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

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ABSTRACT

A simple integrated macroeconomic model of a small, bank-dependent open economy with a managed float and financial frictions is used to study the effects of five types of policy instruments: fiscal policy, monetary policy, macroprudential regulation, foreign exchange intervention, and capital controls. The paper also considers how, following a drop in the world interest rate, these instruments can be combined to restore the initial equilibrium. The analysis illustrates, using simple diagrams, how macro-financial policies can complement each other to manage capital inflows. In particular, it demonstrates that, to stabilize the economy, whether the response of 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 temporary capital controls is also shown to provide, in response to external financial shocks, a potent policy combination.

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 broader 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 instru-

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[1] See Patel and Cavallino (2019) for evidence on the goals of foreign exchange intervention, based on a survey of central banks.

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ments 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 used to calibrate policy responses and inform policy decisions.[2]

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 shocks, they must be calibrated (or estimated) and solved numerically. 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 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 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 possible 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. In that sense, it also provides intuition for some of the results that can be gauged from more advanced, quantitative models.

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 equilbrium—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), coupled 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 combination. 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. [3] 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, as well as liquidity constraints, intertemporal substitution, nominal wage rigidity, and economies of scope in banking. While some components are explicitly micro-founded, others 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. 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 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

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

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

nature of the model, it provides some useful insights with respect to the benefits (or lack thereof) of alternative policy combinations. Section 7 identifies various extensions of the model, whereas the last section offers some concluding remarks.

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. There are six categories of agents: firms, households, commercial banks, the central bank, the financial regulator, and the government.

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.

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.

Let W denote the nominal wage and N the quantity of labor employed. The wage bill, inclusive of borrowing costs, is thus $\left(1+\psi_W i^R\right)WN$, 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

$$N = \arg\max\left[P^D Y - \left(1+\psi_W i^R\right)WN\right]. \quad (1)$$

The production function takes a Cobb-Douglas form,

$$Y = N^{\alpha} K_0^{1-\alpha}, \quad (2)$$

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

Nominal wage rigidity prevails in the short run, so that $W = \overline{W}$. As shown in Appendix A, profit maximization yields

$$N^d = N^d\left(P^D; i^R\right),\ Y^s = Y^s\left(P^D; i^R\right), \quad (3)$$

where $N^d_{P^D}, Y^s_{P^D} > 0$ and $N^d_{i^R}, Y^s_{i^R} < 0$. 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:

$$I = I\left(i^L - \pi^e\right), \quad (4)$$

where i^L is the nominal loan rate, π^e the expected inflation rate, and $I' < 0$. Thus, total loans, L, are given by

$$L = \psi_W W N^d + L_0^I + P^D I,$$

where L_0^I 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.

Households

Households supply labor inelastically and consume the domestic and foreign goods.[4] They hold three categories of imperfectly substitutable financial assets: currency (which bears no interest), domestic–currency deposits, and foreign-currency deposits. They also hold land (equivalently, housing or real estate). Foreigners do not hold domestic assets.

Portfolio allocation

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

[4] 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.

$$F^H = M + D + ED^*, \tag{5}$$

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

This equation can be rewritten as

$$F^H = (M + D + E_0D^*) + (E - E_0)D^*,$$

that is,

$$F^H = F_0^H + (E - E_0)D_0^*, \tag{6}$$

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:

$$D/M = v\left(i^D\right).\ v' > 0 \tag{7}$$

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:

$$ED^*/D = \chi\left[i^D - (i^* + \varepsilon)\right], \chi' < 0 \tag{8}$$

As shown in Appendix A, substituting (7) and (8) in (5) yields

$$D/F^H = d\left(i^D; i^* + \varepsilon\right), \tag{9}$$

where, given that $v' > 0$ and $\chi' < 0, d_{i^D} > 0$ and $d_{i^*+\varepsilon} < 0$. An increase in the rate of return on domestic (foreign) deposits raises (lowers) the demand for domestic deposits.

Using (9) to substitute out for D yields the demand for cash as

$$M/F^H = m\left(i^D; i^* + \varepsilon\right), \tag{10}$$

where, as shown in Appendix A, $m_{i^D}, m_{i^*+\varepsilon} < 0$. [5] An increase in the return on domestic or foreign deposits lowers the demand for cash.

As also shown in Appendix A, from (8) and (9),

$$ED^*/F^H = d^*\left(i^D; i^* + \varepsilon\right), \tag{11}$$

where $d^*_{i^D} < 0$ and $d^*_{i^*+\varepsilon} > 0$. [6] An increase in the return on foreign (domestic) deposits has a positive (negative) effect on the demand for foreign deposits.

Total household wealth, A^H, is defined as

$$A^H = F^H + P^H\bar{h}, \tag{12}$$

where $\bar{h}$ is the fixed supply of land and P^H its nominal price.

The real demand for land is given by

$$H/P^D = h\left(i^D - \pi^e, i^* + \varepsilon - \pi^e, \pi^{H,e}, Y^s\right), \tag{13}$$

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 (Cesa-Bianchi et al. (2015)).

Consumption

Household consumption, C, measured in units of the domestic good, depends positively on income, Y^s, negatively on domestic and foreign expected real returns, $i^D - \pi^e$ 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:

[5] A restriction is needed to ensure that $m_{i^D} < 0$, see Appendix A.

[6] A restriction is also needed to ensure that $d^*_{i^D} < 0$, see Appendix A.

$$C = c_1 Y^s - c_2 \left[\left(i^D - \pi^e \right) + \left(i^* + \varepsilon - \pi^e \right) \right] + c_3 \left(\frac{A^H}{P^D} \right), \tag{14}$$

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 countries (See Agénor and Montiel (2015, chapter 2)). The positive effect of financial and housing wealth on consumption is also well-documented (see Peltonen et al. (2012)). The negative effect of the expected real returns on domestic and foreign deposits captures an intertemporal substitution effect. When these returns increase, 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.

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

$$L + RR + B^{CB} = D + L^B + EL^*. \tag{15}$$

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

$$RR = \mu D, \tag{16}$$

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:

$$i^D = (1 - \mu) i^R. \tag{17}$$

The loan market is monopolistically competitive. In a symmetric equilibrium, the interest rate on investment loans is a mark-up over the marginal cost of funds, that is, the refinance rate:

$$i^L = i^R + \theta - \varkappa \left(\frac{B^{CB}}{L_0^I} \right) + \gamma \tau^L, \tag{18}$$

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

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, $\bar{h}$, times P^H, the nominal price of land) over firms' initial liabilities (that is, beginning-of-period borrowing for investment, L_0^I),

$$\theta = \theta \left(\kappa P^H \bar{h} / L_0^I \right), \tag{19}$$

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.[7]

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. [8]

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

[7] See Agénor and da Silva, 2012, 2017 and Agénor and Jackson (2022) for specific examples, and Agénor (2020, chapters 5 and 6) for a broader discussion.

[8] 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.

$$EL^*/L_0^B = f^F\left[(1+\tau^B)i^* + \varepsilon - i^R\right], \tag{20}$$

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.

The demand function for central bank bonds is given by

$$B^{CB}/L_0^I = f^B\left(i^{CB} - i^R\right), \tag{21}$$

where $f^{B\prime} > 0$. The demand for central bank bonds is positively related to the differential between the return on these bonds, i^{CB}, and the refinance rate. A portfolio equation essentially similar to (21) is derived in Agénor et al. (2020), under economies of scope and a premium that depends on how much banks borrow on world capital markets. [9]

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 (15).

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 a managed float regime and sells its own bonds to banks, to sterilize its intervention operations.[10]

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:

$$E_0R^* + L^B = M + RR + B^{CB}, \tag{22}$$

where capital gains or losses on foreign exchange reserves arising from fluctuations in the market exchange rate relative to its last period's value, $(E - E_0)R^*$, are assumed to be an off-balance sheet item.

Foreign reserves are adjusted through the rule

$$R^* - R_0^* = -\varphi^E[(E - E_0)/E_0], \tag{23}$$

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

Rule (23) captures a systematic *leaning against the wind* objective. It is consistent with the evidence (alluded to earlier) which suggests that middle-income countries tend to intervene frequently 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.

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:

$$B^{CB} - B_0^{CB} = \varphi^S E_0\left(R^* - R_0^*\right), \tag{24}$$

where B_0^{CB} is the beginning-of-period value of B^{CB} and $\varphi^S \in (0,1)$ measures the degree of sterilization.

Substituting (23) in (24) therefore yields

$$B^{CB} - B_0^{CB} = -\varphi^S\varphi^E(E - E_0). \tag{25}$$

Further, substituting (25) in (22) gives the change in the money supply as

$$M - M_0 = -(1-\varphi^S)\varphi^E(E - E_0) + \left(L^B - L_0^B\right) - (RR - RR_0). \tag{26}$$

Thus, if the exchange rate is fully flexible ($\varphi^E = 0$), or if full sterilization prevails ($\varphi^S = 1$), exchange rate fluctuations have no direct effect on domestic liquidity.

For its part, the regulator sets the required reserve ratio, μ, the macroprudential tax, τ^L, and the capital control levy on bank foreign borrowing, τ^B.

[9] Note also that, to simplify, in (20) and (21) central bank borrowing and loans are measured at the beginning of period, as in (18).

[10] The assumption that sterilization bonds are held only by commercial banks, rather than 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.

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, and suppose that the foreign-currency price of imported goods, which is exogenous, is normalized to unity. The cost-of-living index, P, can be defined as

$$P = \left(P^D\right)^{1-\delta} E^{\delta}. \tag{27}$$

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

$$z = E/P^D. \tag{28}$$

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 (21) and (24), so that

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

Substituting the intervention rule (23) for the change in reserves in this expression yields

$$f^B\left(i^{CB} - i^R\right) = \frac{B_0^{CB}}{L_0^I} - \frac{\varphi^S \varphi^E}{L_0^I}(E - E_0). \tag{29}$$

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:

$$Y^s - X(z) = (1 - \delta)C + I + G, \tag{30}$$

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

$$E^{-1} P^D [X(z) - \delta C] + i^* (D_0^* + R_0^* - L_0^*) \tag{31}$$

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

where δC represents real imports in domestic–currency terms.

Given that from (28) $E/P^D = z$, condition (31) can also be written as

$$z^{-1}[X(z) - \delta C] + (1 + i^*)F_0^* - F^* = 0, \tag{32}$$

where $F^* = D^* + R^* - L^*$ is the economy's net stock of foreign assets.

The equilibrium condition of the land market is given by

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

which, using (13) and setting $\bar{h} = 1$, can be solved for the real price of land, p^H:

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

that is, using (3) and (17) to substitute out for Y^s and i^D,

$$p^H = p^H\left(P^D; i^R, \mu, i^* + \varepsilon\right), \tag{33}$$

where[11]

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

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, reduces land prices. 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 (10) and (22). But by Walras law that condition can be eliminated.

Table 1 summarizes the list of variables and their definitions.

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

First, consider the financial market equilibrium condition. By substituting (21) in (18), the third term in the latter expression becomes $-\varkappa f^B\left(i^{CB} - i^R\right)$; thus, using (29) gives the loan rate as

$$i^L = i^R + \theta - \varkappa\left(\frac{B^{CB}_0}{L^I_0}\right) + \varkappa\frac{\varphi^S\varphi^E}{L^I_0}(E - E_0) + \gamma\tau^L. \tag{34}$$

Thus, 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 financial market equilibrium conditions. Noting that $E = zP^D$ from (28) while $P^H = P^D p^H$, and substituting (33) in (19) and the result in (34) for θ, yields

$$i^L = FF\left(P^D, z; i^R, \mu, \tau^L, i^*\right), \tag{35}$$

where

$$FF_{P^D} = \theta'\left(p^H + P^D p^H_{P^D}\right)\left(\frac{\kappa}{L^I_0}\right) + \frac{\varkappa\varphi^S\varphi^E z}{L^I_0},$$

$$FF_z = \varkappa\varphi^S\varphi^E P^D/L^I_0 > 0, FF_{i^R} = 1 + \theta' P^D p^H_{i^R}\left(\kappa/L^I_0\right) > 0,$$

$$FF_{\tau^L} = \gamma > 0, FF_{i^*} = \theta' P^D p^H_{i^*+\varepsilon}\left(\kappa/L^I_0\right) > 0.$$

Eq. (35) 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. 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 $|\theta'|$, which measures the strength of the financial accelerator effect, is sufficiently large, the first effect dominates and $FF_{P^D} < 0$. Otherwise, $FF_{P^D} \gtrless 0$.

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 $|\theta'|$. 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 ($\varkappa = 0$).

[11] From this point on, partial derivatives with respect to $\mu$are discussed in Appendix B, in the subsection on reserve requirements.

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
p^H	Real price of land
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^I	Stock of 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	Default premium
RR	Required reserves
Policy instruments	
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
i^*	Foreign interest rate

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 $FF_{i^R}, FF_{\tau^L} > 0$. 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 Eq. (3) and the investment function (4), together with the consumption function (14), after incorporating (6) and (12) for real wealth, as well as (17) for the domestic deposit rate, in condition (30), together with the equilibrium condition of the housing market (33) for the real price of land, and (28) for the nominal exchange rate, gives

$$Y^s\left(P^D; i^R\right) = (1-\delta)\Big\{c_1 Y^s\left(P^D; i^R\right) - c_2\left[(1-\mu)i^R + i^*\right] \tag{36}$$

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

Finally, consider the equilibrium condition of the market for foreign exchange. Using again the consumption function (14), and (17) to substitute out for the deposit rate, together with the equilibrium condition of the market for land (33), Eq. (32) can be written as

$$z^{-1}X(z) - z^{-1}\delta\Big\{c_1Y^s\Big(P^D;i^R\Big) - c_2\Big[(1-\mu)i^R + i^*\Big]$$
$$+c_3\left[\frac{F_0^H + \Big(zP^D - E_0\Big)D_0^*}{P^D} + p^H\Big(P^D;i^R,\mu,i^*\Big)\right]\Big\} + (1+i^*)F_0^* - F^* = 0. \tag{37}$$

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) loan 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 Eqs. ()()()(35)–(37). However, working with three variables makes it impossible to use simple, two-dimensional diagrams to characterize the equilibrium and conduct policy analysis. Fortunately, a judicious substitution helps to bring the model down to two equilibrium conditions. Indeed, the financial equilibrium condition (35) can be substituted in the goods market equilibrium condition (36) for i^L, the loan rate. At the same time, the equilibrium condition of the balance of payments, (37), 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 (36) using (35), the model collapses to two equations, which can be solved, analytically and graphically, for the remaining two variables, z and P^D.

Internal balance

As shown in Appendix A, substituting the financial market-land market equilibrium condition (35) in the goods market equilibrium condition (36) and solving gives the *internal balance condition*, in terms of a relationship between the real exchange rate and the price of domestic goods:

$$z = FG\Big(P^D;G,i^R,\mu,\tau^L,i^*\Big), \tag{38}$$

where

$$FG_{P^D} = \Delta^{-1}\left\{[1-(1-\delta)c_1]Y^s_{P^D} + \frac{(1-\delta)c_3}{\Big(P^D\Big)^2}(M_0 + D_0) - (1-\delta)c_3p^H_{P^D} - I'FF_{P^D}\right\},$$

$$FG_G = -\Delta^{-1}, FG_{\tau^L} = -\Delta^{-1}I'FF_{\tau^L},$$

$$FG_{i^R} = \Delta^{-1}\Big\{[1-(1-\delta)c_1]Y^s_{i^R} + (1-\delta)c_2(1-\mu) - (1-\delta)c_3p^H_{i^R} - I'FF_{i^R}\Big\},$$

$$FG_{i^*} = \Delta^{-1}\big[(1-\delta)c_2 - (1-\delta)c_3p^H_{i^*} - I'FF_{i^*}\big],$$

$$\Delta = (1-\delta)c_3D_0^* + I'FF_z + X'.$$

Consider first the term Δ, which measures the total effect of a real depreciation on excess demand. 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 effect on exports, X'. The wealth effect arises from the fact that, holding the price of domestic goods constant, a real depreciation is equivalent to a *nominal* depreciation. This depreciation 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. 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, $(1-\delta)c_3(M_0+D_0)/\Big(P^D\Big)^2$ 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; at the same time, they increase real house prices, which has the opposite effect on consumption. It will be assumed in what follows that $p^H_{P^D}$ (or, more specifically, h_{Y^s} in (33)) 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 $FF_{P^D} \gtrless 0$; 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}; 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.[12] 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 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 consider the case where the cost channel is strong—that is, ψ_W, and thus $|Y^s_{i^R}|$, is sufficiently large, given c_2 and c_3—to ensure that $FG_{i^R} < 0$.[13]

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 the 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). 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, $FG_{i^*} > 0$.

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.

As shown in Appendix A, based on the solution for D^*,

$$F^* = F^*\left(z, P^D; i^R, \mu, \tau^B, i^*\right). \tag{39}$$

A depreciation, holding domestic prices constant, 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 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 ($F^*_{\tau^B}, F^*_{i^*} > 0$).

As also shown in Appendix A, substituting (39) in the equilibrium condition of the market for foreign exchange, (37), and solving, yields the *external balance condition*, which relates again the real exchange rate and the price of domestic goods:

$$z = XX\left(P^D; G, i^R, \mu, \tau^L, \tau^B, i^*\right), \tag{40}$$

where

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

[13] 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, $p^H_{i^R}$).

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

$$XX_G = 0, XX_{\tau^L} = 0, XX_{\tau^B} = \Omega^{-1}F^*_{\tau^B},$$

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

$$XX_{i^*} = \Omega^{-1}\left(-z^{-1}\delta c_2 + z^{-1}\delta c_3 p^H_{i^*} - F^*_0 + F^*_{i^*}\right),$$

$$\Omega = z^{-1}\left(X' - \frac{X - \delta C}{z}\right) - F^*_z - z^{-1}\delta c_3 D^*_0.$$

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.[14] The second term, $-F^*_z$, is positive and arises from the combination of valuation and intervention effects associated with an exchange rate change. The third 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. In what 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 $-z^{-1}\delta c_3 D^*_0$), so 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, $z^{-1}\delta c_1 Y^s_{P^D}$, 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, $-z^{-1}\delta c_3\left(P^D\right)^{-2}(M_0 + D_0)$ and $z^{-1}\delta c_3 p^H_{P^D}$, 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, $F^*_{P^D}$, 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. This effect is thus negative, given that $F^*_{P^D} < 0$. 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 maintain equilibrium. Thus, $XX_{P^D} < 0$.[15]

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 $z^{-1}\delta c_1 Y^s_{i^R}$; 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 $z^{-1}\delta c_3 p^H_{i^R}$. 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 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 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

[14] 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 δconstant, 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 δdepends on relative prices is discussed in Appendix B.

[15] Agénor (2021) discussed the case where $XX_{P^D} > 0$.

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.[16]

Graphical illustration

Fig. 1 presents the determination of macroeconomic equilibrium when the financial accelerator is weak and the internal balance curve is positively sloped ($FG_{P^D} > 0$).[17] The external balance curve, XX, has a negative slope, given that $XX_{P^D} < 0$. The equilibrium is at point E. Given the solutions for P^D and z, 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, $Y^s - X$, can be readily derived.

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. Of course, given the static nature of the model, this gradual adjustment process does not involve explicitly an element of time. Nevertheless, as is made clear later on, it helps 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.

Macro-financial policy analysis

We consider the effects of changes in five types of macro-financial policy instruments: fiscal policy, monetary policy, macroprudential regulation, discretionary intervention in the foreign exchange market, and capital controls.[18] As discussed in the introduction, in recent years macroeconomic management in middle-income countries has relied increasingly 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),Coman and Lloyd (2022). Studying the transmission process of these instruments is thus important to determine the degree to which they are complementary, or substitutes, in responding to particular shocks.

Fiscal policy

Consider an increase in government spending, G. As shown in Appendix A, from (38) and (40) the equilibrium response of the real exchange rate and domestic prices are given by

$$dz/dG < 0, dP^D/dG > 0. \tag{41}$$

An increase in government spending leads to higher domestic prices and a real appreciation.

Fig. 2 illustrates these effects. Intuitively, an increase in government spending creates excess demand at the initial levels of prices and production. The real (and 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 (38), $FG_G < 0$. Thus, while curve XX does not shift (it does not depend directly on government spending), curve FG shifts downward to $F'G'$. 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, when the shock occurs, the real exchange rate remains at E. 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.[19]

During the transition, the increase in domestic prices stimulates output (by lowering real wages) and raises the price of land, which lowers 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, $Y^s\left(P^D\right) - X(z)$, unambiguously increase—and so does domestic absorption, as implied by the goods market equilibrium condition (30). By contrast, the equilibrium effect on private consumption cannot be ascer-

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

[17] The case where the financial accelerator effect is strong enough to ensure not only that $FF_{P^D} < 0$ but also $FG_{P^D} < 0$ (that is, the internal balance curve has a negative slope) is discussed in an extended version of this paper, which is available upon request.

[18] The use of reserve requirements as an alternative macroprudential policy tool is discussed in Appendix B.

[19] There is also a valuation effect on capital flows, but this is less central to the adjustment process.

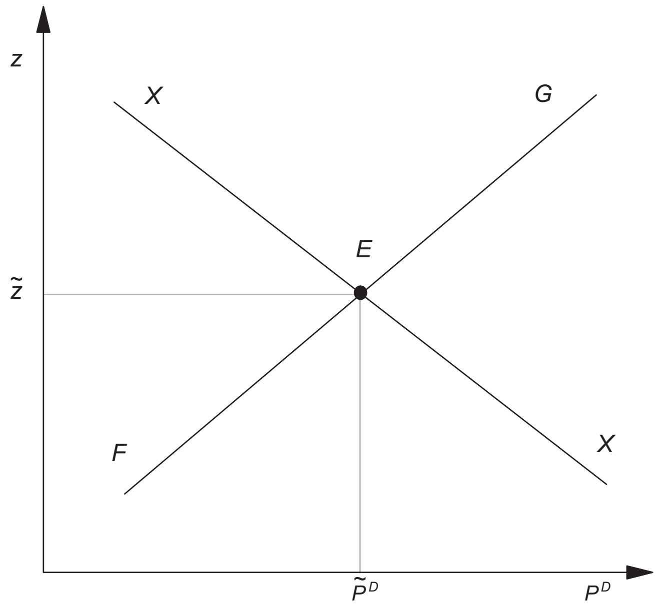

Fig. 1. Macroeconomic equilibrium.

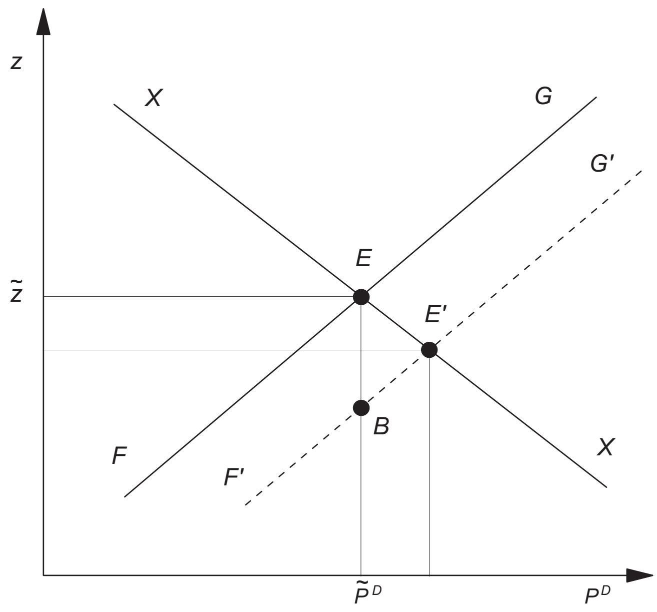

Fig. 2. Increase in government spending.

tained 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-outeffect.

Monetary policy

Consider an increase in the central bank refinance rate, i^R. The equilibrium solutions of the real exchange rate and domestic prices depend now on the strength of the cost channel (as measured by the sign of FG_{i^R}). Consider first the case where this channel is weak ($FG_{i^R} > 0$). As derived in Appendix A, the solution is

$$dz/di^R \gtrless 0, dP^D/di^R < 0, \tag{42}$$

which shows that the impact on domestic prices is negative, whereas the impact on the real exchange rate is ambiguous.

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 borrowers, which reduces investment. There is therefore a contraction in aggregate demand and excess supply prevails. To maintain internal balance at an unchanged value of prices, 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 Fig. 3.

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 must appreciate ($XX_{i^R} < 0$). Thus, XX shifts downward in Fig. 3 and z jumps from E to either B' or B''.

The implication of these shifts is that in the new equilibrium the price of the domestic good definitely falls—a contractionary monetary policy is always deflationary—but the impact on the real exchange rate cannot be ascertained a priori. As shown in Fig. 3, 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).[20]

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, the loan rate continues to increase. This movement corresponds to the *financial accelerator effect*. By implication, investment falls continuously during the adjustment process. While domestic production definitely contracts (the drop in domestic prices raises the real wage), the fact that the equilibrium effect on the real exchange is ambiguous means that the impact on exports is also ambiguous—and so is the net effect on domestic sales, $Y^s - X$. 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 exerts a negative income effect, which compounds the initial drop in spending due to intertemporal substitution.

Consider now the case of a strong cost channel ($FG_{i^R} < 0$). As shown in Appendix A, the solution is $dz/di^R < 0$ and $dP^D/di^R \gtrless 0$. The real exchange rate always appreciates, but the impact on domestic prices is now ambiguous. These results are illustrated in Fig. 4. 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, FG shifts now *downward* to $F'G'$. 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'. However, if the shift in 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. 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 ambiguous.

Macroprudential policy

Consider an increase in the macroprudential tax rate, τ^L. As shown in Appendix A, the equilibrium effects are

$$dz/d\tau^L > 0, dP^D/d\tau^L < 0. \tag{43}$$

Thus, an increase in the macroprudential tax rate leads to a real depreciation and a fall in domestic prices.

Fig. 5 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 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 down-

[20] As shown in the extended version of this paper, when the financial accelerator effect is strong the real exchange rate always depreciates, regardless of the magnitude of the shift in either curve.

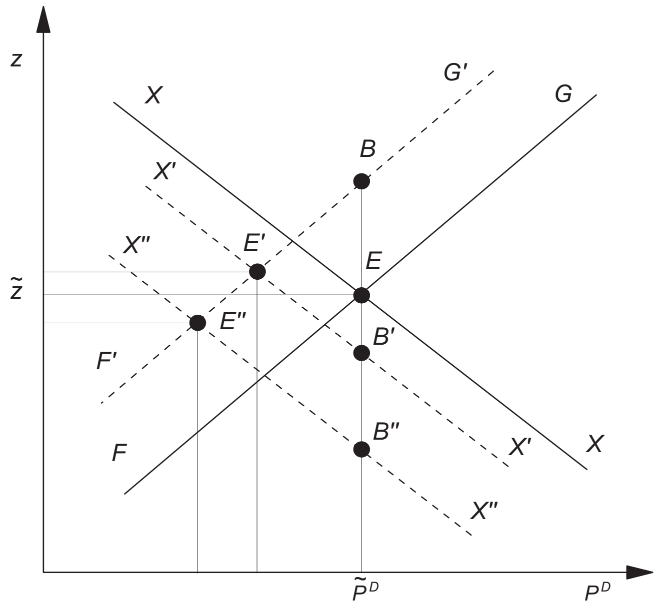

Fig. 3. Increase in refinance rate: weak cost channel.

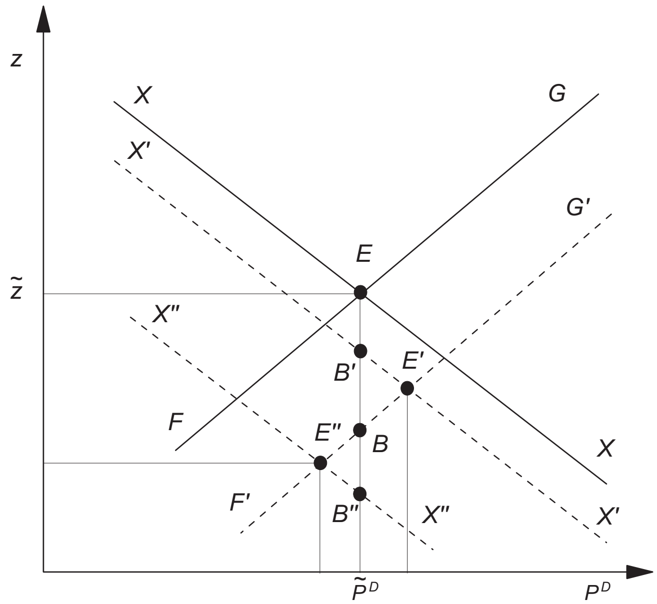

Fig. 4. Increase in refinance rate: strong cost channel.

ward pressure on domestic prices, which in turn (through a positive net wealth effect) raise consumption and imports. The current account therefore deteriorates. During the transition, 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.

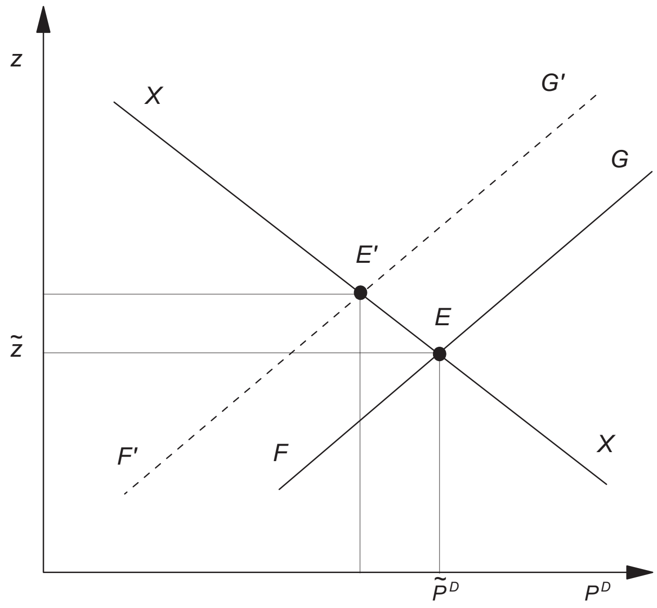

Fig. 5. Increase in macroprudential tax rate.

Foreign exchange intervention

To illustrate the role of foreign exchange intervention, rather than changes in rule (23) we 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 assets held abroad or an increase in bank foreign borrowing, which translates on impact into a reduction in the initial stock of net foreign assets, $\Delta F^* < 0$. For simplicity, intervention and sterilization operations are assumed to take place *before* this inflow affects spending and portfolio decisions.[21] Treating F^* as an exogenous variable in (37), it can be established that $XX_{F^*} = \Omega^{-1} > 0$, where now $\Omega = z^{-1}(X' - \delta c_3 D_0^*)$. 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 Fig. 6.

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, $\Delta M = E_0 \Delta R^*$. 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 is back to where it was initially and the equilibrium remains at E^0, which implies that sterilized intervention has no effect on the exchange rate or prices.

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 (18) and (35) $FF_{R^*} = -\varkappa < 0$. Using this result, from (36) $FG_{R^*} = -I' FF_{R^*} = I' \varkappa < 0$. Thus, an increase in reserves, holding domestic prices constant, induces also a downward shift in FG if $\varkappa > 0$, as shown in Fig. 6. 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, in the presence of a bank portfolio channel, a fully sterilized intervention is expansionary.

Capital controls

Consider an increase in the capital controls levy, τ^B. As shown in Appendix A, the equilibrium responses are given by

$$dz/d\tau^B > 0, dP^D/d\tau^B > 0. \tag{44}$$

Thus, the policy leads to an increase in domestic prices and a real depreciation.

[21] 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.

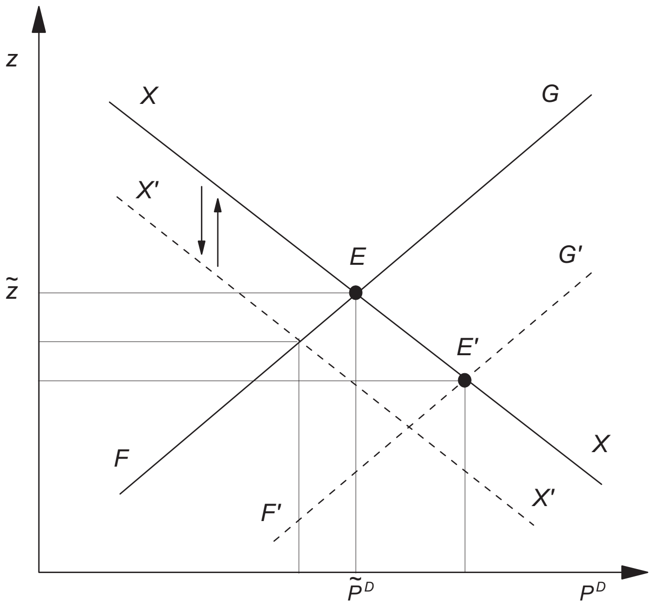

Fig. 6. Sterilized foreign exchange intervention.

Fig. 7 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 do not affect directly the equilibrium conditions of the financial and goods markets—whereas curve *XX* shifts upward to $X'X'$. 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 real wages, and an expansion of output. As shown in Fig. 7, the initial depreciation is followed by a subsequent appreciation to help restore internal balance at E'. 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 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.

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.[22] 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.

Reduction in world interest rate

As shown in Appendix A, the equilibrium responses to an increase in i^* are given by

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

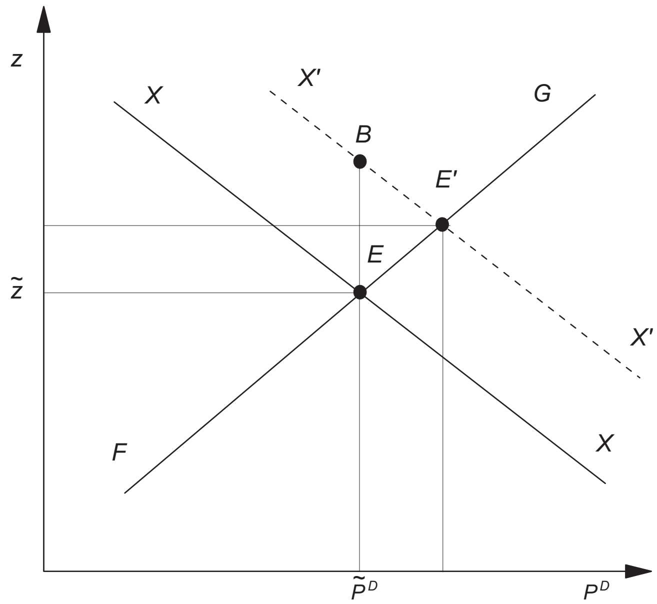

Fig. 7. Increase in capital controls levy.

$$dz/di^* > 0, dP^D/di^* \gtrless 0. \quad (45)$$

Thus, a *reduction*in the world interest rate always leads to a real appreciation but has an ambiguous effect on domestic prices.

Fig. 8 illustrates these effects. Both *FG* and *XX* shift downward. As noted earlier, $FG_{i^*} > 0$ (see (38)), which indicates that (holding domestic prices constant) the real exchange rate should appreciate (to point *B*) to maintain internal equilibrium. Focusing on the case where $XX_{i^*} > 0$ (see (40)), the real exchange rate actually appreciates, from *E* to either *B*′ or *B*″. 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.

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 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 magnitude of the shift in *XX*. Indeed, 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.

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.

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.[23] Moreover, we

[23] Other combinations of financial frictions (for instance, a strong financial accelerator effect coupled with a strong cost channel) can be studied in the same manner and are left to the interested reader.

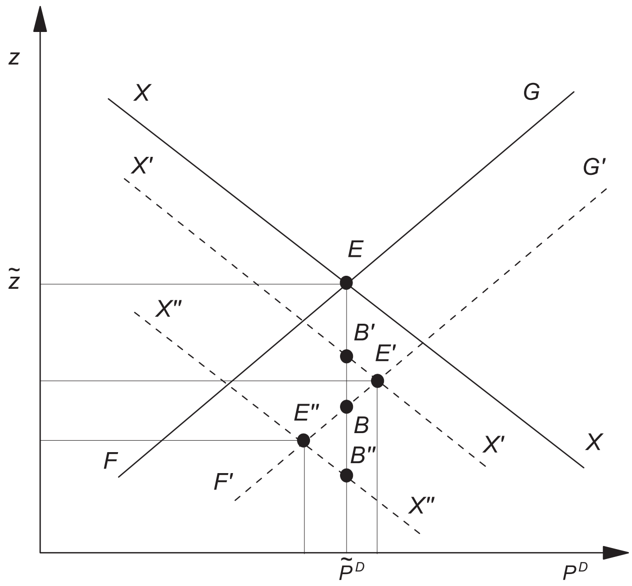

Fig. 8. Reduction in foreign interest rate.

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 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, we assume that the initial equilibrium is at E^0, corresponding to the intersection of curves F^0G^0 and X^0X^0 in Figs. 9 to 13, whereas the new equilibrium is at E^1, corresponding to E' in Fig. 8. The issue, therefore, is how macro-financial policies can be combined to bring about a reduction in domestic prices and a real depreciation in order to return the economy from E^1 to 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.

Given that there are two (core) objectives, Tinbergen's rule suggests that two instruments may be necessary. Therefore, we consider in turn the combinations of *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.

Monetary and fiscal policies

Fig. 9 illustrates outcomes when monetary and fiscal policies are combined. The transmission mechanism of these policies is as discussed earlier and represented in Figs. 2 and 3.

The upper panel of Fig. 9 shows what happens when the refinance rate, i^R, is *increased*. XX shifts downward, from X^1X^1 to X^2X^2, whereas FG shifts upward, from F^1G^1 to F^2G^2. This is consistent with the outcomes illustrated in Fig. 3. 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, to return z to its initial value, the authorities can calibrate a reduction in government spending, G, so as to ensure that 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 Fig. 2). But even if 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.

Suppose instead that the authorities, in a first step, decide to *reduce*the refinance rate. This is illustrated in the lower panel of Figure 9. 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. The monetary policy tightening mitigates therefore capital inflows. In fact, the increase in i^R can be calibrated in such a way that the upward shift in X^2X^2 takes it back 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

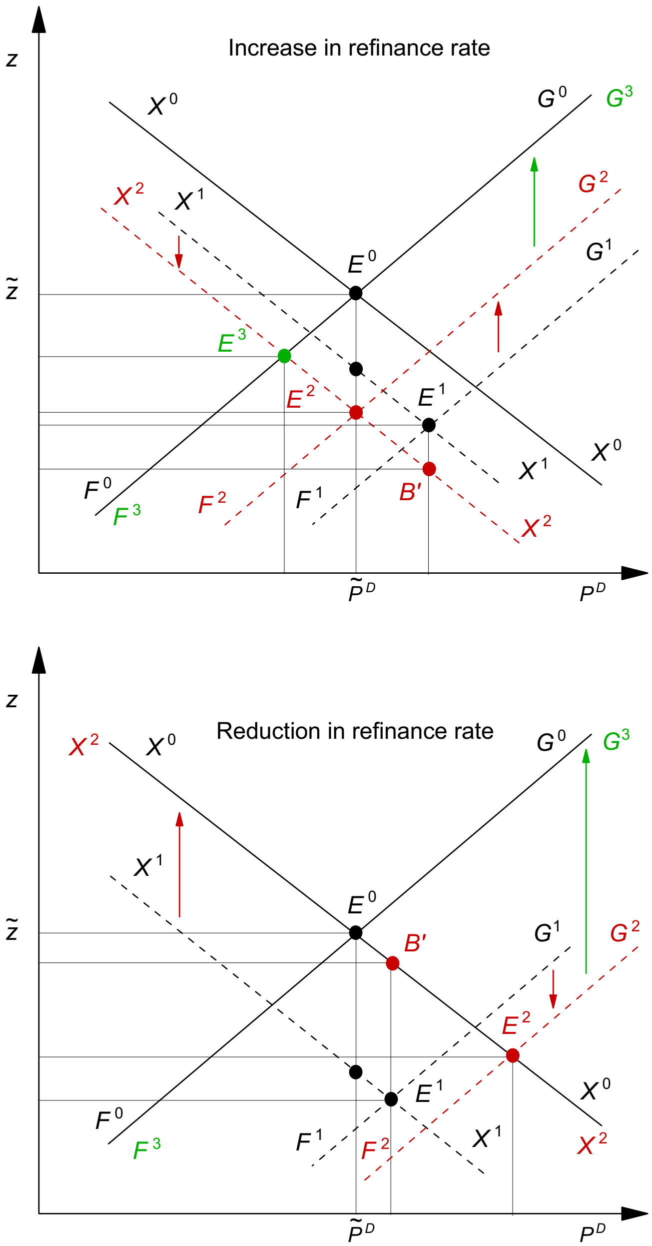

Fig. 9. Policy combination: monetary and fiscal policies.

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.[24]

But 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 (see, for instance, Ghosh et al. (2017)).

[24] 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 managing capital inflows with a single policy instrument.

Monetary policy and sterilized intervention

The case where a contractionary monetary policy is combined with discretionary, sterilized intervention is illustrated in Fig. 10, 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 Fig. 9), 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. 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 from F^1G^1 to F^2G^2, corresponding to the initial curve F^0G^0 . If so, 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 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 toward 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 Fig. 10. The first step (the increase in the refinance rate) is the same, and so is the 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.[25]

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 shift X^1X^1 back to X^0X^0, it would lead to a further shift *downward* in F^1G^1 (given its expansionary demand effects) which cannot be undone by sterilized intervention (which affects only the position of XX).

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.

Monetary and macroprudential policies

The case where policy authorities combine monetary policy and macroprudential regulation is illustrated in Fig. 11. First, consider the case where, as in the upper panel of the figure, the refinance rate is *increased*. As in Figs. 3, 9 and 10, 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 FG 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 Fig. 5. 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.

Second, suppose instead that, in an initial step, the authorities *reduce* the refinance rate. As shown in the lower panel of Fig. 11, XX shifts now upward from X^1X^1 to X^2X^2, whereas FG 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 τ^L can be calibrated in such a way that the internal balance curve shifts upward from F^2G^2 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) is an effective policy combination. 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.

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

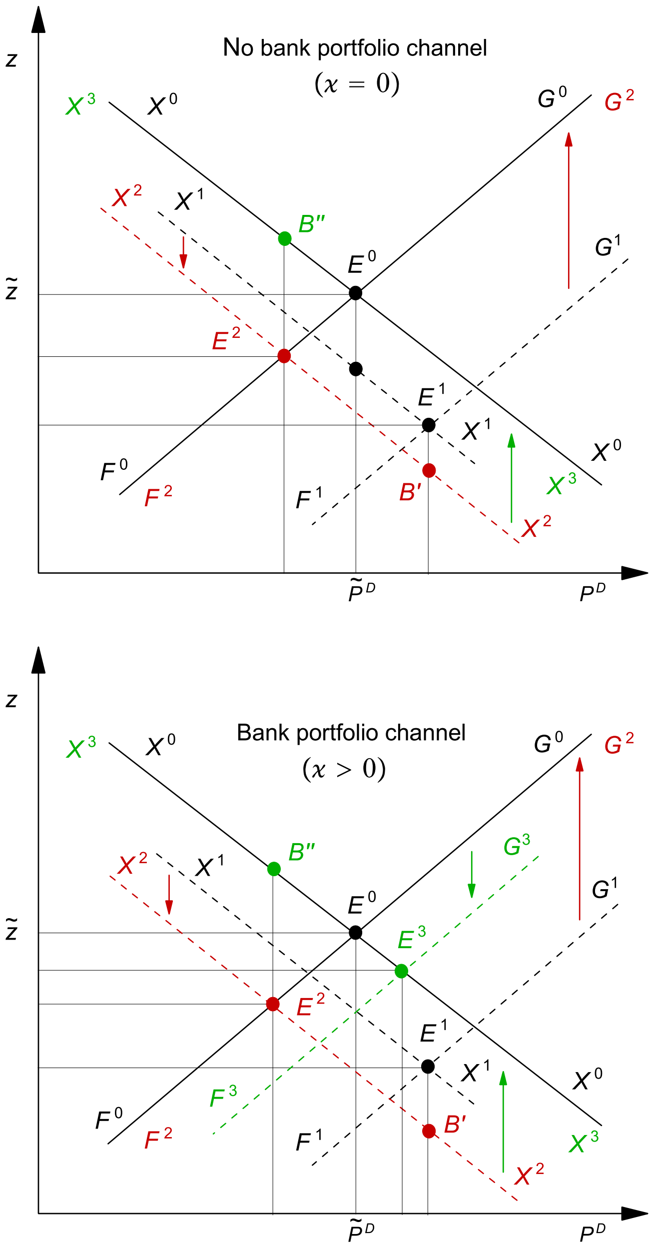

Fig. 10. Policy combination: monetary policy and sterilized intervention.

Monetary policy and capital controls

Consider now the combination of monetary policy and capital controls, which is illustrated in Fig. 12. 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), characterized by higher prices and a more appreciated exchange rate than initially.

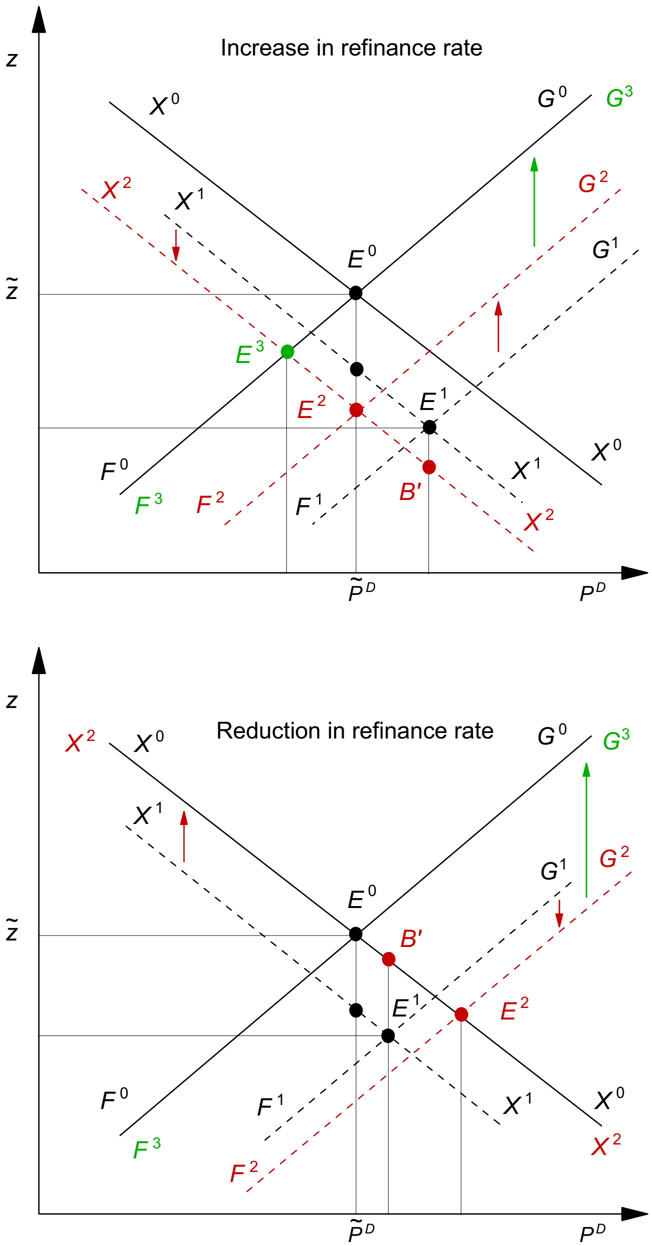

Fig. 11. Policy combination: monetary policy and macroprudential tax.

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 $F^2G^2 = F^0G^0$. 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 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 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 Figs. 9 and 11), 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 what works when, for instance, government spending is the only other tool available to policymakers (an expansionary monetary policy and a cut in spending).

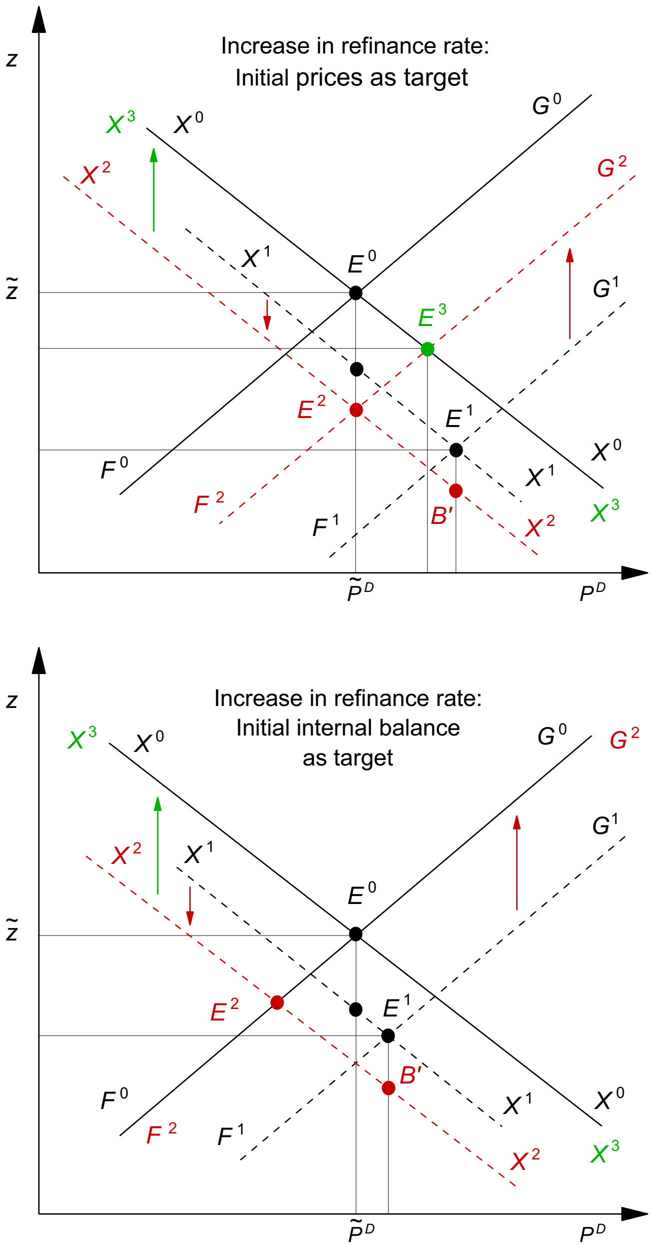

Fig. 12. Policy combination: monetary policy and capital controls levy.

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 Fig. 13. The results are a straightforward combination of Figs. 5 and 7; 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 τ^L can shift the internal balance curve from $F^1G^1$to $F^2G^2 = F^0G^0$, whereas a sufficiently large rise in τ^Bcan 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.[26]

[26] In a very different 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.

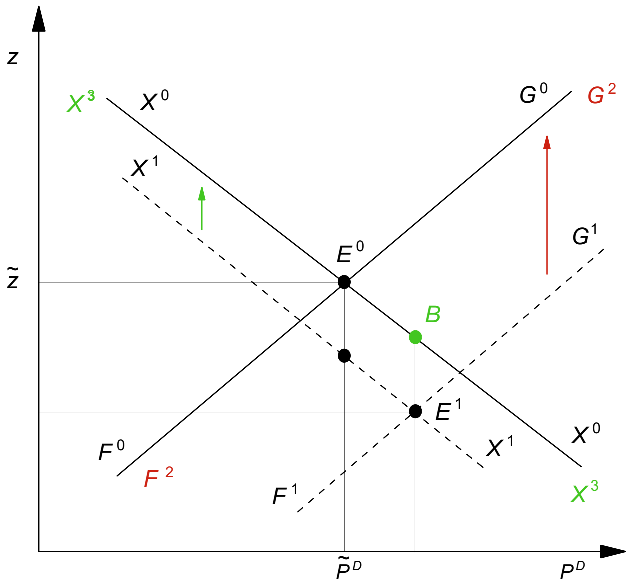

Fig. 13. Policy combination: macroprudential tax and capital controls levy.

In sum, while the previous results are obviously dependent on the structure of the model, the nature of the shock that we consider, and the assumed objectives of policymakers—returning the economy to its initial position, following an external shock—they illustrate fairly well the insights that can be gained on the joint performance of macro-financial policy instruments. Whether monetary policy should be tightened or relaxed in response to capital inflows depends on which other instruments policymakers have at their disposal. Depending on the range of tools available, different combinations may achieve the same result. In particular, 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 rigidities, the lack of fiscal space, and political constraints often make such response difficult to implement in the short term. The combination of tighter monetary policy and capital controls can also be fairly effective.

Extensions

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

The model can also be extended in a number of directions, so as to account for wage indexation, *intra*temporal substitution, endogenous depreciation expectations, changes in reserve requirements, endogenous inflation expectations, dominant currency pricing, asymmetric effects, and alternative shocks. Reserve requirements, for instance, have been used quite extensively in Latin America to respond to shocks—although, at times, as a substitute to monetary policy, rather than a tool to promote financial stability.[27] These extensions are discussed in Appendix B.

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 have been used repeatedly in middle-income countries in response to a variety of shocks.

[27] See Agénor and Pereira da Silva (2016) for a discussion, and Glocker and Towbin (2015), Coman and Lloyd (2019), and Fabiani et al. (2021) for formal empirical evidence.

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 manage capital flows—a perennial challenge for middle-income countries. 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 Ag énor and Pereira da Silva (2019, 2022) with a fiscal policy framework that involves the combination of fiscal rules with a stabilization fund. [28]

To conclude, it is worth pointing out some limitations of the analysis. The model did not address some important aspects of macroeconomic management, namely, the role of policy credibility and its impact on expectations (see, however, Appendix B). Structural features, such as dollarization, or the role of shadow banks, were also ignored. 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. Moreover, 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 face stronger incentives to diversify their policy responses.

Yet, it is also important to keep in mind the main motivation of 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.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jimonfin.2023.102841.

References

Adler, Gustavo, Chang, Kyun Suk, Wang, Zijiao, 2020. Patterns of Foreign exchange intervention under inflation targeting. IMF Working Paper No. 20/69. March.
Adrian, Tobias, Erceg, Christopher J., Kolasa, Marcin, Lindé, Jesper, Zabczyk, Pawel, 2021. A quantitative microfounded model for the integrated policy framework, Working Paper No. 21/292, International Monetary Fund (December 2021).
Agénor, Pierre-Richard, 2020. Monetary Policy and Macroprudential Regulation with Financial Frictions. The MIT Press, Cambridge, Mass..
Agénor, Pierre-Richard, Alper, Koray, da Silva, Luiz Pereira, 2018. External shocks, financial volatility and reserve requirements in an open economy. J. Int. Money Finance, 83, 23-43.
Agénor, Pierre-Richard, Jackson, Timothy, 2022. Monetary and macroprudential policy coordination with biased preferences. J. Econ. Dynam. Control 144, 1–32. November.
Agénor, Pierre-Richard, Jackson, Timothy, da Silva, Luiz Pereira, 2020. Foreign exchange intervention and financial stability, Working Paper No. 889, Bank for International Settlements.
Agénor, Pierre-Richard, Jia, Pengfei, 2020. Capital controls and welfare with cross-border bank capital flows. J. Macroecon. 65, 1–27. September.
Agénor, Pierre-Richard, Montiel, Peter J., 2015. Development Macroeconomics. Princeton University Press, Princeton, New Jersey.
Agénor, Pierre-Richard, da Silva, Luiz Pereira, 2012. Cyclical effects of bank capital requirements with imperfect credit markets. J. Finan. Stabil. 8, 43–56.
Agénor, Pierre-Richard, Pereira da Silva, Luiz, 2016. Reserve Requirements and Loan Loss Provisions as Countercyclical Macroprudential Instruments. IDB Policy Brief No. IDB-PB-250. February.
Agénor, Pierre-Richard, Pereira da Silva, Luiz, 2017. Cyclically adjusted provisions and financial stability. J. Finan. Stabil. 28, 143–162. February.
Agénor, Pierre-Richard, Pereira da Silva, Luiz, 2019. Integrated Inflation Targeting, BIS Publications. Basel.
Aguirre, Álvaro, Bauducco, Sofía, Saravia, Diego, 2018. Capital Flows, Macroprudential Policies and Capital Controls, in Monetary Policy and Financial Stability: Transmission Mechanisms and Policy Implications, ed. by Á lvaro Aguirre, Markus Brunnermeier, and Diego Saravia, Central Bank of Chile (Santiago: 2018).
Aldasoro, Iñaki, Beltrán, Paula, Grinberg, Federico, Mancini-Griffoli, Tommaso, 2020. The macro-financial effects of international bank lending on emerging markets. Working Paper No. 899. November.
Alfaro, Laura, Chari, Anusha, Kanczuk, Fabio, 2017. The real effects of capital controls: firm-level evidence from a policy experiment. J. Int. Econ. 108 (September), 191–210.
Alla, Zineddine, Espinoza, Raphael, Ghosh, Atish R., 2020. FX Intervention in the New Keynesian Model. J. Money, Credit, Bank. 52, 1755–1791. October.

[28] Other contributions to the ongoing debate on the design of IMFPFs include Basu et al. (2020) and Adrian et al. (2021). A systematic comparison between existing approaches would be a fruitful exercise.

Basu, Suman, Boz, Emine, Gopinath, Gita, Roch, Francisco, Unsal, Filiz, 2020. 'A conceptual model for the integrated policy framework, Working Paper No. 20/121, International Monetary Fund (July 2020).
Bergant, Katharina, Grigoli, Francesco, Hansen, Niels-Jakob, Sandri, Damiano, 2020. Dampening global financial shocks: can macroprudential regulation help (more than capital controls)?, Working Paper No. 20/106, International Monetary Fund (June 2020).
Bruno, Valentina, n.d.. Ilhyock Shim, and Hyun Song Shin, 2017. "Comparative Assessment of Macroprudential Policies. J. Finan. Stabil. 28, 183–202 February.
Cesa-Bianchi, Ambrogio, Céspedes, Luis F., Rebucci, Alessandro, 2015. Global liquidity, house prices, and the macroeconomy: evidence from advanced and emerging economies. J. Money, Credit Bank. 47, 301–335. March.
Coman, Andra, Lloyd, Simon P., 2022. In the face of spillovers: prudential policies in emerging economies. J. Int. Money Finance 122, 102554. April.
Fabiani, Andrea, Peydró, José-Luis, López Piñeros, Martha, Soto, Paul, 2021. Capital controls, domestic macroprudential policy and the bank lending channel of monetary policy, Working Paper No. 2021–06, Federal Deposit Insurance Corporation (May 2021).
Fernández, Andrés, Rebucci, Alessandro, Uribe, Martín, 2015. "Are capital controls countercyclical?, J. Monet. Econ., 76 (November 2015), 1-14.
Forbes, Kristin, Fratzscher, Marcel, Straub, Roland, 2015. Capital-flow management measures: what are they good for?, J. Int. Econ., 96 (July 2015), s76-s97.
Frankel, Jeffrey, 2019. Systematic managed floating. Open Econ. Rev. 30, 255–295.
Friedrich, Christian, Guérin, Pierre, 2020. The dynamics of capital flow episodes. J. Money, Credit, Bank. 52, 969–1003. August.
Frost, Jon, Ito, Hiro, van Stralen, René, 2020. The effectiveness of macroprudential policies and capital controls against volatile capital inflows, Working Paper No. 867, Bank for International Settlements (June 2020).
Ghosh, Atish R., Ostry, Jonathan D., Qureshi, Mahvash S., 2017. Managing the tide: how do emerging markets respond to capital flows?, Working Paper No. 17/69, International Monetary Fund (March 2017).
Glocker, Christian, Towbin, Pascal, 2015. Reserve requirements as a macroprudential instrument. J. Macroecon. 44, 158–176. June.
Ilzetzki, Ethan, Reinhart, Carmen, Rogoff, Kenneth, 2019. Exchange arrangements entering the 21st century. Quart. J. Econ., 134, 599-646.
Korinek, Anton, Sandri, Damiano, 2016. Capital controls or macroprudential regulation? J. Int. Econ. 99, s27–s42. March.
Ostry, Jonathan, Ghosh, Atish, Chamon, Marcos, Qureshi, Mahvash, 2012. Tools for managing financial-stability risks from capital inflows. J. Int. Econ., 88 (November 2012), 407-21.
Patel, Nikhil, Cavallino, Paolo, 2019. FX Intervention: Goals, Strategies and Tactics, in Reserve Management and FX Intervention. BIS Paper No. 104.
Peltonen, Tuomas A., Sousa, R.M., Vansteenkiste, I., 2012. Wealth effects in emerging market economies. Int. Rev. Econ. Finance 24, 155–166. October.
Prasad, Nalini, 2018. Sterilized interventions and capital controls. J. Int. Money Finance 88, 101–121. November.
Vargas, Hernando, González, Andrés, Rodríguez, Diego, 2013. Foreign exchange intervention in Colombia, Working Paper No. 757, Central Bank of Colombia (March 2013).