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Foreign Aid Reduces Domestic Capital Accumulation and Increases Foreign Borrowing: A Theoretical Analysis

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In an infinite-horizon model with endogenous time preferences, foreign aid, foreign borrowing, and domestic capital accumulation, a permanent increase in foreign aid leads to a reduction in long-run capital accumulation, a rise in domestic consumption, and an increase in foreign borrowing. Short-run analysis shows that an initial increase in foreign aid leads to a rise in investment, and a reduction in consumption and external borrowing. On the other hand, a temporal increase in foreign aid results in an increase in consumption and foreign borrowing, and a reduction in investment. *Journal of Economic Literature* Classification Numbers: E2, F34, F35, F43, O1, O4.

Key Words: Foreign aid; Foreign borrowing; Capital accumulation.

1. INTRODUCTION

The effects of foreign aid and external borrowing on investment and growth in developing countries have received considerable attention in both academic studies and policy discussions in the 1990s. Recent studies by Boone (1994a, 1994b); White and Luttik (1994); Taylor and Williamson (1994); Feyzioglu, Swaroop, and Zhu (1997); World Bank (1997); Obstfeld (1999); Gong and Zou (2000); and Burnside and Dollar (2000) have reexamined various critical issues related to external finance and capital inflows to developing countries, which were heatedly debated in the 1960s and 1970s. In a series of studies by Hollis Chenery and his associates, they have found that, on the basis of the Harrod-Domar model and realistic parameters on different developing countries, foreign aid and foreign capital inflows can accelerate investment and speed the transition to a targeted self-sustained growth path; see Chenery and Bruno (1962); Adelman and Chenery (1966); Chenery and Strout (1966); and Chenery and Eckstein (1970).The critics of

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this optimistic view have argued that external resource inflows may mainly increase consumption, depress domestic savings, and slow down investment and output growth; see Griffin (1970); and Griffin and Enos (1970). The controversy seems to continue mainly on the empirical side. For conflicting empirical findings on the impact of external finance on savings, investment and output growth, see Rahman (1968); Papanek (1972, 1973); Fry (1978, 1980); Levy (1987, 1988a, 1988b); and Giovannini (1983, 1985), among many others.

More recently, Boone (1994a, 1994b) finds that foreign aid has hardly any effect on investment; in particular, foreign aid mainly serves to augment the consumption of those who are relatively well-off in developing countries. Even if foreign aid is tied to specific sectors and purposes, Feyzioglu *et al* (1997) have found that most of foreign aid appears to be fungible, and many developing countries have diverted foreign aid to public consumption (see also Pack and Pack, 1990, 1993). These recent empirical findings naturally suggest that foreign aid has very little positive impact on capital formation and output growth in developing countries.

In a recent theoretical paper, Obstfeld (1999) has developed a simple Cass-Koopmans optimal growth model relating foreign aid to domestic savings and growth. He finds that foreign aid has no effect on long-run capital accumulation, and that it increases long-run consumption dollar for dollar. But in the short run, foreign aid stimulates investment and speeds up the transition to the long-run steady state of the economy. Taken together, Obstfeld's analysis still predicts some positive impact of foreign aid on investment and short-run output growth.

Our study intends to broaden the Obstfeld model in a few aspects: first, we follow Uzawa (1968); Obstfeld (1981, 1982 , 1990); Lucas and Stokey (1984); and Becker and Mulligan (1997), and postulate an endogenous time preference; second, we consider both foreign aid and foreign borrowing in an infinite horizon model of optimal capital accumulation; third, we follow Judd (1985, 1987) and quantify the short-run impact of foreign aid on investment and foreign borrowing. In sharp contrast to Obstfeld (1999), our main findings show that a permanent rise in foreign aid reduces long-run capital accumulation and increases long-run reliance on external borrowing.

The paper is organized as follows. Section 2 sets up the analytical model. Section 3 studies the long-run properties of the dynamic system and examines how foreign aid affects steady-state capital accumulation, consumption, and external foreign borrowing. Section 4 looks at the short-run (including both initial and temporal) effects of foreign aid on investment, consumption, and external borrowing. Section 5 summarizes the main findings.

2. THE MODEL

We consider an infinite-horizon model of foreign aid, foreign borrowing, and domestic accumulation in an open economy, which is populated by many identical agents. Each agent has an instantaneous utility function defined on consumption, $u(c(t))$, which is increasing, concave, and twice differentiable:

$$u_c > 0, u_{cc} < 0. \tag{1}$$

For the agent's time preference, Δ_t, we follow Uzawa (1968) and Obstfeld (1981, 1982, 1990)[1], and assume that the time preference of the agent is a function of the agent's utility, namely

$$\Delta_t = \int_0^t \delta_s ds, \tag{2}$$

where δ_s is the instantaneous subjective discounted rate at time s and is defined as

$$\delta_s = \delta[u(c(s))], \tag{3}$$

which has the following properties as in Uzawa (1968):

$$\delta(u) > 0, \delta^{'}(u) > 0, \delta^{''}(u) > 0, \quad \delta(u) - u\delta^{'}(u) > 0. \tag{4}$$

The second condition of equation (4) implies that an increase in the consumption level at a certain future date will increase the discounted rate for all consumption made forward, while the third condition is given as in Uzawa (1968), which is used to derive a continuous consumption function; see the detail in Uzawa (1968). The last condition in equation (4) implies that the agent prefers consumption with higher instantaneous utility.

Now, the representative agent's discounted utility can be written as

$$\int_0^\infty u(c)e^{-\Delta t}dt. \tag{5}$$

Output is produced by a typical neoclassical production function, $f(k(t))$ with $k(t)$ denoting the capital input at time t:

$$f^{'}(k(t)) > 0, f^{''}(k(t)) < 0. \tag{6}$$

[1]See Lucas and Stokey (1984); and Becker and Mulligan (1997) for more justification for this approach to endogenizing the time preference.

Let $B(t)$ be the accumulated foreign borrowing at time t. As for the cost of foreign borrowing, $h(B(t))$, we intend to include the constant marginal cost of foreign borrowing, namely, $h(B(t)) = r(t)B(t)$ with $r(t)$ the interest rate in the world capital market, as a special case. Along with Bardhan (1967) and Pitchford (1989), we assume $h(B(t))$ to be an increasing, convex function of the accumulated debt:

$$h^{'}(B(t)) > 0, h^{''}(B(t)) > 0, \tag{7}$$

which implies that the more the agent borrows, the higher the marginal cost he must pay. All analysis in this paper still holds when $h(B(t)) = r(t)B(t)$.

With the inflows of foreign aid, $A(t)$, at time t, the budget constraint for the representative agent can be written as

$$\frac{dk(t)}{dt} - \frac{dB(t)}{dt} = f(k(t)) - c(t) - h(B(t)) + A(t). \tag{8}$$

Denote the net wealth of the agent at time t as $W(t)$, which is defined by

$$W(t) = k(t) - B(t). \tag{9}$$

A simple transformation gives

$$\frac{dW(t)}{dt} = f(k(t)) - c(t) - h(B(t)) + A(t). \tag{10}$$

A representative agent with perfect foresight will choose his consumption path, $c(t)$, capital accumulation path, $k(t)$, and the foreign borrowing path, $B(t)$, to maximize his discounted utility, namely

$$\max \int_0^{\infty} u(c)e^{-\Delta t}dt$$

subject to initial conditions $k(0) = k_0$, $B(0) = B_{0,}$ and the budget constraints (9) and (10).

From equations (2) and (3), we have

$$dt = \frac{d\Delta_t}{\delta[u(c(t))]}. \tag{11}$$

With equation (11), we can transform the optimization problem as

$$\max \int_0^{\infty} \frac{u(c)}{\delta[u(c(t))]}e^{-\Delta}d\Delta \tag{12}$$

subject to

$$\frac{dW}{d\Delta} = \frac{1}{\delta[u(c(t))]}[f(k) - c - h(B) + A], \tag{13}$$

and constraint (9) and the initial conditions.

Define the Hamiltonian as

$$H = \frac{u(c)}{\delta[u(c(t))]} + \lambda[\frac{f(k) - c - h(B) + A}{\delta[u(c(t))]}] + \mu(k - B - W),$$

where λ is the costate variable, which represents the imputed marginal utility of wealth. μ is the multiplier associated with the net wealth constraint (9).

The first-order conditions for an optimum are

$$\{1 - \frac{\delta^{'}}{\delta}[u(c) + \lambda(f(k) - c - h(B) + A)]\}u_c = \lambda, \tag{14}$$

$$-\delta\mu = \lambda h^{'}(B), \tag{15}$$

$$\lambda\frac{1}{\delta}f^{'}(k) + \mu = 0, \tag{16}$$

$$\frac{d\lambda}{d\Delta} = \lambda + \mu, \tag{17}$$

and the transversality condition

$$\lim_{\Delta\to\infty} \lambda W e^{-\Delta} = 0. \tag{18}$$

To explain equation (14), with substitutions we write it as

$$u_c = \lambda + \frac{\delta^{'}}{\delta}[u + \lambda(f(k) - c - h(B) + A)]u_c. \tag{19}$$

The left-hand side is the marginal utility of consumption, the right-hand side is the sum of the marginal utility of wealth and the marginal increase in the present value of the imputed income due to a marginal decrease in the rate of the time preference. Equation (19) says the these two marginal values must equal in the equilibrium.

From equations (15) and (16), we obtain

$$f^{'}(k) = h^{'}(B). \tag{20}$$

Equation (20) implies that the marginal cost of foreign borrowing must equal the marginal productivity of capital at an optimum.

Equation (17) is the familiar Euler equation. Combining it with equation (16) leads to:

$$\frac{d\lambda}{d\Delta} = \lambda(1 - \frac{1}{\delta} f^{'}(k)). \tag{21}$$

Using condition (11), we rewrite equation (21) as follows

$$\frac{d\lambda}{dt} = \lambda(\delta - f^{'}(k)). \tag{22}$$

3. DYNAMICS AND LONG-RUN ANALYSIS

3.1. Dynamic system

In this section we derive the dynamic system for consumption, c, capital stock, k, and foreign borrowing, B, with the aid of the first-order conditions given in the last section.

First, from equation (20), we can represent B as a function of k, namely

$$B = B(k). \tag{23}$$

Differentiating with respect to time, we get

$$\frac{dB}{dt} = B_k \frac{dk}{dt}, \tag{24}$$

where

$$B_k = \frac{f^{''}}{h^{''}(B)} < 0, \tag{25}$$

because $f^{''} < 0$, and $h^{''}(B) > 0$. Equation (25) asserts that an increase in the capital stock will decrease foreign borrowing.

Notice that with equation (14), we can write λ as a function of B, c, and k in the following form

$$\lambda = \frac{(\delta - \delta^{'} u)u_c}{\delta + \delta^{'} u_c(f(k) - c - h(B) + A)}. \tag{26}$$

Taking total differentiation in equation (26) and combining it with the Euler equation (22), we have

$$\begin{aligned} \frac{d\lambda}{dt} &= \lambda_c \frac{dc}{dt} + \lambda_k \frac{dk}{dt} + \lambda_B \frac{dB}{dt} \\ &= \lambda(\delta - f^{'}(k)), \end{aligned} \tag{27}$$

where the coefficients λ_c, λ_k, and λ_B are given in the appendix. In fact, we are only interested in their values at the steady state.

Now, the total dynamic system of the economy can be summarized as

$$\frac{dk}{dt} - \frac{dB}{dt} = f(k) - c - h(B) + A,$$

$$\frac{dB}{dt} = B_k \frac{dk}{dt},$$

and

$$\lambda_c \frac{dc}{dt} + \lambda_k \frac{dk}{dt} + \lambda_B \frac{dB}{dt} = \lambda(\delta - f^{'}(k)),$$

with λ determined by equation (26).

From the above equations we derive the dynamic equations for consumption, c, and capital accumulation, k. Here, the dynamic equation for foreign borrowing can be determined by the dynamic paths of c and k because of equation (24).

$$\frac{dk}{dt} = \frac{h^{''}}{h^{''} - f^{''}}(f(k) - c - h(B) + A), \tag{28}$$

$$\frac{dc}{dt} = \frac{\lambda}{\lambda_c}(\delta - f^{'}(k)) + \frac{\lambda_B}{\lambda_c}(f(k) - c - h(B) + A), \tag{29}$$

$$(\frac{dB}{dt} = B_k \frac{dk}{dt}),$$

where λ, λ_c, and λ_B are given in the appendix.

With equations (28), (29), the initial condition $k(0) = k_0$, and the transversality condition we can determine the optimal consumption path, $c(t)$, and capital accumulation path, $k(t)$. Finally, from equation (24), and the initial condition $B(0) = B_0$ we can determine the foreign borrowing path, $B(t)$.

3.2. The steady state

Obstfeld (1999) has studied the long-run effects of foreign aid in the traditional Cass-Koopmans optimal growth model. He finds that foreign aid generates no long-run effect on domestic capital accumulation, and that it only increases the consumption level by the same amount. Here, we reexamine this issue and see how foreign aid can affect not only long-run consumption, but also long-run domestic capital accumulation and external borrowing.

The steady state of the economy, reached when $\frac{dk}{dt}$ and $\frac{dc}{dt}$ equal zero, is characterized by

$$\frac{h^{''}}{h'' - f''}(f(k^*) - c^* - h(B^*) + A) = 0, \tag{30}$$

$$\frac{\lambda^*}{\lambda_c^*}(\delta - f^{'}(k^*)) + \frac{\lambda_B^*}{\lambda_c^*}(f(k^*) - c^* - h(B(k^*)) + A) = 0. \tag{31}$$

And equations (30) and (31) are equivalent to

$$\begin{aligned} f(k^*) - c^* - h(B(k^*)) + A &= 0, \\ \delta - f^{'}(k^*) &= 0. \end{aligned} \tag{32}$$

Now, from the steady-state conditions, the steady-state values of λ^*, λ_c^*, λ_B^*, and λ_k^* for λ, λ_c, λ_B, and λ_k are determined as follows

$$\begin{aligned} \lambda^* &= \frac{\delta - \delta^{'} u}{\delta} u_c > 0, \\ \lambda_c^* &= \frac{1}{\delta}((\delta - \delta^{'} u)u_{cc} - \delta^{''} u_c^2 u) < 0, \\ \lambda_B^* &= \frac{1}{\delta^2}(\delta - \delta^{'} u)u_c \delta^{'} u_c h^{'}(B) > 0, \\ \lambda_k^* &= -\frac{1}{\delta^2}(\delta - \delta^{'} u)\delta^{'} u_c^2 f^{'}(k) < 0. \end{aligned} \tag{33}$$

Equations in (32) characterize the steady-state conditions. The first equation says that output and foreign aid are used to consume and pay for the cost of foreign borrowing in the equilibrium. The second one shows that the steady-state marginal productivity of capital equals the consumer's time preference.

The linearized system associated with (28) and (29) around the steady state is

$$\begin{pmatrix} \frac{dk}{dt} \\ \frac{dc}{dt} \end{pmatrix} = \begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix} \begin{pmatrix} k - k^* \\ c - c^* \end{pmatrix},$$

where

$$\begin{aligned} \phi_{11} &= \frac{h^{''}}{h'' - f''}(f^{'} - h^{'} B_k), \phi_{12} = -\frac{h^{''}}{h'' - f''}, \\ \phi_{21} &= -\frac{\lambda^*}{\lambda_c^*} f^{''} + \frac{\lambda_B^*}{\lambda_c^*}(f^{'} - h^{'} B_k), \phi_{22} = \frac{\lambda^*}{\lambda_c^*}\delta^{'} u_c - \frac{\lambda_B^*}{\lambda_c^*}. \end{aligned}$$

The determinant of the coefficient matrix is

$$D = -\frac{h''}{h'' - f''}\frac{\lambda^*}{\lambda_c^*}(f'' - \delta' u_c(f' - h' B_k)) < 0.$$

Thus, we know that the steady state is saddle-point stable, i.e., there exists a unique perfect-foresight path. Along this path, consumption, $c(t)$, the capital stock, $k(t)$, and foreign borrowing, $B(t)$, converge to the steady state in the long run.

For the long-run effects of foreign aid on the economy, we have derived the following results in the appendix.

PROPOSITION 1. *A permanent rise in foreign aid reduces long-run capital formation and increases long-run foreign debt:*

$$\frac{dk^*}{dA} = \frac{\delta' u_c}{f'' - \delta' u_c(f' - h' B_k)} < 0, \tag{34}$$

$$\frac{dc^*}{dA} = \frac{f''}{f'' - \delta' u_c(f' - h' B_k)} > 0, \tag{35}$$

and

$$\frac{dB^*}{dA} = \frac{B_k \delta' u_c}{f'' - \delta' u_c(f' - h' B_k)} > 0, \tag{36}$$

because $f'' - \delta' u_c(f' - h' B_k) < 0$, *and* $B_k < 0$.

Now, from equation (34) we know that the a permanent rise in foreign aid decreases the steady-state capital stock. This is because a permanent increase in foreign aid raises the income level of the agent. The agent then can afford to increase his consumption and reduce his investment while maintaining a higher level of long-run consumption, as shown by equation (35). In the end, foreign aid reduces the long-run accumulation of capital stock. This is a powerful result. In a modified Cass-Koopmans model with an exogenously given time preference rate and without foreign borrowing, Obstfeld (1999) has found that a rise in foreign aid has no effect on the long-run accumulation of capital, but it increases the speed of the transition to the steady state. In this sense, foreign aid still has a stimulating role for investment and economic growth in developing countries. But from our analysis, a permanent rise in foreign aid always depresses domestic investment and output growth in developing countries in both the short run and long run. Of course, both models have reached the similar conclusion that foreign aid stimulates consumption.

An equally surprising case is equation (36). It implies that a permanent increase in foreign aid leads to a higher level of foreign debt accumulation. With a permanent rise in foreign aid and, therefore, permanent income, the agent's proportional increase in short-run consumption will be more than the decrease in savings and investment through external borrowing. Therefore short-run external finance will rise. With reduced capital accumulation and lower output in the long run, the long-term level of external debt will also rise.

Our analysis raises some fundamental doubt about the effectiveness of foreign aid on economic growth in developing countries. Foreign aid seems to have no role in breaking "foreign dependency" and establishing "economic independence" in many very poor countries. On the contrary, our analysis predicts that a rising level of foreign aid leads to reduced savings, lower investment and capital accumulation, and more reliance on foreign borrowing in the long run. Our theoretical analysis renders strong support for the negative associations between external finance and domestic savings in Griffin (1970); Griffin and Enos (1970); Fry (1978, 1980); Giovannini (1983, 1985); Taylor and Williamson (1994). Furthermore, our analysis is also in line with the finding that there exists no association between foreign aid and domestic investment and growth by Boone (1994a, 1994b).

4. SHORT-RUN ANALYSIS

In the last section, we discussed the effects of a permanent increase in foreign aid on the steady-state capital stock, k^*, consumption level, c^*, and foreign borrowing, B^*. To make the short-run analysis of the effects of temporal foreign aid, we follow Judd (1982, 1985, 1987).

As in Judd (1982, 1985), suppose the economy is in the steady-state k^* and c^* with foreign aid A^* at time $t = 0$. And at time $t = 0$, foreign aid changes as follows

$$A = A^* + \epsilon z(t), \tag{37}$$

where ϵ is a parameter; function $z(t)$ represents the intertemporal change of various parameters. In this paper, the function $z(t)$ can be regarded as a step function of time. Then a temporary change of foreign aid during time $t \in [0, T]$ can be represented by $z(t) = 1, t \in [0, T]$ and $z(t) = 0$ otherwise.

Substituting equation (37) into the dynamic system of equations (28) and (29), we get

$$\frac{dk}{dt} = \frac{h^{''}}{h'' - f''}(f(k) - c - h(B) + A + \epsilon z(t)), \tag{38}$$

$$\frac{dc}{dt} = \frac{\lambda}{\lambda_c}(\delta - f^{'}(k)) + \frac{\lambda_B}{\lambda_c}(f(k) - c - h(B) + A + \epsilon z(t)). \tag{39}$$

Again, the linearized system associated with the system of (38) and (39) has two eigenvalues, one negative and the other positive, which we denote as μ.

Differentiating with respect to ϵ at $\epsilon = 0$ in equations (38) and (39), we get

$$\begin{pmatrix} \frac{dk_\epsilon(t)}{dt} \\ \frac{dc_\epsilon(t)}{dt} \end{pmatrix} = \begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix} \begin{pmatrix} k_\varepsilon \\ c_\epsilon \end{pmatrix} + \begin{pmatrix} \frac{h^{''}}{h^{''}-f^{''}} z(t) \\ \frac{\lambda_B}{\lambda_c} z(t) \end{pmatrix}, \tag{40}$$

where

$$\begin{aligned}
\phi_{11} &= \frac{h^{''}}{h^{''} - f^{''}}(f^{'} - h^{'}B_k) > 0, \phi_{12} = -\frac{h^{''}}{h^{''} - f^{''}} < 0, \\
\phi_{21} &= -\frac{\lambda^*}{\lambda_c^*} f^{''} + \frac{\lambda_B^*}{\lambda_c^*}(f^{'} - h^{'}B_k) < 0, \\
\phi_{22} &= \frac{\lambda^*}{\lambda_c^*}\delta^{'} u_c - \frac{\lambda_B^*}{\lambda_c^*} = \frac{1}{\lambda_c^*}\frac{1}{\delta^2}(\delta - \delta^{'} u) u_c^2 \delta^{'}(\delta - h^{'}(B)).
\end{aligned}$$

For notational simplicity, we denote

$$c_\epsilon(t) = \frac{\partial c}{\partial \epsilon}(t, 0), \frac{dc_\epsilon(t)}{dt} = \frac{\partial}{\partial t}(\frac{\partial c}{\partial \epsilon})(t, 0).$$

Furthermore, we denote the Laplace transforms by the upper case letters of the associated variables in lower case letters. For example,

$$C_\epsilon(s) = \int_0^\infty c_\epsilon(t) e^{-st} dt.$$

Making the Laplace transform in equation (40), we have

$$s\begin{pmatrix} K_\epsilon(s) \\ C_\epsilon(s) \end{pmatrix} = \begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix} \begin{pmatrix} K_\epsilon(s) \\ C_\epsilon(s) \end{pmatrix} + \begin{pmatrix} \frac{h^{''}}{h^{''}-f^{''}} z(s) + k_\epsilon(0) \\ \frac{\lambda_B}{\lambda_c} z(s) + c_\epsilon(0) \end{pmatrix}. \tag{41}$$

Because the stock of capital (the state variable) cannot jump initially, we have $k_\epsilon(0) = 0$. To determine the initial consumption change $c_\epsilon(0)$, we follow Judd (1985). Please notice that, because the steady state is saddle-point stable, both $C_\epsilon(s)$ and $K_\epsilon(s)$ are bounded when $s = \mu$ (the positive eigenvalue). But when $s = \mu$, the coefficient matrix of the above linear equation is singular. By Cramer's rule, in order to maintain the existence and finiteness for solutions $C_\epsilon(s)$ and $K_\epsilon(s)$ when $s=\mu$, the determinants of the following matrices must be zero

$$\begin{pmatrix} \frac{h''}{h''-f''}z(s) & -\phi_{12} \\ \frac{\lambda_B}{\lambda_c}z(s)+c_\epsilon(0) & \mu-\phi_{22} \end{pmatrix}, \begin{pmatrix} \mu-\phi_{11} & \frac{h''}{h''-f''}z(s) \\ -\phi_{21} & \frac{\lambda_B}{\lambda_c}z(s)+c_\epsilon(0) \end{pmatrix}$$

namely,

$$(\frac{\lambda_B}{\lambda_c}z(\mu)+c_\epsilon(0))(\mu-\phi_{22})+\phi_{12}\frac{h''}{h''-f''}z(\mu)=0, \tag{42}$$

and

$$(\frac{\lambda_B}{\lambda_c}z(s)+c_\epsilon(0))(\mu-\phi_{11})+\phi_{21}\frac{h''}{h''-f''}z(s)=0. \tag{43}$$

From equation (42), we get the initial jump in consumption

$$c_\epsilon(0)=-(\frac{\lambda_B}{\lambda_c}+\frac{h''}{h''-f''}\frac{\phi_{12}}{(\mu-\phi_{22})})z(\mu). \tag{44}$$

Remark 4.1. Because μ is the eigenvalue of the coefficient matrix, we have $(\mu-\phi_{11})(\mu-\phi_{22})-\phi_{21}\phi_{12}=0$. Hence, we can derive the same conclusion from equation (43).

Substituting equation (44) back into equation (40), we have

$$\begin{aligned} \frac{dk_\epsilon(0)}{dt} &= \phi_{12}c_\epsilon(0)+\frac{h''}{h''-f''}z(0), \\ \frac{dc_\epsilon(0)}{dt} &= \phi_{22}c_\epsilon(0)+\frac{\lambda_B}{\lambda_c}z(0). \end{aligned} \tag{45}$$

PROPOSITION 2. *An initial increase in foreign aid will raise the initial investment rate and decrease the rate of initial foreign borrowing.*

Proof. This can be derived from differentiating equation (45),

$$\frac{d}{dz(0)}(\frac{dk_\epsilon(0)}{dt})=\frac{h''}{h''-f''}>0, \tag{46}$$

and from equation (24), we get

$$\frac{d}{dz(0)}(\frac{dB_\epsilon(0)}{dt})=B_k\frac{h''}{h''-f''}<0. \tag{47}$$

▮

This is true because an initial increase in foreign aid causes a dollar for dollar increase in the consumption level. To smooth the consumption path, the agent will increase the initial saving rate, namely, $\frac{d}{dz(0)}(\frac{dk_\epsilon(0)}{dt}) > 0$. With more income available today, the agent will also reduce his rate of initial foreign borrowing.

Proposition 2 supports the analysis in Obstfeld (1999) in a very limited sense; that is to say, foreign aid can accelerate short-run investment if it is perceived as a one-shot rise in income. If foreign aid lasts for a slightly longer period, its effects on investment and foreign borrowing are just the opposite of those predicted by proposition 2 as we will see below.

Effects of temporal foreign aid

Suppose foreign aid is temporal, i.e.,

$$\begin{cases} z(t) = 1, & t \in [0, T]; \\ z(t) = 0, & \text{otherwise}. \end{cases} \tag{48}$$

Then, we have

$$Z(\mu) = \frac{1 - e^{-\mu T}}{\mu}. \tag{49}$$

PROPOSITION 3. *A temporal increase in foreign aid will increase the initial consumption level and foreign borrowing rate. At the same time, it will decrease the initial investment rate.*

Proof. From equation (44), we get

$$\frac{dc_\epsilon(0)}{dZ(\mu)} = -(\frac{\lambda_B}{\lambda_c} + \frac{h''}{h'' - f''}\frac{\phi_{12}}{(\mu - \phi_{22})}). \tag{50}$$

Because the two eigenvalues, μ(positive) and ν (negative) of matrix $\begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix}$satisfy

$$\mu + \nu = \phi_{11} + \phi_{22},$$

we have $\mu - \phi_{22} = \phi_{11} - \nu > 0$. Hence, we have

$$\frac{dc_\epsilon(0)}{dZ(\mu)} > 0.$$

From equation (45), we get

$$\frac{d}{dZ(\mu)}(\frac{dk_\epsilon(0)}{dt}) = \phi_{12}\frac{dc_\epsilon(0)}{dZ(\mu)} < 0, \tag{51}$$

and from equation (24), we obtain

$$\frac{d}{dZ(\mu)}(\frac{dB_\epsilon(0)}{dt}) = B_k\phi_{12}\frac{dc_\epsilon(0)}{dZ(\mu)} > 0. \tag{52}$$

▮

Proposition 3 means that with a temporal increase in foreign aid the agent will increase his initial consumption level as his income rises. In addition, rising income provides him with an incentive to lower his current savings rate and increase his reliance on external financing.

Proposition 3 has a close link to Proposition 1 when the time horizon of foreign aid is sufficiently large. If the time horizon is infinite, these two prepositions coincide, and both predict that a permanent rise in foreign aid reduces capital accumulation and increases external borrowing.

5. SUMMARY

In an infinite-horizon model with endogenous time preferences, foreign aid, foreign borrowing, and domestic capital accumulation, we find that a permanent increase in foreign aid leads to a reduction in long-run capital accumulation, a rise in domestic consumption, and an increase in foreign borrowing. Short-run analysis shows that an initial increase in foreign aid leads to a rise in investment, and a reduction in consumption and external borrowing. On the other hand, a temporal increase in foreign aid results in an increase in consumption and foreign borrowing, and a reduction in investment.

Our theoretical findings support many empirical results on the negative impact of external finance on domestic savings, investment, and growth. It also raises some fundamental doubt about the effectiveness of foreign aid in accelerating economic growth and development in developing countries.

APPENDIX A

In the expression

$$\lambda = \frac{(\delta - \delta' u)u_c}{\delta + \delta' u_c(f(k) - c - h(B) + A)},$$

we differentiate with respect to c, B, and k

$$\begin{aligned}\lambda_c &= \frac{(\delta-\delta' u)u_{cc}-\delta'' u_c^2 u}{\delta+\delta' u_c(f(k)-c-h(B)+A)} \\ &\quad -\frac{(\delta-\delta' u)u_c(f(k)-c-h(B)+A)(\delta'' u_c^2+\delta' u_{cc})}{(\delta+\delta' u_c(f(k)-c-h(B)+A))^2},\end{aligned} \tag{A.1}$$

$$\lambda_B = \frac{(\delta-\delta' u)u_c\delta' u_c h'(B))}{(\delta+\delta' u_c(f(k)-c-h(B)+A))^2}, \tag{A.2}$$

and

$$\lambda_k = -\frac{(\delta-\delta' u)u_c\delta' u_c f'(k)}{(\delta+\delta' u_c(f(k)-c-h(B)+A))^2}. \tag{A.3}$$

Using the steady-state conditions (32), we get

$$\begin{aligned}\lambda^* &= \frac{\delta-\delta' u}{\delta}u_c, \lambda_c^* = \frac{1}{\delta}((\delta-\delta' u)u_{cc}-\delta'' u_c^2 u), \\ \lambda_B^* &= \frac{1}{\delta^2}(\delta-\delta' u)u_c\delta' u_c h'(B), \\ \lambda_B^* &= -\frac{1}{\delta^2}(\delta-\delta' u)\delta' u_c^2 f'(k).\end{aligned}$$

These are just the equations in (33) in the text.

For the proof of proposition 1 in section 3, we take a total differentiation in equation (32)

$$\begin{pmatrix} f'-h' B_k & -1 \\ -f'' & \delta' u_c \end{pmatrix}\begin{pmatrix} dk^* \\ dc^* \end{pmatrix} = \begin{pmatrix} -1 \\ 0 \end{pmatrix} dA.$$

Therefore, we obtain the long-run effects of a permanent increase in foreign aid on the capital stock and consumption

$$\frac{dk^*}{dA} = \frac{\delta' u_c}{f''-(f'-h' B_k)\delta' u_c} < 0,$$

$$\frac{dc^*}{dA} = \frac{f''}{f''-(f'-h' B_k)\delta' u_c} > 0.$$

From equation (24), we have

$$\frac{dB^*}{dA} = \frac{\delta' u_c B_k}{f''-(f'-h' B_k)\delta' u_c} > 0.$$

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