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Monetary Policy Analysis in a Small Open Credit-Based Economy

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Abstract

This paper describes a simple framework for monetary policy analysis in a small open economy where bank credit is is the only source of external finance. At the heart of the model is the link between banks' lending rates (which incorporate a premium over and above the marginal cost of borrowing) and firms' net worth. In contrast to models in the Stiglitz-Weiss or Kiyotaki-Moore tradition, the supply of bank loans is perfectly elastic at the prevailing rate. The central bank sets the refinance rate and provides unlimited access to liquidity at that rate. The model is used to study the effects of changes in official interest rates, under both fixed and flexible exchange rates. Various extensions are also discussed, including income effects, the cost channel, the role of land as collateral, and dollarization.

JEL Classification Numbers: E44, E51, F41.

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Contents

1 Introduction

It is widely recognized that both the instruments through which monetary policy can be conducted, as well as the transmission mechanism for monetary policy, depend on the financial structure of the economy in which the policy is implemented. In industrial countries, the recognition that financial market frictions generate external finance premia that may limit the access of some firms to securities markets has given rise to the perception that a "credit channel" may provide an important mechanism of monetary transmission—one which may well magnify the impact of monetary policy instruments on aggregate demand—and that the importance of this channel may vary both across countries and over time, depending on the state of financial market development.

In countries completely lacking well-functioning securities markets, as is the case in the vast majority of developing countries, the "credit channel" becomes all-important. Under such circumstances, monetary policy is conducted through the provision of central bank credit to the banking system, and monetary policy transmission involves the impact of such measures on bank deposit and lending rates, which determine the spending responses of households and firms to the actions of the central bank. Despite the prevalence of such conditions in many countries around the world, however, the conduct of monetary policy and the factors influencing monetary transmission in a bank-only world have not been explored in sufficient depth. This is particularly unfortunate because a variety of factors—such as the importance of land markets, the imposition of requirements for the holding of government bonds by banks, and the presence of dollarization—potentially affect monetary transmission in this context, making the analysis of monetary policy in bank-only economies a nontrivial task. Moreover, an increasing number of developing countries with financial structures of this type are considering the adoption of inflation targeting, a monetary policy framework in which the credibility of the central bank is predicated, among other things, on its clear understanding of the monetary transmission mechanism, placing such understanding at a premium.

Dwelling in part on Agénor and Montiel (2006, 2007), this paper attempts to provide a framework in which this issue can be explored, in the context of a small open economy. Its objective is to examine how monetary policy works in countries with financial systems dominated by commercial banks and lacking well-functioning securities markets—features that continue to characterize many middle-income countries (see Mohanti et al. (2006)). We focus specifically on analyzing the factors that influence how central bank monetary policy decisions (in the form of changes in interest rates) are transmitted to aggregate demand in this context. A key feature of our approach is the explicit account of an important source of imperfection in credit markets, namely, the fact that exposure to idiosyncratic shocks makes borrowers' ability to repay uncertain. In addition, we account for the fact that weak insolvency laws and inefficient judicial systems—keys feature of developing countries, as documented by Wihlborg (2002) and Djankov et al. (2003)—hamper the ability of financial intermediaries to enforce the terms of loan contracts in case of default. As a result, lending tends to be highly collateralized, and borrowers' net worth have a large impact on the terms of credit. Specifically, because changes in collateralizable wealth affect bank pricing behavior, balance sheet effects play a key role in the transmission mechanism of monetary policy. However, in contrast to models in the tradition of Kiyotaki and Moore (1997) and its variants (see, for instance, Aghion, Bacchetta, and Banerjee (2000)) collateralizable wealth does not act as a strict quantity constraint on bank borrowing; rather, in the tradition of Bernanke and Gertler (1989), it affects the risk premium that banks demand from their customers. At the (premium-inclusive) prevailing lending rate, banks provide all the liquidity that firms need. Nevertheless, because the risk premium varies inversely with the price of physical assets, the model allows monetary policy to generate a "financial accelerator" effect, to the extent that it amplifies changes in collateral values.

For the sake of clarity, we keep the focus on the financial sector by taking a minimalist approach to modeling the real sector in the economy under study—specifically, we restrict ourselves to a simple, *ad hoc* analytical framework to describe private spending decisions, abstracting away from a full-blown analysis of intertemporal factors. Moreover, we take up several extensions to our basic framework one at a time, rather than simultaneously. Our objective in doing so is to sacrifice analytical elegance for clarity.

The remainder of the paper is organized as follows. The next section describes our basic framework. The solution of the model is presented in Section 3, under both fixed and flexible exchange rates. Section 4 analyzes how monetary policy—in the form of changes in the refinance rate—operates in the basic framework. A series of extensions particularly relevant to developing countries are then taken up in Section 5, including the possibility of large income effects associated with changes in asset holdings, the operation of a supply-side "cost channel," the effects of land markets (with land serving as an alternative source of collateral), the role of government bonds, and the impact of dollarization. The last section provides some concluding remarks.

2 A Minimal Framework

Consider a small open economy producing a single (composite) good that is imperfectly substitutable for a foreign good. The economy is small and the world price of the foreign good is exogenous. Domestic output is fixed for the time being. There are five markets in the economy (for currency, bank deposits, credit, goods, and foreign exchange), and four categories of agents: households, commercial banks, the government, and the central bank.

2.1 Household Portfolio Allocation

Households consume both the domestic and foreign goods, and hold two types of assets: domestic currency (which bears no interest) and deposits with commercial banks. Assets are imperfect substitutes and foreigners do not hold domestic assets.

Household financial wealth, F^H, is defined as:

$$F^H = BILL + D, \tag{1}$$

where $BILL$ is currency holdings and D bank deposits.

The demand for currency is proportional to private consumption in nominal terms (to capture a transactions motive) and negatively related to the interest rate on bank deposits, i_D:

$$\frac{BILL}{P_D C} = \nu(i_D), \tag{2}$$

where C is real private consumption (measured in terms of domestic goods), P_D the price of the domestic good, and $\nu' < 0$.[1] We will assume in what follows that financial wealth is predetermined, at F_0^H. Combining (1) and (2) therefore yields

$$D = F_0^H - P_D C \nu(i_D), \tag{3}$$

which is solved later, once the consumption function is specified.

[1] The reason why only the interest rate i_D enters in (**??**) is that currency is the only alternative to holding domestic deposits and there is no direct return to holding cash. The expected inflation rate, however, could also be added.

2.2 Commercial Banks

Liabilities of commercial banks consist of deposits held by households, D, and borrowing from the central bank, L^B, whereas their assets consist of loans to firms, L^F, and required reserves held at the central bank, RR.[2] Banks' balance sheet is thus

$$L^F + RR = D + L^B. \tag{4}$$

Reserves held at the central bank do not pay interest. They are determined by:

$$RR = \mu D, \tag{5}$$

where $\mu \in (0, 1)$ is the reserve requirement ratio.

The outstanding stock of credit is determined by firms' demand for loans, to be described later. Banks set both the deposit and lending rates, i_D and i_L, so as to maximize profits, Π^B:

$$\max_{i_D, i_L} \Pi^B = q i_L L^F - i_D D - i_R L^B,$$

where q is the repayment probability, and i_R the cost of central bank loans (or the refinance rate). The first term, $q i_L L^F$, represents therefore expected repayments.[3] For simplicity, we abstract from operating costs.

Banks internalize the fact that the demand for loans (supply of deposits) depends negatively (positively) on the lending (deposit) rate, and take the repayment probability and the refinance rate as given. Using (4) to substitute L^B out, the maximization problem becomes

$$\max_{i_D, i_L} \Pi^B = q i_L L^F(i_L) - i_D D - i_R[L^F(i_L) - (1-\mu)D].$$

First-order conditions for this problem are given by

$$\frac{\partial \Pi^B}{\partial i_D} = -D - i_D d_2 + i_R(1-\mu)d_2 = 0, \tag{6}$$

$$\frac{\partial \Pi^B}{\partial i_L} = qL^F + q i_L L_1^F - i_R L_1^F = 0, \tag{7}$$

[2] All these variables are measured in nominal terms.

[3] It could be assumed that in case of default, the bank seizes a fraction of the collateral pledged by the firm, subject however to an "enforcement cost" that is increasing with the value of the loan; this would lead to adding the term $(1-q)(\kappa_1 P_D K_0 - \kappa_2 L^F)$, where $\kappa_1, \kappa_2 > 0$.

where $d_2 > 0$ measures the response of deposits to i_D (see equation (18)) and $L_1^F < 0$ the response of the demand for loans to the lending rate (see equation (20)).

Let $\eta_D = d_2 i_D / D$ denote the interest elasticity of the supply of deposits. Condition (6) yields therefore

$$i_D = (1 + \frac{1}{\eta_D})^{-1}(1 - \mu) i_R, \tag{8}$$

which shows that the equilibrium deposit rate is proportional to the refinance rate, adjusted (downward) for the implicit cost of holding reserve requirements.

Similarly, let $\eta_L = L_1^F i_L / L^F$ denote the interest elasticity of the demand for loans. Using this definition, condition (7) yields

$$i_L = (1 + \frac{1}{\eta_L})^{-1} \frac{i_R}{q}, \tag{9}$$

which implies that the lending rate is also proportional to the cost of borrowing from the central bank. The higher the elasticity of the demand for loans, or the lower the repayment probability, the higher the lending rate.

In the standard literature on equilibrium credit rationing the repayment probability is often assumed to be a decreasing function of the lending rate itself, as a result of adverse selection and moral hazard effects on the riskiness of the pool of borrowers (see Stiglitz and Weiss (1981)). Suppose instead that q increases with the amount of collateral provided by firms and falls with the amount borrowed, measured at the beginning of the period, L_0^F. Specifically, let

$$q = \frac{q_0}{1 + \theta_L(P_D K_0 / L_0^F)}, \tag{10}$$

with $q_0, \theta_L > 0$ and $\theta_L' < 0$. Collateral is defined as the value of the firm's beginning-of-period stock of physical capital, K_0, times P_D, the price of the domestic good. Combining (9) and (10) yields

$$i_L = (1 + \frac{1}{\eta_L})^{-1} q_0 [1 + \theta_L(\frac{P_D K_0}{L_0^F})] i_R. \tag{11}$$

The term θ_L may therefore be interpreted as a *risk premium* on lending to firms, which is inversely related to the ratio of firms' assets over their liabilities.[4] As discussed in subsequent sections, the fact that the premium depends endogenously on the price of the domestic good allows monetary policy to generate a "financial accelerator" effect.

Using (5), and given that L^F and D are determined by private agents' behavior, the balance sheet constraint (4) can be used to determine borrowing from the central bank:

$$L^B = \max\{L^F - (1-\mu)D, 0\}. \tag{12}$$

Equation (12) implies that banks borrow from the central bank only if they face a shortfall in resources.

2.3 Central Bank

Assets of the central bank consists of loans to banks and foreign exchange reserves, R^* (measured in foreign-currency terms), whereas its liabilities consist of high-powered money, that is, the monetary base, MB:[5]

$$L^B + E \cdot R^* = MB, \tag{13}$$

where E is the nominal exchange rate.

The monetary base is also the sum of currency in circulation and required reserves:

$$MB = BILL + RR, \tag{14}$$

which implies, using (5), that the supply of cash is

$$BILL^s = MB - \mu D. \tag{15}$$

2.4 Prices and Aggregate Demand

The cost of living, P, is a geometric weighted average of the price of the domestic good, P_D, and the price of imported final goods. Assuming that

[4] Firms' assets could be multiplied by a coefficient $\kappa \in (0,1)$, to measure the proportion of firms' assets that can effectively be used or pledged as collateral. In the Appendix, using a stochastic framework we derive an equation of the form $i_L = i_R + \theta_L$, where θ_L is also inversely related to the value of collateral. Note, however, that the analysis is based solely on working capital needs.

[5] Implicit in (13) is the assumption that, under flexible exchange rates, capital gains or losses on foreign exchange reserves arising from fluctuations in the market exchange rate relative to a reference rate are off-balance-sheet items.

the foreign-currency price of the imported good is constant and normalized to unity yields:

$$P = P_D^{1-\delta} E^{\delta}, \tag{16}$$

where $\delta \in (0,1)$ measures the share of private spending on imported goods. For the time being, we take δ as constant.

Private consumption, C, measured in units of the domestic good, depends positively on income, $\bar{Y}^s$, and real financial wealth, F_0^H, and negatively on the real deposit rate, to capture an intertemporal effect:

$$C = \alpha_1 \bar{Y}^s - \alpha_2(i_D - \pi^a) + \alpha_3(\frac{F_0^H}{P_D}), \tag{17}$$

where π^a is the expected inflation rate, $\alpha_1 \in (0,1)$ is the marginal propensity to consume out of disposable income, and $\alpha_2, \alpha_3 > 0$.

Substituting (17) in (3) for C yields

$$D = d(P_D; i_D), \tag{18}$$

where

$$d_1 = -C\nu + \frac{\nu \alpha_3 F_0^H}{P_D} \lesseqgtr 0, \qquad d_2 = -P_D C \nu' + P_D \nu \alpha_2 > 0.$$

A rise in i_D , for instance, increases the demand for deposits both directly (by reducing the "speculative" component of the demand for cash) and indirectly (by reducing consumption and thus the "transactions motive" for holding cash). A rise in the price of the domestic good has an ambiguous effect; on the one hand, it increases the demand for cash and thus lowers the demand for deposits; on the other, it reduces consumption (through the real balance effect) and raises desired currency holdings. In what follows, we will assume that the direct effect dominates, so that $d_1 < 0$.[6]

Investment is financed entirely by bank loans. It therefore depends negatively on the real lending rate:

$$I = I(i_L - \pi^a), \tag{19}$$

where $I' < 0$. Thus, the demand for loans is given by

$$L^F = L_0^F + P_D I(i_L - \pi^a). \tag{20}$$

[6]This condition is actually quite weak, given that it implies $P_D C > \alpha_3 F_0^H$, that is, using (17), $\alpha_1 \bar{Y}^s > \alpha_2(i_D - \pi^a)$.

Thus, with loan supply perfectly elastic at the rate i_L, the actual stock of credit is demand determined and firms do not face credit constraints.

Exports, X, are positively related to the relative price E/P_D, so that $X' > 0$. The supply of domestic goods to the domestic market is thus $\bar{Y}^s - X(E/P_D)$, and the equilibrium condition in the market for domestic goods is given by[7]

$$\bar{Y}^s - X(\frac{E}{P_D}) = (1-\delta)C + I. \tag{21}$$

2.5 Market for Foreign Exchange

In general, the equilibrium condition of the market for foreign exchange (or, equivalently, the balance of payments) can be written as

$$\frac{P_D}{E}[X(\frac{E}{P_D}) - \delta C] + i^* R_0 - \Delta R^* = 0, \tag{22}$$

where $\Delta R^* = R - R_0^*$ and i^* is the world (risk-free) interest rate.

3 Solution

We now consider the solution of the model under alternative exchange rate regimes. In both cases, there are six market equilibrium conditions to consider: five financial (cash, deposits, loans, central bank credit, and foreign exchange) and one "real" (for domestic goods). Markets for deposits and loans adjust through quantities, with banks setting prices in both cases. Supply of central bank credit is perfectly elastic at the official rate i_R and adjusts also through quantity changes. The market for domestic goods clears through adjustment in the domestic price, P_D.

Adjustment of the market for foreign exchange depends on the prevailing exchange rate regime. Under a fixed exchange rate, $E = \bar{E}$ and equation (22) is used to solve for the change in official reserves, ΔR^*. By contrast, under a flexible exchange rate, $R = R_0^*$ and equation (22) is used to solve

[7]Equation (21) can be written in the more familiar form $\bar{Y} = C + I + [X(E/P_D) - \delta C]$. Note also that a more rigorous derivation of the allocation of output between exports and domestic sales could be based on a constant elasticity of transformation (CET) fuction, as in the two-level decision process often embedded in applied general equilibrium models (see, for instance, Agénor, Bayraktar, and El Aynaoui (2007)). However, qualitatively the end result would be the same.

for the nominal exchange rate E. Note that the fact that liquidity supplied to commercial banks by the central bank is perfectly elastic at the rate i_R implies that base money (and therefore the supply of cash) is endogenous—regardless of the exchange rate regime.[8]

The last market is the market for cash, where demand is determined by (2) and (17), and supply by (15). But Walras' Law implies that one of our market equilibrium conditions can be derived residually from the other equations; there is therefore no need to examine it explicitly.

3.1 Fixed Exchange Rates

Under a fixed exchange rate, as noted earlier, $E = \bar{E}$ and official reserves are endogenous. However, this does not affect the determination of macroeconomic equilibrium; the reason is that it is the beginning-of-period stock of cash that affects private spending. Given our timing convention, the behavior of reserves can therefore be ignored.[9]

To solve the model requires condensing the set of equations described earlier into two equilibrium conditions. The first is the *financial market* equilibrium condition, given by the optimality condition (11). For simplicity, suppose that we normalize q_0 such that $q_0 = (1 + 1/\eta_L)$; this equation yields

$$\frac{\partial i_L}{\partial P_D} = (\frac{K_0}{L_0^F})\theta'_L i_R < 0, \quad \frac{\partial i_L}{\partial i_R} = 1 + \theta_L > 0.$$

An increase in the refinance rate raises the cost of funds for banks, and this is "passed on" directly to borrowers. A rise in domestic prices lowers the equilibrium lending rate, as a result of a financial accelerator effect. In nominal terms, an increase in the domestic price level raises the value of firms' collateralizable net worth relative to their stock of outstanding loans, which are fixed in nominal value. The resulting increase in the repayment probability leads banks to charge a lower premium, thus reducing the lending rate.

The second equilibrium relationship is the *goods market* equilibrium condition, given in (21). Using equations (8), (17), and (19), to substitute out

[8] Note also that L^B has no effect on the determination of the equilibrium, regardless of the exchange rate regime, given that it s determined residually through banks' balance sheet.

[9] However, an equilibrium with, say, continuous losses in official reserves would not be sustainable.

for i_D, C, and I, respectively, and setting $\pi^a = 0$ for simplicity, this condition can be rewritten as

$$\bar{Y}^s - X(\frac{\bar{E}}{P_D}) = (1-\delta)\left\{\alpha_1\bar{Y} - \alpha_2\eta(1-\mu)i_R + \alpha_3(\frac{F_0^H}{P_D})\right\} + I(i_L), \quad (23)$$

where $\eta \equiv (1+\eta_D^{-1})^{-1}$. Solving this equation with respect to i_L yields

$$i_L = i_L(P_D; i_R), \quad (24)$$

where

$$\frac{\partial i_L}{\partial P_D} = \frac{1}{I'}\left\{(1-\delta)\alpha_3(\frac{F_0^H}{P_D^2}) + (\frac{\bar{E}}{P_D^2})X'\right\} < 0,$$

$$\frac{\partial i_L}{\partial i_R} = \frac{(1-\delta)\alpha_2\eta(1-\mu)}{I'} < 0.$$

An increase in the refinance rate raises the deposit rate, which tends to lower consumption, as a result of the intertemporal effect; to maintain equilibrium in the goods market, investment must increase, and this in turn requires a fall in the lending rate. In the absence of any intertemporal effect ($\alpha_2 = 0$) then $\partial i_L/\partial i_R = 0$. A rise in domestic prices exerts two effects. On the one hand, it lowers aggregate demand, because it lowers real wealth and depresses consumption. On the other, it lowers exports, because domestic goods are now more expensive. This tends to increase supply on the domestic market. To offset the fall in consumption and allow demand to match the increase in supply, the lending rate must fall to stimulate investment.

Equations (11) and (24) can be solved simultaneously for the equilibrium values of the loan rate and the price of domestic goods. As shown in the northeast quadrant of Figure 1, the first equation yields the equilibrium curve labeled FF, whereas the second yields the curve labeled GG. Under standard dynamic assumptions, local stability requires GG to be steeper than FF.[10]

[10] Local stability can be analyzed by postulating the following adjustment mechanism, relating changes in P_D to excess demand, $dP_D/dt = \lambda_G[(1-\delta)C + I + X(E/P_D) - \bar{Y}]$, and changes in the lending rate to the difference between the equilibrium and current values, $di_L/dt = \lambda_F[(1+\theta_L)i_R - i_L]$. In these expressions, $\lambda_G, \lambda_F > 0$ denote the speed of adjustment. Necessary and sufficient conditions for stability is that the Jacobian matrix of this system has a positive determinant and a negative trace. Using (17), it can be shown that the trace is $-\lambda_F - (\lambda_G/P_D^2)[(1-\delta)\alpha_3 F_0^H + E \cdot X'] < 0$. The sign of the determinant depends on the sign of $\{1 + [(1-\delta)\alpha_3 F_0^H + E \cdot X']/P_D^2\} - \theta_L' i_R(K_0/L_0^F)I'$, which requires GG to have a steeper slope than FF to be positive.

The supply of domestic goods on the domestic market, given by the left-hand side of (23), is shown in the southeast quadrant; it is an increasing function of the domestic price. The negative relationship between investment and the (real) lending rate is shown in the northwest quadrant. Using the 45-degree line to report $\bar{Y}^s - X$ and I in the southwest quadrant gives private spending on the domestic good, $(1-\delta)C$. The economy's equilibrium is determined at points E, D, H, and J.

3.2 Flexible Exchange Rates

Under a purely flexible exchange rate, official reserves are constant and the equilibrium condition of the market for foreign exchange (22) is solved for E. In fact, in this basic framework, and given that there are no capital movements, setting $R_0^* = 0$ yields

$$X(\frac{E}{P_D}) = \delta C, \tag{25}$$

which implies that the trade balance must always be in equilibrium.

Solving the model is now slightly more involved, given that now there are three equilibrium conditions to consider: the financial market and goods market equilibrium relationships (as before) and condition (25). There are therefore three key endogenous variables: the lending rate, the price of domestic goods, and the nominal exchange rate—or equivalently, the real exchange rate, defined as $z = E/P_D$.

Formally, to determine the solution, we will express the domestic goods market clearing condition (21) and the balance-of-payments equilibrium condition (25) as functions of these three variables, and then use equation (11) to eliminate the lending rate from these equations. The model thus collapses to two equations—an *internal balance* condition describing equilibrium in the domestic goods market, and an *external balance* condition describing balance-of-payments equilibrium—which can be solved for the two unknowns, z and P_D.

Consider first the internal balance condition. Using again (8), (17), and (19), to substitute out for i_D, C, and I, respectively, and setting $\pi^a = 0$, condition (21) becomes

$$\bar{Y}^s - X(z) = (1-\delta)\left\{\alpha_1 \bar{Y} - \alpha_2 \eta (1-\mu) i_R + \alpha_3 (\frac{F_0^H}{P_D})\right\} + I\left\{[1+\theta_L(\cdot)] i_R\right\}. \tag{26}$$

Solving this equation with respect to z yields

$$z = z_I(P_D; i_R), \tag{27}$$

where

$$\frac{\partial z_I}{\partial P_D} = \frac{-\alpha_3(1-\delta)(F_0^H/P_D^2) - I'\theta_L' i_R}{X'} \lesseqgtr 0,$$

$$\frac{\partial z_I}{\partial i_R} = \frac{(1-\delta)\alpha_2\eta(1-\mu) - I'(1+\theta_L)}{X'} > 0.$$

An increase in the official rate lowers both private consumption (by raising the deposit rate) and investment (by raising the lending rate). To maintain equilibrium in the goods market, supply must fall, and this implies a depreciation (to increase exports). A rise in the domestic price level (at the initial level of the real exchange rate) exerts two different effects. The first is a negative wealth effect on consumption, which calls for a *depreciation* to reduce excess supply of domestic goods. The second is the financial accelerator effect: an increase in the domestic price level increases firms' net worth, thereby reducing the lending rate and stimulating investment. To maintain equilibrium in the goods market, the real exchange rate must now *appreciate*, to reduce exports. We will assume in what follows that the wealth effect dominates the financial accelerator effect, so that $\partial z/\partial P_D > 0$.

Next, consider the external balance condition. Using (17) to substitute out for C, the equilibrium condition (25) can be written as:

$$X(z) - \delta\left\{\alpha_1\bar{Y} - \alpha_2\eta(1-\mu)i_R + \alpha_3(\frac{F_0^H}{P_D})\right\} = 0.$$

Solving this equation with respect to z yields

$$z = z_E(P_D; i_R), \tag{28}$$

where

$$\frac{\partial z_E}{\partial P_D} = -\frac{\delta\alpha_3}{X'}(\frac{F_0^H}{P_D^2}) < 0, \qquad \frac{\partial z_E}{\partial i_R} = -\frac{\delta\alpha_2\eta(1-\mu)}{X'} < 0.$$

An increase in the official rate raises the deposit rate and, through intertemporal substitution, lowers private consumption and imports. To maintain external balance, exports must fall, which means that the real exchange rate must appreciate. An increase in domestic prices also lowers private expenditure (through a negative real balance effect) and requires a real appreciation for the balance of payments to remain in equilibrium.

Equations (27) and (28) can be solved simultaneously for the equilibrium values of the real exchange rate and the price of domestic goods. As shown in the northeast quadrant of Figure 2, the first equation defines the internal balance locus, labeled IB, whereas the second defines the external balance locus, labeled EB. Given the assumption $\partial z_E/\partial P_D > 0$, IB has a positive slope, whereas EB has a negative slope.[11] The intersection of these two curves gives the equilibrium values of z and P_D.

The negative relationship (11) between the domestic price and the lending rate, previously defined as the financial equilibrium condition, is displayed in the southeast quadrant, whereas the inverse relationship (19) between investment and the (real) lending rate is shown in the southwest quadrant. The supply of domestic goods on the domestic market, given by the left-hand side of (23), is shown in the northwest quadrant, as a decreasing function of the real exchange rate (through exports). Using the 45-degree line to report investment in the northwest quadrant allows the determination of private spending on the domestic good, $(1-\delta)C$, as the distance M between $\bar{Y}^s - X$ and I. Macroeconomic equilibrium is again determined at points E, D, H, and J.

4 Increase in the Refinance Rate

A variety of policy experiments and exogenous shocks can be analyzed with the minimal framework. We here focus solely on an increase in the refinance rate, i_R.

Consider first the fixed exchange rate regime. An increase in the refinance rate raises the deposit rate directly, which induces households to increase saving and thus reduce spending. To maintain equilibrium in the domestic goods market at an unchanged value of P_D, the loan interest rate must fall. Thus GG shifts downward, as shown in the Northeast quadrant of Figure 3. At the same time, the increase in the refinance rate raises banks' borrowing

[11] Because financial accelerator effects weaken the effects of increases in P_D on the excess demand for domestic goods (as noted earlier), these effects make the internal balance locus flatter than it would otherwise be—that is, a larger increase in the domestic price level is required to restore internal balance after a real depreciation than would be required if financial accelerator effects were absent.

costs, inducing them to increase the lending rate. Consequently, FF shifts upward. The net effect is thus an increase in the equilibrium lending rate and a reduction in the price of domestic goods. The supply of domestic goods on the domestic market drops from H to H' (because the fall in P_D stimulates exports), investment from J to J', whereas the net effect on consumption is ambiguous—the direct effect of the higher deposit rate is to lower private spending, but the drop in prices leads to a positive real balance effect.

Moreover, the increase in the lending rate can be decomposed into a direct "pass-through" effect and a "financial accelerator" effect. The first effect results strictly from the increase in banks' cost of funds and corresponds to the upward shift in FF, at given initial prices; it is depicted at point B. However, the increase in the equilibrium value of the loan interest rate would be larger than this, even if the GG curve did not shift down at the same time—that is, in the absence of the downward shift in GG, the new equilibrium would have been at E'', rather than B.[12] This additional movement results from the financial accelerator effect: the reduction in the price of domestic goods lowers firms' net worth, increases the probability of default, which causes banks to further increase the loan interest rate. This effect is accentuated as the result of the downward shift in GG (due to the drop in investment resulting from the initial rise in the lending rate), because the shift in GG magnifies the effect of the policy on domestic prices.

Consider now the flexible exchange rate regime. The effects of an increase in the refinance rate on consumption (through intertemporal substitution) and investment (through the lending rate) are negative as in the previous case. To maintain internal balance at an unchanged value of P_D, the real exchange rate rate needs to depreciate. Thus IB shifts upward, as illustrated in the northeast quadrant of Figure 4. The fall in consumption leads to a concomitant drop in imports; to maintain external balance, exports must also fall, and this requires an appreciation of the real exchange rate, at the initial level of domestic prices. Thus, EB shifts down. The net effect is that the price of the domestic good must fall—the increase in the refinance rate is contractionary—but the effect of this policy on the real exchange rate is ambiguous. As shown in the northeast quadrant of Figure 4, depending on the magnitude of the shift in IB for a given shift in EB, the economy may move from the initial position E to a point such as E' (corresponding to an

[12] From (24), it can be verified that GG does not shift if $\alpha_2 = 0$, that is, if the intertemporal effect on spending is absent.

appreciation) or E'' (corresponding to an depreciation).[13]

In the southeast quadrant, the increase in the official rate shifts the curve upward; the lending rate therefore rises therefore from H to B on impact. As in the case of fixed exchange rates, the financial accelerator effect (the rise in P_D) translates into an additional upward movement in the lending rate, from B to either H' or H'', depending on the magnitude of the shift in IB.[14] Investment drops from J to J' or J'' in the southwest quadrant, whereas the supply of domestic goods on the domestic market either increases (from D to D') or falls (from D to D''), depending on whether the exchange rate appreciates (from E to E') or depreciates (from E to E''). If the supply of domestic goods increases, then consumption must also increase, because private investment falls. If $\bar{Y}^s - X$ falls, however, the net effect on consumption (given initially by the distance M) is ambiguous. The reason is again the conflict between the direct effect of higher interest rates (which lowers private spending) and the real balance effect resulting from the drop in domestic prices (which tends to increase it). In Figure 4, consumption is shown to increase in both cases, to either M' or M''.

5 Extensions

The "minimal" framework presented in the previous sections can be extended in a number of directions. In what follows we focus on income effects, the cost channel, the role of land as an asset and capital flows, government bonds, and dollarization.

5.1 Income Effects

In discussing household behavior, we took factor income to be exogenous and did not account for the fact that interest income on bank deposits may also affect spending. The second assumption may be justified by the fact that, in the model, stocks are adjusted only at the end of the period, and

[13] A similar graph could be drawn to show that whether the real exchange rate appreciates or depreciates depends on the magnitude of the shift in the EB curve, for a given shift in the IB curve.

[14] Note also that a stronger financial accelerator mechanism flattens out IB; thus, the stronger the accelerator effect is, the larger the drop in prices of domestic goods. Thus, everything else equal, a stronger financial accelerator effect makes it more likely that the real exchange rate will depreciate in response to an increase in the refinance rate.

interest payments are likewise made at the end of each period; they therefore affect the rate of accumulation of financial wealth, rather than (flow) spending during the period. In addition, in the present setting, bank profits are not necessarily zero, but are given instead by $i_L L^F - i_D D - i_R L^B$. We have therefore also implicitly assumed that these profits are distributed to households only at the end of the period.

We will consider in the next subsection the case where factor income is endogenous; for now, let us examine the case where interest payments on bank deposits only are made during the period, based on the beginning-of-period stock of deposits. The consumption function (17) becomes

$$C = \alpha_1[\bar{Y}^s + i_D(\frac{D_0}{P_D})] - \alpha_2\eta(i_D - \pi^a) + \alpha_3(\frac{F_0^H}{P_D}). \tag{29}$$

Solving (23) with (29) yields now

$$\frac{\partial i_L}{\partial P_D} = -\frac{1}{I'}\left\{(1-\delta)[\frac{\alpha_1 i_D D_0 + \alpha_3 F_0^H}{P_D^2}] + (\frac{\bar{E}}{P_D^2})X'\right\} < 0,$$

$$\frac{\partial i_L}{\partial i_R} = \frac{(1-\delta)(1-\mu)(\alpha_2\eta - \alpha_1 D_0)}{I'},$$

which shows that the second derivative is now ambiguous: the intertemporal effect associated with a rise in the official rate is negative, whereas the income effect is positive.

To illustrate the implications of this new specification, consider what happens following a rise in the official rate under fixed exchange rates when the income effect dominates. As shown in the northeast quadrant of Figure 5, curve GG shifts now upward, rather than downward. If FF shifts up a lot compared to GG the net effect is still an increase in the equilibrium value of the lending rate and a fall in domestic prices (point E'). If GG, by contrast, shifts a lot, the outcome will be higher prices, with either a higher lending rate (point E'') or a lower lending rate (point E'''), depending on the magnitude of the shift in FF. In all cases, consumption unambiguously increases, whereas the impact on investment is in general ambiguous. Similar results can be established under flexible exchange rates. Thus, large income effects may explain the "price puzzle", the fact that a contractionary monetary policy may lead to an increase in private spending and higher prices.[15]

[15] This possibility was recently discussed by the magazine *The Economist* (May 3rd,

5.2 Output and the Cost Channel

In the foregoing discussion, output was assumed to be exogenous. We now extend the analysis to endogenize the supply side and introduce a cost channel for monetary policy, by accounting for a direct effect of lending rates on firms' production costs. As discussed by Agénor and Montiel (2008, Chapter 6) this is a common feature of developing economies, and there is evidence that this effect may be important also in industrial countries.[16]

Suppose that firms' working capital needs, which consist solely of labor costs, must be financed prior to the sale of output and that the only available source of financing is borrowing from commercial banks. Total production costs faced by the representative firm are thus equal to the wage bill plus the interest payments made on bank loans. For simplicity, we will assume that loans contracted for the purpose of financing working capital (which are short term in nature, in contrast to those made for capital accumulation), are provided at a fixed mark-up (normalized to unity) on the cost of borrowing from the central bank, at the rate i_R.

Formally, the maximization problem faced by the representative firm can be written as

$$\max_{y} P_D Y - W \cdot N - i_R L^F, \tag{30}$$

where y denotes output, W the nominal wage, N the quantity of labor employed, i_L the nominal (contractual) lending rate charged by commercial banks, and L the nominal amount of loans obtained from commercial banks.

The production function takes the Cobb-Douglas form

$$Y = N^\alpha K_0^{1-\alpha}, \tag{31}$$

where $\alpha \in (0, 1)$. The firm's financial constraint is given by

$$L^F \geq W \cdot N + P_D I, \tag{32}$$

2007) in the context of monetary policy in Japan. See Christiano, Eichenbaum, and Evans (1999), and Bean, Larsen, and Nikolov (2002), for a review of the evidence for industrial countries based on Vector autoregressions.

[16]See, for instance, Ravenna and Walsh (2006) for the United States, Gaiotti and Secchi (2006) for Italy, as well as Chowdhury, Hoffmann, and Schabert (2006), Hulsewig, Mayer, and Wollmershauser (2006), and Tillmann (2006). The link between credit, working capital needs, and output was emphasized early on in the New Structuralist literature by Taylor (1983) and van Wijnbergen (1982) and is the foundation of the so-called Cavallo-Patman effect.

where I denotes investment, as before.

Constraint (32) will be assumed to be continuously binding, because the only reason for firms to demand loans is to finance labor costs and capital accumulation.

Solving problem (30) subject to (31) and (32), taking i_R and I as given, yields the first-order condition

$$\alpha P_D N^{\alpha-1} K_0^{1-\alpha} - (1+i_R)W = 0.$$

Thus, labor demand can be written as

$$N^d = [\frac{\alpha K_0^{1-\alpha}}{(1+i_R)(W/P_D)}]^{1/(1-\alpha)}, \tag{33}$$

which can be substituted in (31) to give

$$Y^s \equiv [\frac{\alpha}{(1+i_R)(W/P_D)}]^{\alpha/(1-\alpha)} K_0. \tag{34}$$

This equation shows that supply of the domestic good is inversely related to the effective cost of labor, $(1+i_L)(W/P_D)$.

The nominal wage is assumed to be fully indexed on the overall price index, P defined in (16):

$$W = P = P_D z^{\delta}. \tag{35}$$

The real wage is thus fixed in terms of the cost-of-living index. However, the product wage, W/P_D, which determines firms' employment decisions, is equal to

$$W/P_D = z^{\delta},$$

which in turn can be substituted into (33) to give

$$N^d = N(z; i_R), \quad N_1^d, N_2^d < 0. \tag{36}$$

Similarly, using (34) yields

$$Y^s = Y(z; i_R), \quad Y_1^s, Y_2^s < 0, \tag{37}$$

which shows that output is negatively related to the real exchange rate and the official interest rate.[17]

[17]It is worth noting that a similar result would obtain under fixed exchange rates if we had assumed instead (in standard Keynesian fashion) that it is the *nominal* wage that is fixed at $\bar{W}$. The product wage would then be $(\bar{W}/E)z$, implying again a negative relationship between the real exchange rate and output.

Using (32), (35), and (36), the firm's demand for credit is now given by

$$L^F = L_0^F + P_D[z^\delta N(z; i_R) + I]. \tag{38}$$

We will also assume that profits are distributed at the end of the period, after the sale of output. Assuming that profits in the previous period are zero, and using (35) and (36), the consumption function therefore takes the form, instead of (17),

$$C = \alpha_1 z^\delta N(z; i_R) - \alpha_2(i_D - \pi^a) + \alpha_3(\frac{F_0^H}{P_D}), \tag{39}$$

The introduction of the cost channel does not affect the financial equilibrium condition under a fixed exchange rate, equation (11). However, it does affect the equilibrium condition of the goods market. Using equations (8), (19), (37), and (39) to substitute out for i_D, I, Y^s, and C, respectively, in the equilibrium condition (21) yields, again with $\pi^a = 0$,

$$Y(\frac{\bar{E}}{P_D}; i_R) - X(\frac{\bar{E}}{P_D}) = I(i_L)$$

$$+(1-\delta)\left\{\alpha_1(\frac{\bar{E}}{P_D})^\delta N(z; i_R) - \alpha_2\eta(1-\mu)i_R + \alpha_3(\frac{F_0^H}{P_D})\right\}.$$

Solving this equation with respect to i_L yields

$$i_L = i_L(P_D; i_R), \tag{40}$$

where

$$\frac{\partial i_L}{\partial P_D} = \frac{1}{I'}\left\{(\frac{\bar{E}}{P_D^2})(-Y_1 + X') + \frac{(1-\delta)}{P_D^2}[\alpha_3 F_0^H + \alpha_1 \bar{E}(z^\delta N_1 + \frac{\delta N^d}{z^{1-\delta}})]\right\} \lesseqgtr 0,$$

$$\frac{\partial i_L}{\partial i_R} = \frac{1}{I'}\left\{Y_2 + (1-\delta)[\alpha_2\eta(1-\mu) - \alpha_1 z^\delta N_2]\right\} \lesseqgtr 0.$$

In contrast to (24), these expressions are now ambiguous. A rise in domestic prices exerts now two additional effects, in addition to lowering aggregate demand (through the real balance effect on consumption) and reducing exports: it boosts aggregate supply, by reducing the real (effective) wage, and may stimulate consumption, as a result of higher labor demand and distributed wage income.[18] The net effect on the lending rate is in general ambiguous, and depends on the relative shifts in sales on the domestic market $Y^s - X$ (which increases unambiguously) and aggregate demand (which depends on the behavior of private spending). Thus, GG may now have a positive, rather than a negative slope. However, this is a rather unlikely outcome; using the normalization $P_D = z = 1$ and the linear approximation $Y_1 \simeq \alpha N_1$, to obtain $\partial i_L/\partial P_D > 0$ requires

$$[\alpha_1(1-\delta) - \alpha]N_1 + (1-\delta)(\alpha_3 F_0^H + \alpha_1 \delta N^d) + X' < 0.$$

Given that $N_1 < 0$ and in practice $\alpha < \alpha_1(1-\delta)$, this condition is unlikely to be met.[19]

An increase in the refinance rate also has an ambiguous on the lending rate. It not only lowers aggregate demand (through the intertemporal effect on consumption), as before, but it reduces also the supply of domestic goods (through its effect on the effective cost of labor, captured through Y_2) and factor income. The second effect (captured by the term $\alpha_1 z^\delta N_2$) compounds the direct negative effect on demand. Because aggregate supply and aggregate demand both fall, the lending rate may either increase or fall to maintain equilibrium in the goods market.[20]

Figure 6 illustrates the case where GG retains a negative slope. The key difference with Figures 1 and 3 is that now, in the southeast quadrant, the supply of domestic goods to the domestic market has a concave shape, given the endogeneity of aggregate output. In addition, however, the supply-side effect of higher official rates is assumed to dominate the demand side, so that GG shifts to the right—just as in Figure 4. The key result now is that—even with inelastic exports—the net outcome could be a contraction in output and a rise in domestic prices, in addition to an overshooting in the lending rate. The rise in the official rate shifts the curve in the southeast

[18] The net effect on distributed wage income (and thus consumption) depends on the sign of $(z^\delta N_1 + \delta N^d / z^{1-\delta})$. Thus, a positive effect requires that $\delta > -zN_1/N^d$, or equivalently that the elasticity of labor demand with respect to the real exchange rate be sufficiently small in absolute value.

[19] The marginal propensity to consume α_1 is in the range of 0.8-0.9, and δ is in the range 0.5-0.6. By comparison, α is about 0.6. Note also that, had we assumed the existence of a proportional income tax at the rate τ, the condition would become $\alpha < \alpha_1(1-\tau)(1-\delta)$.

[20] Using again the normalization $z = 1$ and the linear approximation $Y_2 \simeq \alpha N_2$, it can be established that the supply-side effect of i_R would dominate the demand-side effect, as long as $\alpha > (1-\delta)\alpha_1$—a reasonable assumption in practice. However, as long as $\alpha_2 > 0$, the net effect on the lending rate remains ambiguous.

quadrant inward—whereas in previous experiments (Figures 3 and 5) it did not change. In the case illustrated in the figure, the net outcome is higher domestic prices, a higher lending rate, a contraction in total output due to the direct increase in the cost of working capital, a drop in consumption (as a result of lower factor income, and negative intertemporal and real balance effects), and a reduction in investment. In principle, of course, the supply of domestic goods to the domestic market could *rise*, given that the appreciation of the real exchange rate induced by the increase in domestic prices reduces exports—so much so that it could offset the contraction in total output.[21] In the case shown in the figure, however, $Y^s - X$ also falls. Overall, therefore, the model is capable of generating a "stagflationary" impact of monetary policy.

Note also that there is now a "reverse accelerator" effect: after jumping upward from E to B, as a result of the direct effect of the increase in the refinance rate, the lending rate falls gradually from B to E. In contrast to the case illustrated in Figure 3, there is now "financial deceleration"—the rise in domestic prices translates into an increase in the value of firms' collateral, which in turn mitigates the initial increase in the lending rate.

5.3 Land, Asset Prices, and Capital Flows

In the foregoing discussion, the menu of assets available to households was limited to cash and bank deposits. We now introduce two other types of assets: foreign-currency deposits held abroad, D^*, and land (or housing), whose supply is assumed fixed and normalized to unity. Denoting by P_L the price of land, total wealth, A^H, can be defined as, instead of (1):

$$A^H = BILL + D + E \cdot D^* + P_L \cdot 1 = F^H + P_L, \tag{41}$$

where now only financial wealth, F^H, is predetermined.

Consider first the case where $D^* = 0$. The demand for land, H^d, relative to bank deposits, is defined as

$$\frac{H^d}{D} = h(i_D; \pi_L^e), \tag{42}$$

[21] Note that we do not account in (31) for imported intermediate inputs. In the presence of such goods, real exchange rate movements would also affect the supply side under a flexible exchange rate, in addition to their impact on real wages. This would magnify the contraction in output.

where π_L^e is the expected rate of increase in land prices (assumed constant), $h_1 < 0$, and $h_2 > 0$. The equilibrium condition of the market for land is therefore

$$P_L = D \cdot h(i_D; \pi_L^e), \tag{43}$$

which, using (18), can be solved for the equilibrium price:

$$P_L = p^L(P_D; i_R), \tag{44}$$

where

$$p_1^L = hd_1 < 0, \quad p_2^L = (1-\mu)(hd_2 + Dh_1) \lesseqgtr 0.$$

By reducing the demand for deposits, an increase in the domestic price reduces the demand for land and therefore the price of land. An increase in the refinance rate has, in general, an ambiguous effect on the price of land; on the one hand, it tends to increase it (because it raises the demand for bank deposits), and on the other it reduces it (because the increase in the deposit rate tends to lower demand). We will assume in what follows that the net effect of i_R is to lower the price of land, that is, $p_2^L < 0$.

The channels through which land prices affect the economy are twofold: First, they affect consumption; in a sense, we replace the real balance effect embedded in (17) by a wealth effect, so that

$$C = \alpha_1 \bar{Y}^s - \alpha_2(i_D - \pi^a) + \alpha_3 \left\{ \frac{F_0^H + p^L(P_D; i_R)}{P_D} \right\}. \tag{45}$$

Second, we assume that households, who own firms, can use land as collateral. To highlight differences with the previous case, we will assume actually that physical capital cannot be used to guarantee loans. The banks' premium is thus given by, instead of (11),

$$i_L = [1 + \theta_L\{\frac{p^L(P_D; i_R)}{L_0^F}\}]i_R, \tag{46}$$

where again $\theta_L' < 0$. Because $p_1 < 0$, we now have a *positive* relationship between P_D and the lending rate.

To illustrate the implications of these extensions for macroeconomic equilibrium, let us focus on the fixed-exchange rate case. The financial market equilibrium condition, curve FF in Figure 1, has now a positive slope. By contrast, the fact that we are now considering a wealth effect rather than a real balance effect in consumption does not alter qualitatively the previous results, given that the signs of $\partial i_L/\partial P_D$ and $\partial i_L/\partial i_R$ in (24) remain the same. Thus, GG retains a negative slope. Of course, the transmission process of a change in the refinance is now more complex, due to the role of asset prices.

As shown in Figure 7, an increase in i_R shifts FF upward again, given that $\partial i_L/\partial i_R = (1+\theta_L)+(i_R\theta_L' p_2^L)/L_0^F > 0$. The impact effect of a rise in i_R on aggregate demand is unambiguously negative. On the one hand, it lowers consumption (through the intertemporal effect) and investment, as before; on the other, it lowers the price of land (by inducing a shift toward deposits and reducing the demand for land), which exerts a negative wealth effect. To maintain equilibrium in the market for domestic goods at the initial value of P_D, the lending rate must fall. Thus GG shifts downward.

The initial excess supply of goods tends to lower domestic prices. The net impact effect on the price of land is a priori ambiguous: the direct effect of an increase in the refinance rate is to lower land prices (given that $p_2^L < 0$), but the indirect effect, through P_D, is to increase them (given that $p_1^L < 0$). During the transition to the new equilibrium, however, only the indirect effect operates, implying that land prices unambiguously increase. Consumption is therefore positively affected by two types of wealth effects: a direct effect associated with the fall in domestic prices (as before) and an indirect effect resulting from the rise in the price of land. In addition, the increases in land prices strengthens the value of collateral pledged by firms, and this creates a "reverse financial accelerator" (or decelerator) effect during the adjustment process, that is, a continuous drop in the risk premium and the lending rate.

The new equilibrium is characterized by lower domestic prices, but depending on the magnitude of the change in consumption (that is, the shift in GG), the lending rate may either increase (as shown at E') or fall (as shown at E''). In both cases, there is now a reverse accelerator effect, from B to either E' or E'', in contrast to the "base case" depicted in Figure 3.[22] Another difference between the scenarios depicted in Figures 3 and 7 is the fact that the equilibrium fall in domestic prices is now less pronounced, because the direct, positive wealth effect on aggregate demand that such a fall entails is now compounded by the increase in land prices. In that sense, therefore, *the behavior of land prices hampers the effectiveness of monetary policy.*

[22]The drop in the lending rate during the transition provides an intuitive proof that the net effect of the increase in the refinance rate on the price of land is positive.

Consider now the more general case where $D^* > 0$. The demand for land, H^d, remains as given in (41), whereas the demand for foreign-currency deposits, relative to the demand for domestic-currency deposits, can be defined as

$$\frac{E \cdot D^*}{D} = h^*(i_D; i^* + \varepsilon), \tag{47}$$

where i^* is again the foreign interest rate, ε the expected rate of depreciation, and $h_1^* < 0$, $h_2^* > 0$.

Using (8) and (18), this equation yields

$$E \cdot D^* = d^*(P_D; i_R),$$

where

$$d_1^* = h^* d_1 < 0, \quad d_2^* = h^* d_2 + D h_1^* \lesseqgtr 0.$$

Because an increase in the refinance rate raises the deposit rate on domestic deposits, it reduces the demand for foreign-currency deposits at the same time that it increases the demand for deposits in domestic banks. Assuming that the direct effect dominates implies that $d_2^* < 0$.

Under fixed exchange rates, adding this equation does not change the results much. Under flexible exchange rates, however, changes are quite significant.

5.4 Government Bonds

In many developing countries with financial structures similar to that described here, the banking system is required to hold government bonds at interest rates below those that the banks would require in order to voluntarily hold those assets (these are sometimes referred to as liquidity requirements). Placement of government bonds with the banks, rather than having such bonds held by the central bank, both affects the impacts of other monetary instruments as well as itself becomes an additional instrument of monetary policy. To analyze the implications of mandated holdings of government bonds by commercial banks, consider our previous description of bank behavior.

When banks have to hold government bonds, their balance sheets are given by:

$$L^F + B^B + RR = D + L^B, \tag{48}$$

where B^B is the stock of government bonds involuntarily held by banks, at the below-market interest rate i^B. Banks' profits are now given by:

$$\Pi^B = qi_L L^F + i^B B^B - i_D D - i_R L^B,$$

but because neither i^B not B^B is a choice variable for the banks, the imposition of the requirement has no effect on the first-order conditions described previously for the banks' profit-maximization problem. Specifically, the deposit and lending rates continue to be set by (8) and (9), which are repeated here for convenience:

$$i_D = \eta(1-\mu)i_R, \quad i_L = (1+\frac{1}{\eta_L})^{-1}\frac{i_R}{q}. \tag{49}$$

If the probability that private firms will repay the banks, q, is unchanged, then neither of these interest rates is affected by this policy. All that happens is that the banks' demands for central bank financing changes to:

$$L^B = \max\{L^F + B^B - (1-\mu)D, 0\}. \tag{50}$$

As long as the central bank maintains a perfectly elastic supply of loans for the banks at the rate i_R, then the holding of these bonds by the commercial banks is simply financed by the central bank, and the only implication for banks is that if $i^B > i_R$, they effectively receive a lump-sum subsidy from the central bank for holding government bonds, whereas if $i^B < i_R$ this policy effectively imposes a lump-sum tax on them.

Suppose, however, that the probability of loan repayment on the part of domestic firms depends on the precariousness of the government's fiscal solvency. Specifically, suppose that q depends not just on the amount of collateral provided by firms, but also—negatively—on the stock of government bonds that has been issued to the private (banking) sector. Intuitively, the rationale is that only government debt held by the private sector (and not by the central bank) imposes a fiscal cost on the government, and when the government finds it difficult to service this debt, it may undertake actions (such as the imposition of punitive taxation on firms or their customers) that makes it difficult for private firms to service their debt to banks. In this case, the probability of debt repayment by private firms becomes:

$$q = \frac{q_0}{1+\theta_L(P_D K_0/L_0^F, B^B)}, \tag{51}$$

with $\theta_{L1} < 0$ and $\theta_{L2} > 0$. This situation implies that, other things equal, banks charge a higher risk premium to private firms when they are forced to hold large stocks of government debt:[23]

$$i_L = [1 + \theta_L(\frac{P_D K_0}{L_0^F}, B^B)]i_R. \tag{52}$$

It is easy to see how this situation would affect the process of monetary transmission. First, because the existence of a larger stock of government debt increases the markup that banks apply to the refinance rate in calculating the lending rate, a given change in the refinance rate would have a magnified effect on the lending rate when the stock of government debt held by the banks is large. Second, an increase in the placement of government bonds with commercial banks, either as the result of new government borrowing or as the result of the transfer of such bonds from the central bank, itself becomes a monetary policy instrument. Such a placement would increase the risk premium demanded by banks in their loans to firms, and thus would increase the lending rate at any given value of the refinance rate, exerting a contractionary effect on the economy. In the fixed exchange rate case, for instance, the effect of an increase in the stock of government bonds placed with commercial banks is to displace FF vertically upward, causing the economy to move to the northwest along GG. As a result, the lending rate rises and the domestic price level falls.

In the foregoing discussion, it was assumed that only banks hold government bonds. A more general treatment, of course, would assume that households also hold claims on the public sector. The introduction of these assets adds a new dimension to households' portfolio choices; a demand function for government bonds must be specified, and the fact that the bond rate becomes an opportunity cost for holding other assets must be accounted for. Household expenditure may also now depend on total financial wealth, rather than real money balances only. Beyond that, however, much of the foregoing analysis remains unchanged if consumption continues to depend on beginning-of-period wealth, and if all interest income is distributed at the

[23] In Agénor and Montiel (2006, 2007), we consider the case where banks demand a premium for holding government bonds, up and above the marginal cost of funds, i_R. This is consistent with the evidence for some developing countries, which suggests that financial intermediaries dominate the demand side of the market for government paper. Because in those papers the lending rate is set as a markup over the bond rate, we obtain a relationship similar to (52) between B^B and i_L.

end of the period. If so, as noted earlier, interest payments on government bonds (just like income on bank deposits) would affect the rate at which financial wealth is accumulated, but not consumption expenditure within the period. But if in fact these interest payments are made during the period, based on the beginning-of-period stock of bonds, then results similar to those described in the previous subsection on income effects would follow.

5.5 Dollarization

Dollarization, commonly referred to as a situation in which a foreign currency is used concurrently with the domestic currency as a unit of account, store of value, and a medium of exchange, has important implications for monetary policy in an open economy. To illustrate how our basic framework can be adapted to address some of the issues that arise, consider the case of a flexible exchange rate regime, and suppose that foreign residents do not hold the domestic currency (that is, dollarization is asymmetric). If foreign currency is held only in the form of cash, in quantity $BILL^*$, and if domestic and foreign currencies are perfect substitutes as means of payment, then the demand equation (2) could be replaced as

$$\frac{(BILL + E \cdot BILL^*)}{P_D C} = \nu(i_D).$$

Alternatively, suppose that dollarization represents only asset diversification, which takes the form of foreign-currency deposits held in domestic banks, in quantity D_B^*, in addition to deposits held abroad. The allocation process among the two types of deposits could be specified as in Agénor and Khan (1996) as a two-step process. First, households determine the allocation between domestic- and total foreign-currency denominated deposits (held either at home or abroad), in a manner similar to (47):

$$\frac{E(D^* + D_B^*)}{D} = h_D^*[i_D; (i^*)^{1-\gamma_D}(i_D^*)^{\gamma_D} + \varepsilon],$$

where $\gamma_D \in (0, 1)$ is the (beginning-of-period) ratio of foreign-currency deposits held in domestic banks relative to total foreign-currency deposits, i_D^* the interest rate on foreign-currency deposits held in domestic banks, $h_1^* < 0$, $h_{D2}^* > 0$. The rate of return on foreign-currency assets is thus specified as a weighted averaged of the domestic and foreign interest rates.

Second, households allocate total foreign-currency denominated deposits between deposits in the domestic banking system and deposits abroad, as a function of the interest rate differential between the two assets:

$$\frac{D_B^*}{D^*} = d^*(i_D^* - i^*, x_D),$$

where x_D is an exogenous shift factor that reflects "confiscation risk," that is, the possibility of a forced conversion of foreign-currency deposits into assets denominated in domestic currency, and $d_1^* < 0$, $d_2^* > 0$. Suppose that required reserves apply uniformly at the rate μ on all categories of deposits. Then, in the particular case where banks set $i_D^* = (1-\mu)i^*$, the deposit ratio would be an increasing function of μi^*.

A third aspect of dollarization relates to foreign borrowing by domestic lenders. Let us assume now that, as in Agénor and Aizenman (1998), the financial intermediation process is characterized by a two-level structure: firms borrow from domestic banks (in domestic currency, as before) whereas domestic banks borrow on world capital markets—but only in foreign currency, as a result perhaps of an "original sin" problem.[24] Suppose also that lending at both levels is subject to a premium that depends on the health of the borrower's balance sheet. Equation (11) does not change, but the interest rate faced by domestic banks on world capital markets, i_B^*, could be specified as

$$i_B^* = i^* + \theta_B^* \left\{ \frac{L_0^F - (1-\mu)(D_0 + E \cdot D_{B0}^*) - L_0^B}{E \cdot F_0^B} \right\}, \tag{53}$$

where F^B is banks' foreign borrowing, $\theta_B^{*\prime} < 0$, and the numerator in the expression in brackets denotes net assets (excluding foreign borrowing). The important implication now is that the premium faced by domestic banks is inversely related to the exchange rate, because a nominal depreciation worsens the banks' net worth.

With dollarized liabilities, banks' balance sheet can be written as, instead of (4),[25]

$$L^F + RR = D + E(D_B^* + F^B) + L^B. \tag{54}$$

[24] An alternative approach, followed by Céspedes, Chang, and Velasco (2003, 2004), Elekdag, Justiniano, and Tchakarov (2006), and Gertler, Gilchrist, and Natalucci (2007), is to assume that firms borrow directly on world capital markets.

[25] It could also be assumed, as in Agénor, Jensen, Verghis, and Yeldan (2006), that banks lend to domestic firms in foreign currency as well.

As in Alper (2007), suppose that borrowing from the central bank and borrowing abroad are imperfect substitutes because they are contracted at different maturity—with the former being short term (as is typically the case in practice) and the latter medium or long term. This implies a relative demand equation of the form

$$\frac{E \cdot F^B}{L^B} = f(i_R - i_B^*), \tag{55}$$

with $f' > 0$. Combining (54) and (55) with the new asset demand equations allows us to solve residually for L^B, as before.

At the same time, given (53), the marginal cost of borrowing for banks, i_M, may be specified as a weighted average of both the official rate and the (premium-inclusive) foreign rate:

$$i_M = i_R^{\gamma_M}(i_B^*)^{1-\gamma_M},$$

where $\gamma_M \in (0, 1)$ represents the (beginning-of-period) share of borrowing from the central bank in total borrowing. If so, the price-setting rule (11) becomes

$$i_L = [1 + \theta_L(\frac{P_D K_0}{L_0^F})]i_R^{\gamma_M}(i_B^*)^{1-\gamma_M}. \tag{56}$$

Finally, the balance of payments equilibrium condition (22) therefore becomes, with $R_0^* = 0$,

$$\frac{P_D}{E}[X(\frac{E}{P_D}) - \delta C] + i^* D_0^* - i_B^* F_0^B - \Delta D^* + \Delta F^B = 0,$$

from which the external balance equilibrium condition can be derived.[26]

As can be seen in (54), under a flexible exchange rate regime foreign-currency deposits held in domestic banks as well as foreign borrowing by banks essentially index bank liabilities to the exchange rate. And to the extent that loans extended against these liabilities are denominated in domestic currency, there is a currency mismatch, which weakens banks' balance sheets if the exchange rate depreciates. To reflect this currency mismatch, foreign lenders will charge a higher risk premium, as shown in (53). In turn, the higher "foreign" premium will affect the lending rate to domestic firms (as implied by (56)), and thus investment and aggregate demand.

[26]To solve the model, partial adjustment of both D^* and F^B must now be imposed.

Alper (2007) provides a detailed analysis of a more elaborate model with a similar two-level intermediation process. A key result of his experiments is that the presence of foreign-currency deposits in domestic banks and foreign bank borrowing have important implications for the transmission process of monetary policy, as well as shifts in "market sentiment" on world capital markets. That this is so can be readily inferred from the above set of equations. An exchange rate appreciation induced by an increase in the refinance rate (which raises domestic deposit rates and leads to capital inflows) improves banks' balance sheets and reduces the foreign premium. Depending on the structure of banks' liabilities, this effect may be large enough to dominate the direct impact on the marginal cost at which they borrow. This may lead to lower lending rates, which tends to mitigate the adverse initial effect of the policy on private investment. If the indirect effect is large enough, aggregate demand may actually increase at the same time that output falls—leading to higher, rather than lower, prices. Thus, liability dollarization combined with imperfections on world capital markets may provide an alternative explanation of a "stagflationary" effect of monetary policy.

6 Concluding Remarks

When banks dominate the financial system and securities markets are nonexistent, the process of monetary transmission differs sharply from the standard textbook case typically analyzed in the industrial country context. The key monetary policy instrument is central bank credit to the banking system, a factor that is little more than an afterthought in the standard industrial-country analysis on monetary policy, which typically focuses on open-market operations. We have analyzed the case in which central bank credit policy is price-based rather than quantity based—that is, the central bank uses the refinance rate rather than the stock of credit as its key policy instrument—because this mode of operation is increasingly common in developing countries, as a result of sustained financial reforms.

Our central finding is that the effects on the economy of changes in the refinance rate depend on a host of characteristics of the domestic economy. These include not only familiar textbook considerations such as the exchange rate regime and various interest elasticities of components of aggregate demand, but also less familiar ones such as the roles of land and deposits in households' portfolios, the marketability of land, the effectiveness of firms' collateral, the effects of privately-held government debt on the risk premia charged by banks, the presence of foreign-currency deposits, and access to external financing by banks. The impacts that these factors can have on monetary transmission in a bank-only world are quite substantial—in the case of external borrowing by banks, for instance, potentially reversing the effects of changes in the refinance rate on aggregate demand from what they would otherwise be. The clear implications are that in a bank-only world where credit market imperfections are pervasive, the transmission of monetary policy is highly context-specific. Consequently, understanding the process of monetary transmission in small open developing economies requires a full specification of the environment in which banks operate.

Appendix
Default Risk, Collateral, and Bank Lending Rates

This Appendix presents a partial equilibrium, stochastic framework with credit market imperfections from which a relationship similar to (11) can be derived.[27] We do so in the case, discussed in subsection 5.2, where output is endogenous. In this framework, firms face random shocks to output or, more generally, their repayment capacity. Such shocks make future (end-of-period) repayments on the debt contracted today (at the beginning of the period) uncertain, and leads banks to charge a premium—which is such that the expected yield of the loan is greater than (and, in equilibrium, equal) to the yield that would be obtained if they were to lend at the safe interest rate.

There is no equity market, so firms cannot issue claims on their capital stock. Agents (producers) demand credit from banks (lenders) to finance their working capital needs. Producers rely solely on bank credit to finance the cost of variable inputs, which must be paid prior to production and the sale of output. Output is subject to random productivity shocks. Thus, banks provide loans to firms at the beginning of the period, and face the risk of default on these loans at the end of the period. They are uncertain as to whether they can obtain full legal remedies for breach of contract. Banks are perfect competitors and risk-neutral.

The realized productivity shock is revealed to banks only at a cost. In the event of default by any given producer on its loans, the creditor seizes a fraction of the realized value of output. Seizing involves two types of costs: first, verifying the net value of output (the state of nature) is costly; second, enforcing repayment (in case of default) requires costly recourse to the legal system.

In line with equation (31), output of firm h is given by

$$Y_h = (1+\varepsilon_h)N_h^{\alpha}\bar{K}_h^{1-\alpha}, \tag{A1}$$

where N_h (K_h) denotes labor (physical capital) used by firm h, $\alpha \in (0,1)$, and ε_h is an idiosyncratic productivity shock with zero mean and constant variance. More specifically, ε_h is assumed to follow a symmetric distribution over the interval $(-\bar{\varepsilon}, +\bar{\varepsilon})$, with $\bar{\varepsilon} < 1$. Because ε_h has zero mean, the

[27] The analysis dwells on Agénor and Aizenman (1998, 1999, 2006).

expected value of the productivity shock is unity.[28]

Let i_L^h denote the contractual interest rate on loans made to producer h. The bank determines the lending rate such that the expected net repayment equals the cost of credit. Each bank is assumed to deal with a large number of independent firms; this, in turn, allows the bank to diversify the idiosyncratic risk, ε_h.

Because firms must finance input costs prior to the sale of output, producer h's total variable costs are $(1+i_L^i)\omega N_h$, where ω is the relative price of labor (taken as given by each firm). As in (32), the borrowing constraint is assumed to be continuously binding. Let $P_K\bar{K}_h$ denote the value of the collateral provided by firm i; collateral consists of the stock of physical capital, $\bar{K}_h$, multiplied by its price, P_K. A borrower will choose to default if

$$(1+\varepsilon_h)\chi N_h^\alpha + \kappa P_K \bar{K}_h < (1+i_L^h)\omega N_h, \tag{A2}$$

where $\chi \in (0,1)$ is the fraction of realized output, and $\kappa \in (0,1)$ the fraction of the collateral, that the bank is able to seize in case of default. The left-hand side of equation (A2) is firm h's actual repayment (inclusive of collateral) following a default, whereas the right-hand side is the contractual repayment. We denote by ε_h^M the highest productivity shock leading to default, that is, the value of ε_h for which (A2) holds as an equality:

$$(1+\varepsilon_h^M)\chi N_h^\alpha \bar{K}_h^{1-\alpha} + \kappa P_K \bar{K}_h = (1+i_L^h)\omega N_h, \tag{A3}$$

or equivalently,

$$\varepsilon_h^M = \frac{(1+i_L^h)\omega N_h - \kappa P_K \bar{K}_h}{\chi N_h^\alpha \bar{K}_h^{1-\alpha}} - 1. \tag{A4}$$

If default never occurs—as is the case if the left-hand side of (A3) exceeds the right-hand side—ε_h^M is set at the lower end of the support ($\varepsilon_h^M = -\bar{\varepsilon}$, instead of (A4)).

In case of default, the bank's net revenue is the firm's repayment minus

[28] The production function could be extended to account for an aggregate shock to productivity, as in Agénor and Aizenman (1998) and Agénor, Aizenman, and Hoffmaister (2006).

state verification and contract enforcement costs, given by Λ_h:[29]

$$(1+\varepsilon_h)\chi N_h^{\alpha}\bar{K}_h^{1-\alpha} + \kappa P_K \bar{K}_h - \Lambda_h. \tag{A5}$$

As discussed in the text, commercial banks have access to a perfectly elastic supply of funds by the central bank, at the rate i_R. Suppose also that banks have access to an overnight money market, where resources are borrowed and lent at the risk-free rate i_M. If the market is competitive, then it must be that $i_M = i_R$.[30] Thus, the refinance rate i_R measures also the opportunity cost of lending to firms.

With competitive and risk-neutral banks, the contractual interest rate is determined by the expected break-even condition:

$$(1+i_R)\omega N_h = \int_{\varepsilon_h^M}^{\bar{\varepsilon}} [(1+i_L^h)\omega N_h] f(\varepsilon_h) d\varepsilon_h \tag{A6}$$

$$+ \int_{-\bar{\varepsilon}}^{\varepsilon_h^M} [\chi(1+\varepsilon_h)N_h^{\alpha}\bar{K}_h^{1-\alpha} + \kappa P_K \bar{K}_h - \Lambda_h] f(\varepsilon_h) d\varepsilon_h,$$

where $f(\varepsilon_h)$ is the density function of ε_h. This condition requires that the expected gross repayment from h (evaluated over the range of variation of ε_h) be equal to the gross revenue that could be obtained by lending at the safe interest rate, i_R.

Equation (A6) can be rewritten as

$$(1+i_R)\omega N_h = (1+i_L^h)\omega N_h$$

$$- \int_{-\bar{\varepsilon}}^{\varepsilon_h^M} [(1+i_L^h)\omega N_h - \chi(1+\varepsilon_h)N_h^{\alpha}\bar{K}_h^{1-\alpha} - \kappa P_K \bar{K}_h] f(\varepsilon_h) d\varepsilon_h - \int_{-\bar{\varepsilon}}^{\varepsilon_h^M} \Lambda_h f(\varepsilon_h) d\varepsilon_h,$$

[29] The cost Λ_h is paid by banks in order to identify the productivity shock ε_h, and to enforce adequate payment. The analysis is more involved if some costs are paid *after* obtaining the information about ε_h. In these circumstances, banks will refrain from forcing debt repayment when realized productivity is below an "enforcement threshold." For simplicity of exposition, we refrain from modeling this possibility. We ignore also all other real costs associated with financial intermediation.

[30] On the one hand, if $i_M > i_R$, banks with a liquidity need can borrow at a cheaper rate from the central bank. On the other, banks with excess liquidity have no incentive to set $i_M < i_R$, because banks facing a liquidity shortfall have no other source of finance.

Substituting (A3) for $(1+i_L^h)\omega N_h$ in the second term on the right-hand side of the above equation, the lending rate can be shown to be given by

$$i_L^h = i_R + \theta_L^h, \tag{A7}$$

where θ_L^h is a risk premium defined as

$$\theta_L^h = \frac{\chi N_h^\alpha \bar{K}_h^{1-\alpha} \int_{-\bar{\varepsilon}}^{\varepsilon_h^M} [(\varepsilon_h^M - \varepsilon_h)] f(\varepsilon_h) d\varepsilon_h}{\omega N_h} + \frac{\Lambda_h \int_{-\bar{\varepsilon}}^{\varepsilon_h^M} f(\varepsilon_h) d\varepsilon_h}{\omega N_h}. \tag{A8}$$

The contractual lending rate exceeds the marginal cost of funds for banks (the official refinance rate) by a premium, which is the sum of two terms: the first is the expected revenue lost due to default in bad states of nature, and the second measures the expected state verification and contract enforcement costs.[31]

The producer's expected net income, $E(\Pi^F)$, equals

$$E(\Pi^F) = N_h^\alpha \bar{K}_h^{1-\alpha} - \int_{\varepsilon_h^M}^{\bar{\varepsilon}} [(1+i_L^h)\omega N_h] f(\varepsilon_h) d\varepsilon_h \tag{A9}$$

$$- \int_{-\bar{\varepsilon}}^{\varepsilon_h^M} [\chi(1+\varepsilon_h) N_h^\alpha \bar{K}_h^{1-\alpha} + \kappa P_K \bar{K}_h] f(\varepsilon_h) d\varepsilon_h.$$

The third term on the right-hand side measures the value repaid in the "good" state of nature, when the realized productivity shock is above ε_h^M; this is simply the contractual obligation. The fourth term corresponds to the value of output (inclusive of collateral) that is seized by the bank if the realized productivity shock falls below ε_h^M.

Using (A6), equation (A9) can be simplified to give

$$E(\Pi^F) = N_h^\alpha \bar{K}_h^{1-\alpha} - (1+i_R)\omega N_h - \Lambda_h \int_{-\bar{\varepsilon}}^{\varepsilon_h^M} f(\varepsilon_h) d\varepsilon_h. \tag{A10}$$

The optimal demand for labor, N_h^d, is found by maximizing (A10), that is, by solving the condition $dE(\Pi^F)/dN_h = 0$. It can readily be shown to depend negatively on the *effective* cost of labor, $(1+i_R)\omega$, as shown in the

[31] Note that collateral affects the markup equation (**??**) through ε_h^M; a higher collateral increases the cost of default, thereby reducing the frequency of defaults (ε_h^M falls); consequently, higher collateral reduces the interest rate spread.

text (see equation (33), with $K_0 = \bar{K}_h$). However, equation (33) holds only in the absence of verification and enforcement costs, that is, for $\Lambda_h = 0$, given that in this case (A10) implies that (expected) profits are given by the standard definition $N_h^\alpha \bar{K}_h^{1-\alpha} - (1 + i_R)\omega N_h$. In general, however, it can be shown (by using the implicit function theorem) that labor demand depends also negatively on these costs.

Suppose that the idiosyncratic shock follows a uniform distribution over the interval $(-\bar{\varepsilon}, +\bar{\varepsilon})$; the optimal lending rate defined by (A7)-(A8) is characterized by a quadratic equation, given by

$$i_L^h = i_R + \bar{\varepsilon}\frac{\chi N_h^\alpha \bar{K}_h^{1-\alpha}}{\omega N_h}\Phi_h^2 + \frac{\Lambda_h}{\omega N_h}\Phi_h, \tag{A11}$$

where Φ_h is the probability of default, given by

$$\Phi_h = \int_{-\bar{\varepsilon}}^{\varepsilon_h^M} f(\varepsilon_h) d\varepsilon_h = \frac{\bar{\varepsilon} + \varepsilon_h^M}{2\bar{\varepsilon}}. \tag{A12}$$

Thus, if $\varepsilon_h^M = -\bar{\varepsilon}$ (a condition which, from (A3), requires $(1-\bar{\varepsilon})\chi N_h^\alpha \bar{K}_h^{1-\alpha} + \kappa P_K \bar{K}_h$ to exceed $(1 + i_L^h)\omega N_h$), there is no default risk, and $\Phi_h = \theta_L^h = 0$; the equilibrium lending rate is then equal to the refinance rate ($i_L^h = i_R$). In general, however, banks will typically impose a risk premium, so that $i_L^h > i_R$, as implied by (11).

Combining (A4), with $\kappa = 0$ for simplicity, and (A10)-(A12) yields a quadratic equation linking the contractual lending rate and the refinance rate:

$$i_R + \Psi g(i_L^h)^2 + \frac{\Lambda_h}{\omega N_h} g(i_L^h) - i_L^h = 0, \tag{A13}$$

where

$$\Psi = \frac{\bar{\varepsilon}\chi}{\omega}\left(\frac{\bar{K}_h}{N_h}\right)^{1-\alpha}, \quad g(i_L^h) = \frac{1}{2} - \frac{1}{2\bar{\varepsilon}} + \frac{i_L^h}{2\Psi}.$$

Equation (A13) is quadratic, and it implies that a given i_R can be associated with two values of i_L^h—except in the case where $\Phi_h = 0$, which again implies $i_L^h = i_R$. This result follows from the presence of a trade-off between the interest rate and the frequency of repayment.[32] The efficient point is

[32] A higher interest rate increases the probability of default, implying that the net effect of a higher interest rate on the expected repayment is determined by elasticity considerations. This effect is quite standard in this type of models.

associated with the lower interest rate, as more frequent default is associated with a lower expected surplus (see equation (A10)). For an internal solution where the probability of default is positive, using (A13) and (A3) yields

$$\frac{di_L^h}{di_R} = -\frac{1}{\Phi_h + (\Lambda_h/2\omega N_h \Psi) - 1}. \tag{A14}$$

From (A3), it can be established that if the refinance rate exceeds the value

$$\tilde{\imath}_L^h = \frac{(1-\bar{\varepsilon})\chi N_h^{\alpha} \bar{K}_h^{1-\alpha} + \kappa P_K \bar{K}_h}{\omega N_h} - 1,$$

then $di_L^h/di_R > 0$, but beyond the value $\tilde{\imath}_R$, the contractual lending rate is a convex function of the refinance rate (see Agénor and Aizenman (1998, 1999)). The reason is that an increase in the marginal cost of liquidity is "passed on" to borrowers and therefore raises the probability of default—so much so that, after some threshold $\hat{\imath}_R > \tilde{\imath}_R$, further increases in that rate raise the probability of default at a speed that is high enough to *reduce* expected repayment. At that point credit rationing emerges. In the text, we assume that banks operate along the upward-sloping portion of the i_L^h-i_R curve, so that $di_L^h/di_R > 0$.

It can also be established (see Agénor and Aizenman (1998, 1999)) that a rise in state verification costs, an increase in the value of collateral, or a fall in the proportions of output and collateral that the bank can seize in case of default (coefficients χ and κ), lead to a higher *ex ante* lending rate. Finally, the analysis focuses on an economy composed of a multitude of agents, characterized by idiosyncratic uncertainty; hence, for the aggregate budget constraint, the expected interest rate may be viewed as equivalent to the realized (or actual) rate.

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Figure 1

Macroeconomic Equilibrium:
Fixed Exchange Rates

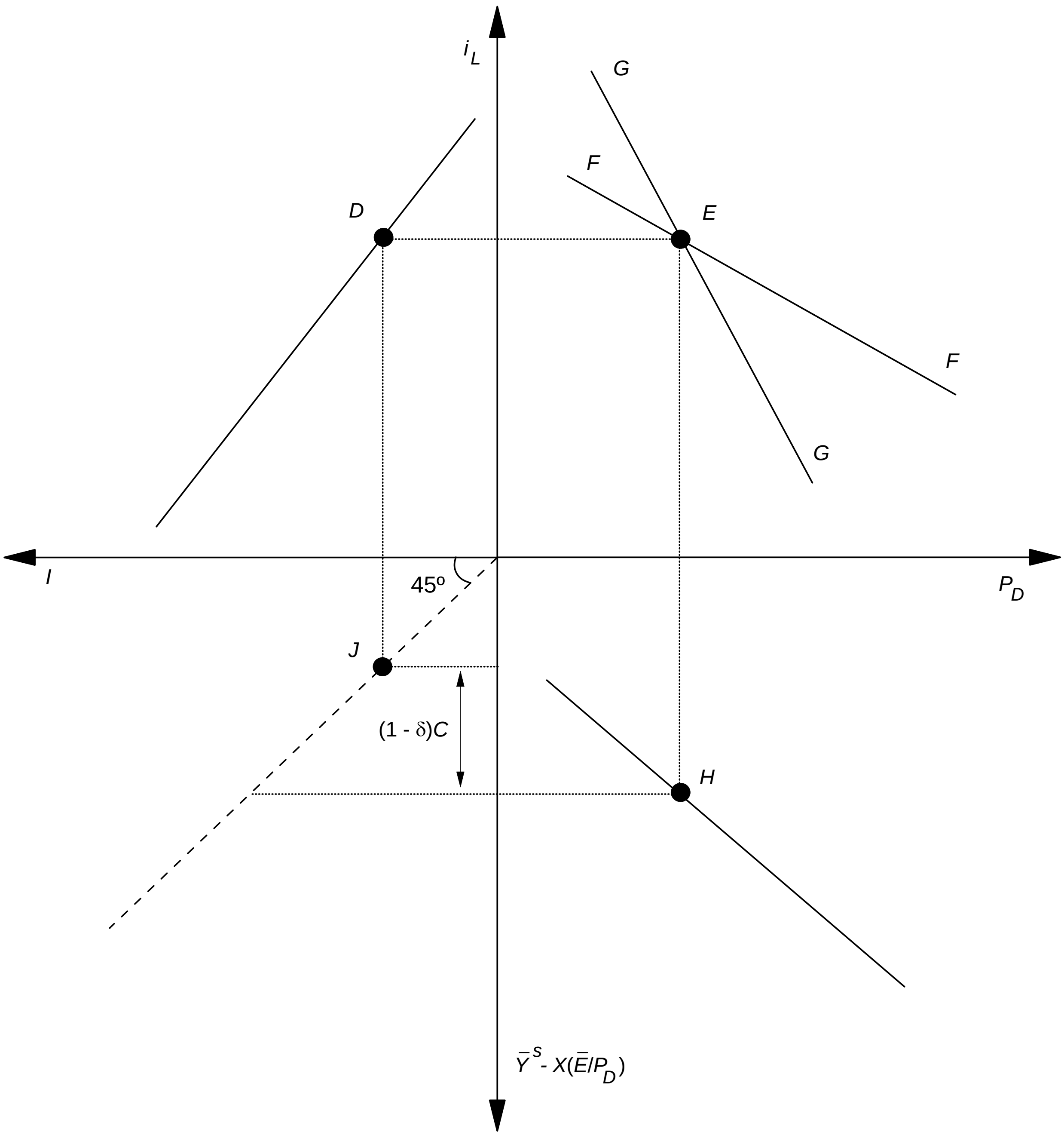

Figure 2

Macroeconomic Equilibrium:
Flexible Exchange Rates

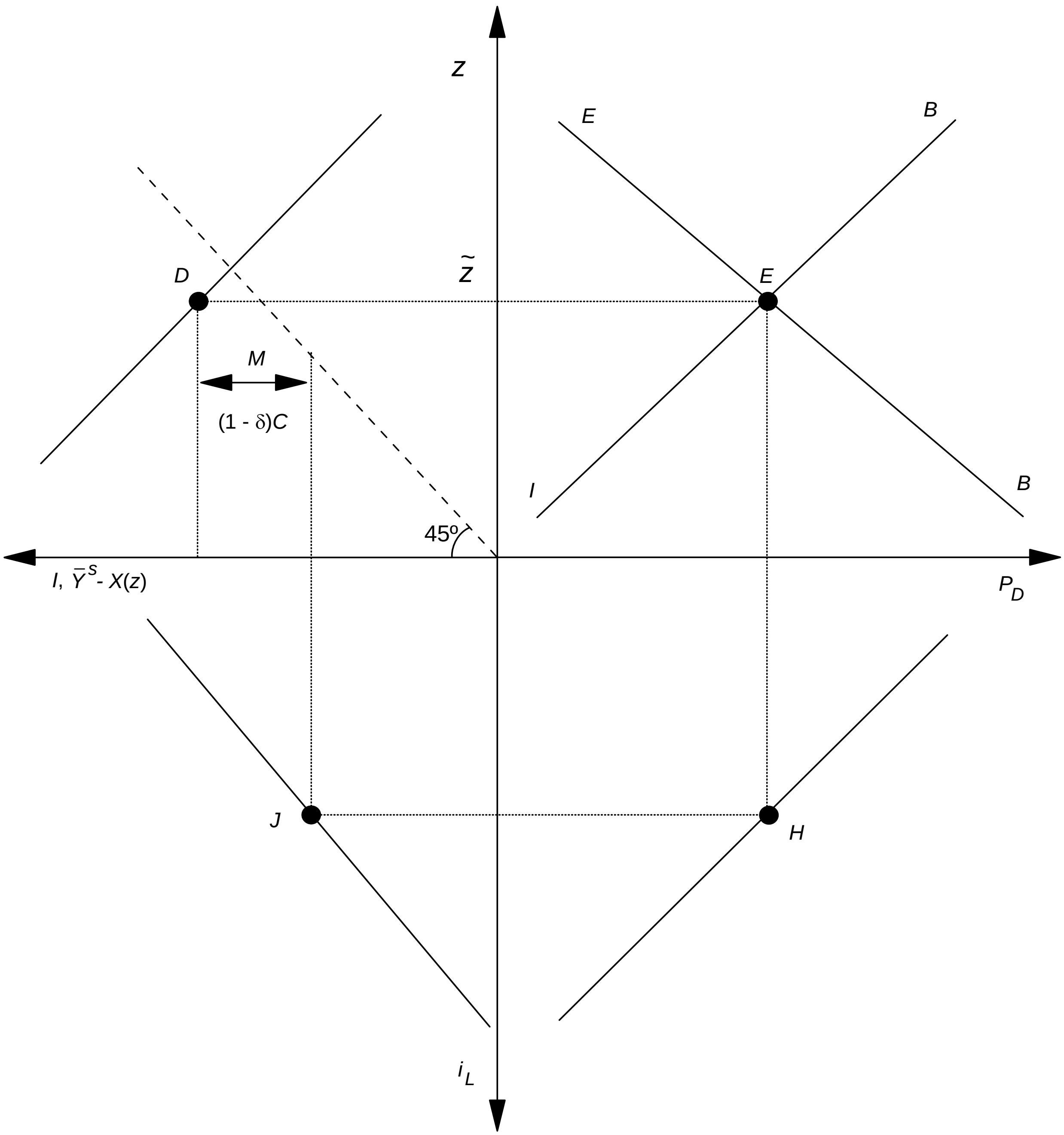

Figure 3

Fixed Exchange Rates: Increase in Refinance Rate

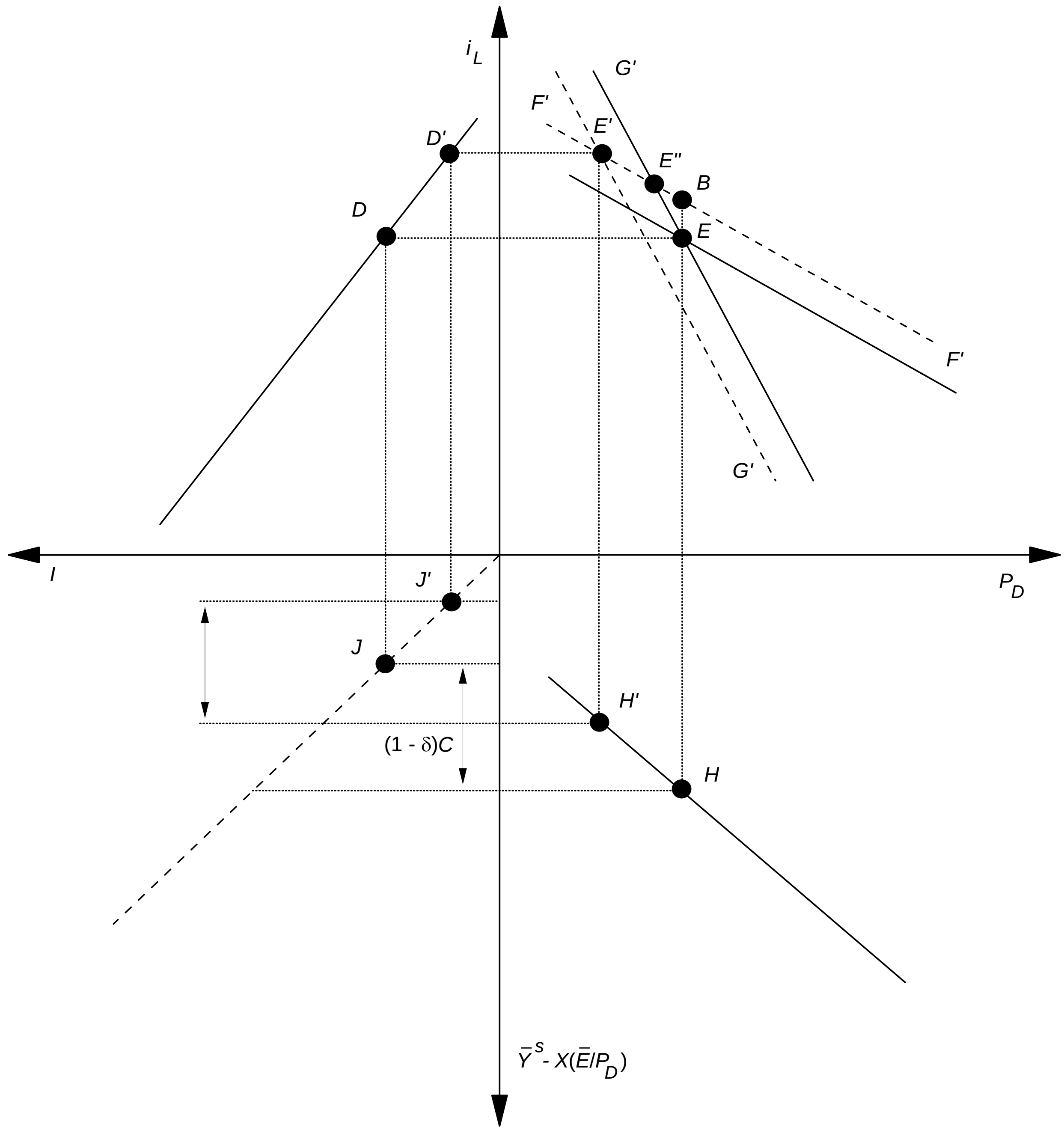

Figure 4

Flexible Exchange Rates:
Increase in Refinance Rate

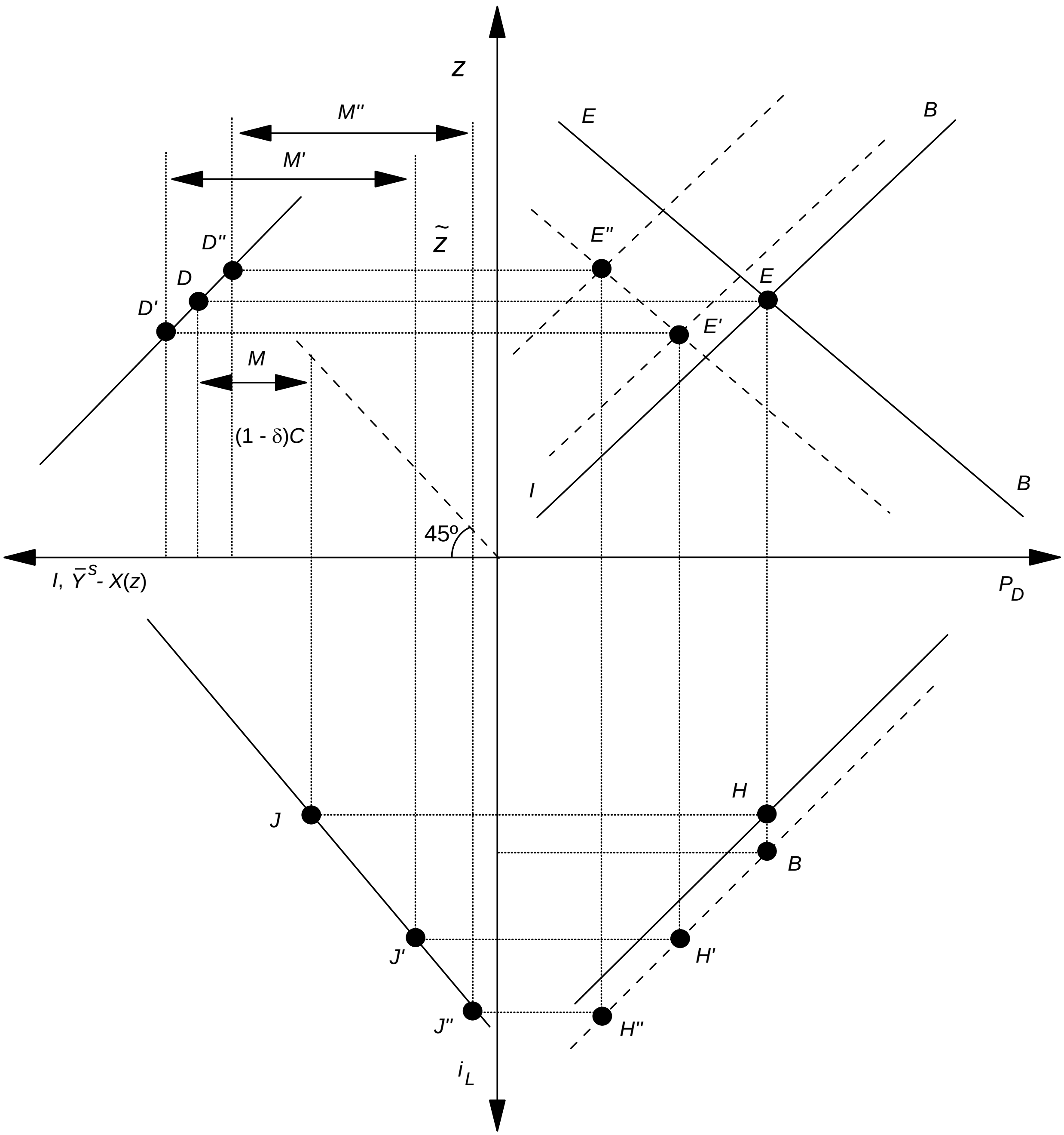

Figure 5

Fixed Exchange Rates:
Increase in Refinance Rate with Large Income Effects

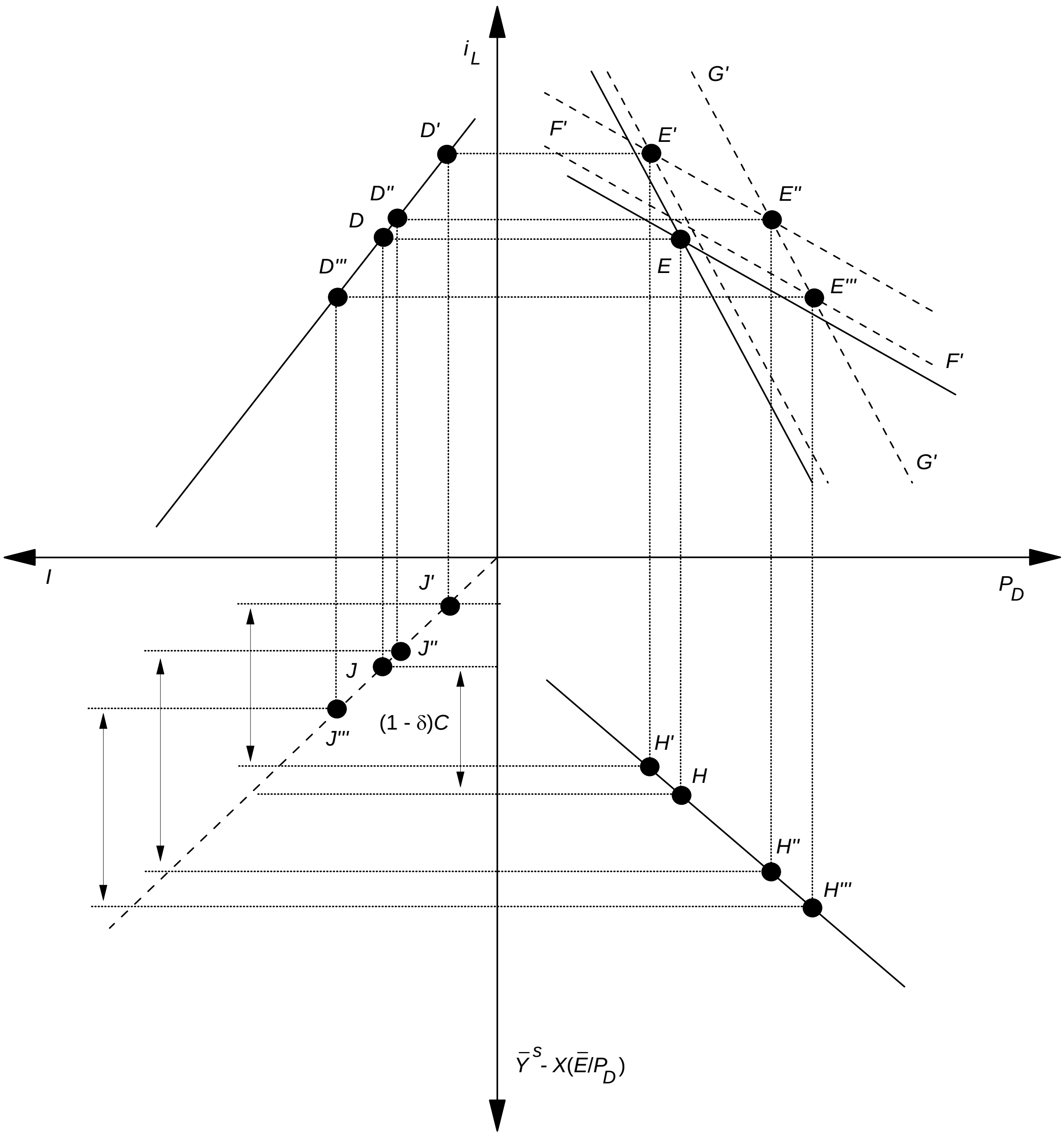

Figure 6

Fixed Exchange Rates:
Increase in Refinance Rate with Endogenous Output

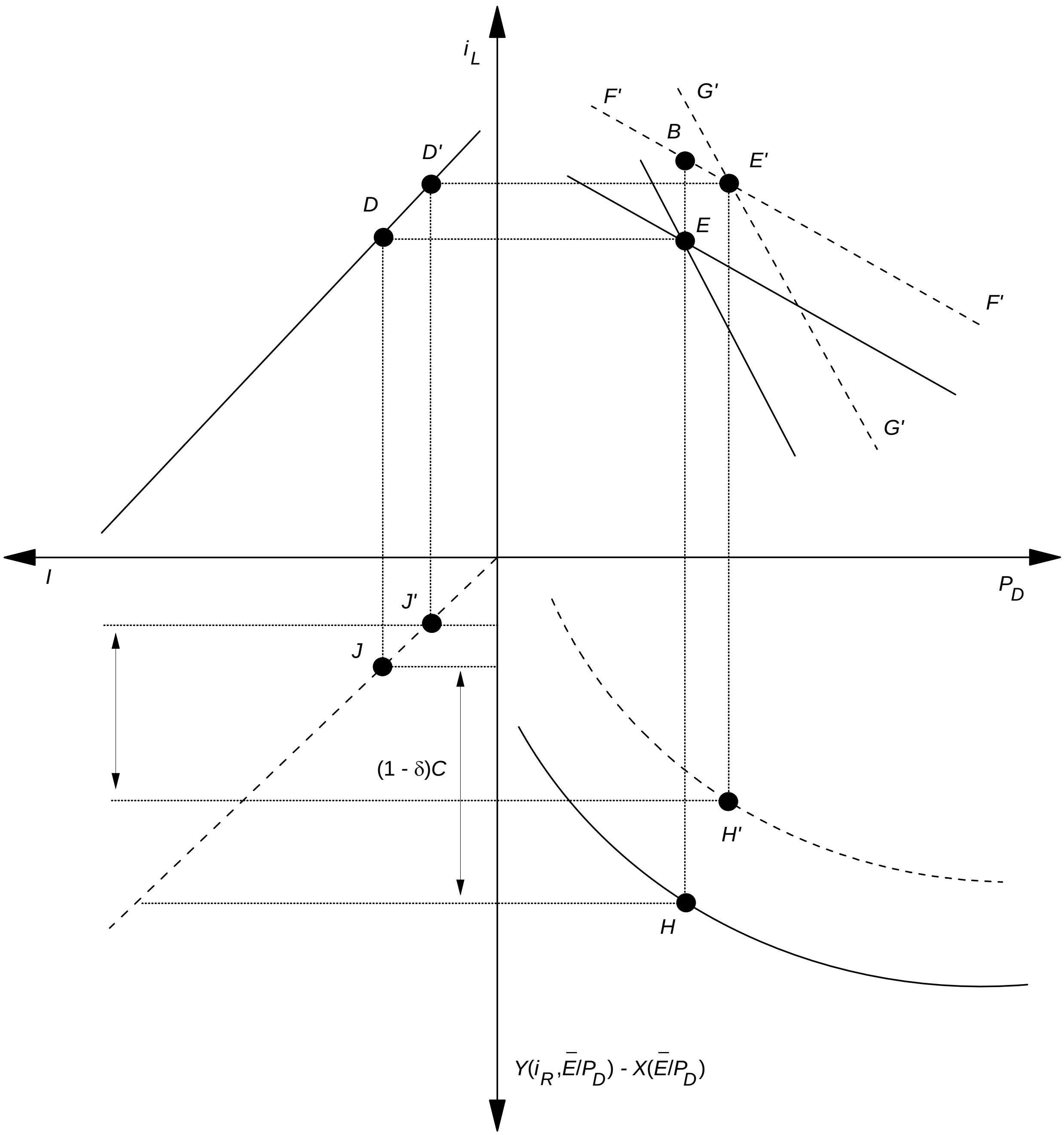

Figure 7

Fixed Exchange Rates:
Increase in Refinance Rate with Land as Collateral