BIS Working Papers

No 964

Macro-financial policies under a managed float: A simple integrated framework

by Pierre-Richard Agénor and Luiz A Pereira da Silva

Monetary and Economic Department

September 2021 (revised May 2023)

JEL classification: E63, F38, F41.

This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)
ISSN 1682-7678 (online)

Macro-Financial Policies under a Managed Float: A Simple Integrated Framework

Pierre-Richard Agénor* and Luiz A. Pereira da Silva**

Abstract

This paper presents a simple integrated macroeconomic model of a small, bank-dependent open economy with a managed float and financial frictions. The model is used to study the effects of five types of policy instruments: fiscal policy, monetary policy, macroprudential regulation, foreign exchange intervention, and capital controls, in the form of a tax on bank foreign borrowing. It also considers how, following a drop in the world interest rate, these instruments can be combined to restore the initial equilibrium. The analysis illustrates how macro-financial policies can complement each other in response to capital inflows. In particular, it is shown that, to stabilize the economy, whether monetary policy should be contractionary (a common prescription in practice) or expansionary depends on which other instruments are available to policymakers. The joint use of macroprudential regulation and capital controls is also shown to provide a potent combination to manage capital inflows.

JEL Classification Numbers: E63, F38, F41

*Hallsworth Professor of International Macroeconomics and Development Economics, University of Manchester; **Deputy General Manager, Bank for International Settlements. We are grateful to Timothy Jackson, colleagues at the Bank for International Settlements, the co-Editor, and two anonymous reviewers for very helpful comments on a previous draft. However, we bear sole responsibility for the views expressed in this paper. A shorter version of this paper is published in the *Journal of International Money and Finance.*

1 Introduction

Recent evidence on the evolution of exchange rate regimes suggests that managed floats remain the norm in middle-income countries—even among those that have adopted inflation targeting, a regime in which the exchange rate should be allowed to float freely to avoid calling into question the preeminence and credibility of the inflation target, as their monetary policy framework. As documented by Frankel (2019), Ilzetzki et al. (2019), and Adler et al. (2020), for instance, in many of these countries central banks intervene frequently, and often through sterilized operations. Moreover, the decision to intervene appears to have been increasingly driven by the goal of mitigating the volatility of the exchange rate, rather than concerns with its level (due, for instance, to competitiveness and exchange rate pass-through considerations), or the need to build foreign reserves for precautionary reasons.[1] This goal is particularly important for countries with currency and maturity mismatches, substantial net foreign liabilities, and for those facing external borrowing constraints.

At the same time, a growing number of central banks have used foreign exchange market intervention as part of a broad combination of policy instruments to contain macroeconomic and financial stability risks—especially those associated with large, short-term capital inflows, a perennial challenge for policymakers in small open developing economies. These instruments include not only monetary policy and macroprudential regulation (whose performance has been the subject of greater scrutiny since the global financial crisis) but also, albeit to a lower extent, fiscal policy and temporary capital controls.

A number of analytical contributions have studied how combinations of these various policy instruments can help to promote economic stability. In particular, research has focused on how monetary and macroprudential policies interact when financial frictions are pervasive, and how they should be combined to promote macroeconomic and financial stability in open economies. These contributions have generated important insights with respect to how quantitative macroeconomic models—especially those belonging to the stochastic dynamic general equilibrium (DSGE) tradition—should be

[1] See, for instance, Sandri (2020, Section 2) for the case of Brazil and Patel and Cavallino (2019) for broader evidence based on a survey of central banks. At the same time, whether foreign exchange intervention can successfully affect the exchange rate remains a matter of debate.

used to calibrate policy responses and inform policy decisions.[2] This has been particularly the case with respect to individual macroprudential policy tools (namely, capital requirements, liquidity requirements, loan-loss provisions, and restrictions on bank foreign borrowing) and their interactions with monetary policy. A key message in that regard—despite the fact that the proper modeling of financial frictions and the specification of implementable, countercyclical policy rules remain matters of contention—is that in response to a variety of shocks, using monetary and macroprudential policy instruments in a complementary manner can strengthen their effectiveness and promote economic stability.[3] Although, as noted by Carstens (2019), theoretical models have yet to account fully for the channels through which the practice of foreign exchange intervention can affect macroeconomic fluctuations, some progress has been made in studying how such intervention can be combined with other instruments to achieve financial stability.

Yet, a potential difficulty with the existing analytical literature is that the micro-founded models upon which it is based are generally fairly complex and often cannot be solved analytically; to study the transmission process of macro-financial policies, and the role of these policies in responding to domestic and external shocks, they must be calibrated (or estimated) and solved numerically.[4] At times, this makes understanding their key properties arduous. The lack of transparency, and sensitivity to particular parameter values, may also make it difficult to draw broad policy insights.

In this paper, we propose to "take a step back" from the more intricate models that have been developed in the literature. We present a simple, tractable, integrated macroeconomic model of a small, bank-dependent open economy—a fairly accurate description for most middle-income countries—in which financial frictions prevail and the central bank operates a managed float. The model is used to study the performance of the various instruments that policymakers have used in recent years, as noted earlier, to manage their economies in response to external financial shocks: monetary

[2] See Agénor (2020) for a fairly comprehensive review of, and detailed references to, this literature.

[3] More broadly, research on the design of macroeconomic policy frameworks in the aftermath of the global financial crisis has also considered how the institutional mandates of central banks and regulators should be reformed, and the extent to which coordination between them should be pursued. See, for instance, the proposal for an *integrated* inflation targeting regime by Agénor and Pereira da Silva (2019, 2022), which focuses on middle-income countries.

[4] See Agénor (2020) for a fairly comprehensive review of, and detailed references to, this literature.

policy, macroprudential regulation, sterilized foreign exchange intervention, and (to a more limited extent) fiscal policy and capital controls. A key advantage of the model, despite its obvious vulnerability to the Lucas critique, is that it is fairly transparent analytically. And because simple diagrams can be used to illustrate the impact of policy and exogenous shocks, understanding its properties and the basic policy insights that it provides is relatively straightforward.[5] In that sense, it also provides intuition for some of the results that can be gauged from more advanced (micro-founded) open-economy quantitative models with financial frictions.

The main results, which are all illustrated graphically, can be summarized as follows. First, although the strength of financial frictions plays an important role in the transmission process (and thus in the underlying transitional dynamics) of exogenous and policy shocks, the direction of equilibrium effects are generally not affected. The most notable exception, as documented in previous studies, relates to monetary policy when the cost channel, associated with bank borrowing to finance working capital needs, is present. However, in our setting, whether a price puzzle emerges depends also on the impact of monetary policy on the exchange rate. Second, in response to capital inflows driven by external financial shocks, whether monetary policy should be contractionary or expansionary in order to restore the economy's initial equilibrium (viewed as a desirable "welfare" objective) depends on which other instrument, or instruments, policymakers have at their disposal. In that regard, the model delivers a number of clear-cut results. In particular, if fiscal policy (that is, government spending) is the only other instrument available, an *effective* policy mix—in the sense of being capable of bringing the economy back to its initial equlbrium— involves a *reduction* in the policy interest rate (which, in effect, targets external balance, by mitigating incentives to capital inflows) and a spending cut (which targets internal balance). The combination of a reduction in the policy rate (again, targeting external balance) and a tightening of macroprudential regulation (which targets internal balance) is also effective. However, if the other instrument available is capital controls, it is an *increase* in the policy rate (geared this time at achieving internal balance, by dampening aggregate demand), cou-

[5] As pointed out by Krugman (2000, p. 41), in his defense of *little models*, "...The point is not that these models are accurate or complete, or that they should be the only models used. Clearly they are incomplete, quite inadequate to examine some questions... But they are easy to use, particularly on real-world policy questions."

pled with a tightening of capital controls (which targets external balance, in a sense by "undoing" the incentives for capital inflows that higher domestic interest rates create) that is most effective to stabilize the economy. Similarly, if the other instrument available is sterilized intervention, it is a combination of *higher* interest rates (again geared towards internal balance) and foreign exchange intervention (geared towards external balance) that represents the preferred policy mix. This combination is effective even in the presence of a bank portfolio channel, if the change in the policy rate is properly calibrated. The fact that an effective policy mix may involve higher, rather than lower, domestic interest rates, depending on which other instrument is available, runs counter to standard policy prescriptions. Finally, when monetary policy cannot be used (possibly due to uncertainty about its effects), the combination of a price-based macroprudential tax (targeted at internal balance) and temporary capital controls on bank foreign borrowing (targeted at external balance) represents also a potent policy combination to manage capital inflows.

The remainder of the paper proceeds as follows. Section 2 presents the model.[6] In line with the foregoing discussion, key features of the model include financial frictions, imperfect asset substitutability and imperfect capital mobility, foreign exchange market intervention, aimed at smoothing excessive movements in the exchange rate, as well as liquidity constraints, intertemporal substitution, nominal wage rigidity, and economies of scope in banking. While some components are explicitly micro-founded, others (especially with respect to the components of aggregate demand) are not. Nevertheless, in those cases behavioral assumptions are plausible and consistent with the empirical evidence for middle-income countries. They are therefore not entirely *ad hoc*. Section 3 characterizes macroeconomic equilibrium, both analytically and graphically. In Section 4, the impact of exogenous changes in the five policy instruments identified earlier are examined.[7] Section 6 considers an external shock of great relevance for middle-income countries—a drop in the world interest rate, and its subsequent effect on cross-border capital flows. The focus then turns to how policy instruments can be adjusted, either

[6]The model dwells significantly on the core framework with fully flexible exchange rates presented in Agénor and Montiel (2015, chapter 6), Agénor (2020, chapter 7) and Agénor (2021).

[7]Because (as also noted earlier) sterilized intervention is the main instrument used by central banks in MICs to mitigate currency fluctuations, we do not consider the case where the exchange rate is targeted through an augmented interest rate rule. See Agénor and Pereira da Silva (2019, pp. 39-40) for a discussion of the evidence on this issue.

individually or jointly, to return the economy to its initial equilibrium position. While this analysis is inevitably partial in nature, given in particular the static nature of the model and the absence of an explicit account of the objectives of policymakers, it provides some useful insights with respect to the benefits (or lack thereof) of alternative policy combinations. Section 7 considers various extensions of the model, whereas the last section offers some concluding remarks.

2 The Model

Consider an open economy producing a specialized, homogeneous good, using labor and capital. The domestic good is imperfectly substitutable to a foreign good, whose price is taken as exogenous. In the Mundell-Fleming tradition, the domestic economy has market power over the price of the good that it produces. Thus, the economy's terms of trade—the relative price of the foreign good in terms of the domestic good, or equivalently the real exchange rate—are endogenous.[8] There are six categories of agents: firms, households, commercial banks, the central bank, the financial regulator, and the government. Their behavior is considered in turn. The definitions of the price index and the real exchange rate, and market-clearing conditions, are then provided.

The financial frictions that are at the core of the model consist of *a*) the link between collateral (in the form of housing) and the cost of bank borrowing, which creates an endogenous wedge between the loan rate and the policy interest rate; *b*) imperfect capital mobility, which reflects imperfections in international capital markets, as discussed in Agénor et al. (2020); *c*) borrowing by firms from domestic banks for short-term working capital needs, which creates a cost channel of monetary policy; and *d*) imperfect substitutability between bank loans and the bonds issued by the central bank to sterilize its foreign exchange operations. As noted earlier, the policy instruments considered are fiscal policy, monetary policy, macroprudential regulation, sterilized intervention, and capital controls.

[8] From an empirical standpoint, a more appropriate production structure for a middle-income economy would presumably involve distinguishing between tradables and nontradables. However, with two production sectors, the solution of the model would be more involved.

2.1 Firms

Firms pay all wages in advance and to do so they must borrow from banks. These loans are not subject to the possibility of default and are therefore made at an interest rate that reflects only the cost at which the central bank provides liquidity to banks, that is, the refinance rate, i^R, which represents (as further discussed later) the marginal funding cost for them.

Let W denote the nominal wage and N the quantity of labor employed. The wage bill, inclusive of borrowing costs, is thus $(1+\psi_W i^R)WN$, where $\psi_W \in (0,1)$ is the fraction of wage costs financed by bank borrowing. Let also Y denote output and P^D the price of the domestic good. The maximization problem faced by firms can therefore be written as

$$N = \arg\max[P^D Y - (1+\psi_W i^R)WN]. \tag{1}$$

The production function takes a Cobb-Douglas form,

$$Y = N^\alpha K_0^{1-\alpha}, \tag{2}$$

where K_0 is the stock of capital at the beginning of the period, which is therefore predetermined, and $\alpha \in (0,1)$.

Substituting (2) in (1), the first-order condition of the maximization problem yields the demand for labor as

$$N^d = [\frac{\alpha P^D}{(1+\psi_W i^R)W}]^{1/(1-\alpha)} K_0, \tag{3}$$

which can be substituted in (2) to give the supply of domestic goods:

$$Y^s = [\frac{\alpha P^D}{(1+\psi_W i^R)W}]^{\alpha/(1-\alpha)} K_0. \tag{4}$$

Equations (3) and (4) show that the demand for labor and the supply of domestic goods are inversely related to the *effective* cost of labor, $(1+\psi_W i^R)W/P^D$, where W/P^D represents the product wage. As discussed later on, the model therefore captures the cost channel of monetary policy.

Nominal wage rigidity prevails in the short run, so that $W = \bar{W}$.[9] Equations (3)

[9]This assumption is consistent with the view, put forward by Christiano et al. (2005), that nominal wage rigidity may be a more important factor than nominal price stickiness in explaining macroeconomic fluctuations. See, for instance, Basu and House (2016) for a more nuanced perspective.

and (4) therefore become

$$N^d = N^d(P^D; i^R), \quad Y^s = Y^s(P^D; i^R), \tag{5}$$

where

$$N^d_{P^D} = (\frac{1}{1-\alpha})\frac{N^d}{P^D} > 0, \quad Y^s_{P^D} = (\frac{\alpha}{1-\alpha})\frac{Y^s}{P^D} > 0,$$

$$N^d_{i^R} = -(\frac{\psi_W}{1-\alpha})\frac{N^d}{1+\psi_W i^R} < 0, \quad Y^s_{i^R} = -(\frac{\alpha\psi_W}{1-\alpha})\frac{Y^s}{1+\psi_W i^R} < 0.$$

An increase in the price of domestic goods, or a reduction in the cost of borrowing (as long as $\psi_W > 0$), lead to an expansion in employment and output.

Investment is entirely financed by bank loans and is, as a result, negatively related to the real cost of borrowing:

$$I = I(i^L - \pi^e), \tag{6}$$

where i^L is the nominal loan rate, π^e the expected inflation rate, and $I' < 0$.

Thus, total loans, L, are given by

$$L = \psi_W W N^d + L^I_0 + P^D I,$$

where L^I_0 is the beginning-of-period stock of investment loans.

Firms repay their loans, with interest, at the end of the period, after goods have been produced and sold. However, while working capital loans are always repaid in full, investment loans are subject to the possibility of default.

2.2 Households

Households supply labor inelastically and consume the domestic and foreign goods.[10] They hold three categories of imperfectly substitutable financial assets: currency (which bears no interest), domestic-currency deposits, and foreign-currency deposits held abroad. They also hold real, physical assets, in the form of land (equivalently, housing or real estate). Foreigners do not hold domestic assets.

[10] Given that labor demand is determined by firms and that the nominal wage is fixed, the assumption that labor supply is inelastic implies that unemployment may emerge in equilibrium. This issue is abstracted from here; see Agénor (2021) for a discussion.

2.2.1 Portfolio Allocation

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

$$F^H = M + D + ED^*, \tag{7}$$

where M is currency holdings, D (D^*) domestic- (foreign-) currency deposits, and E the nominal exchange rate.

This equation can be rewritten as

$$F^H = (M + D + E_0 D^*) + (E - E_0)D^*,$$

that is,

$$F^H = F_0^H + (E - E_0)D_0^*, \tag{8}$$

where E_0 and D_0^* are beginning-of-period values of E and D^*. The term F_0^H is beginning-of-period financial wealth, and is therefore predetermined; $(E - E_0)D_0^*$ represents the capital gain (or loss) due to fluctuations in the exchange rate, and is thus endogenous.

The domestic deposit-cash ratio depends positively on the deposit rate, i^D:

$$\frac{D}{M} = \nu(i^D), \tag{9}$$

where $\nu' > 0$.

The foreign-domestic deposit ratio depends negatively on the differential between the rate of return on domestic deposits, i^D, and the rate of return on foreign deposits, given by the sum of the foreign interest rate, i^*, and the expected depreciation rate, ε:

$$\frac{ED^*}{D} = \chi[i^D - (i^* + \varepsilon)], \tag{10}$$

where $\chi' < 0$.[11]

Substituting (9) and (10) in (7) yields

$$\frac{D}{F^H} = \frac{\nu}{1 + (1 + \chi)\nu} = d(i^D; i^* + \varepsilon), \tag{11}$$

[11] As discussed later on, in the model capital controls (which are similar to a macroprudential tax) apply only to banks, not to households. To account for capital controls on households, equation (10) could be replaced by $ED^*/D = \chi[i^D - (1 - \tau^*)i^* - \varepsilon]$, where $\tau^* \in (0, 1)$ is a levy on the return on foreign-currency deposits.

where, given that $\nu' > 0$ and $\chi' < 0$,

$$d_{i^D} = \frac{\nu' - \chi'\nu^2}{[1 + (1 + \chi)\nu]^2} > 0, \quad d_{i^*+\varepsilon} = \frac{\chi'\nu^2}{[1 + (1 + \chi)\nu]^2} < 0.$$

An increase in the rate of return on domestic (foreign) deposits raises (lowers) the demand for domestic deposits.

Using (11) to substitute out for D yields the demand for cash as

$$\frac{M}{F^H} = \frac{1}{1 + (1 + \chi)\nu} = m(i^D; i^* + \varepsilon), \tag{12}$$

where

$$m_{i^D} = \frac{-[\nu\chi' + \nu'(1 + \chi)]}{[1 + (1 + \chi)\nu]^2} \gtrless 0, \quad m_{i^*+\varepsilon} = \frac{\chi'\nu}{[1 + (1 + \chi)\nu]^2} < 0.$$

An increase in the return on foreign deposits lowers the demand for cash. By contrast, an increase in the return on domestic deposits has an ambiguous effect. On the one hand, it lowers the demand for cash; on the other, it raises it, because it reduces also the demand for foreign-currency deposits, thereby increasing demand for *both* types of domestic assets.[12]

From (10) and (11), the demand for foreign-currency deposits is given by

$$\frac{ED^*}{F^H} = \chi d(i^D, i^* + \varepsilon),$$

that is, using (11),

$$\frac{ED^*}{F^H} = \frac{\nu\chi}{1 + (1 + \chi)\nu} = d^*(i^D; i^* + \varepsilon), \tag{13}$$

where[13]

$$d^*_{i^D} = \frac{\chi\nu' + \chi'\nu(1 + \nu)}{[1 + (1 + \chi)\nu]^2} \gtrless 0, \quad d^*_{i^*+\varepsilon} = \frac{-\chi'\nu(1 + \nu)}{[1 + (1 + \chi)\nu]^2} > 0.$$

Thus, while an increase in the return on foreign deposits has the expected (positive) effect, an increase in the domestic rate of return has in general an ambiguous effect. Intuitively, the reason is that it may lower the demand for cash so much that both types

[12] To ensure that a higher domestic deposit rate also lowers the demand for cash, in addition to increasing the deposit-cash ratio, that is, $m_{i^D} < 0$, we impose the restriction $\nu' i^D/\nu > -\chi' i^D/(1+\chi)$, which requires the elasticity of the domestic deposits-cash ratio to be sufficiently high. This condition essentially means that the increase in domestic deposits resulting from a rise in its own rate of return is large enough to ensure that it is accommodated not only by a reduction in foreign deposits but also by lower holdings of cash.

[13] From (11), (12), and (13), it can of course be established that the standard portfolio restrictions $m_i + d_i + d^*_i = 0$, with $i = i^D, i^*$, hold.

of bank deposits may increase. It is assumed in what follows that a higher rate of return on domestic deposits lowers the demand for foreign deposits, that is, $d^*_{i^D} < 0$.[14]

Total household wealth, A^H, is defined as

$$A^H = F^H + P^H \bar{h}, \tag{14}$$

where $\bar{h}$ is the fixed supply of land and P^H its nominal price, which is fully flexible and adjusts instantaneously to equilibrate supply and demand.

The real demand for land is given by

$$\frac{H}{P^D} = h(i^D - \pi^e, i^* + \varepsilon - \pi^e, \pi^{H,e}, Y^s), \tag{15}$$

where $\pi^{H,e}$ is the expected rate of increase in land prices and $h_{i^D-\pi^e}, h_{i^*+\varepsilon} < 0$, $h_{\pi^{H,e}}, h_{Y^s} > 0$. Thus, a higher rate of return on either domestic or foreign deposits lowers the demand for land, whereas an increase in expected land price inflation, or an increase in income, tend to raise it. The first three effects are standard portfolio effects, whereas the fourth captures the well-documented procyclical relationship between house prices and economic activity.[15]

2.2.2 Consumption

Houesold consumption, C, measured in units of the domestic good, depends positively on income, Y^s, negatively on domestic and foreign expected real returns on deposits, $i^D - \pi^e$ and $i^* + \varepsilon - \pi^e$, and positively on real wealth. Interest on deposits is paid at the end of the period and therefore has no direct effect on spending. Thus, the consumption function takes the form:

$$C = c_1 Y^s - c_2[(i^D - \pi^e) + (i^* + \varepsilon - \pi^e)] + c_3(\frac{A^H}{P^D}), \tag{16}$$

where $c_1 \in (0,1)$ is the marginal propensity to consume and c_2, $c_3 > 0$.

The positive effect of income on consumption is consistent with the evidence regarding the pervasiveness of liquidity constraints on households in developing coun-

[14] To ensure that $d^*_{i^D} < 0$, we must have $\chi\nu' + \chi'\nu(1+\nu) < 0$, or equivalently $\nu' i^D/\nu < -\chi'(1+\nu)i^D/\chi$, which imposes an upper bound as well on the elasticity of the domestic deposits-cash ratio.

[15] See Cesa-Bianchi et al. (2015), for instance, for evidence on the procyclicality of house prices. .

tries.[16] The positive effect of financial and housing wealth on consumption is also well-documented.[17] The negative effect of the expected real returns on domestic and foreign deposits captures an intertemporal substitution effect—even though the model is not explicitly intertemporal. When either one of these returns increases, households have an incentive to save more and to reduce current consumption. For simplicity, the marginal effects of each rate of return are assumed to be the same, c_2.

2.3 Commercial Banks

Bank assets consist of loans to firms, L, reserves held at the central bank, RR, and holdings of central bank bonds, B^{CB}, whereas their liabilities consist of household deposits, D, borrowing from the central bank, L^B, and (unhedged) borrowing abroad, L^*. Banks' balance sheet can therefore be written as

$$L + RR + B^{CB} = D + L^B + EL^*. \tag{17}$$

Reserves held at the central bank do not pay interest and are set as a proportion of deposits:

$$RR = \mu D, \tag{18}$$

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

The deposit market is competitive and banks view domestic-currency deposits and loans from the central bank as perfect substitutes. Thus, the return on these deposits must be equal to the cost of funds provided by the monetary authority, corrected for the (implicit) cost of holding reserves:

$$i^D = (1 - \mu)i^R. \tag{19}$$

The (investment) loan market is monopolistically competitive. In a symmetric equilibrium, the interest rate on investment loans is a mark-up over the marginal cost

[16] See Agénor and Montiel (2015, chapter 2). The assumption that consumption depends on total income (including profits) is not fully consistent with the timing of financial transactions in the model: as stated earlier, borrowing occurs at the beginning of the period but repayment takes place at the end, after the sale of output. A more appropriate assumption, as in Agénor (2020, chapter 2), is to assume that consumption depends on wage income only. However, the qualitative implications are the same. The assumption in (16) simplifies derivations significantly.

[17] See, for instance, Peltonen et al. (2012) for a study based on a group of mostly middle-income countries, Aron and Muellbauer (2013 for South African and Kim et al. (2021) for South Korea. In general, the evidence suggests that the marginal propensity to consume out of housing wealth is higher than for financial wealth. However, we abstract from that evidence for simplicity.

of funds, that is, the refinance rate:

$$i^L = i^R + \theta - \varkappa(\frac{B^{CB}}{L_0^I}) + \gamma\tau^L, \tag{20}$$

where θ is the default premium (or premium, for short), $\tau^L \in (0,1)$ a macroprudential tax on loans, $\gamma > 0$, and $\varkappa \geq 0$.

First, consider the term θ. In this economy, all firms are owned by households. Suppose that, for simplicity, each household owns only one firm and makes its real estate assets available to that firm at no cost, for use as collateral to bank loans. The premium is thus inversely related to the ratio of real estate assets (the stock of land, $\bar{h}$, which is given, times P^H, the nominal price of land) over firms' initial liabilities (that is, beginning-of-period borrowing for investment, L_0^I),

$$\theta = \theta(\frac{\kappa P^H \bar{h}}{L_0^I}), \tag{21}$$

where $\kappa \in (0,1)$ is the proportion of assets that can effectively be pledged as collateral and $\theta' < 0$. Thus, the higher the value of collateralizable wealth, $\kappa P^H \bar{h}$, relative to initial liabilities, L_0^I, the higher the proportion of their loans that banks can recoup in the event of default. This reduces the premium and the cost of borrowing. Because both $\bar{h}$ and L_0^I are predetermined, the premium varies inversely with the price of land.

Second, consider the macroprudential tax rate, τ^L. In line with some recent contributions, the introduction of this tax directly in the loan rate equation can be viewed as a simple, generic specification consistent with the price-based channel through which some macroprudential policy instruments—especially capital requirements and loan-loss provisions—operate, that is, through their impact on market borrowing costs.[18]

Third, consider the term $-\varkappa B^{CB}/L_0^I$. It essentially reflects the existence of economies of scope in managing interest-bearing assets, investment loans and central bank bonds as in, for instance, Vargas et al. (2013) and Agénor et al. (2020). When holdings of central bank bonds increase, relative to the (initial) stock of investment loans, the cost of producing loans falls; as a result, banks reduce the loan rate.[19] The negative effect of

[18] See Agénor and Pereira da Silva (2012, 2017), Agénor et al. (2014), and Agénor and Jackson (2022) for specific examples, and Agénor (2020, chapters 5 and 6) for a broader discussion. To simplify matters, the proceeds of the tax are assumed to have no distortionary effects on the behavior of other agents.

[19] For simplicity, economies of scope relate to investment loans only, and the stock of investment loans is measured at the beginning of the period. This helps to reduce simultaneity and to simplify the solution—without affecting in a fundamental way the key insights of the analysis.

the change in sterilization bonds on the loan rate is also consistent with the empirical evidence on the impact of foreign exchange purchases on market interest rates provided by Garcia (2012), for instance, for Brazil.

Domestic borrowing and foreign borrowing are imperfect substitutes. This is captured by specifying the demand for foreign borrowing by banks as

$$\frac{EL^*}{L_0^B} = f^F[(1+\tau^B)i^* + \varepsilon - i^R], \tag{22}$$

where $\tau^B \in (0,1)$ is the capital controls levy and $f^{F\prime} < 0$. Thus, as in Agénor and Jia (2020), for instance, bank foreign borrowing is subject to a tax that increases proportionally its direct cost.[20]

The demand function for central bank bonds is given by

$$\frac{B^{CB}}{L_0^I} = f^B(i^{CB} - i^R), \tag{23}$$

where $f^{B\prime} > 0$. Thus, the demand for central bank bonds is positively related to the differential between the return on these bonds and the marginal cost of domestic borrowing, that is, the refinance rate. A portfolio equation essentially similar to (23) is derived in Agénor et al. (2020), under economies of scope in banking and a premium that depends on how much banks borrow on world capital markets.[21]

Given the commercial banks' interest rate-setting behavior, bank loans are determined by firms' demand for credit whereas the supply of deposits is determined by households. Borrowing from the central bank is thus determined residually from the balance sheet constraint (17).

2.4 Central Bank and Regulator

The central bank provides liquidity to commercial banks through a standing facility; its supply of funds is perfectly elastic at the prevailing refinance rate, i^R. It also operates

[20] This specification is consistent with the "macroprudential levy" implemented, for instance, in August 2011 by the Bank of Korea—albeit without the maturity dimension—in an attempt to dampen the growth in banks' foreign-currency liabilities. See Bruno and Shin (2014) for a discussion.

[21] By substituting (20) in (23), the demand function for central bank bonds can be related directly to the loan rate, as in Agénor et al. (2020). Note also that in (23), as in (20), the stock of loans is measured at the beginning of period. The same assumption is made in (22) with respect to central bank borrowing.

a managed float regime and sells its own bonds to banks, to sterilize its intervention operations.[22]

The central bank's balance sheet consists, on the asset side, of loans to commercial banks, L^B, and foreign reserves, denoted R^* in foreign-currency terms. On the liability side, it consists of the monetary base, given by the sum of currency in circulation, M, required reserves, and bonds issued through sterilization operations:

$$E_0R^* + L^B = M + RR + B^{CB}, \tag{24}$$

where it is assumed—in line with the evidence on common practice by central banks—that capital gains or losses on foreign exchange reserves arising from fluctuations in the market exchange rate relative to its beginning-of-period period's value, $(E - E_0)R^*$, are an off-balance sheet item.

Foreign reserves are adjusted through the rule

$$R^* - R_0^* = -\varphi^E(\frac{E - E_0}{E_0}), \tag{25}$$

where $\varphi^E > 0$ measures the degree of intervention.

The spot intervention rule (25) captures a *leaning against the wind* objective. It is consistent with the evidence (alluded to earlier) which suggests that middle-income countries tend to intervene frequently, and systematically, in the foreign exchange market to stabilize currency fluctuations—even under an inflation targeting regime. A nominal depreciation, for instance, induces the central bank to sell foreign exchange to strengthen the domestic currency. As a result, its stock of reserves falls. When $\varphi^E = 0$ the exchange rate is fully flexible (with official reserves constant at R_0^*), whereas when $\varphi^E \to \infty$ the exchange rate is fixed at E_0.

To sterilize the effects of foreign exchange operations on the money supply, the central bank also adjusts its stock of bonds in line with changes in its foreign reserves:

$$B^{CB} - B_0^{CB} = \varphi^S E_0(R^* - R_0^*), \tag{26}$$

where B_0^{CB} is the beginning-of-period value of B^{CB} and $\varphi^S \in (0, 1)$ measures the degree of sterilization.[23] Substituting (25) in (26) therefore yields

$$B^{CB} - B_0^{CB} = -\varphi^S\varphi^E(E - E_0). \tag{27}$$

[22] The assumption that sterilization bonds are held only by commercial banks, rather than only households (as in Prasad (2018) or Alla et al. (2020), for instance) helps to sharpen our focus on the bank portfolio channel associated with sterilized intervention.

[23] Unsterilized intervention corresponds therefore to $\varphi^S = 0$, in which case $B^{CB} = B_0^{CB}$.

Further, substituting (27) in (24) gives the change in the money supply as

$$M - M_0 = -(1 - \varphi^S)\varphi^E(E - E_0) + (L^B - L_0^B) - (RR - RR_0). \tag{28}$$

Thus, if the exchange rate is fully flexible ($\varphi^E = 0$), or if full sterilization prevails ($\varphi^S = 1$), exchange rate fluctuations have no effect on domestic liquidity. If intervention is unsterilized, $\varphi^E > 0$ and $\varphi^S = 0$, which implies from (26) that $B^{CB} = B_0^{CB}$ and from (28) that changes in official reserves fully affect money supply.

For its part, the financial regulator sets the required reserve ratio, μ, the macro-prudential tax, τ^L, and the capital controls levy on bank foreign borrowing, τ^B.

2.5 Prices and the Real Exchange Rate

As noted earlier, households consume both domestic and imported goods. Let $\delta \in (0, 1)$ denote the share of household spending on imported goods (with $1 - \delta$ representing therefore the share of spending on domestic goods), assumed constant for the moment, and suppose that the foreign-currency price of imported goods, which is exogenous, is normalized to unity. The cost-of-living index can thus be defined as

$$P = (P^D)^{1-\delta}E^{\delta}. \tag{29}$$

The real exchange rate is the ratio of the domestic-currency price of imports to the price of the domestic good:

$$z = \frac{E}{P^D}. \tag{30}$$

2.6 Market-Clearing Conditions

There are eight equilibrium conditions to consider: six for financial markets (cash, domestic deposits, loans to firms, central bank loans to commercial banks, foreign exchange, and central bank bonds), one for the housing market, and one for the goods market.

At the prevailing deposit, loan, and refinance rates, the markets for domestic deposits, investment loans, and central bank liquidity adjust through quantities. The equilibrium condition of the market for central bank bonds requires equating (23) and (26), so that

$$L_0^I f^B(i^{CB} - i^R) = B_0^{CB} + \varphi^S E_0(R^* - R_0^*).$$

Substituting the intervention rule (25) for the change in reserves in this expression yields

$$f^B(i^{CB} - i^R) = \frac{B_0^{CB}}{L_0^I} - \frac{\varphi^S \varphi^E}{L_0^I}(E - E_0). \tag{31}$$

This equation can be solved for the equilibrium value of the interest rate on central bank bonds, i^{CB}, as a function of the refinance rate and the nominal exchange rate.

The equilibrium condition of the goods market requires equality between the supply of domestic goods to the domestic market and aggregate demand:

$$Y^s - X(z) = (1 - \delta)C + I + G, \tag{32}$$

where G denotes government spending, $X(z)$ exports, both measured in terms of the price of the domestic good, and $(1 - \delta)C$ is consumption spending on domestic goods. Exports are positively related to the real exchange rate, so that $X' > 0$. In what follows, the term $(1 - \delta)C + I + G$ will be referred to as domestic absorption.

The equilibrium condition of the market for foreign exchange, or equivalently the balance of payments, is given by

$$E^{-1}P^D[X(z) - \delta C] + i^*(D_0^* + R_0^* - L_0^*) \tag{33}$$

$$+(L^* - L_0^*) - (D^* - D_0^*) - (R^* - R_0^*) = 0,$$

where δC represents real imports in domestic-currency terms. This condition indicates that the change in the economy's net foreign assets, $D^* + R^* - L^* - (D_0^* + R_0^* - L_0^*)$, is positive if the current account, given by the sum of the trade balance, $E^{-1}P^D[X(z) - \delta C]$, and the services account, $i^*(D_0^* + R_0^* - L_0^*)$, is in surplus.

Given that from (30) $E/P^D = z$, condition (33) can also be written as

$$z^{-1}[X(z) - \delta C] + (1 + i^*)F_0^* - F^* = 0, \tag{34}$$

where $F^* = D^* + R^* - L^*$ is the economy's net stock of foreign assets. Importantly, regardless of whether the central bank intervenes or not, the nominal exchange rate adjusts instantaneously—it can always jump to ensure that the foreign exchange market is in equilibrium, as captured in compact form in (34).

As noted earlier, the supply of land is fixed at $\bar{h}$. The equilibrium condition of the land market is therefore given by

$$\frac{H}{P^D} = \frac{P^H \bar{h}}{P^D},$$

which, using (15) and setting $\bar{h} = 1$, can be solved for the real price of land, p^H:

$$p^H = \frac{P^H}{P^D} = h(i^D - \pi^e, i^* + \varepsilon - \pi^e, \pi^{H,e}, Y^s),$$

that is, using (5) and (19) to substitute out for Y^s and i^D,

$$p^H = p^H(P^D; i^R, \mu, i^* + \varepsilon), \tag{35}$$

where

$$p^H_{P^D} = h_{Y^s} Y^s_{P^D} > 0,$$

$$p^H_{i^R} = (1 - \mu) h_{i^D - \pi^e} + h_{Y^s} Y^s_{i^R} < 0,$$

$$p^H_{\mu} = -i^R h_{i^D - \pi^e} > 0,$$

$$p^H_{i^* + \varepsilon} = h_{i^* + \varepsilon} < 0.$$

An increase in domestic prices, by reducing wages and stimulating output, raises income and the demand for, as well as the real price of, land. An increase in the refinance rate, by lowering output (through the cost channel) and raising the return on domestic deposits, reraises the demand for land as well as its priceduces land prices. An increase in the required reserve ratio, by reducing the return on domestic deposits, . A higher rate of return on foreign deposits also lowers the demand for land as well as its price.

The last equilibrium condition relates to the market for cash, and involves (12) and (24). But by Walras law that condition can be eliminated.[24]

Table 1 summarizes the list of variables and their definitions.

3 Macroeconomic Equilibrium

To establish macroeconomic equilibrium requires combining and condensing the market equilibrium conditions described earlier to bring them down, in a first stage, to four of them, pertaining to the land market, the investment loan (or financial) market, the goods market, and the foreign exchange market. In doing so, the expected rates of

[24]See Agénor (2020, chapter 2). Because household consumption depends on beginning-of-period nominal cash balances, changes in that variable (as shown later on) have no direct bearing on macroeconomic equilibrium.

inflation and depreciation, π^e, $\pi^{H,e}$, and ε, are all assumed constant and normalized to zero.[25]

First, consider the financial market equilibrium condition. Rather than solving for the equilibrium value of the central bank bond rate, i^{CB}, using (31), it can be noted that, by substituting (23) for B^{CB}/L_0^I in (20), the third term in the latter expression becomes $-\varkappa f^B(i^{CB} - i^R)$; ; this implies therefore an inverse relationship between the loan rate and the central bank bond rate. Further, using (31) to substitute out for $f^B(i^{CB} - i^R)$, gives the loan rate as

$$i^L = i^R + \theta - \varkappa(\frac{B_0^{CB}}{L_0^I}) + \varkappa\frac{\varphi^S\varphi^E}{L_0^I}(E - E_0) + \gamma\tau^L. \tag{36}$$

Because holdings of central bank bonds generate economies of scope, and these bonds are issued to sterilize intervention operations, the nominal exchange rate affects positively the loan rate. Put differently, sterilized intervention, in the presence of economies of scope, creates a direct channel through which exchange rate fluctuations may affect credit market conditions. This channel disappears if the central bank does not intervene ($\varphi^E = 0$), if intervention is not sterilized ($\varphi^S = 0$), or if there are no economies of scope in managing bank assets ($\varkappa = 0$).

Next, let us combine the land and credit market equilibrium conditions. Noting that $E = zP^D$ from (30) while $P^H = P^D p^H$, and substituting (35) in (21) and the result in (36) for θ, yields

$$i^L = i^R + \theta[\frac{\kappa P^D p^H(P^D; i^R, \mu, i^* + \varepsilon)}{L_0^I}] - \varkappa(\frac{B_0^{CB}}{L_0^I}) + \varkappa\frac{\varphi^S\varphi^E}{L_0^I}(zP^D - E_0) + \gamma\tau^L,$$

that is,

$$i^L = FF(P^D, z; i^R, \mu, \tau^L, i^*), \tag{37}$$

where

$$FF_{P^D} = \theta'(p^H + P^D p^H_{P^D})(\frac{\kappa}{L_0^I}) + \frac{\varkappa\varphi^S\varphi^E z}{L_0^I},$$

$$FF_z = \frac{\varkappa\varphi^S\varphi^E P^D}{L_0^I} > 0,$$

$$FF_{i^R} = 1 + \theta' P^D p^H_{i^R}(\frac{\kappa}{L_0^I}) > 0,$$

$$FF_\mu = \theta' P^D p^H_\mu(\frac{\kappa}{L_0^I}) < 0,$$

[25] The case of an endogenous expected depreciation rate is considered later.

$$FF_{\tau^L} = \gamma > 0,$$

$$FF_{i^*} = \theta' P^D p^H_{i^*+\varepsilon}(\frac{\kappa}{L_0^I}) > 0.$$

Equation (37) defines the *financial sector equilibrium* condition, which also implicitly account for the equilibrium of the housing market.

An increase in the price of domestic goods, P^D, has in general an ambiguous effect on the loan rate. On the one hand, an increase in domestic good prices (which lowers real wages and stimulates activity) raises the demand for, and the price of, land. This, in turn, raises the value of firms' collateralizable assets relative to their outstanding stock of investment loans. Banks therefore demand a lower premium and reduce the loan rate. This channel is the key source of the *financial accelerator effect*, as discussed in more detail later. On the other, holding the real exchange rate constant, an increase in the price of the domestic good is associated with a nominal depreciation, which induces the central bank to sell reserves and reduce the stock of bonds that it issues to sterilize its intervention operations. At the initial level of investment loans, this tends to increase banks' operational costs and to raise the loan rate. If economies of scope, as measured by $\varkappa$, the degree of intervention, as captured by φ^E, or the degree of sterilization, as measured by φ^S, are relatively small, or if $|\theta'|$ is sufficiently large, the first effect dominates and $FF_{P^D} < 0$. Otherwise, $FF_{P^D} \gtrless 0$. Put differently, the sign of FF_{P^D} captures a key difference between fully flexible exchange rates and a managed float regime (the existence of an exchange rate channel), as well as, in the latter case, a difference in the strength of financial frictions.

A depreciation of the real exchange rate, z, holding domestic prices constant, corresponds to a nominal depreciation and also affects positively the equilibrium loan rate because intervention involves a sale of foreign reserves and a reduction in the stock of central bank bonds held by commercial banks; thus, economies of scope operate in reverse, and $FF_z > 0$. The strength of this effect depends again on $\varkappa$, φ^E, and φ^S, but not on the strength of the financial accelerator effect, as measured by $|\theta'|$. In addition, $FF_z = 0$ if, as noted earlier, there is no intervention ($\varphi^E = 0$), intervention is not sterilized ($\kappa^S = 0$), or economies of scope are absent ($\varkappa = 0$).

An increase in the refinance rate, i^R, or the macroprudential tax rate, τ^L, translate directly into a higher loan rate. In addition, a higher refinance rate also has an indirect effect: by raising the deposit rate it lowers the demand for land, which puts downward pressure on house prices. As a result, the value of collateral falls, and the premium increases. Both effects therefore operate in the same direction, so that $FF_{i^R}, FF_{\tau^L} > 0$.

An increase in the required reserve ratio, μ, lowers the deposit rate, which tends to increase the demand for, and the price of, land. The resulting increase in collateral values tends to lower the premium and the loan rate ($FF_\mu < 0$).[26] Finally, an increase in the world interest rate lowers the demand for, and the price of, land, thereby raising the premium and the loan rate ($FF_{i^*} > 0$).

Consider now the equilibrium condition of the domestic goods market. Substituting the supply equation (5) and the investment function (6), together with the consumption function (16), after incorporating (8) and (14) for real wealth, as well as (19) for the domestic deposit rate, in condition (32), together with the equilibrium condition of the housing market (35) for the real price of land, and (30) for the nominal exchange rate, gives

$$Y^s(P^D; i^R) = (1-\delta)\left\{c_1 Y^s(P^D; i^R) - c_2[(1-\mu)i^R + i^*]\right. \tag{38}$$

$$\left.+c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D} + p^H(P^D; i^R, \mu, i^*)]\right\} + I(i^L) + G + X(z).$$

Finally, consider the equilibrium condition of the market for foreign exchange. Using again the consumption function (16), and (19) to substitute out for the deposit rate, together with the equilibrium condition of the market for land (35), equation (34) can be written as

$$z^{-1}X(z) - z^{-1}\delta\left\{c_1 Y^s(P^D; i^R) - c_2[(1-\mu)i^R + i^*]\right. \tag{39}$$

$$\left.+c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D} + p^H(P^D; i^R, \mu, i^*)]\right\} + (1+i^*)F_0^* - F^* = 0.$$

The upshot is that, after substituting out for the equilibrium price of land, p^H, there are three key endogenous variables in the model: the banks' (investment) lending rate, i^L, the price of domestic goods, P^D, and the real exchange rate, z. In effect, given that $z = E/P^D$, the solutions for z and P^D give implicitly the solution for the *nominal* exchange rate.

The equilibrium values of these three variables can be derived by solving jointly equations (37), (38), and (39). However, working with three variables makes it impossible to use simple, two-dimensional diagrams to characterize the equilibrium and

[26]Because the reduction in the loan rate stimulates investment, through this channel an increase in the required reserve ratio is expansionary. This issue is discussed further later on.

conduct policy analysis. Fortunately, a judicious substitution helps to bring the model down to two equilibrium conditions. Indeed, the financial equilibrium condition (37) can be substituted in the goods market equilibrium condition (38) for i^L, the loan rate. At the same time, the equilibrium condition of the balance of payments, (39), relates the real exchange rate, z, only to the price of domestic goods, P^D; it does not depend directly on the loan rate, i^L. Thus, after substituting for the loan rate in (38) using (37), the model collapses to two equations—an *internal balance condition*, which describes equilibrium in domestic real and financial markets, and an *external balance condition*, which describes balance-of-payments equilibrium. These two conditions can be solved, analytically and graphically, for the remaining two variables, z and P^D.

3.1 Internal balance

Substituting the financial market-land market equilibrium condition (37) in (38) yields

$$Y^s(P^D; i^R) = (1-\delta)\left\{c_1 Y^s(P^D; i^R) - c_2[(1-\mu)i^R + i^*]\right. \tag{40}$$

$$\left.+c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D} + p^H(P^D; i^R, \mu, i^*)]\right\} + I[FF(P^D, z; i^R, \mu, \tau^L, i^*)] + G + X(z).$$

As shown in the Appendix, this equation can be solved to give

$$z = FG(P^D; G, i^R, \mu, \tau^L, i^*), \tag{41}$$

where, noting that $F_0^H - E_0 D_0^* = M_0 + D_0$,

$$FG_{P^D} = \frac{1}{\Delta}\left\{[1-(1-\delta)c_1]Y^s_{P^D} + \frac{(1-\delta)c_3}{(P^D)^2}(M_0 + D_0) - (1-\delta)c_3 p^H_{P^D} - I'FF_{P^D}\right\},$$

$$FG_G = -\frac{1}{\Delta},$$

$$FG_{i^R} = \frac{1}{\Delta}\left\{[1-(1-\delta)c_1]Y^s_{i^R} + (1-\delta)c_2(1-\mu) - (1-\delta)c_3 p^H_{i^R} - I'FF_{i^R}\right\},$$

$$FG_\mu = \frac{1}{\Delta}[-(1-\delta)c_2 i^R - (1-\delta)c_3 p^H_\mu - I'FF_\mu],$$

$$FG_{\tau^L} = -\frac{I'FF_{\tau^L}}{\Delta},$$

$$FG_{i^*} = \frac{1}{\Delta}[(1-\delta)c_2 - (1-\delta)c_3 p^H_{i^*} - I'FF_{i^*}],$$

$$\Delta = (1-\delta)c_3 D_0^* + I'FF_z + X'.$$

Equation (41) is the *internal balance condition*, which combines the equilibrium conditions of the real (goods and land) markets and the financial (credit and deposit) markets as a relationship between the real exchange rate and the price of domestic goods.

Consider first the term Δ, which measures the total effect of a real depreciation on excess demand for domestic goods. It is the sum of a wealth effect on consumption, $(1-\delta)c_3D_0^*$, a financial sector effect, $I'FF_z$, related to the impact of sterilized intervention, and a competitiveness (or relative price) effect on exports, X'. In particular, the wealth effect arises from the fact that, holding the price of domestic goods constant, a real exchange rate depreciation is equivalent to a *nominal* depreciation. This creates a capital gain on foreign-currency deposits, which induces households to increase spending. While the first and third effects are positive, the second is negative. It will be assumed in what follows that $\Delta > 0$. Thus, a real exchange-rate depreciation, all else equal, raises (lowers) excess demand for (supply of) domestic goods.

An increase in the price of domestic goods, P^D, holding the real exchange rate constant, has an ambiguous effect on excess demand for these goods. The first term, $[1-(1-\delta)c_1]Y^s_{P^D}$, captures a *net supply effect*, which is given by the difference between the increase in the production of domestic goods (through a lower real wage), as measured by $Y^s_{P^D}$, and the increase in consumption of these goods (through higher income), as measured by $(1-\delta)c_1Y^s_{P^D}$. Because $(1-\delta)c_1 \in (0,1)$, this effect is positive and tends therefore to *increase* excess supply. The second and third terms, $(1-\delta)c_3(M_0+D_0)/(P^D)^2$ and $-(1-\delta)c_3p^H_{P^D}$, capture a wealth effect on consumption, the first operating through real money balances and the second through real house prices. These effects operate in opposite directions: higher domestic prices reduce real money balances, thereby lowering consumption and increasing excess supply; at the same time, they increase real house prices, which has the opposite effect on consumption and excess supply. It will be assumed in what follows that $p^H_{P^D}$ (or, more specifically, h_{Y^s} in (35)) is small enough to ensure that the net wealth effect is negative. It therefore also contributes to a reduction in aggregate demand and an *increase* in excess supply on the home market for domestically-produced goods.

The fourth term, $-I'FF_{P^D}$, is related to the strength of the financial accelerator effect. Recall that $I' < 0$ and $FF_{P^D} \gtreqless 0$; the sign of this term is thus ambiguous. If, as noted earlier, $|\theta'|$ is sufficiently large—or either $\varkappa$, φ^E, or φ^S, is relatively small—to ensure that $FF_{P^D} < 0$, this term is negative: an increase in domestic prices raises land prices and firms' collateralizable net worth, thus lowering the loan rate and stimulating investment. This, in turn, tends to *reduce* excess supply of domestic goods. Thus, there are two possible cases to consider: first, the case where the strength of the financial accelerator effect is such that it mitigates, but does not reverse, the increase in excess supply of goods associated with the net supply effect and the wealth effects discussed earlier, so that (given that $\Delta > 0$) $FG_{P^D} > 0$, regardless of the sign of FF_{P^D};[27] second, the case where the strength of this effect (again, as measured by $|\theta'|$) is strong enough, to ensure not only that $FF_{P^D} < 0$ but also $FG_{P^D} < 0$.

An increase in government spending, G, raises demand for domestic goods. Holding domestic prices constant, the real (and thus nominal) exchange rate must appreciate to reduce exports and increase sales of the domestic good on the home market. Thus, $FG_G < 0$.

An increase in the refinance rate, i^R, has, in general, an ambiguous effect on the real exchange rate. The reason essentially is that a higher refinance rate leads to a contraction in both aggregate supply (through the cost channel, captured by $Y^s_{i^R} < 0$) and aggregate demand—through the intertemporal effect, the wealth effect operating via house prices on consumption, as well as the direct and indirect effects (the latter through house prices again, but this time because of changes in collateral values) on the loan rate and investment. These last three effects are captured by the terms $(1-\delta)c_2(1-\mu)$, $-(1-\delta)c_3 p^H_{i^R}$, and $-I'FF_{i^R}$, respectively.[28] In what follows, we will first consider the case where the share of wage costs financed by bank borrowing, ψ_W, is relatively low, to ensure that the demand-side effect of an increase in the refinance rate dominates the supply-side effect. Thus, an increase in the policy rate creates excess supply on the domestic goods market. To restore equilibrium, holding the price of domestic goods constant, the real (and thus nominal) exchange rate must depreciate to stimulate exports, reduce domestic sales, and increase aggregate demand through a positive wealth effect on consumption. Thus, $FG_{i^R} > 0$. Alternatively, we will also

[27] When $\varkappa$, φ^E, and φ^S are all positive, a weak financial accelerator effect may also ensure that in (37) $FF_{P^D} > 0$, in which case the condition $FG_{P^D} > 0$ always holds.

[28] The income effect on aggregate demand is captured in the net supply effect, $[1-(1-\delta)c_1]Y^s_{i^R}$, which is unambiguously negative.

consider the case where the cost channel is strong—that is, ψ_W, and thus $\left|Y^s_{i^R}\right|$, is sufficiently large, given c_2 and c_3—to ensure that $FG_{i^R} < 0$.[29]

An increase in the required reserve ratio, μ, holding domestic prices constant, has three effects on the equilibrium real exchange rate. First, it lowers the deposit rate and mitigates, through the intertemporal substitution effect, incentives to save; current consumption increases. Second, the reduction in the deposit rate raises demand for, and the price of, land, which exerts a positive wealth effect on consumption. Third, the increase in house prices raises collateral values and induces an expansion in investment, by reducing the premium and the loan rate. All three effects operate in the same direction—they create excess demand at the initial level of domestic prices. To restore equilibrium, the real (and nominal) exchange rate must appreciate to mitigate the increase in household expenditure and raise sales of the domestic good on the home market by reducing exports; thus, $FG_\mu < 0$.

An increase in the macroprudential tax rate, τ^L, raises the loan rate and lowers investment, thereby creating excess supply at initial prices. All else equal, the real (and, again, nominal) exchange rate must therefore depreciate to reduce excess supply—by stimulating consumption, through a wealth effect, and by expanding exports, through a reduction in domestic sales; thus, $FG_{\tau^L} > 0$.

Finally, an increase in the world interest rate, i^*, affects othe real exchange rate through three channels: it lowers consumption, through intertemporal and wealth effects (the latter due to its negative impact on the demand for land and house prices), as well as investment, through a collateral effect (due to lower house prices and an increase in the premium). All these effects combine to generate excess supply of goods at the initial level of prices, thereby requiring a depreciation to reduce home sales of domestic goods, by raising exports; thus, $FG_{i^*} > 0$.

3.2 External balance

The external balance curve is derived in three steps: a) solution of the demand for foreign deposits, D^*; b) solution of the economy's net foreign assets, F^*; and c) solution of the market for foreign exchange.

[29] Note that, if there is no intertemporal substitution effect ($\alpha_2 = 0$), it would still be the case that $FG_{i^R} > 0$ if financial frictions are weak, through the effect of the refinance rate on the real price of land (that is, $p^H_{i^R}$).

First, using (8), the demand function for foreign deposits, equation (13), can be written as

$$D^* = \frac{d^*(i^D; i^*)}{E}[F_0^H + (E - E_0)D_0^*],$$

where, as shown earlier, $d^*_{i^D} < 0$ and $d^*_{i^*} > 0$. Given that, from (30), $E = zP^D$, and noting again that $F_0^H - E_0 D_0^* = M_0 + D_0$, the above expression can be written as

$$D^* = \frac{d^*(i^D; i^*)}{zP^D}(M_0 + D_0 + zP^D D_0^*). \tag{42}$$

As shown in the Appendix, in functional form this relationship can be written as

$$D^* = D^*(z, P^D; i^R, \mu, i^*), \tag{43}$$

where

$$D^*_z = \frac{-(M_0 + D_0)d^*}{P^D z^2} < 0,$$

$$D^*_{P^D} = \frac{-(M_0 + D_0)d^*}{z(P^D)^2} < 0,$$

$$D^*_{i^R} = \frac{(M_0 + D_0 + zP^D D_0^*)}{zP^D} d^*_{i^D}(1 - \mu) < 0,$$

$$D^*_\mu = -\frac{(M_0 + D_0 + zP^D D_0^*)}{zP^D} d^*_{i^D} i^R > 0,$$

$$D^*_{i^*} = \frac{(M_0 + D_0 + zP^D D_0^*)}{zP^D} d^*_{i^*} > 0.$$

A depreciation of the nominal exchange rate (an increase in E), associated with either a real depreciation (holding P^D constant) or an increase in domestic prices (holding z constant) leads to a fall in holdings of foreign deposits, measured in foreign-currency terms. A higher refinance (or domestic deposit) rate has a similar effect. By contrast, an increase in the required reserve ratio, μ, which lowers the return on domestic deposits, or an increase in the world interest rate, raises demand for foreign deposits.

Second, using (22), (25), (30), and (43), net foreign assets, $F^* = D^* + R^* - L^*$, can be written as

$$F^* = D^*(z, P^D; i^R, \mu, i^*) + R_0^* - \varphi^E(\frac{zP^D - E_0}{E_0}) - \frac{L_0^B}{zP^D} f^F[(1 + \tau^B)i^* - i^R],$$

so that

$$F^* = F^*(z, P^D; i^R, \mu, \tau^B, i^*), \tag{44}$$

where, recalling from (22) that $f^{F\prime} < 0$,

$$F_z^* = D_z^* - \varphi^E \frac{P^D}{E_0} + \frac{L_0^B}{P^D z^2} f^F,$$

$$F_{P^D}^* = D_{P^D}^* - \varphi^E \frac{z}{E_0} + \frac{L_0^B}{z(P^D)^2} f^F,$$

$$F_{i^R}^* = D_{i^R}^* + \frac{L_0^B}{zP^D} f^{F\prime} < 0,$$

$$F_\mu^* = D_\mu^* > 0,$$

$$F_{\tau^B}^* = -\frac{L_0^B}{zP^D} f^{F\prime} i^* > 0,$$

$$F_{i^*}^* = D_{i^*}^* - \frac{L_0^B}{zP^D} f^{F\prime} \tau^B > 0.$$

A real depreciation—or equivalently, at the initial level of domestic prices, a nominal depreciation—has an ambiguous effect on the economy's net foreign assets. On the one hand, it lowers the foreign-currency value of deposits held abroad and leads to a drop in official reserves due to intervention; on the other, it lowers the foreign-currency value of commercial banks' foreign liabilities. Assuming that the first two effects dominate implies that $F_z^* < 0$. An increase in domestic prices, holding the real exchange rate constant, generates similar effects; assuming, again, a weak valuation effect implies that $F_{P^D}^* < 0$. A higher refinance rate lowers holdings of foreign deposits (by raising the return on domestic assets) and induces banks to borrow more abroad; as a result, net foreign assets fall ($F_{i^R}^* < 0$). A higher required reserve ratio has the opposite effect—it lowers the domestic deposit rate and raises foreign deposits and net foreign assets ($F_\mu^* > 0$). A higher capital controls levy, or an increase in the world interest rate, which both make borrowing abroad more expensive for commercial banks, raise net foreign assets ($F_{\tau^B}^*$, $F_{i^*}^* > 0$).

Third, substituting (44) in the equilibrium condition of the market for foreign exchange, (39), yields

$$z^{-1}X(z) - z^{-1}\delta \left\{ c_1 Y^s(P^D; i^R) - c_2[(1-\mu)i^R + i^*] + c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D} \right. \tag{45}$$

$$\left. + p^H(P^D; i^R, \mu, i^*)] \right\} + (1+i^*)F_0^* - F^*(z, P^D; i^R, \mu, \tau^B, i^*) = 0.$$

As shown in the Appendix, this condition can be solved to give

$$z = XX(P^D; G, i^R, \mu, \tau^L, \tau^B, i^*), \tag{46}$$

where, noting again that $F_0^H - E_0 D_0^* = M_0 + D_0$,

$$XX_{P^D} = \Omega^{-1}\left\{z^{-1}\delta c_1 Y^s_{P^D} - \frac{z^{-1}\delta c_3}{(P^D)^2}(M_0 + D_0) + z^{-1}\delta c_3 p^H_{P^D} + F^*_{P^D}\right\},$$

$$XX_G = 0,$$

$$XX_{i^R} = \Omega^{-1}\left\{z^{-1}\delta[c_1 Y^s_{i^R} - c_2(1-\mu)] + z^{-1}\delta c_3 p^H_{i^R} + F^*_{i^R}\right\},$$

$$XX_\mu = \Omega^{-1}(z^{-1}\delta c_2 i^R + z^{-1}\delta c_3 p^H_\mu + F^*_\mu),$$

$$XX_{\tau^L} = 0,$$

$$XX_{\tau^B} = \Omega^{-1}F^*_{\tau^B},$$

$$XX_{i^*} = \Omega^{-1}(-z^{-1}\delta c_2 + z^{-1}\delta c_3 p^H_{i^*} - F_0^* + F^*_{i^*}),$$

$$\Omega = z^{-1}(X' - \frac{X - \delta C}{z}) - z^{-1}\delta c_3 D_0^* - F_z^*.$$

Equation (46) represents the *external balance condition*, which relates again the real exchange rate and the price of domestic goods.

Consider first Ω, which measures the total effect of a change in the real exchange rate on the balance of payments. This expression consists of four terms. The first term, $z^{-1}X' - z^{-2}(X - \delta C)$, where $X - \delta C$ is the initial trade balance in domestic-currency terms, captures an expenditure-switching effect (a shift in exports) and a valuation effect on trade flows. The conventional positive sign is assumed here, so that $z^{-1}X' - z^{-2}(X - \delta C) > 0$. In turn, for this condition to hold, the initial trade surplus cannot be too large ($X - \delta C < zX'$) or, equivalently, the sensitivity of exports to the real exchange rate, X', must be sufficiently high. Thus, a depreciation improves the trade balance.[30] The second term, $-z^{-1}\delta c_3 D_0^*$, captures an expenditure-increasing effect, which results from a positive wealth effect associated with a depreciation-induced capital gain on foreign deposits. The resulting increase in consumption translates into a rise in imports, which causes the trade balance to deteriorate. The third term, $-F_z^*$, is positive (given that $F_z^* < 0$, as shown earlier) and arises from the combination of valuation and intervention effects associated with an exchange rate change. In what

[30] The standard Marshall-Lerner condition states that (assuming exports equal imports initially) for the trade balance to improve following a depreciation, the absolute sum of the elasticities of export supply and import demand must exceed unity. Here, with δ constant, and for a given level of total consumption, the price elasticity of import demand is zero. Thus, if trade is in equilibrium initially ($X = \delta C$), the condition for the trade balance to improve is simply $X' > 0$, which always holds. The case where δ depends on relative prices is discussed later.

follows, it will be assumed that trade is initially balanced ($X - \delta C = 0$), and that the combination of the expenditure-switching and valuation-intervention effects (given by $z^{-1}X' - F_z^*$) is large enough to dominate the expenditure-reducing effect (given by $-z^{-1}\delta c_3 D_0^*$) and ensure that $\Omega > 0$.

An increase in the price of domestic goods, P^D, exerts four types of effects on the balance of payments and the real exchange rate. The first term in brackets in that expression, $z^{-1}\delta c_1 Y_{PD}^s$, captures the positive effect of income on consumption and imports, which translates into a deterioration of the trade balance and the balance of payments. The second and third terms, $-z^{-1}\delta c_3(P^D)^{-2}(M_0 + D_0)$ and $z^{-1}\delta c_3 p_{PD}^H$, capture the expenditure-reducing effect of an increase in the price of domestic goods operating—directly and indirectly, in the latter case through house prices—through a negative net wealth effect, on the trade balance. These effects are the same as those described in the derivation of the FG curve. The reduction in consumption spending implies a contraction in imports, which therefore improves the balance of payments. The last term, F_{PD}^*, is also similar to that discussed earlier in deriving the effects of a real exchange rate depreciation. This time, an increase in P^D, holding z constant, implies a concomitant nominal depreciation and a *reduction* in the economy's net foreign assets ($F_{PD}^* < 0$). Assuming that the net wealth effect on consumption and imports dominates the income and valuation effects implies that an increase in the price of domestic goods, holding the real exchange rate constant, improves the balance of payments. The real exchange rate must therefore appreciate (to reduce exports, in particular) to maintain equilibrium. Thus, $XX_{PD} < 0$.

An increase in government spending, G, has no effect on the balance of payments—and neither does the macroprudential tax rate, τ^L, which operates only through the loan rate and investment ($XX_G = XX_{\tau^L} = 0$).

An increase in the refinance rate, i^R, has four effects on the balance of payments. First, it lowers output and income, as measured by $z^{-1}\delta c_1 Y_{iR}^s$; this tends to reduce total consumption and imports. Second, it raises the domestic deposit rate, as measured by $-z^{-1}\delta c_2(1 - \mu)$, thereby lowering expenditure across the board (on both domestic and imported goods) as a result of intertemporal substitution. Third, again through its effect on the domestic deposit rate, it reduces the demand for land and lowers their price, which generates a negative wealth effect, measured by $z^{-1}\delta c_3 p_{iR}^H$. Fourth, by raising the deposit rate, it also makes domestic-currency deposits more attractive and reduces capital outflows, as measured by $F^*_{i^R}$. All these effects operate in the same direction—they contribute to an improvement in the balance of payments. Consequently, the real exchange rate must appreciate to maintain equilibrium ($XX_{i^R} < 0$).

An increase in the required reserve ratio, μ, lowers the domestic deposit rate, which stimulates consumption and imports *both* through the intertemporal substitution effect and a wealth effect (the latter operating through house prices). These effects are captured by the terms $z^{-1}\delta c_2 i^R$ and $z^{-1}\delta c_3 p^H_\mu$, respectively. The reduction in the domestic deposit rate also contributes to an increase in holdings of foreign-currency deposits ($F^*_\mu > 0$). All these effects operate in the same direction: they contribute to a deterioration of the current account and the balance of payments. Thus, the real exchange rate must depreciate to maintain external equilibrium ($XX_\mu > 0$).

An increase in the capital controls levy, τ^B, reduces foreign borrowing by commercial banks. This mitigates capital inflows and, given that $F^*_{\tau^B} > 0$, requires a depreciation of the real exchange rate to maintain external balance. Thus, $XX_{\tau^B} > 0$.

Finally, an increase in the world interest rate, i^*, leads to an improvement in the current account through both the intertemporal and wealth effects (as measured by $-z^{-1}\delta c_2$ and $z^{-1}\delta c_3 p^H_{i^*}$), which combine to lower consumption and imports. There is also a positive effect on interest payments, as measured by $-F^*_0$. Moreover, the capital account deteriorates, as households increase their holdings of foreign deposits; this effect is measured by $F^*_{i^*}$. Thus, two cases may occur: the improvement in the current account dominates and the real exchange rate must appreciate to maintain external equilibrium, so that $XX_{i^*} < 0$; or capital outflows are large enough to ensure that the real exchange rate must depreciate, in which case $XX_{i^*} > 0$. In what follows we will focus on the second scenario, which is consistent with the evidence on the negative correlation between changes in world interest rates, capital flows, and the real exchange rate.[31]

3.3 Graphical Illustration

Figures 1, 2 and 3 present the determination of macroeconomic equilibrium under two alternative assumptions about the slope of the internal balance curve, as discussed ear-

[31] See Agénor et al. (2018) and the references therein.

lier: the case where the financial accelerator effect is relatively weak, so that $FG_{P^D} > 0$, and the case where this effect is strong enough to ensure not only that $FF_{P^D} < 0$ but also $FG_{P^D} < 0$. By contrast, the external balance curve, XX, has a negative slope, given that $XX_{P^D} < 0$. A rise in domestic prices lowers the demand for imports (through a negative net wealth effect on total consumption) and improves the trade balance, requiring therefore a real appreciation to maintain equilibrium.

Consider first the case where $FG_{P^D} > 0$, that is, the case where the financial accelerator effect mitigates, but does not reverse, the increase in excess supply of goods sold on the home market—resulting from the combination of a (positive) net supply effect and a (negative) net wealth effect—induced by higher domestic prices. As noted earlier, the real exchange rate must depreciate to stimulate consumption and exports, and restore equilibrium.[32] Both curves are depicted in Figure 1 and in the northeast quadrant of Figure 2. The difference between the two is the assumption that, in Figure 2, the loan rate does not depend on the real exchange rate (that is, $FF_z = 0$). This occurs, as can be inferred from (37), when either $\varphi^E = 0$ (no intervention), $\kappa^S = 0$ (intervention is not sterilized), or $\varkappa = 0$ (economies of scope are absent). In that case, the financial sector-land market equilibrium condition (37), which relates the loan rate and the price of domestic goods, is shown as curve FF in the southeast quadrant. In addition, the relationship between investment and the loan rate, as given in (6), is displayed in the southwest quadrant, whereas the positive relationship between the real exchange rate and exports, $X(z)$, is displayed in the northwest quadrant. The economy's equilibrium is determined at points E, D, H, and J. Given these solutions, the equilibrium values of other variables, such as the nominal exchange rate (given that $E = zP^D$) and sales of domestic goods on the local market, $Y^s(P^D; i^R) - X(z)$, can be readily derived.

The case where $FG_{P^D} < 0$, that is, the case where the financial accelerator effect is relatively strong, is depicted in Figure 3. Curve FG is now also downward-sloping, just like curve XX. To determine which curve is steeper—a crucial step for understanding the comparative statics properties of the model and the adjustment process to shocks—

[32] Because the financial accelerator weakens the effects of increases in P^D on excess demand for domestic goods, the internal balance locus is flatter than it would otherwise be—that is, a larger increase in domestic prices is required to restore internal balance after a real depreciation, than would be required if the financial accelerator effect was absent ($FF_{P^D} = 0$).

Samuelson's correspondence principle, which essentially involves analyzing the local stability of the dynamic system associated with (41) and (46), can be used.[33] As shown in the Appendix, stability implies that XX be steeper than FG, as displayed in the figure.[34]

In what follows, it will be assumed that, in response to shocks, the (nominal) exchange rate—regardless of whether the central bank intervenes or not—adjusts instantaneously to maintain external balance, whereas domestic prices adjust only gradually to ensure internal balance.[35] Of course, given the static nature of the model, this gradual adjustment process does not involve explicitly an element of time, as would be the case in a dynamic setting. Nevertheless, as is made clear later on, it helps significantly in explaining in intuitive terms the transmission of policy and exogenous shocks to the economy and the shift between the initial equilibrium and the post-shock equilibrium.

4 Macro-Financial Policy Analysis

The effects of changes in five types of macro-financial policy instruments are considered: fiscal policy (in the form of an increase in government spending), monetary policy (an increase in the refinance rate), macroprudential regulation (a rise in the macroprudential tax rate), discretionary intervention in the foreign exchange market, and capital controls (in the form of an increase in the tax on bank foreign borrowing).[36] As discussed in the introduction, in recent years macroeconomic management in middle-income countries has relied heavily on all of these instruments. In particular, many of these countries have relied on macroprudential regulation as a tool to manage credit and asset price fluctuations driven by large capital inflows and to safeguard financial stability, as documented by Bruno et al. (2017), Ghosh et al. (2017), Aguirre et al. (2018), Aldasoro et al. (2020), Bergant et al. (2020), Frost et al. (2020), International

[33] Samuelson's correspondence principle has been criticized because the dynamic adjustment process can often be specified in several alternative ways. However, in the present case, the adaptive processes that are postulated are both simple and plausible.

[34] In a full diagram, and with $FF_z = 0$, the other quadrants relating i^L and P^D, I and i^L, and X and z, would look exactly the same as in Figure 2.

[35] At the same time, as noted earlier, the loan rate adjusts instantaneously to maintain financial sector equilibrium, whereas the price of land adjusts instantly to ensure equilibrium of the market for land.

[36] The use of reserve requirements as an alternative macroprudential policy tool is also explored later on.

Monetary Fund (2020, chapter 3) and Coman and Lloyd (2022). Aguirre et al. (2018), for instance, found that macroprudential policies—especially those targeted at financial institutions—helped to mitigate the impact of capital inflows in developing economies by dampening fluctuations in credit and leverage. In addition, the evidence suggests that some of these tools may operate through similar channels.[37] Studying analytically their transmission process is thus important to determine the degree to which they are complementary, or substitutes, in responding to particular shocks.

4.1 Fiscal Policy

Consider an increase in government spending, G. The equilibrium response of the real exchange rate and domestic prices can be evaluated by solving the system, from (41) and (46). As shown in the Appendix, with $FG_{P^D} > 0$ the solution is

$$\frac{dz}{dG} = \frac{-\overset{(-)}{FG_G}\overset{(-)}{XX_{P^D}}}{\underset{}{\overset{(?)}{FG_{P^D}}} - \overset{(-)}{XX_{P^D}}} < 0, \quad \frac{dP^D}{dG} = \frac{-\overset{(-)}{FG_G}}{\overset{(?)}{FG_{P^D}} - \overset{(-)}{XX_{P^D}}} > 0. \tag{47}$$

An increase in government spending leads to higher domestic prices and a real appreciation. With $FG_{P^D} < 0$, because the slope of XX is steeper than the slope of FG, we have $-FG_{P^D} < -XX_{P^D}$, or equivalently, $FG_{P^D} - XX_{P^D} > 0$. So results (47) hold in that case as well.

Figure 4 illustrates these effects under both assumptions about the slope of FG. Intuitively, an increase in government spending creates excess demand at the initial levels of domestic prices and production. The real exchange rate (and thus the nominal exchange rate) should therefore appreciate to reduce exports and increase sales on the domestic market, $Y^s - X$, to restore equilibrium. Indeed, as shown in (41), $FG_G < 0$. Thus, while curve XX does not shift (it does not depend directly on government spending), curve FG shifts downward to $F'G'$ in both panels. The real exchange rate should appreciate from E to B to restore internal equilibrium.

However, as noted earlier, the (nominal) exchange rate adjusts instantaneously—whether or not the central bank intervenes—to maintain *external* equilibrium. Thus,

[37] Kim and Mehrotra (2022), for instance, found that the effects of macroprudential policy shocks on output, prices and credit are very similar to those of monetary policy shocks. However, they also argued that there are differences in the transmission mechanism of these shocks: while macroprudential policy shocks mostly affect residential investment and household credit, monetary policy shocks have more widespread effects on the economy.

when the shock occurs, the real exchange rate remains at E. But excess demand leads to higher domestic prices, which (given the assumption that the wealth effect is sufficiently strong) lower consumption and imports. As a result, there is a current account surplus. To maintain external balance, the real exchange rate appreciates from E to E', the new equilibrium point, to reduce exports—regardless of the strength of the financial accelerator effect.[38]

During the transition, the increase in domestic prices stimulates output (by lowering real wages) and raises the price of land, which reduces the premium and therefore the loan rate. Lower borrowing costs stimulate investment. At the new equilibrium, exports are lower, as a result of the real appreciation. The combination of a higher P^D and a more appreciated (lower) z ensures that domestic sales, $Y^s(P^D) - X(z)$, unambiguously increase—and so does domestic absorption, as implied by the goods market equilibrium condition (32). By contrast, the equilibrium effect on private consumption cannot be ascertained a priori; although the increase in income raises household spending, the increase in domestic prices means that real financial wealth falls. As noted earlier, despite the positive effect of higher land prices, the net wealth effect is negative. Thus, the impact on consumption can be either positive or negative, depending on coefficients c_1 and c_3. If private consumption falls, government spending generates a crowding-out effect.

In sum, the equilibrium effects of government spending on prices, the real exchange rate, and the balance of payments are all consistent with textbook open-economy models of the Mundell-Fleming variety.[39] At the same time, what the analysis makes clear is that the effects of fiscal policy depend not only on its direct impact on aggregate demand (in standard Keynesian fashion) but also on its indirect effects operating through the financial system and financial frictions, which affect the pricing of bank loans.

[38] With higher domestic prices and a real appreciation, the equilibrium change in the nominal exchange rate is in general ambiguous. If it depreciates, it must be by a smaller amount than the magnitude by which domestic prices increase, to ensure that the real exchange rate appreciates. Note also that there is a valuation effect on capital flows, but this is less central to the adjustment process.

[39] See, for instance, Feenstra and Taylor (2021) for a discussion of the Mundell-Fleming model and some of its properties.

4.2 Monetary Policy

Consider an increase in the central bank refinance rate, i^R. The equilibrium response of the real exchange rate and domestic prices can be evaluated by solving the system consisting of (41) and (46). However, to sign the resulting solutions, we must now distinguish not only with respect to the strength of the financial accelerator effect (that is, the sign of FG_{P^D}), but also the strength of the cost channel (as measured by the sign of FG_{i^R}). Consider first the case of a weak cost channel ($FG_{i^R} > 0$). As also shown in the Appendix, the solution is

$$\frac{dz}{di^R} = \frac{\overset{(-)}{XX_{i^R}}\overset{(+)}{FG_{P^D}} - \overset{(+)}{FG_{i^R}}\overset{(-)}{XX_{P^D}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}}, \quad \frac{dP^D}{di^R} = \frac{\overset{(-)}{XX_{i^R}} - \overset{(+)}{FG_{i^R}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}}, \tag{48}$$

As shown earlier, regardless of whether FG_{P^D} is positive or negative, $FG_{P^D} - XX_{P^D} > 0$. Thus, with a weak cost channel, equations (48) give $dz/di^R \gtrless 0$ and $dP^D/di^R < 0$ when $FG_{P^D} > 0$, and $dz/di^R > 0$ and $dP^D/di^R < 0$ when $FG_{P^D} < 0$. With a weak financial accelerator effect, the impact on domestic prices is negative, whereas the impact on the real exchange rate is ambiguous; with a strong effect, the impact on prices is again negative, but the real exchange rate definitely depreciates.

An increase in the refinance rate operates directly through changes in both the deposit and loan rates. By raising the deposit rate, the policy induces households to save more and reduce current spending. In addition, the higher refinance rate is passed on fully to the loan rate, which reduces investment. There is therefore a contraction in aggregate demand and excess supply prevails. To maintain internal balance at an unchanged value of P^D, as noted earlier, the real exchange rate should depreciate ($FG_{i^R} > 0$), to increase exports and reduce domestic sales. Curve FG shifts upward and z should jump from E to B, as illustrated in both panels of Figure 5.

At the same time, an increase in the refinance rate has two effects on the external balance condition. First, through its adverse impact on household spending (due to the intertemporal effect discussed earlier), it lowers imports and leads to an improvement in the current account. Second, the higher return on domestic deposits reduces demand for foreign deposits. The resulting capital inflow also helps to improve the balance of payments. Consequently, to maintain external balance, holding domestic prices constant, the real exchange rate has to appreciate ($XX_{i^R} < 0$). Thus, XX shifts downward in Figure 5 and z jumps from E to B' or B'' in the first panel, or from E to B' in the second, given that the exchange rate adjusts instantaneously to maintain external equilibrium.

The implication of these shifts is that, regardless of the strength of the financial accelerator effect, in the new equilibrium the price of the domestic good definitely falls—a contractionary monetary policy is always deflationary—but the impact of this policy on the real exchange rate cannot be ascertained a priori when the financial accelerator effect is weak. As shown in the upper panel of Figure 5, depending on the magnitude of the shift in XX, for a given shift in FG, the economy may move from the initial position E to an equilibrium point such as E' (corresponding to a real depreciation) or E'' (corresponding to a real appreciation). By contrast, when the financial accelerator effect is strong, the real exchange rate always depreciates, regardless of the magnitude of the shift in either curve, as illustrated in the lower panel of the figure.

Because the effect of the financial accelerator mechanism (as noted earlier) is to flatten out the FG curve, it is easy to show that the stronger the financial accelerator effect is, the larger will be the contractionary effect of an increase in the refinance rate, that is, the larger the drop in domestic prices and output. Thus, even when $FG_{P^D} < 0$, a stronger financial accelerator effect always makes it more likely that the real exchange rate will depreciate in response to a tightening of monetary policy.

As noted earlier, the initial effect of an increase in the refinance rate is a higher loan rate. Because domestic prices fall continuously during the transition (in both panels), the loan rate continues to increase. This movement corresponds to the financial accelerator effect. By implication, investment falls continuously throughout the adjustment process. While domestic production definitely contracts (the drop in domestic prices raises the product wage), the fact that the equilibrium effect on the real exchange is ambiguous when $FG_{P^D} > 0$ means that the impact on exports is also ambiguous—and so is the net effect on domestic sales, $Y^s - X$. By contrast, when $FG_{P^D} < 0$, exports unambiguously increase, so domestic sales are definitely lower. Again, whether consumption increases or falls cannot be determined a priori: the fall in domestic prices generates a positive wealth effect, but the contraction in output lowers income, which compounds the initial drop in spending due to intertemporal substitution.

Consider now the case of a strong cost channel ($FG_{i^R} < 0$). Solution (48) gives now $dz/di^R < 0$ and $dP^D/di^R \gtreqless 0$. The real exchange rate always appreciates, but the impact on domestic prices is now ambiguous. The results are illustrated in Figure 6. The aggregate demand effects are the same as before; both consumption and investment fall on impact. However, this time the contraction in aggregate supply (due to the increase in the effective wage) is large enough to lead, at the initial level of prices, to a situation of excess *demand*. The real exchange rate should therefore appreciate, from E to B, to lower exports, increase domestic sales, and restore internal equilibrium. Thus, curve FG shifts now *downward*, regardless of the strength of the financial accelerator effect. At the same time, as before XX shifts downward to either $X'X'$ or $X''X''$, requiring an actual appreciation on impact (from E to B' or B'') to maintain external equilibrium. If the shift in XX is not too large (to, say, $X'X'$), domestic prices *increase* in the new equilibrium E', regardless of the strength of the financial accelerator effect. However, if the shift of XX is relatively large, to $X''X''$, prices in the new equilibrium E'' are lower—as in the standard case considered earlier. The implication, therefore, is that a strong cost channel does not necessarily lead to a *price puzzle*; much depends also on the impact of monetary policy on the balance of payments.[40] In addition, at the new equilibrium (E' or E'') the real exchange rate always appreciates, in contract to what occurs with a weak cost channel. But while exports are always lower, the impact on output, and thus domestic sales, remains ambiguous and depends on whether a price puzzle exists or not. For the same reason, the impact on consumption, the loan rate, and investment, are also in general ambiguous. In addition, when domestic prices are lower in the new equilibrium (at E''), the real exchange rate *overshoots*—the real appreciation on impact (from E to B'') is larger than the equilibrium effect (the vertical distance between B'' and E''), regardless of the strength of the financial accelerator effect.

The upshot of this analysis is that, to evaluate the impact of monetary policy, determining how significant the cost channel is may be as important as assessing the strength of the financial accelerator effect. This is consistent with the large literature on the implications of bank financing of working capital needs for business cycles in middle-

[40] This point is important because most of the existing literature on the prize puzzle associated with the cost channel, which includes Chowdhury et al. (2006), Tillmann (2008), and Henzel et al. (2009), for instance, dwells on closed-economy New Keynesian models.

income countries and some advanced economies.[41] Even though the mere presence of a cost channel does not necessarily affect the transmission mechanism of monetary policy—the fact that a monetary contraction may raise production costs does not imply that the policy is stagflationary—the possibility that output and prices may move in opposite directions in response to changes in interest rates means that policy trade-offs may be exacerbated. Addressing these trade-offs may require greater coordination in policy responses. In addition, the fact that, depending on the strength of financial frictions, the real exchange rate may either appreciate or depreciate in response to a contractionary monetary policy is consistent with the predictions of more complex models, such as Devereux et al. (2006).

4.3 Macroprudential Policy

Consider an increase in the macroprudential tax rate, τ^L. As shown in the Appendix, from (41) and (46), the solution is

$$\frac{dz}{d\tau^L} = \frac{-\overset{(+)}{FG_{\tau^L}}\overset{(-)}{XX_{P^D}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} > 0, \quad \frac{dP^D}{d\tau^L} = \frac{-\overset{(+)}{FG_{\tau^L}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} < 0. \tag{49}$$

Thus, regardless of the sign of FG_{P^D}—given again that, when $FG_{P^D} < 0$, the condition $FG_{P^D} - XX_{P^D} > 0$ also holds—an increase in the macroprudential tax rate leads to a real depreciation and a fall in domestic prices.

Figure 7 illustrates these effects. Intuitively, an increase in the macroprudential tax rate raises the loan rate and lowers investment, thereby creating excess supply at the initial level of domestic prices. Thus, given that $FG_{\tau^L} > 0$, the real (and, again, nominal) exchange rate should depreciate (from E to B in both panels) to restore internal equilibrium, by expanding exports and reducing domestic sales. Thus, curve FG shifts upward, to $F'G'$. Because the macroprudential tax operates directly only through the loan rate, curve XX does not shift.

Once again, because the (nominal) exchange rate adjusts instantaneously to maintain external equilibrium, the real exchange rate remains at E when the shock occurs. At the same time, excess supply of goods on the home market puts downward pressure

[41] See, for instance, Cabezon (2014) for Latin America, and Agénor (2020, chapter 1) for a broader discussion.

on domestic prices, which in turn (through a positive net wealth effect) raise consumption and imports. The current account therefore deteriorates. During the transition, and regardless of the strength of the financial accelerator effect, the real exchange rate must depreciate, from E to E', to maintain external balance. In the new equilibrium, because domestic prices are lower (implying that the product wage is higher) and the real exchange rate has depreciated, both output and domestic sales are also lower. The drop in collateral values is associated with a higher loan rate and a contraction in investment. By contrast, the impact on consumption remains ambiguous, for the same reasons as discussed earlier—the conflict between income and wealth effects.

4.4 Foreign Exchange Intervention

As noted earlier, under a managed float the central bank intervenes systematically to stabilize the exchange rate, through the rule specified in (25). One way to study the role of foreign exchange intervention would therefore consist of looking at changes in the parameter φ^E in rule (25), possibly coupled with a change in the degree of sterilization, as given by φ^S in (26).[42] However, changes in these parameters entail changes in the slopes of FG and XX, which are not particularly informative, given the qualitative focus of the paper. To illustrate the role of foreign exchange intervention in the model, it is more instructive to consider the case where intervention is discretionary (or one-off) and responds to an exogenous shift in capital flows. In line with the evidence discussed earlier, we focus on the case of full sterilization.

Consider an autonomous inflow of foreign exchange, due to either a reduction in household deposits held abroad or an increase in bank foreign borrowing, which translates on impact into a reduction in the initial stock of net foreign assets, $\Delta F^* < 0$.[43] For simplicity, intervention and sterilization operations are assumed to take place *before* this inflow affects spending and portfolio decisions.[44] Treating F^* as an exogenous variable in (39), it can be established that $XX_{F^*} = \Omega^{-1} > 0$, where now

[42] In more elaborate models, both φ^E and φ^S can be viewed as policy instruments, chosen to optimize with respect to a particular objective. See Agénor et al. (2020), for instance.

[43] In the next section, the case of an endogenous inflow of capital, triggered by a drop in the world interest rate, is considered.

[44] This is a reasonable assumption given the fact that in practice these operations are conducted at a very high frequency. In the next section, the case of an *endogenous* inflow of capital, triggered by a drop in the world interest rate, will be considered.

$\Omega = z^{-1}(X' - \delta c_3 D_0^*)$. Thus, holding prices constant, a reduction in net foreign assets implies that the real exchange rate needs to appreciate to maintain external balance; curve XX shifts downward, to $X'X'$, as shown in both panels of Figure 8.

Now, sterilized intervention involves two simultaneous operations. First, the central bank purchases instantaneously all the inflow of foreign currency, thereby increasing its reserves, ΔR^*, and issues domestic currency in return; from (24), holding all other balance sheet items constant, $\Delta M = E_0 \Delta R^*$. As a result of the intervention, F^* increases back to its original value (so that $\Delta F^* = 0$), and curve XX shifts right back to its initial position. Second, the central bank immediately soaks up the newly-issued domestic currency, exchanging it for central bank bonds, which are held by commercial banks. Thus, $\Delta B^{CB} = E_0 \Delta R^*$ and $\Delta M = 0$. If there is no bank portfolio channel (that is, no economies of scope in banking, $\varkappa = 0$), nothing else happens; XX shifts right back to its initial position and the equilibrium remains at E^0, which implies that sterilized intervention has no effect on the exchange rate or prices.[45]

However, if the bank portfolio channel is present ($\varkappa > 0$), the adjustment process does not stop there. Given that $\Delta B^{CB} = E_0 \Delta R^*$, from (20) and (37) $FF_{R^*} = -\varkappa < 0$. Using this result, from (38) $FG_{R^*} = -I' FF_{R^*} = I' \varkappa < 0$. Thus, an increase in reserves, holding domestic prices constant, induces also a downward shift in FG if $\varkappa > 0$, as shown in both panels of Figure 8. The loan rate falls on impact, thereby stimulating investment and aggregate demand. To restore equilibrium, sales of the domestic good must increase; in turn, this requires a drop in exports and therefore a real appreciation. Thus, FG shifts downward, to $F'G'$. The new equilibrium would therefore be at E', characterized by higher domestic prices and a real appreciation. Put differently, if the bank portfolio channel prevails, a fully sterilized intervention is expansionary—even if, in the absence of that channel, it does not affect the exchange rate.

It is worth noting also that, in the model, while unsterilized foreign exchange intervention does affect liquidity ($E_0 \Delta R^* = \Delta M$, as noted earlier), its conventional effects on market interest rates and (by implication) other macroeconomic aggregates do not operate. The first reason is that interest rates are set by banks, rather than market

[45] There is mixed evidence on whether sterilized intervention affects the exchange rate; see Kuersteiner et al. (2018) and especially Fratzscher et al. (2019), whose study uses daily data for 33 countries. Agénor and Pereira da Silva (2019) and Agénor et al. (2020) provided a detailed review of the literature.

forces. Changes in liquidity therefore have no direct effect on the opportunity cost of holding cash or the incentives to save—and, by implication, household spending decisions. The second reason is that, in the model, consumption is assumed to depend only on beginning-of-period financial wealth. As a result, changes in the money supply do not play a direct role in the determination of macroeconomic equilibrium, and sterilized intervention in the absence of the bank portfolio channel generates the same outcomes as unsterilized intervention: in both cases the equilibrium remains at E.

However, what would happen if changes in the money stock had a direct impact on consumption is intuitively clear: with no sterilization (and thus no effect on investment), the increase in the money supply induced by foreign exchange intervention would lead to an expansion in aggregate demand. With unsterilized intervention, although XX would still shift back to its initial position, FG would shift downward, so in the new equilibrium domestic prices would be higher and the real exchange rate would appreciate—just as illustrated in Figure 8. But with sterilized intervention *and* the bank portfolio channel present, FG would shift downward by *more*, because the policy would now lead to an expansion not only in consumption but also in investment.

4.5 Capital Controls

Consider an increase in the capital controls levy, τ^B. As shown in the Appendix, from (41) and (46), the equilibrium responses of the real exchange rate and domestic prices is given by

$$\frac{dz}{d\tau^B} = \frac{\overset{(+)}{XX_{\tau^B}}\overset{(?)}{FG_{P^D}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} \gtrless 0, \quad \frac{dP^D}{d\tau^B} = \frac{\overset{(+)}{XX_{\tau^B}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} > 0. \tag{50}$$

Thus, an increase in the capital controls levy always leads to an increase in domestic prices, regardless of the sign of FG_{P^D} (given again that the condition $FG_{P^D} - XX_{P^D} > 0$ always holds), but its impact on the real exchange rate is in general ambiguous. With a weak financial accelerator effect ($FG_{P^D} > 0$) the real exchange rate will depreciate, whereas with a strong effect ($FG_{P^D} < 0$) the opposite occurs.

Figure 9 illustrates these effects. Intuitively, an increase in the capital controls levy induces banks to borrow less abroad. This dampens capital inflows and leads to a deterioration of the balance of payments. Holding domestic prices constant, the real exchange rate must depreciate on impact to maintain external equilibrium. Graphically, curve FG does not change—capital controls operate only through the cost of foreign borrowing for banks, which does not affect directly the equilibrium conditions of the financial and goods markets—whereas curve XX shifts upward to $X'X'$.[46] The real exchange rate jumps from E to B' on impact.

However, the initial depreciation raises exports and reduces local sales of the domestic good. There is therefore excess demand initially, and this leads to a gradual increase in domestic prices, a reduction in the product wage, and an expansion of output. As shown in Figure 9, and regardless of the strength of the financial accelerator effect, the initial depreciation is followed by a subsequent appreciation to help restore internal balance at E'. The equilibrium depreciation is smaller than the initial depreciation, and there is therefore exchange rate overshooting. During the transition, while domestic prices increase continuously, exports fall, whereas domestic output increases. The increase in goods and land prices lead to a lower premium, which induces an expansion in investment. Thus, the financial accelerator effect is present at well. Both domestic sales and domestic absorption increase, but as with previous experiments, the net effect on consumption remains ambiguous.

The upshot of the analysis is that capital controls are expansionary. This may seem to be in contrast with some of the evidence discussed by Klein (2012), Fernández et al. (2015), and Forbes et al. (2015), for instance, which suggests that episodic controls have little discernible effects on financial variables, the real exchange rate, and output, and Alfaro et al. (2017), which suggests that capital controls, by driving up the cost of external finance for firms, can induce a contraction in investment.

At the same time, it is important to keep in mind that, in the present setting, capital controls operate solely through banks' balance sheets, and that their expansionary impact is fundamentally due to the financial accelerator effect; if this effect is weak, the expansionary effect of capital controls will be significantly mitigated. In addition, as the cost of funding abroad increases, banks borrow less on world capital markets and more from the central bank—with no effect on the refinance rate. However, had it be assumed that the cost of accessing central bank liquidity increases with the amount

[46] The key reason why the cost of foreign borrowing does not influence curves FF and FG is that, as shown in (20), the *marginal* cost of funding for banks is the refinance rate, i^R.

borrowed, for instance, the downward impact of the financial accelerator effect on the loan rate would be highly mitigated, and possibly reversed, in which case capital controls could have either no effects on the economy or even a contractionary effect, in line with some of the evidence.

Table 2 summarizes the impact of fiscal policy, monetary policy, macroprudential regulation, and capital controls on key macroeconomic variables.

5 Policy Responses to External Shocks

Suppose now that the economy is hit by an external financial shock, namely, a reduction in the world interest rate, i^*. As documented extensively in the literature, this type of shocks have often created major challenges for economic management in middle-income countries.[47] In this context, there are two issues to consider. The first is how this shock is transmitted. The second is to what extent the different policy instruments discussed earlier should be combined, to return the economy to its initial equilibrium position.

Intuition suggests that the coordinated use of (some of) these tools could indeed increase policy space, while maximizing their effectiveness and limiting their unintended consequences.[48] For instance, monetary policy and (sterilized) foreign exchange intervention could complement each other during capital inflow episodes, if purchases of foreign currency provide more scope for central banks to adjust domestic interest rates in response to inflationary pressures. Moreover, as illustrated in the foregoing discussion, each policy instrument affects a wide range of real and financial variables. Thus, they could be deployed together, to support a single objective (such as output stability), or separately, with each instrument targeting a specific objective—such as price stability or financial stability. The issue, therefore, is to what extent the various policy instruments considered earlier should be used in a complementary manner (although not necessarily in the same direction) to achieve joint objectives, or independently in pursuit of separate objectives. However, before addressing these issues, we need first to characterize the macroeconomic and financial effects of a reduction in the world

[47] See Agénor and Pereira da Silva (2019) and Agénor (2020, chapter 1), for instance, for a more detailed discussion. In practice, changes in world interest rates are often driven by US monetary policy shocks, as documented by Friedrich and Guérin (2020), among others.

[48] Indeed, a common argument for using combinations of policy instruments is that each of them when used individually may be subject to rapidly diminishing marginal returns, or increasing marginal costs, because of greater incentives to evade their adverse effects.

interest rate.

5.1 Reduction in World Interest Rate

Differentiating (41) and (46), the equilibrium responses of the real exchange rate and domestic prices to an increase in i^* are given by

$$\frac{dz}{di^*} = \frac{\overset{(+)}{XX_{i^*}}\overset{(?)}{FG_{P^D}} - \overset{(+)}{FG_{i^W}}\overset{(-)}{XX_{P^D}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} \gtrless 0, \quad \frac{dP^D}{di^*} = \frac{\overset{(+)}{XX_{i^*}} - \overset{(+)}{FG_{i^*}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} \gtrless 0. \tag{51}$$

Thus, a *reduction* in the world interest rate has, in general, ambiguous effects on both the real exchange rate and domestic prices. With a weak financial accelerator effect ($FG_{P^D} > 0$) the real exchange rate always appreciates ($dz/di^* > 0$), and the price effect is indeterminate; with a strong effect ($FG_{P^D} < 0$), both effects are indeterminate.

Figure 10 illustrates these effects. Both FG and XX shift downward, regardless of the strength of the financial accelerator effect. As noted earlier, $FG_{i^*} > 0$ (see (41)), which indicates that (holding domestic prices constant) the real exchange rate should appreciate (from E to B) to maintain internal equilibrium. Because $XX_{i^*} > 0$ (see (46)), the real exchange rate actually appreciates, from E to either B' or B''. In both panels the new equilibrium point is at E' or E'', characterized indeed by a more appreciated real exchange rate but either lower or higher domestic prices.[49]

Intuitively, a reduction in the world interest rate generates initially (as in the case of an increase in the refinance rate) an intertemporal effect, which leads to higher consumption. It also leads to an increase in the demand for, and the price of, land, which raises on impact collateral values and lowers the premium. This raises investment initially. Both effects combine to create excess demand on the home market for domestic goods. Holding domestic prices constant, a real appreciation (from E to B) would be required to reduce exports and increase domestic sales, $Y^s - X$. At the same time, the initial effect on the balance of payments is ambiguous. On the one hand, a lower world interest rate reduces interest income on net foreign assets, which worsens the current account; on the other, it generates a capital inflow (due to a reduction in deposits held abroad), which improves the capital account. If the latter effect dominates, the real exchange rate appreciates on impact, from E to either B' or B'', depending on the

[49] Again, with a strong amplification effect, the impact on the real exchange rate is also indeterminate; the real appreciation shown in the figure is for illustrative purposes.

magnitude of the shift in XX. Imdeed, if XX does not shift much (which occurs, in particular, if the price sensitivity of exports, X', is relatively large), or if FG shifts a lot (which occurs if there is a strong intertemporal substitution effect, or if investment is highly sensitive to the loan rate), the real exchange rate must appreciate (from E to B') and will continue to do so (from B' to E'), as domestic prices increase to eliminate excess demand for goods. By contrast, if the shift in XX is relatively large, following the initial appreciation (from E to B'') the real exchange rate must depreciate (from B'' to E''), while prices fall to eliminate excess supply. Thus, there is overshooting in the second case.

In addition, despite falling initially due to higher collateral values, the behavior of the loan rate during the transition depends on the movement in domestic prices and their impact on house prices. In the first case (increasing prices), the loan rate continues to fall, given a lower premium, and investment expands. In the second case (falling prices), the opposite occurs. Thus, in the new equilibrium, the impact on the real sector can be either positive or negative. If the shock is inflationary, output and domestic absorption will expand.

In sum, the model is able to reproduce the main stylized facts associated with capital inflows induced by *push factors*, namely, a real appreciation, a current account deficit, pressures on asset prices, and an expansion in credit and aggregate demand.[50] The key channels through which these effects operate are the portfolio effect of reductions in world interest rates and the financial accelerator effect, which reflects changes in collateral values.

5.2 Policy Combinations

The question now is—how should the instruments discussed earlier, be combined, if at all, in managing external financial shocks and associated capital flows? To illustrate the analysis, we focus on the case of a weak cost channel and weak financial accelerator effect.[51] Moreover, we only consider the case where a reduction in the world interest rate leads not only to a real appreciation (which is always the case) but also to higher

[50] See, for instance, Tillmann (2013) on the link between capital inflows and property prices in Asia and Agénor (2020, chapter 1) for a comprehensive list of references.

[51] Other combinations of these two sources of financial frictions can be studied in the same manner and are left to the interested reader.

prices. This corresponds, as noted earlier, to a situation where the price elasticity of exports is large, the intertemporal substitution effect is strong, or investment is highly sensitive to the loan rate. To facilitate comparisons, the initial equilibrium is assumed to be at E^0, corresponding to the intersection of curves F^0G^0 and X^0X^0 in Figures 11 to 15. As discussed previously, a reduction in the world interest rate leads to downward shifts in the internal and external balance conditions, from F^0G^0 to F^1G^1 and from X^0X^0 to X^1X^1. The new equilibrium is at E^1, which corresponding to E' in Figure 10. The issue, therefore, is how macro-financial policies can be combined to bring about a reduction in domestic prices and a real depreciation—the two fundamental variables of the model, from which all other endogenous variables can be derived—in order to return the economy from E^1 to its initial position, E^0. For that to happen, naturally, curve FG must shift from F^1G^1 back to F^0G^0, whereas curve XX must shift from X^1X^1 back to X^0X^0.[52]

Given that there are two core objectives, Tinbergen's rule suggests that two instruments may be necessary. Therefore, the following combinations are considered in turn: a) monetary and fiscal policies; b) monetary policy and sterilized foreign exchange intervention; c) monetary and macroprudential policies; d) monetary policy and capital controls; and e) macroprudential policy and capital controls. While combinations of more than two instruments (as has often been the case in practice) could also be studied, graphical representations would become too opaque; for expositional clarity, we therefore consider them only in pairs.

5.2.1 Monetary and Fiscal Policies

Figure 11 illustrates outcomes when monetary and fiscal policies are combined. The transmission mechanism of these policies is as discussed earlier and represented in the upper panels of Figures 4 and 5.

The upper panel of Figure 11 shows what happens when the refinance rate, i^R, is *increased*. Curve XX shifts downward, from X^1X^1 to X^2X^2, whereas curve FG shifts upward, from F^1G^1 to F^2G^2. This is consistent with the outcomes illustrated in

[52] Note that, using (30), the cost-of-living index (29) can be written as $P = P^D z^\delta$. Thus, when P^D and z move in opposite directions in response to exogenous or policy shocks, the net effect on P is in general ambiguous. However, if, as assumed here, the goal of policy authorities is to stabilize *both* the price of the domestic good and the real exchange rate, by definition they will also stabilize the cost-of-living index—a more common objective in practice.

Figure 5. The upshot is that the policy, through a contraction in aggregate demand, does reduce domestic prices; at E^2, prices are actually back to their original level. However, at the same time, higher domestic interest rates lead to capital inflows; thus, although at E^2 domestic prices are the same as at E^0, the real exchange rate is more appreciated.

In a second step, in an attempt to return z to its initial value, the authorities can calibrate a reduction in government spending, G, so as to ensure that curve FG shifts further upward from F^2G^2 to F^3G^3, which coincides exactly with the initial curve F^0G^0. Thus, starting at E^2, the reduction in government spending induces a real depreciation and a drop in domestic prices (as in Figure 4). But even if curve FG shifts back to its original position, rather than E^0 the new equilibrium would be at E^3, the point of intersection of X^2X^2 and F^0G^0, characterized by lower domestic prices *and* a more appreciated real exchange rate than at the initial equilibrium. The implication, therefore, is that this policy combination (higher refinance rate, cut in government spending) cannot take the economy back to its initial position. The reason, fundamentally, is that an increase in the policy rate, by raising domestic deposit rates, exacerbates capital inflows. As a result, curve XX shifts in a direction opposite to what would be required.

Suppose instead that the authorities, in a first step, decide to *reduce* the refinance rate. This is illustrated in the lower panel of Figure 11. In that case, the internal and external balance conditions move in the opposite direction: X^1X^1 shifts upward to X^2X^2, whereas F^1G^1 shifts downward to F^2G^2. By reducing the attractiveness of domestic bank deposits, a monetary policy tightening mitigates the inflow of capital. In fact, the increase in i^R can be calibrated in such a way that the upward shift in X^2X^2 takes XX back exactly to its original position, X^0X^0; this is the case illustrated in the figure. However, the new equilibrium, if no other action is taken, would be at E^2, characterized by higher prices and a more appreciated exchange rate, compared to E^0. The reason, this time, is that the cut in the refinance rate is expansionary.[53] The fact that an increase, or a reduction, in policy interest rates cannot by itself restore the initial equilibrium illustrates well the dilemma that central banks are typically faced

[53] The fact that an increase, or a reduction, in policy interest rates cannot by itself restore the initial equilibrium illustrates well the dilemma that central banks are typically faced with in managing capital flows with a single policy instrument.

with in managing capital flows with a single policy instrument.

But now suppose also that, in a second step, the authorities are able to calibrate a reduction in government spending that is large enough to ensure that the internal balance condition shifts upward from F^2G^2 all the way to F^3G^3, which corresponds exactly to the initial curve F^0G^0. At that point, the initial equilibrium E^0 is restored. Put differently, a combination of a reduction in the policy interest rate (which, in effect, targets external balance) and a cut in government spending (which targets internal balance) is effective—in the sense that it is a potent strategy to return the economy to its initial equilibrium.

At the same time, it is worth noting that, in practice, and for various reasons (including spending rigidities, political constraints, and so on), fiscal policy has not been used consistently to respond to capital inflows.[54]

5.2.2 Monetary Policy and Sterilized Intervention

The case where a contractionary monetary policy is combined with discretionary sterilized intervention is illustrated in Figure 12, in the presence and absence of the bank portfolio channel.

Consider first the case where the bank portfolio channel is absent, which is illustrated in the upper panel. Starting at E^1 (as in Figure 11), an *increase* in the policy rate has the same effects as before: a downward shift in XX from X^1X^1 to X^2X^2, and an upward shift in FG from F^1G^1 to F^2G^2. However, rather than calibrating the increase in the refinance rate to restore domestic prices to their original level (as in the previous case), suppose instead that the authorities do so to create a contraction in aggregate demand that is large enough to ensure that FG shifts upward from F^1G^1 to F^2G^2, corresponding to the initial curve F^0G^0. If so, and nothing else happens, the new equilibrium would be at E^2, characterized by lower prices and a more appreciated real exchange rate than at E^0.

At the same time, the central bank can intervene discretionarily to fully absorb the inflow of foreign exchange associated with bank foreign borrowing and household

[54] Ghosh et al. (2017), for instance, found no evidence of a systematic use of countercyclical fiscal policy in the face of capital inflows. In turn, this may be due to either an inherent lack of flexibility in public budgets (due to widespread earmarking of outlays, for instance) or the existence of fiscal rules, which may unduly constrain the ability to engage in discretionary policy.

portfolio reallocation, thereby neutralizing its effect on the exchange rate. As a result, XX shifts upward, from X^2X^2 to X^3X^3, which coincides with the original curve X^0X^0. Because intervention is sterilized, the central bank issues bonds, held by banks, as a counterpart to its foreign exchange operations; but in the absence of a bank portfolio channel ($\varkappa = 0$), curve FG is not affected. Thus, this time, the combination of a *higher* policy interest rate (geared towards internal balance, restoring FG to its initial position) and sterilized foreign exchange intervention (geared at restoring the external balance curve XX to its initial position) is an effective strategy to restore the original equilibrium.

Suppose now that the bank portfolio channel prevails ($\varkappa > 0$). This case is illustrate in the lower panel of Figure 12. The first step (the increase in the refinance rate) is the same, and so is the subsequent upward shift in XX associated with intervention. However, with a bank portfolio channel, sterilization generates (as discussed earlier) expansionary effects. In principle, this effect could be internalized when monetary policy is set in the first step; this would require setting the refinance rate even *higher* than in the case discussed earlier, with $\varkappa = 0$—enough for the internal balance condition to shift to a curve F^2G^2 located *above* F^0G^0.[55]

However, if the bank portfolio effect is not internalized, and the interest rate adjustment in the first step is only large enough to shift FG from F^1G^1 to $F^2G^2 = F^0G^0$, sterilized intervention in a second step would lead to a *downward* shift in FG, from F^2G^2 to F^3G^3, in addition to the shift from X^2X^2 to $X^3X^3 = X^0X^0$, and the new equilibrium would be at a point like E^3 rather than E^0, characterized by higher domestic prices and a more appreciated real exchange rate relative to the economy's initial position.

It is also obvious that here, combining a *reduction* in the policy rate with sterilized intervention would not be an effective strategy: even if it can be calibrated to induce a shift in XX from X^1X^1 back to X^0X^0, it would lead to a further *downward* shift in F^1G^1 (given its expansionary effects on consumption and investment) which cannot be undone by sterilized intervention—given that, in the absence of a bank portfolio channel, it affects only the position of XX, and when the bank portfolio channel is present, it would induce a further downward shift in F^1G^1.

[55] This shift in F^2G^2 is not shown in the figure, to avoid unnecessary cluttering.

The thrust of this analysis, therefore, is that even in the presence of a bank portfolio channel, sterilized intervention combined with a (properly calibrated) contractionary monetary policy is indeed an effective combination to restore the economy's initial equilibrium, following an episode of capital inflows. This is consistent with the evidence, alluded to earlier, regarding how frequently these policies have been used in recent years in middle-income countries. At the same time, the analysis also illustrates the importance of a careful calibration of the change in the policy rate and, to that effect, of using an operational model that accurately captures the key features of the financial system.

5.2.3 Monetary and Macroprudential Policies

The case where policy authorities combine monetary policy and macroprudential regulation is illustrated in Figure 13.

First, consider the case where, as in the upper panel of the figure, the refinance rate is *increased*. As in Figures 5, 11 and 12, the external balance curve shifts downward, from X^1X^1 to X^2X^2, whereas the internal balance curve shifts upward, from F^1G^1 to F^2G^2. The assumption in the figure is again that the increase in the policy rate is calibrated so that, at E^2, prices (viewed as the main target variable of monetary policy) are back to their original level. But at E^2, the real exchange rate is more appreciated than at E^0. A sufficiently large increase in the macroprudential tax rate, τ^L (a contractionary policy as well, given that it induces an increase in the loan rate) shifts the internal balance curve from F^2G^2 to F^3G^3, which coincides with F^0G^0. The policy induces therefore a real depreciation and a drop in domestic prices, as illustrated earlier in Figure 7. But again, the new equilibrium would be at E^3, the point of intersection of X^2X^2 and F^0G^0, characterized by lower domestic prices and a more appreciated real exchange rate than at E^0. The implication, therefore, is that this policy combination (higher refinance rate, increase in the macroprudential tax rate) cannot restore the initial equilibrium, because higher interest rates amplify the inflow of capital and upward pressures on the real exchange rate. It induces a shift in XX that goes in the opposite direction of what is desirable.

Second, suppose instead that, in an initial step, the authorities *reduce* the refinance rate. As shown in the lower panel of Figure 13, the external balance curve shifts now upward from X^1X^1 to X^2X^2, whereas the internal balance curve shifts downward from F^1G^1 to F^2G^2. This time, the increase in the refinance rate is calibrated so that X^1X^1 shifts back to $X^2X^2 = X^0X^0$; without any other policy change, the new equilibrium would therefore be at E^2, located to the southeast of E^0. In a second step, the increase in the macroprudential tax rate can be calibrated in such a way that the internal balance condition shifts as before upward from F^2G^2 all the way to $F^3G^3 = F^0G^0$, thereby restoring the initial equilibrium E^0. Again, the combination of a reduction in the policy interest rate (which, in effect, targets external balance) and a tightening of macroprudential regulation (which targets internal balance) generates the desired result. This policy mix is consistent with the evidence, alluded to earlier, which suggests that macroprudential policy has indeed been used repeatedly in recent years, in combination with monetary policy, to manage capital inflows.

5.2.4 Monetary Policy and Capital Controls

Consider now the combination of monetary policy and capital controls, which is illustrated in Figure 14.

Suppose again that the first step involves an *increase* in the refinance rate, which is calibrated to restore domestic prices to their initial value. Curve FG shifts upward from F^1G^1 to F^2G^2, which is located below F^0G^0, whereas curve XX shifts further downward from X^1X^1 to X^2X^2. At E^2, where F^2G^2 and X^2X^2 intersect, domestic prices are indeed the same as at E^0, but the real exchange rate is still more appreciated than initially—essentially because (as discussed earlier) of the capital inflow induced by higher domestic deposit rates.

Now, suppose that, in a second step, the capital controls levy, τ^B, is increased in such a way that the external balance curve shifts from X^2X^2 to X^3X^3, which corresponds exactly to X^0X^0. However, because the tightening of capital controls has no effect on the position of FG, the internal balance curve, the new equilibrium would be at E^3 (the point of intersection of F^2G^2 and X^0X^0), located to the southeast of E^0, and characterized by higher prices and a more appreciated exchange rate than initially. Put differently, the mix of a monetary policy tightening, driven only by the goal of restoring domestic prices to their initial level, and a macroprudential tax that only affects directly capital flows (through bank borrowing), cannot return the economy to its initial equilibrium.

Alternatively, suppose that the increase in the refinance rate is calibrated so as to return the *internal* balance curve to its initial position; in that case, curve FG shifts again upward, but this time all the way from F^1G^1 to $F^2G^2 = F^0G^0$. Curve XX shifts downward, from X^1X^1 to X^2X^2. With no other policy change, the equilibrium would be at E^2, characterized by lower prices and a more appreciated real exchange rate than at E^0. An increase in the capital controls levy can now be used to generate a reduction in foreign bank borrowing that is large enough to shift the external balance curve from X^2X^2 to X^3X^3, which brings XX back to X^0X^0. The economy is thus back to its initial equilibrium E^0. In a sense, this policy mix (higher interest rates, a tigthening of capital controls on foreign borrowing), which has also been used in several middle-income countries in recent years, boils down to assigning monetary policy to restoring internal balance and capital controls to external balance.

It is also worth noting that a *reduction* in the refinance rate (as in the lowers panels of Figures 11 and 13), combined with a tightening of capital controls, would not be an effective policy combination. The key reason is that while a large enough cut in interest rates could shift XX from X^1X^1 all the way back to X^0X^0, it would also shift FG further *downward*, relative to F^1G^1; and a subsequent change in the capital controls levy would be powerless to affect the position of FG. The policy mix that generates the desired result in this case (a tightening of monetary policy and capital controls) is thus opposite to the combination that works best when, for instance, government spending is the only other available tool to policymakers (an expansionary monetary policy and a cut in spending).

5.2.5 Macroprudential Policy and Capital Controls

Finally, consider the case where the only tools available are the macroprudential tax rate and the capital controls levy. This case is illustrated in Figure 15.

The results are a straightforward combination of Figures 7 and 9; the reason is that each policy affects one, and only one, of the equilibrium curves. Indeed, starting at E^1, a sufficiently large increase in the macroprudential tax rate can shift the internal balance curve from F^1G^1 to $F^2G^2 = F^0G^0$, whereas a sufficient tightening of capital controls can shift the external balance curve from X^1X^1 to $X^3X^3 = X^0X^0$. The equilibrium is thus restored at E^0. Again, this combination of tools has also been used in practice, although perhaps less than others, possibly because of their side effects (domestic and foreign leakages, adverse signaling effects to investors, and so on) which are not captured in the model.[56]

In sum, while the previous results are obviously dependent on the structure of the model, the nature of the shock under consideration, and the assumed objectives of policymakers—returning the economy to its initial position, following an external financial shock—they illustrate fairly well the insights that can be gained on the joint performance of macro-financial policy instruments. In particular, whether monetary policy should be tightened or relaxed in response to capital inflows depends on which other instruments policymakers have at their disposal to engage in countercyclical responses. Depending on the range of tools available, different combinations may achieve the same result. A tightening of macroprudential policy, combined with a looser monetary policy, is a potent combination in terms of helping to mitigate the domestic effects of capital inflows with respect to both price and exchange rate stability—as well as financial stability, in the form of more stable borrowing costs. While a cut in government spending would also operate in the same direction, in practice spending reigidities, the lack of fiscal space, and political constraints often make such response difficult to implement in the short term. The combination of tighter monetary polic and temporary capital controls can also be fairly effective.

While our focus has been on combining instruments in pairs, broader insights can be gleaned from combinations involving more than two instruments—as is often the case in practice. For instance, a reduction, in a first step, in policy interest rates, could be supplemented, in a second step, by a combination of government spending cuts and a tightening of the macroprudential tax rate to restore the initial equilibrium. However, more complex combinations may be better studied in the context of policy models with a more quantitative focus.

[56] In a very diffeernt setting, Korinek and Sandri (2016) also highlighted the complementarity between capital controls and macroprudential policy. Empirical evidence on this complementarity is provided by Fabiani et al. (2021), for instance, in the case of Colombia, and by Ostry et al. (2012) for a large group of countries.

6 Extensions

The model presented earlier can be extended in a number of directions. In what follows, we consider briefly four of them: wage indexation, intratemporal substitution, endogenous depreciation expectations, and changes in reserve requirements.[57]

6.1 Wage Indexation

In the foregoing discussion, it was assumed that the nominal wage, W, is fixed at $\bar{W}$. Suppose instead that the wage rate is fully indexed on the cost-of-living index—an assumption that is consistent with the fact that, in this open economy, households (workers) consume both domestic and imported goods. Thus,

$$W = P. \tag{52}$$

From (29) and (30), $P = P^D z^\delta$. The product wage is now given by

$$\omega = \frac{W}{P^D} = z^\delta, \tag{53}$$

which implies a positive relationship between the product wage and the real exchange rate. Differentiating (53) yields

$$d\omega = \delta z^{\delta-1}dz = \delta z^{\delta-1}[-\frac{E}{(P^D)^2}]dP^D = -\delta(\frac{\omega}{P^D})dP^D,$$

which implies a negative relationship between the price of domestic goods and the product wage.

As shown earlier (equations (3) and (4)),

$$N^d = [\frac{\alpha P^D}{(1+\psi_W i^R)W}]^{1/(1-\alpha)}K_0, \quad Y^s = [\frac{\alpha P^D}{(1+\psi_W i^R)W}]^{\alpha/(1-\alpha)}K_0,$$

that is, using (53),

$$N^d = [\frac{\alpha}{(1+\psi_W i^R)z^\delta}]^{1/(1-\alpha)}K_0, \quad Y^s = [\frac{\alpha}{(1+\psi_W i^R)z^\delta}]^{\alpha/(1-\alpha)}K_0,$$

[57]In an unpublished Appendix, the following additional issues are discussed: endogenous inflation expectations; dominant currency pricing; and asymmetric effects and policy response. The case of equilibrium unemployment is discussed in Agénor (2021). Yet another extension would be to account explicitly for bank capital regulation (rather than a generic, lender-based macroprudential instrument) along the lines of Agénor and Pereira da Silva (2012), for instance.

or equivalently,

$$N^d = N^d(z; i^R), \qquad Y^s = Y^s(z; i^R), \tag{54}$$

where $N_z^d, Y_z^s < 0$.

Thus, a real depreciation—resulting from either a nominal depreciation or a reduction in domestic prices—lowers employment and output.[58] Because P^D and z do not necessarily move in the same direction in response to shocks, full indexation may affect significantly some of the results established earlier. At the same time, the graphical analysis of these shocks is also easier, because domestic sales are now given by $Y^s(z) - X(z)$, which depends only on the real exchange rate.[59]

6.2 Intratemporal Substitution

In the foregoing discussion, it was assumed that the share of spending on imports, δ, is constant, and corresponds to the weight of foreign prices in the cost-of-living index (see (29)). However, as the relative price of imports (the real exchange rate) changes, *intratemporal* substitution should induce changes in the allocation of total household spending between domestic and imported goods. For instance, a depreciation of the real exchange rate (a rise in z) makes imported goods more expensive domestically; households therefore have incentives to consume less of these goods and more of domestic goods. This effect can be captured by defining δ as

$$\delta = \delta(z), \tag{55}$$

where $\delta' < 0$. At the same time, to avoid complicating the analysis unduly, it is convenient to keep the weight used in the price index (29) to a base period value, say, δ_0.

To illustrate how the analysis changes as a result of endogenizing δ, note that the internal balance equation, equation (40), takes now the form

$$Y^s() = [1 - \delta(z)] \Big\{ c_1 Y^s() - c_2[(1-\mu)i^R + i^*]$$
$$+ c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D} + p^H()] \Big\} + I[FF()] + G + X().$$

[58]Note that, if it had been assumed that the nominal wage is indexed solely on the price of the domestic good, P^D, instead of the cost-of-living index as in (52), employment and output would be both independent of the real exchange rate because in that case $\omega = 1$.

[59]See Agénor (2020, chapter 7) for a detailed discussion.

The partial derivative of this expression with respect to z therefore becomes

$$\Delta = -\delta' C + (1-\delta)c_3 D_0^* + I' F F_z + X'.$$

Thus, given that $-\delta' C > 0$, the assumption needed to ensure that $\Delta > 0$ is now weaker. Nothing of substance changes with respect to the analysis.

Similarly, the external balance condition, equation (45), is now

$$z^{-1}X() - z^{-1}\delta(z)\left\{c_1 Y^s() - c_2[(1-\mu)i^R + i^*] + c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D}\right.$$

$$\left. +p^H()]\right\} + (1+i^*)F_0^* - F^*() = 0.$$

The partial derivative of this expression with respect to z therefore becomes, given the assumption of balanced trade,

$$\Omega = z^{-1}(X' - \delta' C) - F_z^* - z^{-1}\delta c_3 D_0^*.$$

Again, given that $-\delta' > 0$, the assumption needed to ensure that $\Delta > 0$ is now weaker. Accounting for the intratemporal substitution effect does not affect qualitatively the analysis of the previous sections.

6.3 Endogenous Depreciation Expectations

So far the analysis has assumed that the expected depreciation rate is constant ($\varepsilon = 0$). Under a tightly managed float, this assumption may be reasonable; however, under a managed float regime where the currency has some latitude to fluctuate—and the policy regime lacks credibility—it is is more difficult to justify.

In the static framework considered here it is difficult to provide a fully satisfactory treatment of expectations. However, suppose that exchange rate expectations are extrapolative, so that the expected depreciation rate is given by

$$\varepsilon = \Theta(\frac{E - E_0}{E_0}), \tag{56}$$

where $\Theta > 0$. Thus, a depreciation today (an increase in E) induces agents to expect the exchange rate to depreciate further tomorrow. In that case, equation (42) becomes, noting that $E = zP^D$,

$$D^* = \frac{d^*[i^D; i^* + \Theta(zP^D/E_0 - 1)]}{zP^D}(M_0 + D_0 + zP^D D_0^*).$$

The partial derivatives d_z^* and $d_{P^D}^*$ in (43) are now given by

$$D_z^* = \frac{-(M_0 + D_0)(d^* + d_{i^*}^* \Theta P^D / E_0)}{P^D z^2} < 0,$$

$$D_{P^D}^* = \frac{-(M_0 + D_0)(d^* + d_{i^*}^* \Theta P^D / E_0)}{z(P^D)^2} < 0.$$

Thus, given that the extrapolation parameter Θ is positive, these results are similar to those reported earlier.

In addition, and as can be inferred from (35), which defines the equilibrium price of land, the endogenous treatment of expectations as in (56) creates another channel through which exchange rate fluctuations to affect directly domestic lending conditions. However, depending on the shock, and on the economy's structural features, this channel may operate either procyclically or countercyclically.

Consider, for instance, an increase in the refinance rate. As noted earlier, with a weak cost channel, the result may be either a possible appreciation (weak financial accelerator effect, see Figure 5) or a definite depreciation (strong financial accelerator effect). With endogenous expectations specified as in (56), a depreciation raises the rate of return on foreign assets, thereby lowering the demand for, and thus the price of, land, given that $p_{i^*+\varepsilon}^H < 0$. In turn, this tends to reduce collateral values and to raise the loan rate. The opposite occurs when the real exchange rate appreciates.[60] How strong this channel is depends therefore on the sensitivity of the demand for land with respect to the rate of return on foreign-currency assets.

6.4 Reserve Requirements

Finally, consider the case of a increase in the required reserve ratio, μ. As discussed by Agénor and Pereira da Silva (2016), for instance, this instrument has been used quite extensively in Latin America to respond to domestic and external shocks—although, at times, as a substitute to monetary policy, rather than a tool of financial regulation.[61]

[60] Similarly, with specification (56), a reduction in the world interest rate would now also have an indirect effect on the equilibrium price of land and domestic lending conditions, through its impact on the nominal exchange rate, defined as zP^D.

[61] See Cordella et al. (2014), Glocker and Towbin (2015), Coman and Lloyd (2019), and Fabiani et al. (2021) for formal empirical evidence. In many of these countries, reserve requirements have also been used to conduct sterilization operations.

Differentiating (41) and (46), the equilibrium response of the real exchange rate and domestic prices to an increase in μ is given by

$$\frac{dz}{d\mu} = \frac{\overset{(+)}{XX_\mu}\overset{(?)}{FG_{P^D}} - \overset{(-)}{FG_\mu}\overset{(-)}{XX_{P^D}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} \gtrless 0, \quad \frac{dP^D}{d\mu} = \frac{\overset{(+)}{XX_\mu} - \overset{(-)}{FG_\mu}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} > 0. \tag{57}$$

Thus, while an increase in the required reserve ratio always leads to an increase in domestic prices, in general it has an ambiguous effect on the real exchange rate. With a weak financial accelerator effect ($FG_{P^D} > 0$) the effect on the real exchange rate remains ambiguous, whereas with a strong effect ($FG_{P^D} < 0$) the real exchange rate always appreciates in response to an increase in μ.

These effects are illustrated in Figure 16.[62] First, an increase in the required reserve ratio lowers the deposit rate and induces households to spend more today. Second, the reduction in the deposit rate generates a shift away from deposits and into other assets—foreign deposits and land. The increase in the demand for land raises its price, which in turn exerts initially a positive wealth effect on consumption and raises collateral values. This tends to lower the loan rate—given that $FF_\mu < 0$, as can be inferred from (37)—and to stimulate investment, in line with the financial accelerator effect. The combination of these effects on consumption and investment creates excess demand and, at the initial level of domestic prices, the real exchange rate should appreciate (from E to B) to restore internal equilibrium, ($FG_\mu < 0$ in (41)). Graphically, FG shifts downward to $F'G'$. Third, higher consumption spending raises imports, whereas the reduction in the domestic deposit rate induces households to increase their holdings of foreign deposits. The combination of a worsening current account and a capital outflow means that the real exchange rate must depreciate to maintain external equilibrium ($XX_\mu > 0$). Thus, XX shifts upward to $X'X'$, in both panels of Figure 16 and the real exchange rate jumps from E to B' or B'', depending on the magnitude of the shift in XX. Subsequently, it appreciates, to either E' or E''. With a weak accelerator effect, while output and investment unambiguously increase, changes in exports, domestic sales, consumption and domestic absorption are ambiguous. With a strong effect, output and investment change in the same manner, but now exports are unambiguously lower (given the real appreciation), whereas domestic sales and domestic

[62] The macroeconomic effects of an increase in the required reserve ratio are also summarized in Table 2.

absorption are unambiguously higher.

The key point of this analysis is that an increase in reserve requirements has an expansionary effect on output (as well as, possibly, domestic sales) and raises domestic prices. By implication, with a weak financial accelerator effect, while an increase in reserve requirements may help in terms of mitigating the effects of a reduction in the world interest rate when it comes to the real exchange rate—if it is associated with a depreciation, which is not guaranteed—it could magnify inflationary pressures (see the upper panel of Figure 10).

As discussed at length in Agénor et al. (2018) and Agénor (2020, chapter 2), one way to address this issue is to relax the assumption that deposits and central bank borrowing are perfect substitutes, and introduce instead a *liability composition effect*, which relates the refinance rate positively to the ratio of central bank borrowing and domestic deposits. An increase in the required reserve ratio would now lower these deposits and therefore raise the cost of borrowing from the central bank, thereby raising the loan rate. If this effect dominates the effect on land prices and the premium alluded to earlier, investment will fall. In turn, if the drop in investment is sufficiently large, and excess supply emerges, the net result may indeed be a fall in prices.

An alternative, but fundamentally similar, approach is to consider the case where, as in Agénor and Pereira da Silva (2017), for instance, economies of scope prevail with respect to deposits and loans. Consequently, the loan rate equation (20) is generalized to

$$i^L = i^R + \theta - \varkappa(\frac{B^{CB}}{L_0^I}) - \varkappa_D(\frac{D}{L_0^I}) + \gamma\tau^L, \tag{58}$$

where $\varkappa_D > 0$.[63] From the portfolio equation (11), $D = F_0^H d(i^D; i^* + \varepsilon)$, where $d_{i^D} > 0$. Combined with (19) for the deposit rate, equation (58) implies that an increase in the required reserve ratio would tend to raise the loan rate. Again, if this effect is relatively large, investment will fall. In addition, if the contraction in investment is large relative to the expansionary effect on consumption, aggregate demand will fall and in so doing put downward pressure on domestic prices.[64] In such conditions, increases in the

[63] As before, for simplicity the stock of investment loans is measured at the beginning of the period.

[64] Graphically, curve FG would now shift *upward* in Figure 16, rather than downward. Even then, the possibility that domestic prices increase also in that case cannot be ruled out. For prices to fall, the drop in investment must be large enough to outweigh the increase in consumption (due to the intertemporal and wealth effects) and create excess supply initially.

required reserve ratio can play an effective role in responding to the macroeconomic and financial effects associated with a drop in the world interest rate—possibly, as discussed earlier, in conjunction with other instruments.

7 Concluding Remarks

The purpose of this paper was to present a simple, integrated macroeconomic model of a bank-dependent small open economy in which the central bank operates a managed float regime and financial frictions prevail. The model was used to study, both analytically and diagrammatically, the macroeconomic effects of several macro-financial policy instruments: fiscal policy, monetary policy, macroprudential regulation, sterilization, and temporary capital controls. These instruments (particularly the last four) have been used repeatedly in middle-income countries in recent years to promote macroeconomic and financial stability. The analysis highlighted the interplay between the real and the financial sides of the economy, and the importance of financial frictions, in the transmission process.

We then considered a drop in the world interest rate and (after characterizing its effects on the domestic economy) examined how the policy instruments referred to earlier can be adjusted, either individually or jointly, to restore the initial equilibrium. Our analysis was only partial in nature, given, in particular, the static nature of the model and the absence of an explicit account of policy preferences—beyond the fact that returning the economy to its initial equilibrium, following a disturbance abroad, was considered desirable as a policy goal. Nevertheless, it provided useful insights on how macro-financial policies operate under a managed float and how they can complement each other to nanage capital flows—a perennial challenge for middle-income countries. Again, the role of financial frictions in choosing policy combinations was also highlighted.

From a broader perspective, the simple model presented in this paper can be viewed as a basis for a more elaborate Integrated Macro-Financial Policy Framework (IMFPF), which would blend together the integrated inflation targeting framework proposed by Agénor and Pereira da Silva (2019, 2022) with a fiscal policy framework that involves the combination of fiscal rules with a stabilization fund.[65]

[65] See Agénor and Pereira da Silva (2022) for a more detailed discussion. Other contributions to the

To conclude, it is worth pointing out some limitations of our analysis. First, the model did not address some important aspects of macroeconomic management, namely, the role of policy credibility and its impact on expectations. Structural features, such as dollarization, or the role of shadow banks, are also not considered. With respect to the instruments that were studied, some of their side effects were not considered either. In particular, the fact that monetary policy can lead to increased systemic vulnerabilities via an endogenous increase in risk-taking was not captured. Second, the model dwells on the Mundell-Fleming production structure, which implies that the real exchange rate and the terms of trade are one and the same. In addition, the existence of a natural resource sector, and the link between resource exports and the government budget, are not accounted for. Thus, an important source of macroeconomic fluctuations in resource-dependent middle-income countries, global commodity price shocks, cannot be analyzed. However, extending the model in that direction—perhaps along the lines discussed in Agénor (2016), who focuses on the role of an additional instrument of macroeconomic policy, the allocation rule to a stabilization fund in response to resource windfalls, or García-Cicco and Kawamura (2015)—could result in significant complications. Finally, the issue of coordination was only partially addressed; the optimal combination of instruments, taking explicitly into account the objective function of policymakers and the cost of instrument manipulation, was not considered—and neither were the communication challenges that may arise when multiple instruments are deployed. In particular, if manipulation costs generate diminishing marginal returns in the use of any specific instrument, beyond a certain point policymakers may have stronger incentives to diversify their policy responses. These potential nonlinearities are not captured in our analysis.

Yet, it is also important to keep in mind the main motivation for our contribution—to provide a tractable and transparent framework that can provide some core intuition with respect to the transmission of policy and exogenous shocks under a managed float, and the coordination of policy instruments in response to external shocks. From that perspective, this paper may prove useful not only to policymakers confronted with the need to take practical decisions but also to researchers involved in interpreting the results from more complex, quantitative macroeconomic models.

ongoing debate on the design of IMFPFs include Basu et al. (2020) and Adrian et al. (2021).

References

Adler, Gustavo, Kyun Suk Chang, and Zijiao Wang, "Patterns of Foreign Exchange Intervention under Inflation Targeting," Working Paper No. 20/69, International Monetary Fund (March 2020).

Adrian, Tobias, Christopher J. Erceg, Marcin Kolasa, Jesper Lindé, and Pawel Zabczyk, "A Quantitative Microfounded Model for the Integrated Policy Framework," Working Paper No. 21/292, International Monetary Fund (December 2021).

Agénor, Pierre-Richard, "Optimal Fiscal Management of Commodity Price Shocks," *Journal of Development Economics*, 122 (September 2016), 183-96.

——, *Monetary Policy and Macroprudential Regulation with Financial Frictions*, The MIT Press (Cambridge, Mass.: 2020).

——, "Open-Economy Macroeconomics with Financial Frictions: A Simple Model with Flexible Exchange Rates," unpublished, University of Manchester (October 2021).

Agénor, Pierre-Richard, Koray Alper, and Luiz Pereira da Silva, "Sudden Floods, Macroprudential Regulation, and Stability in an Open Economy," *Journal of International Money and Finance*, 48 (November 2014), 68-100.

——, "External Shocks, Financial Volatility and Reserve Requirements in an Open Economy," *Journal of International Money and Finance*, 83 (May 2018), 23-43.

Agénor, Pierre-Richard, and Timothy Jackson, "Monetary and Macroprudential Policy Coordination with Biased Preferences," *Journal of Economic Dynamics and Control*, 144 (November 2022), 1-32.

Agénor, Pierre-Richard, Timothy Jackson, and Luiz Pereira da Silva, "Foreign Exchange Intervention and Financial Stability," Working Paper No. 889, Bank for International Settlements (October 2020).

Agénor, Pierre-Richard, and Pengfei Jia, "Capital Controls and Welfare with Cross-Border Bank Capital Flows," *Journal of Macroeconomics*, 65 (September 2020), 1-27.

Agénor, Pierre-Richard, and Peter J. Montiel, *Development Macroeconomics*, 4th ed., Princeton University Press (Princeton, New Jersey: 2015).

Agénor, Pierre-Richard, and Luiz Pereira da Silva, "Cyclical Effects of Bank Capital Requirements with Imperfect Credit Markets," *Journal of Financial Stability*, 8 (January 2012), 43-56.

——, "Reserve Requirements and Loan Loss Provisions as Countercyclical Macroprudential Instruments," Policy Brief No. IDB-PB-250, Inter-American Development Bank (February 2016).

——, "Cyclically Adjusted Provisions and Financial Stability," *Journal of Financial Stability*, 28 (February 2017), 143-62.

——, *Integrated Inflation Targeting*, BIS Publications, Bank for International Settlements (Basel: 2019).

——, "Towards a New Monetary-Macroprudential Policy Framework: Perspectives on Integrated Inflation Targeting," in *Macro-financial Stability Policy in a Globalised World: Lessons from International Experience*, ed. by Claudio Borio, Ilhyock Shim, and Hyun Song Shin, World Scientific Publishing (Singapore: 2022).

Aguirre, Álvaro, Sofía Bauducco, and Diego Saravia, "Capital Flows, Macroprudential Policies and Capital Controls," in *Monetary Policy and Financial Stability: Transmis-*

sion Mechanisms and Policy Implications, ed. by Álvaro Aguirre, Markus Brunnermeier, and Diego Saravia, Central Bank of Chile (Santiago: 2018).

Aldasoro, Iñaki, Paula Beltrán, Federico Grinberg, and Tommaso Mancini-Griffoli, "The Macro-Financial Effects of International Bank Lending on Emerging Markets," Working Paper No. 899 (November 2020).

Alfaro, Laura, Anusha Chari, and Fabio Kanczuk, "The Real Effects of Capital Controls: Firm-Level Evidence from a Policy Experiment," *Journal of International Economics*, 108 (September 2017), 191-210.

Alla, Zineddine, Raphael Espinoza, and Atish R. Ghosh, "FX Intervention in the New Keynesian Model," *Journal of Money, Credit, and Banking*, 52 (October 2020), 1755-91.

Aron, Janine, and John Muellbauer, "Wealth, Credit Conditions, and Consumption: Evidence from South Africa," *Review of Income and Wealth*, 59 (October 2013), 161-96.

Basu, Suman, Emine Boz, Gita Gopinath, Francisco Roch, and Filiz Unsal, "A Conceptual Model for the Integrated Policy Framework," Working Paper No. 20/121, International Monetary Fund (July 2020).

Basu, Susanto, and Christopher L. House, "Allocative and Remitted Wages: New Facts and Challenges for Keynesian Models," in *Handbook of Macroeconomics*, Vol. 2, ed. by John B. Taylor and Harald Uhlig, North Holland (Amsterdam: 2016).

Bergant, Katharina, Francesco Grigoli, Niels-Jakob Hansen, and Damiano Sandri, "Dampening Global Financial Shocks: Can Macroprudential Regulation Help (More than Capital Controls)?," Working Paper No. 20/106, International Monetary Fund (June 2020).

Bruno, Valentina, and Hyun Song Shin, "Assessing Macroprudential Policies: Case of South Korea," *Scandinavian Journal of Economics*, 116 (January 2014), 128-57.

Bruno, Valentina, Ilhyock Shim, and Hyun Song Shin, "Comparative Assessment of Macroprudential Policies," *Journal of Financial Stability*, 28 (February 2017), 183-202.

Cabezon, Ezequiel, "Working Capital, Financial Frictions and Monetary Policy in Brazil," unpublished, University of North Carolina at Chapel Hill (November 2014).

Carstens, Agustín, "Exchange Rates and Monetary Policy Frameworks in Emerging Market Economies," lecture at the London School of Economics (May 2019). Available at https://www.bis.org/speeches/sp190502.htm.

Cesa-Bianchi, Ambrogio, Luis F. Céspedes, and Alessandro Rebucci, "Global Liquidity, House Prices, and the Macroeconomy: Evidence from Advanced and Emerging Economies," *Journal of Money, Credit and Banking*, 47 (March 2015), 301-35.

Chowdhury, Ibrahim, Mathias Hoffmann, and Andreas Schabert, "Inflation Dynamics and the Cost Channel of Monetary Transmission," *European Economic Review*, 50 (May 2006), 995-1016.

Christiano, Lawrence J., Martin S. Eichenbaum, and Charles L. Evans, "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, 113 (February 2005), 1-45.

Coman, Andra, and Simon P. Lloyd, "In the Face of Spillovers: Prudential Policies in Emerging Economies," *Journal of International Money and Finance*, 122 (April 2022), 102554.

Cordella, Tito, Pablo Federico, Carlos Végh, and Guillermo Vuletin, "Reserve Requirements in the Brave New Macroprudential World," Policy Research Working 6793, World Bank (February 2014).

Devereux, Michael B., Philip R. Lane, and Juanyi Xu, "Exchange Rates and Monetary Policy in Emerging Market Economies," *Economic Journal*, 116 (April 2006), 478-506.

Fabiani, Andrea, José-Luis Peydró, Martha López Piñeros, and Paul Soto, "Capital Controls, Domestic Macroprudential Policy and the Bank Lending Channel of Monetary Policy," Working Paper No. 2021-06, Federal Deposit Insurance Corporation (May 2021).

Feenstra, Robert C., and Alan M. Taylor, *International Macroeconomics*, 5th ed., Macmillan (London: 2021).

Fernández, Andrés, Alessandro Rebucci, and Martín Uribe, "Are Capital Controls Countercyclical?," *Journal of Monetary Economics*, 76 (November 2015), 1-14.

Forbes, Kristin, Marcel Fratzscher, and Roland Straub, "Capital-Flow Management Measures: What are they Good for?," *Journal of International Economics*, 96 (July 2015), s76-s97.

Frankel, Jeffrey A., "Systematic Managed Floating," *Open Economies Review*, 30 (April 2019), 255-95.

Fratzscher, Marcel, Oliver Gloede, Lukas Menkhoff, Lucio Sarno, Tobias Stöhr, "When is Foreign Exchange Intervention Effective? Evidence from 33 Countries," *American Economic Journal: Macroeconomics* (January 2019), 132-56.

Friedrich, Christian, and Pierre Guérin, "The Dynamics of Capital Flow Episodes," *Journal of Money, Credit, and Banking*, 52 (August 2020), 969-1003.

Frost, Jon, Hiro Ito, and René van Stralen, "The Effectiveness of Macroprudential Policies and Capital Controls against Volatile Capital Inflows," Working Paper No. 867, Bank for International Settlements (June 2020).

Garcia, Márcio G. P., "Can Sterilized FX Purchases under Inflation Targeting be Expansionary?," unpublished, Department of Economics, PUC-Rio (February 2012).

García-Cicco, Javier, and Enrique Kawamura, "Dealing with the Dutch Disease: Fiscal Rules and Macro-prudential Policies," *Journal of International Money and Finance*, 55 (July 2015) 205-39.

Ghosh, Atish R., Jonathan D. Ostry, and Mahvash S. Qureshi, "Managing the Tide: How do Emerging Markets Respond to Capital Flows?," Working Paper No. 17/69, International Monetary Fund (March 2017).

Glocker, Christian, and Pascal Towbin, "Reserve Requirements as a Macroprudential Instrument: Empirical Evidence from Brazil," *Journal of Macroeconomics*, 44 (June 2015), 158-76.

Henzel, Steffen, Oliver Hülsewig, Eric Mayer, and Timo Wollmershäuser, "The Price Puzzle Revisited: Can the Cost Channel Explain a Rise in Inflation after a Monetary Policy Shock?," *Journal of Macroeconomics*, 31(June 2009), 268-89.

Ilzetzki, Ethan, Carmen Reinhart, and Kenneth Rogoff, "Exchange Arrangements Entering the 21st Century: Which Anchor will Hold?," *Quarterly Journal of Economics*, 134 (May 2019), 599-646.

International Monetary Fund, *World Economic Outlook*, IMF Publications (Washington DC: April 2020).

Kim, Soyoung, Aaron Mehrotra, "House Prices, Collateral Effects and Sectoral Output Dynamics in Emerging Market Economies," *Journal of International Money and Finance*, 129 (December 2022), 102724.

Kim, Wonhyeok, Soohyung Lee, and Yoonsoo Lee, "How do House Prices Affect Consumption Patterns across Categories?," *Korean Economic Review*, 37 (June 2021), 367-98.

Klein, Michael W., "Capital Controls: Gates versus Walls," Working Paper No. 18526, National Bureau of Economic Research (November 2012).

Korinek, Anton, and Damiano Sandri, "Capital Controls or Macroprudential Regulation?," *Journal of International Economics*, 99 (March 2016), s27-s42.

Krugman, Paul, "How Complicated does the Model Have to Be?," *Oxford Review of Economic Policy*, 16 (December 2000), 33-42.

Kuersteiner, Guido M., David C. Phillips, and Mauricio Villamizar-Villegas, "Effective Sterilized Foreign Exchange Intervention? Evidence from a Rule-based Policy," *Journal of International Economics*, 113 (July 2018), 118-38.

Ostry, Jonathan, Atish Ghosh, Marcos Chamon, and Mahvash Qureshi, "Tools for Managing Financial-Stability Risks from Capital Inflows," *Journal of International Economics*, 88 (November 2012), 407-21.

Patel, Nikhil, and Paolo Cavallino, "FX Intervention: Goals, Strategies and Tactics," in *Reserve Management and FX Intervention*, BIS Paper No. 104, Bank for International Settlements (Basel: 2019).

Peltonen, Tuomas A., Ricardo M. Sousa, and Isabel Vansteenkiste, "Wealth Effects in Emerging Market Economies," *International Review of Economics and Finance*, 24 (October 2012), 155-66.

Prasad, Nalini, "Sterilized Interventions and Capital Controls," *Journal of International Money and Finance*, 88 (November 2018), 101-21.

Sandri, Damiano, "FX Intervention to Stabilize or Manipulate the Exchange Rate? Inference from Profitability," Working Paper No. 20/90, International Monetary Fund (June 2020).

Tillmann, Peter, "Do Interest Rates Drive Inflation Dynamics? An analysis of the Cost Channel of Monetary Transmission," *Journal of Economic Dynamics and Control*, 32 (September 2008), 2723-44.

——, "Capital Inflows and Asset Prices: Evidence from Emerging Asia," *Journal of Banking and Finance*, 37 (March 2013), 717-29.

Vargas, Hernando, Andrés González, and Diego Rodríguez, "Foreign Exchange Intervention in Colombia," Working Paper No. 757, Central Bank of Colombia (March 2013).

Table 1
Variable Names and Definitions

Variable	Definition
Firms	
Y	Aggregate output
N	Employment
K_0	Capital stock (beginning of period)
P^D	Price of domestic good
W	Nominal wage
I	Investment
X	Exports
Households	
C	Private consumption
A^H	Total wealth
F^H	Financial wealth
M	Currency holdings (cash)
D	Domestic deposits
D^*	Foreign deposits (foreign-currency terms)
H	Real assets (land)
P^H	Nominal price of land
Commercial banks	
L_0^K	Investment loans (beginning of period)
L	Loans to firms, working capital and investment
B^{CB}	Holdings of central bank bonds
RR	Reserve requirements
L^B	Central bank borrowing
L^*	Foreign borrowing (foreign-currency terms)
i^D, i^L	Domestic deposit and loan rates
θ	External premium on investment loans
RR	Required reserves
Policymakers	
G	Government spending
i^R	Refinance rate
τ^L	Macroprudential tax rate
R^*	Foreign reserves (foreign-currency terms)
τ^B	Capital controls levy
μ	Required reserve ratio
Other variables	
E	Nominal exchange rate
z	Real exchange rate
P	Cost-of-living index
π^a	Expected inflation rate
ε	Expected depreciation rate
Y^W	Foreign output
i^W	Foreign interest rate

Table 2
Impact of Macroeconomic Policies under a Managed Float: Summary

	Variable	Strength of financial frictions	
		Weak	Strong
Increase in government spending, G			
Output supply	Y^s	$+$	$+$
Domestic sales	$Y^s - X$	$+$	$+$
Private consumption	C	?	?
Investment	I	$+$	$+$
Domestic absorption	$(1-\delta)C + I + G$	$+$	$+$
Exports	X	$-$	$-$
External premium	θ	$-$	$-$
Loan rate	i^L	$-$	$-$
Price of domestic good	P^D	$+$	$+$
Real price of land	p^H	$+$	$+$
Real exchange rate	z	$-$	$-$
Increase in refinance rate, i^R			
Output supply	Y^s	$-/?$	$-/?$
Domestic sales	$Y^s - X$	$?/?$	$-/?$
Private consumption	C	$?/?$	$?/?$
Investment	I	$-/-$	$-/?$
Domestic absorption	$(1-\delta)C + I + G$	$?/?$	$-/?$
Exports	X	$?/-$	$+/-$
Loan rate	i^L	$+/+$	$+/?$
External premium	θ	$+/?$	$+/?$
Price of domestic good	P^D	$-/?$	$-/?$
Real price of land	p^H	$-/?$	$-/?$
Real exchange rate	z	$?/-$	$+/-$
Increase in macroprudential tax, τ^L			
Output supply	Y^s	$-$	$-$
Domestic sales	$Y^s - X$	$-$	$-$
Private consumption	C	?	?
Investment	I	$-$	$-$
Domestic absorption	$(1-\delta)C + I + G$	$-$	$-$
Exports	X	$+$	$+$
Loan rate	i^L	$+$	$+$
External premium	θ	$+$	$+$
Price of domestic good	P^D	$-$	$-$
Real price of land	p^H	$-$	$-$
Real exchange rate	z	$+$	$+$

Table 2 (continued)
Impact of Macroeconomic Policies under a Managed Float: Summary

	Variable	Strength of financial frictions	
		Weak	Strong
Increase in capital controls levy, τ^B			
Output supply	Y^s	$+$	$+$
Domestic sales	$Y^s{-}X$	?	$+$
Private consumption	C	?	?
Investment	I	$+$	$+$
Domestic absorption	$(1-\delta)C+I+G$	?	$+$
Exports	X	$+$	$-$
External premium	θ	$-$	$-$
Loan rate	i^L	$-$	$-$
Price of Domestic good	P^D	$+$	$+$
Real price of land	p^H	$+$	$+$
Real exchange rate	z	$+$	$-$
Increase in required reserve ratio, μ			
Output supply	Y^s	$+$	$+$
Domestic sales	$Y^s{-}X$	?	$+$
Private consumption	C	?	?
Investment	I	$+$	$+$
Domestic absorption	$(1-\delta)C+I+G$	?	$+$
Exports	X	?	$-$
External premium	i^L	$-$	$-$
Loan rate	θ	$-$	$-$
Price of domestic good	P^D	$+$	$+$
Real price of land	p^H	$+$	$+$
Real exchange rate	z	?	$-$

Notes: 1. From (33), domestic absorption, $(1-\delta)C+I+G$, is equal to domestic sales, $Y^s{-}X$. They therefore have the same sign. 2. For the increase in the refinance rate, the first sign in the table refers to the equilibrium effect when the cost channel is weak, and the second to the equilibrium effect when the cost channel is strong.

Figure 1
Macroeconomic Equilibrium: Weak Financial Accelerator

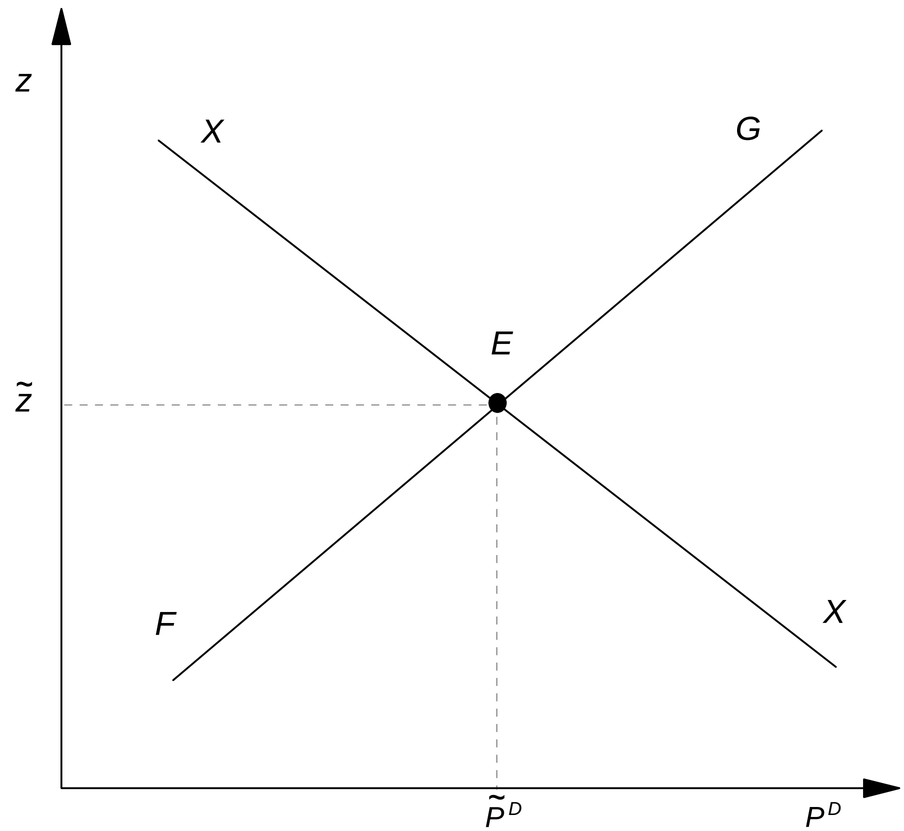


Figure 2
Macroeconomic Equilibrium: Weak Financial Accelerator
No Intervention, Sterilization, or Economies of Scope

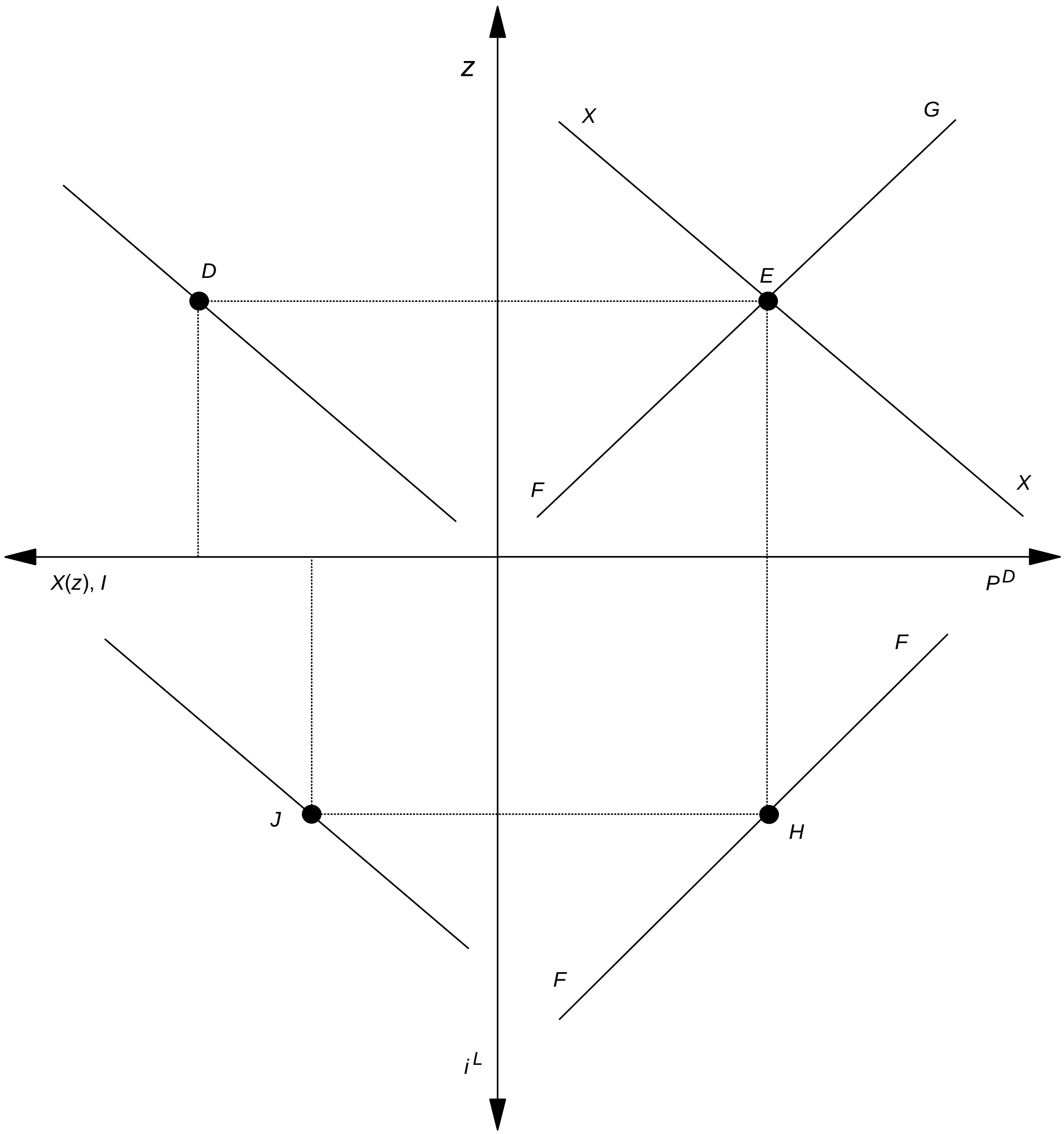


Figure 3
Macroeconomic Equilibrium: Strong Financial Accelerator

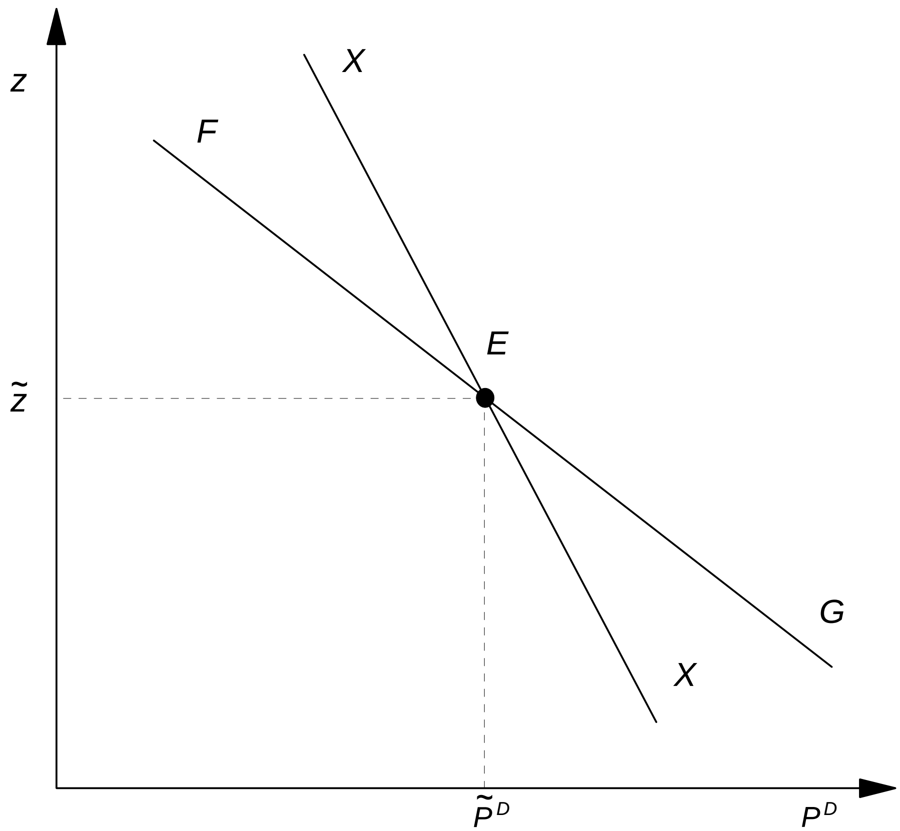
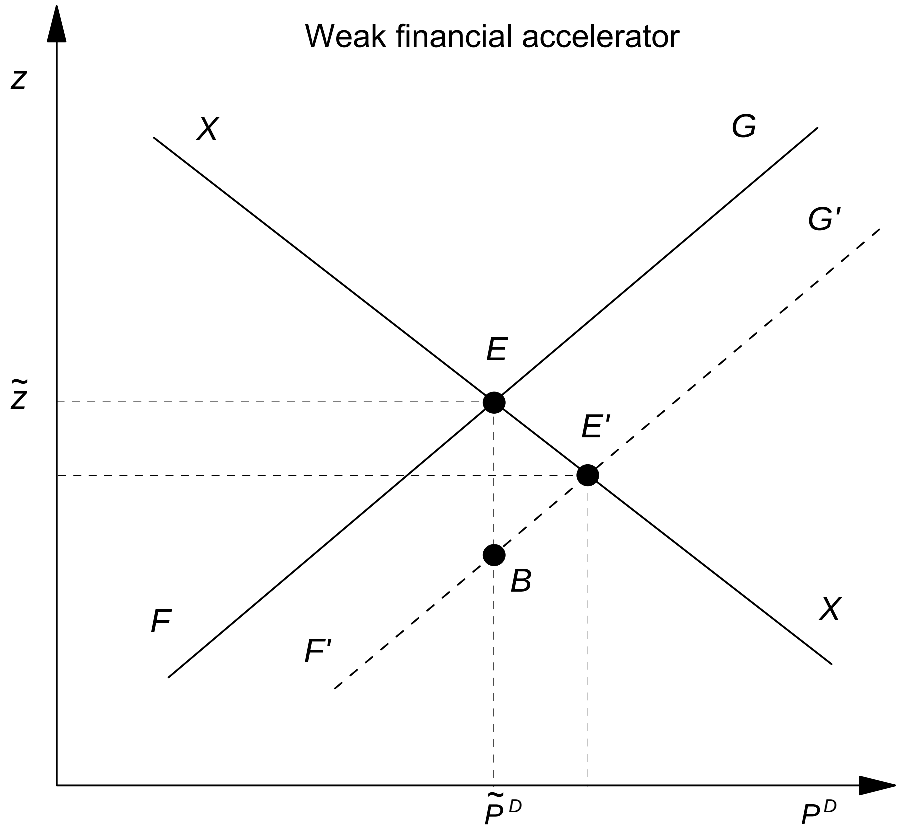


Figure 4
Increase in Government Spending

Weak financial accelerator



Strong financial accelerator

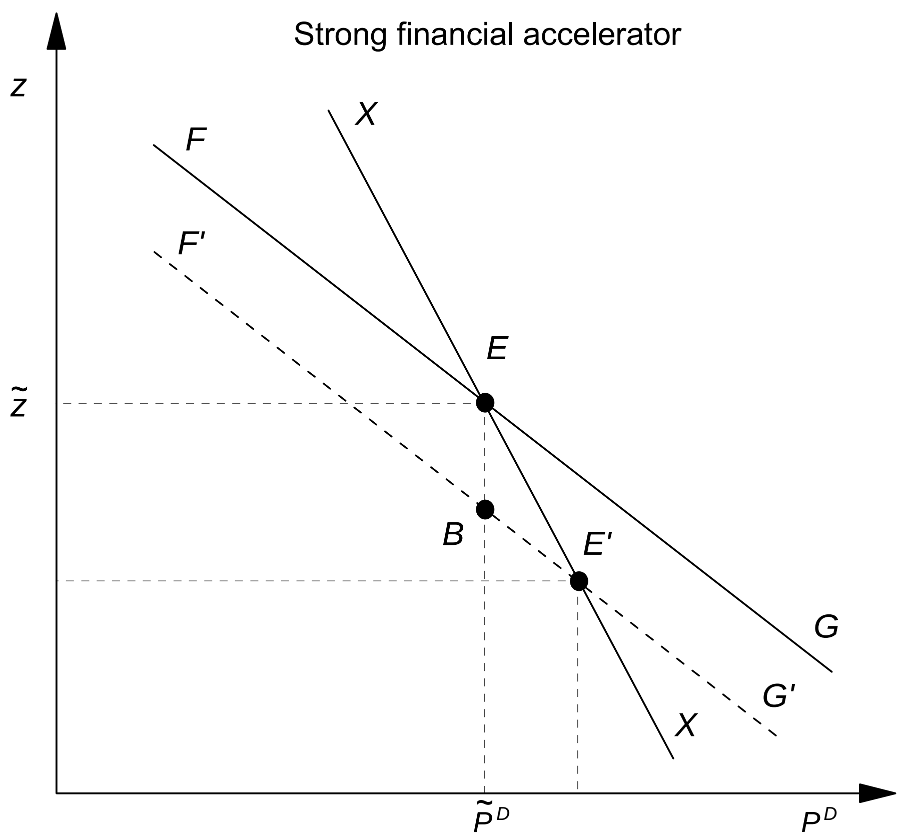


Figure 5
Increase in Refinance Rate: Weak Cost Channel

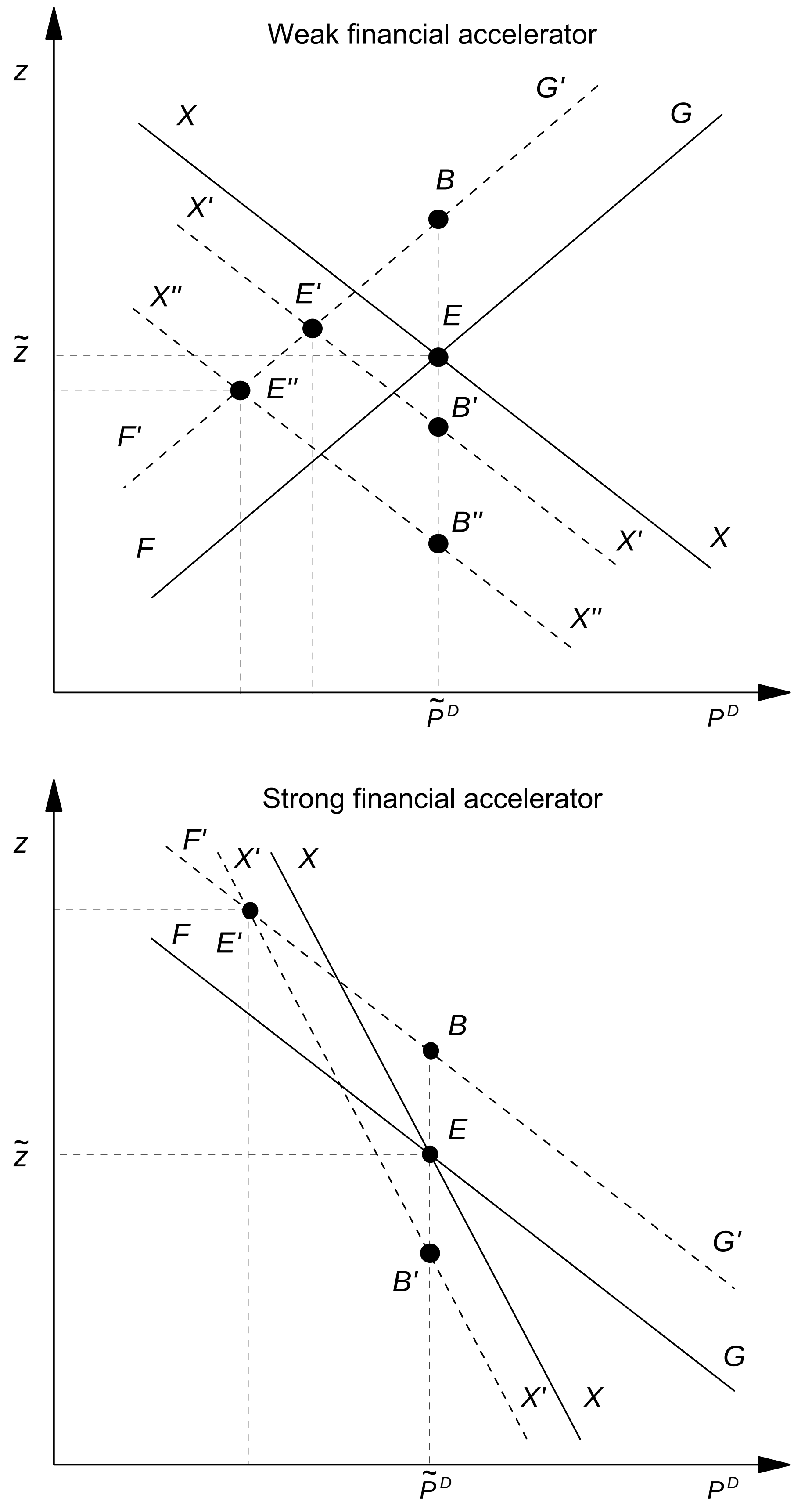
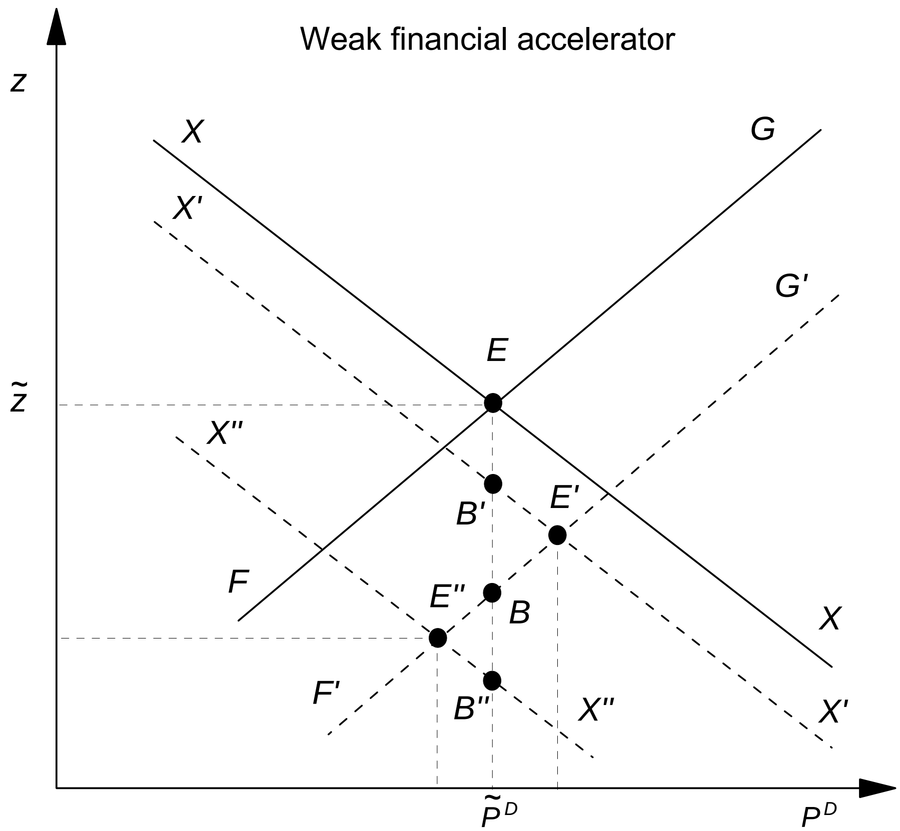


Figure 6
Increase in Refinance Rate: Strong Cost Channel



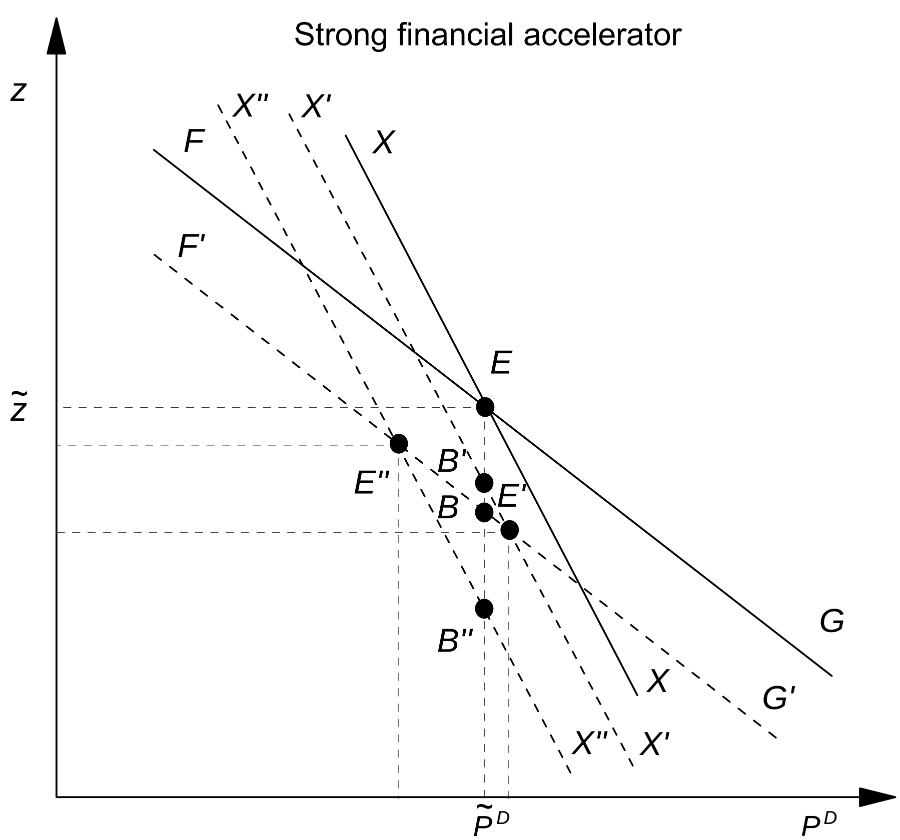


Figure 7
Increase in Macroprudential Tax Rate

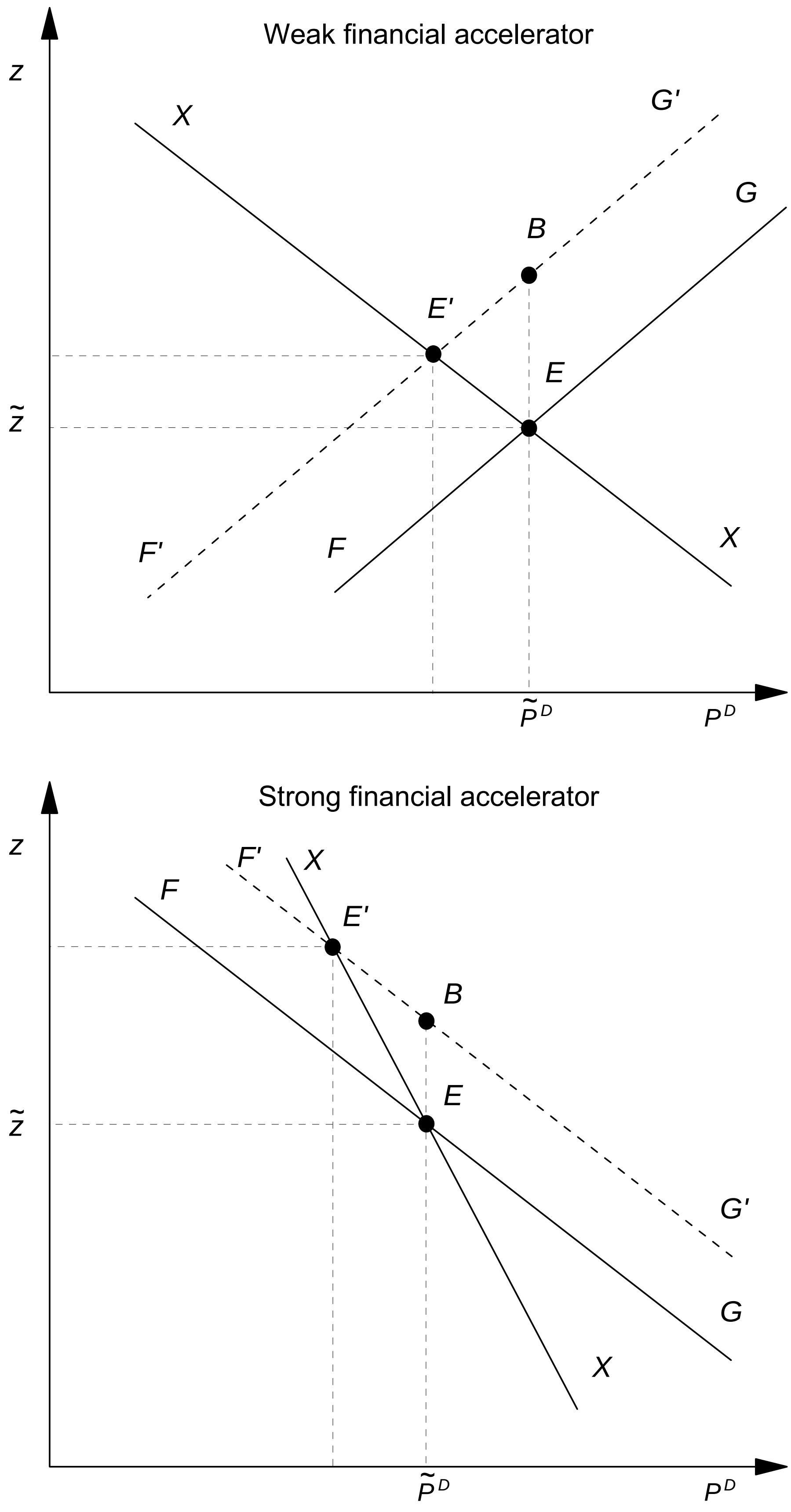


Figure 8
Sterilized Foreign Exchange Intervention

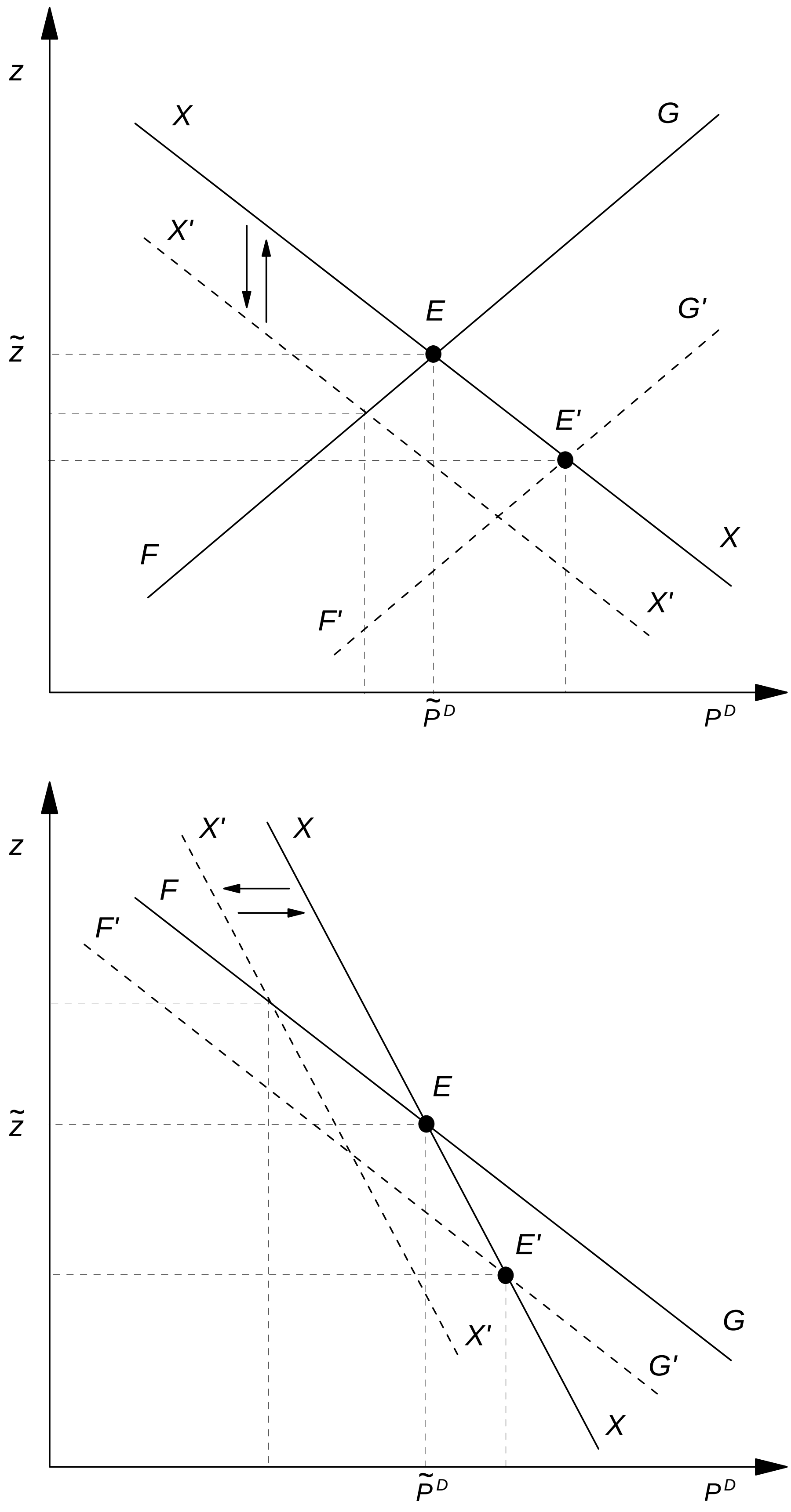


Figure 9
Increase in Capital Controls Levy

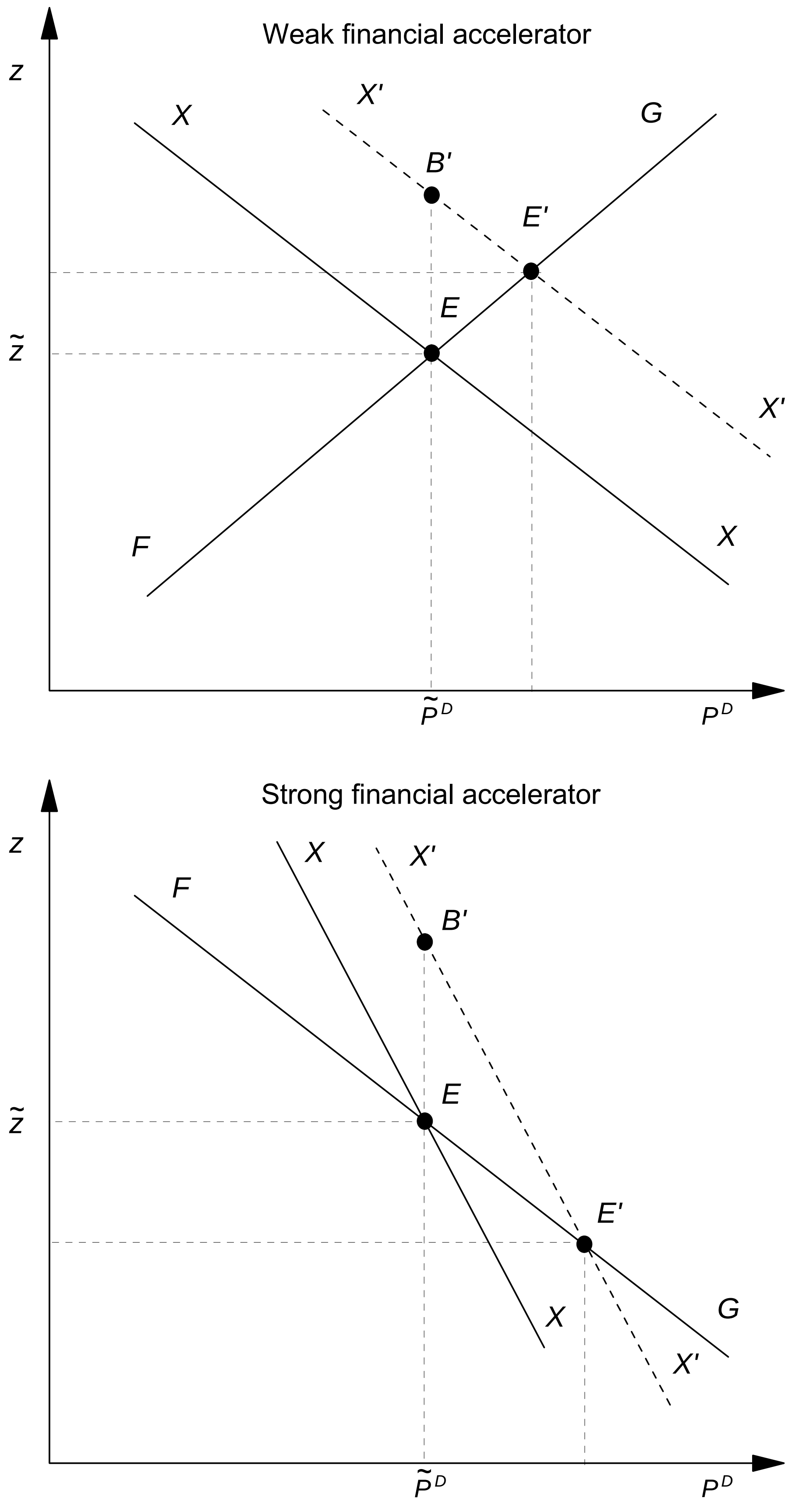


Figure 10

Reduction in Foreign Interest Rate

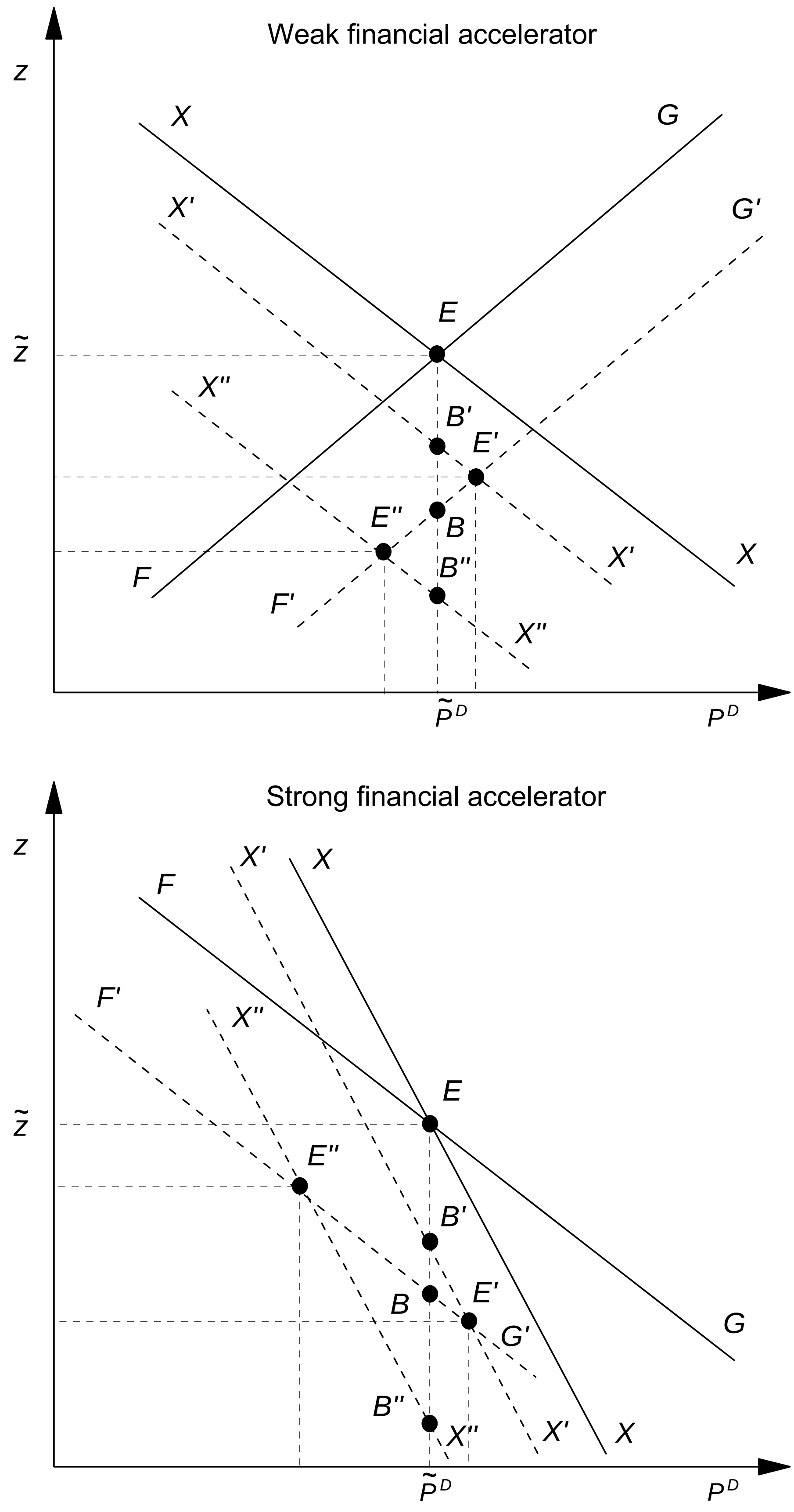


Figure 11
Policy Combination: Monetary and Fiscal Policies
(Weak Cost Channel and Financial Frictions)

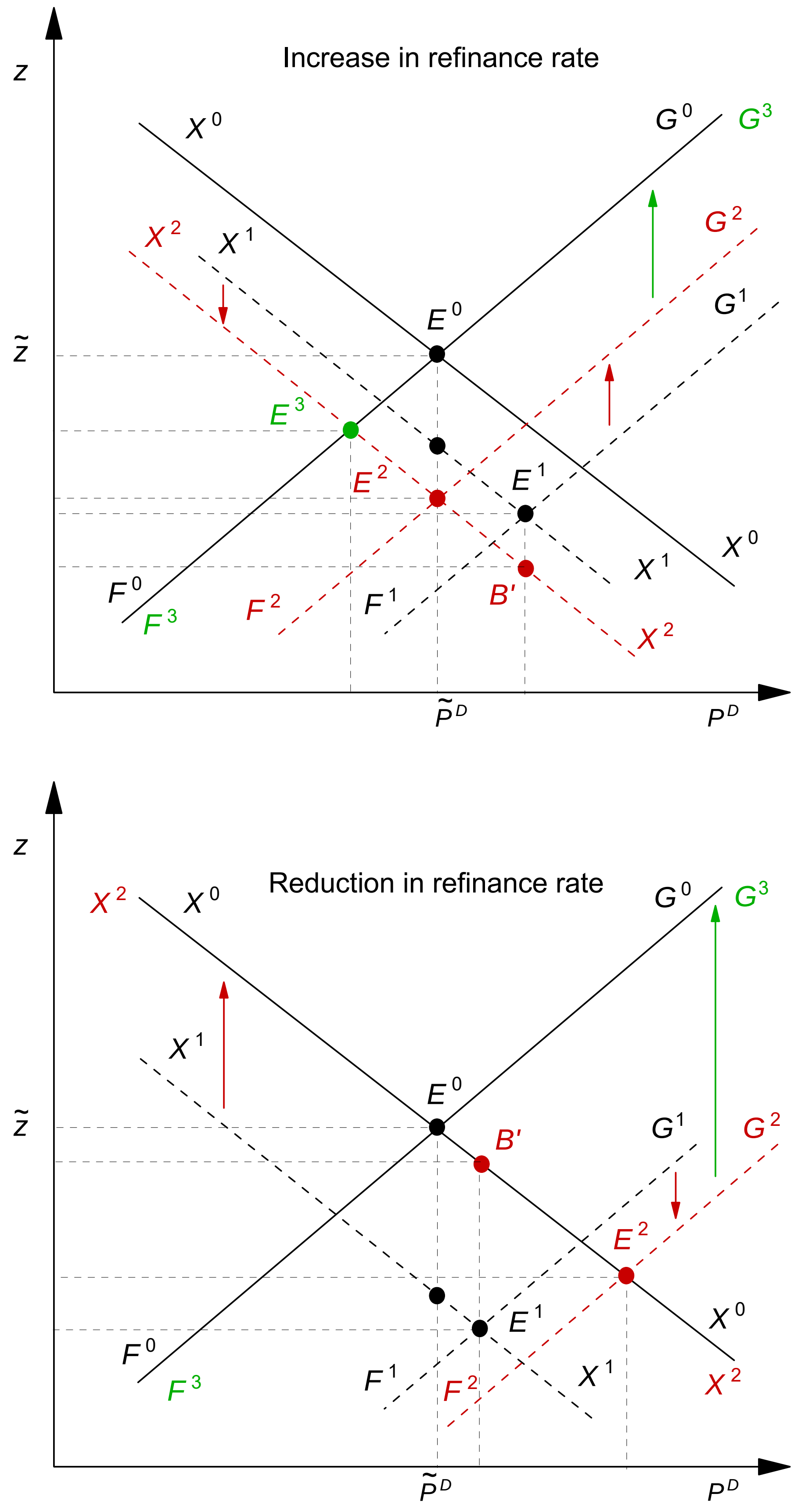
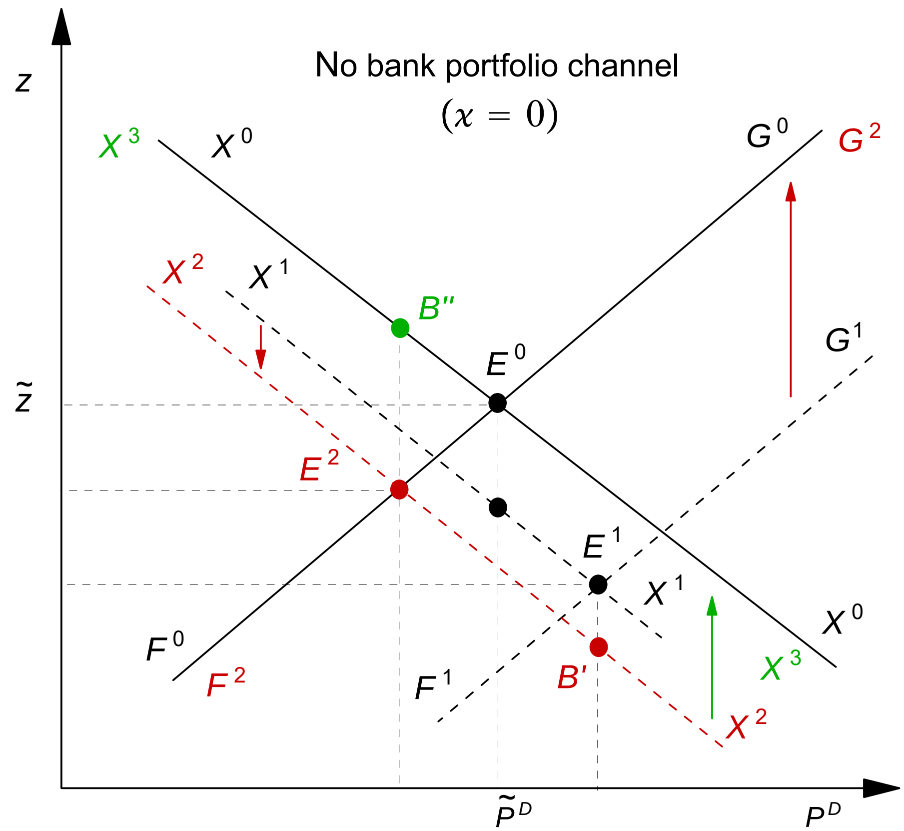


Figure 12
Policy Combination: Monetary Policy and Sterilized Intervention
(Weak Cost Channel and Financial Frictions)



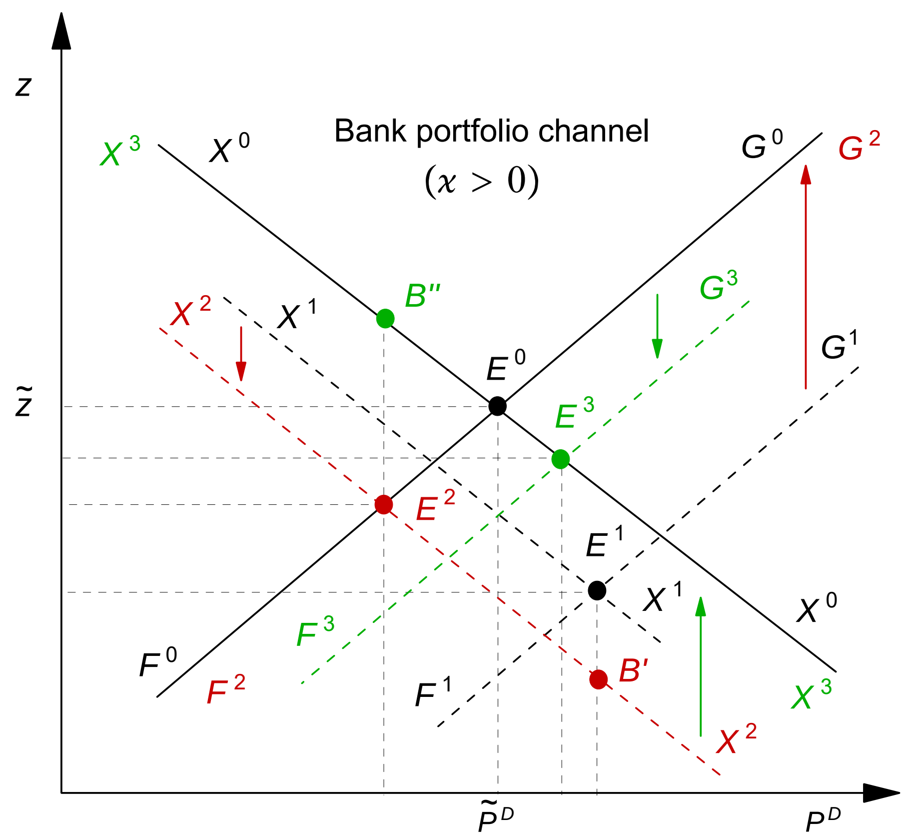


Figure 13
Policy Combination: Monetary Policy and Macroprudential Tax
(Weak Cost Channel and Financial Frictions)

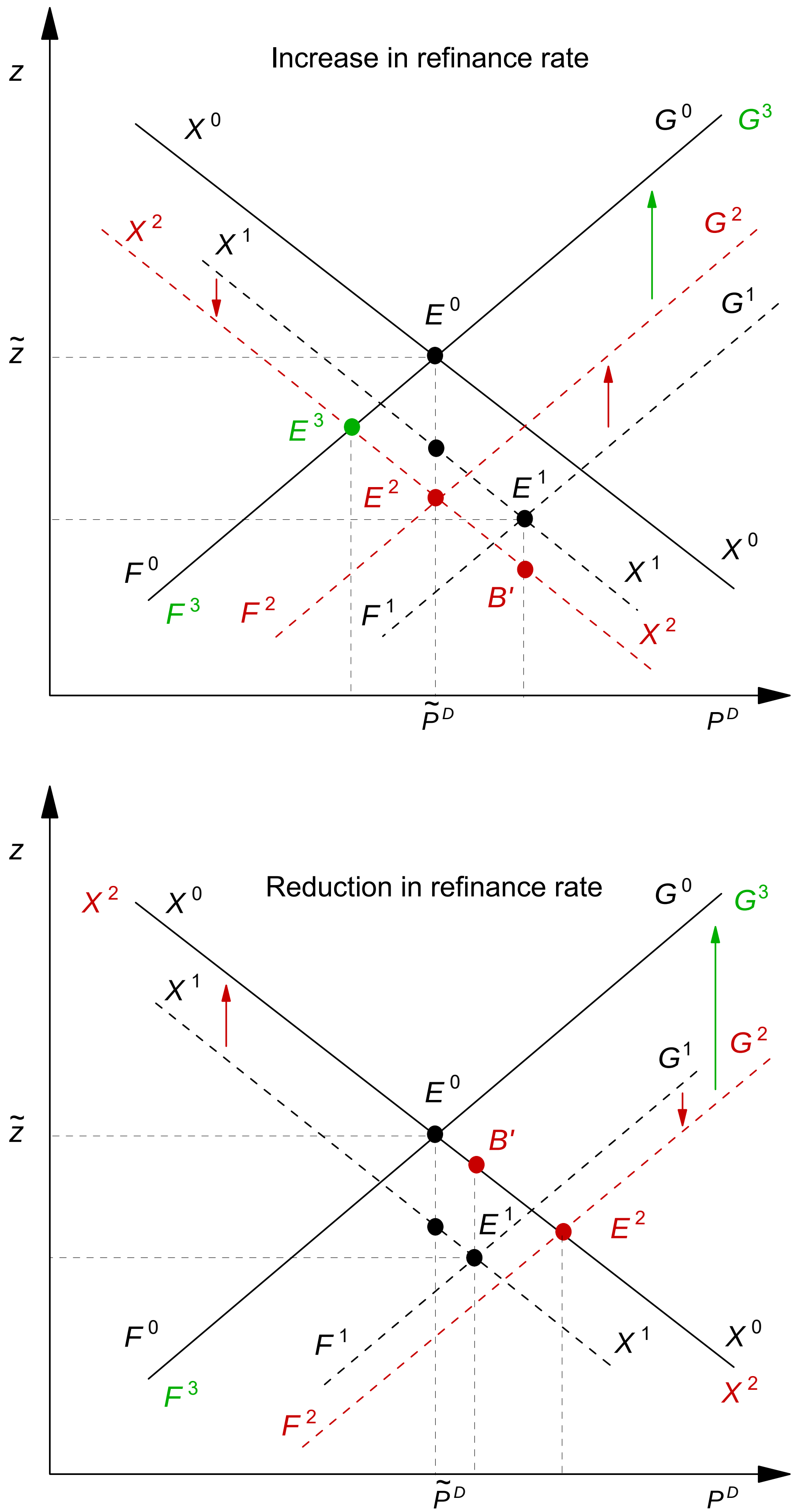


Figure 14
Policy Combination: Monetary Policy and Capital Control levy
(Weak Cost Channel and Financial Frictions)

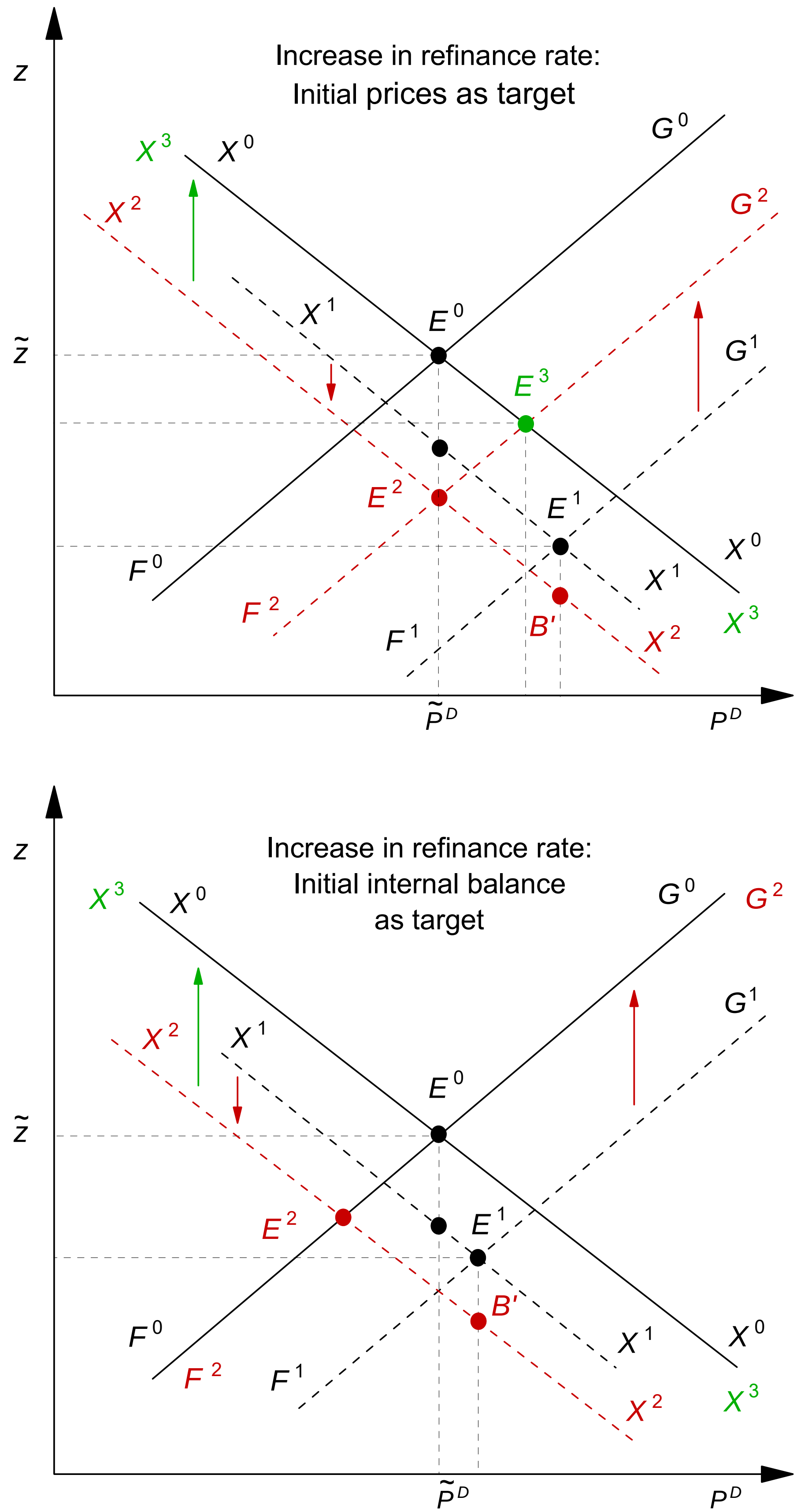


Figure 15
Policy Combination:Macroprudential Tax and Capital Control Levy
(Weak Cost Channel and Financial Frictions)

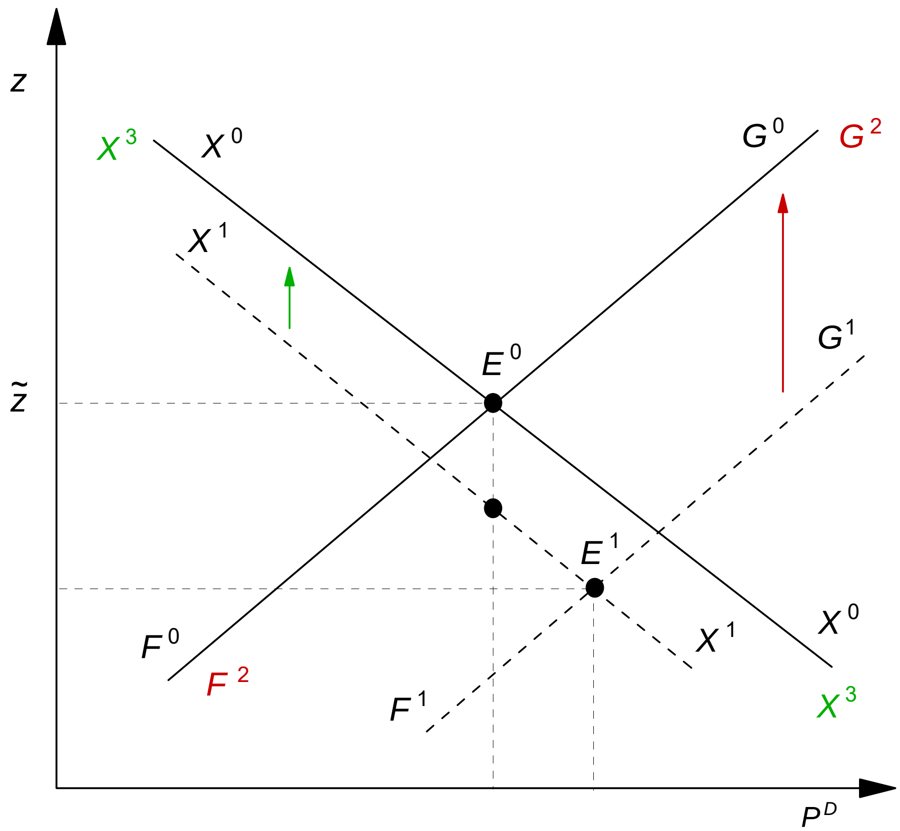
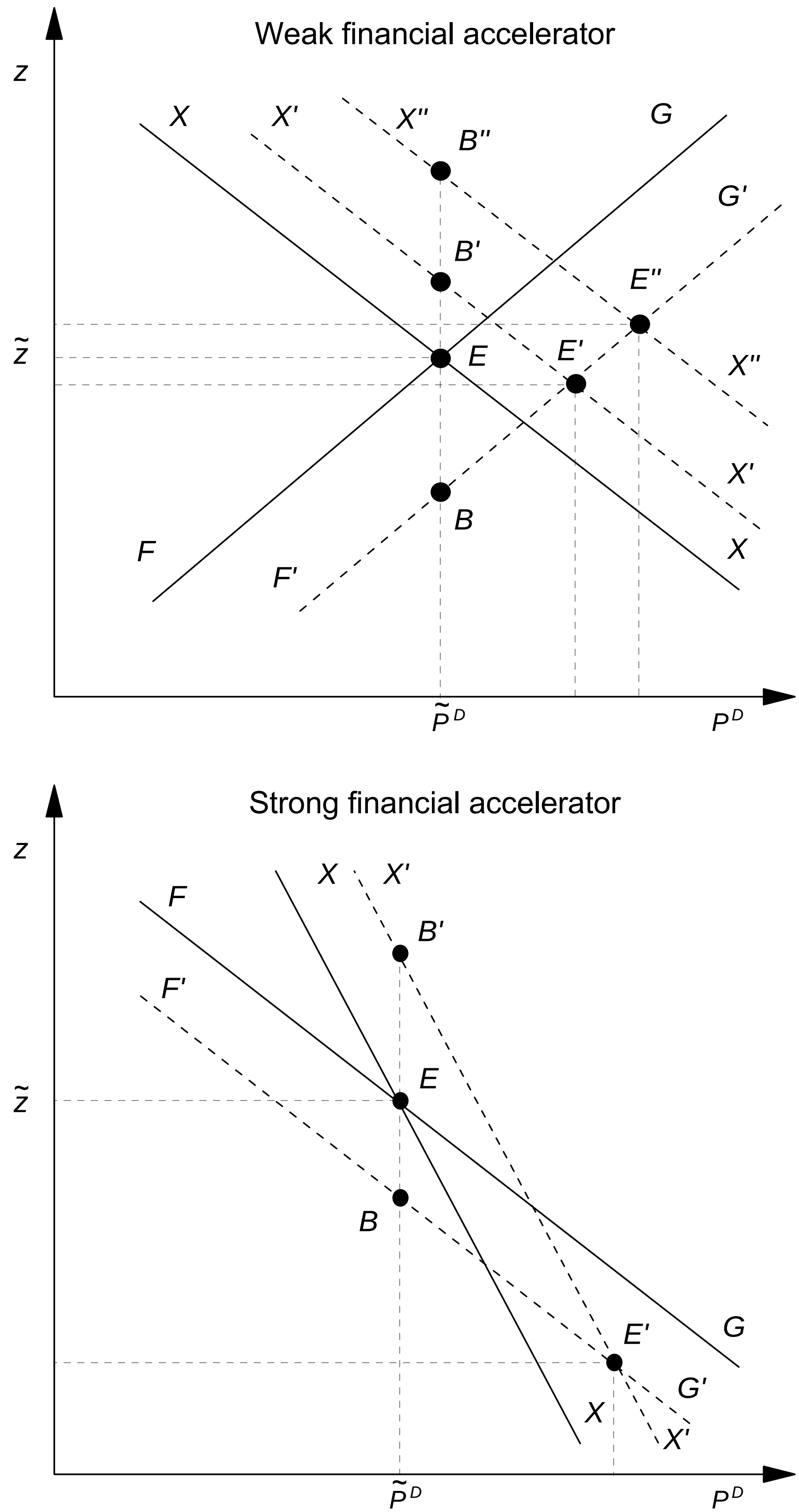


Figure 16
Increase in the Required Reserve Ratio



Appendix
Derivation of FG and XX Curves, Dynamic Stability Analysis, and Comparative Statics Experiments

In this Appendix, full derivations are provided for *a*) the functional forms of FG and XX, *b*) the dynamic stability condition on the slopes of these curves, and *c*) the comparative statics effects of shocks on P^D and z.

A1. Derivations of FG and XX Curves

Differentiating totally equation (40) yields

$$Y^s_{P^D} dP^D + Y^s_{i^R} di^R = (1-\delta)c_1(Y^s_{P^D} dP^D + Y^s_{i^R} di^R)$$

$$-(1-\delta)c_2[(1-\mu)di^R - i^R d\mu + di^*] + (1-\delta)c_3[-\frac{(F^H_0 - E_0 D^*_0)}{(P^D)^2} dP^D + D^*_0 dz]$$

$$+(1-\delta)c_3(p^H_{P^D} dP^D + p^H_{i^R} di^R + p^H_\mu d\mu + p^H_{i^*} di^*)$$

$$+I'(FF_{P^D} dP^D + FF_z dz + FF_{i^R} di^R + FF_\mu d\mu + FF_{\tau^L} d\tau^L + FF_{i^*} di^*) + dG + X'dz,$$

which can be rearranged and written in functional form as

$$z = FG(P^D; G, i^R, \mu, \tau^L, i^*), \tag{A1}$$

whose partial derivatives, noting that $F^H_0 - E_0 D^*_0 = M_0 + D_0$, are defined in the text.

Differentiating totally equation (42) yields

$$dD^* = \frac{d^*}{(zP^D)^2}[zP^D D^*_0(zdP^D + P^D dz) - (M_0 + D_0 + zP^D D^*_0)(zdP^D + P^D dz)] \tag{A2}$$

$$+\frac{(M_0 + D_0 + zP^D D^*_0)}{zP^D}[d^*_{i^D}\{(1-\mu)di^R - i^R d\mu\} + d^*_{i^*} di^*].$$

Noting that

$$zP^D D^*_0(zdP^D + P^D dz) - (M_0 + D_0 + zP^D D^*_0)(zdP^D + P^D dz)$$

$$= -(M_0 + D_0)(zdP^D + P^D dz),$$

equation (A2) becomes

$$dD^* = -\frac{d^*}{(zP^D)^2}(M_0 + D_0)(zdP^D + P^D dz)$$

$$+\frac{(M_0 + D_0 + zP^D D^*_0)}{zP^D}[d^*_{i^D}\{(1-\mu)di^R - i^R d\mu\} + d^*_{i^*} di^*],$$

which can be written in functional form as

$$D^* = D^*(z, P^D; i^R, \mu, i^*). \tag{A3}$$

The partial derivatives in this expression are defined in the text.

Differentiating totally equation (45) yields

$$z^{-1}(X' - \frac{X - \delta C}{z})dz - z^{-1}\delta c_1(Y^s_{P^D}dP^D + Y^s_{i^R}di^R)$$

$$+z^{-1}\delta c_2[(1-\mu)di^R - i^R d\mu + di^*] + z^{-1}\delta c_3[\frac{F_0^H - E_0 D_0^*}{(P^D)^2}]dP^D$$

$$-z^{-1}\delta c_3 D_0^* dz - z^{-1}\delta c_3(p^H_{P^D}dP^D + p^H_{i^R}di^R + p^H_\mu d\mu + p^H_{i^*}di^*) + F_0^* di^*$$

$$-(F_z^* dz + F^*_{P^D}dP^D + F^*_{i^R}di^R + F^*_\mu d\mu + F^*_{\tau^B}d\tau^B + F^*_{i^*}di^*) = 0,$$

so that

$$z = XX(P^D; G, i^R, \mu, \tau^L, \tau^B, i^*), \tag{A4}$$

whose partial derivatives, noting again that $F_0^H - E_0 D_0^* = M_0 + D_0$, are defined in the text.

A2. Local Stability Analysis

As noted in the text, $XX_{P^D} < 0$. Thus, when $FG_{P^D} < 0$, both FG and XX have a negative slope. The question that arises then is: how steep is FG relative to XX? The answer, which is crucial for understanding the comparative statics properties of the model and the adjustment process to shocks, can be provided by relying on Samuelson's correspondence principle, which essentially involves analyzing the local stability of the dynamic system associated with the model.[66]

Formally, consider the following dynamic adjustment process for the real exchange rate and domestic prices, z and P^D. Because the nominal exchange rate can adjust instantaneously to equilibrate the balance of payments—regardless of whether the central bank intervenes or not, as noted in the text—the real exchange rate is a jump variable, which depreciates when its current value is below (more appreciated than) its equilibrium value. In Walrasian fashion, domestic prices increase gradually when excess demand for goods sold at home is positive.

In continuous time, the first dynamic equation is

$$\frac{dz}{dt} = XX(P^D; \cdot) - z, \tag{A5}$$

where $XX()$ is the equilibrium value of z given by the external sector equilibrium condition (46). The second dynamic equation is

$$\frac{dP^D}{dt} = \lambda_G[C + I + G - \{Y^s(P^D; \cdot) - X(z)\}],$$

or, using the internal sector equilibrium condition (40), and noting that $F_0^H - E_0 D_0^* = M_0 + D_0$,

$$\frac{dP^D}{dt} = \lambda_G\left\{(1-\delta)\left\langle c_1 Y^s(P^D; \cdot) - c_2[(1-\mu)i^R + i^*] + c_3(\frac{M_0 + D_0}{P^D} + zD_0^*)\right.\right. \tag{A6}$$

[66] See Agénor (2020, chapter 2) for a more detailed discussion.

$$+ c_3 p^H(P^D;\cdot)\Big\rangle + I[FF(P^D, z;\cdot)] + G - Y^s(P^D;\cdot) + X(z)\Big\},$$

where $\lambda_G > 0$ is the speed of adjustment. Again, at any moment in time, if the real exchange rate is lower (higher) than its equilibrium value, it will increase (fall) subsequently, whereas if there is excess demand (supply) for goods, domestic prices will increase (fall) subsequently. Instantaneous price adjustment occurs when $\lambda_G \to \infty$, whereas the steady state corresponds to $dz/dt = dP^D/dt = 0$.

Linearizing equations (A5) and (A6) in the vicinity of the steady state yields, with a "~" denoting a steady-state value,

$$\begin{bmatrix} dz/dt \\ dP^D/dt \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ \lambda_G a_{21} & \lambda_G a_{22} \end{bmatrix} \begin{bmatrix} z - \tilde{z} \\ P^D - \tilde{P}^D \end{bmatrix}, \tag{A7}$$

and

$$a_{11} = -1 < 0,$$

$$a_{12} = XX_{PD} < 0,$$

$$a_{21} = \Delta = (1-\delta)c_3 D_0^* + I'FF_z + X' > 0,$$

$$a_{22} = -[1-(1-\delta)c_1]Y^s_{PD} - \frac{(1-\delta)c_3}{(P^D)^2}(M_0 + D_0) + (1-\delta)c_3 p^H_{PD} + I'FF_{PD}.$$

Thus, given that $Y^s_{PD} > 0$, $-(P^D)^{-2}(1-\delta)c_3(M_0 + D_0) + (1-\delta)c_3 p^H_{PD} < 0$ (given the assumption, discussed in the text, that the *net* wealth effect of an increase in P^D is negative), and $I' < 0$, if $FF_{PD} > 0$ then the condition $a_{22} < 0$ always holds; but if $FF_{PD} < 0$ and sufficiently large (which occurs if the strength of financial frictions, as measured by θ', is itself sufficiently large, all else equal), then $a_{22} > 0$.

The real exchange rate is a jump variable, whereas the domestic price level is a state variable. Saddlepath stability of the dynamic system (A7) requires therefore that the two eigenvalues be of opposite sign. A necessary and sufficient condition for that to occur is that the matrix of coefficients of the linearized system (or Jacobian), $\mathbf{A}$, which is equal to the product of the roots, has a negative determinant:

$$\det \mathbf{A} = \lambda_G(a_{11}a_{22} - a_{12}a_{21}) < 0.$$

For this condition to hold, it must be that

$$\frac{a_{22}}{a_{21}} < \frac{a_{12}}{a_{11}}. \tag{A8}$$

From the definitions of the a_{ij} coefficients provided earlier,

$$\frac{a_{12}}{a_{11}} = -XX_{PD} > 0,$$

and, given the definition of FG_{PD} provided in the text (see below (41)),

$$\frac{a_{22}}{a_{21}} = -FG_{PD} > 0.$$

Thus, condition (A8) can also be written as

$$-FG_{P^D} < -XX_{P^D}, \tag{A9}$$

which implies that the slope of XX must be steeper, in absolute terms, than the slope of FG.

It is important to note that, in the foregoing analysis, the expected inflation rate (in terms of the price of domestic goods), the expected house price inflation, and the expected depreciation rate, π^e, $\pi^{H,e}$, and ε, are all taken as given (and initially normalized to zero). This assumption is an acceptable way to proceed in a static framework (especially if there is a high degree of inertia in the way expectations are formed) and in a dynamic analysis where the goal is to determine the extent to which stability conditions can help to inform comparative statics exercises—as is the case here. However, in a more general analysis, a more thorough discussion of the issue of how expectations are determined would be essential to study the stability properties of the model and their implications for macroeconomic adjustment. This is best achieved by using more complex, quantitative dynamic general equilibrium models.

A3. Comparative Statics Analysis

Fiscal policy

Differentiating (41) and (46), holding i^R, μ, τ^L, τ^B, and i^* constant, gives

$$dz = FG_{P^D}dP^D + FG_G dG,$$

$$dz = XX_{P^D}dP^D + 0 \cdot dG,$$

or, in matrix form,

$$\begin{bmatrix} 1 & -FG_{P^D} \\ 1 & -XX_{P^D} \end{bmatrix} \begin{bmatrix} dz \\ dP^D \end{bmatrix} = \begin{bmatrix} FG_G \\ 0 \end{bmatrix} dG.$$

This system can be solved using Cramer's rule to give (47).

Monetary policy

Differentiating (41) and (46), holding G, μ, τ^L, τ^B, and i^* constant, gives

$$dz = FG_{P^D}dP^D + FG_{i^R}di^R,$$

$$dz = XX_{P^D}dP^D + XX_{i^R}di^R,$$

or, in matrix form,

$$\begin{bmatrix} 1 & -FG_{P^D} \\ 1 & -XX_{P^D} \end{bmatrix} \begin{bmatrix} dz \\ dP^D \end{bmatrix} = \begin{bmatrix} FG_{i^R} \\ XX_{i^R} \end{bmatrix} di^R.$$

Solving this system using Cramer's rule gives (48).

Macroprudential policy

Differentiating (41) and (46), holding G, i^R, μ, τ^B, and i^* constant, gives

$$dz = FG_{P^D} dP^D + FG_{\tau^L} d\tau^L,$$

$$dz = XX_{P^D} dP^D + 0 \cdot d\tau^L,$$

or, in matrix form,

$$\begin{bmatrix} 1 & -FG_{P^D} \\ 1 & -XX_{P^D} \end{bmatrix} \begin{bmatrix} dz \\ dP^D \end{bmatrix} = \begin{bmatrix} FG_{\tau^L} \\ 0 \end{bmatrix} d\tau^L.$$

Solving this system gives the equilibrium response of the real exchange rate and domestic prices, as shown in (49).

Capital controls

Differentiating (41) and (46), holding G, i^R, μ, τ^L, and i^* constant, gives

$$dz = FG_{P^D} dP^D + 0 \cdot d\tau^B,$$

$$dz = XX_{P^D} dP^D + XX_{\tau^B} d\tau^B,$$

or, in matrix form,

$$\begin{bmatrix} 1 & -FG_{P^D} \\ 1 & -XX_{P^D} \end{bmatrix} \begin{bmatrix} dz \\ dP^D \end{bmatrix} = \begin{bmatrix} 0 \\ XX_{\tau^B} \end{bmatrix} d\tau^B.$$

Solving this system gives the equilibrium response of z and P^D, as shown in (50).

Shock to world interest rate

Differentiating (41) and (46), holding G, i^R, μ, τ^L, and τ^B constant, gives

$$dz = FG_{P^D} dP^D + FG_{i^*} di^*,$$

$$dz = XX_{P^D} dP^D + XX_{i^*} di^*,$$

or, in matrix form,

$$\begin{bmatrix} 1 & -FG_{P^D} \\ 1 & -XX_{P^D} \end{bmatrix} \begin{bmatrix} dz \\ dP^D \end{bmatrix} = \begin{bmatrix} FG_{i^*} \\ XX_{i^*} \end{bmatrix} di^*.$$

Solving this system gives the equilibrium response of z and P^D, as shown in (51).

Change in required reserve ratio

Finally, differentiating (41) and (46), holding G, i^R, τ^L, τ^B and i^* constant, gives

$$dz = FG_{P^D} dP^D + FG_{\mu} d\mu,$$

$$dz = XX_{P^D} dP^D + XX_{\mu} d\mu,$$

or, in matrix form,

$$\begin{bmatrix} 1 & -FG_{P^D} \\ 1 & -XX_{P^D} \end{bmatrix} \begin{bmatrix} dz \\ dP^D \end{bmatrix} = \begin{bmatrix} FG_{\mu} \\ XX_{\mu} \end{bmatrix} d\mu.$$

Solving this system gives the equilibrium response of z and P^D, as shown in (57).

Previous volumes in this series

All volumes are available on our website www.bis.org.