

Capital Goods Imports, the Real Exchange Rate, and the Current Account

Luis Servén

Capital goods account for a major share of international trade, yet trade in capital goods is typically ignored in conventional macroeconomic models of open economies. As a consequence, such models may provide an incomplete — and misleading — assessment of the macroeconomic effects of policy changes and external shocks.



Summary findings

Empirical and aggregate models of open economies typically rule out trade in capital goods. But capital goods account for a significant share of world trade. In 1993, they represented 11 percent of exports and 15 percent of imports. In the same year, capital goods imports represented an average of roughly 30 percent of total imports for 82 industrial and developing countries, and almost 9 percent of their GDP.

Serven shows that the presence of imported capital goods greatly changes the short- and long-run effects of macroeconomic policies and external shocks on key macroeconomic variables. Using a rational expectations aggregate model with intertemporal utility, agents and with trade in both consumption and capital goods, he finds that the long-run equilibrium of the economy displays a negative relationship between the real exchange rate and real output. That is, a real

appreciation is associated with an increase in aggregate output and the capital stock. With investment subject to adjustment costs, the response to unanticipated permanent disturbances involves a change in the real exchange rate and a non-zero current account.

Serven analyzes the macroeconomic consequences of changes in fiscal policy and of transfers of wealth from abroad. He shows that both have well-defined long-run effects on the capital stock and real output. Fiscal expansion, in particular, may have a long-run crowding-in effect on investment.

By contrast, the impact of disturbances on the current account is ambiguous. Serven shows that it depends critically on the degree of intertemporal substitutability in both consumption *and* investment – with the latter measured by the magnitude of investment adjustment costs.

This paper is a product of the Macroeconomics and Growth Division, Policy Research Department. It is part of a larger effort in the department to assess and improve the effects of macroeconomic policies and external shocks. Copies of the paper are available free of charge at the World Bank, 1818 H Street, N.W., Washington, D.C. 20433. Please contact Emory Klune, room N11-060, extension 3477, for a request. May 1994.

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Forthcoming in the
Journal of International Economics

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* I am indebted to Klaus Schmidt-Hebbel for detailed comments and suggestions, and to Lawrence Bouton for excellent research assistance. I also thank Sara Calvo and participants at the XII Latin American Meeting of the Econometric Society for useful comments on an earlier draft.

1 - Introduction

Capital goods account for a major share of international trade. In 1990, they comprised over 40 percent of U.S. merchandise exports and over 30 percent of its imports. In that same year, capital goods imports represented, on average, close to 30 percent of total imports for a sample of 82 developed and developing countries, and almost 9 percent of their GDP.¹

In spite of this evidence, trade in capital goods is typically ignored in conventional open-economy macroeconomic models. As a result, they provide an incomplete -- and potentially misleading -- assessment of the macroeconomic effects of policy changes and external shocks. In particular, by neglecting the import content of capital goods, standard aggregate models rule out any direct impact of import prices on investment decisions. In reality, however, investment goods typically carry a high import content, especially in many developing countries. As a consequence, the real user cost of capital is closely dependent on the relative price of investment imports, and any disturbances that affect the latter must also be reflected in the economy's investment rate and, ultimately, in the capital stock. The recent experience of some developing countries suggests that this transmission mechanism can be very powerful in practice.²

This issue has recently attracted some research. Serven (1991) examines the consequences for investment of anticipated changes in the real exchange rate in a simple Keynesian framework in which investment is subject to installation costs and makes use of imported goods. Gavin (1992) explores the impact of monetary and fiscal policy on investment in a disequilibrium model likewise incorporating capital goods imports. His treatment of investment decisions is similar to the one employed in this paper, but the framework is otherwise quite different: on the one hand, capital and long-run output are

¹ I am grateful to Lant Pritchett for kindly providing this data.

² See Dornbusch (1986) for a description of the Chilean experience of 1979-81, in which a persistent real appreciation was accompanied by a private investment boom and skyrocketing capital goods imports.

exogenously fixed in his model, and therefore the focus is on the short run. On the other hand, consumption plans are not determined optimally, which in particular makes it difficult to analyze rigorously the effects of disturbances on the current account.

This paper re-examines the macroeconomic role of trade in capital goods using an aggregate intertemporal model in which investment and consumption plans are determined optimally, and investment is subject to adjustment costs. Thus, the paper follows a growing recent literature that has explored the implications of rational behavior in both consumption and investment for the economy's response to shocks and for current account dynamics.³ The analysis focuses on the short- and long-run consequences of fiscal and external shocks.

The paper's results show that the presence of imported capital goods has major implications for both the long-run and the dynamic properties of the economy. Long-run capital and output are inversely related to the real exchange rate. The dynamic adjustment to permanent unanticipated demand and current account disturbances involves a changing real exchange rate and a nonzero current account.

The economy's response to shocks is also radically altered. A permanent fiscal expansion in the form of increased spending on domestic goods has a long-run crowding-in effect on capital and output, as does an external transfer. By contrast, if the fiscal expansion takes the form of increased spending on foreign goods, these results are reversed. In turn, the impact of disturbances on the current account balance is generally ambiguous. Its sign depends on two critical factors: the degree of intertemporal substitutability in consumption, that has been extensively discussed in the literature, and the magnitude of investment adjustment costs -- which essentially measure the degree of intertemporal substitutability in investment --, that has received much more limited attention.

³ See, for example, Buiter (1985), Giovannini (1988) and Sen and Turnovsky (1989, 1991). The interaction of optimal savings and investment decisions is also analyzed in two-sector frameworks by Brock (1988), Borenztein (1989) and Murphy (1989, 1992).

The paper is organized as follows. Section 2 lays out the analytical model, and Section 3 describes its short- and long-term equilibrium. The macroeconomic effects of a fiscal expansion and an external transfer are explored in Section 4. Finally, Section 5 concludes.

2 - The Macroeconomic Model

To focus on the macroeconomic role of capital goods imports, the analytical framework will be kept as simple as possible.⁴ We consider an economy producing one single good that can be used for domestic consumption and investment, or sold abroad. The domestic good is an imperfect substitute for a foreign good which is also available for consumption and investment. Domestic production makes use of capital and labor according to a constant returns technology. The economy is small in that it faces given world interest rates and import prices, but it can affect the world price of its exportable. We let e denote the relative price of imports in terms of the domestic good, to which we shall refer as the real exchange rate; therefore, $1/e$ represents the terms of trade in this framework.

We assume the existence of an investment technology that combines domestic goods and imports into investment goods:⁵

$$J = J (J_N, J_F) \quad (1)$$

where J_N and J_F respectively denote domestic and foreign goods used as inputs to the investment process, and the function $J(.)$ will be assumed homogeneous of degree one. Investment is subject to installation costs, assumed quadratic for simplicity. Hence total investment J exceeds effective installation of new capital I , according to

⁴ The basic framework is closely related to that of Sen and Turnovsky (1991).

⁵ This specification of investment is similar to that used by Gavin (1992) and Serven (1991).

$$J = I + \frac{\phi}{2} \frac{I^2}{K} \quad (2)$$

where the positive parameter ϕ measures the rate at which marginal adjustment costs rise with investment. For simplicity, we abstract from depreciation, so that net capital accumulation just equals I .

The homogeneity of $J(\cdot)$ allows a two-stage investment decision: at the first stage, total investment is determined; its cost-minimizing allocation between domestic goods and imports can be decided at the second stage.⁶ Specifically, the investment technology (1) implies the existence of an exact investment price index $p_K = p_K(e)$, with $p_K' > 0$ and $p_K'' < 0$, that measures the (minimized) cost of one unit of real investment in terms of domestic goods.

The economy is populated by a representative, infinitely-lived agent who can borrow and lend at the given world interest rate r^* , and supplies inelastically her entire labor endowment, which for notational simplicity will be ignored. Hence the production technology can just be expressed $Y = Y(K)$, where Y denotes real output of the domestic good, with $Y' > 0$, $Y'' < 0$. The agent's objective is to maximize the utility functional

$$\int_0^{\infty} \exp(-\beta t) \frac{[C(C_N, C_F)]^{1-\theta}}{1-\theta} dt \quad (3)$$

where β is the discount rate, $1/\theta$ is the elasticity of intertemporal substitution in consumption, C_N and C_F respectively denote the instantaneous consumption of domestic and imported goods, and again for analytical convenience the function $C(\cdot)$ will be assumed homogenous of degree one. Thus, just like in the case of investment, consumption decisions can be characterized as the result of a two-stage budgeting

⁶ Homotheticity of $J(\cdot)$ would suffice to allow two-stage budgeting of investment. For a similar two-level specification of investment decisions, see Hayashi and Inoue (1991).

process. C can be interpreted as the real consumption index, and the expenditure function associated with it can be expressed $p_C(e) \bullet C$, where the exact consumption price index $p_C(e)$ (with $p_C' > 0$ and $p_C'' < 0$) represents the cost in terms of the domestic good of one unit of real consumption.

Maximization of (3) is subject to the constraints

$$\dot{A} = \frac{1}{e} \left[Y(K) - p_C(e)C - p_K(e) \left(I + \frac{\phi}{2} \frac{I^2}{K} \right) - T \right] + r \cdot A \quad (4a)$$

$$\dot{K} = I \quad (4b)$$

$$\lim_{t \rightarrow \infty} \exp(-r \cdot t) A = 0 \quad (4c)$$

Here A denotes the agent's net foreign assets, and T are lump-sum taxes. The right-hand side of (4a) is just the agent's current account surplus; in turn, (4c) has to be imposed to rule out Ponzi schemes. The current-value Hamiltonian for this problem is

$$H = \frac{C^{1-\theta}}{1-\theta} + \lambda \left[\frac{1}{e} \left[Y(K) - p_C(e)C - p_K(e) \left(I + \frac{\phi}{2} \frac{I^2}{K} \right) - T \right] + r \cdot A \right] + QI \quad (5)$$

where λ and Q are the shadow value of foreign assets and of the capital stock, respectively. In addition to (4a)-(4c), the first-order conditions for this problem are

$$C^{-\theta} = \frac{\lambda p_C(e)}{e} \quad (6a)$$

$$\frac{\lambda p_K(e)}{e} \left(1 + \frac{\phi}{2} \frac{I}{K} \right) = Q \quad (6b)$$

$$\dot{\lambda} = (\beta - r) \lambda \quad (6c)$$

$$\dot{Q} = \beta Q - \frac{\lambda}{e} \left[Y'(K) + p_K(e) \frac{\phi}{2} \left(\frac{I}{K} \right)^2 \right] \quad (6d)$$

Equation (6a) characterizes optimal consumption, while (6c) relates investment to the shadow value of capital. From (6c) it is immediately obvious that a stationary solution for this model cannot exist unless the rate of time preference equals the world interest rate, as will be assumed henceforth; in such case, (6c) implies that the marginal utility of wealth λ must be constant along the adjustment path.

It will be convenient to define Tobin's q as the shadow value of capital relative to its replacement cost, with the latter measured by the shadow value of the foreign assets foregone to purchase one additional unit of capital, $p_K \lambda / e$. Thus, we let $q = Qe / (p_K \lambda)$. Then, after some manipulation, (6b) and (6d) can be written

$$I = \frac{K}{\phi} (q - 1) \quad (6b')$$

$$\dot{q} = \left[r^* + \frac{\dot{e}}{e} - \frac{\dot{p}_K}{p_K} \right] q - \left[\frac{Y'(K)}{p_K(e)} + \frac{\phi}{2} \left(\frac{I}{K} \right)^2 \right] \quad (6d')$$

Thus, (6b') states that the installation of capital will cease only when the shadow value of the marginal unit of capital equals its replacement cost. In turn, the arbitrage condition (6d') describes the path of Tobin's q . The first term in brackets in the right-hand side is just the real interest rate in terms of capital goods,⁷ which differs from the world real interest rate as long as capital has some domestic content (i.e., $p_K \neq e$); the second term in brackets is the total addition to net output (also in terms of capital goods) of the marginal unit of capital, which consists of its marginal product plus its contribution to reducing installation costs.

⁷ The role of this variable in determining the optimal allocation of investment over time is highlighted in Servén (1991).

Equations (6) determine the intertemporal allocation of aggregate consumption and investment. Their cost-minimizing intra-temporal allocation between domestic and foreign goods follows immediately from Shephard's lemma. Thus, optimal consumption and investment plans can be compactly expressed:

$$c = \left[\frac{e}{\lambda p_c(e)} \right]^{\frac{1}{\theta}} \equiv c(e, \lambda) \quad (7a)$$

$$c_f = p'_c(e) \cdot c \quad (7b)$$

$$c_n = [p_c(e) - e p'_c(e)] \cdot c \quad (7c)$$

$$J = K \cdot \left[\frac{q-1}{\phi} + \frac{1}{2\phi} (q-1)^2 \right] = K \cdot j(q) \quad (8a)$$

$$J_f = p'_k(e) \cdot J \quad (8b)$$

$$J_n = [p_k(e) - e p'_k(e)] \cdot J \quad (8c)$$

where (8a) follows from (2) and (6b'). An important issue in what follows will be the relation between consumption and the real exchange rate. Time differentiation of (7a) (using also (6c)) yields:

$$\frac{\dot{c}}{c} = \frac{1}{\theta} \left[r^* - \beta + \frac{\dot{e}}{e} - \frac{\dot{p}_c(e)}{p_c(e)} \right] = \frac{1}{\theta} s_c(e) \frac{\dot{e}}{e} \quad (9)$$

where $s_c(e) = 1 - e p'_c(e)/p_c(e)$ is the share of domestic goods in consumption expenditure. This is just Dornbusch's (1983) well-known characterization of the optimal consumption path: as long as consumption

has some domestic content (i.e., $p_c \neq e$), it must follow a rising (declining) path if the real exchange rate is depreciating (appreciating). The reason is that anticipated real depreciation raises the real interest rate in terms of consumption above the rate of time preference, encouraging substitution towards the future; anticipated real appreciation has the opposite effect.⁹ The slope of the consumption path is determined by the elasticity of intertemporal substitution $1/\theta$ and the share of domestic goods in consumption expenditure; the larger they are, the higher the sensitivity of consumption growth to anticipated real exchange rate changes.

It is worth noting the analogy between the role of the parameter θ in the utility function and that of the installation cost parameter ϕ in investment: the former measures the cost (in utility terms) of swings in consumption, while the latter determines the cost (in terms of investment goods) of swings in investment. Heuristically, just like $(1/\theta)$ describes the degree of intertemporal substitutability in consumption, $(1/\phi)$ provides a measure of the degree of intertemporal substitutability in investment.

The macroeconomic model is completed with the equilibrium condition for the domestic goods market:

$$Y(K) = C_N + J_N + X(e) + g_N \quad (10)$$

where X denotes real exports, with $X' > 0$, and g_N is public expenditure on domestic goods. Finally, public expenditure is assumed to be entirely tax-financed:

$$T = g_N + eg_F \quad (11)$$

and so equation (4a) in fact describes the overall economy's current account surplus.

⁹ Whether this involves a movement in the same (or in opposite) direction in the consumption of both goods depends on whether they are Edgeworth-complements (substitutes) – that is, whether the instantaneous marginal utility of consumption of one good rises (falls) with the amount consumed of the other good. In the present framework, this is equivalent to the elasticity of intertemporal substitutability $1/\theta$ being larger (smaller) than the elasticity of intratemporal substitutability. Intuitively, intertemporal substitution moves aggregate consumption – and hence both its components – in the same direction as the real exchange rate, while intratemporal substitution causes sectoral consumption demands to move in opposite directions in response to real exchange rate changes.

3 - Steady State and Dynamics

The steady state is characterized by constant stocks of capital and foreign assets, and by constant values of Tobin's q and the real exchange rate. From (4)-(11) above, these requirements can be summarized as:

$$\bar{q} = 1 \quad (12a)$$

$$Y'(\bar{K}) = r \cdot \bar{q} p_K(\bar{e}) \quad (12b)$$

$$\bar{K} = \frac{1}{\bar{e}r} [Y(\bar{K}) - p_C(\bar{e}) \cdot C(\bar{e}, \bar{\lambda}) - (g_N + \bar{e}g_F)] \quad (12c)$$

$$Y(\bar{K}) = [p_C(\bar{e}) - \bar{e} \tau_C(\bar{e})] \cdot C(\bar{e}, \bar{\lambda}) + X(\bar{e}) + g_N \quad (12d)$$

where steady-state values are denoted by an overbar. Thus, in the steady state Tobin's q must equal unity, so that the shadow value of an additional unit of capital equals its replacement cost. In turn, the marginal product of capital must equal its user cost, given by the world interest rate times the relative price of capital goods. For foreign asset accumulation to cease, the current account must be balanced – or, in other words, private consumption expenditure must equal disposable income, inclusive of interest earnings on foreign assets. Finally, (12d) just restates that the domestic goods market must clear at zero investment.

Two features of the long-run equilibrium should be stressed. First, the import content of capital goods is critical for the long-run effects of disturbances. If capital had no import content, then $p_K = 1$, and (12b) would imply that, given the world interest rate, the long-run capital stock (and thus output) depends only on technological parameters. By contrast, if capital goods have an import content then the capital stock and the real exchange rate must be negatively related across steady states. The reason is that a real

appreciation reduces p_K and the user cost of capital, thus raising the optimal capital stock. Given the production technology, any disturbance that causes a long-run real appreciation must also lead to an increase in steady-state capital and output.⁹

Secondly, the long-run equilibrium is path-dependent: the steady-state values of the endogenous variables depend not only on the steady-state values of the exogenous variables, but also on their past history and on the economy's initial conditions. Mathematically, this can be seen from the fact that equations (12) provide four relations involving five endogenous variables (q , K , e , A and λ), and therefore do not fully characterize the long-run equilibrium. The intuitive reason is that the model's steady-state relations do not tie down the long-run stock of foreign assets: in long-run equilibrium, the interest income earned on net foreign assets is entirely consumed, and thus any foreign asset stock is self-replicating.¹⁰ Hence, the long-run foreign asset stock must be found from its initial level and from the current account history along the adjustment path. Since the interest income on foreign assets affects consumption and therefore domestic goods demand, this in turn means that the long-run real exchange rate, capital stock and output must all depend as well on the economy's entire adjustment path¹¹ – which will be described next.

Equilibrium Dynamics

The model's dynamics can be summarized by three differential equations describing the time paths of the capital stock, Tobin's q and foreign asset holdings. In fact, the dynamics can be determined

⁹ If production were assumed to use imported variable inputs, a negative long-run relationship between the real exchange rate and the capital stock would also emerge.

¹⁰ This follows from the assumptions that (i) consumers have an infinite planning horizon, (ii) their rate of time preference is constant, and (iii) the real interest rate at which they can borrow and lend is also constant. Removing any of these assumptions would eliminate the path-dependence of the long-run equilibrium. See Giavazzi and Wyplosz (1983) for further discussion.

¹¹ An exception is the extreme case when consumption has no domestic content; then $p_C(e) = e$, and domestic goods demand is unaffected by the foreign asset stock. In such case, (12b) and (12d) in the text would determine the long-run real exchange rate, capital stock and output fully independently from the long-run stock of foreign assets, and thus from the economy's past history (which would continue to determine the foreign asset stock). Such simplifying – but drastic – assumption is used, for example, by Brock (1988) and Murphy (1989).

sequentially. First, in order to investigate the equilibrium path of the capital stock and Tobin's q , we can use (7) and (8) to solve (10) for the market-clearing real exchange rate near a stationary equilibrium:

$$e = e(\lambda, K, q, g_N) \quad \frac{\partial e}{\partial \lambda} > 0 \quad \frac{\partial e}{\partial K} > 0 \quad \frac{\partial e}{\partial q} < 0 \quad \frac{\partial e}{\partial g_N} < 0 \quad (13)$$

where the signs of the partial derivatives can be easily explained.¹² An increase in the shadow value of foreign assets λ reduces consumption demand and requires an increase in the real exchange rate (a real depreciation) to restore market equilibrium.¹³ In turn, an increase in the capital stock raises output and generates excess supply of domestic goods, leading to a real depreciation. Conversely, an increase in Tobin's q or in public expenditure on domestic goods cause excess demand and require a real appreciation to clear the market.

Time-differencing (13), using (6'), we obtain the linearized pair of equations

$$\begin{bmatrix} \dot{K} \\ \dot{q} \end{bmatrix} = \begin{bmatrix} 0 & \frac{\bar{K}}{\phi} \\ \frac{r^* (1 - s_1(\bar{e})) \frac{\partial e}{\partial K} - \gamma''(\bar{K})}{\bar{e} - s_1(\bar{e}) \frac{\partial e}{\partial q}} & r^* \end{bmatrix} \begin{bmatrix} K - \bar{K} \\ q - \bar{q} \end{bmatrix} \quad (14)$$

where $s_1(e) = 1 - ep_K'(e)/p_K(e)$ is the share of domestic goods in total investment expenditure. From the signs of the partial derivatives in (13), the determinant of this matrix is negative and thus the model is saddlepoint stable, which reflects the fact that the capital stock is a predetermined variable while Tobin's

¹² The straightforward derivations are described in the technical appendix.

¹³ Observe that an increase in e , at given λ , unambiguously increases excess demand in the domestic goods market. This is due to its positive effect on consumption expenditure mentioned above, which reinforces the substitution effect.

q is not. Letting $\mu < 0$ denote the negative eigenvalue of the matrix, their trajectories along the convergent path are

$$K - \bar{K} = (K_0 - \bar{K}) \exp\{\mu t\} \quad (15a)$$

$$q - \bar{q} = \frac{\mu \phi}{K} (K - \bar{K}) \quad (15b)$$

where K_0 is the initial capital stock. Thus, along the stable arm q and K move in opposite directions. It also follows (from (13) above) that on the convergent path the real exchange rate moves in the same direction as the capital stock: capital accumulation (decumulation) generates excess supply (demand) and leads to real depreciation (appreciation) to clear the domestic goods market. Finally, from (9) it also follows that along the adjustment trajectory real consumption must be moving along with the capital stock.

In turn, the speed of adjustment of the system is given by the absolute value of the stable root μ . As is intuitively clear, the more rapidly increasing are investment adjustment costs (as measured by the parameter ϕ), the closer μ is to zero and hence the slower the convergence towards the long-run equilibrium.

The dynamics of the foreign asset stock can be determined next along the lines described in Turnovsky and Sen (1989). First, using (11), (7a) and (8a), the current account surplus (4a) can be rewritten:

$$\dot{A} = \left[r \cdot A + \frac{Y(K)}{e} - \left(\frac{g_N}{e} + g_F \right) \right] - \left[\frac{P_C(e)}{e} c(e, \lambda) + \frac{P_K(e)}{e} K \cdot j(q) \right] \quad (16)$$

where the first term represents private disposable income, and the second is private expenditure, both in terms of foreign goods. Linearizing around a stationary equilibrium with balanced private trade¹⁴ and using (8a), (12) and (15b), yields

$$\dot{A} = r^* (A - \bar{A}) + \Gamma (K - \bar{K}) \quad (17a)$$

where

$$\Gamma \equiv \left[\frac{Y'(\bar{K})}{\bar{e}} - \mu \phi \frac{P_K(\bar{e})}{\bar{e}} \right] j' - \left[\frac{1}{\bar{e}} \frac{\partial (P_C(e) C(e, \lambda))}{\partial e} \left(\frac{\partial e}{\partial K} + \mu \phi \frac{\partial e}{\partial Q} \right) \right] \quad (17b)$$

Direct integration of (17a) subject to the no-Ponzi-game condition (17d) yields

$$A - \bar{A} = -\Gamma \cdot (r^* - \mu)^{-1} \cdot (K_0 - \bar{K}) \exp\{\mu t\} \quad (18)$$

Hence, at $t=0$,

$$A_0 - \bar{A} = -\Gamma \cdot (r^* - \mu)^{-1} \cdot (K_0 - \bar{K}) \quad (19)$$

where A_0 denotes the initial foreign asset stock.

Two points are worth noting. First, equation (19) is the 'missing relation' that completes the characterization of the economy's steady state. It shows that, as argued earlier, both the economy's initial conditions and the speed of adjustment affect the long-run foreign asset stock – and through it, the long-run values of the other endogenous variables.

¹⁴ That is, $X = e \cdot C_p$, which together with current account equilibrium also implies $r^* A = g_p$; in words, the private sector's foreign assets equal the present value of its tax liabilities indexed to the real exchange rate g_p/r^* . If this were not the case, the expression for Γ ((17b) in the text) would include an extra term reflecting the initial real exchange rate-indexed liability position of the private sector. For simplicity, this additional complication will be ignored.

Secondly, whether along the adjustment path capital accumulation is accompanied by a current account deficit or surplus depends on the sign of the term Γ defined in (17b), which summarizes the two opposing effects of capital accumulation on the current account. On the one hand, as capital is accumulated during the transition to the steady state, real output is rising and investment falling -- and more so the higher the speed of adjustment of the system (i.e., the smaller the installation cost parameter ϕ); through both channels -- captured by the first large square brackets in (17b) -- the current account must be improving along the adjustment path, which means that it must show a deficit. On the other hand, the output increase and the investment decline also create excess supply in the domestic goods market and lead to real depreciation, hence consumption expenditure must be rising¹⁵ -- more so the larger the elasticity of intertemporal substitution $1/\theta$ -- and the current account must be deteriorating, which means that it must show a surplus along the transition path; this is reflected by the second term in square brackets in (17b).

The net result is therefore ambiguous. For given values of the remaining parameters, the outcome can be easily related to the magnitudes of intertemporal consumption substitutability and investment adjustment costs.¹⁶ The higher consumption substitutability, the stronger the consumption-savings effect outlined above, and thus the more likely a negative value of Γ , so that along the adjustment path both capital and foreign assets are simultaneously accumulated or decumulated¹⁷. Conversely, the lower investment adjustment costs, the stronger the investment effect, and the more likely a positive Γ , so that along the adjustment path the accumulation of capital and of foreign assets proceed in opposite directions.

¹⁵ From (7a), it is straightforward to verify that $\partial[p_c(e)C(e,\lambda)]/\partial e = (p_c(e)/e)C(e,\lambda)[1 - \epsilon_c + \theta^{-1}b_c] > 0$.

¹⁶ The intuitive argument that follows is formalized in the appendix.

¹⁷ In particular, with perfect intertemporal substitutability in consumption, Γ must be negative regardless of the magnitude of investment adjustment costs.

4 - The effects of permanent disturbances

The working of the model can be illustrated with the help of Figure 1. The top panel portrays the economy's steady state. The KK schedule depicts the long-run marginal productivity condition (12b); it is downward sloping, and flatter the larger the unit import content of investment. In turn, the NN schedule represents equilibrium in the domestic goods market (12d) and current account balance.¹⁸ Under the standard Marshall-Lerner condition that a real depreciation, given consumption expenditure in terms of domestic goods, causes a current account improvement, NN must be upward sloping:¹⁹ an increase in the capital stock causes excess supply for domestic goods and requires a real depreciation to clear the market. The initial long-run equilibrium is at E_0 .

The other two panels of Figure 1 depict the model's dynamics. The middle panel represents the convergent trajectory of Tobin's q and the capital stock (15b) as the downward sloping SS line; the long-run equilibrium is at the intersection of SS with the horizontal line drawn for $q = 1$. Finally, the FF line in the bottom panel of Figure 1 depicts the equilibrium relationship between capital and foreign assets (19). The slope of FF depends on the sign of the term Γ defined earlier. If Γ is positive, the FF locus is downward sloping, as represented in the figure; for negative Γ it would be upward sloping. The initial foreign asset stock is A_0 .

[Insert Figure 1 about here]

Figure 1 brings out clearly the implications of the import content of investment. If capital goods had zero import content – as conventionally assumed – the KK schedule would be a vertical line at K_0 , and the equilibrium capital stock (and thus output as well) would depend only on technological parameters and on the world interest rate; it would be wholly unaffected by any disturbances in the goods market and/or the current account. Further, the economy's response to any permanent unanticipated demand or

¹⁸ Thus, along the NN locus the long-run stock of foreign assets changes with the capital stock according to (19), while the shadow value of foreign assets λ adjusts endogenously to maintain current account balance (12c).

¹⁹ However, the NN locus may be upward sloping even if the Marshall-Lerner condition fails to hold, provided the speed of adjustment $|\mu|$ is high enough. This is guaranteed to be the case if investment adjustment costs ϕ are sufficiently low.

current account shock would just entail a discrete jump in the real exchange rate, without any dynamic adjustment.

However, as will be shown below, these results are radically altered in the more realistic scenario that allows both consumption and investment to make use of imported goods. We focus on two types of disturbances: a rise in public expenditure, considering the two sub-cases of increased spending on domestic goods and on imports, and a wealth transfer from abroad -- e.g., a 'debt relief' operation. For brevity, the analysis is limited to the case of permanent unanticipated disturbances.²⁰

(a) Increase in government expenditure on the domestic good

Consider first the case of an unanticipated, permanent increase in g_N , matched by an equal tax increase. Its effects can be illustrated with the help of Figure 1. The net effect of the public spending rise and the tax hike is an increase in the demand for domestic goods, which requires a real appreciation to restore market equilibrium.²¹ Hence the NN schedule in the top panel of Figure 1 shifts to the right, to $N'N'$.

If capital goods were fully domestic, the real exchange rate would jump to e'' , leaving unchanged the capital stock, output and foreign assets. Thus, the only consequence of the fiscal expansion would be a simultaneous downward jump in private consumption and in real exports. But when capital has an import content the real appreciation reduces the real cost of investment goods imports, thereby raising the optimal capital stock and real output. In other words, the increased public spending on domestic goods

²⁰ Notice that because the model's long-run equilibrium is path-dependent, transitory disturbances would also have permanent effects in this framework. The consequences of transitory fiscal shocks are analyzed in Servén (1993), where it is shown that under fairly general conditions the long-run impacts of permanent and transitory policy changes on key macroeconomic variables may go in opposite directions.

²¹ Giovannini (1988) also explores the long-run effect of a fiscal expansion on the real exchange rate in a framework where consumers have uncertain lifetimes (and capital goods have no import content). In his setup, the increased public expenditure can crowd-out private consumption so severely as to require a long-run real depreciation.

crowds in private investment²². Hence, the new long run equilibrium at E' involves a higher capital stock K' and a more moderate real appreciation, to e' .

The dynamic adjustment of Tobin's q and the capital stock in response to the fiscal expansion appears in the middle panel of Figure 1. The rise in g_N shifts the convergent path SS to the right, to $S'S'$. Given K_0 , Tobin's q must immediately jump to $q(0)$ on the new saddle path, leading to an investment expansion. Notice that, with output given in the short term, this adds to the instantaneous real appreciation caused by the increase in public expenditure. In fact, with the capital stock adjusting only gradually, the short run must be characterized by real exchange rate overshooting. Over time, the capital stock rises and q declines back to unity; on both accounts, the real exchange rate must be depreciating along the adjustment path, which in turn implies that real consumption must be rising.

What happens to the current account balance? Unlike the previous results, this depends on the parameters governing intertemporal substitutability in consumption and investment adjustment costs. As already noted, the bottom panel of Figure 1 depicts the case of relatively low intertemporal consumption substitutability and investment adjustment costs ($\Gamma > 0$). Thus, the rise in the long run capital stock from K_0 to K' is accompanied by a fall in foreign assets from their initial level A_0 to A' . The adjustment takes the form of a downward movement along FF – i.e., a persistent current account deficit. However, if Γ were negative instead of positive (so that FF slopes upward), foreign assets would rise and the economy would run a current account surplus along the adjustment path.

The ambiguous current account impact can be explained as follows. The fiscal expansion raises the optimal capital stock and causes an increase in investment expenditure, more so the smaller investment adjustment costs. In turn, private consumption expenditure $P_c \bullet C$ must fall on impact due to the tax increase, but the extent of its decline reflects two opposing forces: on the one hand, the adverse effect of the tax hike on private consumption is dampened by consumption smoothing of the anticipated higher

²² This crowding-in effect is similar to that identified by Gavin (1992); however, his model really focuses on the short run by assuming fixed capital and long-run output. Sen and Turnovsky (1991) likewise find crowding-in, although through a quite different mechanism, involving the labor-leisure decision.

future output; on the other hand, the anticipation of real depreciation along the adjustment path raises the consumption-based real interest rate and encourages intertemporal substitution against present consumption.²³

Since real output is given in the short run, the impact on the current account depends on whether the investment rise or the consumption expenditure fall dominates.²⁴ With low investment adjustment costs and low intertemporal substitutability in consumption, the outcome is an investment boom and a moderate decline in consumption expenditure, and hence a current account deficit, as assumed in the figure. Conversely, high intertemporal substitutability in consumption, and high investment adjustment costs, cause a current account surplus, which results from a moderate investment rise and an abrupt consumption decline -- with the latter followed by a steep climb along the transition path. Indeed, if intertemporal consumption substitutability is very high, the initial consumption drop can be so severe, and the consumption path so steep, that long-run consumption would actually rise above its original level.²⁵

(b) Increase in government expenditure on the foreign good

Assume now that the fiscal shock takes the form of a permanent rise in g_F . The consequences are almost exactly the opposite to those of the previous exercise: the tax increase reduces demand for the domestic good, and the NN schedule in the top panel of Figure 2 shifts to the left, leading to a long-run real depreciation. If capital had no import content, the real exchange rate would depreciate all the way to e^* in the figure, with no change in the capital stock. However, with capital goods being partly

²³ Because of these opposing influences, real consumption C may rise or fall upon impact. In either case, the transition to the new long-run equilibrium must involve rising consumption, due to the parallel depreciation of the real exchange rate along the adjustment path. Hence, real consumption must initially undershoot its new long-run level.

²⁴ Numerical simulations reported by Borenstein (1989) also highlight the importance of investment adjustment costs for the response of the current account to a fiscal shock.

²⁵ Nevertheless, it can be shown that the new consumption trajectory must involve reduced welfare -- except in the extreme case when domestic goods demand is so inelastic to the real exchange rate that the economy is characterized by 'immiserizing growth'.

imported the real depreciation raises their real cost and leads to a decline in the steady-state capital stock (to K' in the figure) and output; the real exchange rate depreciates to e' . Thus, in contrast with the previous case, increased public expenditure now has a crowding-out effect on private investment. On impact, Tobin's q drops to $q(0)$ and net investment turns negative, as shown in the middle panel of the figure; thereafter, the adjustment involves a gradual return of q towards unity along with continuing capital decumulation. On both accounts, the real exchange rate must be appreciating along the adjustment path, so that the short-run is again characterized by real exchange rate overshooting.

[Insert Figure 2 about here]

What happens with consumption and the current account? Unlike in the previous case, now the tax hike and the permanent decline in output reinforce each other to reduce private consumption in the long run. However, in the short term the fall in private consumption is dampened by intertemporal substitution against future consumption, due to the anticipation of real appreciation along the adjustment path; the higher intertemporal substitutability, the smaller the impact consumption decline and the steeper its subsequent fall along the adjustment path. Indeed, if intertemporal substitutability is very high, real consumption may actually rise in the short term, to decline afterwards at an accelerated pace.

Hence the roles of intertemporal consumption substitutability and investment adjustment costs in determining the current account outcome are now reversed with respect to the case in which the increased public expenditure fell on domestic goods: with low adjustment costs and low intertemporal consumption substitutability, both investment and consumption fall sharply, and the current account must turn into surplus; this is the case represented in the bottom panel of Figure 2. In the opposite case, high adjustment costs in investment and high intertemporal substitutability in consumption would lead to a decline in private savings in excess of that in investment, causing a current account deficit along the transition to the new steady state.

(c) An external wealth transfer

Finally, consider the case of a one-time asset transfer from abroad -- i.e., an exogenous increase in the initial stock of foreign assets, resulting for example from 'debt relief'. This has the effect of shifting world demand towards domestic goods. If capital goods had zero import content, the only consequences would be an immediate rise in private consumption and a real appreciation; the ensuing trade deficit would exactly match the increased interest earnings on foreign assets, and the capital stock, output and the current would remain unaffected.

By contrast, when capital goods have an import content the foreign asset transfer has a crowding-in effect identical to the one illustrated in Figure 1 above: the rightward shift of the NN schedule caused by higher consumption demand for domestic goods leads to a long-run real appreciation and to an increase in the capital stock and output. Private consumption must also be higher in the new steady state. The short-run response involves an upward jump in Tobin's q and investment and a real appreciation. Along the adjustment path, q must be declining and the real exchange rate must be depreciating; hence consumption must be rising.

In the long run, the stock of foreign assets must unambiguously rise. However, it may rise by more or by less than the initial asset transfer -- depending on whether the current account is in surplus or in deficit along the transition path. Like in the previous exercises, the key is the degree of intertemporal substitutability in consumption and the magnitude of investment adjustment costs. In the short run, investment must rise, and more so the lower adjustment costs. In turn, consumption may rise or fall on impact: with low intertemporal substitutability, consumption rises in reflection both of the external transfer and the anticipated future output increase; by contrast, if intertemporal substitutability is high, consumption falls in the short term due to the anticipation of real depreciation, which pushes up the consumption-based real interest rate and causes substitution towards the future.

As before, with low intertemporal substitutability in consumption and low adjustment costs to investment, the wealth transfer would lead to a current account deficit. Such situation is depicted in the

top panel of Figure 3, which -- like in the previous exercises -- assumes that the FF line is downward sloping. The asset transfer raises the initial foreign asset stock from A_0 to $A(0)$; thus the FF line shifts upward. Thereafter, the adjustment process entails a downward movement along the $F'F'$ schedule, with positive capital accumulation and a current account deficit; the final stock of foreign assets is A' . The opposite situation is depicted in the lower panel of Figure 3: if intertemporal substitutability in consumption and adjustment costs are both very high, the short-run response is a modest investment rise and an abrupt consumption fall. The initial increase in foreign assets is now augmented by a persistent current account surplus as the economy travels along the upward sloping $F'F'$ line, so that in the new long-run equilibrium the foreign asset stock exceeds $A(0)$.

5 - Concluding Remarks

This paper has explored the macroeconomic implications of trade in investment goods, which is arbitrarily ruled out in most conventional open-economy macroeconomic models. Using an aggregate framework with consumption and investment decisions derived from intertemporal optimization, which allows a rigorous analysis of the optimal current account trajectory, the discussion has focused on the short- and long-run effects of fiscal and external shocks.

The results illustrate three main points. First, removing the unrealistic assumption that capital goods have zero import content has major consequences for the steady-state and dynamic properties of the economy. The long run capital stock and output cease to be exclusively determined by the world real interest rate and technological considerations; instead, they are negatively correlated with the long-run real exchange rate. Given the economy's technological parameters, any disturbances leading to long-run real appreciation (depreciation) must also lead to higher (lower) capital and output. With investment subject to installation costs, the adjustment to permanent unanticipated disturbances generally involves changing levels of output and the real exchange rate, and a nonzero current account; further, the short-run impact of permanent disturbances is characterized by real exchange rate overshooting.

Second, a permanent rise in public spending has a crowding-out or crowding-in effect depending on whether the increased expenditure is directed towards foreign or domestic goods, respectively. In the former case, the shock leads to a permanent real depreciation and thus to a rise in the relative price of capital goods; hence, the long-run capital stock, output and private consumption must all fall. In the latter case, the real exchange rate appreciates and steady-state capital and output must rise, while the impact on private consumption is ambiguous. Moreover, the two fiscal disturbances must also affect the current account balance in opposite directions. In turn, the effects of a one-time wealth transfer from abroad are broadly similar to those of an increase in public expenditure on domestic goods, in that it also leads to permanently higher capital and output; however, it must lead to higher long-run private consumption as well.

Third, the sign of the current account during the transition to the new long-run equilibrium is generally-ambiguous. In the model, the current account trajectory reflects the interaction of optimal consumption and investment decisions. The ambiguity of the current account response is due to the opposing influences on the savings-investment balance of intertemporal substitutability in consumption and in investment – with the latter measured by (the inverse of) the slope of marginal adjustment costs. Low substitutability in consumption and high substitutability in investment cause capital accumulation to be accompanied by external deficits (and decumulation by surplus): the reason is that consumption is high in anticipation of future output gains, while investment is also high as the gap between the actual and optimal capital stocks is closed quickly. In such case, an increase in public expenditure on domestic (foreign) goods leads to an external deficit (surplus); a wealth transfer from abroad has the same consequences – with the somewhat surprising implication that a 'debt relief' operation causes a current account deficit. Conversely, high substitutability in consumption and low substitutability in investment cause capital accumulation to be matched by an external surplus, in which case the current account impact of these disturbances is reversed.

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Appendix

1 - The market-clearing real exchange rate

Straightforward differentiation of (10) near a stationary equilibrium with balanced trade, using (7) and (8), yields:

$$\begin{aligned}\frac{\partial e}{\partial \lambda} &= \frac{e c_N}{\theta \lambda} \frac{1}{\Delta} > 0 \\ \frac{\partial e}{\partial K} &= e Y'(K) \frac{1}{\Delta} > 0 \\ \frac{\partial e}{\partial q} &= -e p_K s_1 \frac{K}{\phi} \frac{1}{\Delta} < 0 \\ \frac{\partial e}{\partial g_N} &= -\frac{e}{\Delta} < 0\end{aligned}\tag{A1}$$

where $\Delta \equiv e c_M [\epsilon_x + \sigma_c s_c + \frac{s_c^2}{1-s_c} \frac{1}{\theta}] > 0$, and ϵ_x and σ_c respectively denote the elasticity of exports and the elasticity of intratemporal substitution in consumption.

2 - The sign of Γ

Using (7a) in the text and replacing (A1) above into (17b), it immediately follows that the sign of Γ is given by:

$$\Gamma > 0 \text{ as } \frac{1 - s_c + \frac{s_c}{\theta}}{(1 - s_c) [\epsilon_x + (\sigma_c - 1) s_c] + s_c \left[1 - s_c + \frac{s_c}{\theta} \right]} < \frac{r^* - \mu}{r^* - \mu s_1}\tag{A2}$$

This seemingly complex expression has a simple interpretation. The right-hand side is the ratio between the direct effect on the current account (through higher output and lower investment expenditure) of a unit increase in the capital stock, and its effect on domestic goods excess supply; it is larger than unity and an increasing function of the speed of adjustment $|\mu|$ -- i.e., a decreasing function of the adjustment cost parameter ϕ .

In turn, the left-hand side measures the impact on consumption expenditure of the real depreciation caused by a unit increase in domestic goods supply. Notice that the denominator, which captures the impact of a real depreciation on excess demand for domestic goods, consists of two terms: the first is the demand-switching effect at given real expenditure (in terms of domestic goods), and the second is the scale effect of the expenditure increase. Thus, the former is just the standard Marshall-Lerner expression, which we assume positive. This in turn implies that the left-hand side of (A2) is an increasing function of the elasticity of intertemporal substitution $1/\theta$.

It can be easily verified that the left-hand side of (A2) is less than or equal to one if either (i) private consumption has no import content (i.e., $s_c = 1$); or (ii) the consumption expenditure impact of the real exchange rate falls short of its trade account impact at given consumption expenditure, i.e., $[1 - s_c + s_c \theta^{-1}] < [\epsilon_x + s_c(\sigma_c - 1)]$, which can be rewritten as an upper bound on intertemporal consumption substitutability: $\theta^{-1} < [\epsilon_x + \sigma_c s_c - 1]/s_c$. Under either of (i) or (ii), Γ is positive; conversely, if neither (i) nor (ii) hold, then Γ is positive for small θ and large μ and negative in the opposite case.

3 - Long run impact of disturbances

The steady-state effects of disturbances can be easily determined by differentiating (12) and (19). Straightforward algebra yields:

$$d\bar{K} = \frac{1}{\bar{\Omega}} \left[\frac{1-s_c}{e s_c} dg_N - dg_F + r \cdot dA_0 \right] \quad (A3a)$$

$$d\bar{e} = \frac{eY''}{r \cdot p_K (1-s_l)} d\bar{K} \quad (A3b)$$

$$d\bar{A} = dA_0 - \frac{\Gamma}{(r^* - \mu)} d\bar{K} \quad (A3c)$$

and also

$$d\bar{Y} = Y' d\bar{K} \quad (A3d)$$

$$d\bar{C} = \frac{eC_F}{s_c} \left[(\epsilon_x + \sigma_c s_c) \Sigma + \frac{s_c^2}{1-s_c} \frac{1}{\theta} Y' \right] d\bar{K} - \frac{1}{s_c} dg_N \quad (A3e)$$

where

$$\Sigma \equiv Y' - \frac{\Delta Y''}{r \cdot p_K (1-s_l)} > 0$$

$$\Omega \equiv \frac{C_F}{s_c} \frac{1}{\Delta} \left[\Sigma (\epsilon_x + (\sigma_c - 1) s_c) - \frac{(1-s_l)\mu}{r^* - \mu} \frac{Y'}{e} \right] > 0.$$

It immediately follows that

$$\frac{d\bar{K}}{dg_N} > 0, \quad \frac{d\bar{K}}{dg_F} < 0, \quad \frac{d\bar{K}}{dA_0} > 0;$$

$$\frac{d\bar{e}}{dg_N} < 0, \quad \frac{d\bar{e}}{dg_F} > 0, \quad \frac{d\bar{e}}{dA_0} < 0;$$

$$\frac{d\bar{A}}{dg_N} \geq 0, \quad \frac{d\bar{A}}{dg_F} \geq 0, \quad \frac{d\bar{A}}{dA_0} > 0;$$

$$\frac{d\bar{Y}}{dg_N} > 0, \quad \frac{d\bar{Y}}{dg_F} < 0, \quad \frac{d\bar{Y}}{dA_0} > 0;$$

$$\frac{d\bar{C}}{dg_N} \geq 0, \quad \frac{d\bar{C}}{dg_F} < 0, \quad \frac{d\bar{C}}{dA_0} > 0.$$

Apart from the ambiguous response of the long-run foreign asset stock to fiscal disturbances, which is due to the ambiguous sign of Γ , the other uncertain result is the impact on private consumption of an increase in g_N . As (A3e) suggests, if θ is very small (so that intertemporal consumption substitutability is very high), then consumption may rise in the new steady state, reflecting strong substitution towards the future along the adjustment path.

Figure 1

Increase in government expenditure on the domestic good

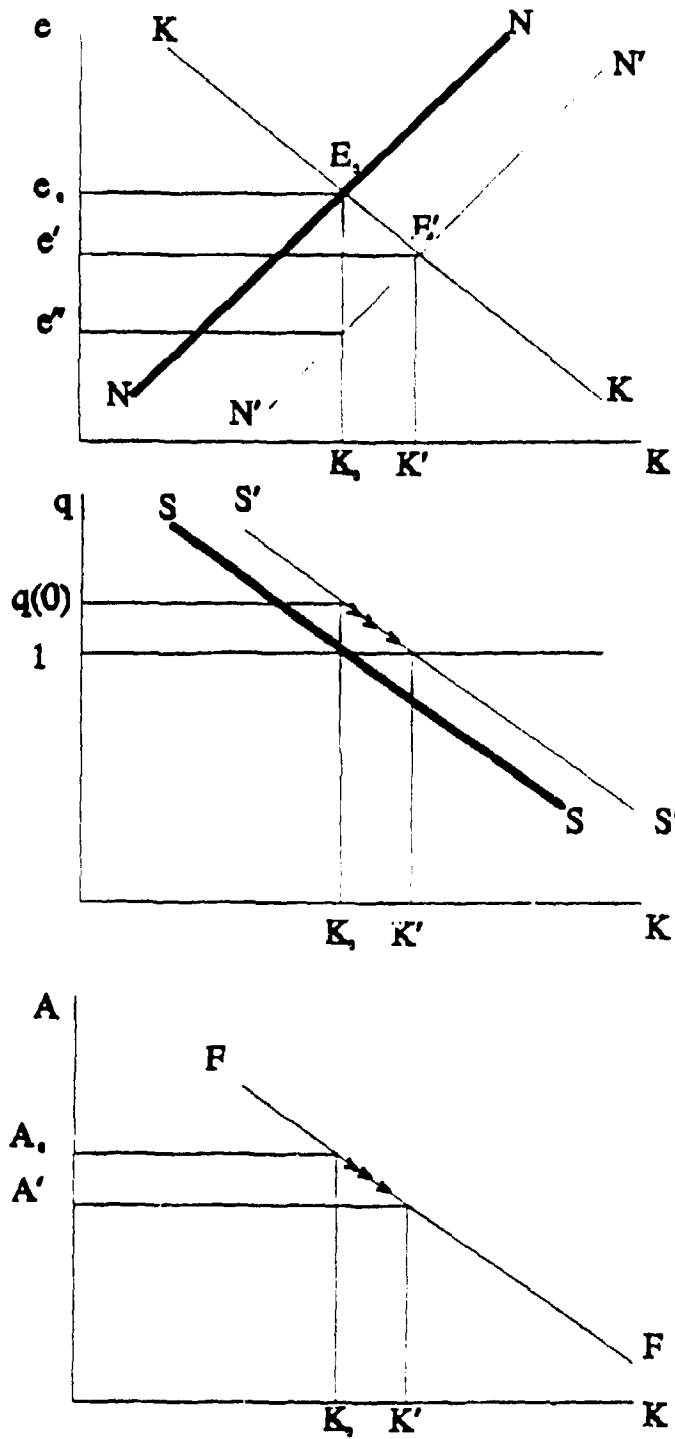


Figure 2

Increase in government expenditure on the foreign good

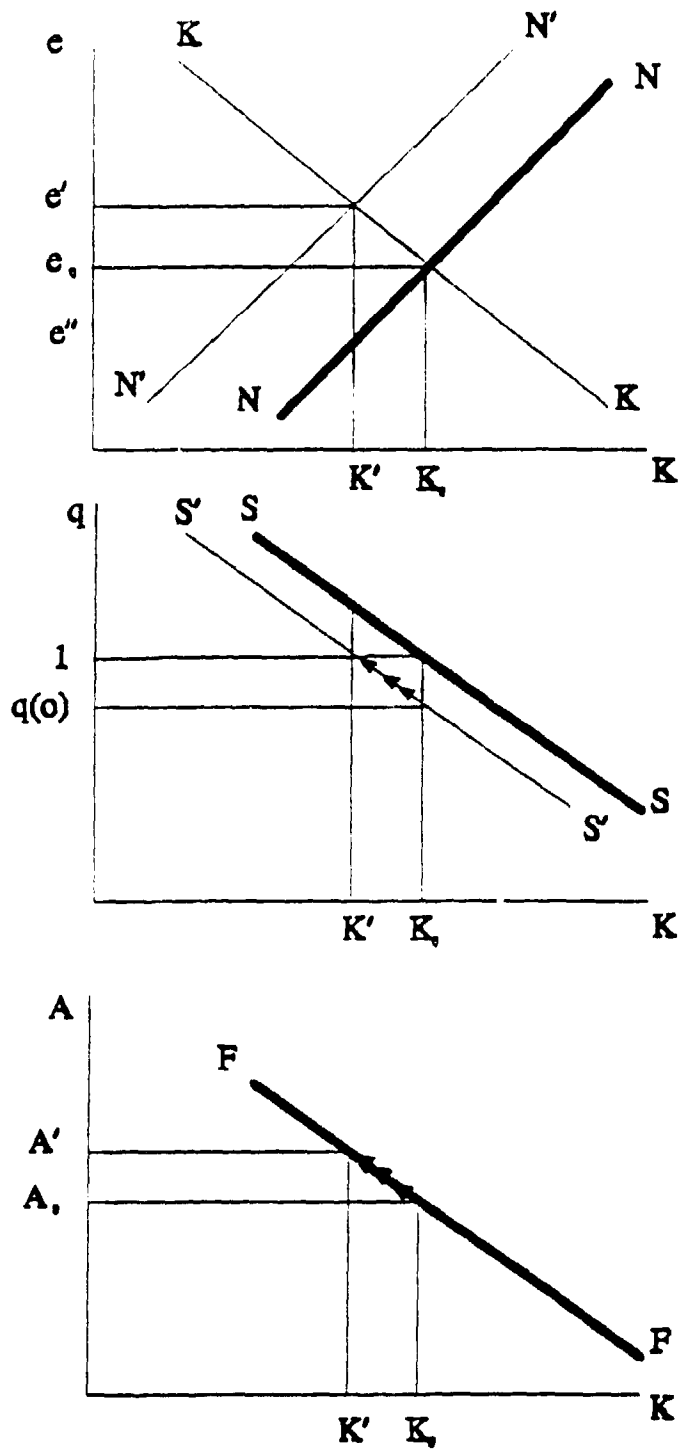
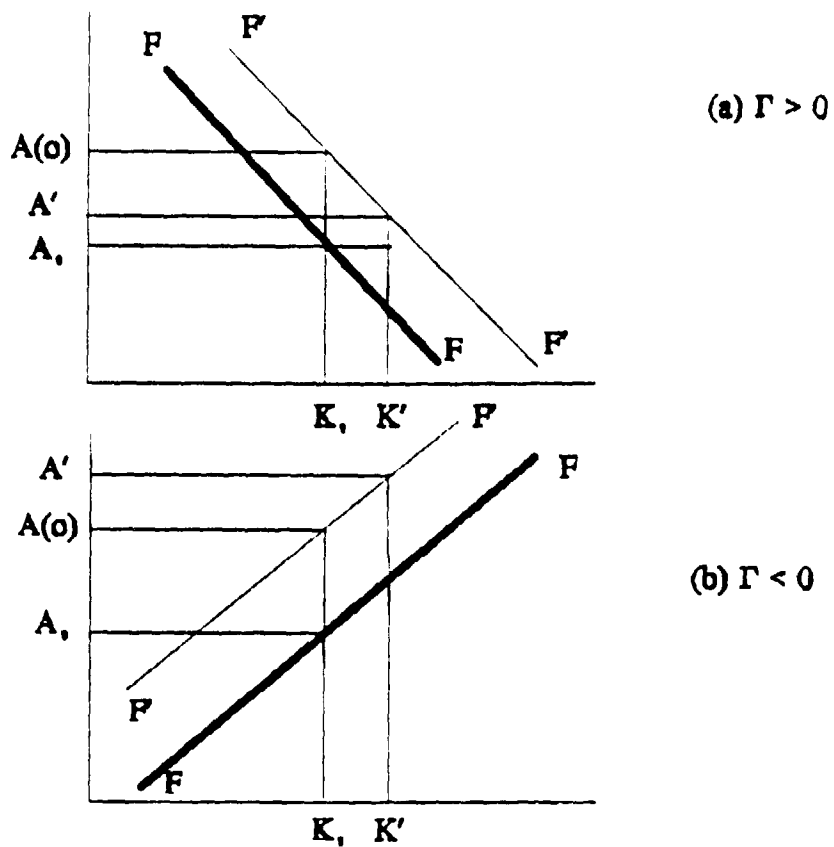


Figure 3
Wealth Transfer from abroad



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