European Economic Review 47 (2003) 1077–1103
www.elsevier.com/locate/econbase

Unilateral capital transfers, public investment, and economic growth

Santanu Chatterjee[a], Georgios Sakoulis[b], Stephen J. Turnovsky[c,*]

[a] *Department of Economics, Terry College of Business, The University of Georgia, Athens, GA 30602, USA*
[b] *JP Morgan Fleming Asset Management, London EC2Y 9AQ, UK*
[c] *Department of Economics, University of Washington, 301 Savery Hall, PO Box 353330, Seattle, WA 98195, USA*

Accepted March 2002

Abstract

We contrast the effects of a transfer tied to investment in public infrastructure from a traditional pure transfer. The latter has no growth or dynamic consequences; it is always welfare improving, the gains increasing with the stock of government debt and the benefits of debt reduction. A tied transfer generates dynamic adjustments, as public capital is accumulated in the recipient economy. Its long-run growth and welfare effects depend upon the initial stock of infrastructure, as well as co-financing arrangements. These contrasts also apply to temporary transfers, particularly the transitional dynamics. A temporary pure transfer has only modest short-run growth effects and leads to a permanent deterioration of the current account, while a productive transfer has significant impacts on short-run growth, leading to permanent improvements in key economic variables including the current account.

JEL classification: E0; E6; F0

Keywords: Capital transfers; Public investment; Economic growth

1. Introduction

Investment in public infrastructure has long been considered important for developing countries and recently has assumed a central role in the context of the expanding European Union (EU). Services associated with the use of infrastructure account for

* Corresponding author. Tel.: +206-685-8028; fax: +206-685-7477.
E-mail address: sturn@u.washington.edu (S.J. Turnovsky).

0014-2921/03/$ - see front matter
PII: S0014-2921(02)00235-0

roughly 7–9% of GDP in low- and middle-income countries. Infrastructure in these countries typically represents about 20% of total investment and 40–60% of public investment.[1] The stock of physical infrastructure is thus an important input in the production process of such economies, raising the efficiency and productivity of the private sector, and thereby providing a crucial channel for growth, distribution of output, and ultimately higher living standards.

However, financing new investment in infrastructure is a contentious issue, especially in poor, resource-constrained developing countries. A significant source for financing new investment in public infrastructure is external financing. Such financing could be in the form of borrowing from abroad, through bilateral or multilateral loans, or through unilateral capital transfers, in the form of tied grants or official development assistance, as recently observed in the EU. In several instances, the per capita level of GDP of joining members to the EU has been below the Union average, accompanied by low and, in some cases, declining growth rates. As a consequence, the EU introduced pre-accession aid programs to assist these and other potential member nations in their transition into the union. This process of "catching up" began in 1989 with a program of unilateral capital transfers from the EU to its aspiring members through its Structural Funds Program, and subsequent programs were introduced in 1993 and in 2000.[2] These assistance programs tied the capital transfers (or grants) to the accumulation of public capital, and were aimed at building up infrastructure in the recipient nation, thereby enabling it to attain strong positive growth differentials relative to the EU average in the short run, achieve higher and sustainable living standards in alignment with EU standards, and ultimately gain accession to EU membership.

The objective of this paper is to analyze the process of developmental assistance in the form of tied-capital transfers to a small growing open economy. The model has the following key characteristics. First, the assistance is tied to the accumulation of public capital, which is therefore an important stimulus for private capital accumulation and growth. Second, we assume that public investment in infrastructure is financed both by the domestic government, as well as via the flow of international transfers, thereby incorporating the important element of domestic co-financing, characteristic of most bilateral aid programs that are tied to specific public investment projects. The international transfers are assumed to be tied to the scale of the recipient economy and therefore are consistent with maintaining an equilibrium of sustained (endogenous) growth.

We also assume that the small open economy faces restricted access to the world capital market in the form of an upward-sloping supply curve of debt, according to which the country's cost of borrowing depends upon its debt position, relative to its total capital stock, the latter serving as a measure of its debt-servicing capability. This assumption is motivated by the large debt burdens of most developing countries, which give rise to the potential risk of default on international borrowing. Indeed, evidence suggesting

[1] World Bank (1994).

[2] Greece, Ireland, Spain, and Portugal were recipients of unilateral capital transfers tied to public investment projects under the Structural Funds Program between 1989 and 1999. A similar tied transfer program, called Agenda 2000, has been initiated for 11 aspiring member nations (Central-Eastern European countries), and is expected to continue until 2006; see EU (1998a, b).

that more indebted economies pay a premium on their loans from international capital markets to insure against default risk has been provided by Edwards (1984).

Because of the complexity of the model, most of the analysis is conducted numerically. In general, the impact of a transfer on the economy depends crucially upon (i) whether or not it is "pure" or "tied" to public investment [3] and (ii) how the recipient government responds. The main results of our model include the following. A permanent pure transfer has no intertemporal effects; it simply raises current consumption instantaneously, increasing welfare correspondingly. By contrast, a tied transfer generates a dynamic adjustment. But whether it benefits or harms the economy depends upon its initial stock of public capital. Furthermore, we show how the government can maximize the benefits of the tied transfer by the appropriate coordinated determination of its expenditure and tax rates. But we also show that if it responds by choosing its policy instruments to maximize the growth rate, it can be made worse off by the tied transfer. There is thus a sharp trade-off between welfare maximization and growth maximization, absent in the Barro (1990) model, but present in Futagami et al. (1993).

Both a temporary pure transfer and a temporary productive transfer generate transitional dynamics, though of a sharply contrasting nature. Temporary pure transfers have only modest short-run growth effects, which impact most directly on private capital and consumption. The tied transfer has much more potent short-run growth effects, and by impinging more directly on public capital and debt, yields very different transitional dynamics. By influencing the transitional growth rates, temporary transfers have *permanent* effects on the *levels* of key variables such as the capital stocks, output, and welfare, these being more significant for the productive transfer. One striking contrast between the two transfers is that the productive transfer leads to a decline in the long-run debt of the recipient economy, whereas the pure transfer leads to greater long-run indebtedness.

Interest in the impact of public capital on private capital accumulation and economic growth originated with the seminal theoretical work of Arrow and Kurz (1970) and the more recent empirical research of Aschauer (1989a, b). Most of the subsequent literature has focused on closed economies, using both the Ramsey model and the AK endogenous growth framework; see e.g. Futagami et al. (1993), Baxter and King (1993), Glomm and Ravikumar (1994), Fisher and Turnovsky (1998) and Turnovsky (1997b). Turnovsky (1997a) extends Futagami et al. to a small open economy and introduces various forms of distortionary taxation, as well as the possibility of both external and internal debt financing. Devarajan et al. (1998) address the issue of whether public capital should be provided through taxation or through granting subsidies to private providers. [4]

This paper extends and contributes to the above literature in three important directions. First, as Brakman and van Marrewijk (1998) point out, in the post World War II

[3] Bhagwati (1967) points out that tied assistance may take different forms. The transfer or aid from abroad may be linked to a (i) specific investment project, (ii) specific commodity or service, or (iii) to procurement in a specific country. We focus our analysis on the first type of tying, i.e. to an investment project.

[4] The efficient use of infrastructure is a further important issue. For example, Hulten (1996) shows that inefficient use of infrastructure accounts for more than 40% of the growth differential between high- and low-growth countries.

era, unilateral capital transfers have increasingly taken the form of development assistance or foreign aid. The present paper analyzes the role of tied development assistance as a mode of financing public investment and its effect on the transitional adjustment path of a growing open economy. This is important when one recognizes that between two-thirds and three-fourths of official development assistance to infrastructure is fully or partially tied (see footnote 1). On the other hand, most of the existing development literature, which examines the possible effects of aid on saving and investment in developing countries, has been based mainly on static models and does not address two important issues. The first is the effect of aid on investment and capital accumulation, which requires a dynamic intertemporal framework to analyze; the second is the fact that most development assistance is temporary in nature.[5] This paper seeks to address these issues in the context of an endogenously growing open economy, and explicitly characterizes and contrasts the dynamic response of such an economy to a temporary aid program that may or may not be tied to public investment.

Second, since it is likely that external assistance and borrowing will fail to meet the total financial needs for public investment, domestic participation by both the government and the private sector is also important. Recently, in a panel study of 56 developing countries and six 4-year periods (1970–93), Burnside and Dollar (2000) find that foreign aid is most effective when combined with a positive policy environment in the recipient economy. In earlier works, Gang and Khan (1990) and Khan and Hoshino (1992) report that most bilateral aid for public investment in LDCs is tied and is given on the condition that the recipient government invests certain resources into the same project. We specifically characterize the consequences of domestic co-financing of public investment and outline the trade-offs faced by a recipient government when it responds optimally to a flow of external assistance from abroad.

Third, the question we address is also closely related to the "transfer problem," one of the classic issues in international economics, dating back to Keynes (1929), Ohlin (1929), and others. This early literature was concerned with "pure" (untied) transfers, which could be in the form of an unrestricted gift or as debt relief.[6] Recent research on the transfer problem has focused on the welfare effects of such pure international transfers.[7] By contrast, our analysis differs from the existing literature by focusing on "productive" (tied) transfers, the use of which is tied to public investment. Moreover, the formulation we develop parameterizes the transfer so that we can conveniently identify the pure transfer and the productive transfer as polar cases. Embedding the transfer in an intertemporal framework enables us to compare both the short- and the long-run effects of the two types of transfers on the dynamic evolution and growth rate of the economy, and ultimately on welfare. Both permanent and temporary transfers are analyzed. Indeed, in light of the fact that typical transfer programs, such as those operated by the EU, are only temporary, this latter case becomes particularly relevant.

[5] See Cassen (1986), and more recently, Brakman and van Marrewijk (1998) for a survey of this literature. Two exceptions include Djajic et al. (1999) and Hatzipanayotou and Michael (2000), who examine the effects of transfers in an intertemporal context.

[6] See for example, Bhagwati et al. (1983) and Galor and Polemarchakis (1987).

[7] Turunen-Red and Woodland (1988) and Brock (1996).

The rest of the paper is organized as follows. Section 2 outlines the model and its chief characteristics. Section 3 provides a numerical examination of the transitional paths in response to permanent transfer shocks and characterizes the different forms of government response in the recipient country. Temporary transfers are addressed in Section 4, and Section 5 concludes.

2. The analytical framework

2.1. Private sector

We consider a small open economy populated by an infinitely lived representative agent who produces and consumes a single traded commodity. Output, Y, of the commodity is produced using the constant returns to scale production function,

$$Y = \alpha \left(\frac{K_G}{K}\right)^{\eta} K = \alpha K_G^{\eta} K^{1-\eta}, \quad \alpha > 0, \ 0 < \eta < 1, \tag{1a}$$

where K denotes the representative agent's stock of private capital and K_G denotes the stock of public capital. Eq. (1a) assumes that the services of public capital enhance the productivity of private capital, though at a diminishing rate. The model abstracts from labor so that private capital should be interpreted broadly to include human, as well as physical capital; see Rebelo (1991).

The agent consumes this good at the rate C, yielding utility over an infinite horizon represented by the isoelastic utility function

$$U \equiv \int_0^{\infty} \frac{1}{\gamma} C^{\gamma} \mathrm{e}^{-\beta t} \, \mathrm{d}t, \quad -\infty < \gamma < 1. \tag{1b}$$

The agent also accumulates physical capital, with expenditure on a given change in the capital stock, I, involving adjustment (installation) costs specified by the quadratic function [8]

$$\Psi(I, K) = I + h_1 \frac{I^2}{2K} = I\left(1 + \frac{h_1}{2}\frac{I}{K}\right). \tag{1c}$$

Letting δ_K denote the rate of depreciation of private capital, the net rate of capital accumulation is

$$\dot{K} = I - \delta_K K. \tag{1d}$$

Agents may borrow internationally on a world capital market. The key factor we wish to take into account is that the creditworthiness of the economy influences its cost of borrowing from abroad. Essentially, we assume that world capital markets assess an economy's ability to service debt costs and the associated default risk, the key indicator of which is the country's debt–capital (equity) ratio. As a result, the

[8] This equation is an application of the familiar cost of adjustment framework, where we assume that the adjustment costs are proportional to the *rate* of investment per unit of installed capital (rather than its level). The linear homogeneity of this function is necessary for a steady-state equilibrium having ongoing growth to be sustained.

interest rate countries are charged on world capital markets increases with this ratio. This leads to the upward-sloping supply schedule for debt, expressed by assuming that the borrowing rate, $r(N/K_T)$, charged on (national) foreign debt, N, is of the form

$$r(N/K_T) = r^* + \omega(N/K_T), \quad \omega' > 0, \tag{1e}$$

where r^* is the exogenously given world interest rate, $K_T = K + K_G$ is the sum of private plus public capital stock in the economy (both of which therefore serve as collateral), and $\omega(N/K_T)$ is the country-specific borrowing premium that increases with the nation's debt–capital ratio. [9]

The agent's decision problem is to choose consumption, and the rates of accumulation of capital and debt, to maximize intertemporal utility (1b) subject to the flow budget constraint

$$\dot{B} = C + r(N/K_T)B + \Psi(I,K) - (1-\tau)Y + \bar{T}, \tag{2}$$

where B is the stock of debt held by the private sector, τ is the income tax rate, and $\bar{T}$ denotes lump-sum taxes. [10] It is important to emphasize that in performing his optimization, the representative agent takes the borrowing rate, $r(.)$ as given. This is because the interest rate facing the debtor nation, as reflected in its upward-sloping supply curve of debt, is a function of the economy's *aggregate* debt–capital ratio, which the individual agent assumes he is unable to influence.

The optimality conditions with respect to C and I are, respectively,

$$C^{\gamma-1} = v, \tag{3a}$$

$$1 + h_1(I/K) = q, \tag{3b}$$

where v is the shadow value of wealth in the form of internationally traded bonds, q' is the shadow value of the agent's private capital stock, and $q = q'/v$ is defined as the market price of private capital in terms of the (unitary) price of foreign bonds. The first of these conditions equates the marginal utility of consumption to the shadow value of wealth, while the latter equates the marginal cost of an additional unit of investment, which is inclusive of the marginal installation cost $h_1 I/K$, to the market value of capital. Eq. (3b) may be immediately solved to yield the following expression

[9] The homogeneity of the relationship is required to sustain a balanced growth equilibrium. A rigorous derivation of (1e) presumes the existence of risk. Since we do not wish to model a full stochastic economy, we should view (1e) as representing a convenient reduced form, one supported by empirical evidence; see e.g. Edwards (1984) who finds a significant positive relationship between the spread over LIBOR (e.g. r^*) and the debt–GNP ratio. Eaton and Gersovitz (1989) provide formal justifications for the relationship (1e). Various formulations can be found in the literature. The original formulation by Bardhan (1967) expressed the borrowing premium in terms of the absolute stock of debt; see also Obstfeld (1982), Bhandari et al. (1990). Other authors such as Sachs (1984) also argue for a homogeneous function such as (1e). We have also considered the Edwards (1984) formulation, $r = r(N/Y)$, and very similar results to those reported are obtained.

[10] It is natural for us to assume $B > 0$, so that the country is a debtor nation. However, it is possible for $B < 0$ in which case the agent accumulates credit by lending abroad. For simplicity, interest income is assumed to be untaxed.

for the rate of private capital accumulation:

$$\frac{\dot{K}}{K} \equiv \phi_K = \frac{q-1}{h_1} - \delta_K. \tag{3b'}$$

Applying the standard optimality conditions with respect to B and K implies the usual arbitrage relationships, equating the rates of return on consumption and investment in private capital to the costs of borrowing abroad:

$$\beta - \frac{\dot{v}}{v} = r\left(\frac{N}{K_T}\right), \tag{4a}$$

$$\frac{(1-\tau)(1-\eta)\alpha K_G^{\eta} K^{-\eta}}{q} + \frac{\dot{q}}{q} + \frac{(q-1)^2}{2h_1 q} - \delta_K = r\left(\frac{N}{K_T}\right). \tag{4b}$$

Finally, in order to ensure that the agent's intertemporal budget constraint is met, the following transversality conditions must hold:

$$\lim_{t\to\infty} vB\mathrm{e}^{-\beta t} = 0, \quad \lim_{t\to\infty} q' K\mathrm{e}^{-\beta t} = 0. \tag{4c}$$

2.2. *Public capital, transfers, and national debt*

The resources for the accumulation of public capital come from two sources: domestically financed government expenditure on public capital, $\bar{G}$, and a program of capital transfers, TR, from the rest of the world. We therefore postulate that the accumulation of public capital, G, to be

$$G \equiv \bar{G} + \lambda\, TR, \quad 0 \leqslant \lambda \leqslant 1, \tag{5}$$

where λ represents the degree to which the transfers from abroad are tied to investment in the stock of public infrastructure. The case $\lambda = 1$ implies that transfers are completely tied to investment in public capital, representing a "productive" transfer. In the other polar case, $\lambda = 0$, incoming transfers are not invested in public capital and hence represent a "pure" transfer, of the Keynes–Ohlin type.

We assume that, analogous to private capital, G, is also subject to convex adjustment costs: [11]

$$\Omega(G, K_G) = G(1 + (h_2/2)(G/K_G)).$$

[11] Note that there are different ways of specifying how aid is tied. The specification (5) does so by relating it to the accumulation of new public capital. An alternative formulation is to tie the aid to total investment costs, inclusive of installation costs, replacing (5) by $\Omega(G, K_G) - \Omega(\bar{G}, K_G) = \lambda\, TR$. The difference between these two specifications is minor and is as follows. Eq. (5) implies that to the extent that the transfer is tied in this way ($\lambda > 0$), a larger transfer increases installation costs that must be financed by some other domestic source, leading to the crowding out of private consumption, and thus reducing the benefits from the foreign transfer. According to the alternative specification, higher installation costs imply that more of the transfer is committed to installing the capital, leaving less available for the accumulation of new capital. These two specifications thus imply analogous trade-offs between the rate of accumulation of new public capital and its associated installation costs, and thus have similar implications. Since there is no compelling evidence favoring one formulation over the other, we adopt (5), which turns out to be marginally simpler.

In addition, public capital depreciates at the rate δ_G so that its net rate of accumulation is

$$\dot{K}_G = G - \delta_G K_G. \tag{6}$$

To sustain an equilibrium of on-going growth, both domestic government expenditure on infrastructure ($\bar{G}$) and the flow of transfers from abroad must be tied to the scale of the economy: [12]

$$\bar{G} = \bar{g}Y \text{ and } TR = \sigma Y, \quad 0 < \bar{g} < 1, \ \sigma > 0, \ 0 < \bar{g} + \sigma < 1.$$

We can therefore rewrite (6) in the following form:

$$\dot{K}_G = G - \delta_G K_G = gY - \delta_G K_G = (\bar{g} + \lambda\sigma)Y - \delta_G K_G, \quad g = \bar{g} + \lambda\sigma > 0, \tag{6'}$$

and dividing (6) by K_G, the growth rate of public capital is given by

$$\frac{\dot{K}_G}{K_G} \equiv \phi_G = (\bar{g} + \lambda\sigma)\frac{Y}{K_G} - \delta_G. \tag{6''}$$

The government faces the flow budget constraint

$$\dot{A} = \Omega(G, K_G) + r(N/K_T)A - \tau Y - TR - \bar{T}. \tag{7}$$

This equation states that the excess of domestic government expenditure on public infrastructure and interest payments on debt over tax and transfer receipts is financed by accumulating debt (A). The extent to which transfers are tied has a bearing on the flexibility of the government's financing options. This is seen most simply by abstracting from adjustment costs, when (7) simplifies to

$$\dot{A} + \tau Y + TR + \bar{T} = \bar{G} + \lambda\, TR + r(N/K_T)A.$$

If $\lambda = 1$ a unit increase in transfers leads to an equivalent increase in the total flow of government purchases that needs to be financed. To the extent $\lambda < 1$, the government may use part of the transfer to substitute for domestic tax financing or to reduce government debt. In addition we require that the government satisfy its intertemporal budget constraint specified as

$$\lim_{t\to\infty} A e^{-r(.)t} = 0. \tag{7'}$$

National debt is the sum of private and public debts, $N = B + A$. Thus, combining (7) and (2) we get the national budget constraint (the nation's current account):

$$\dot{N} = r(N/K_T)N + C + \Psi(I, K) + \Omega(G, K_G) - Y - TR. \tag{8}$$

[12] The approximate constancy of $\bar{G}/Y$ is plausible in a growing economy. While TR/Y is unlikely to remain constant permanently, it does characterize the temporary transfers occurring in the EU. For example, the first phase of the Community Support Framework (CSF I, between 1989 and 1993), provided transfers to Greece, Ireland, Portugal, and Spain at 4.5%, 6%, 6.1%, and 1.6% of their respective GDP. In the second phase (1994–1999), these fractions were changed to 7.2%, 5%, 7.1%, and 3.4 % of GDP. Under Agenda 2000, 11 Eastern European countries are receiving tied transfers for various public investment projects between 4% and 6% of their GDP, and will continue to receive this fraction until 2006, when the first phase of this program comes to an end.

Eq. (8) states that the economy accumulates debt to finance its total expenditures on public capital, private capital, consumption and interest payments net of output produced and transfers received. It is immediately apparent that higher consumption or investment raises the rate at which the economy accumulates debt. The direct effect of a larger unit transfer on the growth rate of debt is given by $(\lambda - 1) + (h_2/K_G)\lambda G$. An interesting observation is that the more transfers are tied to public investment (the higher λ), the lower the decrease in the growth rate of debt. When transfers are completely tied to investment in infrastructure, i.e., $\lambda = 1$, debt increases due to higher installation costs. However, the indirect effects, induced by the change will still need to be taken into account.

2.3. Macroeconomic equilibrium

The steady-state equilibrium has the characteristic that all real quantities grow at the same constant rate and that the relative price of capital, q, is constant. Thus, we shall express the dynamics of the system in terms of the following stationary variables, normalized by the stock of private capital, $c \equiv C/K$, $k_g \equiv K_G/K$, $n \equiv N/K$, and q. The equilibrium system is derived as follows.

First, taking the time derivative of k_g and substituting (6″) and (3b′) yields

$$\frac{\dot{k}_g}{k_g} \equiv \phi_G - \phi_K = (\bar{g} + \lambda\sigma)\alpha k_g^{\eta-1} - \frac{(q-1)}{h_1} - (\delta_G - \delta_K). \tag{9a}$$

Next, dividing (8) by N, and substituting, we can rewrite (8) as

$$\frac{\dot{N}}{N} \equiv \phi_N = r\left(\frac{n}{1+k_g}\right) + \frac{1}{n}\left[\{(\bar{g} + \lambda\sigma) - (1+\sigma)\}\alpha k_g^{\eta} + \alpha^2 \frac{h_2}{2}(\bar{g} + \lambda\sigma)^2 k_g^{2\eta-1} + \frac{(q^2-1)}{2h_1} + c\right]. \tag{8′}$$

Taking the time derivative of n and combining with $(3b')$ leads to

$$\frac{\dot{n}}{n} \equiv \phi_N - \phi_K = r\left(\frac{n}{1+k_g}\right) + \frac{1}{n}\left[\{(\bar{g} + \lambda\sigma) - (1+\sigma)\}\alpha k_g^{\eta} + \alpha \frac{h_2}{2}(\bar{g} + \lambda\sigma)^2 k_g^{2\eta-1} + \frac{(q^2-1)}{2h_1} + c\right] - \left(\frac{q-1}{h_1}\right) + \delta_K. \tag{9b}$$

Third, from (3a) and (4a), we derive the growth rate of consumption:

$$\frac{\dot{C}}{C} \equiv \phi_C = \frac{r(n/(1+k_g)) - \beta}{1-\gamma}.$$

Taking the time derivative of c and combining with (3b′) leads to

$$\frac{\dot{c}}{c} \equiv \phi_C - \phi_K = \frac{r(n/(1+k_g)) - \beta}{1-\gamma} - \frac{(q-1)}{h_1} + \delta_K. \tag{9c}$$

Finally, rewriting (4b) implies

$$\dot{q} = r\left(\frac{n}{1+k_g}\right)q - (1-\tau)(1-\eta)\alpha k_g^{\eta} - \frac{(q-1)^2}{2h_1} + \delta_K q. \tag{9d}$$

Eqs. (9a)–(9d) provide an autonomous set of dynamic equations in k_g, n, c, and q, from which the evolution of government debt can be derived.

2.4. Steady-state equilibrium

The economy reaches steady state when $\dot{k}_g = \dot{n} = \dot{c} = \dot{q} = 0$, implying that $\dot{K}/K = \dot{K}_G/K_G = \dot{N}/N = \dot{C}/C \equiv \tilde{\phi}$, the balanced growth rate of the economy. The steady state is thus described by

$$(\bar{g} + \lambda\sigma)\alpha\tilde{k}_g^{\eta-1} - \delta_G = \frac{\tilde{q}-1}{h_1} - \delta_K, \tag{10a}$$

$$r\left(\frac{\tilde{n}}{1+\tilde{k}_g}\right) - \frac{1}{\tilde{n}}\left[\{1-\bar{g}+(1-\lambda)\sigma\}\alpha\tilde{k}_g^{\eta} - \alpha\frac{h_2}{2}(\bar{g}+\lambda\sigma)^2 k_g^{2\eta-1} - \frac{(\tilde{q}^2-1)}{2h_1} - \tilde{c}\right] = \left(\frac{\tilde{q}-1}{h_1}\right) - \delta_K, \tag{10b}$$

$$r\left(\frac{\tilde{n}}{1+\tilde{k}_g}\right)\tilde{q} - (1-\tau)(1-\eta)\alpha\tilde{k}_g^{\eta} - \frac{(\tilde{q}-1)^2}{2h_1} + \delta_K\tilde{q} = 0, \tag{10c}$$

$$\frac{r(\tilde{n}/(1+\tilde{k}_g)) - \beta}{1-\gamma} = \frac{(\tilde{q}-1)}{h_1} - \delta_K = \tilde{\phi}. \tag{10d}$$

These equations determine the steady-state equilibrium in the following recursive manner. First, Eqs. (10a)–(10d) jointly determine $\tilde{k}_g$, $\tilde{q}$, and $\tilde{r}(.)$, from which the steady-state growth rate $\tilde{\phi}$ immediately follows. Having determined $\tilde{r}$ and $\tilde{k}_g$, the equilibrium stock of debt–capital ratio, $\tilde{n}$, is obtained from (1e). Given $\tilde{k}_g$, $\tilde{q}$, $\tilde{r}(.)$, and $\tilde{n}$, the equilibrium consumption–capital ratio, $\tilde{c}$, is obtained from the current account equilibrium condition (10b). Provided $\tilde{r} > \tilde{\phi}$ (which we shall show below is required for the transversality condition to hold), higher marginal borrowing costs reduce total interest payments raising the consumption–capital ratio. Also, higher installation costs, h_2, reduce the amount of output available for consumption, $\tilde{c}$. Because this system is highly non-linear, it need not be consistent with a well-defined steady-state equilibrium with $\tilde{k}_g > 0$, $\tilde{c} > 0$. Our numerical simulations, however, yield well-defined steady-state values for all plausible specifications of all the structural and policy parameters of the model.

2.5. Equilibrium dynamics

Eqs. (9a)–(9d) form the dynamics of the system in terms of k, n, q, and c. Linearizing these equations around the steady-state values of k_g, n, q, and c obtained from (10a) to (10d),

$$\begin{pmatrix} \dot{k}_g \\ \dot{n} \\ \dot{c} \\ \dot{q} \end{pmatrix} = \begin{pmatrix} \eta\alpha(\bar{g}+\lambda\sigma)\tilde{k}_g^{\eta-1} - \delta_G - \tilde{\phi} & 0 & 0 & -(\tilde{k}_g/h_1) \\ a_{21} & \dfrac{r'(.)\tilde{n}}{1+\tilde{k}_g} + r(.) - \tilde{\phi} & 1 & \dfrac{1}{h_1}(\tilde{q}-\tilde{n}) \\ \dfrac{-\tilde{n}\tilde{r}'(.)}{(1+\tilde{k}_g)^2}\dfrac{\tilde{c}}{(1-\gamma)} & \dfrac{\tilde{r}'(.)}{(1+\tilde{k}_g)}\dfrac{\tilde{c}}{(1-\gamma)} & 0 & -(\tilde{c}/h_1) \\ \dfrac{-\tilde{n}\tilde{r}'(.)}{(1+\tilde{k}_g)^2}\tilde{q} - \eta\alpha(1-\tau)(1-\eta)\tilde{k}_g^{\eta-1} & \dfrac{\tilde{r}'(.)}{(1+\tilde{k}_g)}\tilde{q} & 0 & r(.) - \tilde{\phi} \end{pmatrix} \begin{pmatrix} k_g - \tilde{k}_g \\ n - \tilde{n} \\ c - \tilde{c} \\ q - \tilde{q} \end{pmatrix}, \qquad (11)$$

where

$$a_{21} \equiv -\left[\frac{\tilde{n}^2}{(1+\tilde{k}_g)^2} r'(.) + \eta\{1 - \bar{g} + (1-\lambda)\sigma\tilde{k}_g^{\eta-1}\} + (2\eta-1)\alpha^2(h_2/2)(\bar{g}+\lambda\sigma)^2 k_g^{2\eta-2} \right].$$

The determinant of the coefficient matrix of (11) can be shown to be positive under the condition that $r(.) > \tilde{\phi}$ i.e., the steady-state interest rate facing the small open economy must be greater than the steady-state growth rate of the economy. Imposing the transversality condition (4c), we see that this condition is indeed satisfied. Since (11) is a fourth-order system, a positive determinant implies that there could be 0, 2, or 4 positive (unstable) roots. Imposing the following conditions: (i) $-1/2 < \gamma < 0$, (ii) $\delta_G \leqslant \delta_K$, and (iii) $\tilde{q} > \tilde{n}$, suffices to rule out the case of 0 and 4 positive roots.[13] Thus the dynamic system (11) can be shown to be saddle-point stable with two positive

[13] Note that conditions (i)–(iii) are sufficient for saddle-point stability. Conditions (ii) and (iii) are quite plausible, the latter asserting that the net asset position of the domestic private sector is positive. Other more complex (but less restrictive) sufficiency conditions can also be derived. Numerical solutions yield saddle-point behavior in all cases and do not require the imposition of these sufficient conditions. A more complete discussion of the equilibrium dynamics is provided in an appendix, available on request.

(unstable) and two negative (stable) roots, the latter being denoted by μ_1 and μ_2, with $\mu_2 < \mu_1 < 0$.

3. Numerical analysis of transitional paths

Further insights into the effects of transfers are obtained by analyzing the model numerically. We begin by calibrating a benchmark economy, using the following parameters representative of a small open economy, which starts out from an equilibrium with zero transfers.[14]

The Benchmark Economy

Preference parameters:	$\gamma = -1.5,\ \beta = 0.04$
Production parameters:	$\alpha = 0.4,\ \eta = 0.2,\ h_1 = 15,\ h_2 = 15.$
Depreciation rates:	$\delta_K = 0.05,\ \delta_G = 0.04$
World interest rate:	$\bar{r} = 0.06$
Premium on borrowing:	$a = 0.1$
Policy parameters:	$\tau = 0.15,\ \bar{g} = 0.05$
Transfers:	$\sigma = 0,\ \lambda = 0$

These parameter values are conventional and lead to the following plausible benchmark equilibrium reported in row 1 of Table 1(A): the ratio of public–private capital is 0.29; the consumption–output ratio is 0.59; the debt to output ratio is 0.58, leading to an equilibrium borrowing premium of 1.4% over the world rate; the capital–output ratio is over 3, with the equilibrium growth rate being just under 1.4%.[15] This equilibrium is a reasonable characterization of a small medium-indebted economy experiencing a modest steady rate of growth and having a relatively small stock of public capital. Rows 2–3 summarize key short- and long-run changes to this equilibrium following the specified changes.[16] The final column in the table summarizes the effects on economic welfare, measured by the optimized utility of the representative agent:

$$W = \int_0^{\infty} \frac{1}{\gamma} C^{\gamma} e^{-\beta t}\, dt,$$

[14] The functional specification of the upward-sloping supply curve that we use is: $r(.) = \bar{r} + e^{(an/(1+k_g))} - 1$. Thus, in the absence of any borrowing premium, when $a = 0$, $r = \bar{r}$, the world interest rate.

[15] The choice of adjustment cost $h_1 = 15$ is consistent with Ortigueira and Santos (1997), who find that $h_1 = 16$ leads to a plausible speed of convergence of around 2%. Auerbach and Kotlikoff (1987) assume $h_1 = 10$, recognizing that this is at the low values of estimates, while Barro and Sala-i-Martin (1995) propose a value above 10. We have also assumed smaller values of h_1, h_2 with little change in results. Note also that the equality of adjustment costs between the two types of capital serves as a plausible benchmark.

[16] Our analysis is based on the conventional assumption that the system starts out from an initial steady-state equilibrium. This limitation should be borne in mind when interpreting our analysis in the EU context, in which the motivation for the transfers arose because the potential recipient economies were in a transitional state.

Table 1

	$\tilde{k}_g$	$\tilde{r}$ (%)	$\widetilde{C/Y}$	$\widetilde{N/Y}$	$\widetilde{Y/K}$	ϕ_K (0) (%)	ϕ_G (0) (%)	ϕ_Y (0) (%)	ϕ_C (0) (%)	$\tilde{\phi}$ (%)	Δ (W) (%)
(A) *Responses to permanent changes*											
Benchmark											
$\sigma = 0, \lambda = 0,$ $\bar{g} = 0.05, \tau = 0.15$	**0.291**	**7.423**	**0.593**	**0.584**	**0.312**	**1.37**	**1.37**	**1.37**	**1.37**	**1.37**	—
Pure transfer											
$\sigma = 0.05, \lambda = 0,$ $\bar{g} = 0.05, \tau = 0.15$	0.291	7.423	0.643	0.584	0.312	1.37	1.37	1.37	1.37	1.37	+8.43
Tied transfer											
$\sigma = 0.05, \lambda = 1,$ $\bar{g} = 0.05, \tau = 0.15$	0.610	8.845	0.528	1.246	0.362	1.711	6.739	2.72	1.37	1.938	+10.35
(B) *Optimal responses by recipient government to tied transfer*											
No govt. response											
$\sigma = 0.05, \lambda = 1,$ $\bar{g} = 0.05, \tau = 0.15$	**0.610**	**8.845**	**0.528**	**1.246**	**0.362**	**1.938**	**1.938**	**1.938**	**1.938**	**1.938**	—
Welfare-maximizing, govt. response											
$\sigma = 0.05, \lambda = 1,$ $\bar{g} = 0.02, \tau = 0.02$	0.376	9.31	0.518	1.361	0.329	3.77	0.15	3.05	1.938	2.12	+6.94
Growth-maximizing govt. response											
$\sigma = 0.05, \lambda = 1,$ $\bar{g} = 0.16, \tau = 0.16$	1.362	10.41	0.270	2.393	0.425	2.41	8.47	3.62	1.938	2.562	−23.18

where C is evaluated along the equilibrium path. These welfare changes are calculated as the percentage change in the initial stock of capital necessary to maintain the level of welfare unchanged following the particular shock.

3.1. Permanent shocks

Row 2 of Table 1(A) reports the effects of a permanent *pure transfer* equal to 5% of the recipient country's GDP. This represents a pure wealth effect, which from (10a) to (10d) has no effect on $\tilde{k}_g$, $r(.)$, $\tilde{n}$, $\tilde{\phi}$, and therefore no effect on the transitional adjustments. All that happens is that the transfer leads to an immediate and permanent increase in consumption, raising the consumption–output ratio from 0.59 to 0.64, and leading to an increase in welfare of 8.4%.

Row 3 describes the impact of a permanent *productive transfer*, fully tied to investment in public capital, and which is also 5% of the economy's GDP. In the new steady state the ratio of public to private capital increases from 0.29 to 0.61, thereby generating a huge investment boom in infrastructure. The increase in the stock of public capital increases the marginal productivity of private capital, thereby leading to a positive, though lesser accumulation of private capital. Although the transfer stimulates consumption through the wealth effect (like the pure transfer) the higher long-run productive capacity has a greater effect on output, leading to a decline in the long-run consumption–output ratio from 0.59 to 0.53. The higher productivity raises the long-run growth rate to 1.94%, while long-run welfare improves by 10.35%, as indicated in the last column of row 3. The increased accumulation of both private and public capital lead to a higher demand for external borrowing as a means of financing new investment in private capital and the installation costs of public capital. This results in an increase in the steady-state debt–output ratio from 0.58 to 1.25, raising the borrowing premium to over 2.8%. However, this higher debt relative to output is sustainable since it is caused by higher investment demand rather than higher consumption demand. The long run increase in the economy's productive capacity (as measured by the higher stocks of public and private capital, and output) ensures that the higher debt is sustainable.[17]

The transitional dynamic paths are depicted in Fig. 1. Fig. 1(1) illustrates the stable adjustment locus in k_g–n space, indicating how k_g and n increase almost proportionately during the transition. The contrasting transitional paths of the four growth rates ϕ_K, ϕ_G, ϕ_Y and ϕ_C toward their common long-run growth rate are shown in Fig. 1(2). The stimulus to public capital raises its initial growth rate to over 6.7%, after which it declines monotonically. By contrast, private capital adjusts only gradually. Indeed, after increasing on impact to 1.71%, it declines marginally, before the stimulating effect of the higher public capital has its full impact and eventually raises its growth rate toward the equilibrium. The growth rate of output is an average of the growth rates of the two capital stocks. The fact that the growth rate of output initially doubles from 1.37% to 2.72% is of interest and is consistent with the experiences of some of the recipient countries in the EU. Finally, the growth rate of consumption is unaffected on impact and responds only gradually. The reason for this is evident from the fact that it depends upon the sluggishly evolving debt–capital ratio, n. Figs. 1(3)–1(5) illustrate the transition paths for the capital–output, debt-output, and the consumption–output ratios, respectively. The K/Y ratio declines and the N/Y ratio increases monotonically through time. This is because the accumulation of public capital raises the average productivity of private capital, while the accumulation of both types of capital raises the need to borrow from abroad. By contrast, the C/Y ratio initially increases before declining through time. This is because the wealth effect associated with the transfer raises consumption immediately, while the effect on the economy's productive capacity, through capital accumulation, takes time.[18]

3.2. *Domestic co-financing and welfare gains*

Table 1(B) deals with the issue of domestic co-financing in response to a transfer shock, a feature common to most bilateral aid flows for public investment projects, especially in the context of the EU's recent aid programs to aspiring member nations. As our results show, the effect of a capital transfer on the domestic economy depends in part upon the response (if any) of the recipient government. In this respect we can easily show that a *tied* fiscal transfer of a given amount, coupled with an equivalent

[17] This view has also been expressed by Roubini and Wachtel (1998).

[18] We have also considered the time path for the instantaneous utility and find that it is uniformly higher at each instant of time with the tied transfer.

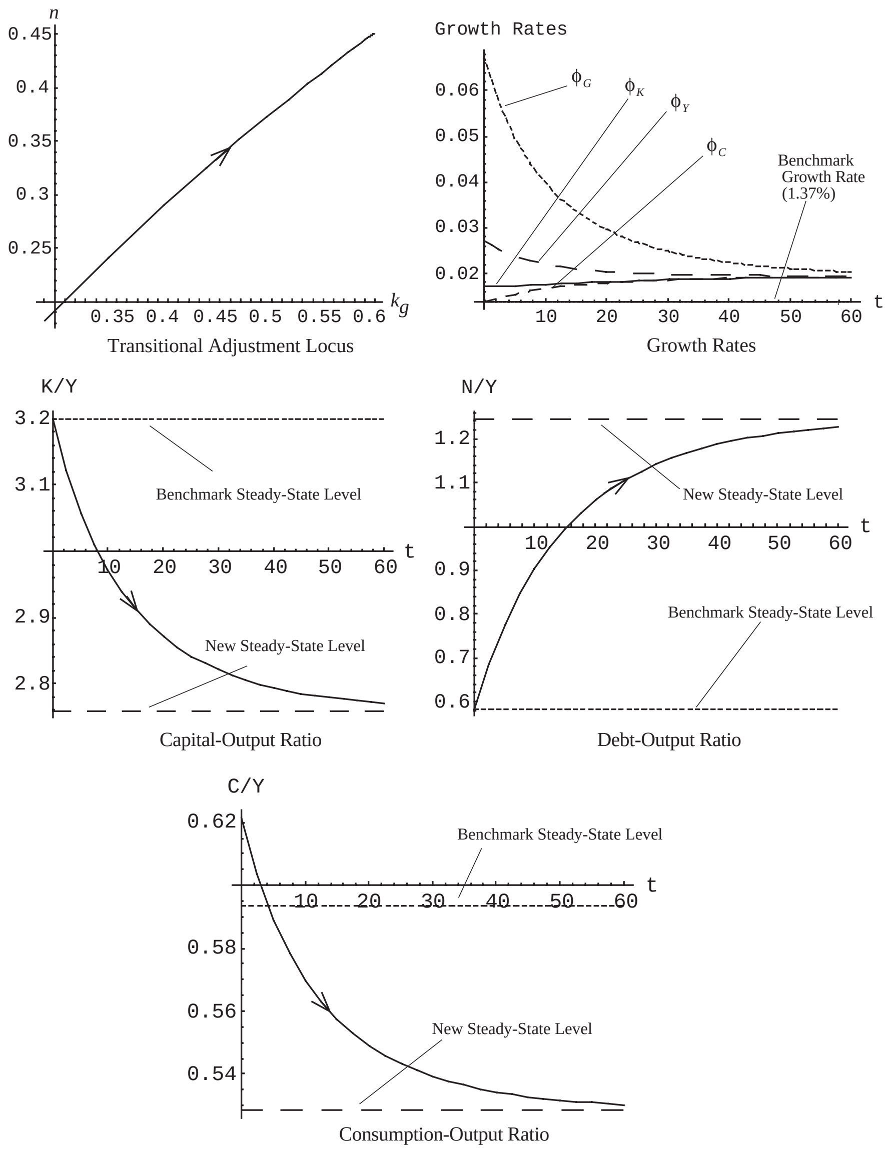

Fig. 1. Transitional adjustment to a permanent productive transfer shock $\lambda = 1$; $\sigma = 0.05$: (1) Transitional adjustment locus; (2) growth rates; (3) capital–output ratio; (4) debt–output ratio; (5) consumption–output ratio.

decrease in domestic government expenditure, is equivalent to an *untied* transfer of an equivalent amount. We focus primarily on the welfare-maximizing fiscal response.[19]

[19] In an expanded version of the paper we have considered additional co-financing arrangements, such as where the domestic government matches the foreign contribution.

We assume that the government sets its expenditure rate, $\bar{g}$, and its tax rate, τ, so as to balance the costs of the net purchase of capital, given the transfers, namely[20]

$$\tau = \bar{g} - (1 - \lambda)\sigma. \tag{12}$$

We then determine the optimal fiscal responses, τ, $\bar{g}$ constrained by (12) that maximize the welfare gains generated by the transfer, namely

$$\Delta(W) = \int_0^\infty \frac{1}{\gamma}[(C(t))^\gamma - (\tilde{C}(t))^\gamma]\mathrm{e}^{-\beta t}\,\mathrm{d}t, \tag{13}$$

where $\tilde{C}$ is the consumption along an initial equilibrium balanced growth path. Setting $\tau, \bar{g}$ in accordance with (12), we find that the equilibrium path (9a)–(9d) is independent of λ. This is important since it implies that by combining the transfer with the appropriate expenditure and tax mix, the recipient economy can choose an equilibrium path and associated level of welfare that is independent of any constraints imposed by the donor country.

This welfare-maximizing response is summarized in row 2. Without loss of generality, setting $\lambda = 1$ the optimal response is $\bar{g} = \tau = 0.02$ ($g = 0.07$). This implies a long-run growth rate of 2.1%, with the short-run growth rates of public capital, private capital, and output, being 0.15%, 3.8% and 3%, respectively. The corresponding intertemporal gain in welfare is 6.9%.

For comparison the steady-state growth maximizing fiscal policies are reported in row 3 and illustrate a dramatic trade-off between growth maximization and welfare maximization. Growth maximization implies $\hat{\tau} = 0.16 = \bar{g} = 0.16$ ($= \hat{g} = 0.21$). This response causes the steady-state growth rate to nearly double from the original benchmark value of 1.37–2.56%, with all short-run growth rates undergoing similar dramatic increases. This emphasis on growth and capital accumulation leaves less output available for consumption. This is undesirable from a welfare standpoint, and indeed, welfare drops by a huge margin of 23.2% relative to the new benchmark.[21]

3.3. Some sensitivity analysis

While the above parameters represent a plausible description of a small poorly endowed economy, some of the results are dependent upon this characterization. Tables 2 and 3 conduct some sensitivity analysis. Table 2 considers two alternative benchmark economies, corresponding to $\bar{g} = 0.12$ (large domestic government investment) and $\bar{g} = 0.02$ (small domestic government investment). In the first case (benchmark II), a tied transfer leads to a small welfare loss of 1.65%. By contrast, the untied transfer is highly desirable, improving welfare by 10.5%. The reason for this is such an economy is characterized by an overly large stock of public capital relative to private capital and a large foreign debt. It is clearly better off by reducing its debt and is only made worse off by increasing its stock of public capital.

[20] That is, we assume $\bar{G} + \lambda TR = \tau Y + TR$ from which (12) follows.

[21] This specific result does depend upon the magnitude of the adjustment costs. If, instead, $h_1 = h_2 = 8$, we find that the growth-maximizing response is also welfare-improving relative to the benchmark.

Table 2
Alternative benchmarks

	$\widetilde{k_g}$	$\tilde{N}/\tilde{Y}$	$\tilde{\phi}$%	$\Delta(W)$%
Benchmark II				
$\sigma=0, \lambda=0,\ \bar{g}=0.12, \tau=0.15$	**0.742**	**0.846**	**2.096**	—
Pure transfer				
$\sigma=0.05, \lambda=0,\ \bar{g}=0.12, \tau=0.15$	0.742	0.846	2.096	+10.50
Tied transfer				
$\sigma=0.05, \lambda=1,\ \bar{g}=0.12, \tau=0.15$	1.077	0.972	2.410	−1.65
Benchmark III				
$\sigma=0, \lambda=0,\ \bar{g}=0.02, \tau=0.15$	**0.109**	**−0.114**	**0.069**	—
Pure transfer				
$\sigma=0.05, \lambda=0,\ \bar{g}=0.02, \tau=0.15$	0.109	−0.114	0.069	+7.55
Tied transfer				
$\sigma=0.05, \lambda=1,\ \bar{g}=0.02, \tau=0.15$	0.417	0.876	1.634	+32.10

Table 3
Welfare sensitivity to installation costs and capital market imperfections ($\sigma=0$–0.05; $\lambda=1$)

a	$h_2=1$		$h_2=15$		$h_2=50$	
	$\lambda=0$ (%)	$\lambda=1$ (%)	$\lambda=0$ (%)	$\lambda=1$ (%)	$\lambda=0$ (%)	$\lambda=1$ (%)
0.03	9.44	26.75	9.79	18.58	10.78	−4.81
0.10	8.17	17.01	8.43	10.35	9.15	−7.83
10	7.73	15.32	7.96	9.47	8.60	−6.09

For benchmark III things are reversed. The country has only a small ratio of public to private capital and actually is a foreign creditor. The tied transfer improves welfare dramatically by 32.1%. With small debt, the pure transfer is now only moderately welfare improving, and indeed less than for benchmark II.

A natural question concerns the extent to which the gains from a foreign transfer depend upon (i) the installation costs associated with public capital (h_2) and (ii) the borrowing premium or default risk (parameterized by a). Table 3 presents these gains for the two cases $\lambda=0$ and 1, for three values of each of these parameters, in the case that the domestic government acts passively. The values of $h_2=1$, 15, and 50 correspond to low, medium, and high installation costs, while $a=0.03, 0.10$, and 10 correspond to low, medium, and high borrowing premiums. The percentage changes reported in the table refer to the benchmark that would correspond to the associated combination of parameters. Thus, for example, the figures in the top left-hand corner imply that an economy for which $a=0.03$, $h_2=1$ will enjoy an 9.44% improvement in welfare if it experiences a 5% pure transfer, and a 26.75% welfare gain if the transfer is tied to investment in public capital. From this table we can make the following observations:

(i) For a given country borrowing premium (i.e. given a) an increase in the installation costs of public capital (h_2) leads to larger welfare gains from a pure transfer of a given magnitude, but a decrease in welfare gains if the transfer is tied to public capital.

(ii) For given installation costs, an increase in the borrowing premium in general leads to lower long-run welfare gains from the transfer.

(iii) For very high installation costs the economy is better off with a pure transfer: A tied or productive transfer is welfare reducing in the long run, irrespective of the nature of world capital markets. However, in all other cases, welfare gains from productive transfers are higher than those from pure transfers.

The result in (iii) that under very high adjustment costs, a tied transfer is welfare deteriorating is interesting. Intuitively, it reflects the fact that by tying the transfers, the donor country is committing the recipient country to devote a large portion of its resources to the costly task of installation, thereby making it worse off.

4. Temporary transfers

Most transfer programs, whether pure or productive, are only temporary. Thus it is important to analyze the consequences of a temporary transfer. As before, we assume that the magnitude of the transfer is 5% of the recipient country's GDP, and we focus on the polar cases of a pure transfer ($\lambda = 0$) and a fully tied productive transfer ($\lambda = 1$), respectively. We assume that the duration of the transfer is 10 years, consistent with the average length of the EU's Structural Funds Programs.

The results of our experiments are reported in Table 4(A) and 4(B), and their dynamics are illustrated in Figs. 2–4.[22] The first four columns of Table 4(A) report the instantaneous impact of a temporary transfer on the growth rates of private and public capital, output, and consumption, respectively. Rows 1 and 2 describe the nature of the transfer shock, i.e., whether it is tied or pure.

4.1. Pure transfer

We turn first to the pure transfer, reported in row 1. Neither the growth rate of consumption nor debt responds immediately. In the case of consumption, the reason for this remains as for the permanent transfer; its growth rate is tied via the borrowing rate to the debt–capital ratio, n, which is constrained to evolve continuously over time. Similarly, when $\lambda = 0$, ($6''$) implies that the growth rate of public capital responds to the productivity of public capital, Y/K_G, which also evolves only gradually. By contrast, the growth rate of private capital, being determined by q, does respond on impact, increasing from 1.37% to 1.57%. This is because with the transfer being only temporary, the initial response in the consumption–output ratio is dampened from 0.64, if it were permanent, to about 0.625, thereby freeing some domestic output, which then becomes available for investment in private capital. The short-run higher growth rate

[22] The formal solutions for the case of temporary shocks are provided in an Appendix available from the authors.

Table 4
(A) Key responses to a temporary transfer shock Benchmark steady state : $\lambda = 0$; $\sigma = 0$; $\bar{g} = 0.05$; $\tau = 0.15$; $T = 10$ years and (B) Permanent effects of a temporary transfer shock

(A)	Initial response of growth rates of key variables					
	ϕ_K (0) (%)	ϕ_G (0) (%)	ϕ_C (0) (%)	ϕ_Y (0) (%)	$\tilde{\phi}$ (%)	
Pure transfer						
$\lambda = 0$; $\sigma = 0.05$	1.58	1.37	1.37	1.54	1.37	
Productive transfer						
$\lambda = 1$; $\sigma = 0.05$	1.74	6.74	1.37	2.74	1.37	
(B)	Permanent gains/losses (relative to the benchmark) across steady states (Benchmark = 1)					
	K	K_G	C	N	Y	W (%Δ)
Pure transfer						
$\lambda = 0$; $\sigma = 0.05$	1.03	1.03	1.03	1.04	1.03	4.46 %
Productive transfer						
$\lambda = 1$; $\sigma = 0.05$	1.08	1.10	1.08	0.79	1.08	5.32 %

of private capital raises the short-run growth rate of output to 1.54%, this reflecting the relative importance of private capital in production.

In contrast to the permanent pure transfer, the adjustments are characterized by transitional dynamics. These can be understood by considering Fig 2(1), the phase diagram describing the dynamic adjustments of the ratio of public to private capital, k_g and the debt–capital ratio n, in conjunction with the growth rates for, K and K_G illustrated in Fig. 2(2), and N (not illustrated).[23]

Suppose that the economy starts out from the equilibrium point A in Fig. 2(1). Since the transfer has no impact on the initial growth of public capital, while leading to more private investment, the ratio of public capital to private capital, k_g, begins to decline. At the same time, while the untied transfers reduce the accumulation of debt, the higher investment and consumption has the opposite effect. On balance, the former effect dominates, and the initial growth rate of debt falls from its benchmark value of 1.37–0.5%, so that the debt–capital, n, ratio begins to decline as well. The economy therefore begins to move along the locus AB in Fig. 2(1). During the early stages of the decline in k_g and n, the growth rate of private capital continues to increase, though at a declining rate, reaching a peak at about 1.61% after 6 periods, after which it too begins to decline. This is because the initial jump in q, together with the decline in k_g reduces the rate of return on private capital, requiring $\dot{q} > 0$, to ensure that the return on capital equals the cost on debt, which initially declines at a slower

[23] The reason for not illustrating the growth rate of N is one of scale. Its growth rate is much larger (in magnitude) than that of Y, a fact that can be inferred from the N/Y ratio illustrated in Fig. 2(3). Critical values are as follows. During the duration of the temporary pure transfer $\dot{N}/N$ declines from 0.5% to −5.6% until $t = 10$, when it immediately jumps to +5.9% before converging back to the steady-state value of 1.37%.

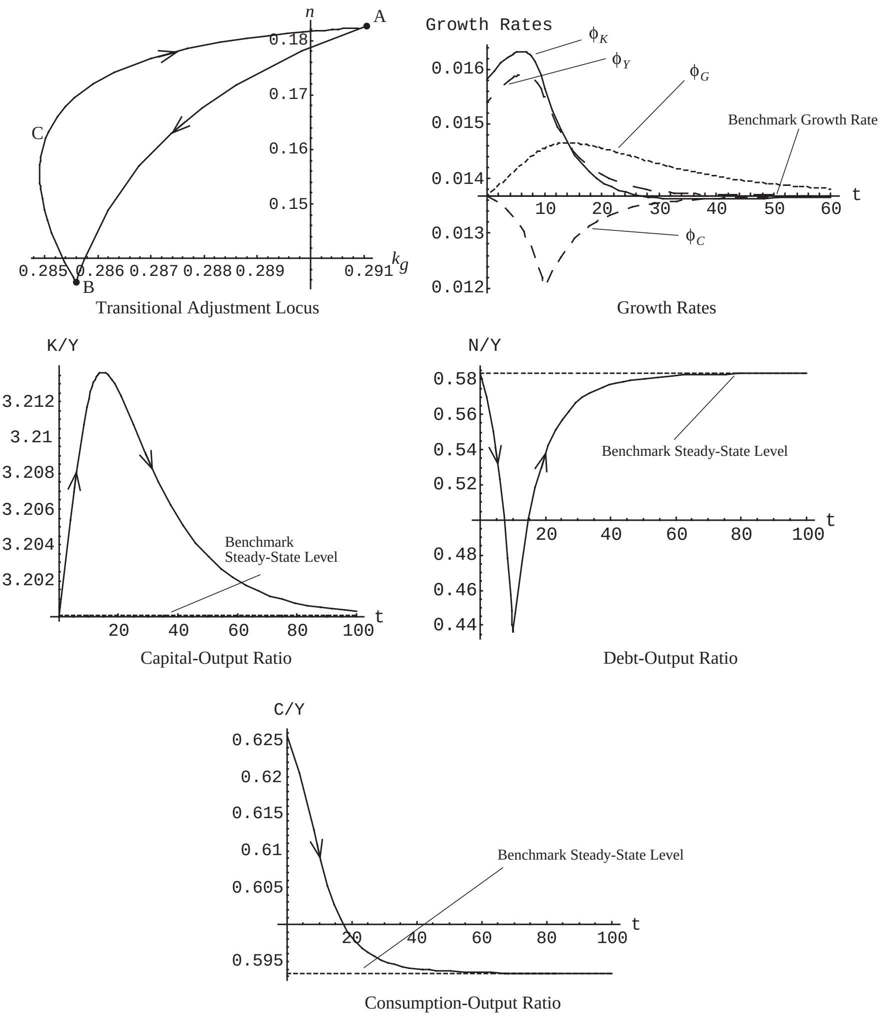

Fig. 2. Transitional adjustment to a temporary pure transfer shock $\lambda = 0$; $\sigma = 0.05$; duration of shock $=10$ years: (1) Transitional adjustment locus; (2) growth rates; (3) capital–output ratio; (4) debt–output ratio; (5) consumption–output ratio.

rate. The increase in the private capital stock raises the growth rate of output, thereby gradually increasing the growth of public capital, and thus slowing the decline in k_g. By contrast, as n declines, the decline in the growth rate of debt accelerates dramatically, due primarily to the lower interest costs. After 10 periods, when the transfer ceases, the economy is at B. At that point, the growth rates of K, K_G, and N are, respectively, 1.56%, 1.45%, and −5.60%. However, the removal of the transfer immediately raises the growth rate of debt to 5.88%, so that the debt–capital ratio starts to increase. By contrast, with private capital still being accumulated at a faster rate than public capital,

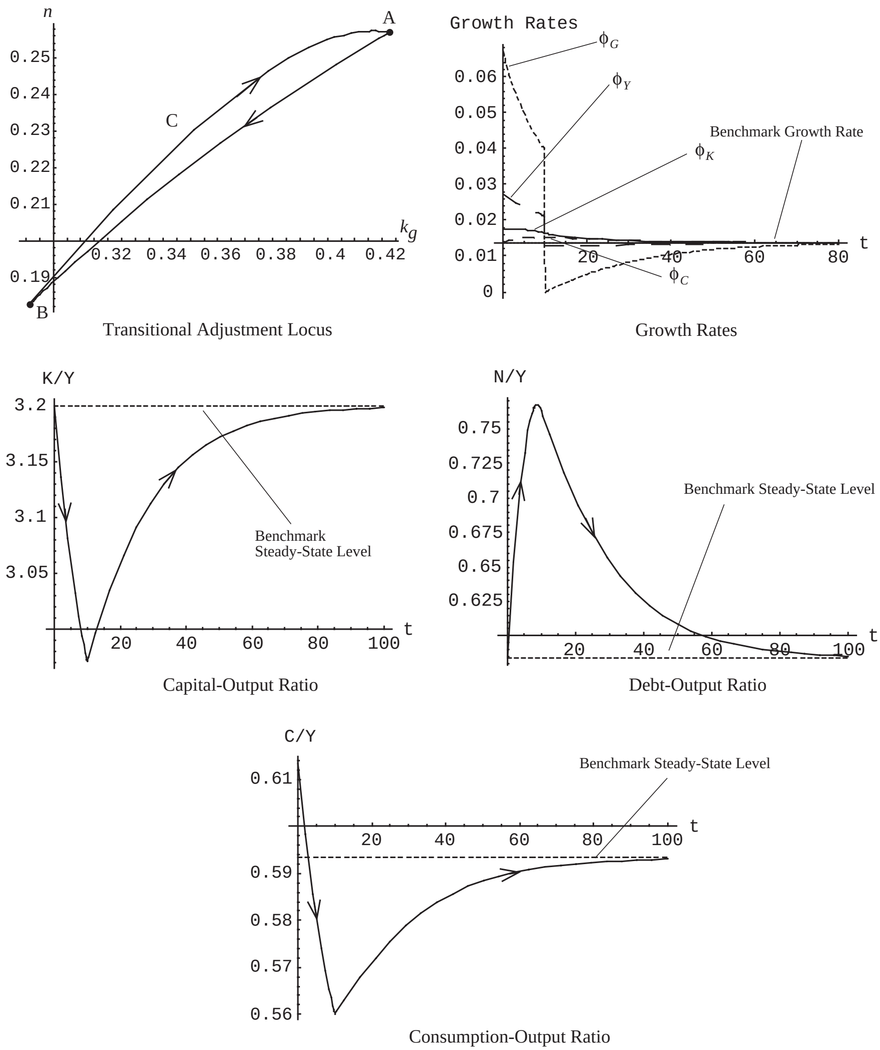

Fig. 3. Transitional adjustment to a temporary productive transfer shock $\lambda = 1$; $\sigma = 0.05$; duration of shock $=10$ years: (1) Transitional adjustment locus; (2) growth rates; (3) capital–output ratio; (4) debt–output ratio; (5) consumption–output ratio.

k_g continues to decline, though with the former declining and the latter increasing, this decline ceases at time 15, when the economy is at C. Thereafter, the reduced relative stock of public capital raises its productivity, encouraging public investment so that the economy returns to its original equilibrium along CA, with both k_g and n increasing. From Fig. 2(2) the growth rate of output is seen to be an average of that of the two capital stocks, while the time path for the consumption growth rate reflects that of the time path of n.

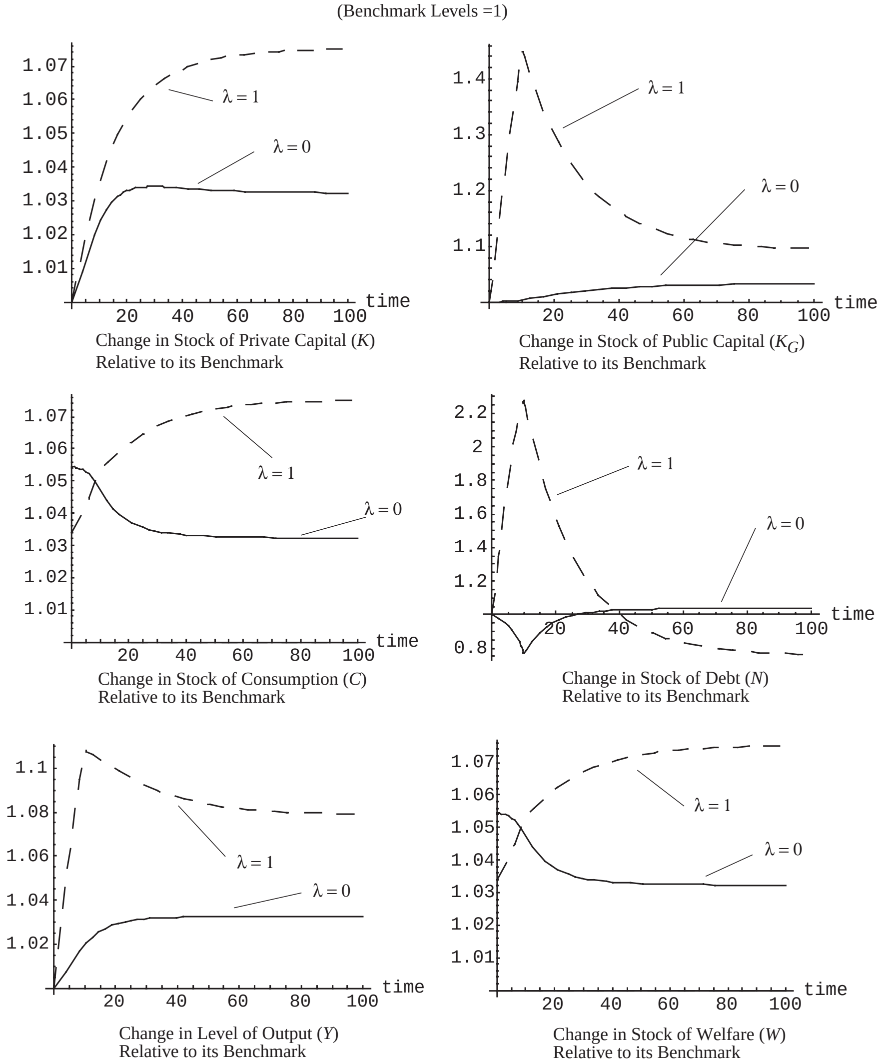

Fig. 4. Comparison of the permanent effects of temporary productive and pure transfer shocks (Benchmark Levels =1): (1) Change in stock of private capital (K) relative to its benchmark; (2) Change in stock of public capital (K_g) relative to its benchmark; (3) Change in stock of consumption (C) relative to its benchmark; (4) Change in stock of debt (N) relative to its benchmark; (5) Change in level of output (Y) relative to its benchmark; (6) Change in stock of welfare (W) relative to its benchmark.

Figs. 2(3)–2(5) illustrate the dynamic time paths of the capital–output, debt–output, and consumption–output ratios, respectively. These all mirror the differential growth rates set out in Fig. 2(2). Thus, for example, the K/Y ratio is increasing or decreasing, as long as the ratio k_g is falling, or rising. Likewise the fact that C/Y falls rapidly at first is because during this period Y is rising while C is falling; the decline is more gradual when the two growth rates are close to converging.

4.2. Tied transfer

Row 2 of Table 4(A) reports the impact of a temporary tied (productive) transfer. Again, the growth rate of consumption does not respond instantaneously. However, the growth rates of all other variables respond instantaneously with the magnitudes of these initial jumps being significantly higher than for a pure transfer. Thus, the growth rate of private capital increases on impact to 1.74% as compared to 1.58% for a pure transfer. With the transfer being tied to public investment, the growth rate of public capital increases to 6.7%, a sharp contrast to its sluggish response to a pure transfer. As a result, the growth rate of output increases to 2.74% as against 1.53% for a pure transfer. It is interesting to observe that when compared to the corresponding jumps for a permanent productive transfer shock (see Table 1(A); columns 6–9), we find that a temporary productive transfer induces a marginally larger initial responses in growth rates than does a permanent shock of equal magnitude. Thus, in the short run, while the transfer program is in effect, strong positive differentials are created in growth rates relative to the benchmark.

The dynamics can be understood by considering Fig. 2 in conjunction with the growth rates illustrated in Fig. 3. These indicate a dramatic contrast from those of the pure transfer; indeed the time paths for most variables are generally reversed. [24] Suppose that the economy starts out at point A in Fig. 3(1). With the dramatic increase in the growth rate of public capital, far exceeding that of private capital, the ratio of public to private capital begins to rise. At the same time, with the tied transfers being unavailable for debt reduction, the higher consumption and investment leads to a similar dramatic increase in the growth rate of debt, which increases at the rate of 19% on impact, so that the debt–capital ratio begins to rise sharply as well. The economy therefore begins to move along the locus ACB in Fig. 3(1). As k_g and n both increase, the growth rates of both public capital and debt decline dramatically, the latter more so, with the economy reaching B after 10 periods. The permanent elimination of the transfer at that time reverses the dynamics, taking the economy back to its original equilibrium along the locus BDA.

From Fig. 3(2), we see that following the initial jump, the growth rates of public and private capital, and output start declining toward the benchmark growth rate. The growth rate of consumption, although unaffected initially, increases slightly in transition. At the end of the program, when the transfer flows cease, the growth rate of public capital jumps down below its benchmark level, after which it then increases back to its (unchanging) equilibrium level.

[24] Again, the growth rate of N cannot be conveniently illustrated in Fig. 4(2), because of differences in magnitude, which are now even more dramatic. Critical values are now as follows. During the duration of the temporary tied transfer $\dot{N}/N$ declines from 19% to 3.2% at $t=10$, when it immediately jumps to -2.8% before converging back to the steady-state value of 1.37%.

Figs. 3(3)–3(5) present the dynamic paths of the capital–output, debt–output, and consumption–output ratios, respectively. These are all generally opposite to those for the pure transfer, reflecting the reversal in the dynamics of k_g and n. One interesting difference arises with respect to the consumption–output ratio, which falls below its benchmark during the period the transfer is in effect. This is due to a short-run substitution of consumption for capital accumulation. However, the end of the transfer program causes a reverse substitution towards consumption, and the ratio increases to its benchmark in the long run. The main general picture to emerge in comparing Figs. 2 and 3, we see that the particular nature of the incoming transfer has important implications for the economy's dynamic adjustment, both in the short run as well as in the long run. In our case, the transitional dynamics of a pure transfer are very different from those of a productive transfer.

4.3. Permanent effects of a temporary transfer shock

In this section we show how a temporary transfer program, by altering the growth rate during the transition, can have permanent effects on the *levels* of key variables such as the capital stock, output, and consumption of the recipient economy. In addition we show how the type of incoming transfer (pure or tied) affects the magnitude and direction of the permanent effects. Fig. 4 and Table 4(B) report the permanent effects of temporary transfers. Specifically, we normalize the benchmark steady-state level to unity and express the new steady-state levels relative to the normalized benchmark. Thus, the ratio of 1.10 across steady states implies a 10% increase in levels relative to the benchmark.[25]

From Table 4(B) we see that temporary transfers do indeed have permanent effects on the levels of key economic variables. However, as the results reveal, the magnitude of the effects are different, depending upon the specific nature of the transfer. From row 1 we see that a temporary pure transfer leads to only a 3% long-run improvement in the stocks of private and public capital and in the levels of consumption and output. However, the debt position of the economy worsens by 4% in the long run. On the other hand, the long-run effects of a productive transfer are less uniform and larger in magnitude. Row 2 indicates that a temporary productive transfer increases the long-run stocks of private and public capital by 7% and 10%, respectively. Consumption and output increase by 7% and 8%, respectively. For both types of transfer, the effects on intertemporal welfare are substantial being 4.46% and 5.32%, respectively. The relatively small difference is due to the fact that the greater benefits associated with the tied transfer occur through time and therefore are discounted. The long-run debt position of the economy actually improves by over 20%. This is in contrast to the result for pure transfers: a temporary productive transfer improves the current account permanently, while a pure transfer causes a permanent deterioration of the current account. This is due to the fact that the increase in long-run productive capacity, as measured by the long-run changes in the stock of private and public capital, and the level of output, is much larger for a productive shock. The higher long-run

[25] The formal details are provided in an appendix available on request from the authors.

productive capacity enables the economy to improve its long-run debt position. The above results are graphically represented in Fig. 4.

5. Conclusions

In this paper we have addressed an important issue, namely the impact of a program of tied transfers, such as those implemented recently by the EU, on the growth and macroeconomic performance of the recipient country. We have considered both permanent and temporary transfers, the former serving as a benchmark, the latter being a closer representation of actual policies.

The main general conclusion to emerge is that there is a sharp contrast in the effects of pure transfers of the traditional Keynes–Ohlin type and the current program of tied transfers adopted by the European Union. A permanent pure transfer has no growth or dynamic consequences. It is always welfare improving, the gains varying positively with the size of the government, when the stock debt and the benefits of debt reduction increase. A tied transfer generates dynamic adjustments, as public capital is accumulated in the recipient economy. Its effect on the long-run growth rate, and the extent to which this is beneficial, depends upon the size of the infrastructure in the economy, as well as the co-financing arrangements, if any, imposed on that economy, and how its government chooses to react to the additional flow of resources. For what we consider to be the most applicable case of an economy relatively poorly endowed with public capital, a tied transfer will both raise the long-run growth rate and yield greater intertemporal benefits than does a pure transfer. However, the benefits from an equal co-financing, similar to that proposed by the EU, are substantially smaller than if no such arrangement were imposed. If the economy is relatively well endowed with government capital a tied transfer is welfare deteriorating, and is particularly harmful if it involves domestic co-financing.

These contrasts also apply to temporary transfers, and in particular to the transitional dynamics in the two cases. Whereas a temporary pure transfer has only a modest short-run growth effect, the productive transfer has significant impacts on short-run growth thus validating the position taken by the EU. Both transfers, although only temporary, have permanent effects on levels, with those of the tied shock being significantly greater. For example, for the benchmark economy we find that a 10 year tied transfer of 5% of the recipient economy's GDP raises long-run output by 8% and its welfare by 5%, values we find to be significant.

We conclude with two final comments. First, the fact that the effects of the tied transfer are less certain than those of the pure transfer, depending upon the size of the government in the recipient economy, suggests that the donor economy must be careful to ensure that it has accurate information on the recipient economy. Otherwise, it may lead to a welfare deterioration in the recipient economy. Second, we should note that we have focused on the effects of the transfer on the economic performance of a small recipient economy. Being small, this has no feedback on the donor economy. But such transfers are being proposed simultaneously for a number of prospective member nations, the collective feedback effects of which on the donor economy need no longer be negligible. A natural extension of this analysis is, therefore, to consider the transfer in a multicountry growth equilibrium setting.

Acknowledgements

We would like to thank Philip Brock, Theo Eicher, Charles Engel, Thorvaldur Gylfason, Levis Kochin, Marcus Miller, Neil Rankin, Jordan Rappaport, Partha Sen and seminar participants at the Academia Sinica, Emory University, and the Universities of Georgia, Kansas, Warwick, and Washington for comments. The paper has also benefited from presentation at the Eighth World Congress of the Econometric Society in Seattle, as well as at the CEPR–EPRU Conference on Dynamic Aspects of Public Expenditure in Copenhagen. Finally, we are grateful to two anonymous referees and the Editor, Jordi Gali, for their suggestions, which have significantly improved the paper. This research was supported in part by the Castor Endowment at the University of Washington. In addition, Chatterjee gratefully acknowledges financial support from the Grover and Creta Ensley Fellowship. Sakoulis would like to thank the James K. and Viola M. Hall Fellowship for financial support. The opinions expressed in this paper are those of the authors and do not necessarily reflect those of JP Morgan Fleming Asset Management.

References

Arrow, K.J., Kurz, M., 1970. Public Investment, the Rate of Return, and Optimal Fiscal Policy. Johns Hopkins University Press, Baltimore, MD.

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

Aschauer, D.A., 1989b. Does public capital crowd out private capital? Journal of Monetary Economics 24, 171–188.

Auerbach, A.J., Kotlikoff, L.J., 1987. Dynamic Fiscal Policy. Cambridge University Press, Cambridge, UK.

Bardhan, P.K., 1967. Optimal foreign borrowing. In: Shell, K. (Ed.), Essays on the Theory of Optimal Economic Growth. MIT Press, Cambridge, MA, pp. 117–128.

Barro, R.J., 1990. Government spending in a simple model of endogenous growth. Journal of Political Economy 98, 103–125.

Barro, R.J., Sala-i-Martin, X., 1995. Economic Growth. McGraw-Hill, New York.

Baxter, M., King, R.G., 1993. Fiscal policy in general equilibrium. American Economic Review 83, 315–334.

Bhagwati, J.N., 1967. The tying of aid. In: Bhagwati, J.N., Eckaus, R.S. (Eds.), Foreign Aid. Penguin, Harmondsworth, pp. 235–293.

Bhagwati, J.N., Brecher, R.A., Hatta, T., 1983. The generalized theory of transfers and welfare: bilateral transfers in a multilateral world. American Economic Review 83, 606–618.

Bhandari, J.S., Haque, N.U., Turnovsky, S.J., 1990. Growth, external debt, and sovereign risk in a small open economy. IMF Staff Papers 37, 388–417.

Brakman, S., van Marrewijk, C., 1998. The economics of international transfer. Cambridge University Press, Cambridge, UK.

Brock, P.L., 1996. International transfers, the relative price of non-traded goods, and the current account. Canadian Journal of Economics 29, 163–180.

Burnside, C., Dollar, D., 2000. Aid, policies, and growth. American Economic Review 90, 847–868.

Cassen, R., 1986. Does Aid Work? Clarendon Press, Oxford.

Devarajan, S., Xie, D., Zou, H., 1998. Should public capital be subsidized or provided? Journal of Monetary Economics 41, 319–331.

Djajic, S., Lahiri, S., Raimondos-Moller, P., 1999. Foreign aid, domestic investment and welfare. Economic Journal 109, 698–707.
Eaton, J., Gersovitz, M., 1989. Country risk and the organization of international capital transfer. In: Calvo, G., Findlay, R., Kouri, P., Braga de Macedo, J. (Eds.), Debt, Stabilization and Development: Essays in Memory of Carlos Diaz-Alejandro. Blackwell, Oxford, UK, pp. 109–129.
Edwards, S., 1984. LDC foreign borrowing and default risk: An empirical investigation 1976–80. American Economic Review 74, 726–734.
European Union, 1998a. Council regulation for an instrument for structural policies for pre-accession. Draft proposal.
European Union, 1998b. Commission Communication to the Council and to the European Parliament on the Establishment of a New Financial Perspective for the Period 2000–2006.
Fisher, W.H., Turnovsky, S.J., 1998. Public investment, congestion, and private capital accumulation. Economic Journal 108, 339–413.
Futagami, K., Morita, Y., Shibata, A., 1993. Dynamica analysis of an endogenous growth model with public capital. Scandinavian Journal of Economics 95, 607–625.
Galor, O., Polemarchakis, H.M., 1987. Intertemporal equilibrium and the transfer paradox. Review of Economic Studies 54, 147–156.
Gang, I.N., Khan, H.A., 1990. Foreign aid, taxes, and public investment. Journal of Development Economics 34, 355–369.
Glomm, G., Ravikumar, B., 1994. Public investment in infrastructure in a simple growth model. Journal of Economic Dynamics and Control 18, 1173–1187.
Hatzipanayotou, P., Michael, M.S., 2000. The financing of foreign aid and welfare: Income versus consumption tax. Review of Development Economics 4, 21–38.
Hulten, C.R., 1996. Infrastructure capital and economic growth: How well you use it may be more important than how much you have. NBER working paper 5847.
Keynes, J.M., 1929. The German transfer problem. Economic Journal 39, 1–7.
Khan, H.A., Hoshino, E., 1992. Impact of foreign aid on the fiscal behavior of LDC governments. World Development 20, 1481–1488.
Obstfeld, M., 1982. Aggregate spending and the terms of trade: Is there a Laursen–Metzler effect? Quarterly Journal of Economics 97, 251–270.
Ohlin, B.G., 1929. Transfer difficulties, real and imagined. Economic Journal 39, 172–178.
Ortigueira, S., Santos, M.S., 1997. On the speed of convergence in endogenous growth models. American Economic Review 87, 383–399.
Rebelo, S., 1991. Long-run policy analysis and long-run growth. Journal of Political Economy 94, 1002–1037.
Roubini, N., Wachtel, P., 1998. Current account sustainability in transition economies. NBER working paper 6468.
Sachs, J., 1984. Theoretical issues in international borrowing. Princeton Studies in International Finance, Vol. 54.
Turnovsky, S.J., 1997a. Public and private capital in an endogenously growing open economy. In: Jensen, B.S., Wong, K.Y. (Eds.), Dynamics, Economic Growth, and International Trade. University of Michigan Press, Ann Arbor, MI, pp. 171–210.
Turnovsky, S.J., 1997b. Public and private capital in an endogenously growing economy. Macroeconomic Dynamics 1, 615–639.
Turunen-Red, A.H., Woodland, A.D., 1988. On the multilateral transfer problem: Existence of Pareto improving international transfers. Journal of International Economics 25, 249–269.
World Bank, 1994. World Development Report 1994: Infrastructure for Development. Oxford University Press, New York.