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How do Capital Controls Affect the Transmission
of Foreign Shocks?

Dudley Cooke

HOW DO CAPITAL CONTROLS AFFECT THE TRANSMISSION OF FOREIGN SHOCKS?*

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Abstract: This paper studies the short-run transmission of foreign shocks in a small open economy with capital controls and a fixed exchange rate. Capital controls alter the transmission of shocks because endogenous changes in the domestic nominal interest rate affect savings and investment decisions. The economy's reaction to export shocks hinges on how the government chooses to restrict capital flows; that is, whether inflows or outflows are restricted. For foreign interest rate shocks, private capital flows are important, but so are the government's holdings of foreign exchange reserves. Finally, a simple graphical apparatus is developed to provide a contrast to the case when capital flows are unrestricted.

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1. Introduction

The exchange rate regime and degree of capital mobility take centre stage when thinking about an economy's exposure to foreign shocks. Recently, a number of attempts have been made to either develop, or improve on, the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions, which provides *de jure* measures for both of these. Along one dimension, Reinhart and Rogoff (2004) and Levy-Yeyati and Sturzenegger (2005) present *de facto* classifications of exchange rate regimes.¹ Along the other, Lane and Milesi-Ferretti's (2001, 2006) work, documenting countries' net external wealth positions, leads to a *de facto* index of capital account openness. These studies show that, although financial market integration has risen, capital controls, in one form or another, are still used in a majority of countries. Capital controls are also often used to support a managed exchange rate.² Given this, it is an important task to understand exactly how capital controls affect an economy's reaction to foreign shocks.³

This paper uses a sticky-price model of a small open economy to investigate the short-run transmission of foreign shocks, when the exchange rate is fixed, and the government imposes a capital control. The capital control is introduced through a separate exchange rate applied to financial transactions; that is, a dual exchange rate system. It is well-known that dual exchange rates and capital controls are formally equivalent, but an important contribution of this paper is to show that by integrating capital controls into a model with nominal rigidities, monopolistic competition, and physical capital, there is also an equivalence between the textbook Mundell-Fleming and DGE approaches.⁴ Without capital controls, a balance-of-payments condition, similar to that presented in Céspedes *et al.* (2004), determines investment behavior, consumption is pinned down by an investment-savings condition, and when prices are sticky, output is determined by current levels of demand. When the exchange rate is fixed, money demand determines the level of money supply residually. With capital controls, investment demand is decreasing in the domestic interest rate. Given the

¹Reinhart and Rogoff (2004) argue that 50% of official pegs float through the use of dual exchange rates, whereas Levy-Yeyati and Sturzenegger (2005) cite hidden pegs and fear of floating as prevalent.

²Alesina *et al.* (1993) discuss the political economy aspects of this situation.

³Miniane (2004) develops a detailed *de jure* measure of capital account restrictions and Miniane and Rogers (2007) use this to assess whether capital controls insulate domestic countries' interest rates from U.S. monetary shocks.

⁴This intertemporal equivalence is first shown in Adams and Greenwood (1985). I use the terms 'dual exchange rates' and 'capital controls' interchangeably.

investment-savings relationship, and sticky prices, investment demand is increasing in output; or rather, the balance-of-payments relationship is ‘upward-sloped’. In addition to the usual national intertemporal budget constraint, a period national budget constraint, linking government reserves to the flow of private capital, is also required to hold when there are capital controls. Because the money supply is tied to the flow of government reserves, money demand becomes central in determining the equilibrium, even if the exchange rate is fixed. Thus, the DGE model developed here, generates familiar looking IS, BP, and LM conditions, when there are capital controls. The important difference is that household and firm conditions are derived from optimizing behavior, and the private sector distortions and public sector revenues that capital controls introduce are accounted for through budget constraints.

Two foreign shocks are studied; export shocks and foreign interest rate shocks. The key mechanism that alters the reaction of the economy to these shocks is the (endogenous) change in the domestic nominal interest rate. An adverse shock to exports, taken to represent lower global demand for the domestic commodity - or, more loosely, a tariff imposed on sales - reduces GDP by more than it does with unrestricted capital flows, whenever the government imposes a capital outflow. In this case, investment reacts by more than output because, to force the outflow of private capital, the government needs to allow the domestic interest rate to rise. This reinforces the negative effects of the shock and, in this sense, capital controls add to the variability of output. Regardless of the restriction on the flow of capital, the domestic interest rate and investment fall when the foreign interest rate rises. However, the reaction of consumption depends explicitly on the target the government sets for the capital account, and also its holdings of foreign exchange reserves. Only when the country is neither a net creditor nor debtor internationally is the result unambiguous: consumption is insulated from the shock. When this special case does not hold, consumption may rise or fall with the shock, depending on whether the economy is a net creditor or debtor, respectively. Thus, the often assumed insulation properties of capital controls with regard to GDP and foreign interest rate shocks fail to hold, and the governments holdings of foreign exchange reserves are important for determining the co-movement of macro aggregates.

There is a related literature that studies capital controls in economies with money. The Mundell-Fleming framework emphasizes insulation from foreign interest rate shocks, and the possibility of independent monetary policy. However, using a portfolio-balance approach, Marion (1981), for example, shows that insulation occurs only as a special case,

and Aizenman (1985) shows that limited capital mobility does not necessarily increase the scope for monetary policy, when the exchange rate is fixed. Both the Mundell-Fleming and portfolio-balance model offer useful but limited insights. This is particularly true of the former because it does not account for the flow of net foreign assets. Studies based on this framework cannot disentangle the inflow and outflow of reserves and neither can they explain the implications of temporary capital account restrictions. More closely related to the analysis here, Guidotti and Végh (1992) analyze capital controls in an explicitly intertemporal framework. However, in the representative agent economy they develop output is exogenous. More recently, Calvo *et al.* (1995) and Reinhart and Smith (2002) study the intertemporal implications of capital controls in economies with traded and non-traded goods.⁵ Finally, Céspedes *et al.* (2004) and Lahiri *et al.* (2006) study the optimality of different exchange rate regimes when capital market imperfections arise in the private sector. The former, incorporates liability dollarization, whereas Lahiri *et al.* (2006) introduce exogenously segmented asset markets.

The remainder of the paper is organized as follows. Section two describes the model economy. Section three develops a simple representation of the equilibrium conditions of the model and section four studies the reaction of the economy to export and foreign interest rate shocks. Section five concludes.

2. The Model Economy

There is a small domestic economy and a large foreign economy, which exist for two periods.⁶ Other than their size the domestic and foreign economies are identical.

A. Firms

There are two types of domestic firms; those producing a homogenous final good and those producing a differentiated intermediate good.⁷ Final good firms have access to the following

⁵Mendoza (1991) provides an analysis of capital controls in a business cycle model of a small open economy with technology shocks. The obvious drawback of omitting money is that once the capital account is regulated, so is the current account.

⁶It would be possible to extend the analysis to an infinite horizon if I were interested in examining the implications for the length of the capital account restrictions. See Frenkel and Razin (1986) for an analysis of these considerations.

⁷The analysis of this section draws on the open economy macroeconomics literature that stresses the use of monopolistic competition and nominal rigidities, such as Chari *et al.* (2002).

Cobb-Douglas technology,

$$z_t = y_{h,t}^n y_{f,t}^{1-n} / n^n (1-n)^{1-n} \quad (1)$$

where z_t is the final good, and $y_{h,t}$ and $y_{f,t}$ are aggregate bundles of the intermediate goods, produced in the domestic and foreign economies respectively. These firms maximize profits, $P_t z_t - P_{h,t} y_{h,t} - P_{f,t} y_{f,t}$, choosing $y_{h,t}$ and $y_{f,t}$, subject to (1), implying the demand functions for domestic and foreign intermediate goods are,

$$y_{h,t} = z_t (P_t / P_{h,t}) n \quad (2)$$

$$y_{f,t} = z_t (P_t / P_{f,t}) (1-n) \quad (3)$$

where $P_t \equiv P_{h,t}^n P_{f,t}^{1-n}$ is the consumer price index (CPI) and $P_{h,t}$ is the price of the domestic intermediate good. Foreign firms face the same problem, but because of the asymmetry introduced by the small open economy assumption $n^* \rightarrow 0$. In this case, the foreign version of (1) implies $z_t^* \cong y_{f,t}^*$, and the corresponding foreign CPI is $P_t^* \cong P_{f,t}^*$, which is exogenous. This does not mean exports are zero, because z_t^* itself is large. Using a law of one price assumption, $P_{h,t} = e_t P_{h,t}^*$, where e_t is the goods market exchange rate, export demand is,

$$y_{h,t}^* = g_t^* (e_t / P_{h,t}) \quad (4)$$

where $g_t^* \equiv z_t^* n^*$ is restricted to be non-zero and finite, and is exogenous from the viewpoint of the domestic economy. Export demand depends explicitly on the relative price.

The aggregate bundle of intermediate goods is produced using a constant elasticity of substitution production function. For the domestic firm,

$$y_{h,t} = \left[\int_0^1 y_{h,t}(j)^{(\theta-1)/\theta} dj \right]^{\theta/(\theta-1)} \quad (5)$$

where $y_{h,t}(j)$ is the j^{th} intermediate input and the parameter $\theta > 1$ measures the substitution elasticity between types. Profits, $P_{h,t} y_{h,t} - \int_0^1 P_{h,t}(j) y_{h,t}(j) dj$, are maximized, choosing $y_{h,t}(j)$, subject to (5). The solution to this problem implies a downward sloping input demand function of the form,

$$y_{h,t}(j) = (P_{h,t}(j) / P_{h,t})^{-\theta} y_{h,t} \quad (6)$$

where $P_{h,t} = \left(\int_0^1 P_{h,t}(j)^{1-\theta} dj \right)^{1/(1-\theta)}$ is the corresponding price index, derived from the zero profit condition.

The differentiated intermediate goods are produced using competitively supplied domestic labor and capital with a Cobb-Douglas technology.

$$y_{h,t}(j) + y_{h,t}^*(j) = k_t^\gamma l_t(j)^\alpha \quad (7)$$

where $\gamma + \alpha = 1$, k_t is capital, l_t is the labor input, and $y_t(j) = y_{h,t}(j) + y_{h,t}^*(j)$ is domestic GDP. Intermediate good firms maximize profits, $\int_0^1 P_{h,t}(j)y_t(j)dj - w_t l_t(j) - Q_t k_t$, choosing $k_t, l_t(j)$, and $P_{h,t}(j)$, where w_t are nominal wages, and Q_t is the nominal rental rate of capital, such that (6) and (7) hold.

Cost minimization implies factor demands can be written as,

$$k_t/l_t(j) = [(1 - \alpha) / \alpha] w_t / Q_t \quad (8)$$

Given factor demand, firm j sets the price of it's good as a mark-up over marginal cost, mc_t .⁸ In equilibrium, intermediate good firms set the same price,

$$P_{h,t} = [\theta / (\theta - 1)] E_{t-1} \{mc_t\} \text{ for } t = 0, 1 \quad (9)$$

where $\theta / (\theta - 1) > 1$ is the monopoly markup.⁹

B. Households

Domestic households choose foreign nominal bond and domestic nominal money holdings, consumption, labor supply, and investment. Suppressing the j index, households maximize,

$$U = u(C_0, m_0, l_0) + \beta u(C_1, m_1, l_1)$$

subject to the period budget constraint and capital accumulation equation,

$$s_t (\Delta B_t - B_{t-1} i_{t-1}^*) = \vartheta_t + w_t l_t + Q_t k_t - P_t (C_t + x_t) - M_t + M_{t-1} - \mathcal{T}_t \quad (10)$$

$$x_t = k_{t+1} \quad (11)$$

for $t = 0, 1$. Above, $\beta \in (0, 1)$ is the discount factor, C_t is total consumption, $m_t \equiv M_t / P_t$ are real money balances, x_t is investment, so that $P_t x_t$ represents nominal expenditure on

⁸Constant returns to scale in production and perfectly competitive factor markets imply $k_t/l_t(j) = k_t/l_t \forall j$, with nominal marginal cost $mc_t = w_t^\alpha Q_t^\gamma / \alpha^\alpha \gamma^\gamma$.

⁹I write this expression with an expectations operator because although the $t = 1$ version holds exactly the $t = 0$ version may not hold ex-post, given an unanticipated shock. Note also that $mc_t = w_t / f_l = w_t l_t / \alpha k_t^\gamma l_t^\alpha$ and that the price setting equation can be expressed as, $P_{h,t} = [\theta / \alpha (\theta - 1)] E_{t-1} \{w_t l_t / y_t\}$.

capital, and ϑ_t are monopoly profits from the production of the differentiated intermediate good. The foreign net nominal interest rate is i_t^* , s_t is the financial exchange rate, B_t are foreign currency bonds, so that ΔB_t represents the change in foreign assets holdings of individual j . Finally, \mathcal{T}_t is a nominal lump-sum government tax. In (11), it has been assumed, for simplicity, that capital depreciates completely in production.

I specialize period utility to $u = \ln C_t + a \ln (M_t/P_t) - \kappa l_t$, where $a > 0$ is a measure of monetary frictions and $\kappa > 0$ is the weight attached to the dis-utility of labor. The first-order conditions imply,

$$P_1 C_1 = \beta P_0 C_0 (1 + i_0) \quad (12)$$

$$w_t = \kappa P_t C_t \text{ for } t = 0, 1 \quad (13)$$

$$P_1 C_1 = \beta C_0 Q_1 \quad (14)$$

$$M_0 = a P_0 C_0 (1 + i_0) / i_0 \quad (15)$$

$$M_1 = a P_1 C_1 \quad (16)$$

Equation (12) is the consumption Euler equation, (13) represents labor supply, and (14) the optimal choice of capital.¹⁰ Equations (15) and (16) express the demand for money, where money held in the terminal period is independent of the interest rate.

Of the two exchange rates, the financial exchange rate, s_t , is important for flows of net foreign assets, and it alone appears in the household budget constraint. Equations (12), (14) and (15) are affected by the financial exchange rate through the domestic nominal interest rate because, in the current period, one unit of domestic currency purchases $1/s_0$ units of foreign currency, not $1/e_0$ units. I assume this purchase can only be repatriated the following period at the rate s_1 . During the period, the $1/s_0$ units earn i_1^*/s_0 units of interest income, so the amount of foreign currency repatriated into domestic currency is $i_1^* s_1 / s_0$. The combination of these two returns leads to the following real UIP condition.

$$q_0 (1 + r_0) = q_1 (1 + r_0^*) / f_0 \quad (17)$$

where $q_t \equiv e_t/P_t$ is the the real exchange rate and $f_0 \equiv (s_0/e_0)/(s_1/e_1)$ measures the wedge that distorts intertemporal consumption trade. Using the Fisher equation, $(1 + i_0) =$

¹⁰Equivalent to the firms decision I can write, $w_t/P_{h,t} = MRS_t \equiv -u_l/u_C$.

$(1 + i_0^*) \tau_0$, where $\tau_0 \equiv s_0/s_1$. Whenever the exchange rates are unified $f_0 = 1$, so there is no distortion, despite $\tau_0 \neq 1$. Whenever the commercial exchange rate is pegged $\tau_0 (= f_0)$ can be thought of as the distortion.

C. Government

The government consists of a central bank, an import-export authority (IEA), and an exchange rate authority (ERA). The central bank-cum-fiscal authority levies lump-sum taxes and transfers, prints money and earns revenue from interest income on reserves. Printing money, issuing credit, and reserve holdings are connected by a balance sheet condition,

$$M_t - M_{t-1} = e_t \cdot \Delta R_t + d_t - d_{t-1} \quad (18)$$

where R_t are foreign exchange reserves and d_t is domestic credit. The exchange rate attached to reserves is that associated with commercial transactions because the government is free to enter the foreign exchange market without restriction. The central banks period budget constraint is,

$$T_t = d_{t-1} - d_t - e_t R_t i_{t-1}^* \text{ for } t = 0, 1 \quad (19)$$

Intertemporally, central bank transfers, T_t , are constrained by the initial levels of the money supply and reserves, seigniorage revenues and (interest) income lost due to issuing money.

The IEA restricts intratemporal trade in domestic and foreign goods, thereby eliminating the possibility of arbitrage between the commercial and financial exchange rates.¹¹ The ERA restricts intertemporal trade. If a domestic resident wants to exchange one unit of *period t domestic output* for *foreign currency bonds* in order to consume one unit of the *period t + 1 foreign output*, one unit of domestic output is taken to the ERA, who, in exchange for it's

¹¹If a domestic resident wants to export one unit of the *period t domestic output* in exchange for one unit of *period t foreign output* they take the unit of domestic output to the IEA, where its foreign currency value is $P_{h,t}/e_t$. The foreign currency is then used to purchase foreign output, through the IEA, and at the foreign currency price, $P_{f,t}^*$ per unit. Agents hold foreign currency whilst interacting with the IEA and are prevented from interacting with foreign residents directly. Domestic residents are also prevented from obtaining foreign currency (at the exchange rate e_t) in order to buy foreign bonds (at the exchange rate s_t) eliminating arbitrage possibilities. The IEA is not assumed to earn revenue for the government despite its role as the economy's monopoly supplier of the foreign output. If it did this would be equivalent to imposing a tariff on imports. See Fender and Yip (2000) for an analysis of goods market tariffs in a sticky-price environment.

domestic currency value, $P_{h,t}$, issues a credit of $P_{h,t}/s_t$ units of foreign currency. Interest is paid on the credit so that in period $t + 1$ the foreign bond pays back $(1 + i_t^*)P_{h,t}/s_t$ units of foreign currency and the domestic resident receives $(1 + i_t)P_{h,t}$ units of domestic currency.¹²

The ERA generates revenue from these actions because in period t , for one unit of the domestic output, $P_{h,t}/s_t$ units of foreign currency are credited to the domestic resident. This unit is sold to foreign residents for $P_{h,t}^*$. Using the LOP assumption, the profit made on the transaction is $[1 - (e_t/s_t)] P_{h,t}^*$. The ERA buys back the foreign bond from the domestic resident in period $t + 1$ paying out domestic currency to the value of $(1 + i_t^*) (s_{t+1}/s_t) P_{h,t}/P_{f,t+1}$ units of foreign output. The ERA then redeems the bond with the foreign issuers and receives $(1 + i_t^*)P_{h,t}/s_t$ units of foreign currency. But this amount of currency buys $(1 + i_t^*) (1/s_t) P_{h,t}/P_{f,t+1}^*$ units of foreign output on world markets and the profit on the redemption is, $(1 + i_t) [(s_{t+1}/e_{t+1}) - 1] e_t P_{h,t}^*$.

Therefore, by setting $s_t > e_t$, the ERAs actions make it more expensive for domestic residents to gain a credit of one unit of foreign output today than to actually buy and consume that unit. But, by setting $s_{t+1} < e_{t+1}$, domestic residents who cash in their bonds receive less, in terms of foreign output, than the amount which the bonds would yield if domestic agents were able to directly interact with foreign agents. Combining the general profit level of the ERA with the resources available to the domestic residents the ERA period constraint is,

$$\mathfrak{X}_t = (e_t - s_t) (\Delta B_t - B_{t-1} i_{t-1}^*) \text{ for } t = 0, 1 \quad (20)$$

This is the counterpart of the central bank's period constraint, and whenever $s_t \neq e_t$, private bond holdings create revenue which is reflected in the difference between domestic and foreign rates of return on financial investments. However, as stressed before, it is the ratio of the percentage change of the two exchange rates that distorts capital markets.

D. Equilibrium

The resource constraint is $z_t = C_t + \int_0^1 x_t(j) dj$. Using the intratemporal micro-demand conditions, and the definition of domestic GDP, the goods market equilibrium condition is,

$$y_t P_{h,t} = n (C_t + k_{t+1}) P_t + e_t g_t^* \quad (21)$$

where $k_{t+1} = x_t$ and $x_1 = 0$ such that future output on the demand-side is independent of the level of investment.

¹²The ERA finances this action by buying foreign bonds to the value $P_{h,t}/s_t$ in period t .

Wages are flexible, and an economy-wide supply curve relating output, consumption, and capital holds each period.

$$y_t = k_t \{[\theta\kappa / (\theta - 1) \alpha] C_t P_t / P_{h,t}\}^{\alpha/(\alpha-1)} \quad (22)$$

Both the goods and labor market equilibrium conditions link output, consumption and investment to relative prices. When the price is set one period in advance, in the current period, and for a given stock of capital, (21) alone determines the level of output and g_t^* can be thought of as a demand-shifter. To determine investment, factor demands need to be included. In the future period, due to perfect foresight, the goods and labor market equilibrium conditions, and factor demands, determine output.

Finally, solving the government and individual budget constraints forward, gives the national intertemporal budget constraint (NIBC).

$$0 = \sum_{t=0}^1 (P_{h,t} y_{h,t}^* - P_{f,t} y_{f,t}) / [(1 + i_0^*) \dots (1 + i_{t-1}^*)] \quad (23)$$

where $P_{h,t} y_{h,t}^* - P_{f,t} y_{f,t}$ is net exports, $(1 + i_0^*) \dots (1 + i_{t-1}^*) \equiv 1$ when $t = 0$, and $(R_1 + B_1) = 0$ replaces the no Ponzi-game condition. From (23), the discounted sum of the trade balance (evaluated using the foreign interest rate) is equal to the initial economy-wide net foreign asset position.

3. Capital Controls

The central bank fixes the exchange rate through reserve transactions, and the IEA and ERA segment the goods and bond markets so that the government can restrict the flow of private capital.¹³ As usual, the NIBC needs to hold, however, with capital controls, so does a period national budget constraint (NBC). The NBC can be expressed in the following way.

$$\Delta R = CA_0 + \Delta B \quad (24)$$

This constraint has a very standard interpretation: the balance-of-payments, ΔR , equals the sum of the current account, CA_0 , and the capital account, ΔB . As the initial level

¹³One might imagine there is a degree of imperfection in separation, which is more realistic. However, for clarity, it is more natural to consider polar cases without speculating on the scope of government control over goods and financial markets. Dornbusch (1988) explains this segmentation idea in greater detail.

of economy-wide debt is zero, $\bar{P}_h y_{h,0}^* - P_{f,0} y_{f,0}$, which is the trade balance, also measures the current account, which we normally think of as, $\bar{P}_h y_{h,0}^* - P_{f,0} y_{f,0} + i_{-1}^* B_{-1}$. When $\bar{P}_h y_{h,0}^* > P_{f,0} y_{f,0}$, there is a current account surplus. The change in private agents holdings of net foreign assets, $B_0 - B_{-1}$, is now captured by B_0 . When $B_0 > 0$ domestic residents buy foreign bonds and there is a capital outflow. When $B_0 < 0$ domestic residents sell foreign bonds and there is a capital inflow. Above, $\Delta B \equiv -B_0$, and thus, $\Delta B > 0$ represents a capital inflow, and $\Delta B < 0$ a capital outflow.¹⁴ Finally, since reserves are used to fix the exchange rate, $CA_0 \neq \Delta B$. Above, $R_0 - R_{-1} = R_0 \equiv \Delta R$. If $\Delta R > 0$, the government is accumulating reserves, and the balance-of-payments is in surplus. When $\Delta R < 0$, there is a balance-of-payments deficit.¹⁵

The reserve position of the government also needs to be consistent with the central banks balance sheet because reserve holdings are simply the sum of domestic credit and the money supply, $M_0 = \Delta R + D_0$. This implies the following condition holds when the aggregate flow of private capital is restricted to $\Delta \bar{B}$.

$$\Delta \bar{B} = \bar{P} C_0 \left[a \left(\frac{1 + i_0^*}{(1 + i_0^*) - \tau_0} \right) + (1 - n) \right] + (1 - n) \bar{P} x_0 - (\bar{e} g_0^* + D_0) \quad (25)$$

This condition implies there is an economy-wide (aggregate) limit to lending; $\Delta \bar{B}$ cannot be ‘too’ negative. In particular, we cannot lend more than the sum of the economy’s holdings of *current* credit and the *current* level of exports in nominal terms; $\Delta \bar{B} > -(\bar{e} g_0^* + D_0)$. Recall, $\bar{e} g_0^* \geq 0$ is exogenous, as is $D_0 \geq 0$, but this is a policy variable. Thus, it is possible for $\Delta \bar{B} \rightarrow -\infty$, but only if either exports are very high, or the level of credit is expanded. It is permissible for $\Delta \bar{B} \rightarrow +\infty$ for any $\bar{e} g_0^* \geq 0$, $D_0 \geq 0$; that is, the government is not restricted in how much the economy borrows today (the extent of capital inflows). Finally, with unrestricted private capital flows, the NIBC alone matters for the net foreign asset position of the economy. When capital controls are imposed, money demand becomes central to determining the behavior of output, through the NBC, which relates to the balance-of-payments.

The determination of consumption and investment is more standard. Using the consumption Euler and nominal UIP equations, the NIBC can be expressed in terms of current consumption, the change in the financial exchange rate, and investment, consistent with the

¹⁴Likewise, $\Delta B > 0$ is a capital account surplus, and $\Delta B < 0$ a deficit.

¹⁵From this we can also write the NIBC as, $-CA_0 = CA_1 / (1 + i_0^*)$.

intertemporal approach to modelling the current account. This only leaves investment demand. The approach adopted in this paper is related to Céspedes *et al.* (2004), in that the factor demand and price setting conditions are used to determine future nominal output as a function of investment and the domestic nominal interest rate. Goods market equilibrium then provides a second condition in these variables, once it is itself combined with the NIBC. This second step is important because although, in aggregate, private agents holdings of net foreign assets are determined by government policy, and therefore constrained by (25), at the individual, level savings are determined endogenously.

A. IS, LM, and BP Schedules

Because the equilibrium conditions of the model are non-linear I describe the economy through conditions linearized around the no-shock equilibrium.¹⁶ Output is demand constrained in the current period, so the goods market equilibrium condition and NIBC produce an IS equation in output, investment and the domestic nominal interest rate. Since the domestic interest rate is related, via UIP, to the tax on financial asset transactions, the IS condition is written in the following way.

$$\widehat{y}_0 = \rho_{g^*} \widehat{g}^* - \rho_{i^*} \widehat{i}_0^* + \rho_x \widehat{x}_0 + \rho_\tau \widehat{\tau}_0 \quad (26)$$

where a circumflex denotes the percentage deviation from the no-shock equilibrium. The coefficients, which are functions of underlying structural parameters, and the policy variable, $\Delta \bar{B}$, lie between zero and one.¹⁷ The restriction $\rho_x + \rho_{g^*} = 1$ holds for the IS parameters because firms have access to Cobb-Douglas technologies and the export shock is permanent. Output is increasing in investment and exports and decreasing in the foreign interest rate and the tax on foreign financial assets.

In linear form the BP equation has the following representation.

$$\widehat{x}_0 = \widehat{g}^* - \lambda_{i^*} \widehat{i}_0^* + \lambda_\tau \widehat{\tau}_0 \quad (27)$$

¹⁶Since the focus of the analysis is on the initial impact of shocks I do not include the analysis of the long-run here. Moreover, it seems natural to focus on the initial reaction of the economy (when output is demand determined), given that capital controls are an inherently short-run phenomenon.

¹⁷Because the model is non-linear, it is not possible to solve explicitly for the no-shock equilibrium as a function of $\Delta \bar{B}$. Thus $\Delta \bar{B}$ pins down the models endogenous parameters implicitly. Numerically, any feasible $\Delta \bar{B}$ produces a two values for τ_0 . However, since $\tau_0 \in (0, 1 + i_0^*)$, one solution can always be ruled out.

where $\lambda_{i^*} \in (0, 1)$ and $\lambda_\tau > 0$. Investment is increasing in exports and decreasing in the foreign interest rate and the tax. Note that if, for example, $\widehat{\tau}_0$ were an exogenous policy variable, the IS and BP equations would solve for output, with the BP alone determining investment patterns.¹⁸ However, when goods and bond markets are separated, the third condition required to pin down the equilibrium comes from the NBC and money demand. Since output is demand constrained, the linear LM equation can be written in the following way.

$$\widehat{y}_0 = \phi_{g^*} \widehat{g}^* + \phi_{i^*} \widehat{i}_0^* + \phi_x \widehat{x}_0 - \phi_\tau \widehat{\tau}_0 \quad (28)$$

where all coefficients lie between zero and one, except $\phi_{g^*} > 0$. As optimization based approaches to capital controls have tended to neglect the supply-side the most natural point of comparison is with the Mundell-Fleming literature. In Flood and Marion (1982), for example, money demand only depends on output and the interest rate.¹⁹ Here, the equivalent condition, provides a link between government policy and the nominal interest rate, via the NBC.

B. ISBP-AD Representation

The IS, LM, and BP equations are re-expressed as a two variable system to facilitate a comparison with the no capital controls case, which naturally forms a two variable system in \widehat{x}_0 and \widehat{y}_0 . Absent capital controls, the BP determines investment, and the IS, given investment demand, determines output. The LM equation need not be included as an equilibrium condition because it only yields the level of money supply necessary for a particular equilibrium to obtain. In $(\widehat{x}_0, \widehat{y}_0)$ space, the BP schedule is flat, and the IS schedule is positively sloped. The simplest representation with capital controls is of ‘ISBP-AD’ form.

$$\begin{bmatrix} 1 & -\Gamma_x \\ 1 & -\Phi_x \end{bmatrix} \begin{bmatrix} \widehat{y}_0 \\ \widehat{x}_0 \end{bmatrix} = \begin{bmatrix} -\Gamma_{g^*} & \Gamma_{i^*} \\ \Phi_{g^*} & \Phi_{i^*} \end{bmatrix} \begin{bmatrix} \widehat{g}^* \\ \widehat{i}_0^* \end{bmatrix} \quad (29)$$

The Γ and Φ coefficients in this system depend on the structural parameters of the model and government policy. In particular, from the ISBP schedule, $\Gamma = \Gamma(n, \beta, \Theta; \Delta \bar{B})$, where the structural parameters lie between zero and one and $\Delta \bar{B} \in (-\bar{e}g_0^* - D_0, \infty)$.²⁰ From the

¹⁸The BP curve would simply ‘shift’ the BP curve up/down in investment-output space.

¹⁹Flood and Marion (1982) study dual exchange rates in a log-linear Mundell-Fleming model. Converting to the notation in this paper, the equivalent condition is, $\widehat{M}_0 - \widehat{P}_0 = \alpha_0 - \alpha_1 \widehat{i}_0 + \alpha_2 \widehat{y}_0$, where the α ’s are independent of the economy’s structure.

²⁰The parameter Θ is a combination of the monopoly markup and capital’s share in production.

AD schedule, $\Phi = \Phi(a, n, \beta, \Theta; \Delta \bar{B})$, where $a > 0$ measures monetary frictions, and plays a role because of money demand. Given Φ_x and Γ_x , it is also relatively straightforward to depict the equilibrium in (\hat{x}_0, \hat{y}_0) space. The AD schedule is steeper than the 45 degree line, i.e. $\Phi_x = (\phi_x + \rho_x(\phi_\tau/\rho_\tau)) / (1 + (\phi_\tau/\rho_\tau)) \in (0, 1)$, since ϕ_x and ρ_x are also both less than one. The slope of the ISBP is determined by $\Gamma_x \equiv \rho_x + (\rho_\tau/\lambda_\tau)$. The parameter Γ_x also lies between zero and one and, more importantly, it is possible to show that $\Gamma_x > \Phi_x$.²¹ Thus, in (\hat{x}_0, \hat{y}_0) space, both the AD and ISBP schedules are steeper than the 45 degree line, are never vertical, and the AD schedule is always steeper than the ISBP schedule. Finally, it should be clear that the economy exhibits a key similarity to the Mundell-Fleming model under capital controls - not only does the equilibrium depend non-trivially on the LM equation, via aggregate demand, but the ISBP schedule is upward-sloped. The transformed BP schedule is not derived *using* the LM equation, but is a consequence of the capital controls.

4. The Transmission of Foreign Shocks

Before discussing the transmission of export and interest rate shocks when there are capital controls it is useful to clarify the transmission of these shocks when capital flows are unrestricted. A fall in exports reduces current consumption, which lowers output through a Keynesian-type multiplier effect. Output is also affected through the goods market because the terms of trade do not adjust to the shock, and investment demand falls. The changes in consumption, investment, and output are proportional. Changes in the foreign interest rate also affect current output through the savings and investment decisions of private agents. It is worth noting that, as usual, the change in the foreign interest rate produces an income and substitution effect. But under the simplifying assumption of a unit intertemporal substitution elasticity the result is unambiguous.²² Higher interest rates motivate agents to increase their level of saving, and to invest less, both of which lead to a reduction in the current level of output. The reaction of consumption and investment to changes in exports and the foreign interest rate is standard, and consistent with the intertemporal approach to the current account, originally emphasized in Sachs (1981).²³

²¹See Appendix.

²²Before the shock it is assumed that agents are neither borrowing nor lending.

²³A related point is that agents decisions do not exhibit a pure savings-investment separation, even with capital mobility. Consumption allocations influence investment decisions because the economy contains a home-bias feature in the final goods technology, i.e. $n \neq n^*$. Home-bias is implicit in a small open economy that trades in specialized outputs. In a model without home-bias (or with a single traded good), $r_t = r_t^*$.

A. Export Shocks

When capital flows are restricted the domestic nominal interest rate is endogenous, and for a given foreign interest rate, a higher domestic interest rate is consistent with a lower value of τ_0 . Any change in the domestic nominal interest rate can be thought of as an increase in financial market distortions. A permanent fall in exports will always produce a fall in investment, consumption, and output. However, the magnitude of the change in these variables depends on whether the government chooses to impose a restriction on the inflow or outflow of private capital. This policy decision also has a direct implication for the change in the domestic interest rate that results from the shock. In particular, if the government imposes capital inflows, the interest rate falls when exports fall, whereas if it imposes a capital outflow, the interest rate rises. Thus, the magnitude of the change in investment, consumption, and output are linked to the change in the domestic interest rate that results from the export shock, which is effectively offsetting or reinforcing.

To understand how this mechanism works it useful to study the shock diagrammatically. Consider the simplest case, where the government imposes $\Delta\bar{B} = 0$. The export shock will shift both the ISBP and AD schedules, but the result will be a proportional change in output and investment, which is represented as a movement along a 45-degree line.

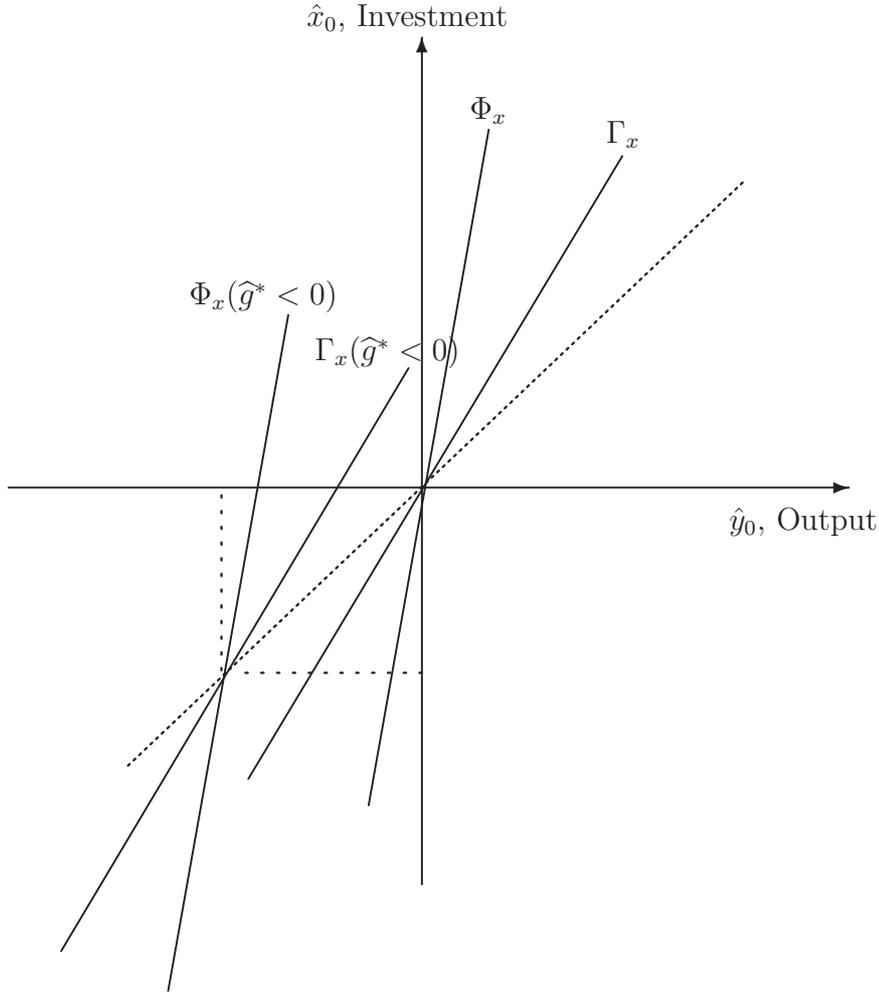


Figure 1: Fall in Exports

The proportional change in output and investment also occurs when private capital is unrestricted. However, without capital controls, the domestic interest rate is not affected by the shock. Here it is endogenous, and dependent on the source of the shock, but when a policy of $\Delta\bar{B} = 0$ is adopted the interest rate is independent of the change in exports, and this is why the capital mobility result is reproduced. Another way to interpret this result is in terms of the elasticities of the ISBP and AD schedules, defined in (29), which depend explicitly on $\Delta\bar{B}$. For output to over react; that is, for output to fall by more than the drop in exports, the following condition is required.

$$\Phi_{g^*} + \Phi_x = \frac{\phi_{g^*} + \phi_x + (\phi_\tau/\rho_\tau)}{1 + (\phi_\tau/\rho_\tau)} > 1 \quad (30)$$

That is, the sum of the elasticities of output with respect to export demand and investment

that characterize the AD schedule have to be larger than one. This result is attractive if one considers that the only additional equation in (29), versus the no capital controls case, is the LM equation, which forms part of the AD schedule. In fact, it is clear that the elasticity condition in (30) only requires $\phi_{g^*} + \phi_x > 1$. In other words, it is the sum of the elasticities of output with respect to export demand and investment arising in the money market that determine whether output and investment mimic the no capital controls case with export shocks.²⁴ The elasticity condition relates directly to government policy because it is possible to show, when $\Delta\bar{B} < 0$, $\phi_{g^*} + \phi_x > 1$, and when $\Delta\bar{B} > 0$, the opposite holds. That is, when the government chooses to force capital outflows, the sum of the elasticities of output with respect to export demand and investment in the money market are greater than one. In this case, output over reacts to the export shock.

The intuitive explanation for this result can be understood from the reaction of the interest rate. Suppose the government chooses a policy of $\Delta\bar{B} < 0$. This implies that private agents are forced to save. To induce this type of behavior the domestic interest rate has to rise. But if this happens, consumption and investment fall. However, the drop in exports already lowers consumption and investment, as in the case without capital controls. Thus, the policy of $\Delta\bar{B} < 0$ exacerbates the impact of the shock. Likewise, if the government picks a policy of $\Delta\bar{B} > 0$, the interest rate will fall, shielding output from the change in exports. There is another important implication of this result, which can be understood from the diagram. Suppose the government forces private outflows of capital and output over reacts to the shock. In this case, investment will be more variable than output, and in terms of the diagram, we will always be below the 45-degree line. Thus, restrictions on capital flows may not only contribute to the variability of output when there are shocks to exports, they can also affect the relationship between output and investment.

Under the form of capital controls studied here the government acts directly as the financial intermediary because it holds a monopoly position in the supply of foreign bonds. Relative to the case where capital flows are unrestricted, this should offer some protection from to the domestic economy. However, this simple explanation turns out to be incorrect. One important implication of the analysis is that adopting capital controls in the face of export disturbances is a potentially bad idea in the sense that it may increase the variability of

²⁴This requirement arises because the IS restriction, $\rho_x + \rho_{g^*} = 1$, implies $\Gamma_x - \Gamma_{g^*} = 1$ in the ISBP equation.

output. At a minimum an important distinction can be drawn between the effects of inflow and outflow restrictions. If countries do, as Reinhart and Rogoff (2004) suggest, adopt dual exchange rate policies as a means to control the flow of private capital, this result also provides an interesting interpretation of the stylized fact that developing economies tend to have more volatile levels of GDP than their industrialized counterparts. Since one argument for capital controls is to insulate the economy from changes in foreign monetary conditions, even if this works, it opens up the possibility of large swings in domestic output as a result of export shocks.

B. Interest Rate Shocks

It is also often assumed that capital controls offer insulation from changes in the foreign interest rate. Without capital controls, changes in the foreign interest rate feed directly through to the domestic economy, and given this, the argument that capital controls offer a form of ‘insulation’ is relatively simple; by using a capital control the domestic nominal interest rate is no longer pegged to the foreign nominal interest rate. However, despite the use of capital controls, evidence of interest rate pass-through, such as that presented in Rogers and Miniane (2007), suggests higher foreign interest rates result in a higher domestic interest rates. Here, the same is true, and the pass-through has important implications because, when the flow of capital is unrestricted, a higher foreign interest rate has unambiguous implications for consumption, investment, and output - all fall. That is not the case when capital flows are restricted, as an increase in the foreign interest rate has two effects on consumption and output. There is a substitution effect away from current consumption which leads to lower current output. But there is also an off-setting or re-enforcing effect depending on the net foreign asset position of the economy because a higher interest rate makes the country either poorer or richer. Therefore, the reaction of consumption to changes in the interest rate is similar to the reaction of an individual - the income effect of the change implies that a borrower is hurt by the rise in interest rates, whilst a lender benefits. That is, consumption rises or falls with the shock, and this causes a potential ambiguity in the reaction of output.

Again, we can link the reaction of the economy to the shock back to the parameter that characterizes the AD schedule. In particular, it can be shown that the sign of Φ_{i^*} depends on the (endogenous) current period net foreign asset position of the economy; that is, $\Phi_{i^*} \equiv \Phi(\Delta R - \Delta \bar{B})$. When $\Delta R > \Delta \bar{B}$ the economy is a net international creditor, and $\Phi_{i^*} > 0$.

Consider the expression for the change in output, as a result of a change in the foreign interest rate.

$$\hat{y}_0 = \frac{\Gamma_x \Phi (\Delta R - \Delta \bar{B}) - \Gamma_{i^*} \Phi_x \hat{i}_0^*}{\Gamma_x - \Phi_x}$$

The overall impact of the shock is ambiguous, but it is clear that a large part of this arises from the reaction of consumption. Again, it helps to consider a special case. When $\Delta R = \Delta \bar{B}$ output must fall when the foreign interest rate rises. Diagrammatically, only the ISBP shifts when $\Delta R = \Delta \bar{B}$.

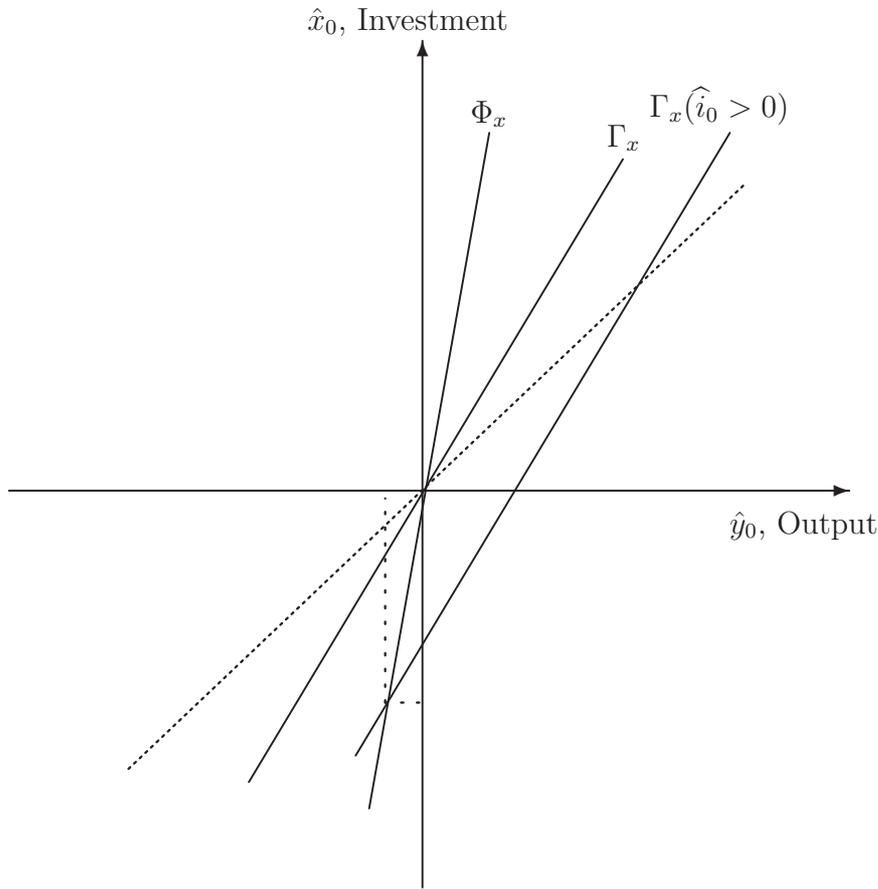


Figure 2: Rise in the Foreign Interest Rate

It is clear from figure two that the reason output falls when the foreign interest rate rises and $\Delta R = \Delta \bar{B}$ is that investment falls. The potential ambiguity in changes in output therefore arise entirely from the income and substitution effects associated with consumption. It is also clear, in this case, that $\hat{x}_0 > \hat{y}_0$, and as ΔR changes, for a given policy choice over private capital flows, the relationship between consumption, investment, and output is affected.

This is an important result because it suggests that whilst capital controls can insulate an economy from changes in the foreign interest rate this insulation only works through aggregate demand. The governments holdings of foreign exchange also have implications for the behavior of output. In the context of previous studies, Flood and Marion (1982) use a stochastic Mundell-Fleming model and find that dual exchange rates provide full insulation from foreign interest rate shocks. This possibility fails here and the use of capital controls may have somewhat more severe consequences than previously thought.

One way to think about this result is through the non-linear NIBC, rewritten in terms of the domestic nominal interest rate,

$$(\Delta R - \Delta \bar{B}) (1 - 1/\tau_0) = \sum_{t=0}^1 CA_t / [(1 + i_0) \dots (1 + i_{t-1})] \quad (31)$$

where $(1 + i_0) \dots (1 + i_{t-1}) \equiv 1$ when $t = 0$. When $\tau_0 = 1$, the domestic and foreign rates of return are equalized, the left-hand side of this expression is zero, and discounting by the domestic or foreign nominal interest rate is equivalent, because there is no distortion in financial markets. However, when there is a capital control, the left-hand side of (31) is zero only when the economy is neither a net creditor nor debtor internationally. In response to the interest rate shock, τ_0 changes, and the net foreign asset position of the economy affects wealth levels such that if, for example, the economy is a net creditor ($\Delta R > \Delta \bar{B}$), consumption rises, whilst investment falls. The wealth mechanism through which consumption rises does not operate when there are shocks to exports. That reserves matter for the macro consequences of interest rate shocks is particularly interesting. As Dollar and Kraay (2006) note, in China, reserve accumulation has largely mirrored the inflow of capital, which, relative to wealth, as reached around 4%. Thus, China's zero net foreign asset position reflects debt flows and FDI that have been roughly balanced by the central banks accumulation of reserves. Given that China has a large number of capital controls in place, this points to the possibility that China could be insulated from any change in global interest rates.

5. Conclusion

This paper develops a general equilibrium model of a small open economy with physical capital, monopolistic competition and sticky prices to understand the implications of capital

controls. I show that the intertemporal equivalence between capital controls and dual exchange rates extends to a more general equivalence between the Mundell-Fleming and DGE approaches. The DGE economy has an upward-sloped balance-of-payments schedule and money demand plays an important role in determining the behavior of output, despite the exchange rate being fixed. As both of these features are a result of government policy, at first glance, the model appears to be much like the textbook Mundell-Fleming model. However, the economy differs from Mundell-Fleming in that budget constraints are imposed on individual behavior and also dictate how government reserves respond to external shocks. Some of the results contrast strongly to the standard logic which supposes that restrictions on capital flows help reduce output fluctuations in response to external shocks. If, as Reinhart and Rogoff (2004) suggest, countries have been using capital controls by imposing a financial exchange rate, the analysis points to an interesting explanation of why output in developing economies is more volatile - capital controls themselves are a source of instability.

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Appendix

Here I derive the ISBP-AD representation of the economy with capital controls, given by equation (29). I start with the national budget constraint,

$$\begin{aligned}\bar{e} [R_t + B_t - (R_{t-1} + B_{t-1}) (1 + i_{t-1}^*)] &= P_{h,t} y_{h,t}^* - P_{f,t} y_{f,t} \\ &= \bar{e} g_t^* - (1 - n) (\Omega_t + P_t x_t)\end{aligned}$$

where the intratemporal micro-demand conditions are imposed. I first make some simplifications. Since R_{-1} and B_{-1} are given, I set them to zero, and since I consider permanent changes in exports, $g_0^* = g_1^* \equiv g^*$. Both the NIBC and NBC need to hold with capital controls. These are, respectively,

$$(1 - n) \left[(\Omega_0 + \bar{P}x_0) + \frac{\Omega_1}{1 + i_0^*} \right] = \bar{e} g^* \left(1 + \frac{1}{1 + i_0^*} \right)$$

and

$$M_0 - D_0 = \bar{e} g^* - (1 - n) (\Omega_0 + \bar{P}x_0) + \Delta \bar{B}$$

where $M_0 = \bar{e} \cdot \Delta R + D_0$ has been imposed. Using the consumption Euler condition the NIBC becomes,

$$(1 - n) \left[\Omega_0 \left(1 + \frac{\beta}{T_0} \right) + \bar{P}x_0 \right] = \bar{e} g^* \left(1 + \frac{1}{1 + i_0^*} \right)$$

In the current period output is demand constrained. Using the goods market equilibrium condition, (21), with the NIBC produces the IS equation.

$$y_0 \bar{P}_h = \left[\frac{n \left(1 + \frac{1}{1 + i_0^*} \right) \tau_0}{(1 - n) (\tau_0 + \beta)} + 1 \right] \bar{e} g^* + \left(\frac{\beta n}{\tau_0 + \beta} \right) \bar{P}x_0 \quad (32)$$

Money demand needs to be consistent with the NBC, as in the main text. Combining this with the goods market equilibrium condition produces the LM equation,

$$y_0 \bar{P}_h = \frac{n (\Delta \bar{B} + D_0)}{a \tilde{\tau}_0 + 1 - n} + \bar{e} g^* \left(\frac{a \tilde{\tau}_0 + 1}{a \tilde{\tau}_0 + 1 - n} \right) + n \bar{P}x_0 \left(\frac{a \tilde{\tau}_0}{a \tilde{\tau}_0 + 1 - n} \right) \quad (33)$$

where $\tilde{\tau}_0 \equiv (1 + i_0^*) [(1 + i_0^*) - \tau_0]^{-1}$. To derive the BP equation, start with the future period goods market equilibrium condition. Since $x_1 = 0$,

$$y_1 P_{h,1} = n \Omega_1 + \bar{e} g^*$$

Substituting in the NIBC and the consumption Euler equation, thereby eliminating future consumption,

$$y_1 P_{h,1} = \left[\frac{n\beta(2+i_0^*)}{(1-n)(\tau_0+\beta)} + 1 \right] \bar{e}g^* - \left(\frac{n\beta(1+i_0^*)}{\tau_0+\beta} \right) \bar{P}x_0$$

From the factor demand and price setting conditions,

$$k_1 Q_1 \Theta = y_1 P_{h,1}$$

where $\Theta \equiv \theta/(\theta-1)\gamma$. From the households capital and consumption choices, $Q_1 = \bar{P}(1+i_0^*)/\tau_0$. Combining these conditions and eliminating $y_1 P_{h,1}$, which is endogenous, produces the BP equation.

$$\bar{P}x_0 (= \bar{P}k_1) = \frac{\bar{e}g^*}{1-n} \left(\frac{\tau_0}{n\beta\tau_0 + \Theta(\tau_0+\beta)} \right) \left[n\beta \left(1 + \frac{1}{1+i_0^*} \right) + \frac{(\tau_0+\beta)(1-n)}{1+i_0^*} \right] \quad (34)$$

Also note, the relative price of goods can be expressed using the following conditions; $(\bar{e}/\bar{P}) = \bar{q}$, $(\bar{e}/\bar{P}_h) = \bar{q}^{1/n}$, and $(\bar{P}/\bar{P}_h) = \bar{q}^{(1-n)/n}$.

I linearize the three conditions; (32), (33), and (34) around the no-shock equilibrium. **IS:**

$$\hat{y}_0 = \rho_x \hat{x}_0 + \rho_\tau \hat{\tau}_0 + \rho_{g^*} \hat{g}^* - \rho_{i_0^*} \hat{i}_0^* \quad (35)$$

where,

$$\begin{aligned} \rho_x &\equiv \frac{\bar{q}^{(1-n)/n} x_0}{y_0} \frac{n\beta}{\tau_0+\beta}; \quad \rho_\tau \equiv \frac{C_0 \bar{q}^{(1-n)/n}}{y_0} \frac{n\beta}{\tau_0+\beta} \\ \rho_{g^*} &= 1 - \rho_x; \quad \rho_{i_0^*} \equiv \frac{i_0^*}{(1+i_0^*)^2} \frac{\bar{q}^{1/n} g^*}{y_0(1-n)} \frac{n\tau_0}{\tau_0+\beta} \end{aligned}$$

with $\rho_x \in (0, 1)$, because $yP_h = n(\Omega + xP) + \bar{e}g^*$, and where all remaining terms on the right hand side are positive. **LM:**

$$\hat{y}_0 = \phi_x \hat{x}_0 - \phi_\tau \hat{\tau}_0 + \phi_{g^*} \hat{g}^* + \phi_{i_0^*} \hat{i}_0^* \quad (36)$$

where,

$$\begin{aligned} \phi_x &\equiv \frac{\bar{q}^{(1-n)/n} x_0}{y_0} \frac{na(1+i_0^*)}{a(1+i_0^*) + (1-n)[(1+i_0^*) - \tau_0]} \\ \phi_\tau &\equiv \frac{C_0 \bar{q}^{(1-n)/n}}{y_0} \frac{na\tau_0 \tilde{\tau}_0}{a(1+i_0^*) + (1-n)[(1+i_0^*) - \tau_0]} \\ \phi_{g^*} &\equiv \frac{\bar{q} g^*}{y_0} \frac{a(1+i_0^*) + [(1+i_0^*) - \tau_0]}{a(1+i_0^*) + (1-n)[(1+i_0^*) - \tau_0]} \\ \phi_{i_0^*} &\equiv \frac{C_0 \bar{q}^{(1-n)/n}}{y_0} \frac{a\tau_0 i_0^* / [(1+i_0^*) - \tau_0]}{a(1+i_0^*) + (1-n)[(1+i_0^*) - \tau_0]} \end{aligned}$$

with $\phi_x, \phi_{i^*} \in (0, 1)$ and $\phi_{g^*}, \phi_\tau > 0$. **BP:**

$$\widehat{x}_0 = \widehat{g}^* + \lambda_\tau \widehat{\tau}_0 + \lambda_{i^*} \widehat{i}_0^* \quad (37)$$

where,

$$\lambda_\tau \equiv \left[\frac{\tau_0 (1-n)}{n\beta (2+i_0^*) + (\tau_0 + \beta) (1-n)} + \frac{\Theta\beta}{n\beta\tau_0 + (\tau_0 + \beta) \Theta} \right]$$

$$\lambda_{i^*} \equiv \frac{i_0^*}{1+i_0^*} \left[\frac{n\beta + (\tau_0 + \beta) (1-n)}{n\beta (2+i_0^*) + (\tau_0 + \beta) (1-n)} \right]$$

with $\lambda_\tau > 0$ and $\lambda_{i^*} \in (0, 1)$. Combine (35) and (37). **ISBP:**

$$\widehat{y}_0 = \Gamma_x \widehat{x}_0 - \Gamma_{g^*} \widehat{g}^* + \Gamma_{i^*} \widehat{i}_0^* \quad (38)$$

where,

$$\Gamma_x \equiv \frac{\rho_\tau}{\lambda_\tau} + \rho_x; \Gamma_{g^*} \equiv \frac{\rho_\tau}{\lambda_\tau} - \rho_{g^*}; \Gamma_{i^*} \equiv \lambda_{i^*} \frac{\rho_\tau}{\lambda_\tau} - \rho_{i^*}$$

where $\rho_{g^*} = 1 - \rho_x$ implies $\Gamma_x = 1 + \Gamma_{g^*}$. Combine (35) and (36). **AD:**

$$\widehat{y}_0 = \Phi_x \widehat{x}_0 + \Phi_{g^*} \widehat{g}^* + \Phi_{i^*} \widehat{i}_0^* \quad (39)$$

where,

$$\Phi_x \equiv \frac{\phi_x + \frac{\rho_x \phi_\tau}{\rho_\tau}}{1 + \frac{\phi_\tau}{\rho_\tau}}; \Phi_{g^*} \equiv \frac{\phi_{g^*} + \frac{\rho_{g^*} \phi_\tau}{\rho_\tau}}{1 + \frac{\phi_\tau}{\rho_\tau}}; \Phi_{i^*} \equiv \frac{\phi_{i^*} - \frac{\rho_{i^*} \phi_\tau}{\rho_\tau}}{1 + \frac{\phi_\tau}{\rho_\tau}}$$

Equations (38) and (39) form (29) in the main text.

Now consider a permanent change in exports. The multiplier is,

$$\widehat{y}_0 = \frac{\begin{vmatrix} 1 - \Gamma_x & -\Gamma_x \\ \Phi_{g^*} & -\Phi_x \end{vmatrix}}{\begin{vmatrix} 1 & -\Gamma_x \\ 1 & -\Phi_x \end{vmatrix}} \widehat{g}^* = \left[\frac{(1 - \Gamma_x)(-\Phi_x) + \Gamma_x \Phi_{g^*}}{\Gamma_x - \Phi_x} \right] \widehat{g}^*$$

First, note $\Gamma_x > \Phi_x > 0$, and $\Gamma_{g^*} > 0 \Rightarrow \Gamma_x > 1$. Second, we can determine when $\widehat{y}_0 > \widehat{g}^*$ because, in this case, $(1 - \Gamma_x)(-\Phi_x) + \Gamma_x \Phi_{g^*} > \Gamma_x - \Phi_x$, or,

$$\Phi_{g^*} + \Phi_x = \frac{\phi_{g^*} + \frac{\rho_{g^*} \phi_\tau}{\rho_\tau}}{1 + \frac{\phi_\tau}{\rho_\tau}} + \frac{\phi_x + \frac{\rho_x \phi_\tau}{\rho_\tau}}{1 + \frac{\phi_\tau}{\rho_\tau}} > 1$$

Imposing $\rho_{g^*} = 1 - \rho_x$,

$$\begin{aligned} \frac{\rho_x \phi_\tau}{\rho_\tau} + \phi_x + \frac{(1 - \rho_x) \phi_T}{\rho_\tau} + \phi_{g^*} &> 1 + \frac{\phi_\tau}{\rho_\tau} \\ \phi_x + \phi_{g^*} &> 1 \end{aligned}$$

which can be expressed as,

$$n\bar{q}^{(1-n)/n} x_0 a \tilde{\tau}_0 + \bar{q}^{1/n} g^* (a \tilde{\tau}_0 + 1) > y_0 [a \tilde{\tau}_0 + (1 - n)]$$

However, we also know the goods market equilibrium condition holds, so the previous condition reduces further, and only holds if $\Delta \bar{B} + D_0 < 0$. Suppose $D_0 = 0$. Then; (outflows) $\Delta \bar{B} < 0 \implies$ overreact; (private autarky) $\Delta \bar{B} = 0 \implies$ equal change; (inflows) $\Delta \bar{B} > 0 \implies$ under react. Likewise, if $\hat{y}_0 > \hat{g}^*$, it is also possible to show $\hat{x}_0 > \hat{y}_0$.

Now consider a change in the foreign interest rate. The multiplier is,

$$\hat{y}_0 = \frac{\begin{vmatrix} \Gamma_{i^*} & -\Gamma_x \\ \Phi_{i^*} & -\Phi_x \end{vmatrix}}{\Gamma_x - \Phi_x} \hat{g}^* = \left[\frac{-\Gamma_{i^*} \Phi_x + \Phi_{i^*} \Gamma_x}{\Gamma_x - \Phi_x} \right] \hat{g}^*$$

Here, Φ_{i^*} measures the consumption response to the shock, and its sign depends on the net foreign asset position of the entire economy. To see this note,

$$\Phi_{i^*} \left(1 + \frac{\phi_\tau}{\rho_\tau} \right) = \left(\frac{\phi_{i^*}}{\phi_\tau} - \frac{\rho_{i^*}}{\rho_\tau} \right) \phi_\tau$$

where,

$$\frac{\phi_{i^*}}{\phi_\tau} = \frac{i_0^*}{1 + i_0^*}, \frac{\phi_{i^*}}{\phi_\tau} = \frac{i_0^*}{1 + i_0^*} \left(\frac{\bar{e}g^*/(1 + i_0^*)}{(1 - n)\Omega_0} \right) \left(\frac{\tau_0}{\beta} \right)$$

Using these conditions with the NBC it can be shown that,

$$\begin{aligned} \Phi_{i^*} &= \frac{i_0^* \phi_\tau}{1 + i_0^*} \left(1 + \frac{\phi_\tau}{\rho_\tau} \right)^{-1} \left(\frac{\tau_0/\beta}{(1 - n)\Omega_0} \right) (\bar{e}R_0 - \Delta \bar{B}) \\ &\equiv \Phi (\Delta R - \Delta \bar{B}) \end{aligned}$$

as claimed in the text.