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Credit Market Imperfections and the Monetary Transmission Mechanism Part I: Fixed Exchange Rates

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Abstract

This paper develops a simple static model with credit market imperfections and flexible prices for monetary policy analysis in a fixed-exchange rate economy. Lending rates are set as a premium over the cost of borrowing from the central bank. The premium itself depends on firms' net worth. In the basic framework, banks' funding sources are perfect substitutes and the provision of liquidity by the central bank is perfectly elastic at the prevailing refinance rate. The model is used to perform a variety of experiments, such as changes in the refinance and reserve requirement rates, central bank auctions, shifts in the premium and contract enforcement costs, and changes in public spending and world interest rates. The analysis is then extended to examine credit targeting and sterilization policies.

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1 Introduction

Credit market imperfections play a central role in the transmission process of monetary policy. When there is imperfect information, for instance, the strength of firms' balance sheets becomes a major factor in the determination of the availability and price of external funds. And because alternative forms of borrowing from financial intermediaries are no longer perfect substitutes, firms face a non-trivial choice of external finance. This approach to the monetary policy transmission is often referred to as the broad credit channel view. In addition, some firms may be particularly dependent on bank finance, because their characteristics prevent them from accessing alternative markets for funds (such as corporate paper or bond markets). This gives rise to the bank lending channel, which is particularly important in developing countries in general, and Latin America in particular (see Kamin et al. (1995) and Inter-American Development Bank (2004)).

Despite the widespread recognition that the credit channel is an important mechanism through which monetary policy affects the economy, there are very few tractable models for monetary policy analysis that account explicitly for the credit market and its imperfections. An early attempt to separate the credit and bond markets in the standard IS-LM model was proposed by Bernanke and Blinder (1988), whose analysis was subsequently extended to an open economy in various contributions.[1] But monetary policy in many of these models is defined in terms of changes in the stock of liquidity, whereas in practice central banks use a short-term interest rate as their instrument.

Indeed, as pointed out by Romer (2000), one of the basic assumptions of the IS-LM model is that the central bank targets the money supply, while most central banks nowadays pay little attention to monetary aggregates in conducting monetary policy. Romer's approach is to replace the LM curve, together with the assumption that the central bank targets the money supply (or, more specifically, the supply of liquid reserves to commercial banks), by the assumption that it follows a real interest rate rule. However, this is not necessarily a good characterization of monetary policy either. Central banks, in practice, set nominal, not real, interest rates. In the short run, they cannot respond to changes in expected inflation, and therefore cannot control real interest rates. Moreover, there is no distinction in Romer's model

[1] See for instance Spiegel (1995) and Ramírez (2004). Freixas and Rochet (1997) provide a convenient presentation of the Bernanke-Blinder framework.

between the official (policy) rate and market-determined interest rates, which depend on the behavior of banks (lenders) and private agents (borrowers and depositors). This requires modeling credit market imperfections as well as private financial decisions.

This paper presents a simple framework for monetary policy analysis in small open economies with fixed exchange rates. The model accounts explicitly for an important source of imperfection in credit markets, namely, limited enforceability of contracts. We do not derive behavioral relations explicitly from first principles; instead, in the IS-LM tradition, we postulate these relations and provide some background rationalization and intuitive arguments.[2] The reason for doing so is that we view our model as essentially a way to communicate results from other, more fully articulated, stochastic macroeconomic models where credit market imperfections play a prominent role—such as those dwelling on Townsend's (1979) costly state verification approach (see, for instance, Bernanke and Gertler (1989), Agénor and Aizenman (1998, 2006), and Agénor, Aizenman, and Hoffmaister (2005)), or those based on borrowing constraints in the tradition of Kiyotaki and Moore (1997), such as Cordoba and Ripoll (2004), and Krishnamurthy (2003). As in some of these models, we relate the risk premium (defined as a markup over funding costs) charged by banks to borrowers' net worth—but we do so in a relatively straightforward manner, without bringing explicitly into the picture the stochastic shocks that may lead borrowers to default.

Explicit optimization problems are not solved not only because they would make the presentation of some of the key insights of our analysis more complicated, as noted earlier, but also because some of our postulated behavioral equations could be derived from an explicit intertemporal optimizing model under appropriate constraints. For instance, the assumption that consumption is related to current disposable income could be derived from a life-cycle model if, in addition, agents have short planning horizons or face liquidity constraints (see Agénor and Montiel (2006*a*)). In a sense, then, the model presented in this paper should be viewed as a way to communicate in as simple a formulation as possible some important ideas and results, embedded in more complicated and fully articulated models, that are relevant for monetary policy analysis in an open economy.

[2] In recent years much effort has been devoted to the development of an "optimizing" or "expectational" IS-LM model, with proper micro-foundations; see Clarida, Galí, and Gertler (1999), and King (2000). However, most of this "new IS-LM" literature continues to treat bonds and loans as perfect substitutes and ignores entirely the credit market.

The remainder of the paper is organized as follows. Section 2 presents the basic framework. In line with the foregoing discussion, key features of the basic model are the assumption that banks' funding sources are perfect substitutes and that lending rates are set as a premium over the cost of borrowing from the central bank. The premium is a function of firms' collateralizable net worth. Thus, credit market imperfections in our setting mean that access to loans is more costly for firms with a weak financial position (as measured by their net worth), as opposed to weak (usually small) firms being denied access outright to bank loans. Put differently, we do not account explicitly for credit rationing. Loan supply and the provision of liquidity by the central bank are perfectly elastic at the prevailing official rate. As noted earlier, most existing expository models of monetary policy do not account explicitly for an exogenous policy rate. Yet, nowadays in many countries (including a large number of middle-income developing countries, as documented by Archer (2006)), monetary policy is conducted by manipulating a short-term interest rate, with liquidity supply being perfectly elastic at that rate. In addition, in the model, capital mobility is imperfect, allowing the domestic bond rate to be determined from domestic macroeconomic equilibrium conditions, rather than being tied to the world interest rate.[3]

Section 3 characterizes the solution of the basic model, taking expectations as exogenous. An attractive feature of the basic model is that its solution is recursive; the equilibrium can be described in terms of the bank lending rate and the price of domestic goods only, with no explicit role for the balance of payments and the money (or currency) market. The equilibrium interest rate on government bonds, in particular, can be solved independently, once the lending rate and the price of domestic goods are determined. Put differently, the structure of the basic model is such that it allows one to go quickly and easily into policy analysis, and postpone a complete simultaneous solution until a later stage. Section 4 presents a variety of policy experiments, including changes in the refinance and reserve requirement rates, central bank auctions, exogenous shifts in the premium and contract enforcement costs, and changes in public spending and the world interest rate. Section 5 extends the analysis to consider credit targeting and sterilization policies. The last section offers some concluding remarks and identifies several issues that may warrant further investigation—including an extension of the present frame-

[3] There is significant evidence in favor of imperfect capital mobility for developing countries, even upper middle-income ones; see Agénor and Montiel (2006a).

work to the case of a flexible exchange rate regime, which we intend to pursue in a companion paper.

2 The Basic Framework

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

2.1 Household Portfolio Allocation

Households supply labor inelastically, consume the domestic and foreign goods, and hold four categories of assets: domestic currency (which bears no interest), deposits with the banking system, foreign-currency deposits held abroad, and land (whose supply is fixed and normalized to one). All assets are imperfect substitutes in household portfolios.[4] Foreigners do not hold domestic assets. Total household wealth, A^H, is thus defined as:

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

where $BILL$ is currency holdings, D (D^*) domestic (foreign) bank deposits, and Q the price of land. It will be useful to define the financial component of household wealth as:

$$F^H = A^H - Q = BILL + D + E \cdot D^*. \tag{2}$$

Because the monimal exchange rate is fixed at $E = \bar{E}$, and because we distinguish between beginning- and end-of-period stocks, total financial wealth at the beginning of the period, F_0^H, is predetermined.

[4]Substitution across assets can be impeded by a variety of factors, such as heterogeneous information, institutional constraints, and government-induced distortions. The empirical evidence for most developing countries suggests that the assumption of perfect substitutability between domestic and foreign assets is rejected even for assets that differ only in a single dimension, such as the currency of denomination or maturity. See Agénor and Montiel (2006) for a detailed discussion.

Asset demand equations are as follows. The demand for currency is assumed to be related negatively to the opportunity cost of holding it (measured by the interest rate on bank deposits):

$$\frac{BILL}{D} = \nu(i_D), \tag{3}$$

where i_D is the interest rate on bank deposits and $\nu' < 0$. Households view currency only as an alternative to domestic deposits; thus, given that there is no direct rate of return on currency, only the interest rate i_D enters in (3).[5]

The real demand for deposits in domestic banks is taken to depend positively on output, Y, and the bank deposit rate, as well as negatively on the rate of return on alternative assets, that is, the interest rate on foreign deposits and the expected rate of increase in the price of land, $\hat{q}$:

$$\frac{D}{P} = d(i_D, i^*, \hat{q}, Y), \tag{4}$$

where P is the cost-of-living index, i^* the interest rate on deposits held abroad, d_{i_D}, $d_Y > 0$, and d_{i^*}, $d_{\hat{q}} < 0$. The expected rate of change of land prices is taken to be exogenous. Using (3), we will assume that

$$\frac{\eta_D}{\eta_\nu} > \frac{BILL}{BILL + D} = \frac{\nu}{1+\nu}, \tag{5}$$

where $\eta_D = Pd_{i_D}i_D/D > 0$ and $\eta_\nu = -\nu' i_D/\nu > 0$. That is, the ratio of the interest elasticity of demand for deposits to that of the currency-deposit ratio exceeds the share of currency in the total money stock, given by $BILL + D$. When this condition is satisfied, an increase in the deposit interest rate will increase the total demand for money (that is, $\partial(BILL + D)/\partial i_D > 0$).

The demand function for land is given by:

$$Q = q(i^*, \hat{q})(A^H - BILL - D),$$

or, given that $A^H = F^H + Q$,

$$Q = \frac{q(i^*, \hat{q})}{1 - q(i^*, \hat{q})}(F^H - BILL - D), \tag{6}$$

where $q_{i^*} < 0$ and $q_{\hat{q}} > 0$. Thus, because $F^H - BILL - D = \bar{E} \cdot D^*$, the demand for land is proportional to foreign-currency deposits as long as i^* and $\hat{q}$ are constant. In turn, the demand for foreign-currency deposits can be derived residually from Equations (1) to (6).

[5]We do not account explicitly for the expected rate of inflation by assuming that its effect on the demand for currency and the demand for deposits is exactly the same.

2.2 Commercial Banks

Banks allocate their investable assets (that is, assets net of required reserves) between bank loans and government bonds. They can borrow reserves from the central bank in order to match their assets and liabilities, but cannot borrow abroad. Assets of the commercial banks consist of credit extended to firms, L^F, reserves held at the central bank, RR, and government bonds, B^B. Bank liabilities consist of deposits held by households, D, and borrowing from the central bank, L^B. The balance sheet of the representative commercial bank can therefore be written as:

$$L^F + RR + B^B = D + L^B, \tag{7}$$

where all variables are measured in nominal terms. Reserves held at the central bank do not pay interest and are determined by:

$$RR = \mu D, \tag{8}$$

where $\mu \in (0, 1)$ is the coefficient of reserve requirements.[6]

Banks set both deposit and lending interest rates. Banks are indifferent as to the source of their domestic-currency funds—or, equivalently, they view domestic-currency deposits and loans from the central bank as perfect substitutes (at the margin).[7] Accordingly, the deposit rate on domestic currency-denominated deposits, i_D, is set equal to the cost of funds provided by the central bank, i_R corrected for the (implicit) cost of holding reserve requirements on deposits:

$$1 + i_D = (1 + i_R)(1 - \mu). \tag{9}$$

The supply of deposits by commercial banks is perfectly elastic at the rate i_D.

Other than the central bank, commercial banks are the only holders of domestic government debt. The interest rate that banks demand to be paid

[6]It could be assumed that (as is the case in many countries) banks are subject to a capital adequacy regulation that requires them to set aside a fraction p of their loans as general provisioning. Total liquid reserves held would thus be $\mu D + pL^F$.

[7]With *imperfect* substitution between borrowed reserves and deposits, the deposit rate could be specified as a positive function of both the cost of borrowing from the central bank and variables such as the expected inflation rate. Alternatively, a wedge between i_D and i_R, reflecting the degree of competition or the cost of servicing deposits, could also be introduced.

on government bonds, i_B, is set as a premium over their marginal cost of funds. Given the arbitrage condition (9), this cost is simply the cost of borrowing from the central bank, i_R:

$$1 + i_B = (1 + \theta_B)(1 + i_R), \tag{10}$$

and θ_B is the risk premium on government bonds. We assume that this premium is increasing in the ratio of the stock of such bonds in the possesion of banks to the maximum debt that the government's fiscal plans can support, $B^{\max}$.[8] Thus:

$$\theta_B = \theta_B(B^B/B^{\max}), \qquad \theta_B' > 0. \tag{11}$$

Finally, the domestic loan rate, i_L, is set at a premium over the prevailing interest rate on government bonds:

$$1 + i_L = (1 + \theta_L)(1 + i_B), \tag{12}$$

where the risk premium $\theta_L$on lending to firms is inversely related to the ratio of firms' assets (the value of their beginning-of-period physical capital stock, K_0, which is taken as given, times P_D, the price of the domestic good) over their liabilities, that is, beginning-of-period domestic borrowing, L_0^F:

$$\theta_L = \theta_L(\frac{\kappa P_D K_0}{L_0^F}; x_P), \tag{13}$$

where x_P is a shift parameter, whereas $\theta_{L_{K/L^F}} < 0$ and $\theta_{L_{x_P}} > 0$. As in Agénor, Jensen, Verghis, and Yeldan (2006), the coefficient $\kappa \in (0,1)$ in (13) measures the proportion of assets that can effectively be used or pledged as collateral; $\kappa P_D K_0$ therefore measures firms' "collateralizable" wealth.

The view that underlies this specification is that the risk premium charged by banks reflects the perceived risk of default on their loans to domestic firms. The link between the premium and firms' net worth has been much emphasized in the recent literature on real-financial sector linkages. Bernanke, Gertler, and Gilchrist (2000), and Gertler, Gilchrist, and Natalucci (2003), in particular, emphasized the impact of collateralizable wealth—or the net

[8]Because we do not explicitly account for the govenrment budget constraint, and given the static nature of our model, we take $B^{\max}$ as given. A more thorough treatment would of course treat $B^{\max}$ as endogenous, relating it for instance to the government's capacity to tax.

present value of firms' profits—on bank pricing decisions.[9] The higher the value of firms' physical assets, relative to domestic liabilities, the higher the proportion of total lending that banks can recoup in the event of default. This reduces the risk premium and the cost of borrowing.[10]

Notice that, in principle, collateralizable wealth could also act as a strict quantity constraint on bank borrowing, as for instance in the model of Kiyotaki and Moore (1997) and its variants (see, for instance, Krishnamurthy (2003) and Xie and Yuen (2003)). Shocks to credit-constrained firms would then be amplified through changes in collateral values and transmitted to output. In the present setting, firms are not subject to "strict" rationing, based on their ability to pledge collateral; banks provide all the liquidity that firms need at the prevailing lending rate. Nevertheless, because both K_0 and L_0^F are predetermined, the risk premium varies inversely with the price of the domestic good, P_D. As in the Kiyotaki-Moore framework, and as discussed below, this introduces a "financial accelerator" in the effects of monetary policy.

With interest rates set as above, commercial banks' total holdings of government bonds are determined by central bank policies. Specifically, holdings of government bonds by commercial banks are determined by the difference between the total stock of bonds outstanding, $\bar{B}$, which is exogenous (given the time frame of the analysis), and bonds held by the central bank, B^C:

$$B^B = \bar{B} - B^C. \tag{14}$$

Given the commercial banks' interest rate-setting behavior, their stock of loans outstanding is determined by firms' demand for credit, to be described below.[11] With B^B and L^F determined in this way, equation (7) implies that borrowing from the central bank must be determined residually:

$$L^B = L^F + RR + B^B - D.$$

[9] See, however, Cordoba and Ripoll (2004) for a dissenting view on the ability of collateral constraints to magnify output fluctuations.

[10] See, for instance, Booth and Booth (2006) for some recent evidence on the links between collateral, default risk, and borrowing costs in the United States. Note that land is held by households only and cannot be used as collateral by firms.

[11] Note that in the present setting bank profits are not necessarily zero, but rather given by $i_L L^F + i_B B^B - i_D D - i_R L^B$. For simplicity, we assume that these profits are retained as an off-balance sheet item by banks, rather than distributed to households. In a dynamic setting, this would of course be unsatisfactory, the impact of retained profits on banks' net worth would need to be explicitly accounted for.

Using (4) and (8), this equation becomes:

$$L^B = L^F + B^B - (1-\mu)d(i_D, i^*, \hat{q}, Y)P. \tag{15}$$

2.3 Central Bank

The central bank ensures the costless conversion of domestic currency holdings into foreign currency at the officially-determined exchange rate, E. It also supplies reserves elastically to commercial banks at the fixed official (or refinance) rate, i_R. Because banks set their deposit rate on the basis of this official rate, monetary policy operates largely through the effects of the refinance rate on the banking system's cost of funds. And because the supply of liquidity is perfectly elastic at rate i_R, base money is endogenous; it responds passively to shocks to banks' liquidity needs—which are themselves related to banks' asset pricing decisions, the central bank's auctions of government bonds, and the demand for credit by domestic firms.

The balance sheet of the central bank consists, on the asset side, of loans to commercial banks, L^B, foreign reserves, R^* (in foreign-currency terms), and government bonds, B^C. On the liability side, it consists only of the monetary base, MB:

$$E \cdot R^* + B^C + L^B = MB. \tag{16}$$

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

$$MB = BILL + RR, \tag{17}$$

which implies, using (8), that the supply of currency is

$$BILL^s = MB - \mu D. \tag{18}$$

In this framework, which is intended to realistically represent the financial structure of many developing countries, the central bank has three monetary policy instruments at its disposal: the refinance rate, i_R, the amount of government bonds that it retains on its books rather than auctioning them off to the banking system, B^C, and the required reserve ratio, μ. With the central bank following an interest rate rule, the monetary base will be entirely passive. We shall consider later on the case where the central bank engages in sterilization, with the goal of controlling the path of the monetary base.

2.4 Price Level and the Real Sector

The cost of living, P, is defined as a geometrically weighted average of the price of the domestic good, P_D, and the price of imported final goods, EP_M^*, where P_M^* is the foreign-currency price of the good (assumed exogenous):

$$P = P_D^{\delta}(EP_M^*)^{1-\delta}, \tag{19}$$

where $\delta \in (0, 1)$. Setting $P_M^* = 1$, this equation becomes

$$P = P_D z^{1-\delta}, \tag{20}$$

where $z = E/P_D$ is the real exchange rate.

Real consumption expenditure by households, C, measured in units of the domestic good, is assumed to depend on the resources available to households in the form of human as well as physical capital and wealth, and on intertemporal relative prices. Because our model is not explicitly intertemporal, we capture the contribution of human and physical capital by allowing consumption to depend positively on disposable income and on the real value of financial wealth. To capture the effects of intertemporal relative prices we allow it to depend negatively on rates of return on the assets held by households (domestic deposits, foreign deposits, and land). We treat the partial effects of each of these rates of return on present consumption as being identical.[12] Thus, consumption spending can be written as:

$$C = C_0 + \alpha_1(\bar{Y} - T) - \alpha_2(i_D + i^* + \hat{q}) + \alpha_3(A^H/P), \tag{21}$$

where $\bar{Y}$ is output (or income), assumed exogenous, T denotes lump-sum taxes, $\alpha_1 \in (0, 1)$ the marginal propensity to consume out of disposable income, and $\alpha_2, \alpha_3 > 0$.

The desired capital stock by firms, K^d, is inversely related to the real lending rate, $i_L - \pi^a$, where π^a is the expected inflation rate. Real investment spending by domestic firms, I, is taken to be a linear function of the difference between the desired stock and the actual stock, K_0:

$$I = K^d(i_L - \pi^a) - K_0 = I(i_L - \pi^a; K_0), \tag{22}$$

[12] As is well known, life-cycle models would predict a relationship between wealth and consumption rather than income. However, as noted in the introduction, liquidity-constrained consumers would indeed tend to adjust consumption as a function of (disposable) income.

where $I_1 = I_{i_L - \pi^a} < 0$. In what follows we assume that all investment must be financed by bank loans. Thus, with the beginning-of-period stock of loans given by L_0^F, new loan demand from commercial banks is equal to[13]

$$L^F = L_0^F + P_D I. \tag{23}$$

Let $X(z)$ denote exports, which are positively related to the real exchange rate, so that $X' > 0$. The supply of domestic goods to the domestic market is thus $\bar{Y} - X(z)$. Also, let δ denote the share of spending by domestic households on imported goods, and suppose that δ is negatively related to the real exchange rate, so that $\delta' < 0$. The equilibrium condition of the market for domestic goods is thus given by:

$$\bar{Y} - X(z) = [1 - \delta(z)]C + I + G, \tag{24}$$

where G is government spending on domestic goods.

3 Model Solution

A macroeconomic equilibrium in our model requires simultaneous equality between supply and demand in the markets for five financial assets (domestic currency, domestic deposits, government bonds, commercial bank loans, and central bank credit), as well as that for the model's single traded real asset (land), and the market for domestic goods. By Walras' Law, the six asset market equilibrium conditions are not independent; one of them can be derived residually from the other equations, and can therefore be eliminated. Given the assumption that the central bank fixes the policy interest rate i^R and supplies all the credit demanded by banks at that rate, the market for central bank credit is always in equilibrium. We derive the equilibrium conditions for domestic deposits, government bonds, and commercial bank loans from the asset pricing decisions of the commercial banks, and analyze the equilibrium condition in the market for land separately. We choose therefore to eliminate the equilibrium condition for the market for currency.

[13]Internal finance could be added to the model by simply assuming that retained earnings are a constant fraction χ of total output, $\bar{Y}$; new borrowing by firms would thus be $P_D(I - \chi\bar{Y})$. This, however, would not alter much the results of our policy experiments, given that output is exogenous.

To solve the model, then, consider first the determination of the price of land. Substituting equations (3), (4), and (19), in equation (6) yields

$$Q = \frac{q(i^*, \hat{q})}{1 - q(i^*, \hat{q})}[F^H - [1 + v(i_D)]d(i_D, i^*, \hat{q}, \bar{Y})P_D^{\delta}E^{1-\delta}],$$

that is,

$$Q = Q(P_D; i_R, \mu, B^B, ...), \tag{25}$$

where, given assumption (5),[14]

$$Q_1 = \frac{\partial Q}{\partial P_D} = -(\frac{q}{1-q})\delta(1+\nu)dz^{1-\delta} < 0,$$

$$Q_2 = \frac{\partial Q}{\partial i_R} = -(\frac{q}{1-q})(1-\mu)(\frac{D}{i_D})\eta_\nu(1+\nu)(\frac{\eta_D}{\eta_\nu} - \frac{\nu}{1+\nu}) < 0,$$

$$Q_3 = \partial Q/\partial \mu = (\frac{q}{1-q})(\frac{D}{i_D})\eta_\nu(1+\nu)(\frac{\eta_D}{\eta_\nu} - \frac{\nu}{1+\nu})(1+i_R) > 0,$$

$$Q_4 = \partial Q/\partial B^B = 0.$$

Thus, an increase in the domestic price level reduces the price of land, because it causes households to reallocate their portfolios into currency and deposits and away from land. The partial equilibrium effect of an increase in the refinance rate on the price of land is also negative, because a higher refinance rate raises banks' deposit rate, thus inducing households to shift their portfolios away from both currency and land, which has the effect of reducing the price of land. However, an increase in the required reserve ratio raises the price of land, because it reduces the deposit interest rate and causes households to switch out of deposits and into land. Holdings of government bonds by commercial banks are determined residually from equation (14) and have no direct effect on the price of land.

Turning to the loan interest rate, from equations (10) to (13) we can write:

$$i_L = [1 + \theta_L(\frac{\kappa P_D K_0}{L_0^F}; x_P)][1 + \theta_B(\frac{B^B}{B^{\max}})](1 + i_R) - 1. \tag{26}$$

[14]When calculating derivatives with respect to P_D, we do not account for the fact that δ is, in principle, a function of z. Implicitly, therefore, we assume that the weights appearing in the price level are given in some base period. This is a natural way to proceed here, in order to distinguish changes in behavior from changes in measurement.

This equation is essentially the model's financial market equilibrium condition. It determines the equilibrium loan rate as a function of the arbitrage conditions that determine the banks' equilibrium allocation of funds. The effects on the equilibrium loan rate of changes in the domestic price level and in the monetary policy variables controlled by the central bank are given by:

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

$$\frac{\partial i_L}{\partial i_R} = (1+\theta_L)(1+\theta_B) > 0,$$

$$\frac{\partial i_L}{\partial \mu} = 0,$$

$$\frac{\partial i_L}{\partial B^B} = (\frac{\theta'_B}{B^{\max}})(1+\theta_L)(1+i_R) > 0.$$

Thus, the equilibrium loan rate falls as the domestic price level rises. This reflects 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 (alternatively, in real terms, the real value of their outstanding loans falls relative to that of their real collateral). The implication is that banks are willing to accept a lower risk premium, thus reducing the loan rate. By contrast, an increase in the refinance rate raises the cost of funds for banks, and because the loan rate reflects this cost of funds plus the markup factor $(1+\theta_L)(1+\theta_B)$, this induces an increase in the lending rate. An increase in the required reserve ratio has no effect on the loan rate: with the marginal cost of funds set by the refinance rate, its only effect is to lower the deposit rate. Finally, a reduction in central bank holdings of government bonds requires that more of these bonds be held by commercial banks. Because this increases the stock of government debt in private hands relative to the government's debt servicing capacity, the effect is to increase the risk premium on both government debt as well as as loans to private firms, resulting in a higher lending rate.

Turning to the real sector, using equations (19), (21), and (22), and assuming that financial wealth is measured at the beginning of the period, we can write the goods market equilibrium condition, equation (24), as:

$$\bar{Y} = [1-\delta(\frac{E}{P_D})][C_0 + \alpha_1(\bar{Y}-T) - \alpha_2(i_D + i^* + \hat{q}) + \alpha_3(\frac{F_0^H + Q}{P_D})] \quad (27)$$

$$+I(i_L - \pi^a; K_0) + G + X(E/P_D).$$

Using (9) to solve for i_D and substituting (25) for Q, this equation implicitly defines a set of combinations of the loan interest rate and the domestic price level that are consistent with equilibrium in the market for domestic goods, given by:

$$i_L = i_L(P_D; i_R, \mu, B^B, ...), \tag{28}$$

where

$$\frac{\partial i_L}{\partial P_D} = -\{\delta' \frac{zC}{P_D} + (1-\delta)\alpha_3[\frac{Q_1}{P_D} - (\frac{A^H}{P^2})z^{1-\delta}] - X'(\frac{z}{P_D})\}/I_1 < 0,$$

$$\frac{\partial i_L}{\partial i_R} = (1-\delta)[\alpha_2(1-\mu) - \alpha_3(\frac{Q_2}{P_D})]/I_1 < 0,$$

$$\partial i_L/\partial \mu = -(1-\delta)[\alpha_2(1+i_R) + \alpha_3(\frac{Q_3}{P_D})]/I_1 > 0,$$

$$\partial i_L/\partial B^B = 0.$$

Equations (26) and (28) can be solved together for the equilibrium values of the loan interest rate $i_L$and the price of domestic goods P_D.The solution can be depicted graphically as in Figure 1. Both equations trace out curves with negative slopes in i_L-P_D space. However, it is easy to show that under standard dynamic assumptions, local stability requires the goods-market equilibrium curve derived from equation (28), labeled GG in Figure 1, to be steeper than the financial-market equilibrium curve derived from equation (26), labeled FF. Thus the economy's equilibrium values of i_L and P_D are determined at the point of intersection of the relatively flat FF curve and relatively steep GG curve, as shown in Figure 1.

Once the equilibrium values of the loan interest rate and the price of domestic goods are determined, the remaining endogenous variables in the model can be pinned down in straightforward fashion. It is worth noting, in particular, how the financial side of the model is solved. Given the equilibrium value of the loan interest rate and the domestic price level, the scale of nominal investment by domestic firms is determined. In turn, this determines the flow of new loan demand from commercial banks. Thus, the scale of new loans is determined on the demand side of the market, given the loan interest rates set by the banking system. Banks finance these loans by borrowing from the central bank at the policy interest rate i_R, and in turn the central bank finances its loans to commercial banks by issuing new base money. Like the supply of loans to firms, then, that of loans to banks is determined on the demand side of the market, given the price-setting behavior of the lender.

Note also that changes in official foreign reserves (which are endogenous under fixed exchange rates) play no direct role in defining the equilibrium. In principle, the balance-of-payments equilibrium condition requires that

$$E^{-1}P_D[X(z) - \delta(z)C] + i^*(D_0^* + R_0^*) - (D^* - D_0^*) - (R^* - R_0^*) = 0,$$

where D_0^* and R_0^* are the beginning-of-period stocks of household deposits abroad and official reserves, respectively. Given the definition of the monetary base (equation (16)), changes in foreign reserves affect the monetary base one-to-one in the absence of sterilization—and, from (18), the supply of currency. However, given (3), which fixes the demand for currency in proportion to the demand for domestic bank deposits, and Walras' Law (which was used to eliminate the equilibrium condition of the market for currency), equation (18) plays no direct role in the solution of the model. Thus, official reserves may take on any value required to ensure external balance. At the same time, however, an equilibrium with, say, continuous losses in official reserves would not be sustainable. Because we do not require reserves to remain constant (and given our treatment of expectations and the supply side), our concept of equilibrium remains essentially short run in nature.[15]

4 Policy and Exogenous Shocks

To illustrate the functioning of our framework, we consider several experiments: an increase in the official rate, i_R; central bank auctions, leading to a change in B^B; an increase in the reserve requirement rate, μ; exogenous shifts in the premium, x_P, and contract enforcement costs, κ; and changes in public spending, G, and the world interest rate, i^*.

4.1 Increase in the Refinance Rate

As indicated earlier, changes in the refinance rate are intermediated through the banking system to the bond rate as well as to loan interest rates. As

[15] A longer-run equilibrium concept would require reserves to remain constant in the long run, while allowing them to adjust endogenously in the short run. In turn, this would force the capital account to move in opposite direction to the current account—in effect, determining capital flows residually, rather than through a portfolio equation.

shown in the discussion of the goods market equilibrium condition (28), an increase in the refinance rate reduces demand for domestic goods because it is passed on directly by banks to the deposit rate. This exerts both interest rate and wealth effects on consumption. An increase in the deposit interest rate directly induces consumers to increase saving and thus reduce spending on domestic goods. It also induces them to switch away from other assets—including land—and into deposits, thereby depressing land prices. The lower land prices represent a reduction in household wealth, which reinforces the depressing effects of higher deposit interest rates on consumption. The upshot is that to maintain equilibrium in the domestic goods market at an unchanged value of P_D, the loan interest rate would have to fall. Thus the GG curve shifts downward, as in Figure 2.

At the same time, the increase in the refinance rate increases banks' borrowing costs, inducing them to increase their loan interest rates, given that those rates are set as a markup over banks' cost of funds. Consequently, the FF curve shifts upward. The implication, as shown in Figure 2, is that an increase in the refinance rate results in an increase in the equilibrium loan interest rate as well as a reduction in the price of domestic goods. The contractionary effects of this policy are transmitted through three channels: direct interest rate effects on consumption, wealth effects on consumption arising from a reduced portfolio demand for land, and direct interest rate effects on investment arising from the increase in banks' borrowing costs.

It is worth noting that the final increase in the loan interest rate is more than proportionate to the increase in banks' cost of funds, that is, $di_L/di_R > 1$. The increase in i_L resulting strictly from the increase in banks' cost of funds corresponds to the upward shift in FF in Figure 2. 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 C, rather than B. This additional effect on the loan rate represents the influence of the financial accelerator: the reduction in the price of domestic goods increases the real value of firms' debt to banks, reducing the portion of this debt that is covered by collateralizable real assets and thus increasing the risk of lending to firms. This reduction in the domestic price level thus causes banks to further increase the loan interest rate. This effect is accentuated as the result of the downward shift in GG, because the shift in GG magnifies the effect of the policy on the domestic price level. As in more sophisticated models of credit market imperfections, the financial accelerator imparts a counter-cyclical pattern to changes in loan rates.

4.2 Central Bank Auctions

Another common monetary policy tool used by central banks in middle-income developing countries is the auctioning of government bonds to commercial banks. To examine the macroeconomic effects of this policy instrument, consider the consequences of a central bank auction that raises the stock of government bonds, B^B, that must be held by commercial banks. Because this measure has no effect on bank deposit rates, it does not affect the rates of return faced by domestic households on the assets they hold in their portfolios. Consequently, there is no incentive for households to reallocate portfolios, and no impact effect on household demand for land. The implication is that land prices are not a vehicle for monetary transmission in this case and the position of the goods market equilibrium curve GG is undisturbed.

However, the additional bonds held by commercial banks increase the risk associated with this asset, Because the government's debt-servicing capacity (as measured by $B^{\max}$) remains unchanged. Consequently, banks increase the premium θ_B that they demand for holding government bonds. Because the loan interest rate is determined as a markup over the interest rate on government bonds, the lending rate demanded by banks in order to continue to hold the amount of loans outstanding increases as well, shifting the FF curve upward, as in Figure 3. The upshot is that the economy moves to the northwest along a stationary GG curve from a point like E to one like E': the loan interest rate rises and the price of domestic goods falls. Notice that the transmission mechanism is somewhat different in this case than in the previous one: neither direct interest rate nor wealth effects on consumption are part of the monetary transmission mechanism. Instead, monetary policy works through the adverse effects of higher loan rates on investment spending by domestic firms.

Although changes in land prices do not play any direct role in the monetary transmission process in this case, land prices do not remain unchanged. As a result of the reduction in the domestic price level, households engage in portfolio reallocations from currency and deposits to land and foreign assets. Consequently, in equilibrium land prices are actually higher. The role of real asset prices in this case, then, is to actually weaken the effect of monetary policy on the real economy—although this effect, which is already captured in the slope of the GG curve, cannot offset the overall contractionary effect of the bond auction.

4.3 Increase in the Reserve Requirement Rate

The third monetary policy instrument included in our model is the required reserve ratio μ. An increase in the required reserve ratio makes deposits less attractive to banks as a source of funding, and causes them to lower the deposit interest rate. This affects the goods market both directly, because the lower deposit rate discourages saving and stimulates consumption, as well as indirectly, as the lower deposit rate causes household to reallocate their portfolios away from deposits and into real assets such as land, causing land prices to rise and stimulating consumption through a wealth effect. Because both effects tend to increase demand for domestic goods, a higher loan rate is required to clear the goods market. Thus the GG curve shifts upward. By contrast, under the assumption that the central bank stands ready to supply funds to banks perfectly elastically at the policy rate i_R, the increase in reserve requirements has no effect on banks' marginal cost of funds. Consequently, the FF curve is unaffected by this policy. The upshot, as shown in Figure 4, is that an increase in the required reserve ratio is actually expansionary.

As already mentioned, the explanation for this seemingly counterintuitive result is that, under our assumed monetary policy regime, changes in reserve requirements have no effect on banks' cost of funds. Because the central bank stands ready to provide the funds desired by banks at the given policy rate i_R, increases in reserve requirements leave banks' cost of funds—and therefore their lending rates—unaffected while *lowering* the interest rate that represents the opportunity cost of current versus future consumption, as well as of holding real assets as opposed to financial ones. As we shall see in Section 5.1, this result does not survive a change in the monetary policy regime.

4.4 Shifts in the Risk Premium and Contract Enforcement Costs

Our model also allows us to analyze the effects of non-policy financial shocks on the economy. Consider, for instance, the effects of changes in banks' perceived risks of lending to private firms. We can capture this in the model in the form of a change in the risk parameter x_P.[16] If the risks that banks perceive as associated with lending to private firms were to increase (as represented by an upward shift in x_P), banks would demand a higher risk premium. Just as in the case of central bank auctions, this would have no effect on the goods-market equilibrium condition or the GG curve, but would shift the FF curve upward, reflecting the increase in the loan rate required for banks to extract a larger risk premium. Again, the macroeconomic results are as depicted in Figure 3: the equilibrium loan interest rate rises, and the price of domestic goods falls. A financial accelerator is at work once again: an increase in the loan interest rate is required to offset the initial shift in perceived risk, because the rise in the real value of loans outstanding lowers the collateral offered by firms, increasing banks' intermediation costs.

An alternative type of financial shock is a reduction in contract enforcement costs, an item that is now on the financial reform agenda in many developing countries. Such a reduction would in effect increase the proportion of firms' real assets that is collateralizable, and can be captured in our model in the form of an increase in κ. The improved quality of collateral reduces banks' intermediation costs and allows them to charge a lower premium. Thus the markup on lending to firms θ_L is reduced and the FF curve shifts downward, as in Figure 5. This is clearly an expansionary development, as the domestic price level rises and the loan interest rate falls. Notice that in this case the financial accelerator magnifies the reduction in the loan rate, because the increase in the domestic price level reduces the real value of firms' loans, and thus increases the effective value of their collateral over and above what is achieved through the reduction in contract enforcement costs.

4.5 Changes in Public Expenditure and World Interest Rates

It is straightforward to extend the analysis to the case of real shocks. For instance, a fiscal policy shock in the form of a bond-financed increase in gov-

[16] In developing countries—even in those that have undertaken financial liberalization in a sustained fashion—bank spreads remain high, much higher than in industrial countries. As noted for instance by Barajas, Steiner, and Salazar (1999) and Chirwa and Machila (2004), this often reflects—in addition to lack of competition and, in some cases, high inflation—high monitoring costs as well as contract enforcement costs.

ernment spending on domestic goods would shift the GG curve to the right, increasing the domestic price level and reducing the loan interest rate.[17] The latter might seem counterintuitive, but recall that the central bank follows an accommodative monetary policy under our assumptions, keeping the refinance rate i_R fixed and rediscounting freely to meet banks' demands for funds. Thus, the supply of funds to banks is perfectly elastic, and in the absence of financial accelerator effects the loan interest rate would remain unchanged. The effect on the loan rate thus arises purely from the financial accelerator effect, which in this case acts to reduce the loan rate—because the higher domestic price level reduced the real value of firms' outstanding debt to banks.

Similarly, a change in world interest rates has a straightforward effect in the model. An increase in i^*, for instance, has no direct effect on the economy's financial market equilibrium, because banks are assumed to neither borrow nor lend abroad. Households, however, do have access to foreign assets, and the higher foreign deposit rate induces them to shift their portfolios out of domestic and into foreign assets. This implies a reduced demand for land, and a fall in the price of land. As a result, the GG curve shifts to the left, the price of domestic goods falls, and the loan interest rate rises as a result of financial accelerator effects.

5 Extensions

The basic framework developed in the previous sections can be extended in a number of important and interesting ways. In this section, we consider two issues: credit targeting and sterilization policies.

5.1 Domestic Credit Targeting

In the previous sections, we examined monetary transmission on the assumption that the central bank provided commercial banks with a perfectly elastic supply of credit at the official rate, i_R. While this is a realistic description

[17] Given our timing convention, the increase in govenrment spending in the current period translates into an increase in the outstanding stock of public bonds only in the next period. There are, therefore, no contemporaneous wealth effects. Alternatively, one could analyze the case where the increase in spending is financed by an rise in lump-sum taxes, T.

of the way monetary policy operates in many developing countries, it is not uncommon for central banks in some countries to restrict the supply of credit to commercial banks by nonprice means, that is, by imposing aggregate ceilings on the stock of credit to commercial banks.[18] In such a case, the supply of central bank credit to commercial banks, L^B, becomes a monetary policy variable. In this section we investigate how monetary transmission works under this alternative operating procedure for the central bank.

If the central bank restricts the supply of credit to commercial banks below the equilibrium value implied by the solution of the model in Section 3, then the official refinance rate no longer represents the marginal cost of funds, because commercial banks would be not be able to obtain additional funds from the central bank at their discretion. Instead, they can increase their investable resources only by increasing their deposit base. To do so, they would have to offer a more attractive deposit interest rate. The key implication for the model, therefore, is that the deposit interest rate is no longer tied to the refinance rate through equation (9), but is instead determined by the interaction of commercial banks' financing needs with the household portfolio decisions that determine the supply of deposits to banks. It follows that in this case, equation (9) must be replaced by an equilibrium condition in the market for bank deposits.

To see what the change in operating procedure implies for monetary transmission, we begin by deriving this equilibrium condition. First, from the commercial banks' balance sheet, equation (7), and the determination of required reserves, equation (8), we can derive the banks' demand for deposits as:

$$D = \frac{L^F + (B^B - L^B)}{1 - \mu}, \tag{29}$$

where B^B and L^B are both now policy variables. Because banks' supply of loans to domestic firms is perfectly elastic at the interest rate that covers the risk attached to such lending (given by equation (26)), the quantity of loans continues to be demand-determined. Because this demand arises from firms' demand for funds to finance new investment, the demand for loans continues to be given by equation (23), which is repeated here for convenience:

$$L^F = L_0^F + P_D I(i_L - \pi^a; K_0).$$

[18]Indeed, stabilization programs negotiated with the IMF often stipulate central bank credit ceilings as a performance criterion.

Equilibrium in the market for commercial bank loans requires that the lending rate, i_L, which appears in equation (23), be the rate at which banks are willing to lend. Replacing $(1+i_R)$ by $(1+i_D)/(1-\mu)$ in equation (26), we can write this rate as:

$$i_L = [1+\theta_L(\frac{\kappa P_D K_0}{L_0^F}; x_P)]\frac{[1+\theta_B(B^B/B^{\max})](1+i_D)}{1-\mu} - 1. \tag{30}$$

Substituting equation (30) into (23), the equilibrium value of commercial bank lending is given by:

$$L^F = L^F(P_D; i_D, B^B, \mu, ...), \tag{31}$$

where

$$\frac{\partial L^F}{\partial P_D} = I + P_D I_1\ (\frac{\kappa K_0}{L_0^F})\theta_L' \frac{(1+\theta_B)(1+i_D)}{1-\mu} > 0,$$

$$\frac{\partial L^F}{\partial i_D} = P_D I_1\ \frac{(1+\theta_L)(1+\theta_B)}{1-\mu} < 0,$$

$$\frac{\partial L^F}{\partial \mu} = P_D I_1 \frac{(1+\theta_L)(1+\theta_B)(1+i_D)}{(1-\mu)^2} < 0,$$

$$\frac{\partial L^F}{\partial B^B} = P_D I_1(\frac{\theta_B'}{B^{\max}})\frac{(1+\theta_L)(1+i_D)}{1-\mu} < 0.$$

The demand for loans is an increasing function of the price of domestic goods, both because the higher that price the higher the nominal value of the funds required to finance a given level of real private investment, and because a higher price of domestic goods raises the nominal value of firms' collateral, thus reducing the loan interest rate. By contrast, the demand for loans is decreasing in the deposit interest rate, the required deposit ratio, and the stock of government bonds that banks must hold, because increases in each of these raise the loan interest rate.

Substituting this expression for L^F in equation (29), we can express banks' demand for deposits as:

$$D = \frac{L^F(P_D; i_D, B^B, \mu, ...) + (B^B - L^B)}{1-\mu}. \tag{32}$$

Because the effects of changes in the domestic price level, P_D, and the deposit interest rate, i_D, on the demand for deposits operate only through the effects of these variables on the demand for bank loans, their effects on the demand for deposits are straightforward. Similarly, the effects of changes in the supply of central bank credit to the banking system are also direct: because these funds represent a lower-cost alternative to banks than attracting deposits, an increase in L^B reduces the demand for deposits on a proportional basis.

Matters are somewhat more complicated, however, with respect to changes in the amount of government bonds auctioned by the central bank, B^B, and in the required reserve ratio, μ. While increases in each of these variables unambiguously reduce the equilibrium quantity of commercial bank lending, they have an ambiguous effect on banks' demand for deposits. The reason is that, while higher values of B^B and μ reduce the quantity of bank lending by increasing the loan interest rate and thus discouraging firms from borrowing, they also absorb bank resources that could otherwise have been used for lending into the holding of government bonds or unremunerated reserves. Whether the net effect is to increase or reduce banks' demand for new resources (in the form of deposits) depends, among other things, on the elasticity of firms' demand for loans. The less elastic this demand is, the more likely it is that the resource-contraction effect will dominate the loan-contraction effect and cause increases in B^B and μ to leave banks with insufficient resources to fund their loan portfolios, thus inducing them to increase their demand for deposits. We will concentrate on this case in what follows, though it is worth emphasizing the uncertainty that this ambiguity introduces into the functioning of the transmission mechanism under domestic credit targeting.

Equation (32) can be depicted as the negatively-sloped deposit demand curve, D^D, in Figure 6. The deposit supply curve is given by equation (4), and is drawn with a positive slope in the same figure. Equilibrium in the market for deposits is determined at the intersection of the two curves. The equilibrium deposit rate is therefore given implicitly by:

$$\frac{L^F(P_D; i_D, B^B, \mu, ...) + (B^B - L^B)}{1 - \mu} = P_D^\delta E^{1-\delta} d(i_D, i^*, \hat{q}, Y), \qquad (33)$$

and we can summarize its determinants as:

$$i_D = i_D(P_D; L^B, B^B, \mu, ...), \qquad (34)$$

where

$$\frac{\partial i_D}{\partial P_D} = \Delta^{-1}\{(1-\mu)^{-1}[I + P_D I_1 \,(\frac{\kappa K_0}{L_0^F})\theta_L' \frac{(1+\theta_B)(1+i_D)}{1-\mu}] - \delta dz^{1-\delta}\} \gtreqless 0,$$

$$\partial i_D/\partial L^B = -\Delta^{-1}(1-\mu)^{-1} < 0,$$

$$\frac{\partial i_D}{\partial B^B} = \Delta^{-1}(1-\mu)^{-1}\{P_D I_1(\theta_B'/B^{\max})\frac{(1+\theta_L)(1+i_D)}{1-\mu} + 1\} > 0,$$

$$\frac{\partial i_D}{\partial \mu} = \Delta^{-1}(1-\mu)^{-2}\{P_D I_1 \frac{(1+\theta_L)(1+\theta_B)(1+i_D)}{(1-\mu)} + L^F + (B^B - L^B)\} > 0,$$

and

$$\Delta \equiv Pd_{i_D} - (1-\mu)^{-2} P_D I_1 (1+\theta_L)(1+\theta_B) > 0.$$

These properties can be verified graphically by manipulating the deposit supply and demand curves in Figure 6. An increase in the price of domestic goods increases the demand for loans, both because it increases the nominal cost of a given volume of real investment and because it induces firms to undertake additional real investment by increasing the value of collateral, thus reducing the loan rate charged by banks. The higher volume of loans causes banks to increase their demand for deposits with which to fund them, thus making the deposit demand curve shift to the right. At the same time, however, a higher domestic price level also increases the supply of deposits because the higher price level causes households to hold larger transactions balances, which induces them to shift assets into the banking system. The deposit supply curve therefore also shifts to the right. The upshot is that the equilibrium quantity of deposits must rise, but the deposit interest rate may rise or fall.

By contrast, an increase in central bank credit to the banking system reduces the banks' need for deposit resources to fund their lending portfolios, causing the deposit demand curve to shift to the left, reducing the deposit rate as well as the equilibrium quantity of deposits. The effects of increases in reserve requirements and on the volume of government bonds auctioned by the central bank depend on whether these policies increase or decrease banks' demand for deposits. Under our assumption that both policies cause the demand for deposits to rise, the deposit demand curve shifts to the right and the deposit interest rate goes up.

When the central bank restricts the supply of credit to commercial banks, equation (34) replaces equation (9) in our model. Equation (34) is thus the new element that differentiates the policy of domestic credit targeting from that of targeting the deposit interest rate through the refinance rate.

To solve the extended model under this alternative operating procedure, we can proceed as in Section 3. Consider first the effects of monetary policy on the price of land. Substituting (34) into equation (25) yields

$$Q = \frac{q(i^*, \hat{q})}{1 - q(i^*, \hat{q})} \left\{ F^H - [1 + \nu(i_D(P_D; L^B, B^B, \mu, ...))] \right. \tag{35}$$
$$\left. \times\, d[i_D(P_D; L^B, B^B, \mu, ...), i^*, \hat{q}, \bar{Y}] P_D^{\delta} E^{1-\delta} \right\}.$$

As shown above, although an increase in the price of domestic goods has an ambiguous effect on the deposit interest rate, it unambiguously increases holdings of deposits in household portfolios. Because this increase in households' demand for deposits comes partially at the expense of their demand for land, the equilibrium price of land must fall when the price of domestic goods rises. Under our assumptions about the effects of government bond auctions and increases in reserve requirements on banks' demand for deposits, contractions in central bank credit, government bond auctions, and increases in reserve requirements all increase the deposit interest rate and thus reduce the price of land by inducing households to engage in portfolio substitution into deposits and away from land. That is, if we write the equilibrium price of land as:

$$Q = Q^{CT}(P^D; L^B, B^B, \mu, ...), \tag{36}$$

we then have $Q_1^{CT} < 0$, $Q_2^{CT} > 0$, $Q_3^{CT} < 0$, and $Q_4^{CT} < 0$.

Consider next the effects of monetary policy on the loan interest rate. From equations (10) to (13), and using (34), we can write:

$$i_L = [1 + \theta_L(\frac{\kappa P_D K_0}{L_0^F}; x_P)] \frac{[1 + \theta_B(B^B/B^{\max})][1 + i_D(P_D; L^B, B^B, \mu, ...)]}{1 - \mu} - 1. \tag{37}$$

This is the financial market equilibrium condition under credit targeting. It differs from equation (26) because the determination of the deposit rate, which was previously simply equal to the refinance rate i_R, is now substantially more complicated. The effects on the equilibrium loan rate of changes in the domestic price level and in the monetary policy variables are now:

$$\frac{\partial i_L}{\partial P_D} = \frac{1 + \theta_B}{1 - \mu} \{ (\frac{\kappa K_0}{L_0^F}) \theta_L'(1 + i_D) + (1 + \theta_L) \frac{\partial i_D}{\partial P_D} \} \lesseqgtr 0,$$

$$\frac{\partial i_L}{\partial L^B} = [\frac{(1+\theta_L)(1+\theta_B)}{1-\mu}]\frac{\partial i_D}{\partial L^B} < 0,$$

$$\frac{\partial i_L}{\partial B^B} = \frac{1+\theta_L}{1-\mu}\{(1+i_D)(\theta_B'/B^{\max}) + (1+\theta_B)\frac{\partial i_D}{\partial B^B}\} > 0,$$

$$\frac{\partial i_L}{\partial \mu} = \frac{(1+\theta_L)(1+\theta_B)}{1-\mu}\{\frac{(1+i_D)}{1-\mu} + \frac{\partial i_D}{\partial \mu}\} > 0.$$

Notice that, in contrast to equation (26), the effect of an increase in the domestic price level on the loan rate, given by $\partial i_L/\partial P_D$, is now ambiguous. The implication is that the FF curve of Section 3 may have either a negative or a positive slope, in contrast with its unambiguously negative slope in that section. The reason for this is that there is now a potential offset to the "financial accelerator" effect that determined the slope of the FF curve in Section 3. The term $(\kappa K_0/L_0^F)\theta_L'(1+\theta_B)(1+i_D)$ in the expression for $\partial i_L/\partial P_D$ captures the financial accelerator effect, and has a negative sign. But under credit targeting, there is a new term $(1+\theta_L)(1+\theta_B)(\partial i_D/\partial P_D)$ in the expression for $\partial i_L/\partial P_D$. This term captures the effect of changes in the price of domestic goods on the bank deposit rate, and through the bank deposit rate on the loan rate. As we saw previously, $\partial i_D/\partial P_D$ can be positive or negative, depending on whether an increase in the domestic price level has a stronger impact on banks' demand for deposits or households' supply of deposits. If the effect of higher domestic prices on the demand for transactions balances is dominant, as in textbook LM curves, then $\partial i_D/\partial P_D$ will be negative (the deposit supply curve will shift to the right more than the demand curve, causing the deposit rate to fall), and the FF curve would retain the negative slope that we associated with it in Section 3. The role of the financial accelerator mechanism in this case will be to make the FF curve flatter than it would otherwise be, thus causing the effects of real (goods market) shocks to be magnified.

The remaining effects on the loan rate are straightforward. The impact of an expansion in central bank credit on the loan rate operates through the deposit rate. As the supply of central bank credit increases, banks can afford to lower their deposit rates; and because the markup is unchanged, the loan rate falls as well. Regarding the required reserve ratio and central bank bond auctions, under our assumption that the resource-contraction effects are dominant, the positive effects of increases in B^B and μ on the loan rate by increasing the markup over the deposit rate are here magnified through the effects of these policies on the deposit rate itself. Thus, increases in B^B and

μ raise the loan rate *both* by increasing the markup as well as by increasing the deposit rate. The former is captured by the first term inside the curved brackets in the expressions for $\partial i_L/\partial\mu$ and $\partial i_L/\partial B^B$, and the latter by the second term.

The real sector remains as before, except that the determination of the deposit interest rate is now explained by equation (34) rather than (9), and that of the price of land by equation (36) rather than (25). The implication is that now all of the central bank's monetary policy instruments affect the goods market directly through their effects on the deposit rate and the price of land. Thus the goods market equilibrium condition remains as given in equation (27), which is repeated here for convenience:

$$\bar{Y} = [1-\delta(\frac{E}{P_D})][C_0 + \alpha_1(\bar{Y}-T) - \alpha_2(i_D + i^* + \hat{q}) + \alpha_3(\frac{F^H + Q}{P_D})]$$

$$+I(i_L - \pi^a; K_0) + G + X(E/P_D).$$

However, the value of the loan rate that clears the goods market is now given by:

$$i_L = i_L(P_D; L^B, B^B, \mu, ...), \tag{38}$$

where

$$\frac{\partial i_L}{\partial P_D} = -\frac{1}{I_1}\{\frac{zC\delta'}{P_D} - \alpha_2(1-\delta)\frac{\partial i_D}{\partial P_D}\} - \frac{1}{I_1}\{(1-\delta)\alpha_3(\frac{Q_1^{CT}}{P_D} - \frac{A^H}{P_D^2} - \frac{zX'}{P_D}\} < 0,$$

$$\frac{\partial i_L}{\partial L^B} = \frac{(1-\delta)}{I_1}[\alpha_2(\frac{\partial i_D}{\partial L^B}) - \alpha_3(\frac{Q_2^{CT}}{P_D})] > 0,$$

$$\frac{\partial i_L}{\partial B^B} = \frac{(1-\delta)}{I_1}[\alpha_2(\frac{\partial i_D}{\partial B^B}) - \alpha_3(\frac{Q_3^{CT}}{P_D})] < 0,$$

$$\frac{\partial i_L}{\partial \mu} = .\frac{(1-\delta)}{I_1}[\alpha_2(\frac{\partial i_D}{\partial \mu}) - \alpha_3(\frac{Q_4^{CT}}{P_D})] < 0.$$

The dependence of the deposit interest rate on the domestic price level under credit targeting introduces the new term $(1-\delta)\alpha_2\partial i_D/\partial P_D$ inside the curved brackets in $\partial i_L/\partial P_D$. As we saw above, $\partial i_D/\partial P_D$ is ambiguous in sign. Again, if the dominant influence on the deposit interest rate arising from an increase in the price of domestic goods is that operating on households' demand for transaction balances (rather than through banks' demand for additional investable resources), then the sign of $\partial i_D/\partial P_D$ will be negative. This effect tends to *increase* the equilibrium value of the loan interest rate, tending to offset negative effects on the loan rate operating thorough household wealth and the real exchange rate. If the slope of the GG curve remains negative, this effect therefore tends to make it steeper.

Turning to the monetary policy variables, an increase in central bank credit is expansionary: it reduces the deposit rate, stimulating consumption through interest rate effects given by $-(1-\delta)\alpha_2\partial i_D/\partial L^B$, as well as by wealth effects given by $(1-\delta)\alpha_3 Q_2^{CT}/P_D$ (recall that $Q_2^{CT} > 0$). Thus, an increase in L^B requires an increase in the loan rate to keep the goods market in equilibrium. A similar analysis applies for increases in the scale of bond auctions by the central bank and the required reserve ratio. Both measures increase the deposit rate and depress the price of land, reducing consumption spending through interest rate and wealth effects. Both therefore require a reduction in the loan rate to keep the goods market in equilibrium.

We can analyze the model graphically as in the previous section, and consider once again the effects of a variety of monetary and real shocks. However, the key implications of the change in monetary policy operating procedure are evident by inspection of the properties of equations (37) and (38)—the algebraic counterparts of the FF and GG curves of the last section, respectively—so a quick overview of the effects of monetary policy variables will suffice.

Consider, for instance, the effects of an expansion in central bank credit. Because the supply of central bank credit was perfectly elastic under the interest rate rule of the last section, this is a new monetary instrument in the model. As we can see from equations (37) and (38), an increase in L^B shifts the FF curve downward and the GG curve upward. As shown in Figure 7, the effect is to increase the domestic price level while reducing the loan rate.

It is easy to see from the properties of equations (37) and (38) that changes in B^B and μ also shift the FF and GG curves in opposite vertical directions, so a diagram similar to Figure 7 would describe the effects on the loan rate and price of domestic goods of *reductions* in B^B and μ. Notice that when the central bank determined deposit rates through its refinance rate, changes in B^B affected the goods market only through their influence on the loan rate (that is, they caused the FF curve to shift, but had no direct effect on the GG curve). Under domestic credit targeting, however, the mechanism of monetary transmission for this policy works not just through the loan rate, but also through deposit rates and the price of land. In the case of changes in reserve requirements, under interest rate targeting the economy was affected only through the GG curve. Because the marginal cost of funds for banks was unaffected by such changes, the FF curve was unaffected. Moreover, increases in reserve requirements were expansionary. Under credit targeting, both the goods and financial market equilibrium conditions are disturbed and, more importantly, the effects of changes in reserve requirements on aggregate demand are the opposite of what they are under interest rate targeting: increases in reserve requirements are contractionary, precisely because they tend to increase the marginal cost of funds for banks.

5.2 The Monetary Base and Sterilization

An interesting aspect of our model concerns its implications for the behavior of the monetary base, and the consequences of that behavior for the macroeconomic effects of monetary sterilization. Exploring these issues illustrates well the importance of grounding an understanding of monetary transmission in the specific context of a country's financial structure. As we shall show in this section, the failure to do so can prove highly misleading not only in interpreting the stance of monetary policy in developing countries, but also in monetary policy design in general.

To illustrate these points, consider the determination of the monetary base in our model. Using equations (3), (4), and (8) in equation (17) yields

$$MB = [\nu(i_D) + \mu]d(i_D, i^*, \widehat{q}, Y)P_D^{\delta}E^{1-\delta}. \tag{39}$$

To see what this equation implies, suppose that $\eta_D/\eta_\upsilon > \nu/(\nu+\mu)$, where $\eta_D = Pd_{i_D}i_D/D$ and $\eta_\nu = -\nu' i_D/\nu$ as before; the demand for monetary base is thus an increasing function of the deposit interest rate, other things equal.[19] This has some important implications. Consider the model of Section 2, in which the central bank sets a policy value of the refinance rate and makes the supply of credit to the banking system perfectly elastic at that rate. In that setting, contractionary monetary policy consists of an increase in the policy-determined central bank lending rate, as shown in Section 4.1. But because by equation (9) the deposit interest rate paid by commercial banks is an increasing function of the refinance rate, equation (39) implies that the

[19]Because $\mu < 1$, the assumption $\eta_D/\eta_\upsilon > \nu/(\nu + \mu)$ ensures that condition (5) holds.

tighter monetary policy must be associated with an *increase* in the monetary base at the initial value of the domestic price level.

What differentiates this case from the standard industrial-country story about monetary transmission, in which *reductions* in the monetary base are associated with higher domestic interest rates, is that the interest rate through which aggregate demand is affected in this case (specifically, the deposit rate, because it is through the deposit rate that bank lending rates and land prices are affected by monetary policy) is not an interest rate on an asset that substitutes for money in household portfolios. In fact, just the opposite is true: the interest rates that rise under tight monetary policy include the own rate of return on holding money, whereas the interest rates on money substitutes are unaffected. This is why a monetary tightening is associated with an increase in the monetary base on impact (that is, at a given value of the domestic price level).

Whether the monetary base turns out to be higher or lower in the new macroeconomic equilibrium that emerges after the monetary contraction, however (that is, after the domestic price level is allowed to adjust), cannot be determined unambiguously in our model. It depends on the net effect of two offsetting influences: the increase in the deposit interest rate and decrease in the domestic price level. By (39), the former increases the demand for base money whereas the latter reduces it, leaving the net effect dependent on a variety of elasticities in the model. The same analysis holds when the central bank targets credit to banks L^B, as in Section 5. In that case, a monetary contraction consists of a reduction in L^B, which increases the deposit interest rate and thus has the same effect on the monetary base as just described.

This analysis has at least two important implications. First, because a monetary tightening could be associated with an increase in the monetary base and a monetary expansion with a reduction in the base, the stance of monetary policy in an economy such as the one we are examining cannot be inferred from the behavior of the monetary base. As just shown, the impact of monetary policy on the monetary base may be either in the same or in the opposite direction as its impact on aggregate demand. Second, consider the effects of a policy of monetary sterilization. In principle, the central bank could use any of its three instruments to stabilize the monetary base in response to shocks: the refinance rate i_R, lending to banks L^B, and changes in its stock of government bonds B^C.

For concreteness, suppose the central bank varies i_R so as to stabilize the monetary base; in other words, consider sterilization within the context of the model of Section 2. Again for concreteness, suppose that the shock in question is an increase in the foreign interest rate, i^*. We saw in Section 4.5 that, holding the policy rate i^R constant, an increase in the foreign interest rate would cause the GG curve to shift to the left and the price of domestic goods to fall. In other words, this shock has a contractionary effect on aggregate demand. From equation (39), the combination of a higher rate of return on foreign assets and lower domestic price level cause the monetary base to contract, because they combine to reduce the demand for deposits. The contraction in the monetary base stems from a combination of capital outflows as households switch from domestic deposits to foreign assets, as well as reduced commercial bank borrowing from the central bank, because the lower domestic price level increases bank lending rates and reduces firms' demand for loans. To sterilize these effects and stabilize the monetary base, the central bank would be led, by (39), to try to induce an increase in the demand for deposits by increasing deposit interest rates. It could do this by raising its refinance rate. But as shown in Section 4.1, this policy also has contractionary effects on aggregate demand. Thus, rather than stabilize the economy in response to real shocks, sterilization does exactly the opposite: in order to stabilize the monetary base, it destabilizes aggregate demand. The upshot is that when the economy's financial structure is as described here, the conventional wisdom based on the familiar Poole-type analysis of the optimal choice of monetary policy instruments is stood on its head: in response to real shocks, interest rate targeting is superior to monetary targeting.

6 Concluding Remarks

In this paper we developed a simple static framework with credit market imperfections and flexible prices for monetary policy analysis in a fixed-exchange rate economy. A key feature of the model is the assumption that lending rates are set as a markup over the cost of funds. In turn, the markup rate is a function of firms' collateralizable net worth. In the basic framework, banks' funding sources are perfect substitutes, and loan supply and the provision of liquidity by the central bank are perfectly elastic at the prevailing lending and refinance rates. Changes in the price of land (or housing) have liquidity and wealth effects, which stimulate private consumption. Private investment is specified as a function of the real lending rate. The model was used to perform a variety of policy experiments, such as changes in the refinance and reserve requirement rates, central bank auctions, exogenous shifts in the premium and contract enforcement costs, and changes in public spending and the world interest rate. The analysis was then extended to examine credit targeting and sterilization policies.

As noted in the introduction, our view is that the model proposed in this paper is a useful tool for basic monetary policy analysis. Its main virtue is that its mechanics are relatively straightforward, its intuition can be conveyed easily, and it can be adapted to address a number of issues beyond those discussed in the paper. Although its microeconomic foundations were not fully derived, our analysis of various experiments suggests that it leads to sensible policy lessons.

There are indeed many directions in which our framework can be extended. First, one could consider the case of a floating exchange rate, and examine the net worth effects associated with changes in the domestic-currency value of foreign debt. We are pursuing this direction in a companion paper, where we also address the issue of price and exchange rate expectations (Agénor and Montiel (2006*b*)). Second, one could endogenize the supply side and introduce a cost channel for monetary policy, by accounting for a direct effect of lending rates on firms' marginal production costs. This is a common feature of developing economies, and there is some evidence that this effect may be important also in industrial countries.[20] Third, we adopted the Mundell-Fleming one-good production structure for tractability; instead, a tradable-nontradable structure, although somewhat more complicated to handle, could be used. As documented by Tornell and Westermann (2003), in several middle-income countries there is a pronounced asymmetry in size and financing opportunities available to firms across tradables and nontradables sectors. Firms in the tradables sector tend to be large and have access to world capital markets (in addition to domestic loans), because they can either pledge export receivables as collateral, or can get guarantees from closely linked firms. By contrast, firms in the nontradables sector tend to be smaller on average, are more dependent on bank credit, and may face borrowing constraints. Fourth, additional forms of credit market imperfections could be captured. For instance, it may be worth accounting for the maturity structure of bank loans. In particular, the share of long-term loans in total

[20]See, for instance, Christiano and Eichenbaum (1992) and Ravenna and Walsh (2006) for the United States. 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.

loans may affect—in addition to the factors identified in our analysis—the determination of lending rates. This may impart some degree of stickiness in response to changes in official interest rates, as suggested by the results of Gambacorta (2004). Capturing asymmetric price-setting behavior by banks would also be important. If banks have excess liquidity, for instance, they may not adjust deposit rates upward in response to a rise in the official rate, as postulated in our basic framework. Finally, adding stochastic shocks to the model would allow one to address a host of issues, such as the determination of optimal interest rate rules and sterilization policies under a flexible exchange rate regime.

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Figure 1
Goods and Financial Market Equilibrium

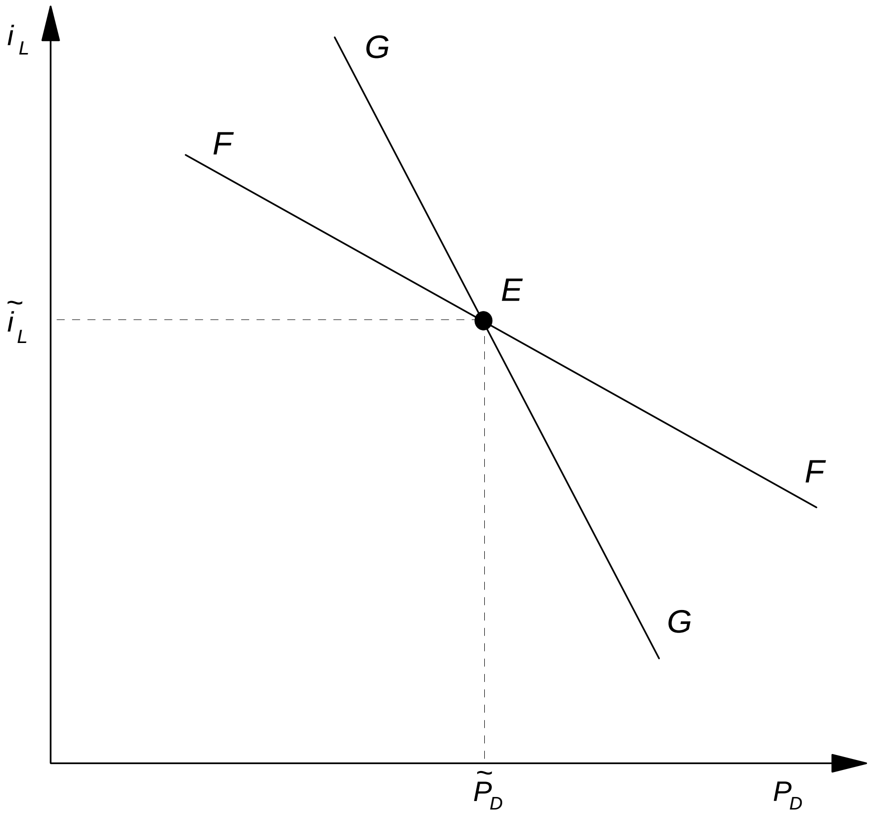

Figure 2
Increase in the Central Bank Refinance Rate

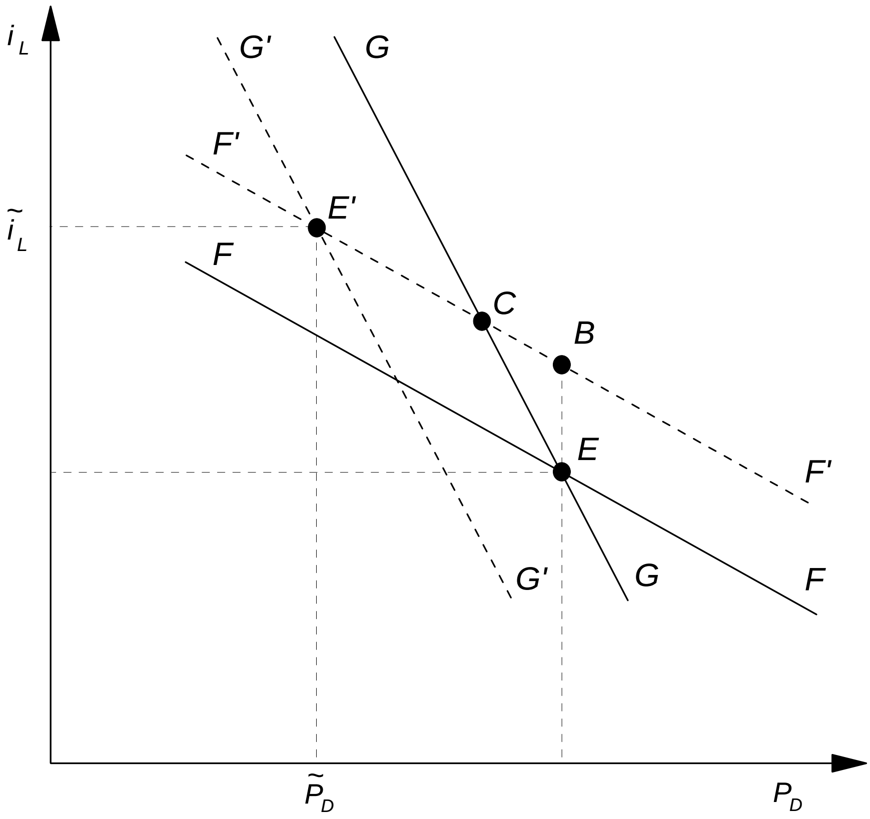

Figure 3
Bond Auction by the Central Bank

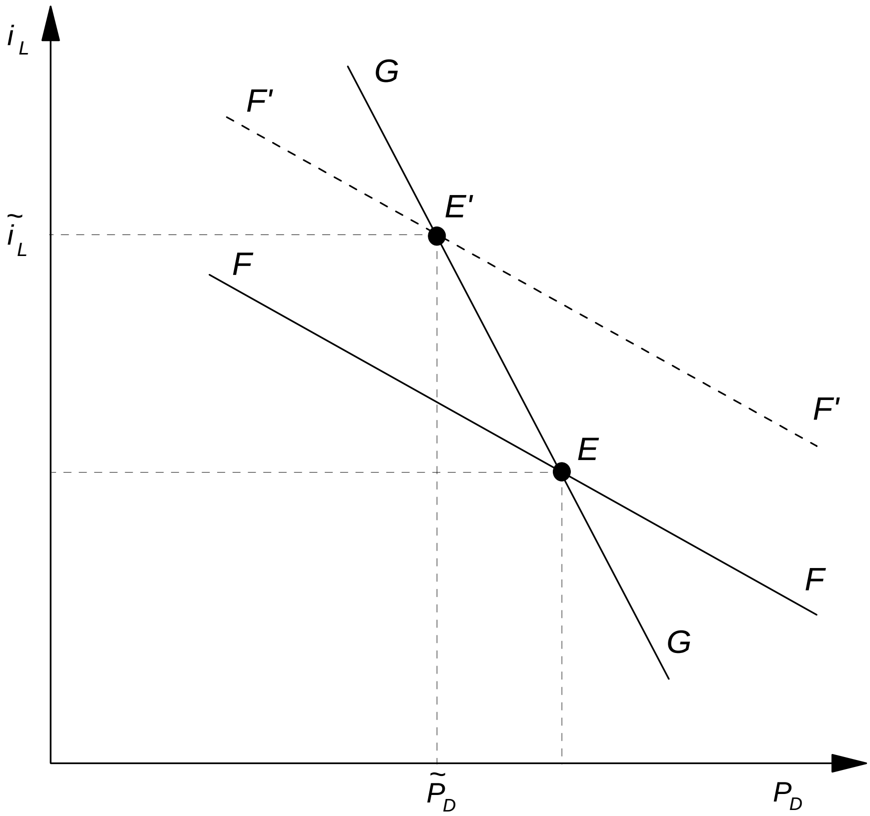

Figure 4
Increase in the Required Reserve Ratio

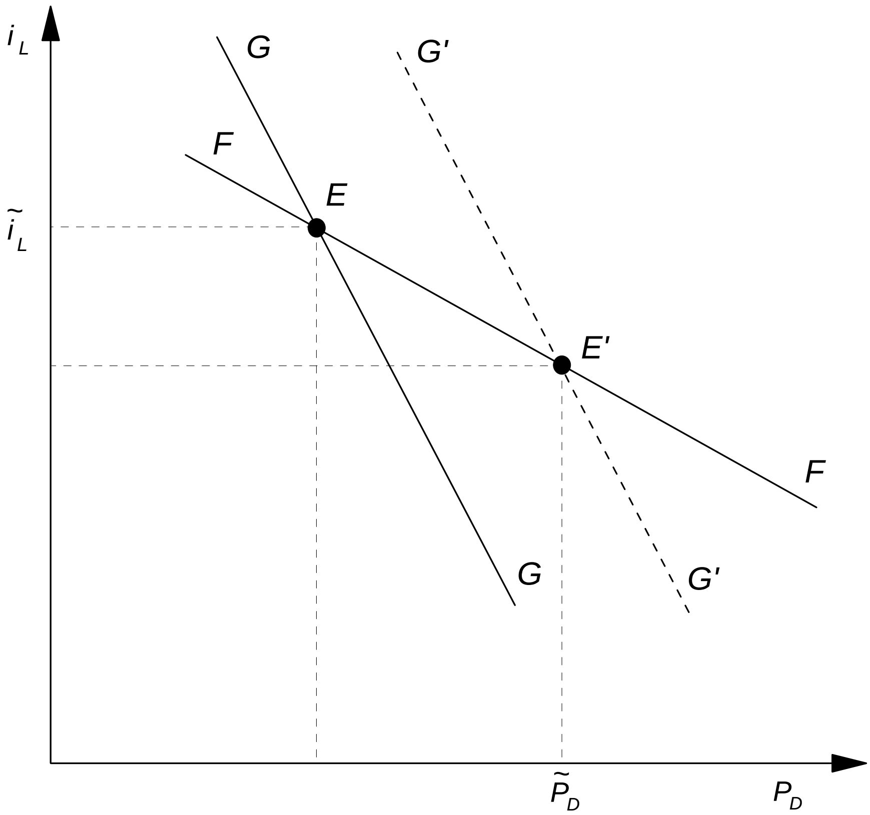

Figure 5
Reduction in Contract Enforcement Costs

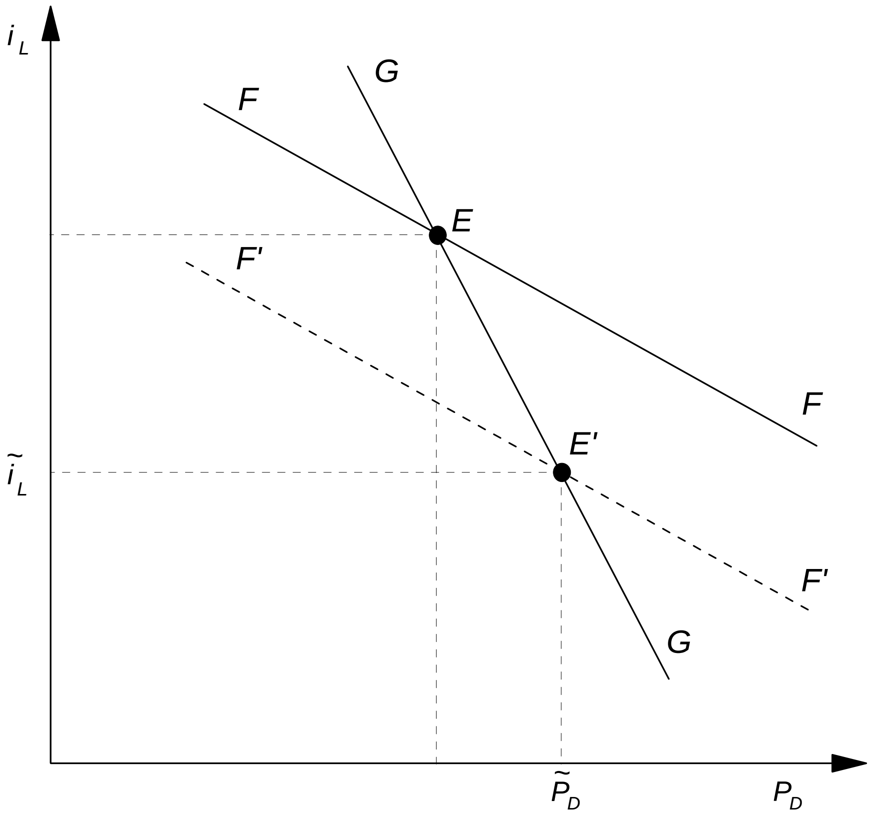

Figure 6
Equilibrium in the Market for Bank Deposits

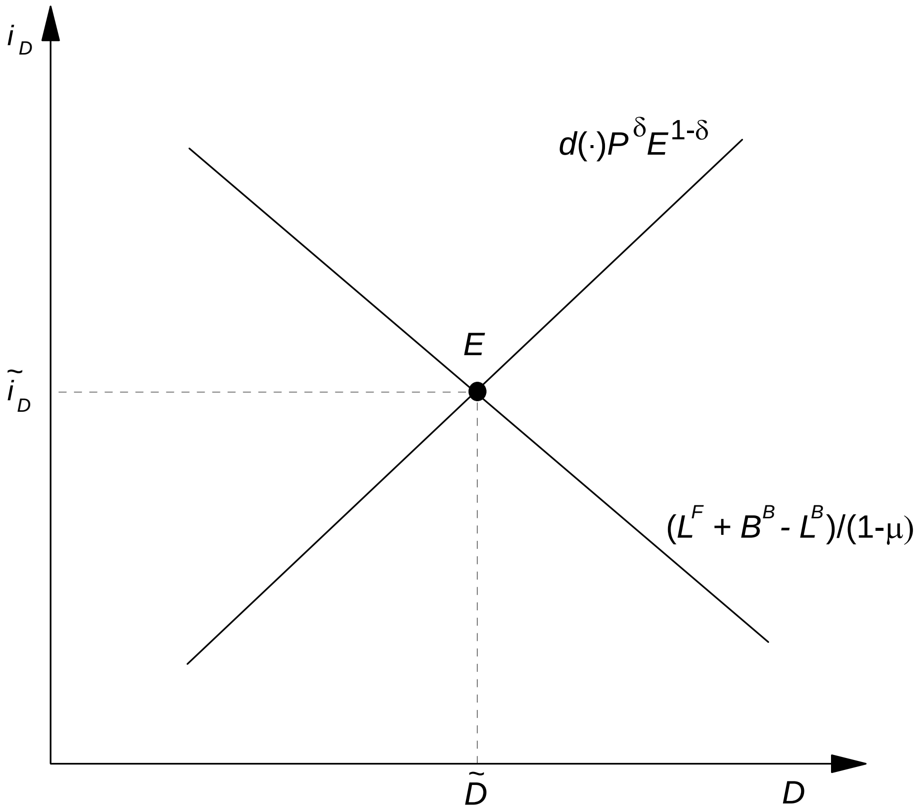

Figure 7
Increase in Central Bank Credit under Credit Targeting