likely to be lower from (27). To restore the equilibrium condition, current investment needs to be cut.

When there is an anticipated future increase in the foreign military threat, the current asset accumulation is going to accelerate from (28). That is to say, either current investment or current military spending or both will increase. It is very easy to see that current investment is going to increase. Just look at the Euler equation,

$$\dot{\lambda}/\lambda = \delta + \rho - f'(k). \tag{12}$$

As shown in Eq. (26), the current shadow price λ rises when more foreign military threat emerges in the future. Therefore, the optimal condition (12) calls

for more current investment and more capital formation to reduce the marginal productivity of capital.

We use Fig. 2 to illustrate the effects of an anticipated temporary rise in future military threat. In Fig. 2, anticipating a temporary rise of military threat in the future, the home country will cut consumption in the short run and invest more in both capital and arms stocks. This is depicted in the dynamic path from the initial equilibrium A to point B. Since the threat is anticipated to be temporary in the future, with the accumulation of more capital and arms in the short run, the home country will gradually reduce its asset accumulation and increase its consumption; eventually the economy will restore its initial equilibrium A. The stage of asset decumulation is depicted on the dynamic path from point B to point A in Fig. 2.

As a corollary of Proposition 4, when the utility function is separable, more foreign military threat happening both today and in the future brings about an ambiguous impact on current investment in the home country.

We provide some economic intuitions for our propositions here.[1] In this model, since the utility from consumption is independent of the weapon stocks, an *unanticipated* rise in the *current* foreign military threat does not change the marginal utility of consumption and the steady state level of consumption is not affected by a momentary change in the military threat. Hence,

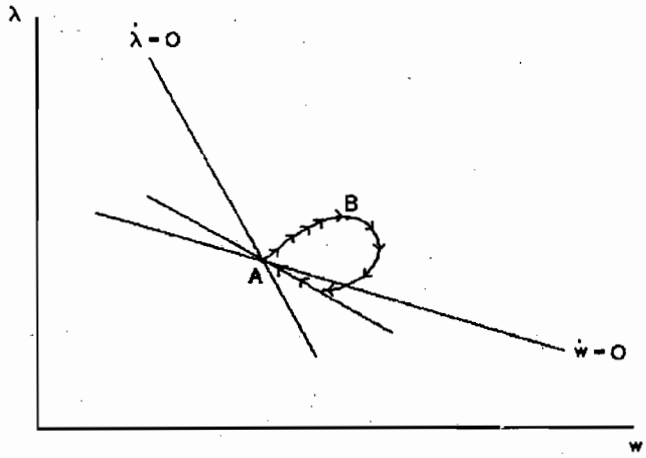


Fig. 2. An anticipated temporary rise in the future military threat.

[1] I thank two anonymous referees for providing further economic reasoning of these results and for applying these results to explain the stylized facts from empirical studies on military spending, savings and growth.

an unanticipated increase in current military threat, requiring increased armaments, can only be obtained by redirecting investment from capital formation to arms accumulation (see Judd, 1985, for a similar result about the effects of current government spending on current consumption and current investment); therefore, current investment is reduced. On the other hand, anticipating more foreign threat in the future, the home country can build up its defense by consuming less and investing more in both capital and arms today. More capital formation today means more output in the near future. With more output, more resource is available for more military spending, which in turn leads to a larger weapon stock. As a larger stock of weapon in the home country improves its position in the confrontation with the foreign country, the home country can afford to gradually slow down the rate of capital formation and channel more resource to consumption. In the long run, with a lower investment rate, the capital stock returns to its equilibrium level which is determined by the modified golden rule and is not affected by any military shock.

These propositions have strong empirical implications. As summarized in Deger (1986), econometric studies have found two interesting stylized facts regarding the impact of military expenditure on growth. The first says that the direct effect of defense spending on growth rates across countries seems to give an ambiguous relationship. These studies show that there is no impact or even, contrary to expectation, a somewhat weakly positive impact. The second empirically validated observation is that defense spending quite definitely reduces national saving–income ratios. Our results derived in this paper can explain quite well these two stylized facts. Superneutrality (Proposition 1) implies that the direct impact of defense spending and military shocks have little or no impact on the steady state capital stock. Thus the standard neoclassical result holds that the steady state growth rate is exogenously determined. Therefore, empirical studies of the effect of defense on growth would generally be inconclusive since they generally use cross-section data and therefore reflect long-run or steady state parameters. On the other hand, Proposition 4 indicates that current increases in the military threat reduce current investment. This result seems to explain well why saving–income ratios are often significantly negatively related to military spending. Further, as an anticipated future increase in the military threat stimulates current investment, countries planning well for future threats would increase current investment to get the rewards of both higher defense and consumption in the future. So we have the theoretical results validating cases like South Korea and Taiwan because they have always been anticipating and preparing for the break out of war with North Korea and mainland China, respectively, by accelerating their capital formation and arms accumulation.

These propositions also offer insights on testing the relation between military spending and investment. As we said in the introduction, both military spending and investment are endogenous variables in our model. A system of two simultaneous equations in terms of military spending and investment can be

constructed to test how these two variables respond to current foreign military threat and future military threat. For example, we can propose the following form of regression equations:

$$\dot{k}(t) = \phi(\Delta m^*(t), \Delta m^*(t+1), \theta),$$

$$\dot{m}(t) = \kappa(\Delta m^*(t), \Delta m^*(t+1), \theta),$$

where $\Delta m^*(t)$ represents the change in the current military threat and $\Delta m^*(t+1)$ the expected change in future military threat; θ is other exogenous factors.

5. The case of the nonseparable utility function

Our analysis so far has been focusing on the utility function separable between consumption and the weapon stocks. In this section, we present our analysis for the utility function nonseparable between consumption and the weapon stocks. Recall that the general utility function $U(c, m, m^*)$ is assumed to have the following properties in Section 2 [Eqs. (1) and (2)]:

$$U_1 > 0, \quad U_2 > 0, \quad U_3 < 0, \quad U_{11} < 0, \quad U_{22} < 0,$$

$$U_{12} = U_{21} \geq 0, \quad U_{13} = U_{31} \leq 0, \quad U_{23} = U_{32} > 0.$$

With this general utility function, the current-value Hamiltonian is

$$H = U(c, m, m^*) + \lambda(f(k) - c - \delta w) + \gamma(w - k - m).$$

The first-order conditions for optimality are

$$U_1(c, m, m^*) = \lambda, \tag{9'}$$

$$U_2(c, m, m^*) = \lambda f'(k), \tag{10'}$$

$$w = k + m, \tag{11'}$$

$$\dot{\lambda}/\lambda = \delta + \rho - f'(k), \tag{12'}$$

$$\dot{w} = f(k) - c - \delta w, \tag{13'}$$

$$\lim \lambda w e^{-\rho t} = 0. \tag{14'}$$

These conditions are similar to, or the same as, conditions (9) to (14) in Section 2. Their explanations are more or less the same and we omit them here.

We first note that in the steady state, namely, $\dot{\lambda} = 0$ and $\dot{w} = 0$, condition (12′) implies that the steady state capital is again independent of military spending and military shocks: $f'(k) = \delta + \rho$. That is to say, even when the utility function is nonseparable, the optimal steady state capital stock is determined again by the modified golden rule. Hence we have verified the superneutrality result for both separable and nonseparable utility functions.

To analyze the short-run effects, as in the case of the separable utility function, we first solve c, m, and k as functions of λ, w, and m^* and substitute the solutions $c(\lambda, w, m^*)$, $m(\lambda, w, m^*)$, and $k(\lambda, w, m^*)$ into (12′) and (13′), and again denote

$$h(\lambda, w, m^*) = \delta + \rho - f'(k(\lambda, w, m^*)),$$

$$g(\lambda, w, m^*) = f(k(\lambda, w, m^*)) - c(\lambda, w, m^*) - \delta w,$$

then we have

$$\dot{\lambda} = \lambda h(\lambda, w, m^*), \tag{15a′}$$

$$\dot{w} = g(\lambda, w, m^*). \tag{15b′}$$

The properties of these functions – $c(\lambda, w, m^*)$, $m(\lambda, w, m^*)$, $k(\lambda, w, m^*)$, $h(\lambda, w, m^*)$, and $g(\lambda, w, m^*)$ – are presented in Appendix 2. In particular, we note that, for the separable utility function, only the sign g_w is not determined; but now with a nonseparable utility function, in addition to the sign of g_w, we cannot determine the signs of h_{m^*} and g_{m^*}. These ambiguous signs will prevent us from drawing clear conclusions from the short-run analysis. Recall that

$$\lambda_z(0) = \{[\bar{\lambda} g_w h_{m^*} - \bar{\lambda} h_w g_{m^*}] - \bar{\lambda}\mu_1 h_{m^*}\}(\mu_1 - g_w)^{-1} Z(\mu_1), \tag{26}$$

$$\begin{aligned}\dot{w}_z(0) &= g_\lambda \lambda_z(0) + g_{m^*} z(0) \\ &= g_\lambda\{[\bar{\lambda} g_w h_{m^*} - \bar{\lambda} h_w g_{m^*}] - \bar{\lambda}\mu_1 h_{m^*}\}(\mu_1 - g_w)^{-1} Z(\mu_1) + g_{m^*} z(0).\end{aligned} \tag{28}$$

Now the coefficients for the future military threat $Z(\mu_1)$ and the current military threat $z(0)$ are all ambiguous because h_{m^*} and g_{m^*} do not have definite signs as a result of the nonseparability in the utility function between consumption and the weapon stocks.

With the nonseparable utility function, consumption is still negatively related to the shadow price of the total asset as given by Eq. (B.2a) in Appendix 2. But even if λ has a definite sign, from the change of λ alone we cannot derive the effect on consumption because, unlike in the case of a separable utility function, the

simple relation between c and λ in Eq. (9), $u'(c) = \lambda$, does not hold any more; the new optimal condition is

$$U_1(c, m, m^*) = \lambda. \tag{9'}$$

From (9′), it is clear that even an unanticipated military threat rises today, today's marginal utility of consumption will be reduced since $U_{13}(c, m, m^*)$ is negative. On the other hand, an increase in the home military stock m will increase the marginal utility of consumption due to the assumption that $U_{12}(c, m, m^*)$ is positive. Therefore, facing a current increase in the foreign military threat, the home country will cut its current consumption and spend more on weapon accumulation.

What is the effect of the unanticipated current military threat on current investment? With the separability in the utility function, we know that current consumption is not affected and current investment is cut as a result of the unanticipated current military threat. When the utility function is nonseparable, current consumption is going to be reduced as we have argued above. The effect on current investment may be ambiguous. We can provide the following reason. If the marginal utility is reduced significantly as a result of the current increase of foreign military threat, namely, $U_{13}(c, m, m^*)$ is large, consumption will be reduced to a great extent and the short-run investment may not be affected. On the other hand, if the marginal utility of consumption is affected by the foreign military threat very weakly, current consumption will not be reduced very much as a result of an unanticipated current foreign military threat. In this case, current investment will be partly sacrificed. In the extreme or the limit case when the marginal utility of consumption is independent of the current military threat and the weapon stocks, namely, $U_{13}(c, m, m^*) = 0$ and $U_{12}(c, m, m^*) = 0$, we return to the separable utility case where current consumption is not affected and all increased military spending will come at the cost of current investment as shown in Proposition 4 in Section 4.

Similar reasoning applies to the effects of an anticipated military threat in the future. But we need to emphasize that, when the marginal utility of consumption is severely affected by the military threat, the short-run investment may even be sacrificed in order to build up the defense as soon as possible.

6. Summary

This paper has made an attempt to answer the important question underlying many policy discussions and empirical studies: How does military spending affect investment and output growth? Our answer consists of the following: (1) for the most general utility function, superneutrality holds in the long run; capital accumulation is independent of the military threat; (2) when the utility

function is separable in consumption and the weapon stocks, any anticipating military tension in the future stimulates current investment and any unanticipated current military threat reduces current investment; (3) when the utility function is nonseparable between consumption and the weapon stocks, a current increase in the foreign military threat will directly reduce current consumption, and current investment may be sacrificed as well.

These theoretical results are helpful for us in explaining the empirical findings about the ambiguous effects of military spending on growth rates and the negative impact of defense spending on national saving–income ratios, they also indicate new directions about how to statistically test both military spending and investment as functions of exogenous military shocks; in particular, our theoretical conclusions point out the importance of treating current military threat and future military threat differently in the regression analysis.

Appendix 1

In this appendix, we essentially undertake an analysis along the line of Arrow and Kurz (1970) and Mankiw (1987). Suppose that the total asset, the shadow price of the asset, and the foreign military threat are given. How does the home country choose its consumption, capital, and arms? Totally differentiating (9), (10), and (11), we have

$$\begin{bmatrix} u''(c) & 0 & 0 \\ 0 & v_{11}(m, m^*) & -\lambda f''(k) \\ 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} \mathrm{d}c \\ \mathrm{d}m \\ \mathrm{d}k \end{bmatrix} = \begin{bmatrix} \mathrm{d}\lambda \\ f'(k)\mathrm{d}\lambda - v_{12}(m, m^*)\mathrm{d}m^* \\ \mathrm{d}w \end{bmatrix}. \tag{A.1}$$

It is easy to show that the determinant of the 3×3 matrix in (A.1), denoted as Δ, is positive:

$$\Delta = u''(c)v_{11}(m, m^*) + \lambda f''(k)u''(c) > 0.$$

By Cramer's rule,

$$\mathrm{d}c/\mathrm{d}\lambda = (v_{11}(m, m^*) + \lambda f''(k))/\Delta < 0, \tag{A.2a}$$

$$\mathrm{d}c/\mathrm{d}m^* = 0, \tag{A.2b}$$

$$\mathrm{d}c/\mathrm{d}w = 0, \tag{A.2c}$$

$$\mathrm{d}m/\mathrm{d}\lambda = f'(k)u''(c)/\Delta < 0, \tag{A.2d}$$

$$\mathrm{d}m/\mathrm{d}m^* = -v_{12}(m, m^*)u''(c) > 0, \tag{A.2e}$$

$$\mathrm{d}m/\mathrm{d}w = \lambda f''(k)u''(c)/\Delta > 0, \tag{A.2f}$$

$$\mathrm{d}k/\mathrm{d}\lambda = -f'(k)u''(c)/\Delta > 0, \tag{A.2g}$$

$$\mathrm{d}k/\mathrm{d}m^* = v_{12}(m, m^*)u''(c)/\Delta < 0, \tag{A.2h}$$

$$\mathrm{d}k/\mathrm{d}w = v_{11}(m, m^*)u''(c)/\Delta > 0. \tag{A.2i}$$

Substituting $c(\lambda, w, m^*)$, $m(\lambda, w, m^*)$, and $k(\lambda, w, m^*)$ into (12) and (13), and denoting

$$h(\lambda, w, m^*) = \delta + \rho - f'(k(\lambda, w, m^*)),$$

$$g(\lambda, w, m^*) = f(k(\lambda, w, m^*)) - c(\lambda, w, m^*) - \delta w.$$

Then, we have

$$\dot{\lambda} = \lambda h(\lambda, w, m^*), \tag{A.3a}$$

$$\dot{w} = g(\lambda, w, m^*). \tag{A.3b}$$

With (A.1), the functions (A.3) have the following properties:

$$h_\lambda(\lambda, w, m^*) = -f''(k)\mathrm{d}k/\mathrm{d}\lambda > 0, \tag{A.4a}$$

$$h_w(\lambda, w, m^*) = -f''(k)\mathrm{d}k/\mathrm{d}w > 0, \tag{A.4b}$$

$$h_{m^*}(\lambda, w, m^*) = -f''(k)\mathrm{d}k/\mathrm{d}m^* < 0, \tag{A.4c}$$

$$g_\lambda(\lambda, w, m^*) = f'(k)\mathrm{d}k/\mathrm{d}\lambda - \mathrm{d}c/\mathrm{d}\lambda > 0, \tag{A.4d}$$

$$g_w(\lambda, w, m^*) = f'(k)\mathrm{d}k/\mathrm{d}w - \delta, \tag{A.4e}$$

$$g_{m^*}(\lambda, w, m^*) = f'(k)\mathrm{d}k/\mathrm{d}m^* < 0. \tag{A.4f}$$

Note that the sign for g_w is not determined.

Appendix 2

As in Appendix 1, we suppose that the total asset, the shadow price of the asset, and the foreign military threat are given. We want to find out how the home country choose its consumption, capital, and arms. Totally differentiating (9′), (10′), and (11′), we have

$$\begin{bmatrix} U_{11} & U_{12} & 0 \\ U_{21} & U_{22} & -\lambda f''(k) \\ 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} \mathrm{d}c \\ \mathrm{d}m \\ \mathrm{d}k \end{bmatrix} = \begin{bmatrix} \mathrm{d}\lambda - U_{13}\mathrm{d}m^* \\ f'(k)\mathrm{d}\lambda - U_{23}\mathrm{d}m^* \\ \mathrm{d}w \end{bmatrix}. \tag{B.1}$$

Since $U(c, m, m^*)$ is assumed to be concave in c and m, it is easy to show that the determinant of the 3×3 matrix in (B.1), denoted as Δ'', is positive:

$$\Delta'' = [U_{11}U_{22} - (U_{12})^2] + \lambda f''(k)U_{11} > 0.$$

By Cramer's rule,

$$\mathrm{d}c/\mathrm{d}\lambda = (U_{22} + \lambda f''(k) - U_{12}f'(k))/\Delta'' < 0, \tag{B.2a}$$

$$\mathrm{d}c/\mathrm{d}w = -U_{12}\lambda f''(k)/\Delta'' > 0, \tag{B.2b}$$

$$\mathrm{d}c/\mathrm{d}m^* = [-U_{22}U_{13} + U_{12}U_{23} - U_{13}\lambda f''(k)]/\Delta'', \tag{B.2c}$$

$$\mathrm{d}m/\mathrm{d}\lambda = [U_{11}f'(k) - U_{12}]/\Delta'' < 0, \tag{B.2d}$$

$$\mathrm{d}m/\mathrm{d}m^* = [-U_{11}U_{23} + U_{12}U_{13}]/\Delta'', \tag{B.2e}$$

$$\mathrm{d}m/\mathrm{d}w = \lambda f''(k)U_{11}/\Delta'' > 0, \tag{B.2f}$$

$$\mathrm{d}k/\mathrm{d}\lambda = [U_{12} - U_{11}f'(k)]/\Delta'' > 0, \tag{B.2g}$$

$$\mathrm{d}k/\mathrm{d}m^* = [-U_{12}U_{13} + U_{11}U_{23}]/\Delta'', \tag{B.2h}$$

$$\mathrm{d}k/\mathrm{d}w = [U_{11}U_{22} - (U_{12})^2]/\Delta'' > 0. \tag{B.2i}$$

We note that, due to the nonseparability in the utility function, three derivatives, $\mathrm{d}c/\mathrm{d}w$, $\mathrm{d}m/\mathrm{d}m^*$, and $\mathrm{d}k/\mathrm{d}m^*$, do not have definite signs in the expressions above. We can substitute $c(\lambda, w, m^*)$, $m(\lambda, w, m^*)$, and $k(\lambda, w, m^*)$ into (12′) and (13′), and again denote

$$h(\lambda, w, m^*) = \delta + \rho - f'(k(\lambda, w, m^*)),$$

$$g(\lambda, w, m^*) = f(k(\lambda, w, m^*)) - c(\lambda, w, m^*) - \delta w.$$

Then, we have

$$\dot{\lambda} = \lambda h(\lambda, w, m^*), \tag{B.3a}$$

$$\dot{w} = g(\lambda, w, m^*). \tag{B.3b}$$

With (B.1), the functions (B.3) have the following properties:

$$h_\lambda(\lambda, w, m^*) = -f''(k)\mathrm{d}k/\mathrm{d}\lambda > 0, \tag{B.4a}$$

$$h_w(\lambda, w, m^*) = -f''(k)\mathrm{d}k/\mathrm{d}w > 0, \tag{B.4b}$$

$$h_{m^*}(\lambda, w, m^*) = -f''(k)\mathrm{d}k/\mathrm{d}m^*, \tag{B.4c}$$

$$g_\lambda(\lambda, w, m^*) = f'(k)\mathrm{d}k/\mathrm{d}\lambda - \mathrm{d}c/\mathrm{d}\lambda > 0, \tag{B.4d}$$

$$g_w(\lambda, w, m^*) = f'(k)[\mathrm{d}k/\mathrm{d}w] - [\mathrm{d}c/\mathrm{d}w] - \delta, \tag{B.4e}$$

$$g_{m^*}(\lambda, w, m^*) = f'(k)[\mathrm{d}k/\mathrm{d}m^*] - [\mathrm{d}c/\mathrm{d}m^*]. \tag{B.4f}$$

For the separable utility function, only the sign g_w is not determined. Now with the nonseparable utility function, in addition to the sign of g_w, we cannot determine the signs of h_{m^*} and g_{m^*}.

References

Arrow, K. and M. Kurz, 1970, Public investment, the rate of return and optimal fiscal policy (Johns Hopkins Press, Baltimore, MD).

Brito, D., 1972, A dynamic model of arms race, International Economic Review 13, 359–375.

Deger, S., 1986, Military expenditure in third world countries: The economic effects (Routledge, London).

Deger, S. and S. Sen, 1983, Military expenditures, spin-off and economic development, Journal of Development of Economics 13, 67–83.

Deger, S. and S. Sen, 1984, Optimal control and differential game models of military expenditures in less developed countries, Journal of Economic Dynamics and Control 7, 153–169.

Deger, S. and S. Sen, 1992, Military expenditure, aid and economic development, in: Proceedings of the World Bank Annual Conference on Development Economics, 159–189.

Dixit, A., 1990, Growth theory after thirty years, in: P. Diamond, ed., Growth/productivity/unemployment (MIT Press, Cambridge, MA).

Fischer, S., 1979, Capital accumulation on the transition path in a monetary optimizing model, Econometrica 47, 1433–1439.

Hewitt, D., 1991, What determines military expenditures?, Finance and Development 28, 22–25.

Intriligator, M., 1975, Strategic considerations in the Richardson model of arms races, Journal of Political Economy 83, 339–353.

Intriligator, M. and D. Brito, 1976, Formal models of arms race, Journal of Peace Science 2, 77–88.
Judd, K., 1982, An alternative to steady state comparison in perfect foresight models, Economics Letters 10, 55–59.
Judd, K., 1985, Short-run analysis of fiscal policy in a simple perfect foresight model, Journal of Political Economy 93, 298–319.
Judd, K., 1987, Debt and distortionary taxation in a simple perfect foresight model, Journal of Monetary Economics 20, 51–72.
Landau, D., 1992, The impact of military spending on economic growth in LDCs, Mimeo. (World Bank, Washington, DC).
Mankiw, N.G., 1987, Government purchases and real interest rates, Journal of Political Economy 95, 407–419.
McNamara, Robert S., 1992, The post-cold war world: Implications for military expenditure in the developing countries, in: Proceedings of the World Bank Annual Conference on Development Economics, 95–125.
Richardson, L.F., 1960, Arms and insecurity (Boxwood Press, Chicago, IL).
Saaty, T., 1968, Mathematical models of arms control and disarmament (Wiley, New York, NY).
Sidrauski, M., 1967, Rational choice and patterns of growth in a monetary economy, American Economic Review, Papers and Proceedings 57, 534–544.
Simaan, M. and J. Cruz, Jr., 1975, Formulation of Richardson's model of arms race from a differential game viewpoint, Review of Economic Studies 42, 67–77.
van der Ploeg, F. and A. de Zeeuw, 1990, Perfect equilibrium in a model of competitive arms accumulation, International Economic Review 31, 131–146.