Macro-financial policy analysis in bank-dependent economies: an operational manual

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With contributions by Timothy P. Jackson (Chapters 4 and 5), and Alexandre Tombini (Chapter 6)

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Foreword by Agustín Carstens

A few years ago, I wrote in the preface to the "Integrated Inflation Targeting" Bank for International Settlements (BIS) book by Pierre-Richard Agénor and Luiz A Pereira da Silva that the practice of monetary policymaking had in some areas moved ahead of theory. Indeed, since the Great Financial Crisis, policymakers and academics have made great progress in the construction of what are now labelled macroeconomic and financial stability policy frameworks (MFSPFs). These efforts, informed by the lessons of the crisis, have led to renewed emphasis on the role of banks and financial frictions in macroeconomic fluctuations, as well as the value of combining macroeconomic and regulatory policies in response to domestic and external shocks. They have also examined how the institutional mandates of central banks and regulators should adapt when the objectives of price stability and financial stability are intertwined. Interactions between monetary policy and macroprudential regulation have received particular attention, especially in middle-income developing countries, whose vulnerability to external disturbances is well established. Along these lines, a key focus has been on the role of foreign exchange intervention and the management of short-term capital flows as a means to promote stability. Addressing these issues is complex. As I stated a few years ago, theoretical models had yet to incorporate the channels through which these various policy tools affect macroeconomic and financial stability.

In this new book, which builds on their past research, Pierre-Richard Agénor and Luiz A Pereira da Silva "attempt to bridge this gap between theory and practice". Their contribution focusses on the specification of macroeconomic models with financial frictions, and hence with an explicit modelling of the financial sector, to study the performance of macroeconomic and financial policies. It also explores how to combine and calibrate these policies to promote stability.

This book responds also to our stakeholders' demands. On many occasions, we at the BIS have felt that Governors from middle-income developing economies were asking us to provide further analytical underpinnings to their current policy responses when facing external financial shocks and their domestic implications for price and financial stability. Together with the BIS Representative Offices in the Americas and Asia, the BIS has done significant work on this topic, for the G20, for regional groupings of central banks in those regions, and in our 2019 Annual Economic Report. We also discussed these issues internally and externally and felt that a new contribution, with firmer analytical underpinnings – particularly with respect to the sequencing and combination of various policy instruments – and with due consideration to operational implications, was warranted. Importantly also, the models presented in this contribution are not a "one size fits all". They can be adapted to each institution's needs, for instance by integrating some of their components in existing operational models.

More broadly, this new contribution by Pierre-Richard Agénor and Luiz A Pereira da Silva addresses some of our stakeholders' questions. In an integrated and pedagogical setting, they provide a systematic account of how central banks can combine monetary policy with the array of other policy instruments now available in their toolkit (including macroprudential policies, capital flow management measures, and foreign exchange intervention), possibly complemented by fiscal policy, to manage large swings in capital flows.

Finally, as an institution serving the central banking community, our hope at the BIS is that a systematic presentation of these tools in a single manual will provide analytical support for economists in central banks and international financial institutions to use and adapt to their own needs, for example by integrating some of their components in their existing operational models. With that we provide our contribution to the current cutting-edge discussions in the community of our stakeholders as well as making progress in research, so that, at the end, theory gets a bit closer to practice.

Content

Introduction and Overview

Since the global financial crisis of 2007-08, much academic and policy-oriented research has focused on the design, or redesign, of macroeconomic and financial policy frameworks. This literature has brought to the fore the role of banks and financial frictions in macroeconomic fluctuations. It has also explored how macroeconomic and regulatory policies should be combined to respond to domestic and external shocks, and how the institutional mandates of central banks and regulators should be formulated, or amended, when both price stability and financial stability matter for society. In that context, interactions between monetary policy and macroprudential regulation – with its focus on systemic risk, and the stability of the financial system as a whole – have received particular scrutiny.[1] In middle-income countries, where vulnerability to external shocks has been a perennial problem, much attention has also been devoted to the role of foreign exchange intervention and short-term capital controls in promoting stability.

This Manual presents some of the analytical research that we have conducted in the past decade, both independently and in collaboration with other colleagues and co-authors. Much of our agenda has focused on the specification of macroeconomic models with financial frictions, both theoretical and quantitative, to study the performance of macroeconomic and macroprudential policies, as well as whether, and how, these policies should be combined and calibrated to promote macroeconomic and financial stability.[2] Our research has also aimed to bring new insights on the design of central bank mandates and macro-financial policy frameworks, with respect most notably to how inflation targeting should be adapted – and possibly rethought in a fundamental way – to reflect the new dilemmas that policymakers have faced since the global financial crisis.[3]

Our goal in this Manual is to focus, more specifically, on those contributions that are most relevant to the policy challenges that middle-income countries (MICs) are confronted with. Among these, the long-standing issue of managing short-term capital flows remains the most pressing. Without a doubt, the environment is now different from what it was a decade or two ago: today many of these countries operate a managed float. This is the case even among those that have adopted inflation targeting as their monetary policy framework – a regime in which the exchange rate should be allowed, in principle, to float freely to avoid calling into question the preeminence and credibility of the inflation target. In many of these countries, central banks consistently react to foreign exchange market pressure with frequent intervention, in the form of sterilized operations. Moreover, the decision to intervene appears to have been increasingly driven by the goal of mitigating exchange rate volatility, rather than concerns with its level (due to considerations related to competitiveness and the degree of exchange rate pass-through, for instance) or the need to build foreign reserves for precautionary reasons.[4] In addition to intervening in foreign exchange markets, countries have used a range of tools, including fiscal, monetary and macroprudential policies, as well as capital controls, to manage capital flows. This raises two fundamental and broader questions: how do these policies operate in an economy subject to a variety of financial frictions? How should they be combined in response to shocks, not only external but also domestic? From that perspective, the key issue is whether there exists an "optimal" (possibly shock-specific) policy mix, involving the simultaneous use of several instruments, that can be relied upon to promote macroeconomic and financial stability. The models developed in the Manual are also useful to study the performance (or lack thereof) of macroeconomic policies aimed at responding to inflationary shocks associated with a combination of adverse supply-side disruptions and expansionary demand shocks – a challenge that central banks all around the world are faced with at the time of this writing.

Addressing these issues is not straightforward. For instance, as noted by Carstens (2019), theoretical models have yet to account fully for the channels through which the practice of foreign exchange intervention can affect macroeconomic fluctuations. Our analysis reflects recent progress made, by ourselves and others, in studying how such intervention can be combined with other instruments to promote economic stability.

At the same time, rather than focus at the outset on a fairly complex model with all the necessary ingredients accounted for, this Manual deliberately takes a more gradual approach. It begins with a simple closed-economy model, which is solved analytically, and culminates with an open-economy dynamic stochastic general equilibrium (DSGE) model, which is calibrated and solved numerically. Corresponding software tools (including Excel simulation spreadsheets for the simple models, and DYNARE codes for the more advanced model) are also provided. The

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1 See Galati and Moessner (2018), Agénor (2020), and Martin et al. (2021), as well as the references therein.

2 A thorough analytical discussion, with a stronger emphasis on theoretical foundations, is provided in Agénor (2020), which is referred to on several occasions later on. The present contribution, as is made clear later on as well, takes a deliberately more operational approach.

3 See Agénor and Pereira da Silva (2019, 2022*b*) for a detailed discussion of this issue.

4 See, for instance, Sandri (2020) for the case of Brazil and Patel and Cavallino (2019) for broader evidence.

hope is that these tools will encourage the target audience (namely, economists in central banks and international financial institutions) to use the underlying models as they are, adapt them to their own needs, or integrate some of their components in their existing operational models. By starting with a simple basic framework, whose properties can be illustrated using standard two-dimensional diagrams, rather than a fairly complex quantitative model, this Manual puts significant emphasis on clarity and pedagogy.

The Manual is organized as follows. Chapter 1 provides a brief background to the analysis. It discusses the key structural features of bank-dependent, middle-income countries which are captured (albeit in stylized fashion) in the models used in the rest of the Manual. It discusses, in particular, the nature of the financial frictions that prevail in these countries, as well as their vulnerability to the global financial cycle. It also outlines the underlying rationale for our modeling methodology and its deliberate focus on operational considerations.

Chapters 2 and 3 describe simple static models with banks and financial frictions. These models, which can be explicitly solved analytically, help to provide intuition for some of the results that can be gauged from the more advanced quantitative model presented and used in Chapters 4 and 5. A key advantage of these models is that they are fairly transparent. And because standard, two-dimensional diagrams can be used to study and illustrate the impact of policy and exogenous shocks, understanding their properties, and the basic insights that they provide, is relatively straightforward.[5]

Chapter 2 focuses on a closed economy. After presenting the model's structure and its solution, and characterizing the transmission mechanism of fiscal, monetary, and macroprudential policies, the performance of various policy combinations in response to real and financial disturbances is examined. Various extensions, including the existence of working capital needs financed by bank borrowing, are also discussed. At the outset, the analysis highlights the interplay between the real and the financial sides of the economy, and the importance of financial frictions in the transmission process of shocks, as well as the benefits of policy combinations to restore macroeconomic and financial stability.

Chapter 3 extends the analysis to a small open economy in which the central bank operates (consistent with the evidence referred to earlier) a managed float regime. The structure of the model and its solution are again examined and explained step by step. In addition to studying the performance of fiscal, monetary and macroprudential policies, as in the previous chapter, two additional instruments that policymakers in MICs have often used in recent years to manage their economies are also considered: foreign exchange intervention and capital controls. How these five policy instruments should be combined in response to a variety of transitory disturbances, domestic and external, is also examined. Understanding how these combinations operate and how they perform in response to a variety of shocks is a key step for addressing the challenges that policymakers face in today's global economy. Again, the fact that the model can be solved analytically, and that a wide range of policy combinations can be studied graphically, makes it also easier to relate the analysis to current practice with respect, in particular, to the management of external financial shocks.

Nevertheless, while analytical tractability and the ability to perform diagrammatic analysis are important, they impose a number of restrictions on the range of issues that can be addressed by simple macroeconomic models. These include the treatment of expectations, the dynamics of consumption, asset and physical capital accumulation, and so on. By construction, simple models can only provide qualitative insights, not a sense of magnitudes involved – although illustrative calibrations, using the Excel tools alluded to earlier, can help in that regard – and their static nature prevents a full assessment of how shocks and policy responses affect the economy over time.

Accordingly, Chapters 4 and 5 extend the analysis by presenting a full-blown DSGE model of a small open economy with financial frictions and a managed float regime. Unlike the simple (albeit plausible) specifications adopted for some behavioral equations in Chapters 2 and 3, micro-foundations are provided in most cases. In particular, explicit optimisation problems are specified for households, firms, and banks. A richer trade and production structure is also considered. At the same time, the resulting model is fairly complex and cannot be solved analytically; to study the transmission process of macroeconomic and financial policies, and policy responses to domestic and external shocks, it must be calibrated (or, more precisely in this case, parameterized) and solved numerically. Yet, the insights garnered from the analysis in Chapters 2 and 3 make understanding some of its key properties less arduous; and sensitivity to particular parameter values can also be assessed.

While Chapter 4 focuses on a description of the model, its steady-state solution, the choice of parameter values, and the impact of exogenous policy changes, as well as domestic and external shocks, on the economy,

[5] In that sense, these models can also be viewed, more generally, as a useful "entry point" to the more advanced models with financial frictions used in the literature. See Agénor (2020, 2021) for a detailed discussion.

Chapter 5 focuses on policy responses, with instruments considered both individually and in combinations, to capital inflows induced by a drop in world interest rates. Policy objectives are examined both in terms of a policy loss function for each policymaker (the central bank and the macroprudential regulator) and household welfare, as well as a *hybrid* specification in which policymakers, in a first stage, determine the optimal setting of their respective instruments based on their specific loss function and, in a second stage, assess the performance of these instruments in terms of their welfare benefits.

At the outset, it is important to note that the model developed in Chapters 4 and 5 does not incorporate an explicit, micro-founded definition of systemic risk, which could serve as a rationale for macroprudential policy intervention. Instead, the focus is on an *intermediate target* for financial stability – credit fluctuations. As discussed in Chapter 1, a rationale for doing so is that it is consistent with the empirical evidence on credit growth in the lead-up to financial crises. At the same time, the modelling approach, and numerical solution techniques, used in these chapters are not well suited to study episodes of excessive volatility, occasionally binding constraints, or full-blown financial crises.

Chapter 6 concludes with a review of the evidence on policy responses to capital flows in the aftermath of the global financial crisis, with a broad focus on Asia and Latin America initially, and subsequently a more detailed discussion of the experiences of Brazil and Malaysia. In line with the analysis in the previous chapters, this review focuses not only on monetary policy and macroprudential regulation – whose performance has been the subject of greater scrutiny since the global financial crisis – but also on foreign exchange intervention and, albeit used to a lower extent, fiscal policy and capital controls. The evidence pertaining to combinations of these policies is also discussed, thereby providing a useful illustration of the analytical results. Finally, the epilogue offers some concluding remarks regarding the policy challenges that MICs may face going forward.

The foregoing discussion makes it clear that much of the theoretical and numerical analysis presented in this Manual is motivated by the experience of bank-dependent MICs. However, we believe that the models presented in Chapters 2 and 3 are equally relevant for small advanced economies as well, as long as banks play a central role in their financial system. Indeed, while there may be differences in degree in terms of the strength and importance of particular financial frictions between the two types of economies (with respect, for instance, to the strength of financial amplifications effects, or the degree of international capital mobility), fundamentally the core analytical framework appears to be useful for either setting. The policy experiments and the analysis of policy combinations involving fiscal, monetary, and macroprudential policies in response to real and financial shocks are also relevant for bank-dependent, small advanced economies. What differentiates the two types, rather, is the fact that the range of policies used by MICs to manage external financial shocks is wider, with greater reliance on foreign exchange intervention and capital controls.[6] By implication, as discussed in Chapters 3 and 5, the scope of policy combinations is also broader.

* * *

This Manual is the product of the decade-long research agenda developed, both jointly and independently, by Pierre-Richard Agénor at the University of Manchester, and Luiz A. Pereira da Silva, initially at the World Bank and the Central Bank of Brazil, and subsequently at the Bank for International Settlements. All these institutions have provided us with excellent conditions for carrying out our work. The Financial Stability and Development Group (the research and knowledge-sharing network formed by the major central banks of Latin America, and administered by the Inter-American Development Bank), and the Centro de Estudios Monetarios Latinoamericanos (CEMLA), also provided significant support over the years. Timothy Jackson is a co-author of Chapters 4 and 5, whereas Alexandre Tombini co-authored chapter 6 with Luiz Pereira da Silva. We are grateful to both of them for their contribution.

We have also benefited from collaborative projects and interactions with numerous colleagues at the University of Manchester and the Bank for International Settlements, as well as former students and co-authors in a number of other institutions, including the Central Bank of Brazil, the Central Bank of the Republic of Turkey, and the World Bank. We would like to mention, in particular, Joshua Aizenman, Koray Alper, Alessandro Flamini, Leonardo Gambacorta, Timothy Jackson, Gianni Lombardo, Peter Montiel, Damiano Sandri, and Hyun Song Shin. We are also grateful to Cumhur Ciçekçi and Metin Bicer for reviewing the MATLAB codes used for Chapters 4 and 5, and to Tobias Adrian and Christopher Erceg for organizing a presentation at the International Monetary Fund where the material in Chapters 2 to 5 was discussed. Rafael Guerra and Nicolas Lemercier provided able research

[6] There is evidence that, in recent years, central banks in small advanced economies have intervened in foreign exchange markets (beyond smoothing operations) and imposed temporary controls on capital flows. However, by and large these measures have remained sporadic.

assistance. We are thankful to all for their contributions, although we retain sole responsibility for the opinions expressed herein.

In preparing this Manual, we have relied in part on material from several papers published in professional journals. We thank the *International Journal of Central Banking*, the *Journal of Banking and Finance*, the *Journal of Financial Stability*, the *Journal of Economic Dynamics and Control*, the *Journal of Macroeconomics*, the *Journal of International Money and Finance*, the *Journal of Money, Credit, and Banking*, and *Macroeconomic Dynamics* for enabling us to dwell on these articles.

Chapter 1. Background

As noted in the Introduction and Overview, the goal of this Manual is to present an integrated set of macroeconomic models with banking and financial frictions that can help to address some of the policy challenges that middle-income countries (MICs), and bank-dependent economies in general, must confront in today's integrated world economy.

To set the stage for the analysis, this chapter provides a review of some of the structural economic features, and key facts, that these models should capture. It proceeds as follows. Section 1 highlights the role of banks in MICs. Section 2 summarizes the key structural features for which macroeconomic models built to analyse policy responses in bank-dependent MICs should account. These features include various types of financial frictions, the nature of the exchange rate regime, the vulnerability to global financial cycles, the link between capital flows, credit booms and domestic stability, and the reliance on a greater set of short-term policy instruments than in small advanced economies in response to external shocks.[1] Section 3 outlines the modeling approach followed in the remainder of this Manual.

1.1. Banks and the Financial System

In many developed and developing countries, banks continue to play a critical role in the financial system. In MICs, it is not unusual for commercial banks to account for four-fifths or more of the assets of, and loans extended by, the domestic financial system. Despite some exceptions, in these countries the expansion of nonbank financial intermediaries, the shift toward the *originate and distribute* model of banking, and the development of opaque, off-balance sheet instruments, have not reached the same importance as they have in advanced economies. This is well-documented in recent reports including, most importantly, by the Financial Stability Board (2021). The lack of development of capital markets means that there are limited alternatives (such as corporate bonds, stocks, and commercial paper) to bank credit to finance either short-term working capital needs or longer-term investment projects.

1.1.1. Banking Sector Indicators

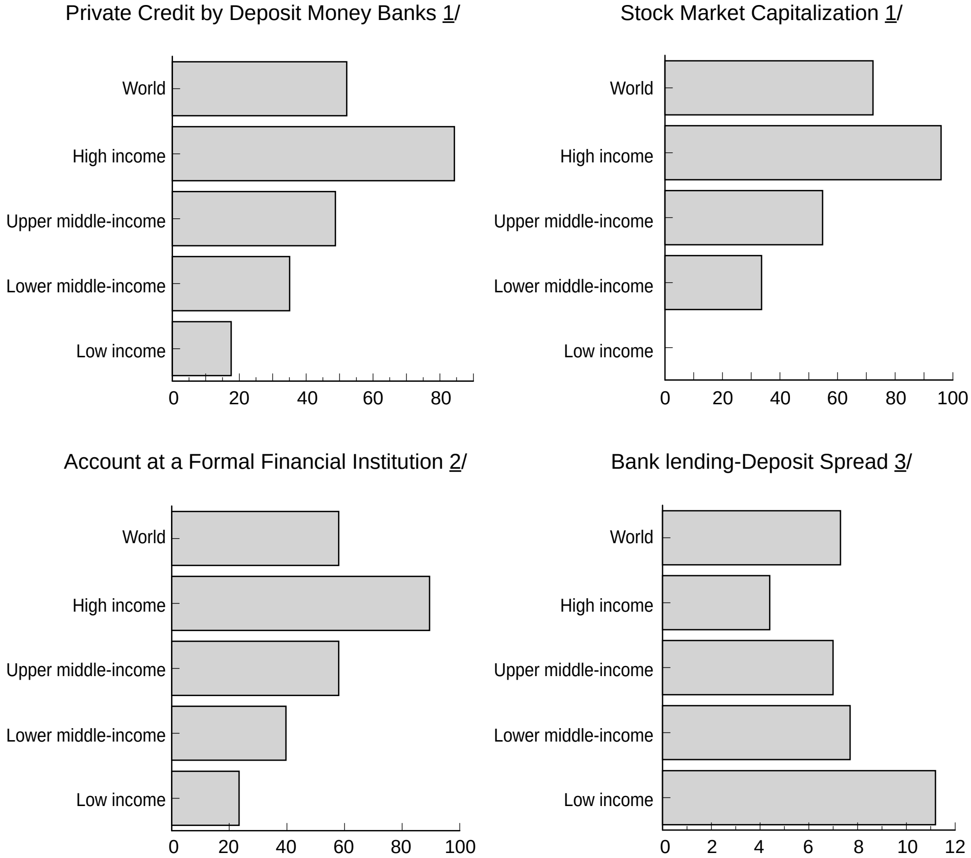
According to the World Bank (2020, Appendix A), the share of private credit by deposit money banks in proportion of GDP for the world as a whole was 52.2 percent over the period 2015-17. During the same period, it was 84.4 percent for high-income countries (HICs), 48.8 percent for upper MICs, 35.1 percent for lower MICs, and 17.6 percent for low-income countries (LICs; see Figure 1.1). There therefore appears to be a positive correlation between credit and income, although the direction of causality remains a matter of debate. There are also large differences by regions: in East Asia the ratio is 58.2 percent, whereas it is 42.0 percent in Latin America and the Caribbean, and 21.6 percent in sub-Saharan Africa (see Figure 1.2). A possible reason for the relatively low ratios in Latin America is a history of high and chronic inflation, which typically fosters financial disintermediation. At the same time, stock market capitalization in percent of GDP (an indicator of the depth of financial markets) is also consistent with the pattern of bank credit. Over the period 2015-17, the capitalization ratio is 96.0 percent for HICs, 54.8 percent for upper MICs, 33.6 percent for lower MICs, and almost inexistent for LICs. By region, the capitalization ratio is 75.0 percent for East Asia, 29.2 percent for Latin America and the Caribbean, and 81.4 percent in sub-Saharan Africa – a somewhat surprising number in the latter case.

Data on access to financial institutions show similar disparities (Figures 1.1 and 1.2). The proportion of individuals (age 15 or older) with an account at a formal institution is, for the same period considered earlier, 58.0 percent for the world, 89.6 percent for HICs, 58.0 percent for upper MICs, 39.7 percent for lower MICs, and 23.4 percent for LICs. The results by region are, by and large, similar to those discussed earlier; the ratio is 52.2 percent in East Asia, 46.3 percent in Latin America and the Caribbean, and 30.1 percent in sub-Saharan Africa.

[1] The latter issue is discussed in more detail and from a more practical perspective in Chapter 6, with a focus on a group of Asian and Latin American countries.

Banks and Financial System Indicators: By Income Levels

Figure 1.1



1/ In percent of GDP.
2/ In percent, individuals aged 15 and above.
3/ In percent.

Source: World Bank (2020).

The available data also suggest that the bank lending-deposit spread (a measure of the efficiency of banking intermediation) varies inversely with the level of income. Over the period 2015-17, the spread is 4.4 percent for HICs, 7.0 percent for upper MICs, 7.7 percent for lower MICs, and 11.2 percent for LICs (Figure 1.1). The results by region are now more contrasted: the spread is 5.8 percent in East Asia, 9.9 percent in Latin America and the Caribbean, and 9.3 percent in Sub-Saharan Africa (Figure 1.2). Thus, in Latin America and the Caribbean, spreads tend to be significantly higher than in sub-Saharan Africa, a region where a large number of poor countries are concentrated. A possible reason, as noted later on, is greater difficulty of seizing collateral in case of default, which induces banks to charge *ex ante* a higher premium.

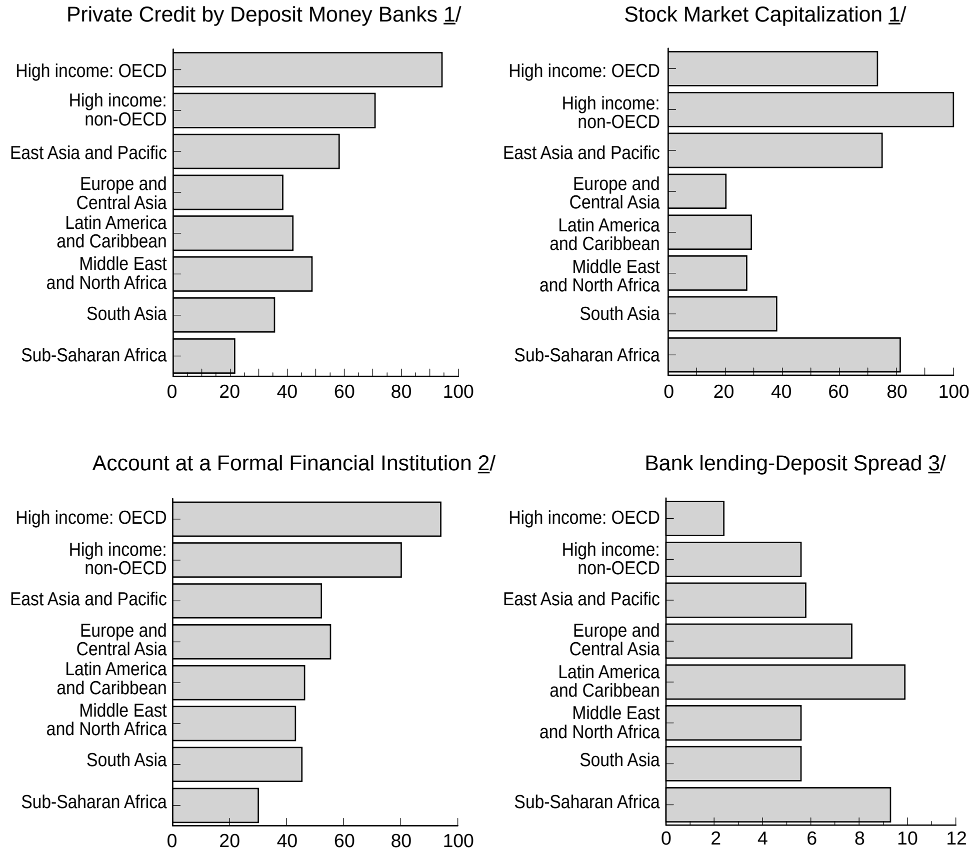
1.1.2. Banking Sector Regulation and Supervision

The decade that followed the global financial crisis was characterized by increased regulation of banking sectors across the world, in both advanced and developing economies. One of the major objectives of these new regulations were aimed at improving the resiliency of the financial system. To that effect, the Basel III framework, initiated in 2011, was intended to increase both the quantity and quality of capital.[2]

[2] However, the scope for leakages within the financial system and for cross-border regulatory arbitrage have increased at the same time. Financial integration has indeed made it more difficult to supervise banks, and requires more coordination between regulators. See Agénor et Pereira da Silva (2022) for a discussion.

Banks and Financial System Indicators: By Regions

Figure 1.2



1/ In percent of GDP.
2/ In percent, individuals aged 15 and above.
3/ In percent.

Source: World Bank (2020).

Since the global financial crisis, a large number of advanced economies have adopted (or adapted) most of the major components of Basel III. As a result, in high-income OECD countries, for instance, regulatory capital to risk-weighted asset ratios have increased from about 12 percent in 2004 to about 18 percent in 2018 (World Bank (2020, p. 13)). However, progress among developing countries has been less significant. While many of them have continued to shift out of Basel I, only less than half have adopted the core elements of Basel III. Between 2005 and 2017, for instance, Tier 1 capital as a proportion of regulatory capital has increased from 79 percent to only about 87 percent in these countries, compared to an increase from 75 percent to about 88 percent for high-income OECD countries (World Bank (2020, p. 15)). As of 2019, more than 80 percent of high-income countries had adopted Basel III, while only about half of upper MICs, and one-third of lower MICs, had done so.

Moreover, many developing countries have also been selective in the adoption of Basel III rules. Many of them have avoided entirely some of the more complicated components of the new regime, such as using internal models to assess bank risk and countercyclical capital buffers. For instance, as of 2016, only 29 percent of countries in Latin America and the Caribbean had adopted the Internal Ratings-Based (IRB) approach, compared to 96 percent of high-income OECD countries (World Bank (2020, p. 93)). Similarly, only 50 percent of the countries in Latin America and the Caribbean had adopted the countercyclical capital buffer rule, compared to 87 percent of high-income OECD countries (World Bank (2020, p. 94)).

A possible reason for this is that supervisory capacity in the developing world did not improve to keep up with the increasing complexity of bank regulations. New regulations (regarding information disclosure, resolution of failed banks, and stress-testing, for instance) allow for a significant amount of discretion by supervisors, and therefore require experienced and specialized personnel, with adequate legal protection against personal liability (with regard, in particular, to decisions to close a weak or nonviable financial institution). Indeed, the quality of bank supervision – as measured by the overall compliance index with the Basel core principles for effective bank supervision – remains lower in many MICs, compared to advanced economies.[3] This is consistent with the broader evidence suggesting that the level of economic development is an important factor in explaining differences in the quality of regulatory and supervisory frameworks across countries.[4] Thus, administrative and personnel constraints may well explain why countries at lower levels of income may have been so far unable (rather than unwilling) to implement some of the Basel III rules.

At the same time, as documented in some studies (such as Anginer et al. (2018)), the relationship between the systemic risk of individual banks and capital ratios appears to be stronger in countries where the supervisory power of regulators is limited and the institutional environment is weaker. Enhancing the quality and quantity of bank capital can therefore mitigate the adverse effects of a lack of supervisory capacity and information availability. This result is particularly relevant for developing countries, where (as noted earlier) enforcing banking regulation and supervision may be prohibitive, given a lack of specialized human capital. Nevertheless, another important implication of a weak regulatory environment is that it may lead to regulatory capture and create perverse incentives for banks to engage in risky activities. It also implies, in line with the *principle of proportionality* in regulatory parlance, that prudential instruments should not be overly complex to implement in order to mitigate compliance costs and for them to be promptly deployed when needed.[5] Less complex regulations, in countries where sophisticated financial markets do not exist and institutions are underdeveloped, may also mean more effective enforcement by supervisors and better market monitoring.

1.2. Key Structural Features

The key structural features that macroeconomic models for MICs should account for relate to the production structure, financial frictions, the nature of the exchange rate regime, the vulnerability to external shocks, the link between capital flows and domestic credit booms, and the reliance on a wider range of policy instruments in response to external financial shocks.

1.2.1. Intermediate Goods and Production Structure

As documented in the literature, global value chains have played an increasingly important role in international trade. Currently, more than two-thirds of international trade take place within global value chains, up from 60 percent in 2001 (World Trade Organization (2019)). The result is that trade between countries, both developed and developing, involves essentially intermediate products. For instance, according to Eurostat, in 2020 extra-EU imports consisted of 54.5 percent of intermediate goods and only 22.6 percent of consumption goods. Similarly, according to World Bank data, in 2019 the share of intermediate goods (broadly defined to include raw materials and fuels, in addition to manufactured products) was 41 percent for Brazil, compared to imports of consumption goods of 25 percent. Corresponding numbers for Turkey are 44 and 19 percent, respectively.

The importance of imports of intermediate goods must be captured in the production structure. This is what is done in Chapter 4, dwelling on the approach proposed by McCallum and Nelson (2001). Indeed, in that setting all imports are assumed to consist of intermediate goods, rather than finished consumer goods. In turn, imports of intermediate goods are combined with domestic intermediate goods to produce domestic final goods, which are used for domestic consumption and investment, and for exports.

1.2.2. Financial Frictions

Because banks continue to play a dominant role in the financial system in MICs, accounting for financial frictions in macroeconomic models – even in stylized fashion – is essential to study the effectiveness of macro-financial policies and how these policies interact. Specifically, the following features are important to capture.

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3 These principles are the minimum global standards deemed necessary for the sound prudential regulation and supervision of banks. Initially published in 1997, and updated in 2006 and 2012, they contain 29 principles. For details, see https://www.bis.org/fsi/fsisummaries/bcps.htm.

4 See, for instance, Čihák and Tieman (2011), who also found that there are substantial differences in regulatory quality across regions, but not all of which can be explained by differences in economic development. There is also substantial variability within regions as well.

5 This may explain why reserve requirements, for instance, are so widely used in these countries.

1. The banking system is often characterized by limited competition, which leads to monopolistic or oligopolistic market structure and pricing practices, segmentation of credit markets, and efficiency losses.

2. Asymmetric information problems in MICs tend to be more severe than in advanced economies. This makes screening out good credit risks from bad ones hard, and fosters collateralized lending and short-maturity loans.

3. Disclosure and transparency requirements on corporate firms are often weak, thereby making it also more difficult for banks to screen and monitor borrowers.

4. Contract enforcement is often difficult because property rights are weak and the legal system is highly inefficient. In particular, procedures for liquidating the assets of firms in default can be very costly. Bankruptcy law typically provides little creditor protection.

5. A weak judiciary environment and high recovery costs encourage collateralized lending.

6. Small and medium-sized firms (especially those operating in the informal sector) are often squeezed out of the credit market. Those who do have access to it – often well-established firms, with "traditional" connections with specific banks – face an elastic supply of loans and borrow at terms that depend on their existing liabilities and their ability to pledge seizable collateral.

7. Short-term loans to finance working capital needs are a significant fraction of total lending, whereas lending to households (beyond short-maturity mortgages and credit card debt) remains relatively underdeveloped.

8. Limited ability to enforce financial regulation militates in favor of selecting instruments that are not overly complex and can be implemented through simple policy rules.

These frictions often result in weak intermediation, a high cost of borrowing, high rates of collateralized lending, or low recovery rates for creditors. Moreover, financial distortions tend to be magnified in a volatile economic environment, characterized by high exposure to domestic and external shocks, such as abrupt movements in capital flows. In turn, increased exposure to adverse shocks magnifies the possibility of default and the risk of bankruptcy by borrowers and lenders alike, culminating time and again in full-blown financial crises.

1.2.3. Exchange Rate Regime

As noted in the Introduction and Overview, recent evidence on the evolution of exchange rate regimes suggests that managed floats remain the norm in MICs – even among those that have adopted inflation targeting as their monetary policy framework, 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 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 increasingly so through sterilized operations. Moreover, the decision to intervene appears to have been driven more and more by concerns about excessive exchange rate volatility, rather than concerns about its level (due to considerations related to competitiveness and the degree of exchange rate pass-through, for instance), or the precautionary need to accumulate foreign reserves to manage external shocks.[6]

At the same time, a growing number of central banks have used foreign exchange market intervention as part of a broad combination of policy instruments to contain macroeconomic and financial stability risks – especially those associated with large, short-term capital flows, a perennial challenge for policymakers in small open developing economies. These instruments have included 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.[7] As noted by Carstens (2019), accounting for the channels through which the practice of foreign exchange intervention can affect macroeconomic fluctuations, and how such intervention can be combined with other instruments to achieve financial stability, should be an important feature of macroeconomic models designed for MICs.

6 See, for instance, Sandri (2020) for the case of Brazil and Patel and Cavallino (2019) for broader evidence based on a survey of central banks.

7 For an overview of the effectiveness of macroprudential policies see, for instance, Araujo et al. (2020) and Borio et al. (2022). Chapter 6 provides a more focused discussion of the experience of 11 middle-income countries, in the context of policy responses to capital flows.

1.2.4. *Exposure to External Shocks*

Over the past three decades, and despite a temporary reversal coinciding with the global financial crisis, the degree of integration of international financial markets has increased significantly. There is also growing evidence that short-term capital flows across regions are driven by a global financial cycle, which is significantly (albeit not exclusively) influenced by US monetary policy.[8]

Although there are significant potential benefits associated with financial integration and capital flows in general (as discussed in Agénor (2012), for instance), large short-term capital inflows can exacerbate domestic volatility and create risks to macroeconomic and financial stability. Indeed, a large literature has documented the fact that episodes of large capital inflows – or sudden floods, as opposed to *sudden stops* – are associated with rapid increases in credit and liquidity, aggregate demand and asset price pressures, real exchange rate appreciation, and a deterioration of external accounts.[9] The more open and integrated a country is to global financial markets, the deeper are the channels through which capital inflows will impact both the real economy and the financial system – and the more critical the policy response becomes to ensure macroeconomic and financial stability.[10] Thus, capital flows can be a potential source of instability, not because of their size *per se* but rather because they may amplify cyclical movements in domestic financial conditions and exacerbate domestic imbalances – especially in countries where, to begin with, financial vulnerabilities exist and the capacity of regulators to address them is (as discussed earlier) weak. Increased exposure to adverse shocks magnifies the possibility of default and the risk of bankruptcy by borrowers and lenders alike, raising in the process the likelihood of a full-blown financial crisis.

From the perspective of financial stability, the main source of concern is *gross*, rather than *net*, capital flows – purchases of domestic assets by foreign agents, or purchases of foreign assets by domestic agents, rather than the difference between the two (see Forbes and Warnock (2012) and Broner et al. (2013)). Among gross flows, bank-related flows are especially important because of their potential direct impact on credit expansion (as noted earlier) and their role in transmitting international financial shocks. In fact, the high correlation between total capital inflows and outflows documented in the literature appears to be driven mainly by banking sector flows; that is, domestic banks' borrowing from foreigners is closely correlated with domestic banks' lending to foreigners (Avdjiev et al. (2022)). Concerns with bank-related flows have increased in recent years, in light of the rapid pace at which the globalization of banking has proceeded (World Bank (2018)) and the greater incentives for global banks to engage in cross-border regulatory arbitrage (Buch and Goldberg (2017)).

1.2.5. *Credit Booms and Financial Instability*

MICs, and developing countries in general, have suffered many costly crises over the past decades, characterized by large contractions in economic activity, sharp increases in unemployment rates, and persistent credit crunches. Less extreme events also tend to be costly, especially when they are associated with financial disruptions (see Claessens et al. (2012)).

More generally, there is strong evidence to suggest that rapid credit growth – often associated with episodes of large capital inflows in MICs, as documented earlier – is a robust warning sign of financial instability (in terms of the volatility of asset prices, for instance) or financial crisis. In fact, this evidence relates not only to developing countries but also to advanced economies over long periods of time.[11] During credit booms, credit flows tends to flow disproportionately to the non-tradable sector; these flows systematically predict financial crises, in contrast to credit to the tradable sector (Müller and Verner (2022)). The allocation of credit, in addition to its source, may therefore be important for understanding the link between credit expansions and financial fragility. In addition, some contributions (including Anundsen et al. (2016) and Aldasoro et al. (2018)) found that booms in house or property prices can be an independent cause of financial fragility and financial crises – especially in an environment where borrowers are able to concomitantly lever up the collateral value of their assets.[12]

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8 See Cerutti et al. (2019), Habib and Venditti (2019), Lodge and Manu (2019), Miranda-Agrippino and Rey (2020), and Scott et al. (2021), for empirical evidence and a more detailed discussion. The latter study also distinguishes between gross and net capital flows.

9 The term *sudden stops* was coined by Calvo (1998) whereas the term *sudden floods* was first used by Agénor et al. (2014*a*).

10 Policy challenges were heightened in the aftermath of the global financial crisis, as a result of the massive increase in global liquidity that followed the adoption of quantitative easing and other unconventional policies in advanced economies.

11 See Taylor (2015), Aikman et al. (2016), and Anundsen et al. (2016).

12 Some contributions, such as Krishnamurthy and Muir (2017), have found that low credit spreads tend also to precede episodes of financial instability.

1.2.6. Degree of Capital Mobility

Global financial integration, as noted earlier, has been associated with larger capital flows. This has increased the degree of interconnectedness between national financial systems (see Agénor and Pereira da Silva (2022*a*)). However, capital mobility between advanced economies and middle-income countries remains far from perfect. The evidence, discussed by Agénor and Montiel (2015), suggests that there is not only imperfect substitutability between domestic and foreign financial assets, due to differences in riskiness and liquidity, but also imperfect capital mobility, due to the existence of transactions costs.[13]

1.2.7. Range of Policy Instruments and Combinations

Because of the nature of the challenges that they have faced – including, importantly, managing capital flows, as noted earlier – MICs have used a wider range of macroeconomic policy instruments than advanced economies. By and large, these tools have included fiscal policy (namely, changes in government expenditure), monetary policy (in the form of adjustments in short-term interest rates), macroprudential regulation, as well as foreign exchange intervention and capital controls.[14] With respect to macroprudential regulation, individual tools have included sectoral instruments (loan-to-value and debt-to-income ratios, for instance), liquidity requirements, loan-loss provisions, countercyclical capital buffers, and restrictions on bank foreign exchange operations. On the issue of capital controls, restrictions have occurred with respect to bank foreign borrowing (which makes them therefore also macroprudential in nature), and restrictions on private short-term capital flows.

As noted in the Introduction and Overview, understanding how these policies should be used both individually and in combination to promote economic stability is at the heart of what macroeconomic models, both theoretical and quantitative, should address in order to inform the policy debate in bank-dependent MICs. Indeed, the issue is under what conditions (that is, in response to which shocks) should the various instruments available to policy authorities be deployed in a complementary manner in order to strengthen their effectiveness and promote economic stability.[15]

1.3. Modeling Approach

The literature on macroeconomic models with financial frictions has evolved in a number of different directions in recent years. Four main approaches can be identified.[16] The first is the Kiyotaki-Moore model of collateral constraints, which restricts borrowing to a fraction of durable assets (physical capital or housing) and emphasizes the role of these constraints, and changes in asset prices, in amplifying business cycle fluctuations. Bahadir and Gumus (2022) provide a recent application of this approach, in a two-sector open economy setting. The second is the agency cost-financial accelerator model of Bernanke et al. (1999), hereafter BGG, which focuses on the demand side of the credit market. The third is the Gertler-Kiyotaki-Karadi model with moral hazard between banks and depositors, in which banks may default on their obligations and walk away with a share of intermediated assets. The fourth is the Holmström-Tirole double moral hazard model, in which financial frictions result from the combination of an asymmetric information problem between borrowers and banks, and an incentive for banks to shirk.

The evidence so far on the empirical performance of these various approaches to financial frictions is mixed; in fact, some studies have concluded that a *combination* of financial frictions matches the data better than a single friction. At the same time, trying to combine alternative models of financial frictions may be difficult if not intractable – even in models that are solved numerically, rather than analytically. Accordingly, in this Manual the focus is on one approach, discussed in detail in Agénor (2020, Chapter 1) which is most closely related to the BGG model.

At the core of the BGG model is the existence of an agency problem between non-financial borrowers and lenders, which is solved through an appropriate loan contract, with a role for leverage. The key mechanism in the model relies on the interaction between the production technology and asymmetric information. The acquisition of capital is financed through both entrepreneurial net worth and external funds. Dwelling on the costly state verification

13 This assumption is also in line with recent theoretical interpretations of deviations in uncovered interest parity; see Maggiori (2021), for instance.

14 See, for instance, Bruno and Shin (2014), Bruno et al. (2017), Ghosh et al. (2017), Frost et al. (2020), Bussière et al. (2021), Erten et al. (2021), Loipersberger and Matschke (2022), and Bergant et al. (2023). Chapter 6 provides a more detailed discussion of the evidence on the policy mix used by a group of Asian and Latin American countries in recent years.

15 More broadly, research on the design of macroeconomic policy frameworks in the post-crisis world has also considered how the institutional mandates of central banks and regulators should be reformed, and the extent to which coordination between them should be pursued. See, for instance, the proposal for an *integrated* inflation targeting regime by Agénor and Pereira da Silva (2019, 2022*b*).

16 See Agénor (2020, Chapter 1) for a more detailed discussion.

approach of Townsend (1979), the BGG model assumes that firms can observe the returns to their individual investment projects, but to do so lenders must incur a cost. This agency problem is solved with an optimal contract that entails a trade-off between verification costs and the likelihood of default. It involves an external finance premium (the wedge between the cost of funds raised externally and the opportunity cost of internal funds) which depends inversely on borrowers' net worth.[17] Consequently, the external finance premium is countercyclical, thereby propagating shocks to the real economy and amplifying swings in borrowing (and hence investment), aggregate demand, and prices.[18]

The approach that underlies the models presented in this manual also emphasizes balance sheet conditions (or collateral values) on the default premium and the cost of borrowing. As such, this view seems more in line with the way credit markets operate in *normal* times in MICs, with binding constraints taking the form of complete exclusion of some potential borrowers from access to loans (small entrepreneurs with limited or no collateral), and others subject to a premium, embedded in the loan rate, which varies as a function of their net worth. In this setting, collateral serves as both an insurance mechanism and an incentive-mitigating device. Its existence is therefore motivated, as in some of the banking literature on credit market imperfections, by limited contract enforceability and moral hazard concerns.

However, the approach followed in subsequent chapters also departs from the BGG model in three important ways. First, it emphasizes *non-contingent* monitoring costs and is more in line with traditional microeconomic approaches to banking. As in Diamond (1984), the fundamental reason why banks exist is because they provide monitoring services to depositors, avoiding therefore duplication costs. But although banks are efficient at evaluating borrowers, and at ensuring that they comply with their contractual obligations, the cost of performing these activities is not trivial and may vary with the state of the business cycle. At the same time, these monitoring activities differ from the *ex post* monitoring activity emphasized in the BGG model, where lenders monitor when the project outcome is realized, and only when the borrower defaults on repayments. The cost of monitoring in that literature is an expected default or *state-contingent* verification cost, more akin to a bankruptcy cost associated with auditing, accounting, and legal expenses due to liquidation.

Moreover, the more advanced models in this Manual rely on a common simplifying assumption in micro-based banking models – the existence of a one-to-one relationship between bank monitoring intensity and the probability that borrowers repay their loans (see, for instance, Allen et al. (2011) and Dell'Ariccia et al. (2014)). This assumption translates into a direct link between the probability of default and interest rate spreads. The resulting banking structure is simpler, while preserving fundamentally the same insights as more complex, micro-founded specifications – especially with respect to the role of financial amplification effects, which operate through endogenous changes in the repayment probability.

Second, collateral in our approach is based on housing assets, rather than physical capital, as in BGG. This is consistent with the evidence which shows that creditors are often reluctant to accept movable assets, such as machinery, as guarantees. Third, in the model there are two channels through which the financial accelerator operates – both of which affect the borrowers' repayment probability, whose inverse determines the magnitude of the premium that banks charge. The first is through changes in asset prices and collateral values. This is conceptually similar to the balance sheet effect and its impact on the external finance premium emphasized in the BGG model, the difference being that the asset price through which the amplification effect occurs is the price of housing, as noted earlier, rather than the price of physical capital. The second channel is cyclical output, which affects (as discussed later) unit monitoring costs. If shocks have positive effects on both house prices and cyclical output, these channels will typically reinforce each other and amplify the financial accelerator effect. However, if shocks have conflicting effects on these variables, it is possible that the net effect is a financial *decelerator* effect – even if collateral values increase.

Finally, the models emphasize, in line with the foregoing discussion with respect to the type of financial frictions that are observed in MICs, imperfect competition in the banking sector. By introducing banks and accounting explicitly for their pricing decisions under monopolistically competition, the analysis accounts not only for the demand side of the credit market (as in the BGG model) but also for the supply side. This allows a more thorough description of the channels through which monetary policy and macroprudential regulation operate, making it possible to study the extent to which shocks originating in the financial sector have significant spillover effects on the real economy. In addition, the explicit account of banks helps to provide a more in-depth discussion of the role, and transmission mechanism, of macroprudential policy.

17 Thus, in the BGG model the cost of external financing is increasing in borrowing for a given net worth of the borrower, because higher leverage induces higher agency costs. In addition, because profits and asset prices are procyclical, borrowers' net worth is procyclical as well.

18 Christiano et al. (2010) argued that, in addition to the BGG financial accelerator effect, there is a second, complementary channel through which changes in net worth can be propagated: the Fisher deflation effect, which operates when debt contracts are formulated in *nominal* terms.

Chapter 2. A Simple Closed-Economy Model

As documented in Chapter 1, financial market imperfections cover a broad spectrum in bank-dependent economies. The existence of these imperfections has important implications for the transmission mechanism of macro-financial policies, both individually and in coordination.

This chapter presents a simple static model of a bank-dependent closed economy in which the impact of macroeconomic policies can be explored and some core intuition established.[1] A key feature of the model is that it accounts explicitly for an important source of imperfection in credit markets – namely, the fact that exposure to idiosyncratic shocks makes borrowers' ability to repay uncertain. In addition, because weak insolvency laws and inefficient judicial systems hamper the ability of financial intermediaries to enforce the terms of loan contracts in case of default (as also noted in the previous chapter), lending is collateralized. Thus, borrowers' net worth affects the terms of at which they borrow.

To begin, Section 1 describes the main assumptions of the model. The model's structure is presented in Section 2. The macroeconomic equilibrium is derived in Section 3, and the impact of macro-financial policies is examined in Section 4. The effects of three instruments are analysed: fiscal policy (changes in government spending), monetary policy (changes in the policy interest rate), and macroprudential policy (in the form of changes in a tax on loans and changes in reserve requirements). Section 5 considers the impact of two autonomous shocks (a productivity shock and a financial shock) and how various pairs of policy instruments can be combined to restore the pre-shock equilibrium. Section 6 considers several extensions of the model, including the cost channel, by assuming that the working capital needs of firms to bank credit.

2.1. Key Features and Assumptions

In line with the discussion in Chapter 1, the key features of the model are as follows.

1. Banks, and financial frictions, take center stage. These frictions reflect distortions in the pricing mechanism (namely, the formation of interest rates) in credit markets, which can be related at a fundamental level to asymmetric information between lenders and borrowers or monitoring costs.

2. Banks' funding sources consist of household deposits and central bank loans, which they view as perfect substitutes.

3. Banks lend only to firms. This is consistent with the evidence, discussed in Chapter 1, which shows corporate firms still predominantly rely on bank borrowing (in addition to retained earnings) to finance investment, and that household debt in bank-dependent MICs remains relatively low compared to corporate debt.

4. Firms depend solely on bank finance, because they have no access to alternative markets for funds. But loans are subject to default, and loan contracts cannot be fully enforced in court by lenders. As a result of these frictions, firms' balance sheet (which reflects their assets and liabilities) are a major factor in the determination of the cost of credit. Indeed, to reflect the risk of default, loan rates are set as a premium over the cost of borrowing from the central bank.

5. The premium is a function of borrowers' collateralizable net worth. Thus, although all firms have access to the credit market (that is, there is no credit rationing), financial frictions imply that access to bank loans is more costly for firms with a weak financial position (those with low net worth).

6. The central bank operates a standing facility to conduct monetary policy, whereas the regulator sets macroprudential policy in the form of a tax on loans.

7. Loan supply by banks to firms, and the provision of liquidity by the central bank to commercial banks, are perfectly elastic at prevailing interest rates.

8. Although they are not explicitly derived from explicit microeconomic optimisation problems, investment and consumption functions are postulated in a manner consistent with the empirical evidence. While investment is related inversely with the real loan rate (a proxy variable for the cost of capital), consumption varies inversely with

[1] The model dwells on Agénor (2020, Chapter 2, 2021) and Agénor (2021). A counterpart open-economy model is presented in Chapter 3.

real deposit rates (intertemporal effect) and positively with current income (which reflects liquidity constraints) and real financial wealth.

2.2. Model Structure

Consider a closed economy producing a homogeneous good, which can be either consumed or invested. There are six categories of agents: firms, households, commercial banks, the central bank, the financial regulator, and the government. The central bank operates a standing facility; it fixes the cost at which banks can borrow and provides all the funding (liquidity) that banks ask for. The supply of liquidity by the central bank is thus perfectly elastic. At the same time, banks' funding sources (household deposits and borrowing from the central bank) are perfect substitutes: to fund their lending operations, banks are indifferent between using deposits or resources borrowed from the central bank.

The behaviour of agents is described first, and market-clearing conditions next.

2.2.1. Firms

Let Y denote output of the homogeneous good. The production function takes a Cobb-Douglas form:

$$Y = AN^{\alpha}K_0^{1-\alpha}, \tag{2.1}$$

where K_0 is the stock of capital at the beginning of the period (which is inherited from the past, and can therefore be considered as predetermined), N the quantity of labour employed, $\alpha \in (0,1)$, and $A > 0$ is a productivity parameter. Thus, production exhibits *constant returns to scale* with respect to the two inputs, labour and capital.

Comment 2.1. The production function $Y = F(N, K_0)$ exhibits *constant returns to scale* (CRS) if doubling the quantities of N and K_0 doubles the amount of output produced. Formally, the CRS assumption implies that if N and K_0 are multiplied by any positive constant $\lambda > 0$, output will increase by the same factor:

$$F(\lambda N, \lambda K_0) = \lambda F(N, K_0),$$

which implies, equivalently, that the function is homogeneous of degree 1. In the present case, $F(N, K_0) = N^{\alpha}K_0^{1-\alpha}$, so that

$$F(\lambda N, \lambda K_0) = (\lambda N)^{\alpha}(\lambda K_0)^{1-\alpha} = \lambda^{\alpha+1-\alpha}N^{\alpha}K_0^{1-\alpha} = \lambda Y.$$

Let W denote the nominal wage; the wage bill is thus WN. Let also P denote the price of the good. Firms' profits, Π, can therefore be defined as

$$\Pi = PY - WN,$$

that is, substituting equation (2.1) for Y,

$$\Pi = PAN^{\alpha}K_0^{1-\alpha} - WN. \tag{2.2}$$

Firms determine the level of employment, N, so as to maximise profits.[2] Using (2.1), and taking P and W as given, the first-order condition of the maximisation problem is thus

$$\frac{d\Pi}{dN} = \alpha PAN^{\alpha-1}K_0^{1-\alpha} - W = 0,$$

or equivalently

$$AN^{\alpha-1}K_0^{1-\alpha} = \frac{W}{\alpha P},$$

[2] Because the capital stock is predetermined at K_0, it is not a choice variable for firms.

or again

$$N^{1-\alpha} = (\frac{A\alpha P}{W})K_0^{1-\alpha} \ ,$$

so that the demand for labour, N^d, is

$$N^d = (\frac{A\alpha P}{W})^{1/(1-\alpha)}K_0. \tag{2.3}$$

Substituting this equation in the production function (2.1) gives the supply of goods, Y^s, as

$$Y = [(\frac{A\alpha P}{W})^{1/(1-\alpha)}K_0]^{\alpha} K_0^{1-\alpha} = (\frac{A^{\alpha} P}{W})^{\alpha/(1-\alpha)}K_0^{\alpha+1-\alpha} \ ,$$

so that

$$Y^s = (\frac{A\alpha P}{W})^{\alpha/(1-\alpha)}K_0. \tag{2.4}$$

Equations (2.3) and (2.4) show that the demand for labour and the supply of goods (or output, for short) are inversely related to the real wage, defined as $\omega = W / P$, that is, the nominal wage divided by the price of the good.

In what follows, it will be assumed that the nominal wage, W, is rigid. Thus, $W = \bar{W}$. This assumption is consistent with the evidence which suggests that, in the short run, wages do not adjust quickly – possibly because employment contracts are signed for multiple periods.[3] The labour demand equation (2.3) can therefore be written as

$$N^d = N^d(P; A), \tag{2.5}$$

with the derivatives of N^d with respect to P and A, given by, from (2.3),

$$N_P^d = (\frac{1}{1-\alpha})\frac{N^d}{P} > 0, \quad N_A^d = (\frac{1}{1-\alpha})\frac{N^d}{A} > 0.$$

An increase in the price of the good, by lowering the real wage, raises labour demand. A positive productivity shock also raises the demand for labour.

Similarly, the supply equation (2.4) can be written as

$$Y^s = Y^s(P; A), \tag{2.6}$$

with the derivatives of Y^s with respect to P and A given by, from (2.4),

$$Y_P^s = (\frac{\alpha}{1-\alpha})\frac{Y^s}{P} > 0, \quad Y_A^s = (\frac{\alpha}{1-\alpha})\frac{Y^s}{A} > 0.$$

An increase in the price of the good, or a positive productivity shock, by raising labour demand, raises output as well.

Comment 2.2. If the nominal wage is indexed on the price level, so that $W = P$, the product wage ω is constant; there is *real wage rigidity*. Labour demand and the supply of goods would not depend on prices ($N_P^d = Y_P^s = 0$). If so, fluctuations in equilibrium prices would be driven by supply shocks and changes in aggregate demand, as discussed later on.

3 See, for instance, Cobb and Opazo (2008) for evidence on nominal wage rigidity in Chile. This assumption is also consistent with the view, put forward by Christiano et al. (2005), that nominal wage rigidity may be a more important factor than nominal price stickiness in explaining macroeconomic fluctuations. See, for instance, Basu and House (2016) for a more nuanced perspective.

Comment 2.3. Let $\bar{N}^s$ denote the fixed supply of labour. If wages are fully flexible, the market-clearing condition is $\bar{N}^s = (A\alpha\omega)^{1/(1-\circ)}K_0$. Output is thus constant at $A(\bar{N}^s)^\circ K_0^{1-\circ}$ and would again be independent of prices.

Let i^L be the loan rate charged by banks for investment loans. Real investment by firms, I, is given by

$$I = I(i^L - \pi^e), \tag{2.7}$$

where π^e is the expected inflation rate, taken as given. Investment is assumed to vary inversely with the real loan rate, which measures the cost of borrowing. Thus, $I' < 0$.

Comment 2.4. In principle, the real loan rate is defined as $(1+i^L)/(1+\pi^e)$. Assuming that i^L is relatively small, using the result that $\ln[(1+x_1)/(1+x_2)] = \ln(1+x_1) - \ln(1+x_2)$ and the approximation $\ln(1+x) \simeq x$, yields $i^L - \pi^e$, as defined in equation (2.7).

2.2.2. Households

Households supply labour inelastically. Employment is therefore determined by the demand side of the labour market. They consume goods and hold financial assets. Portfolio decisions follow a two-stage process.

Comment 2.5. The assumption that household labour supply is *inelastic* means that, with the level of employment that firms desire given by (2.5) and the nominal wage fixed at $\bar{W}$, unemployment can emerge in equilibrium. The link between unemployment and wages is discussed later on.

Financial Assets

The financial assets held by households consist of *a*) currency (or cash, which bears no interest); and *b*) deposits with the banking system. Cash and deposits are imperfect substitutes in household portfolios, which means essentially that their rates of return are determined independently from each other.[4]

In the first stage of the portfolio allocation process, households choose how to allocate their financial wealth, F^H, defined as:

$$F^H = M + D, \tag{2.8}$$

where M is currency holdings, and D deposits.

Once again, there is a distinction between beginning- and end-of-period stocks; here, total financial wealth is predetermined. Thus,

$$F^H = F_0^H. \tag{2.9}$$

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

$$\frac{D}{M} = \nu(i^D), \tag{2.10}$$

where $\nu()$ is a function with derivative $\nu' > 0$. Thus, an increase in the deposit rate raises the share of deposits relative to cash.

From (2.10), $M = D/\nu(i^D)$. Substituting this result in the definition of financial wealth (2.8) yields

$$F^H = \frac{D}{\nu(i^D)} + D,$$

so that

$$\frac{D}{F_0^H} = \frac{1}{\frac{1}{\nu(i^D)} + 1},$$

[4] If two assets, A and B, are perfect substitutes, their rates of return, i^A and i^B are equal, so that $i^A = i^B$, and how much individuals hold of each asset is undetermined.

or equivalently, multiplying both terms on the right-hand side by $\nu(i^D)$,

$$\frac{D}{F_0^H} = \frac{\nu(i^D)}{1+\nu(i^D)} = d(i^D), \tag{2.11}$$

with derivative given by

$$d' = \frac{(1+\nu)\nu' - \nu\nu'}{(1+\nu)^2} = \frac{\nu'}{(1+\nu)^2},$$

so that, given that $\nu' > 0$, $d' > 0$. An increase in the deposit rate raises the demand for these deposits.

Consider now the demand for cash. Again, from (2.10), $M = D / \nu(i^D)$. Using (2.11) to substitute out for D yields

$$\frac{M}{F_0^H} = \frac{d(i^D)}{\nu(i^D)} = \frac{1}{\nu(i^D)}\frac{\nu(i^D)}{1+\nu(i^D)} = \frac{1}{1+\nu(i^D)},$$

or equivalently

$$\frac{M}{F_0^H} = m(i^D), \tag{2.12}$$

where, given again that $\nu' > 0$,

$$m' = \frac{-\nu'}{(1+\nu)^2} < 0.$$

Holding financial wealth constant, an increase in the deposit rate raises the demand for deposits (as noted earlier) and therefore must lower the demand for cash.

Total household wealth, A^H, is defined as

$$A^H = F^H + P^H h_0, \tag{2.13}$$

where h_0 is the quantity of land (or housing) and P^H its nominal price.

In the second stage of the portfolio allocation process, household determine their demand for land, which is given by

$$\frac{H}{P} = h(i^D - \pi^e, \pi^{H,e}, Y^s), \tag{2.14}$$

where $\pi^{H,e}$ is the expected rate of increase in land prices, and $h_{i^D} < 0$, $h_{\pi^{H,e}} > 0$, and $h_{Y^s} > 0$. Thus, an increase in the rate of return on 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 two effects are standard portfolio effects, whereas the third captures the well-documented procyclical relationship between house prices and economic activity.[5]

Household Consumption

Interest on deposits is paid at the end of each period. Real consumption expenditure, *C*, depends *a*) positively on disposable income, $Y^s - T$, where *T* represent taxes; *b*) negatively on the real deposit rate, $i^D - \pi^e$; and *c*) positively on real financial wealth at the beginning of the period, F_0^H / P. Thus, consumption spending can be written as:

$$C = c_0 + c_1(Y^s - T) - c_2(i^D - \pi^e) + c_3\left(\frac{F_0^H + P^H h_0}{P}\right), \tag{2.15}$$

[5] Evidence on the procyclicality of house prices is provided, for instance, by Cesa-Bianchi et al. (2015).

where, as before, π^e is the expected inflation rate (again, assumed constant), $c_1 \in (0,1)$ the marginal propensity to consume, $c_0 \geq 0$, and c_2, $c_3 > 0$.

Comment 2.6. In principle, the real deposit rate is defined as $(1+i^D)/(1+\pi^e)$. Assuming that i^D is relatively small and using again $\ln[(1+x_1)/(1+x_2)] = \ln(1+x_1) - \ln(1+x_2)$ and $\ln(1+x) \simeq x$ yields $i^D - \pi^e$, as defined in equation (2.15).

1. The positive effect of disposable income on consumption is consistent with the evidence regarding the pervasiveness of *liquidity* or *borrowing constraints* on households.[6] Life-cycle models predict a relationship between consumption and (the stock of) wealth, rather than (current) income. However, liquidity-constrained households cannot borrow from the financial system to keep consumption stable over time when they are faced with adverse shocks (for instance, a spell of unemployment), and therefore tend to adjust their spending on the basis of changes in their current earnings only.

2. The negative effect of the expected real return on deposits captures an *intertemporal substitution effect*: when the (expected) return on deposits increases, households have an incentive to save more (for future consumption) and to reduce current consumption.

3. The positive effect of wealth on consumption captures the fact that individuals tend to spend more when the real value of their (financial and physical) assets increases.[7]

2.2.3. Commercial Banks

Bank assets consist of loans to firms, L, and reserves held at the central bank, RR, whereas their liabilities consist of deposits held by households, D, and borrowing from the central bank, L^B. The balance sheet of banks can therefore be written as:

$$L + RR = D + L^B. \tag{2.16}$$

Loans are given by

$$L = L_0 + PI,$$

where L_0 is the beginning-of-period stock of loans and I is again real investment, as defined in (2.7). Thus, bank lending serves only to finance investment.

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

$$RR = \mu D, \tag{2.17}$$

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; they are indifferent as to which source of funding they use to finance their loans. Thus, the return on these deposits must be equal to the cost of funds provided by the monetary authority, i^R, also referred to in what follows as the *refinance rate*, corrected for the (implicit) cost of holding reserves:

$$i^D = (1-\mu)i^R. \tag{2.18}$$

Comment 2.7. The refinance rate represents the *marginal cost of borrowing* for banks because, with the supply of deposits to banks determined by households (as implied by their portfolio equation (2.11)), if banks need an extra unit of funding to support lending to firms they must obtain it from the central bank, at the rate i^R.

Banks set the loan rate, i^L, at a premium over the marginal cost of funds, that is, the refinance rate, and account for the macroprudential tax rate, τ^L:

$$i^L = i^R + \theta + \gamma\tau^L, \tag{2.19}$$

6 For instance, the proportion of constrained households in the Euro area is estimated to vary between 20 percent and 40 percent.

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

where θ is the default premium (or premium, for short) and $\gamma > 0$.[8]

First, consider the term θ. In this economy, all firms in the economy 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 difference between real estate assets (the stock of land, H, times P^H, the nominal price of land) and firms' initial liabilities (that is, beginning-of-period borrowing, L_0):

$$\theta = \theta(\kappa P^H h_0 - L_0), \tag{2.20}$$

where $\kappa \in (0,1)$ is the proportion of physical assets that can effectively be used or pledged as collateral, or, equivalently, the fraction of pledged assets that lenders can recover in case of default.

On the one hand, the higher the value of collateral, $\kappa P^H h_0$, relative to outstanding liabilities, L_0, the higher the proportion of their loans that banks can recoup in the event of default. More collateral may therefore reduce incentives for banks to monitor borrowers and exercise due diligence in general – a phenomenon often referred to as the *lazy bank* effect. On the other, however, collateral may mitigate moral hazard on the side of borrowers and induce them to exert more effort in ensuring that their investments are successful. In light of the evidence, in what follows the effect on borrowers' incentives is assumed to dominate, so that $\theta' < 0$. Thus, an increase in *net collateralizable assets* (land only in the present case) reduces the premium and the cost of borrowing. Because both h_0 and L_0 are predetermined, the premium varies inversely with the price of land. As shown later, this introduces a *financial amplification effect* in assessing the impact of monetary policy.[9]

Second, consider the macroprudential tax rate, τ^L. In line with several existing 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. Put differently, macroprudential policy influences the funding costs of firms directly.[10]

Comment 2.8. The case where the capital stock, PK_0, can be pledged as collateral is discussed in the last section of this chapter.

Given that commercial banks set the loan rate, the amount of loans outstanding is determined by firms' demand for credit, which itself depends on investment, as given in (2.7). With deposits being determined again by households, equations (2.16) and (2.17) imply that borrowing from the central bank is determined residually:

$$L^B = L - (1-\mu)D. \tag{2.21}$$

2.2.4. Central Bank and Financial Regulator

The central bank's balance sheet consists, on the asset side, of loans to commercial banks, L^B, and, on the liability side, of the monetary base, which consists of the sum of currency in circulation, M, and required reserves, RR:

$$L^B = M + RR. \tag{2.22}$$

As noted earlier, the central bank operates a standing facility; it supplies liquidity elastically to commercial banks at the prevailing refinance rate, i^R, which represents the main instrument of monetary policy. It also sets the required reserve ratio, μ. Banks' liquidity needs, L^B, are determined residually in (2.21). Reserve requirements are proportional to household bank deposits, which are determined by the portfolio equation (2.11). Thus, equation (2.22) determines the supply of cash, M^s.

For its part, the financial regulator sets the macroprudential tax rate, τ^L.

8 See Agénor (2021, Appendix A) for a micro-founded derivation of this specification when $\gamma = 0$.

9 To avoid a scaling issue, the premium could be specified as a function of the ratio of assets to liabilities, $\kappa P^H h_0 / L_0$. However, this makes no qualitative difference in the present case.

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

2.2.5. Market-Clearing Conditions

There are five market equilibrium conditions to consider: four of them related to financial markets (deposits, commercial bank loans, central bank loans, and cash), one to the market for land, and one to the goods market.

At the going deposit, loan, and refinance rates, the markets for deposits, commercial bank loans, and central bank loans adjust through quantities. Indeed, at the rate i^D, banks accept all the deposits that households are willing to make; at the rate i^L, banks supply all the loans that firms demand to finance investment; and at the rate i^R the central bank provides all the liquidity that banks need, given the amount of loans that they have to provide and the deposits that they receive from households. Only the three remaining equilibrium conditions need to be considered, those related to: the market for land, the goods market, and the market for cash.

Equilibrium of the Market for Land

As noted earlier, the supply of land is fixed at h_0. The equilibrium condition of the land market is therefore given by

$$\frac{H}{P} = \frac{P^H h_0}{P}, \tag{2.23}$$

which, using (2.14) and setting $h_0 = 1$, can be solved for the real price of land, $p^H = P^H / P$:

$$p^H = h(i^D - \pi^e, Y^s; \pi^{H,e}),$$

that is, using (2.6) and (2.18) to substitute out for Y^s and i^D,

$$p^H = p^H(P; i^R, \mu, A), \tag{2.24}$$

where

$$p_P^H = h_{Y^s} Y_P^s > 0,$$

$$p_{i^R}^H = (1-\mu)h_{i^D-\pi^e} + h_{Y^s} Y_{i^R}^s < 0,$$

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

$$p_A^H = h_{Y^s} Y_A^s > 0.$$

An increase in prices, by reducing real wages and stimulating output, raises income and the demand for land, as well as its real price. A positive productivity shock has a similar effect. An increase in the refinance rate, by raising the return on deposits, reduces the demand for land and its real price. An increase in the required reserve ratio has the opposite effects – by reducing the return on deposits, it raises the demand for land as well as its price.

Equilibrium of the Goods Market

The equilibrium condition of the goods market requires equality between aggregate supply, given by Y^s, and aggregate demand, given by the sum of household spending, C, investment, I, and public expenditure, G, that is, domestic absorption:

$$Y^s = C + I + G. \tag{2.25}$$

Equilibrium of the Market for Cash

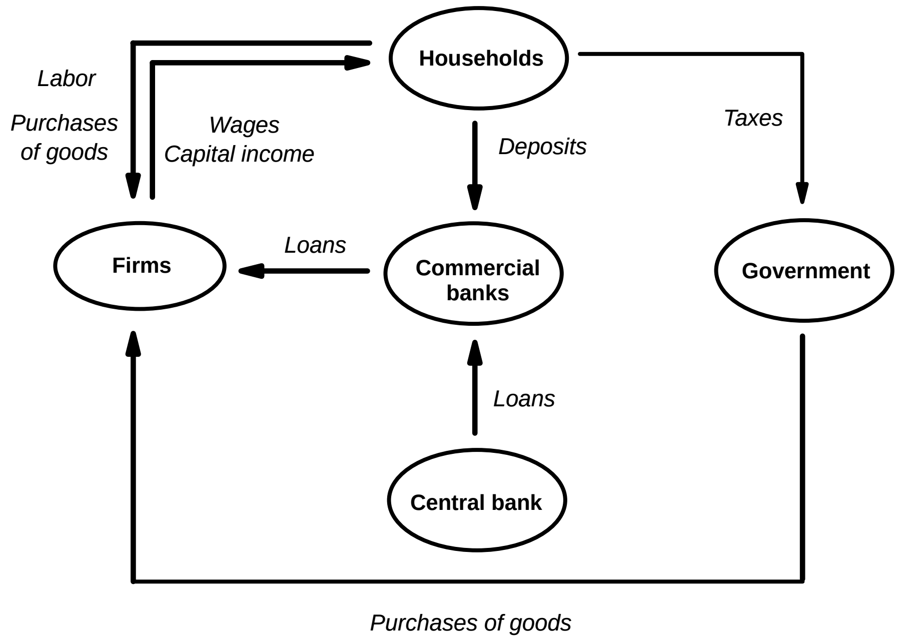
The last equilibrium condition relates to the market for cash and involves equating (2.12), which defines the demand for currency in proportion to total financial wealth, and (2.22), which defines money supply. Thus,

$$m(i^D)F_0^H = M^s. \tag{2.26}$$

However, by *Walras law* it is not necessary to consider this condition explicitly when solving the model.

FF-GG Model of a Closed Economy: Main Real and Financial Linkages

Figure 2.1



Comment 2.9. *Walras law* states that, in an economy with n markets, if $n-1$ markets are in equilibrium, then the n-th market must also be in equilibrium. In this particular case, the n-th market is the market for cash.[11]

The main real and financial linkages between agents are shown in Figure 2.1, whereas Table 2.1 summarizes the list of variables and their definitions.

2.3. Macroeconomic Equilibrium

First, consider the financial market equilibrium condition. Combining (2.19) and (2.20), and using (2.24) to substitute out for $P^H = p^H P$, yields

$$i^L = i^R + \theta \kappa p^H (P; i^R, \mu, A)P - L_0] + \gamma \tau^L,$$

that is,

$$i^L = FF(P; G, i^R, \mu, \tau^L, A), \tag{2.27}$$

where

$$FF_P = \kappa \theta'(p^H + P p_P^H) < 0,$$

$$FF_G = 0,$$

$$FF_{i^R} = 1 + \kappa \theta' P p_{i^R}^H > 0,$$

$$FF_\mu = \kappa \theta' P p_\mu^H < 0,$$

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

$$FF_A = \kappa \theta' P p_A^H < 0.$$

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

Variable Names and Definitions	Table 2.1
Variable	Definition
Firms	
Y	Aggregate output
A	Productivity shock
N	Employment
K_0	Capital stock (beginning of period)
P	Price of good
p^H	Real price of land
W	Nominal wage
I	Investment
Households	
C	Expenditure
F^H	Financial wealth
M	Currency holdings (cash)
D	Deposits
Commercial banks	
L	Loans to firms
L^B	Borrowing from the central bank
i^D	Deposit rate
i^L	Loan rate
θ	Default premium
Government	
G	Expenditure
Central bank	
i^R	Refinance rate
μ	Required reserve ratio
Regulator	
τ^L	Macroprudential tax rate
Other variable	
π^e	Expected inflation rate

Comment 2.10. Partial derivatives FF_P, FF_{i^R}, FF_μ, and FF_A are calculated using the formula for the derivative of a function of a function, of the form $H(x) = h[g(x)]$, that is, $H' = dH / dx = (dh / dg)(dg / dx) = h'g'$.

Equation (2.27) defines the *financial sector equilibrium* condition, which also implicitly accounts for the equilibrium of the housing market. The interpretation of these derivatives is as follows.

1. An increase in the price level, P, has a negative effect on the equilibrium loan rate ($FF_P < 0$). Through its effect on production and income, it raises the demand for land as well as its price, which in turn raises the net value of firms' collateralizable assets. Thus, banks demand a lower premium and reduce the loan rate. This effect, which depends on the magnitude of θ' (that is, the strength of collateral effects) is the key source of the *financial accelerator* effect – or, more accurately perhaps (as noted by Romer (2018, p. 142)), the *financial amplifier* effect – which is discussed in more detail later.

2. An increase in government spending, G, has no direct effect on financial sector equilibrium.

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

4. An increase in the required reserve ratio, μ, lowers the deposit rate and increases the demand for, and the price of, land (recall that, from (2.24), $p^H_\mu > 0$). This raises collateral values and lowers the premium, so that $FF_\mu < 0$.

5. An increase in the macroprudential tax, τ^L, raises directly the loan rate, so that $FF_{\tau^L} > 0$.

6. A positive productivity shock, A, raises income and increases the demand for, and the price of, land. Again, this raises collateral values and lowers the premium, so that $FF_A < 0$.

Consider next the equilibrium condition of the goods market, equation (2.25).

Substituting (2.6), (2.7), (2.15), (2.18), and (2.24), for Y^s, I, C, i^D and p^H, respectively, in that equation, and setting the expected inflation rate to 0 for convenience ($\pi^e = 0$), as well as $T = 0$, yields

$$Y^s(P;A) = c_0 + c_1 Y^s(P;A) - c_2 i^R + c_3[\frac{F_0^H}{P} + p^H(P;i^R,\mu,A)] + I(i^L) + G, \tag{2.28}$$

which implicitly defines a set of combinations of the loan rate, i^L, and the price level, P, that are consistent with equilibrium in the goods market.[12]

Totally differentiating equation (2.28) gives

$$Y_P^s dP + Y_A^s dA = c_1(Y_P^s dP + Y_A^s dA) - c_2(1-\mu)di^R + c_2 i^R d\mu - c_3(\frac{F_0^H}{P^2})dP$$

$$+c_3(p_P^H dP + p_{i^R}^H di^R + p_\mu^H d\mu + p_A^H dA) + I' di^L + dG,$$

or regrouping terms,

$$\left\{Y_P^s - c_1 Y_P^s + c_3(\frac{F_0^H}{P^2}) - c_3 p_P^H\right\} dP = -[c_2(1-\mu) - c_3 p_{i^R}^H]di^R$$

$$+(c_2 i^R + c_3 p_\mu^H)d\mu + (-Y_A^s + c_1 Y_A^s + c_3 p_A^H)dA + I' di^L + dG.$$

This expression describes a functional relationship between the loan rate, prices and the other variables which can be written in the form:

$$i^L = GG(P;G,i^R,\mu,\tau^L,A), \tag{2.29}$$

where, recalling that $Y_P^s, Y_A^s, > 0$, $c_1 \in (0,1)$, and $I' < 0$,

$$GG_P = \frac{1}{I'}\left\{(1-c_1)Y_P^s + c_3(\frac{F_0^H}{P^2}) - c_3 p_P^H\right\},$$

$$GG_G = -\frac{1}{I'} > 0,$$

$$GG_{i^R} = \frac{c_2(1-\mu) - c_3 p_{i^R}^H}{I'} < 0,$$

$$GG_\mu = -\frac{c_2 i^R + c_3 p_\mu^H}{I'} > 0,$$

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

$$GG_A = \frac{(1-c_1)Y_A^s - c_3 p_A^H}{I'} < 0.$$

12 Rather than setting $\pi^e = 0$, the expected inflation rate could be made an increasing function of the current value of output relative to some "full employment" value, Y^f, which corresponds to the case of full real wage flexibility, as defined earlier. Thus, $\pi^e = f(Y - Y^f)$, with $f' > 0$. This extension is left to the interested reader.

Equation (2.29) defines the *goods market equilibrium* condition. The signs of the partial derivatives can be explained as follows.

1. An increase in the price of the final good, P, exerts four types of effect:

a) it increases the production of goods (by lowering the real wage), as measured by Y_P^s;

b) it raises consumption by increasing income, as measured by $c_1Y_P^s$;

c) it lowers real financial wealth and reduces consumption, as measured by $c_3F_0^H / P^2$; and

d) it raises real wealth and stimulates consumption, as measured by $-c_3p_P^H$, by raising income and real land prices.

Because $Y_P^s > 0$, and $c_1 \in (0,1)$, the *net supply effect*, given by the difference between *a*) and *b*) and measured by $(1-c_1)Y_P^s$, is unambiguously positive. The wealth effects, *c*) and *d*), operate in opposite directions. It will be assumed in what follows that p_P^H – or, more precisely, the sensitivity of the demand for land to income, as measured by h_{Y^s} in (2.14) – is small enough to ensure that the *net wealth effect* is to reduce consumption ($-c_3F_0^H / P^2 + p_P^H < 0$, or equivalently $c_3F_0^H / P^2 - p_P^H > 0$). Thus, while aggregate demand may increase or fall (depending on whether the income effect is stronger than the net wealth effect or not), excess supply always prevails on the goods market. To restore equilibrium, aggregate demand must increase; for that to occur, investment must rise, and in turn, for that to happen, the loan rate must fall. Thus, $GG_P < 0$.

2. An increase in government spending, G, raises demand for goods. At the initial level of supply to the market, Y^s, there is therefore *excess demand*. Holding prices constant, to restore equilibrium aggregate demand must fall; for that to occur, investment must fall and, in turn, for that to happen, the loan rate must increase. Thus, $GG_G > 0$.

3. An increase in the refinance rate, i^R, raises the return on bank deposits, that is, the return to saving. Through the intertemporal substitution effect, therefore, households will consume less today. At the same time, a higher refinance rate raises the deposit rate, which in turn lowers the demand for land as well as its real price (recall that $p_{i^R}^H < 0$). This negative wealth effect also lowers consumption. As a result, at the initial level of prices, there is *excess supply*. To restore equilibrium aggregate demand must increase; for that to occur, investment must rise and, in turn, for that to happen, the loan rate must fall. Thus, $GG_{i^R} < 0$.

4. An increase in the required reserve ratio, μ, lowers the deposit rate. This raises consumption directly through intertemporal substitution. At the same time, it increases (as noted earlier) and through the demand for land and its price (recall that $p_\mu^H > 0$), which exerts a positive wealth effect and also raises consumption. There is therefore *excess demand* at the initial level of prices; to restore equilibrium, investment must fall, which implies that the loan rate must increase. Thus, $GG_\mu > 0$.

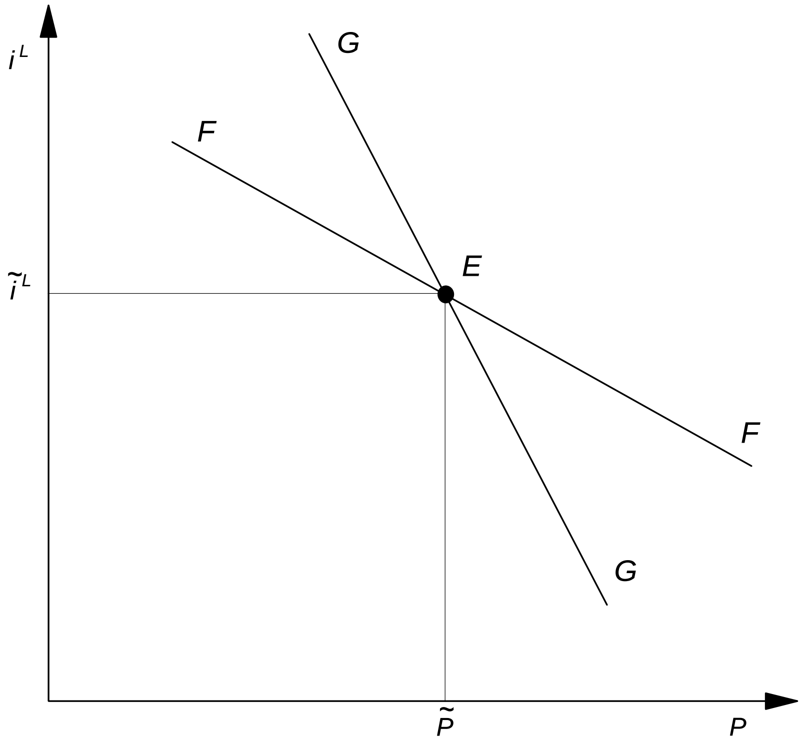
5. An increase in the macroprudential tax, τ^L, has no direct effect on the goods market equilibrium.

6. A positive productivity shock, A, raises production, disposable income, and consumption. Because the net supply effect is positive (as noted earlier), this creates *excess supply* on the goods market. At the same time, the increase in income raises the demand for land and its real price (recall that $p_A^H > 0$). This also raises consumption and aggregate demand through a wealth effect. Assuming again that the sensitivity of the demand for land to income, as measured by h_{Y^s}, is not too large, *excess supply* prevails. To maintain equilibrium at the initial level of prices, investment must increase, and for that to happen the loan rate must fall. Thus, $GG_A < 0$.

Equations (2.27) and (2.29) can be solved together for the equilibrium values of the loan rate, i^L, and the price of goods, P. The solution is depicted in Figure 2.2, in i^L - P space. Curve FF corresponds to equation (2.27); its slope is negative and given by

$$\left.\frac{di^L}{dP}\right|_{FF} = FF_P < 0.$$

Figure 2.2



Source: Agénor (2020).

Similarly, curve GG corresponds to equation (2.29); its slope is also negative and given by

$$\left.\frac{di^L}{dP}\right|_{GG} = GG_P < 0.$$

Because both FF and GG are downward-sloping, the issue then is: which curve is steeper than the other? The answer to this question is important to use the model to study policy and exogenous shocks. As discussed in Agénor (2020, Chapter 2) by applying *Samuelson's Correspondence principle*, it can be established (see the Appendix) that GG must be steeper than *FF*. Thus, in absolute terms,

$$|GG_P| > |FF_P|. \tag{2.30}$$

Comment 2.11. Samuelson's Correspondence principle, formulated by Samuelson (1947), establishes a link between *comparative statics analysis* (the comparison of two economic outcomes, before and after a change in some underlying exogenous parameter or policy variable) and dynamic stability analysis (the study of conditions under which a model converges over time to an equilibrium).

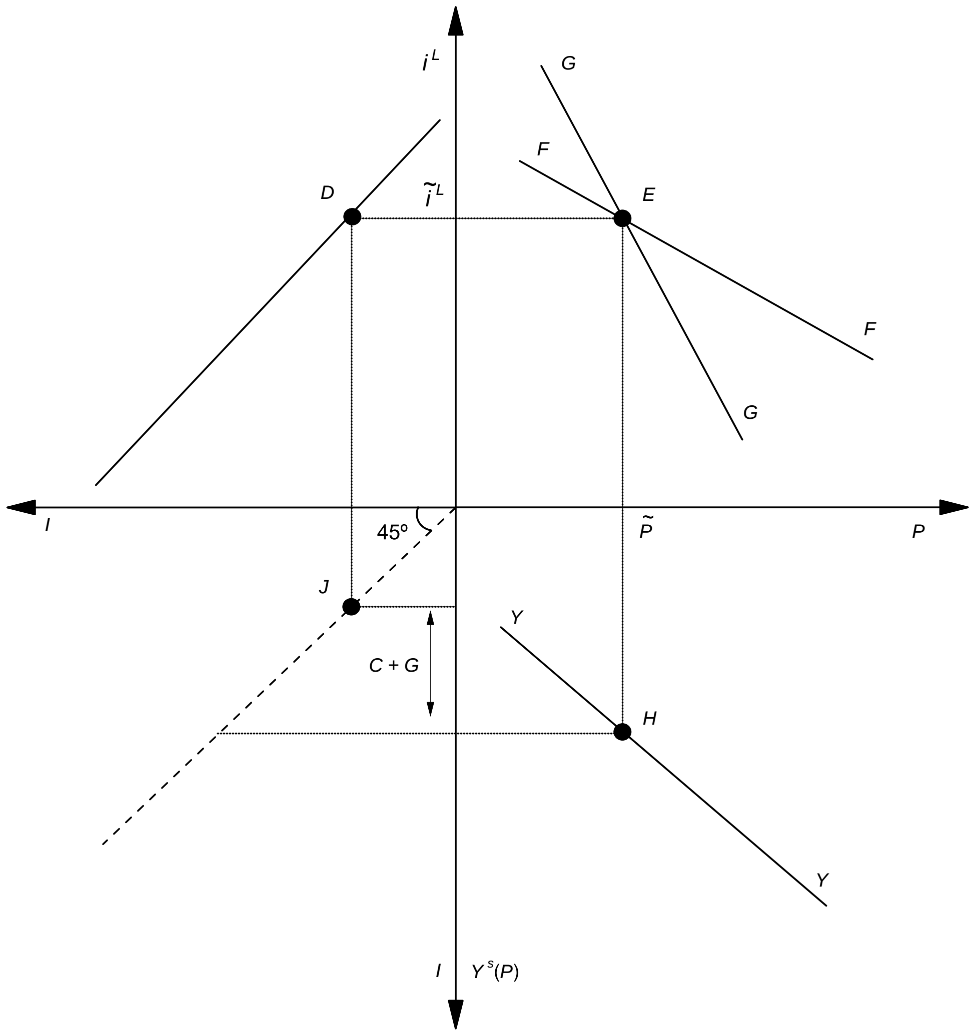
Macroeconomic equilibrium obtains at the point of intersection of the two curves, that is, point E in Figure 2.2.

A full diagrammatic characterization of the equilibrium is provided in Figure 2.3. In the northeast quadrant, curves FF and GG are again represented in i^L-P space, just as in Figure 2.2. The northwest quadrant shows the negative relationship between the loan rate i^L and investment I, that is, equation (2.7). Using the 45-degree line, this value is then reported in the southwest quadrant. The southeast quadrant shows the positive relationship between the price level, *P*, and production, Y^s, given that from (2.6) $Y_P^s > 0$.

From the equilibrium condition of the goods market (2.25), the difference between production and investment, $Y^s - I$, gives the equilibrium level of (private and public) spending on goods, $C + G$. This is also shown in the southwest quadrant. The economy's equilibrium is achieved at points *E*, *D*, *H*, and *J*.

Macroeconomic Equilibrium: Full Diagram

Figure 2.3



Source: Agénor (2020).

2.4. Macro-Financial Policy Analysis

This section studies the macroeconomic and financial effects of fiscal policy, in the form of an increase in government spending, monetary policy, taking the form of an increase in the refinance rate, and macroprudential policy, in the form of an increase in the tax rate on loans.

2.4.1. Fiscal Policy

Consider an increase in government spending, G. Differentiating (2.27) and (2.29), holding , μ, τ^L and A constant, the equilibrium response of the loan rate and prices can be evaluated by solving the system:

$$di^L = FF_P dP + 0 \cdot dG,$$

$$di^L = GG_P dP + GG_G dG,$$

which can be written in matrix form as

$$\begin{bmatrix} 1 & -FF_P \\ 1 & -GG_P \end{bmatrix} \begin{bmatrix} di^L \\ dP \end{bmatrix} = \begin{bmatrix} 0 \\ GG_G \end{bmatrix} dG.$$

Applying *Cramer's rule*, the solution is

$$\frac{di^L}{dG} = \frac{\overset{(+)}{GG_G}\overset{(-)}{FF_P}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} < 0, \quad \frac{dP}{dG} = \frac{\overset{(+)}{GG_G}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} > 0, \tag{2.31}$$

given that $|GG_P| > |FF_P|$, or equivalently, $-GG_P > -FF_P$, which is the condition, noted earlier, requiring the slope of GG to be steeper than FF (see (2.30)). These expressions indicate that an increase in government spending leads to a reduction in the loan rate and higher prices.

Comment 2.12. Cramer's rule provides an explicit formula for the solution of a system of linear equations with as many equations as unknowns. Consider the following system of two equations in two unknowns, x_1 and x_2:

$$a_{11}x_1 + a_{12}x_2 = b_1,$$

$$a_{21}x_1 + a_{22}x_2 = b_2,$$

in which coefficients a_{ij} are non-zero. In matrix form, this system can be written as

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}.$$

Applying Cramer's rule gives the solutions

$$x_1 = \frac{\begin{vmatrix} b_1 & a_{12} \\ b_2 & a_{22} \end{vmatrix}}{\det \mathbf{A}} = \frac{b_1a_{22} - b_2a_{12}}{a_{11}a_{22} - a_{12}a_{21}}, x_2 = \frac{\begin{vmatrix} a_{11} & b_1 \\ a_{21} & b_2 \end{vmatrix}}{\det \mathbf{A}} = \frac{b_2a_{11} - b_1a_{21}}{a_{11}a_{22} - a_{12}a_{21}},$$

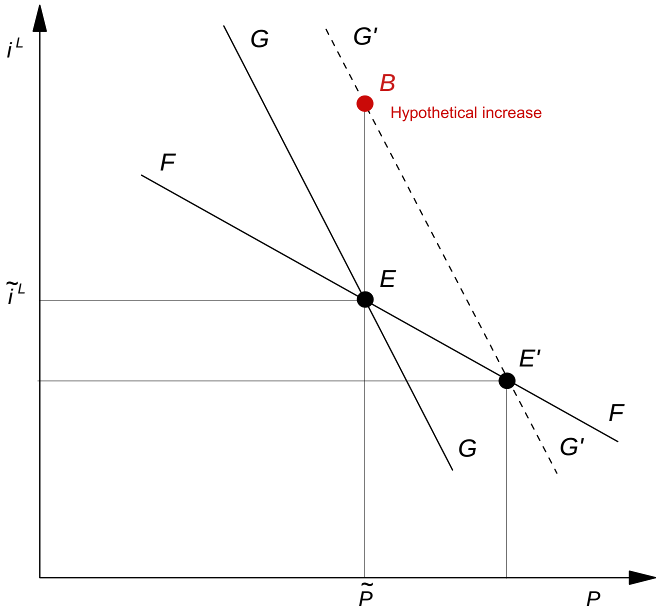
where $\det \mathbf{A} = \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} = a_{11}a_{22} - a_{12}a_{21}$.

Figure 2.4 illustrates these effects. Curve FF does not change (given that it does not depend directly on government spending) but curve GG does. The reason is that, as noted earlier, $GG_G > 0$ for P given, which means that, at the initial level of prices, the loan rate must rise (see (2.29)). Graphically, this is captured by an *upward* movement of GG (relative to the horizontal axis) or, what is visually equivalent, a *rightward* shift of GG (relative to the vertical axis) to $G'G'$. Thus, at the initial level of prices, the loan rate would need to increase from E to B to restore equilibrium in the goods market. However, *this increase is hypothetical*; the loan rate is set by commercial banks and does not change on impact in this experiment – because the refinance rate and the macroprudential tax rate are constant, and prices are taken as given.

The new equilibrium point is at E', characterized indeed by a higher P and a lower i^L. The full diagram, displayed in Figure 2.5, shows production, Y^s, and investment, I, also increase, and so does the sum of private and government spending, $C + G$. The new equilibrium is at E', D', H' and J'.

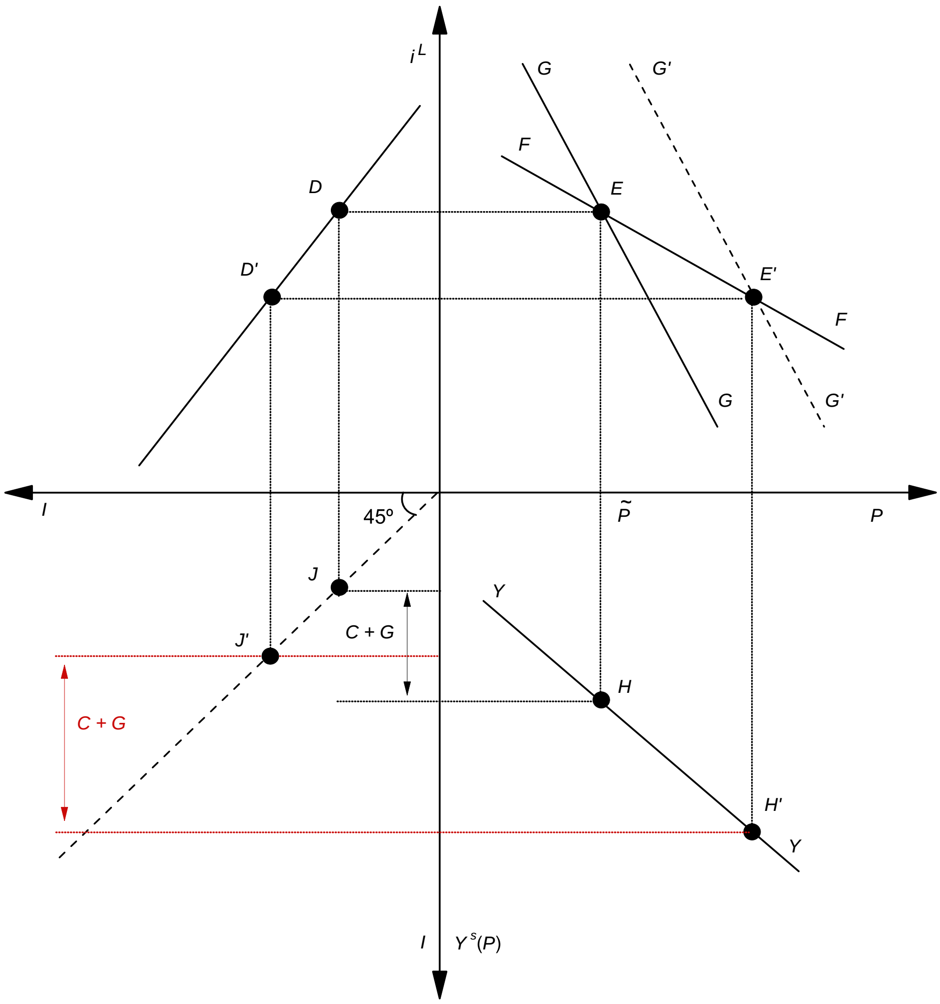
Increase in Government Spending

Figure 2.4



Increase in Government Spending: Full Diagram

Figure 2.5



Intuitively, an increase in government spending creates *excess demand* for goods. Prices must therefore increase. In turn, the increase in prices generates three effects:

• It lowers the real wage, which induces an increase in production and contributes to reducing excess demand, despite the increase in private consumption;[13]

• It lowers real wealth, which reduces private consumption, thereby mitigating also the initial increase in aggregate demand;

• It raises the real price of land (by increasing income and the demand for land), and collateral values, which reduces the premium that banks charge and therefore lower the loan rate. This, in turn, leads to an expansion in investment and a further increase in initial excess demand.

During the transition from the initial equilibrium E to the new equilibrium at point E', the loan rate falls continuously, whereas prices, output and investment increase continuously. However, the equilibrium effect on household consumption cannot be ascertained a priori. On the one hand, higher output and income tend to increase private spending; on the other, higher prices lower real wealth and tend to reduce household expenditure. The net effect can be either positive or negative, depending on how large coefficients c_1 and c_3 are. If private consumption falls – because of a relatively strong negative wealth effect, that is, a high value of c_3 – there is *crowding out*; the government spends more, but in a sense this is at the expense of households, because of a relatively strong negative wealth effect.

Comment 2.13. In this experiment, the issue of how the increase in public spending is financed was not addressed. Implicitly, it occurs through borrowing. If it is financed by an increase in taxes, so that $dG = dT$, it can be established from (2.28) that $GG_G = -(1-c_1)/I' > 0$, which is still positive – albeit lower than before, given that higher taxes lower disposable income and household consumption. Thus, qualitatively the previous results are not affected.

2.4.2. Monetary Policy

Consider an increase in the central bank refinance rate, i^R. Differentiating (2.27) and (2.29), holding G, μ, τ^L and A constant, the equilibrium response of the loan rate and prices can be evaluated by solving the system:

$$di^L = FF_P dP + FF_{i^R} di^R,$$

$$di^L = GG_P dP + GG_{i^R} di^R,$$

which can be written in matrix form as

$$\begin{bmatrix} 1 & -FF_P \\ 1 & -GG_P \end{bmatrix} \begin{bmatrix} di^L \\ dP \end{bmatrix} = \begin{bmatrix} FF_{i^R} \\ GG_{i^R} \end{bmatrix} di^R.$$

Applying Cramer's rule, the solution of this system is

$$\frac{di^L}{di^R} = \frac{\overset{(-)}{GG_{i^R}}\overset{(-)}{FF_P} - \overset{(+)}{FF_{i^R}}\overset{(-)}{GG_P}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} > 0, \quad \frac{dP}{di^R} = \frac{\overset{(-)}{GG_{i^R}} - \overset{(+)}{FF_{i^R}}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} < 0, \tag{2.32}$$

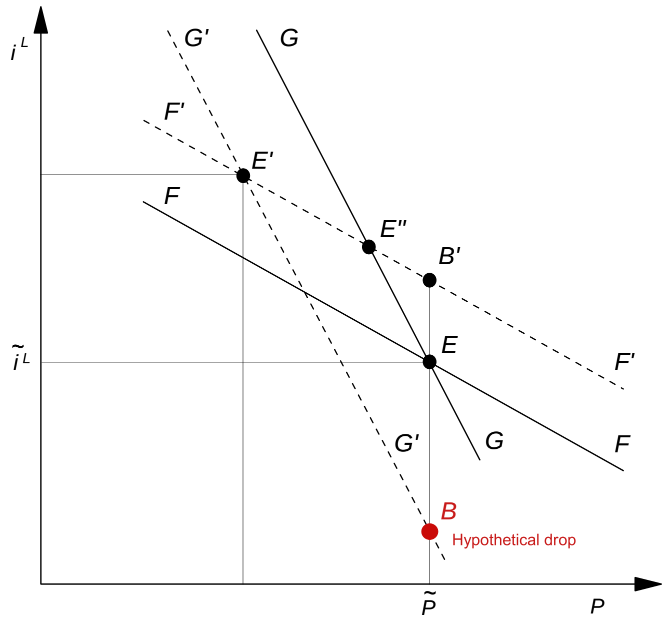
given that, once again, from condition (2.30) $FF_P - GG_P > 0$. These expressions indicate therefore that an increase in the refinance rate leads to a higher loan rate and lower prices.

Figure 2.6 illustrates these effects. Curve FF shifts upward, whereas curve GG shifts downward. The loan rate increases initially from E to B', and then, during the transition, from B' to E'. The full diagram is shown in Figure 2.7. Production, Y^s, contracts from H to H' in the southeast quadrant, as prices drop and the real wage increases. The increase in the loan rate is accompanied by a contraction in investment, from D to D', whereas household consumption, C, and thus $C+G$, may either increase or fall; in the scenario depicted in the figure, it increases.

[13] The increase in Y^s, as measured by $dY^s = Y_P^s dP$, also raises household income and spending. But as noted earlier, the income effect is to raise consumption by $c_1 Y_P^s dP$ only, given that $c_1 < 1$. The *net supply effect*, as measured by $(1-c_1)Y_P^s dP$, is therefore positive and translates into a reduction in excess demand.

Increase in the Refinance Rate

Figure 2.6



Source: Agénor (2020)

Intuitively, the immediate impact of a higher refinance rate is a rise in the loan rate. Because an increase in the refinance rate raises the marginal cost of funds for lenders, it is "passed on" directly, and fully, to borrowers. Curve FF shifts upward, to $F'F'$. The increase in the loan rate lowers investment immediately. At the same time, the higher refinance rate raises the deposit rate, which lowers consumption as a result of intertemporal substitution – households choose to consume less and save more today, in order to consume more tomorrow. Because *both* investment and consumption fall, the net impact effect on aggregate demand is unambiguously negative. At the initial level of prices, there is therefore excess supply on the goods market; restoring equilibrium would require a *fall* in the loan rate to stimulate investment. Graphically, curve GG shifts downward, to $G'G'$, and the loan rate would need to fall from E to B. However, this drop is *hypothetical*; the loan rate is set by commercial banks and definitely increases on impact, as noted earlier.

Thus, the initial contraction in aggregate demand, and the concomitant excess supply, puts downward pressure on prices, which in turn generates three effects:

1. It raises the real wage, which translates into lower production of goods. This contributes to mitigating excess supply, despite a further contraction in aggregate demand;[14]

2. It raises real wealth, which induces households to consume more. This also mitigates excess supply;

3. It lowers the real price of land (by reducing income and the demand for land), and collateral values, which raises the premium and the loan rate. This, in turn, leads to a further contraction in investment and aggregate demand, thereby amplifying excess supply.

Graphically, on impact the loan rate jumps from the initial equilibrium at point E to point B', which reflects the direct effect of a higher refinance rate. However, the adjustment process does not stop there; following its initial jump, the loan rate continues to increase, from B' to the new equilibrium point E', corresponding to the intersection of $F'F'$ and $G'G'$, as prices continue to fall to restore equilibrium in the goods market. As prices fall, so does the value of collateralizable real assets, thereby increasing the premium and inducing banks to raise the loan rate further. This effect is magnified as a result of the downward shift in GG because it amplifies the impact of the policy on the price level. The movement from B' to E' corresponds to the *financial amplification effect*.

14 Again, the reduction in Y^s, as measured by $Y_P^s dP$, also lowers household spending. But the latter falls by $c_1 Y_P^s dP$ only, given that $c_1 < 1$. The *net supply effect*, as measured by $(1-c_1)Y_P^s dP$, is therefore negative and translates into a reduction in excess supply of goods.

Throughout the transition from the initial to the new equilibrium, the drop in prices also stimulates consumption through the wealth effect. In addition, the fall in prices leads to a higher real wage, which contributes to a continuous reduction in production.[15]

Note that if consumption decisions are not affected by intertemporal substitution considerations, then $c_2 = 0$. As a result, $GG_{i^R} = 0$ and GG does not shift following an increase in the refinance rate. However, even in that case the financial amplification effect would still operate, this time from B to E'', where E'' is the equilibrium corresponding to the intersection of the new $F'F'$ curve and the original GG curve. In either case ($c_2 > 0$ or $c_2 = 0$), the final increase in the loan rate is more than proportionate to the rise in the central bank's refinance rate, that is, $di^L / di^R > 1$.[16] Thus, once again *the financial amplification effect exacerbates the countercyclical pattern of loan rates*.

It is worth noting also that at the new equilibrium (point E' if $c_2 > 0$, or E'' if $c_2 = 0$), investment is definitely lower, given that it depends only on the loan rate, which is higher than at E. For consumption, as noted earlier, a higher i^R (and thus i^D) tends to lower spending initially, but lower P (through the wealth effect) tends to raise it during the transition. At the same time, the drop in output and income contributes to a contraction in consumption. The net effect is thus ambiguous in general. In the case illustrated in Figure 2.7, household consumption (given that government spending is constant) increases.

2.4.3. Macroprudential Policy

Consider an increase in the macroprudential tax rate, τ^L. Differentiating (2.27) and (2.29), holding G, i^R, μ and A constant, the equilibrium response of the loan rate and prices can be evaluated by solving the system:

$$di^L = FF_P dP + FF_{\tau^L} d\tau^L,$$

$$di^L = GG_P dP + 0 \cdot d\tau^L,$$

which can be written in matrix form as

$$\begin{bmatrix} 1 & -FF_P \\ 1 & -GG_P \end{bmatrix} \begin{bmatrix} di^L \\ dP \end{bmatrix} = \begin{bmatrix} FF_{\tau^L} \\ 0 \end{bmatrix} d\tau^L.$$

Applying Cramer's rule, the solution of this system is

$$\frac{di^L}{d\tau^L} = \frac{-\overset{(+)}{FF_{\tau^L}}\overset{(-)}{GG_P}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} > 0, \quad \frac{dP}{d\tau^L} = \frac{-\overset{(+)}{FF_{\tau^L}}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} < 0, \tag{2.33}$$

given that, once again, from condition (2.30) $FF_P - GG_P > 0$. These expressions indicate that an increase in the tax on loans leads to a higher loan rate and lower prices – just like an increase in the refinance rate.

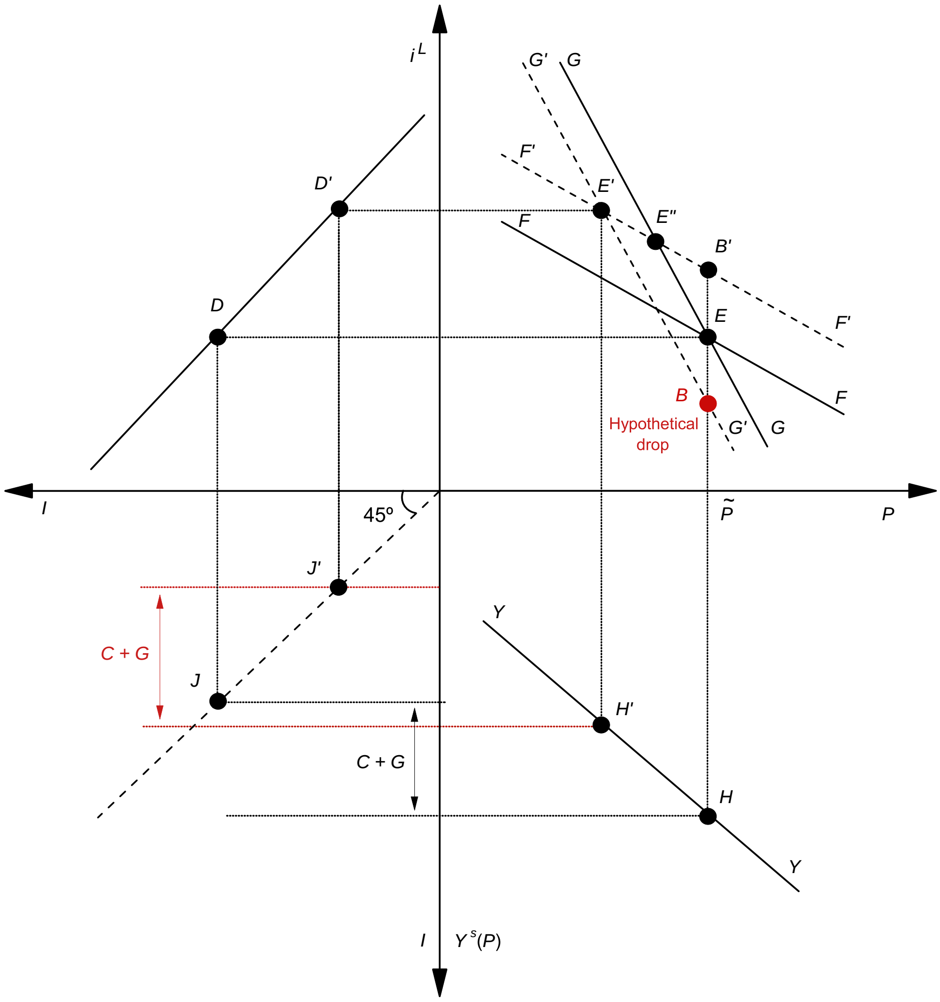
Figures 2.8 and 2.9 illustrate these effects. A higher τ^L leads to an upward shift in FF, given that $FF_{\tau^L} > 0$. Because changes in τ^L have no direct effect on aggregate demand, GG does not change. The new equilibrium corresponds to E', D', H', and J'. The increase in the loan rate is associated with a contraction in credit and investment, as well as a fall in prices; in turn, the fall in prices raises the real wage, which also leads to a contraction in output. A financial amplification effect is once again at play: After the loan rate jumps from point E to point B', there is excess supply of goods (at the initial level of prices) due to the contraction in investment. As prices fall, real land prices and collateral values also drop. The premium therefore rises, thereby inducing a further increase in the loan rate from B' to E'.

[15] Because we know for sure that Y^s falls, equality (2.25) implies that aggregate demand, $C + I + G$, also unambiguously falls in equilibrium – despite consumption possibly increasing.

[16] From (2.32), in order for $di^L / di^R > 1$, it must be that $GG_{i^R} FF_P - FF_{i^R} GG_P > FF_P - GG_P$. Given that $FF_{i^R} = 1$, this expression boils down to $FF_P(1 - GG_{i^R}) < 0$, which always holds given that $GG_{i^R} \leq 0$ when $c_2 \geq 0$ and $FF_P < 0$.

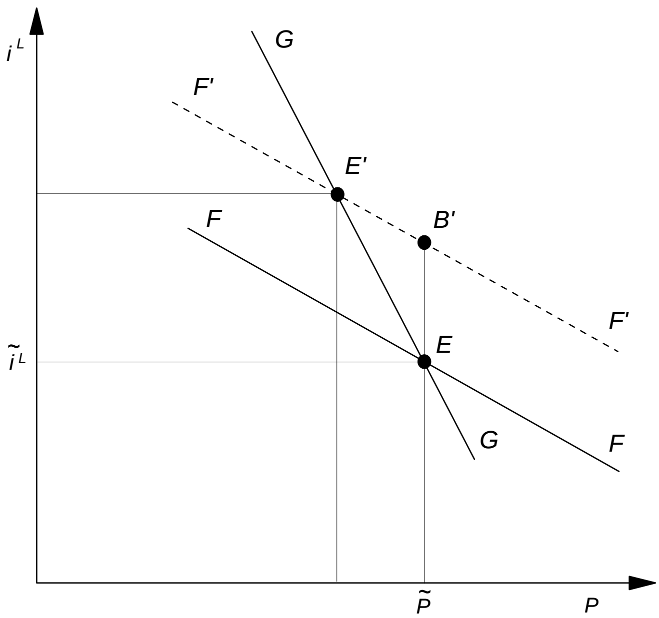
Increase in the Refinance Rate: Full Diagram

Figure 2.7



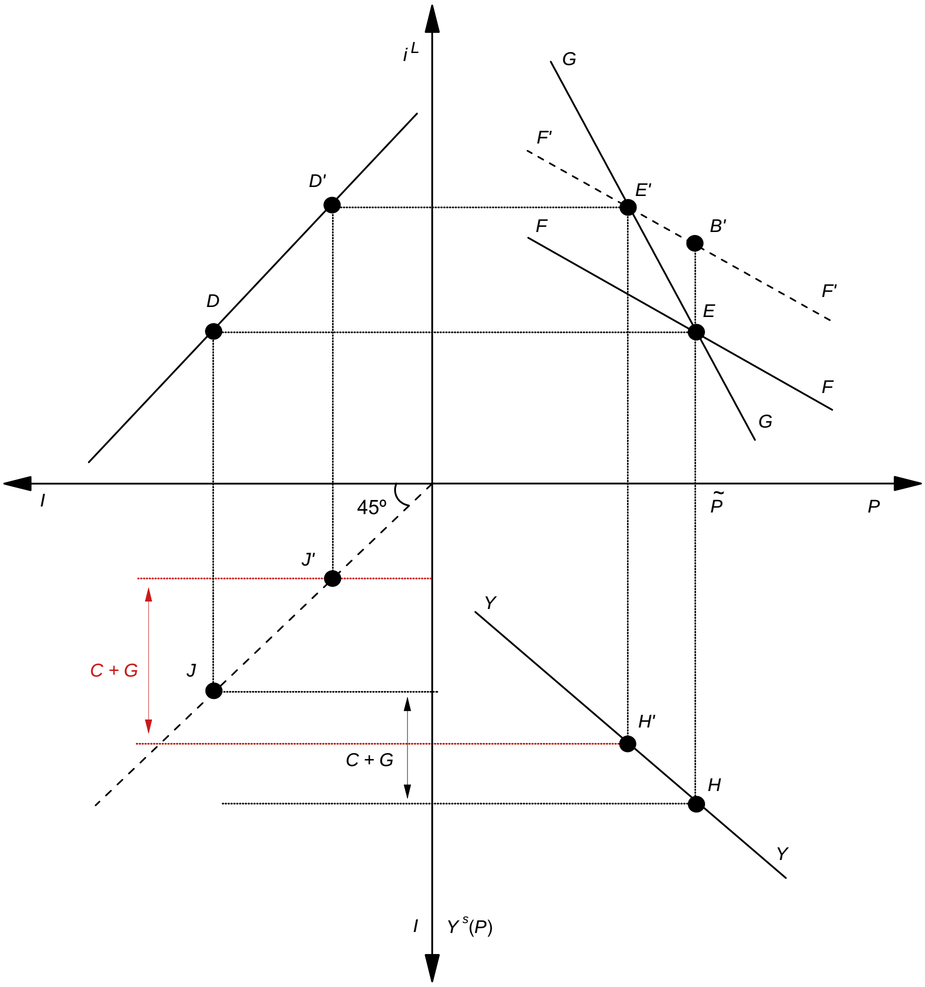
Increase in the Macroprudential Tax Rate

Figure 2.8



Increase in the Macroprudential Tax Rate: Full Diagram

Figure 2.9



Source: Agénor (2020).

The fundamental reason why financial amplification occurs is because an increase in the tax on loans, just like a rise in the refinance rate, raises on impact the cost of borrowing and initiates a gradual drop in goods and asset prices, which lowers collateral values and raises the premium during the adjustment process. The key difference between the two instruments is that because the tax on loans has no effect on the deposit rate (unlike the refinance rate), the contraction in aggregate demand at the initial level of prices results solely from a drop in investment, not consumption.

Table 2.2 summarizes the impact of fiscal, monetary and macroprudential policies on key macroeconomic variables.

2.4.4. Transmission with No Amplification Effect

Finally, it is worth illustrating the adjustment mechanism when the financial accelerator does *not* operate – that is, $\theta' = 0$ and the premium is constant at θ_m. To do so, consider as before the case of an increase in the refinance rate.

The results are illustrated in a full diagram in Figure 2.10. As shown in the figure, curve FF is now horizontal. An increase in the refinance rate, i^R, leads to an upward shift in FF and raises the loan rate in the exact same proportion, so that $di^L / di^R = 1$. The loan rate jumps to point B' and remains at that value while prices fall gradually from B' to E'. Thus, without the financial amplification effect, the contraction in investment is smaller, and so are the drop in prices and production. This makes an increase in consumption more likely. Thus, financial amplification affects the *magnitude*, not the *direction*, of these effects.

Impact of Fiscal, Monetary and Macroprudential Policies: Summary

Table 2.2

	Variable	Impact
Increase in government spending, G		
Production	Y^s	+
Consumption	C	?
Investment	I	+
Absorption	$C+I+G$	+
Loan premium	θ	–
Loan rate	i^L	–
Prices	P	+
Increase in refinance rate, i^R		
Production	Y^s	–
Consumption	C	?
Investment	I	–
Absorption	$C+I+G$	–
Loan premium	θ	+
Loan rate	i^L	+
Prices	P	–
Increase in macroprudential tax rate, τ^L		
Production	Y^s	–
Consumption	C	?
Investment	I	–
Absorption	$C+I+G$	–
Loan premium	θ	+
Loan rate	i^L	+
Prices	P	–

Note: From equation (2.25), absorption, $C+I+G$, is equal to production, Y^s. Thus, changes in absorption and changes in production have the same sign, even though changes in private consumption may be ambiguous.

2.5. Exogenous Shocks

Consider now exogenous shocks, specifically a contractionary financial shock and a positive productivity shock.[17]

2.5.1. Financial Shock

Suppose that the premium, as defined in equation (2.20), takes now the form

$$\theta = \theta_0 + \theta(\kappa PK_0 - L_0), \tag{2.34}$$

where $\theta_0 > 0$ is an autonomous component. Combined with (2.19), this implies that the FF curve is now defined as in (2.27), with the additional partial derivative $FF_{\theta_0} = 1 > 0$. An increase (reduction) in the autonomous component of the premium raises (lowers) the loan rate and is therefore contractionary (expansionary).

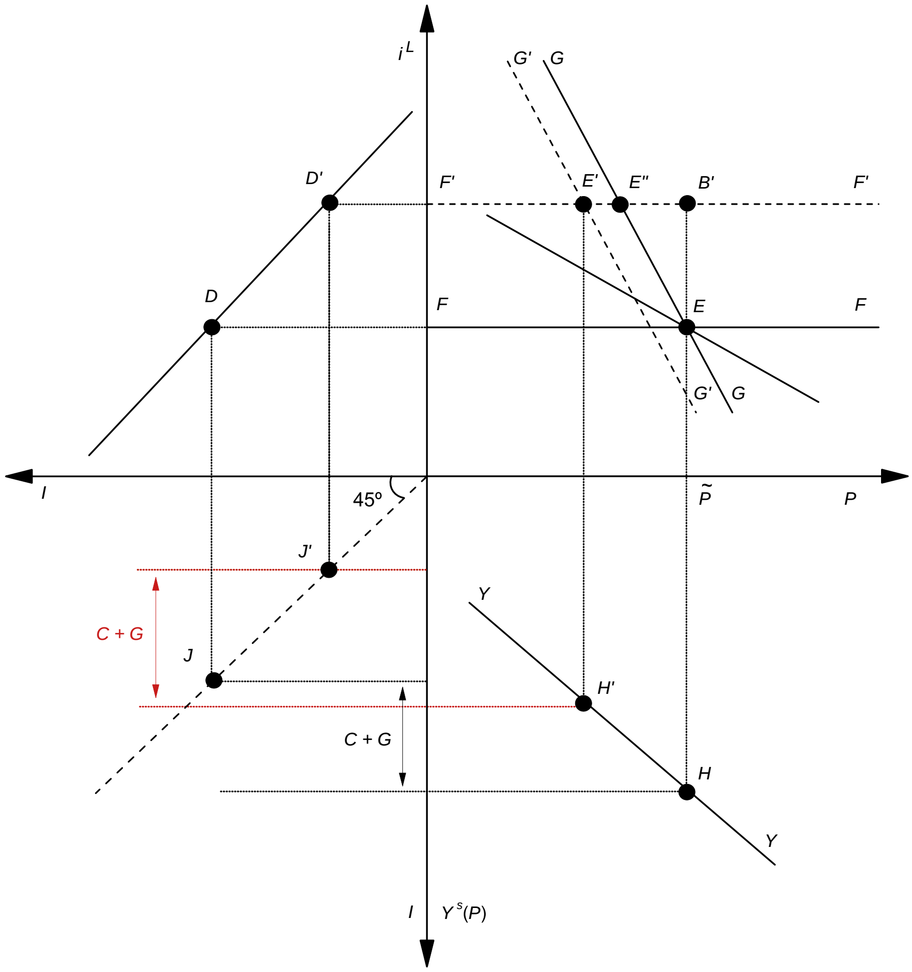
Suppose now that θ_0 increases. Using the same solution procedure as before gives:

$$\frac{di^L}{d\theta_0} = \frac{-\overset{(+)}{FF_{\theta_0}}\overset{(-)}{GG_P}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} > 0, \quad \frac{dP}{d\theta_0} = \frac{-\overset{(+)}{FF_{\theta_0}}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} < 0. \tag{2.35}$$

[17] Another shock that could be studied is a drop in household expenditure (reflecting a decline in consumer confidence, for instance), as measured by a fall in c_0.

Increase in the Refinance Rate with Constant Premium: Full Diagram

Figure 2.10



These expressions show that, as is the case with a higher τ^L an autonomous increase in the premium raises the loan rate and lowers prices.

By implication, graphical illustrations are exactly as shown in Figures 2.8 and 2.9, corresponding to an increase in the macroprudential tax rate. Curve FF shifts upward, whereas GG does not change. The increase in the loan rate is associated with a contraction in credit and investment, as well as a fall in prices; in turn, the fall in prices raises the real wage, which induces a contraction in production. At the same time, the fall in prices amplifies the effects of the shock, because land prices and collateral values also drop. The premium therefore rises further, and so does the loan rate. The contraction in investment is magnified, because the shock itself is amplified by the endogenous response of bank pricing decisions to changes in collateral values.

2.5.2. Productivity Shock

Consider now a positive productivity shock, that is, an increase in A. Differentiating (2.27) and (2.29), holding G, i^R, μ and τ^L constant, the equilibrium response of the loan rate and prices can be evaluated by solving the system:

$$di^L = FF_P dP + FF_A dA,$$

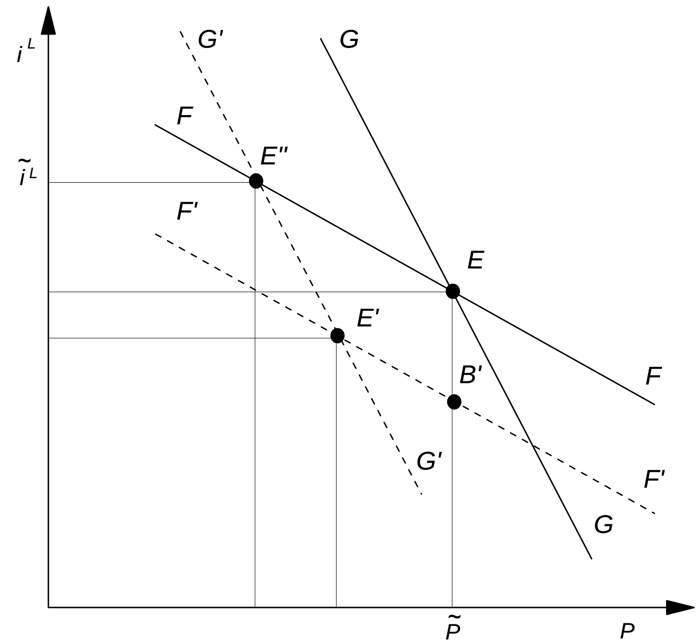
$$di^L = GG_P dP + GG_A dA,$$

which can be written in matrix form as

$$\begin{bmatrix} 1 & -FF_P \\ 1 & -GG_P \end{bmatrix} \begin{bmatrix} di^L \\ dP \end{bmatrix} = \begin{bmatrix} FF_A \\ GG_A \end{bmatrix} dA.$$

Positive Productivity Shock

Figure 2.11



Applying Cramer's rule, the solution of this system is

$$\frac{di^L}{dA} = \frac{\overset{(-)}{GG_A}\overset{(-)}{FF_P} - \overset{(-)}{FF_A}\overset{(-)}{GG_P}}{\underset{}{\overset{(-)}{FF_P}} - \overset{(-)}{GG_P}} \gtrless 0, \quad \frac{dP}{dA} = \frac{\overset{(-)}{GG_A} - \overset{(-)}{FF_A}}{\overset{(-)}{FF_P} - \overset{(-)}{GG_P}} \gtrless 0, \tag{2.36}$$

given that, once again, from condition (2.30) $FF_P - GG_P > 0$. These expressions indicate that a positive productivity shock has ambiguous effects on the loan rate and prices.

The results are shown in Figures 2.11 and 2.12. The increase in productivity raises both production (as shown by the upward shift in YY in the southeast quadrant of Figure 2.12) and consumption, but the net effect is excess supply on the goods market. Holding prices constant, to maintain equilibrium investment should increase; for that to happen, the loan rate should fall. Thus, curve GG shifts downward. At the same time, higher income raises the demand for land as well as its price, which lowers the premium and the loan rate. Curve FF therefore also shifts downward. But while the loan rate always falls on impact (from E to B'), whether the loan rate and prices are higher in the new equilibrium cannot be ascertained a priori. If the downward shift in GG is large relative to FF, both variables may be lower, as is the case at E'. During the transition from B' to E' prices fall continuously, whereas the loan rate increases. Nevertheless, in the new equilibrium, the loan rate is lower than initially, investment is higher and, despite the fact that lower prices lead to a higher real wage, so is output (at H', compared to H). Private consumption is also unambiguously higher, because the income and wealth effects operate in the same direction.

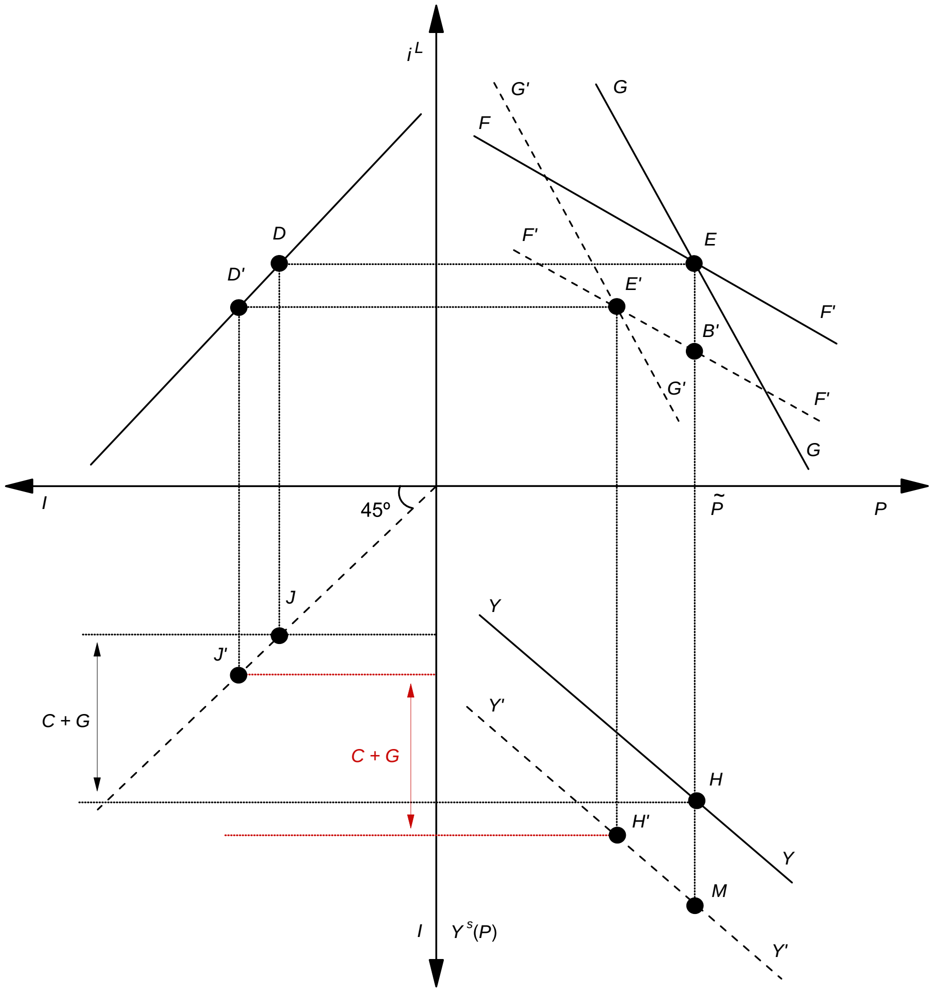
Note also that if the demand for land does not depend on income (that is, $h_{Y^s} = 0$ in (2.14)), then $FF_P = FF_A = 0$. Thus, FF would be horizontal, as in Figure 2.10, and would not shift following a change in A. In that case, as can be inferred from (2.36), i^L would not change ($di^L / dA = 0$) but prices would unambiguously fall ($dP / dA < 0$). Of course, a similar result would obtain if $\theta' = 0$, that is, if there is no financial amplification effect.

2.6. Policy Combinations

The model can also be used to illustrate the benefits of combining monetary, fiscal and macroprudential policies, in response to exogenous shocks. Responses to a contractionary financial shock and responses to a productivity shock, the transmission of which have been illustrated in the previous section, are considered in turn.

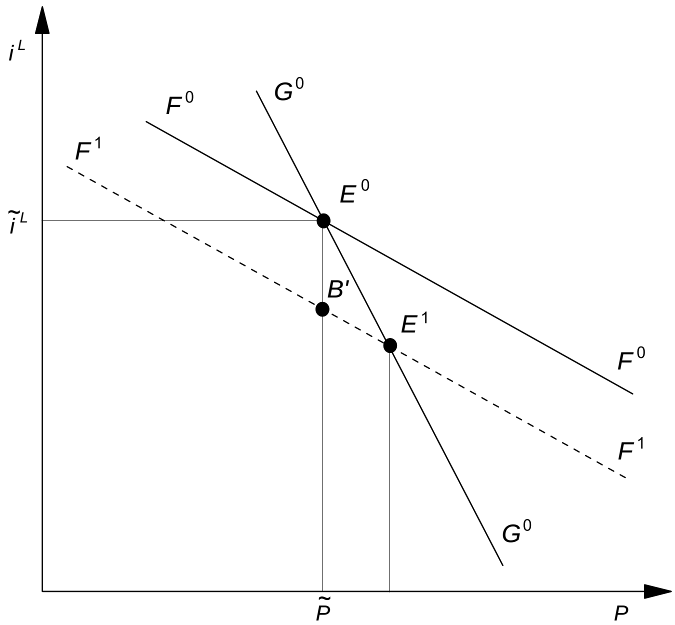
Positive Productivity Shock: Full Diagram

Figure 2.12



Expansionary Financial Shock

Figure 2.13



2.6.1. Response to Financial Shock

Suppose that the autonomous component of the premium in (2.34), θ_0, falls. Graphically, as shown in Figure 2.13, the initial equilibrium of the economy is at E^0, corresponding to the intersection of F^0F^0 and G^0G^0. As a result of the shock, curve FF shifts downward from F^0F^0 to F^1F^1, whereas curve GG remains at G^0G^0.

The adjustment process is now opposite to what was described in the previous section: holding goods prices constant, the autonomous reduction in the premium leads to a drop in the loan rate from E^0 to B', and this stimulates investment. In turn, higher investment generates excess demand, which leads to higher goods prices, and thus a further drop in the loan rate during the transition, as collateral values go up. Output also increases, because the real wage falls. The equilibrium shifts from E^0 to E^1, the point at which F^1F^1 and G^1G^1 intersect. The financial amplification effect corresponds to the movement from B' to E^1.

Fiscal Policy Only

Consider first the case where policymakers use fiscal policy only, that is, a change in *G*. It is immediately clear that such a policy cannot return the economy from E^1 to its initial position, E^0. The fundamental reason is that changes in G can shift only curve *GG*, not curve *FF*.

Indeed, an *increase* in G would shift GG upward and would imply a new equilibrium to the southeast of E^1, characterized by even higher prices and a lower loan rate than at E^1, thus further away from the initial equilibrium E^0.

Can a *reduction* in G perform better? Only with respect to one of the two objectives. For instance, as shown in Figure 2.14, a relatively small reduction in G would shift GG downwards, in such a way that it intersects F^1F^1 at E^2 (which corresponds also to point B). At that point, the initial level of prices is restored, given that E^2 is vertically below E^0. However, at E^2 the equilibrium loan rate is still *below* its initial value, despite being higher than at E^1.

Alternatively, as also shown in Figure 2.14, a relatively large reduction in G could shift GG downwards so much that it intersects F^1F^1 at E^3. At that point, the initial value of the loan rate is restored. However, at E^3 the equilibrium level of domestic prices remains *below* its initial value.

The upshot of this analysis, therefore, is that while fiscal policy can be used to restore the initial equilibrium value of either prices or the loan rate, by itself it cannot restore *both* variables (that is, back to the initial equilibrium E^0) to their initial values. With a single instrument, policymakers cannot achieve two targets.

Monetary Policy Only

Consider next the case where policymakers use monetary policy only, that is, a change in i^R. Clearly, a *reduction* in the refinance rate cannot possibly work, given that it is expansionary; it would only lead to higher prices, and therefore further away from the initial equilibrium E^0. To avoid this outcome, the policy must be contractionary.

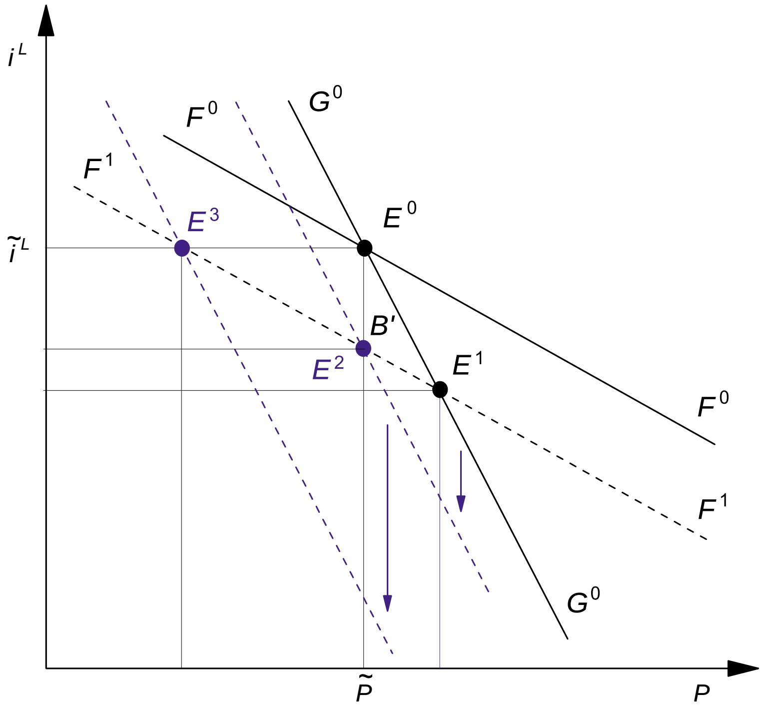
Suppose then that the policy authorities *increase* the refinance rate. As shown in Figure 2.15, the rise in the policy rate can indeed be calibrated for curve FF to shift upward, from F^1F^1 to exactly F^0F^0. However, at the same time, and as long as $c_2 > 0$, GG shifts downwards, due to the direct effect of the refinance rate on consumption, through intertemporal substitution, that is, *further away from* G^0G^0. The adjustment process would be similar to Figures 2.6 and 2.7 – an upward jump in the loan rate from E^1 to ″, followed by an increase from B'' to the new equilibrium point E^2, corresponding to the intersection of F^0F^0 and the new GG curve. However, at E^2, prices are *lower* than their initial value, and the loan rate is *higher* than its initial value.

In principle, the increase in the policy rate could be calibrated so that the point of intersection of the new FF curve, and the new GG curve, occurs exactly at the initial level of prices. This is the case illustrated in Figure 2.16. In that case, the upward shift in FF would not take it back all the way to its initial position at F^0F^0; but the downward shift in GG would also be mitigated, so that the new equilibrium point, E^2, would now be located vertically below E^0. However, at that point, although prices have been restored to their initial value, the loan rate remains lower than it was initially (despite being higher than at E^1).

The upshot is that, by itself, monetary policy cannot restore *both* variables to their initial values if consumption is driven to some degree by intertemporal considerations. Again, with one instrument, policymakers cannot achieve two targets – initial prices and the loan rate.

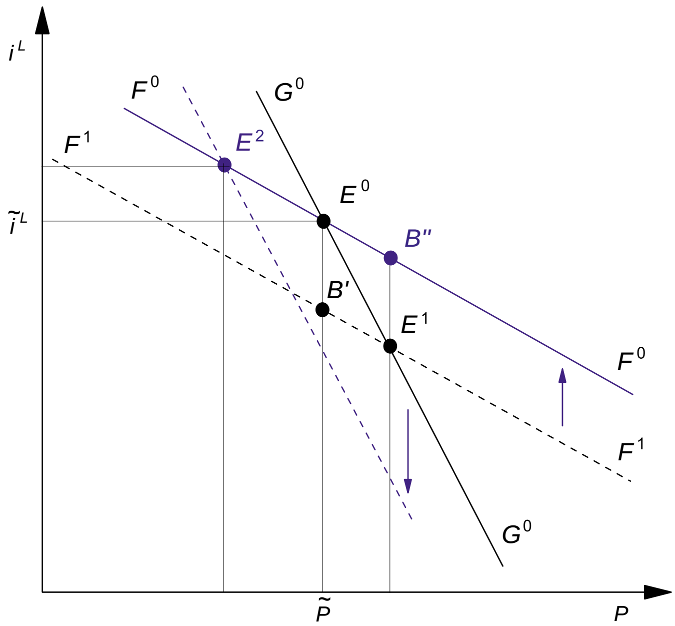
Response to Expansionary Financial Shock: Fiscal Policy only

Figure 2.14



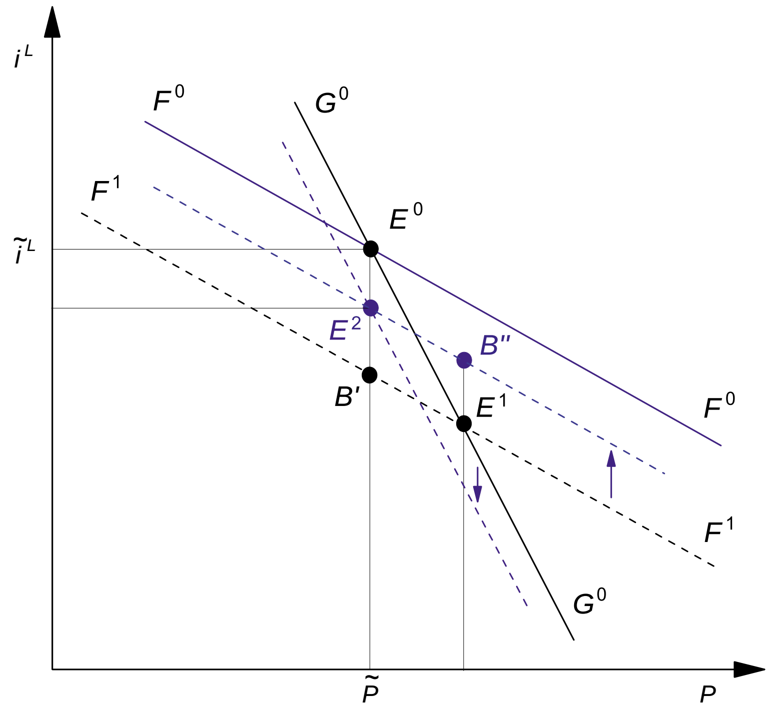
Response to Expansionary Financial Shock: Monetary Policy only

Figure 2.15



Response to Expansionary Financial Shock: Monetary Policy only, Calibrated to Return Prices to their Original Value

Figure 2.16



Comment 2.14. As noted earlier, if $c_2 = 0$ the increase in the refinance rate would have no effect on the position of GG. Thus, using monetary policy alone would be sufficient to return F^1F^1 to F^0F^0; a single instrument is all that is needed to offset the expansionary impact of the financial shock.

Macroprudential Policy Only

Finally, consider the case where policymakers can use macroprudential policy only, that is, a change in τ^L. It is immediately clear that such a policy is the right choice to return the economy from E^1 to its initial position, E^0. Indeed, as shown in Figure 2.17, an increase in τ^L can be calibrated in such a way that it returns FF exactly from F^1F^1 to F^0F^0. The loan rate jumps upward from E^1 to $B^{\circ\circ}$, followed by an increase from $B^{\circ\circ}$ to the original equilibrium point E^0. And because the policy has no direct effect on GG (in contrast to monetary policy), there are no "side effects" to address. Put differently, because of the nature of the shock, using a single instrument is sufficient to return both the loan rate and prices to their initial values.

Combination of Fiscal and Monetary Policies

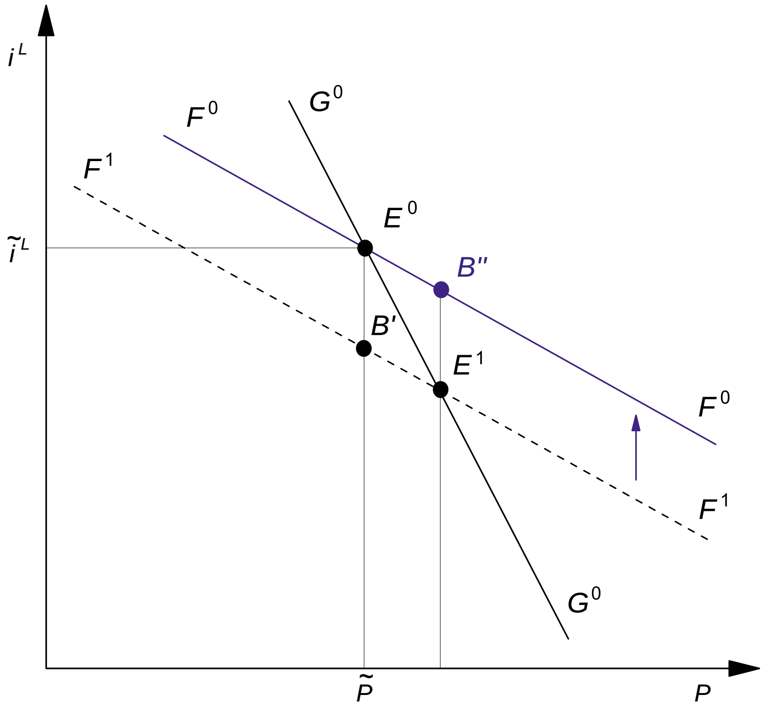
Now, suppose that the macroprudential tax rate – the most effective instrument to use in response to the type of financial shocks under consideration – is *not* available. Can a combination of fiscal and monetary policies (which, as shown earlier, are not capable of restoring the original equilibrium if used individually) help to achieve the desired objective?

Suppose that, in a first step, the policy authorities *increase* the refinance rate. As shown in Figure 2.18, just as in Figure 2.15, the change in the refinance rate can indeed be calibrated to ensure that curve FF shifts upward, from F^1F^1 to $F^2F^2 = F^0F^0$. But again, as long as $c_2 > 0$, GG shifts downwards, from G^0G^0 to G^2G^2. If policymakers do not take any further action, the new equilibrium point would be at E^2, corresponding to the intersection of $F^0F^0 = F^2F^2$ and G^2G^2, as in Figure 2.15. At E^2, neither variable is at its original value.

Suppose also that, in a second step, government spending is *increased*, in order to offset the contractionary effect of the increase in the refinance rate. The adjustment process is then exactly as described in Figures 2.4 and 2.5: curve GG shifts upward, from G^2G^2 to $G^3G^3 = G^0G^0$, if the increase in spending is calibrated properly. As illustrated in Figure 2.18, the new equilibrium is now at E^0, and both prices and the loan rate are back to their initial values. The fact that policymakers need two instruments to achieve two targets is an application of the so-called *Tinbergen rule*.

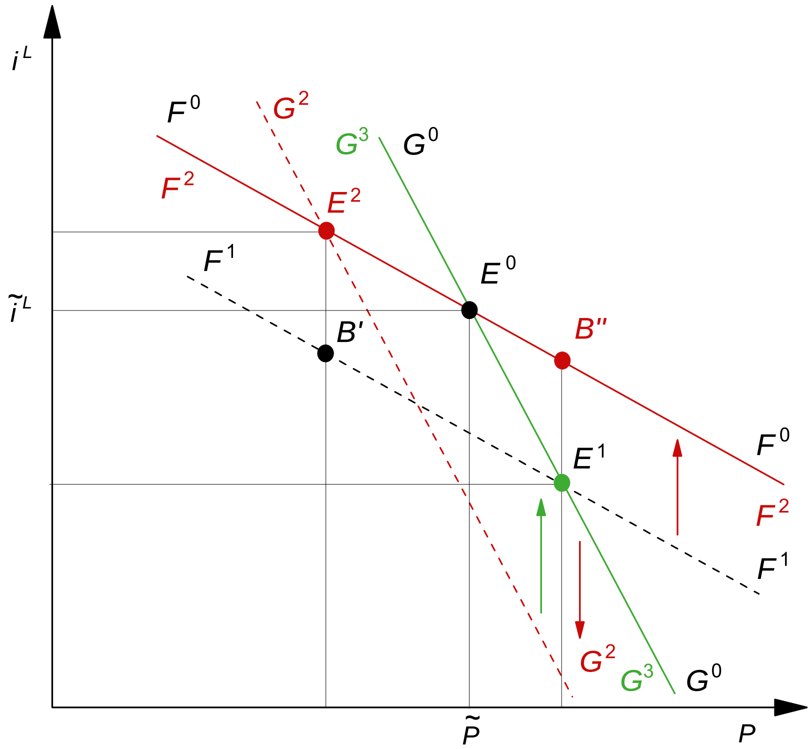
Response to Expansionary Financial Shock: Macroprudential Policy only

Figure 2.17



Response to Expansionary Financial Shock: Combination of Monetary and Fiscal Policies

Figure 2.18



Comment 2.15. The Tinbergen rule states that, to achieve n independent policy targets, policymakers need to have at their disposal at least n independent policy instruments.

In the present case, a contractionary monetary policy is adjusted in a first step, primarily to restore financial equilibrium (by raising borrowing costs), whereas an expansionary fiscal policy is used in a second step to offset the contraction in aggregate demand (due to lower household consumption) generated by a tightening of monetary policy. In a sense, monetary policy is assigned to restoring financial sector equilibrium, and fiscal policy to goods market (price) equilibrium. Moreover, although the policies are adjusted in *opposite directions*, they are fundamentally *complementary* – they are both needed to restore macroeconomic equilibrium.

Combination of Monetary and Macroprudential Policies

Finally, is a combination of monetary and macroprudential policies necessary, or desirable, in response to a financial shock? As shown earlier, if consumption is driven in part by intertemporal considerations (that is, $^{\circ}{}_2 > 0$), a change in the refinance rate is ineffective because it induces changes in *both* FF and GG. At the same time, a change in the macroprudential tax works exactly as expected, because it induces shifts only in FF. The implication though is that when $^{\circ}{}_2 = 0$, monetary policy has no direct impact on the position of GG; in that case, either instrument can be used to shift FF back to its initial position, as shown in Figure 2.17. Put differently, in the particular case where intertemporal substitution effects are absent, monetary policy and macroprudential regulation are *substitutes*.

2.6.2. Response to Productivity Shock

Next, consider policy responses to a positive productivity shock. Graphically, as shown in Figure 2.19, the initial equilibrium of the economy is at E^0, corresponding to the intersection of F^0F^0 and G^0G^0. As a result of the shock, curve FF shifts downward from F^0F^0 to F^1F^1, whereas curve GG remains at G^0G^0. Thus, Figure 2.19 is the same as Figure 2.11, except for the change in labeling, and so is the transmission process of the shock. It again assumes that, in the new equilibrium, both the loan rate and prices are lower than initially.

Fiscal Policy Only

Consider first the use of fiscal policy alone. As noted earlier, a change in G affects only GG, not FF. Thus, an increase in G can be calibrated to shift curve GG upward in such a way that it intersects F^1F^1 exactly at the original level of prices, in which case the new equilibrium is at E^2 in Figure 2.20, or all the way to the original curve G^0G^0, in which case the new equilibrium is at E^3. [18] However, at E^2 the loan rate is still below its initial equilibrium value, whereas at E^3 not only is the loan rate lower than initially but prices are also higher, due to the expansionary effect of the increase in spending. Thus, fiscal policy, by itself, is not a potent instrument to return the economy to its initial equilibrium.

Monetary Policy Only

Alternatively, consider monetary policy and suppose that the central bank chooses to *increase* the refinance rate, i^R. [19] Consistent with the earlier discussion (see Figures 2.6 and 2.7), the policy change can be calibrated to ensure that curve FF shifts upward from F^1F^1 back to F^0F^0. However, because the policy induces a contraction in aggregate demand, curve GG shifts further downward at the same time. The new equilibrium would obtain at E^2 in Figure 2.21. At that point the loan rate is higher, and prices lower, than at the initial equilibrium, given the contractionary nature of the policy.[20]

If instead the central bank chooses to *reduce* the policy rate, the opposite would occur: GG would shift upward, possibly all the way back to G^0G^0 (the policy is now expansionary) but FF would shift further downward, below F^1F^1. The end result would be higher domestic prices and a lower loan rate than at E^0. Once again, by itself, monetary policy cannot return the economy to the initial equilibrium – fundamentally because it affects FF and GG in opposite directions.

---

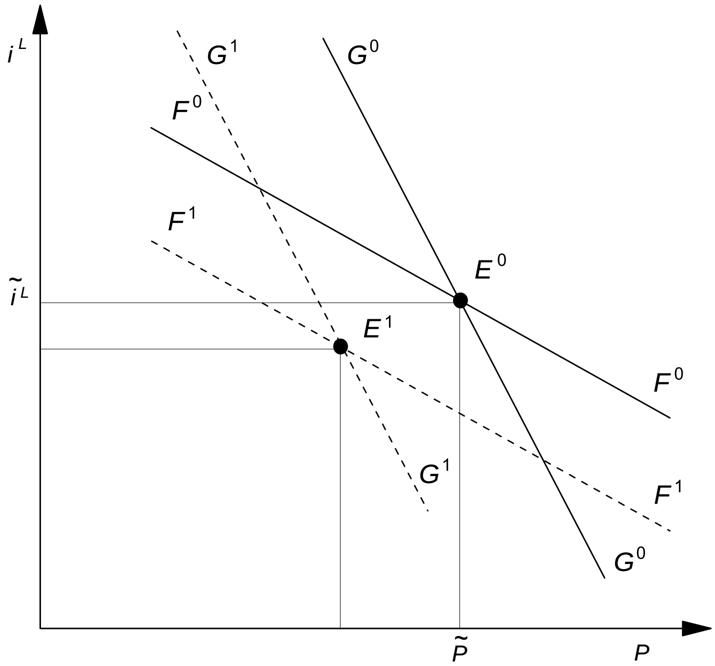
18 A *reduction* in G would obviously make little sense; it would shift G^1G^1 further downward, moving the economy further away from E^0.

19 An *increase* in i^R would obviously make little sense; it would shift both F^1F^1 and G^1G^1 further downward, moving the economy further away from E^0.

20 The same occurs with respect to E^1.

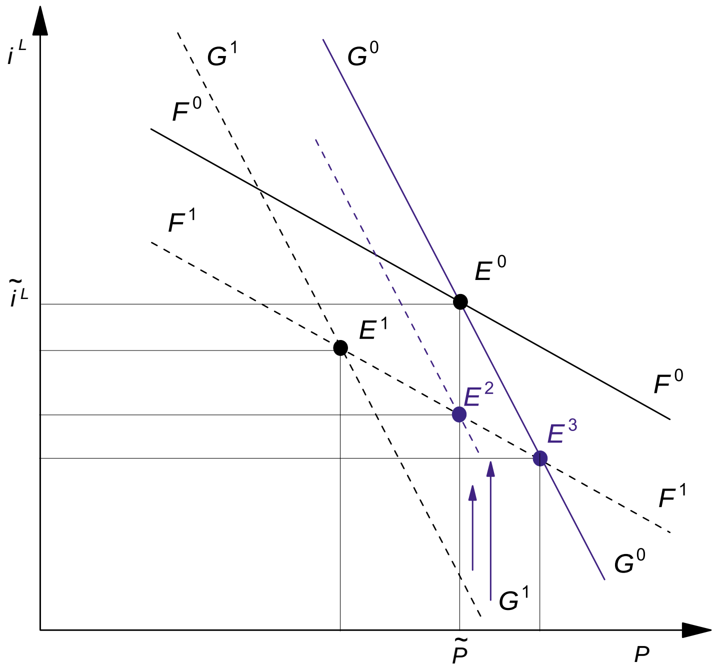
Positive Productivity Shock

Figure 2.19



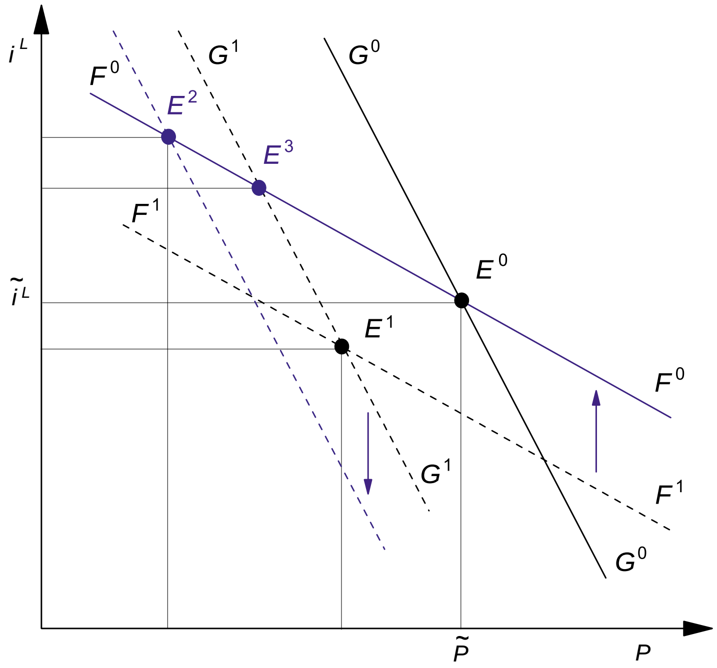
Response to Positive Productivity Shock: Fiscal Policy Only

Figure 2.20



Response to Positive Productivity Shock: Monetary Policy Only

Figure 2.21



Macroprudential Policy Only

Finally, consider macroprudential policy. In contrast to the case of a financial shock considered earlier, this policy cannot work either: while an increase in τ^L could be calibrated to return curve FF from F^1F^1 to F^0F^0, the policy does not affect the position of the GG curve.[21] Thus, the new equilibrium would be at a point like E^3 in Figure 2.21, at the intersection of F^0F^0 and curve G^1G^1, where the loan rate is higher, and prices lower, than at the initial equilibrium E^0. Again, this policy cannot, by itself, bring the economy back to its initial position.

Combination of Fiscal and Monetary Policies

The question now is whether policies can be combined to achieve a shift from E^1 back to E^0. To illustrate, consider two scenarios: first, the case where only fiscal and monetary policies are available; and second, the case where only monetary and macroprudential policies can be used.

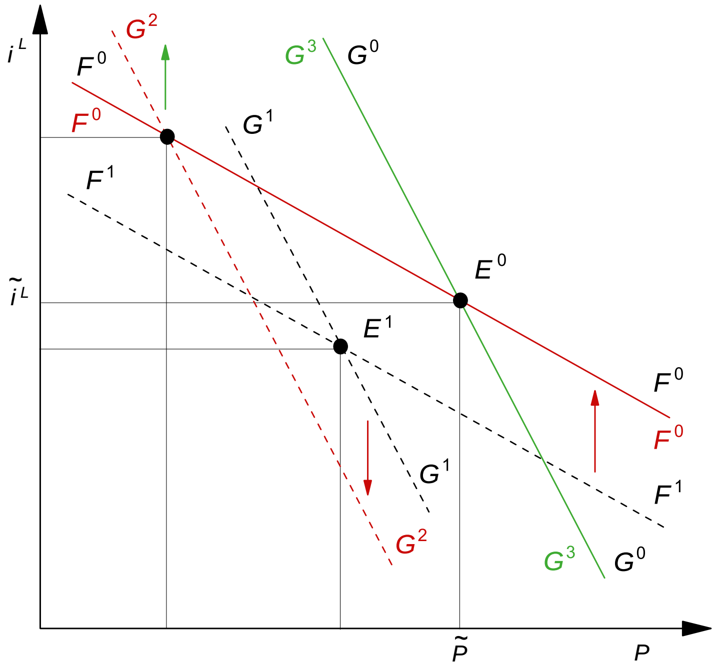
The case where fiscal and monetary policies are combined is illustrated in Figure 2.22. The first thing to note is that such a combination cannot involve a *reduction* in i^R. The reason is that, as shown earlier, a lower refinance rate shifts the GG curve upward (which works in the right direction) but the FF curve shifts further downward, that is, further away from F^1F^1 and F^0F^0. And because (as also shown earlier) government spending has no direct impact on FF, it cannot be used to affect the position of that curve.

Thus, the policy combination must necessarily involve, in a first step, an *increase* in the refinance rate. The policy shifts FF upward and back to $F^2F^2 = F^0F^0$ (if calibrated properly) and moves GG away from its initial position, from G^1G^1 to G^2G^2, further away from G^0G^0, ,just as in Figure 2.21. However, now, in a second step, policymakers can *raise* government spending – in effect, "undoing" the contractionary effect of monetary policy – thereby inducing a shift from G^2G^2 back to $G^3G^3 = G^0G^0$ in Figure 2.22. The economy is thus back to its initial equilibrium, E^0. Put differently, the policy mix consisting of an increase in the refinance rate and a cut in government spending – which, in effect, involves assigning monetary policy to restoring financial sector equilibrium, and fiscal policy to reestablishing goods market equilibrium – allows the authorities to achieve both of their objectives, the initial values of the loan rate and prices.

21 Because a change in the macroprudential tax rate does not affect the position of *GG*, it makes little sense to consider a *reduction* in τ^L; it would lead to a downward shift in *FF*, further away from F^0F^0.

Response to Positive Productivity Shock: Combination of Fiscal and Monetary Policies

Figure 2.22



Combination of Monetary and Macroprudential Policies

The case where monetary and macroprudential policies are combined is illustrated in Figure 2.23. Recall that the macroprudential tax cannot affect the position of GG. So the first step is to *reduce* the refinance rate, so as to shift GG from G^1G^1 back to $G^2G^2 = G^0G^0$. At the same time, the policy entails a further shift downward in FF from F^1F^1 to F^2F^2; thus, in the second step, the macroprudential tax rate must be increased to shift FF from F^2F^2 to its initial position $F^3F^3 = F^0F^0$. In effect, macroprudential policy is used to offset the expansionary effect of the fall in the refinance rate that operates through a reduction in the loan rate. This policy combination, which involves assigning monetary policy to restoring goods market (price) equilibrium, and macroprudential policy to re-establishing financial sector equilibrium, is consistent with the views of a number of observers regarding how these two policies should be combined (see, for instance, Svensson (2017)).

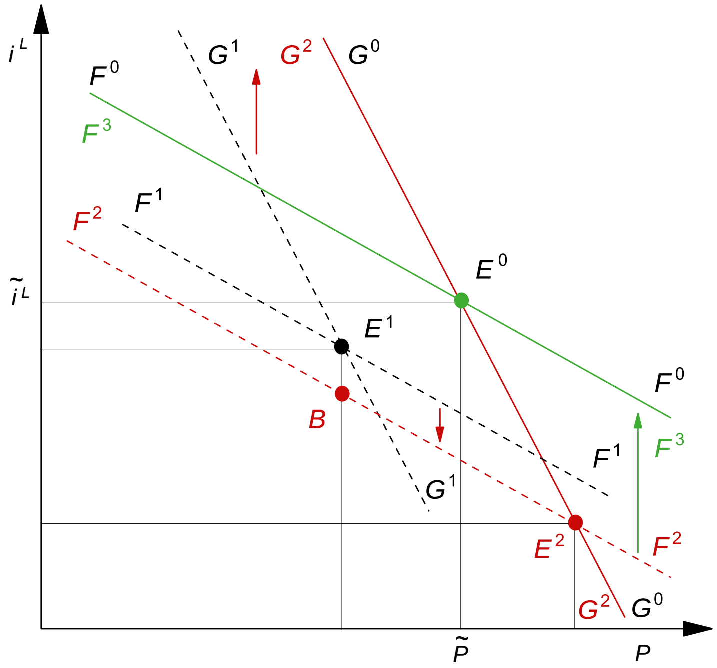
Combination of Fiscal and Macroprudential Policies

Finally, the case where fiscal and macroprudential policies are combined is illustrated in Figure 2.24. In this case, the policy response is fairly straightforward, because each instrument affects the position of one curve, and *one curve only*: an increase in government spending leads to a shift in GG from G^1G^1 to $G^2G^2 = G^0G^0$, whereas an increase in the macroprudential tax rate leads to a shift in FF from F^1F^1 to $F^2F^2 = F^0F^0$. As discussed further in the next chapter, this combination of policies is particularly important in an open-economy setting where monetary policy may be unavailable in response to capital flows induced by changes in world interest rates.

The upshot of the analysis is that how instruments should be combined, and assigned to a particular objective, and the direction in which these instruments should be altered, depends on which instruments are available. In response to a positive productivity shock, a potent combination involves an *increase* in the refinance rate and a cut in government spending, if macroprudential policy is not available; if, instead, fiscal policy is not available, the best combination involves a *reduction* in the refinance rate and an increase in the macroprudential tax rate. In the first case, monetary policy aims mainly at restoring financial sector equilibrium, whereas in the second it aims essentially at restoring goods market (price) equilibrium.

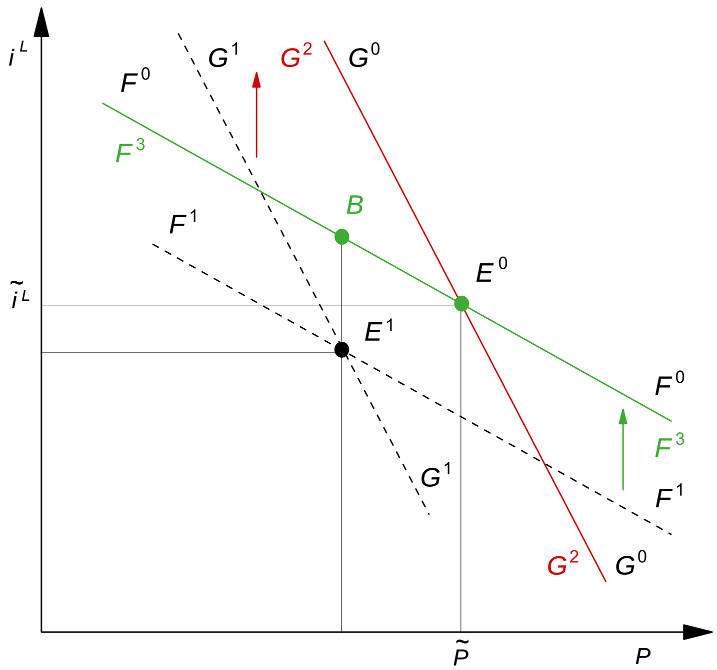
Response to Positive Productivity Shock: Combination of Monetary and Macroprudential Policies

Figure 2.23



Response to Positive Productivity Shock: Combination of Fiscal and Macroprudential Policies

Figure 2.24



2.7. Extensions

The model presented earlier can be extended in a number of directions.[22] In what follows, the following extensions are considered: physical capital as collateral, working capital needs, imperfect substitution between deposits and central bank borrowing, and credibility and inflation expectations.[23]

2.7.1. Physical Capital as Collateral

In the foregoing discussion, it was assumed that collateral consists of land. This is consistent with the evidence on the type of guarantees that banks demand from small and medium-sized firms – when they are not rationed out entirely of the credit market – for which the owner's main pledgeable asset is housing.

Alternatively, it could be assumed that firms can pledge physical collateral, K_0, to secure loans.[24] Thus, valuing capital at the price of investment goods, equation (2.20) can be replaced by

$$\theta = \theta(\kappa PK_0 - L_0), \tag{2.37}$$

where again $\kappa \in (0,1)$ is the proportion of assets that can be pledged as collateral and $\theta' < 0$.

How does this alternative specification of the premium affect the functioning of the model? The key point is that, as shown earlier in equation (2.24), the equilibrium price of land is positively correlated to the price of goods, through its effect on income. Thus, having prices enter directly in the premium through the value of the capital stock as in (2.24) does not affect the qualitative features of the equilibrium. The key difference is that now, changes in the refinance rate, the required reserve ratio, and the productivity shock do not affect the premium and the loan rate through their impact on the price of land. By implication, in (2.27), the partial derivatives of the financial equilibrium condition FF with respect to these variables become

$$FF_{i^R} = 1, \quad FF_{\mu} = FF_A = 0,$$

which show that while the effect of the refinance rate remains qualitatively the same, productivity shocks and changes in the required reserve ratio no longer have a direct impact on financial equilibrium. However, it is still the case that $FF_P = \kappa\theta' K_0 < 0$, which implies that the financial amplification effect operates exactly as described earlier.

The fact that $FF_A = 0$ when specification (2.37) is used is fairly straightforward. A positive productivity shock would have no effect (as noted earlier) on the position of FF. In Figure 2.11, the equilibrium would be at a point E'', rather than E'. However, in both cases, prices are lower and the loan rate higher, as a result of financial amplification. Thus, even though the transmission mechanism is altered, the equilibrium effects of the shock remain qualitatively the same. Similarly, with $FF_{\mu} = 0$, an increase in the required reserve ratio would lead to an equilibrium at E''' in Figure 2.26, as discussed later on.

A further simplification of the model, when specification (2.37) is adopted, is to abstract entirely from the existence of land as a portfolio asset. In such conditions, equations (2.13) and (2.14) can be ignored, and equation (2.15) can be replaced by

$$C = c_0 + c_1(Y^s - T) - c_2(i^D - \pi^e) + c_3(\frac{F_0^H}{P}), \tag{2.38}$$

where parameters are as defined before. By implication, in (2.29), the partial derivatives of the goods market equilibrium condition GG with respect to P, i^R, μ, and A become

$$GG_P = \frac{1}{I'}\left\{(1-c_1)Y_P^s + c_3(\frac{F_0^H}{P^2})\right\} < 0, \; GG_{i^R} = \frac{c_2(1-\mu)}{I'} < 0,$$

$$GG_{\mu} = -\frac{c_2 i^R}{I'} > 0, \; GG_A = \frac{(1-c_1)Y_A^s}{I'} < 0.$$

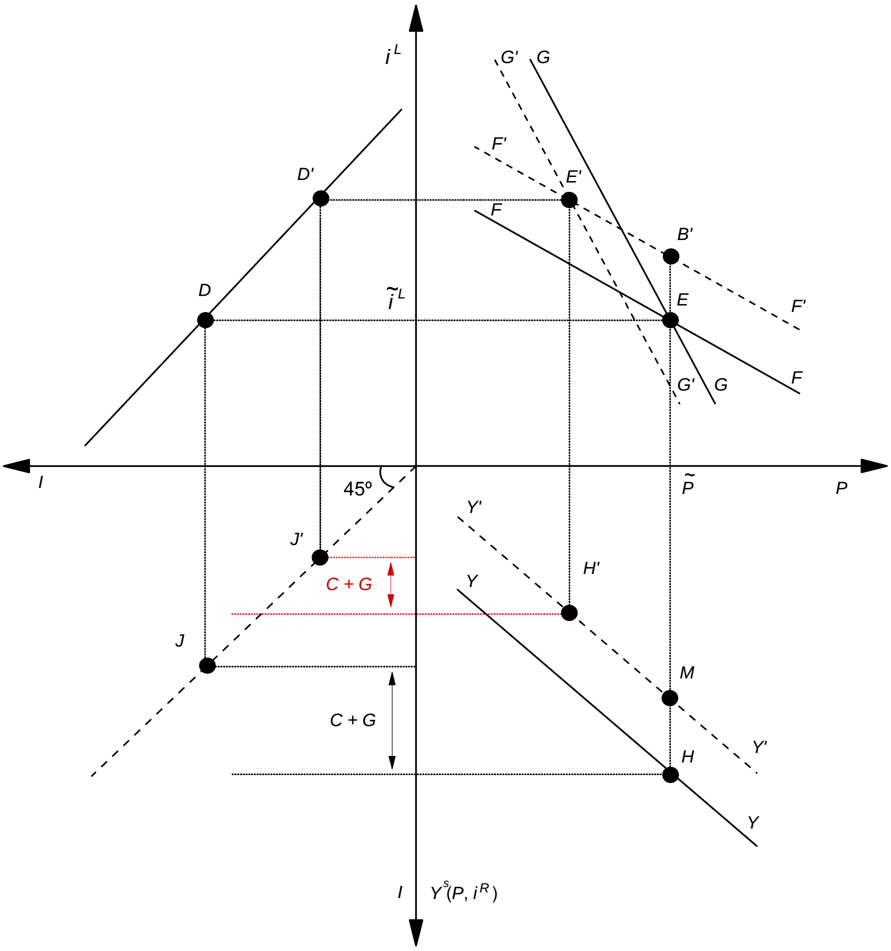
[22] See Agénor (2020, Chapter 2; 2021) for a more detailed discussion of some of these extensions, as well as others.

[23] Agénor (2021) discussed how to account for unemployment. Another extension would be to account explicitly for bank capital regulation (rather than a generic, cost-based macroprudential instrument) along the lines of Agénor and Pereira da Silva (2012), for instance, in a related, closed-economy framework.

[24] The use of physical capital as collateral is more in line with models with financial frictions in the tradition of Bernanke et al. (1999), in which net worth also determines the premium at which firms can borrow.

Increase in the Refinance Rate: Weak Cost Channel

Figure 2.25



Source: Agénor (2020).

Thus, the derivatives with respect to i^R, μ, and A retain the same sign; their transmission channel through the goods market remains qualitatively the same. Regarding the derivative with respect to *P*, it was assumed earlier that the sensitivity of the demand for land to income is small enough to ensure that the *net wealth effect* is to reduce consumption, so that $GG_P < 0$. Obviously, this property is automatically satisfied when real assets are ignored in measuring the effect of wealth on private spending. Thus, once again, the qualitative features of the transmission process, as described earlier, are not affected.[25]

2.7.2. Working Capital Needs

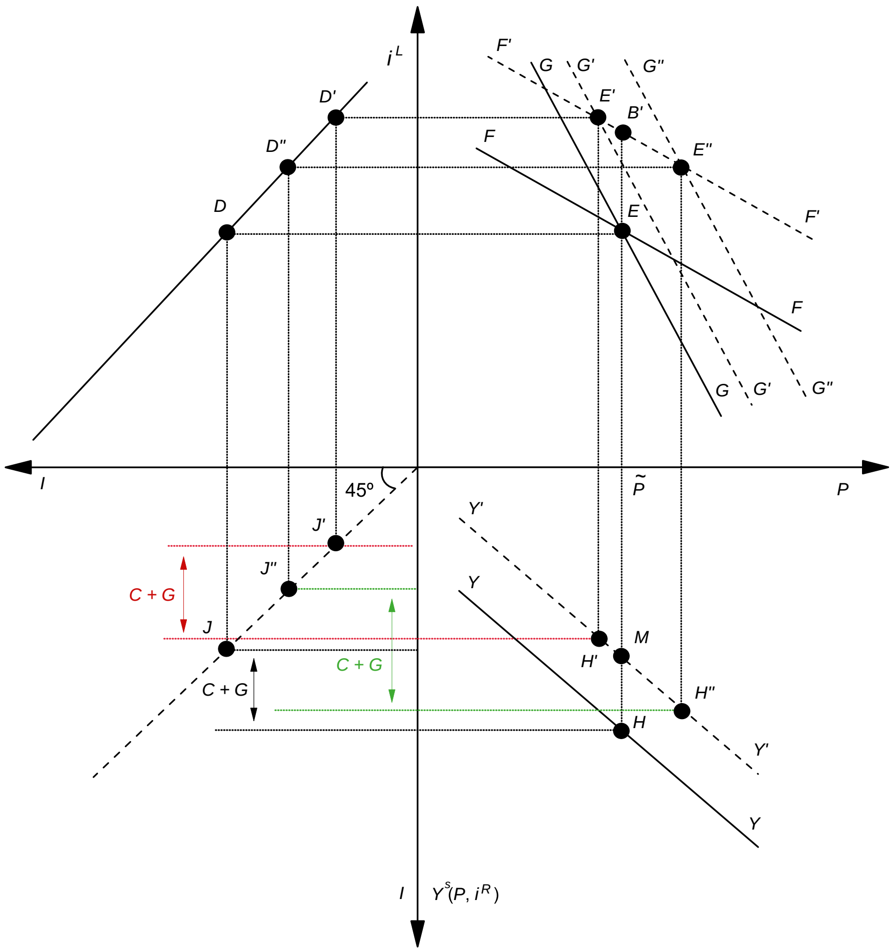
So far it has been assumed that the only borrowing is from firms, and for investment purposes only. In practice, as noted in Chapter 1, firms also borrow before the sale of production to cover their working capital needs (salaries, purchases of intermediate goods, and so on). Suppose then that firms must pay for production costs prior to the sale of output. Specifically, suppose that firms must also borrow from banks to pay wages in advance. In addition, suppose that working capital loans, being short term in nature, are not subject to default risk and are therefore made at a rate that reflects only the refinance rate, i^R.[26] Firms repay these loans, with interest, at the end of the period, after goods have been produced and sold.

25 This version of the model is studied in more detail in Agénor and Montiel (2015, Chapter 6) and Agénor (2020, Chapter 2). It can be analyzed graphically using a simple Excel simulation tool, which is circulated in parallel with this Manual.

26 Addiing a constant mark-up above and beyond the refinance would not affect the results.

Increase in the Refinance Rate: Strong Cost Channel

Figure 2.26



Source: Agénor (2020).

As before, let W denote the nominal wage and N the quantity of labour employed. Let also $\psi_W \in (0,1)$ is the fraction of wage costs financed by bank loans. The wage bill, inclusive of borrowing costs, is thus $(1-\psi_W)WN + \psi_W(1+i^R)WN = (1+\psi_W i^R)WN$, where $(1+\psi_W i^R)W$ is the *effective wage*, which accounts not only for the direct cost of labour, but also for the cost of borrowing to pay wages at the beginning of the production process.

Nominal profits are now therefore given by, instead of (2.2),

$$\Pi = PAN^{\alpha}K_0^{1-\alpha} - (1+\psi_W i^R)WN. \tag{2.39}$$

The first-order condition of firms' maximisation problem with respect to N is now

$$\alpha PAN^{\alpha-1}K_0^{1-\alpha} - (1+\psi_W i^R)W = 0,$$

which yields the demand for labour as, with again $W = \bar{W} = 1$,

$$N^d = \left(\frac{A\alpha P}{1+\psi_W i^R}\right)^{1/(1-\alpha)} K_0. \tag{2.40}$$

This equation can be substituted in the production function (2.1) to give

$$Y^s = \left(\frac{A\alpha P}{1+\psi_W i^R}\right)^{\alpha/(1-\alpha)} K_0. \tag{2.41}$$

Thus, the demand for labour and the supply of goods are now inversely related to the effective cost of labour,

Equations (2.40) and (2.41) can be written as

$$N^d = N^d(P; A, i^R), \quad Y^s = Y^s(P; A, i^R), \tag{2.42}$$

with $N_j^d, Y_j^s > 0, \quad j = P, A$ as before, as well as

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

An increase in the refinance rate exerts now a *contractionary effect* on employment and aggregate supply.

Given (2.42), the main implication of this extension relates to curve GG, where the derivative with respect to i^R is now given by

$$GG_{i^R} = \frac{(1-c_1)Y_{i^R}^s + c_2(1-\mu) - c_3 p_{i^R}^H}{I'} \gtrless 0,$$

which is ambiguous, given that $c_2(1-\mu) - c_3 p_{i^R}^H > 0$ (as shown earlier) and $Y_{i^R}^s < 0$, compared to the case considered previously, that is, $\psi_W = Y_{i^R}^s = 0$.[27]

By inducing a rise in the deposit rate, thereby increasing incentives to save, and a drop in land prices, a higher refinance rate lowers consumption and aggregate demand. To maintain equilibrium in the goods market at the initial level of prices, investment must increase, and this in turn requires a (hypothetical) fall in the loan rate. This effect is the same as the one discussed earlier.

In addition, an increase in the refinance rate *reduces now also aggregate supply*, through its effect on the effective cost of labour (captured through $Y_{i^R}^s$).[28] But because both aggregate supply and aggregate demand fall, the loan rate may either need to increase or fall to maintain equilibrium in the goods market. If aggregate supply falls relatively more, the loan rate will need to *increase* to dampen investment and eliminate excess demand ($GG_{i^R} > 0$). Alternatively, it will have to *fall* ($GG_{i^R} < 0$).

If ψ_W, the proportion of wage costs financed by bank credit, is sufficiently small to ensure that $GG_{i^R} < 0$, then the case considered previously continues to prevail. By extension, the assumption that $GG_{i^R} < 0$ ($GG_{i^R} > 0$) corresponds to the case where the cost channel of monetary policy is weak (strong).

Formally, given that $I' < 0$, in order to have $GG_{i^R} < 0$ it must be that

$$(1-c_1)Y_{i^R}^s + (1-\mu)c_2 - c_3 p_{i^R}^H > 0,$$

which, given the definition of $Y_{i^R}^s$ stated above, gives an implicit restriction on ψ_W. Of course, if $\psi_W = 0$, the condition for $GG_{i^R} < 0$ boils down to $(1-\mu)c_2 - c_3 p_{i^R}^H > 0$, which always holds.

To illustrate the difference between the two cases, consider again an increase in the refinance rate. Differentiating equations (2.27) and (2.29), holding G, μ, τ^L and A constant, yields the system

$$\begin{bmatrix} 1 & -FF_P \\ 1 & -GG_P \end{bmatrix} \begin{bmatrix} di^L \\ dP \end{bmatrix} = \begin{bmatrix} FF_{i^R} \\ GG_{i^R} \end{bmatrix} di^R,$$

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

[28] Aggregate demand also falls as a result of lower income, but given again that $1-c_1 > 0$, the net effect is indeed a reduction in supply.

the solution of which gives

$$\frac{di^L}{di^R} = \frac{\overset{(?)}{GG_{i^R}}\,\overset{(-)}{FF_P} - \overset{(+)}{FF_{i^R}}\,\overset{(-)}{GG_P}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}}, \quad \frac{dP}{di^R} = \frac{\overset{(?)}{GG_{i^R}} - \overset{(+)}{FF_{i^R}}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}}. \tag{2.43}$$

As before, the condition $|GG_P| > |FF_P|$ is required for local stability. Thus, $FF_P - GG_P > 0$. However, the numerator in both expressions is now ambiguous in general, so the effects on the loan rate and the price level cannot be determined a priori. If, as in the initial case, GG_{i^R} remains negative, the results are the same as those established previously: $di^L / di^R > 0$ and $dP / di^R < 0$.

The effects of an increase in the refinance rate are illustrated in Figure 2.25 for the case where ψ_W is relatively small (so that the cost channel is weak and $GG_{i^R} < 0$), and in Figure 2.26 for the case where the combination of ψ_W and other parameters is such that the cost channel is strong and $GG_{i^R} > 0$.

Consider first Figure 2.25. The policy exerts three immediate effects. First, there is a direct impact on the loan rate; because an increase in the refinance rate raises the marginal cost of funds, it is "passed on" directly, and fully, to borrowers. In the northeast quadrant, curve FF shifts outward to $F'F'$ and the loan rate increases on impact from point E to B'. This increase is accompanied by a contraction in investment. Second, because a higher refinance rate also raises the deposit rate, intertemporal substitution leads to a drop in consumption; this leads to an inward shift in GG to $G'G'$. These two effects are the same as those discussed before; they both operate through aggregate demand (see Figures 2.6 and 2.7).

In addition, there is a third effect now – a higher refinance rate also raises production costs and lowers output. Graphically, there is an inward shift of the supply curve in the southeast quadrant from YY to $Y'Y'$ and production drops from point H to M on impact. At points B' and M, both aggregate demand and aggregate supply are lower, but because $GG_{i^R} < 0$, the drop in demand is larger; there is therefore *excess supply* at the initial level of prices.

Consequently, the transition from the initial equilibrium at E to the new equilibrium at E' proceeds in the same way as before: as prices fall, the loan rate increases from B' to E', a movement that corresponds to the financial amplification effect. With prices falling, the value of collateral falls also, thereby inducing banks to raise the premium and the loan rate; and through a positive wealth effect, consumption tends to increase. However, in addition, the fall in prices raises the real wage, which reduces supply. After falling from H to M on the new curve $Y'Y'$, output continues to fall from M to H'. This reduction in output and employment translates into lower income for households, which tends to reduce consumption. Thus, while investment unambiguously falls (as before), consumption may either increase or decrease in the new equilibrium. In the scenario shown in Figure 2.25, consumption actually falls (from the distance C to C' in the southwest quadrant), due to a relatively large (two-step) drop in output.

Consider next the case where $GG_{i^R} > 0$, which is illustrated in Figure 2.26. This time, following an increase in the refinance rate curve GG shifts *outward*. But even in that scenario, it is still possible that it does not shift by a large amount; if so, the adjustment process for i^L and P is qualitatively the same as what obtains with $GG_{i^R} < 0$. Formally, from (2.43), given again that the denominator is positive, this occurs if the numerators are such that

$$\overset{(+)}{GG_{i^R}}\,\overset{(-)}{FF_P} - \overset{(+)}{FF_{i^R}}\,\overset{(-)}{GG_P} > 0, \quad \overset{(+)}{GG_{i^R}} - \overset{(+)}{FF_{i^R}} < 0,$$

or equivalently

$$\frac{GG_{i^R}}{FF_{i^R}} > \frac{GG_P}{FF_P}, \quad \frac{GG_{i^R}}{FF_{i^R}} < 1.$$

If these conditions hold, the adjustment process is exactly as before. In particular, the loan rate will follow the path $EB'E'$, and aggregate supply will follow the path HMH', just as in Figure 2.25. The financial amplification effect therefore continues to operate. Intuitively, at the initial level of prices, the increase in the refinance rate lowers supply by more than demand, as a result of a strong cost channel. To eliminate excess demand and restore equilibrium of the goods market, the loan rate would need to increase by, say, an amount x to reduce investment. Thus,

GG shifts upward, just like FF. However, the *actual* increase in the loan rate, from point E to point B', resulting from banks passing on the increase in the refinance rate to their borrowers, may be *larger* than *x*. If so, the drop in investment is larger than what would be required to restore equilibrium between supply and demand on the goods market, and excess supply prevails as before. In turn, this implies that prices begin to fall, while the loan rate continues to rise from B' to E'.

However, if either one of the conditions above, or both, fails to hold, then alternative scenarios may occur. Indeed, Figure 2.26 also illustrates the case where the first condition holds but the second does not. This corresponds to a scenario where the cost channel is strong, as noted earlier. In this case, the adjustment process leads to *stagflation*: lower output and higher prices (points E'' and H''). In addition, the transition process is now characterized by a *financial decelerator* effect. On impact, the loan rate jumps again from E to B', but at that point there is *excess demand*, rather than excess supply. As a result, prices begin to *increase*, instead of falling. Because land prices also increase, collateral values rise as well, lowering the premium in the process. The loan rate falls gradually, from B' to E''. At the same time, higher prices tend to lower consumption through the wealth effect and to raise output by reducing real wages. After dropping on impact from point H to point M, output begins to expand and increases to the new equilibrium point H''. However, in the case illustrated in the figure, the benefit stemming from a reduction in real labour costs does not allow activity to fully recover; at the new equilibrium, production is still lower than it was initially.

The combination of higher prices and lower output in the new equilibrium shows indeed that, when the cost channel is strong, a restrictive monetary policy can be stagflationary. In addition, despite output being lower, consumption is higher in the new equilibrium due to a relatively larger contraction in investment.[29]

2.7.3. Reserve Requirements

In the foregoing discussion, the required reserve ratio was presented as an instrument of monetary policy. Indeed, central banks in many developing countries (especially in Latin America) have used changes in required reserves extensively, time and again, as a substitute for monetary policy, especially in response to large capital inflows.[30] At the same time, their potential value as a tool that may help to mitigate systemic risk and promote financial stability has regained importance in recent years – despite the fact that required reserves may distort the financial intermediation process in the long run. One reason for this may be the fact that (as noted in Chapter 1) the weak capacity to supervise financial institutions and to enforce financial regulations has led many MICs to rely on prudential instruments that are relatively easy to implement in a timely fashion.

From (2.27) and (2.29), the general equilibrium effect of a rise in μ can now be calculated by solving the system

$$\begin{bmatrix} 1 & -FF_P \\ 1 & -GG_P \end{bmatrix} \begin{bmatrix} di^L \\ dP \end{bmatrix} = \begin{bmatrix} FF_\mu \\ GG_\mu \end{bmatrix} d\mu,$$

which gives

$$\frac{di^L}{d\mu} = \frac{\overset{(+)}{GG_\mu}\overset{(-)}{FF_P} - \overset{(-)}{GG_P}\overset{(-)}{FF_\mu}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} < 0, \quad \frac{dP}{d\mu} = \frac{\overset{(+)}{GG_\mu} - \overset{(-)}{FF_\mu}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} > 0, \tag{2.44}$$

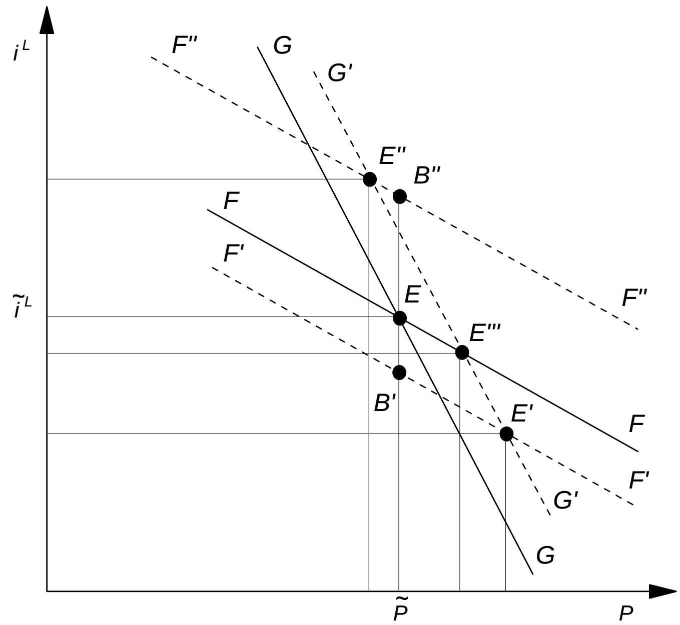
given again that $FF_P - GG_P > 0$.

The effects of an increase in the required reserve ratio are illustrated in Figure 2.27. As can be inferred from (2.18), the immediate effect of the policy is to lower the deposit rate, which reduces the incentive to save and stimulates current consumption. At the initial level of prices, the increase in aggregate demand requires a higher loan rate to clear the goods market; thus, GG shifts unambiguously upward, to $G'G'$. At the same time, as noted earlier (see (2.27)), the reduction in the deposit rate associated with the increase in the required reserve ratio raises the demand for land as well as its price ($p_\mu^H > 0$); in turn, this raises collateral values and lowers the premium ($FF_\mu < 0$). Thus, FF shifts downward. The loan rate falls from E to B' and continues to fall until the new equilibrium is

29 See Agénor (2020, Chapter 2) for a full analysis of the case $GG_{i^R} > 0$, albeit in a model without land prices.
30 See Agénor and Pereira da Silva (2017) and Chapter 6 for a discussion.

Increase in the Required Reserve Ratio

Figure 2.27



reached at E'. In the new equilibrium, the loan rate is lower and both investment and prices are higher. As a result, real wages are lower and aggregate output is also higher. The combination of higher investment and higher output means that consumption may again either rise or fall. Most importantly, in the core specification of the model, an increase in the required reserve ratio is both expansionary and inflationary.

To account for a contractionary effect of changes in the required reserve ratio, suppose now that there is imperfect substitution between bank deposits and central bank borrowing. To preserve the simplicity of the model, this is done in an indirect way, by accounting for a *liability composition effect* on the cost of borrowing from the central bank.

Formally, suppose again that competition prevails in the deposit market, so that the no-arbitrage condition (2.10) continues to hold. Thus, from the perspective of commercial banks, bank deposits and central bank borrowing remain perfect substitutes. However, from the perspective of the central bank, this is no longer the case. Specifically, the cost of borrowing from the monetary authority is now defined as the sum of a constant base policy rate, i^T, and a penalty rate, which increases the ratio of central bank borrowing to deposits,

$$i^R = i^T + \upsilon(\frac{L_0^B}{D}), \tag{2.45}$$

where $\upsilon' \geq 0$. To simplify matters, central bank borrowing is measured at the beginning of the period.[31] By charging a higher refinance rate when the relative share of deposits in banks' liabilities is low, the central bank induces them to raise their deposit rate, which in turn encourages market funding. The case considered earlier, of course, corresponds to $\upsilon' = 0$, in which case both i^R and i^T are exogenous.

From (2.11) and (2.18), $D = d[(1-\mu)i^R]F_0^H$. A higher required reserve ratio imposed by the regulator therefore reduces the deposit rate (as before), which lowers deposits and raises the central bank borrowing-deposit ratio. From (2.45), this leads to an increase in the penalty and refinance rates, and consequently the loan rate. Thus, in the financial sector equilibrium condition (2.27), the expression for FF_μ is now given by

$$FF_\mu = \kappa\theta' P p_\mu^H + (1 + \kappa\theta' P p_{i^R}^H)(\frac{\partial \upsilon}{\partial D})(\frac{\partial D}{\partial \mu}),$$

[31] In the more elaborate DSGE model presented in subsequent chapters, a more general treatment of the penalty rate is provided.

which is in general ambiguous in sign. However, it is clear that if υ' is large enough, it is possible for FF_μ to be positive now, rather than negative. With $FF_\mu > 0,$ the above solutions become

$$\frac{di^L}{d\mu} = \frac{\overset{(+)}{GG_\mu}\overset{(-)}{FF_P} - \overset{(-)}{GG_P}\overset{(+)}{FF_\mu}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} \gtrless 0, \quad \frac{dP}{d\mu} = \frac{\overset{(+)}{GG_\mu} - \overset{(+)}{FF_\mu}}{\underset{(-)}{FF_P} - \underset{(-)}{GG_P}} \gtrless 0. \tag{2.46}$$

The case where $FF_\mu > 0$ is positive and large enough to ensure that the loan rate increases and prices fall is also illustrated in Figure 2.26. Curve FF shifts now upward, from FF to $F''F''$, significantly more than the shift in GG. The loan rate this time jumps upward from E to B'', and continues to increase until the new equilibrium is reached at E''. During the movement from B'' to E'', the contraction in aggregate demand drives prices down, as well as house prices and collateral values. Output also falls, as a result of the increase in real wages. Put differently, the policy is now contractionary and deflationary, mainly because the required reserve ratio generates an indirect effect on the loan rate through the penalty rate set by the central bank. Conceptually, a similar result would obtain by introducing an interbank market and heterogeneity in banks' funding positions, and by assuming that banks with a funding surplus charge a premium, determined in a way similar to (2.45), to those who borrow.[32]

2.7.4. Credibility and Inflation Expectations

Although there is evidence suggesting that short-run inflation expectations in middle-income countries have a strong backward-looking component in "normal" times (see Agénor and Bayraktar (2010), for instance), a useful extension of the analysis is to explore how these expectations can be endogenized.

To do so the expected inflation rate could be specified as

$$\pi^e = \xi\pi^T + (1-\xi)(\frac{P-P_0}{P_0}),$$

where π^T is an (exogenous) inflation target, P_0 a base value of the domestic price level, and $\xi \in (0,1)$ measures the degree of credibility of the target. Thus, price expectations are extrapolative: an increase in prices today would induce agents to raise their expected inflation rate. The less anchored (to the inflation target) inflation expectations are, the lower the value of ξ, and the larger the response of expected inflation to current movements in prices.

With the endogenous treatment of inflation expectations, three equations would be affected: the investment function (equation (2.7)), the demand function for land (equation (2.14)), and the consumption function (equation (2.15)). It is immediately clear from (2.14) and (2.23) that an increase in domestic prices would still have a positive effect on the equilibrium price of land (equation (2.24)): on the one hand, it raises output and income (as before), and, on the other, it lowers the real deposit rate. In both cases the demand for land increases and its price therefore also goes up. Consequently, the model's implications would remain unchanged with respect to that.

Regarding the implications for the goods market equilibrium condition, it is clear from equations (2.7), (2.15), and (2.25) that, with the specification given above, an increase in today's prices raises the expected inflation rate, and this, in turn (all else equal) will further stimulate investment and household consumption. Thus, this expansionary effect may dominate the contractionary effect associated with the adverse effect of higher prices on real wealth. If that effect is relatively large, it could lead to changes in the sign of the derivative FF_P. Put differently, poorly anchored expectations (or, more generally, lack of credibility of the inflation target, π^T) could be a source of perverse dynamics – but only under certain conditions, which cannot be assessed without a full numerical analysis.

[32] In a more elaborate setting, Chapter 5 also shows that similar effects can be obtained by introducing economies of scope in banking.

Appendix

Local Stability Analysis and the Slopes of *FF* and *GG*

As discussed in the text, both FF and GG have a negative slope, reflecting the fact that $F_P, G_P < 0$. The question then is how steep is GG relative to *FF*? The answer, which is crucial for understanding the comparative statics properties of the model and the adjustment process to shocks, can be provided by relying on *Samuelson's correspondence principle*, which essentially involves analysing the local stability of the dynamic system associated with the financial and goods market equilibrium conditions.[33]

Formally, consider the following dynamic adjustment process for the loan rate and prices, i^L and *P*: changes in the loan rate are related to the difference between its equilibrium and current values, and changes prices are related to excess demand for goods. In *continuous time*, the first dynamic equation is

$$\frac{di^L}{dt} = \lambda_F[FF(P;\cdot) - i^L], \tag{A2.1}$$

where $\lambda_F > 0$ is the speed of adjustment and $FF()$ corresponds to financial sector equilibrium condition (2.27) in the text. The second dynamic equation is

$$\frac{dP}{dt} = \lambda_G(C + I + G - Y^s),$$

or, using the goods market equilibrium condition (2.28) in the text,

$$\frac{dP}{dt} = \lambda_G\left\{c_0 + c_1 Y^s(P,\cdot) - c_2 i^R + c_3[\frac{F_0^H}{P} + p^H(P;\cdot)] + I(i^L) + G - Y^s(P;\cdot)\right\}, \tag{A2.2}$$

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

Linearizing equations (2.1) and (2.2) in the vicinity of the steady state yields, with a "~" denoting a steady-state value,[34]

$$\begin{bmatrix} di^L/dt \\ dP/dt \end{bmatrix} = \begin{bmatrix} \lambda_F a_{11} & \lambda_F a_{12} \\ \lambda_G a_{21} & \lambda_G a_{22} \end{bmatrix} \begin{bmatrix} i^L - \tilde{i}^L \\ P - \tilde{P} \end{bmatrix}, \tag{A2.3}$$

and, given the definitions of FF_P and GG_P provided in the text,

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

$$a_{12} = FF_P = \kappa\theta'(p^H + P p_P^H) < 0,$$

$$a_{21} = I' < 0,$$

$$a_{22} = -(1 - c_1)Y_P^s - c_3(\frac{F_0^H}{P^2}) + c_3 p_P^H = -I' GG_P < 0.$$

33 This Appendix is based on Agénor (2020, Chapter 2), which provides a more detailed discussion.

34 Let $dx_t/dt = f(x_t, z_t)$, where x_t and z_t are two variables. A *first-order Taylor series expansion* in the neighborhood of $(\tilde{x}, \tilde{z})$ yields $dx_t/dt \simeq f(\tilde{x}, \tilde{z}) + f_x(x_t - \tilde{x}) + f_z(z_t - \tilde{z})$. Because in the steady state both x_t and z_t are constant, $f(\tilde{x}, \tilde{z}) = 0$. The same reasoning applies to $dz_t/dt = g(x_t, z_t)$.

Because the loan rate and the price level are both state (slow-moving) variables, stability of the dynamic system (2.3) requires *two negative eigenvalues*. Necessary and sufficient conditions for that to occur are that the matrix of coefficients (or Jacobian), **A**, has a *positive determinant* (to guarantee either two positive or two negative eigenvalues) and a *negative trace* (to ensure two negative eigenvalues):[35]

$$\det \mathbf{A} = \lambda_F \lambda_G (a_{11}a_{22} - a_{12}a_{21}) > 0,$$

$$\text{tr}\mathbf{A} = \lambda_F a_{11} + \lambda_G a_{22} < 0.$$

The condition on tr**A** is always satisfied, given that $a_{11}, a_{22} < 0$ and $\lambda_F, \lambda_G > 0$. However, given that $a_{12}, a_{21} < 0$, the condition on $\det \mathbf{A}$ does not always hold; for that to occur requires

$$\frac{a_{22}}{a_{21}} > \frac{a_{12}}{a_{11}}. \qquad \text{(A2.4)}$$

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

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

and

$$\frac{a_{22}}{a_{21}} = \frac{-I'GG_P}{I'} = -GG_P > 0.$$

Thus, condition (2.4) can also be written as

$$-GG_P > -FF_P,$$

which implies that the slope of GG must be steeper, in absolute terms, than the slope of *FF*.

Intuitively, given that GG_P captures the strength of the net supply effect and the wealth effect on consumption, whereas FF_P captures the strength of the collateral effect on the loan rate, stability requires that the real effects of an increase in prices be stronger than its effect on the financial sector.

35 These conditions are related to the fact that the determinant of the Jacobian is the *product* of the eigenvalues, whereas its trace is equal to the *sum* of the eigenvalues.

Chapter 3. A Simple Open-EconomyModel

This chapter extends the closed-economy model with banks and financial frictions presented in Chapter 2 to the case of a bank-dependent, small open economy operating a managed float regime. Section 1 summarizes the key features of the extended model. Section 2 describes its structure and Section 3 characterizes macroeconomic equilibrium, both analytically and graphically. The impact of macro-financial policies are studied in Section 4. The model captures now five types of macro-financial policies: fiscal policy (in the form of changes in public expenditure), monetary policy (in the form of changes in a short-term interest rate), and macroprudential policy (in the form of changes in a tax on loans and reserve requirements), as before; but also systematic and one-off foreign exchange intervention, as well as capital controls (in the form of a tax on bank foreign borrowing). As discussed already in Chapter 1, and subsequently in Chapter 6, a growing number of central banks in MICs – especially in Asia and Latin America – have used foreign exchange market intervention as part of a broad combination of policy instruments to contain macroeconomic and financial stability risks, especially those associated with large, short-term capital inflows. From that perspective, Section 5 considers an external shock of great relevance for these countries – a drop in the world interest rate, and its transmission through cross-border capital flows to the domestic economy. Section 6 studies if, and how, macro-financial policies should be combined in response to these flows, to stabilize the economy. As before, all policy combinations are illustrated diagrammatically, thereby making it relatively easy to relate the analysis to policymakers' current practice and intuitions. Again, while this analysis is inevitably partial in nature, given in particular the static nature of the model and the absence of an explicit account of the objectives of policymakers, it provides some useful insights with respect to the benefits (or lack thereof) of alternative policy combinations. Section 7 discusses some extensions of the analysis.

3.1. Key Features

The core open-economy model presented in this chapter shares the same features of the closed-economy model studied previously. In particular, banks' funding sources are perfect substitutes, the loan rate is set as a premium over the cost of borrowing from the central bank, the premium itself is a function of borrowers' collateralizable net assets, and loan supply by banks to firms, and the provision of liquidity by the central bank to commercial banks, are perfectly elastic at prevailing interest rates. Macroprudential policy takes the form of a tax on loans. In addition, the model again accounts for nominal wage rigidity, and consumption is driven by both liquidity constraints and intertemporal substitution.

Because the economy is now open, it also incorporates several new features, which can be summarized as follows:

1. Households hold foreign-currency deposits, which are imperfect substitutes for domestic deposits.

2. Capital mobility is imperfect, implying that domestic interest rates are determined at home, rather than being tied to the world interest rate.

3. Central bank operates a managed float and intervenes, both systematically and at discretion, on the spot market for foreign exchange to smooth excessive currency fluctuations. Intervention is sterilized by issuing bonds, which are held by domestic banks.

4. Economies of scope in banking create imperfect substitutability between domestic loans and sterilization bonds in banks portfolio.

5. Capital controls take the form of a tax on bank foreign borrowing.

The chapter proceeds as follows. The structure of the model is presented in Section 2, and its solution in Section 3. The impact of macro-financial policies is examined in Section 4. The effects of all five of the macro-financial policy instruments alluded to earlier are analysed. Section 5 describes the impact of a reduction in the world interest rate on capital flows and the domestic economy, whereas Section 6 considers how pairs of policy instruments can be combined to restore the pre-shock equilibrium. Section 7 considers several extensions of the model, including physical capital and working capital needs (as in Chapter 2), intratemporal substitution, and endogenous depreciation expectations.

3.2. The Model

Consider a small open economy producing a specialized, homogeneous good, using labour and capital. The domestic good is imperfectly substitutable for 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.[1] Thus, the economy's terms of trade – the relative price of the foreign good in terms of the domestic good, or equivalently the real exchange rate – are endogenous. As in Chapter 2, there are six categories of agents: firms, households, commercial banks, the central bank, the financial regulator, and the government. Their behaviour is considered in turn. The definitions of the price index and the real exchange rate, and market-clearing conditions, are then provided.

3.2.1. Firms

Let Y denote output, N employment, and K_0 is the stock of capital at the beginning of the period. The production function takes again a Cobb-Douglas form,

$$Y = AN^{\alpha}K_0^{1-\alpha}, \tag{3.1}$$

where A is a productivity parameter and $\alpha \in (0,1)$.

Let W denote the nominal wage and P^D the price of the domestic good. Firms' profits, Π, can therefore be defined as

$$\Pi = P^D Y - WN,$$

where WN is the wage bill. Substituting (3.1) for Y in this expression yields

$$\Pi = P^D AN^{\alpha}K_0^{1-\alpha} - WN. \tag{3.2}$$

With the capital stock predetermined at K_0, firms determine the level of employment, N, so as to maximise profits. Using (3.1), and taking P^D and W as given, the first-order condition of the maximisation problem is thus

$$\frac{d\Pi}{dN} = \alpha P^D AN^{\alpha-1}K_0^{1-\alpha} - W = 0,$$

or equivalently

$$AN^{\alpha-1}K_0^{1-\alpha} = \frac{W}{\alpha P^D},$$

or again

$$N^{1-\alpha} = (\frac{A\alpha P^D}{W})K_0^{1-\alpha},$$

so that the demand for labour, N^d, is

$$N^d = (\frac{A\alpha P^D}{W})^{1/(1-\alpha)}K_0. \tag{3.3}$$

Substituting this equation in the production function (3.1) gives the supply of goods, Y^s, as

$$Y^s = [(\frac{A\alpha P^D}{W})^{1/(1-\alpha)}K_0]^{\alpha}K_0^{1-\alpha} = (\frac{A^{\alpha} P^D}{W})^{\alpha/(1-\alpha)}K_0^{\alpha+1-\alpha},$$

[1] See, for instance, Feenstra and Taylor (2021) for a discussion of the Mundell-Fleming model and its underlying structure.

so that

$$Y^s = \left(\frac{A^{\circ} P^D}{W}\right)^{\circ/(1-\circ)} K_0. \tag{3.4}$$

Equations (3.3) and (3.4) show that the demand for labour and the supply of goods are inversely related to the *product wage*, defined as W / P^D, that is, the nominal wage divided by the price of the domestic good.

Comment 3.1. In the open economy, households consume both domestic and imported goods. The price of the consumption basket (or the cost-of-living index, as defined later on) differs therefore from the price of the domestic good. The *consumption wage* corresponds to the nominal wage divided by the cost-of-living index and differs from the product wage.

Assuming again that nominal wage rigidity prevails in the short run, so that $W = \bar{W}$, equations (3.3) and (3.4) become

$$N^d = N^d(P^D; A), \quad Y^s = Y^s(P^D; A), \tag{3.5}$$

where

$$N_P^d = \left(\frac{1}{1-\circ}\right)\frac{N^d}{P^D} > 0, \quad N_A^d = \left(\frac{1}{1-\circ}\right)\frac{N^d}{A} > 0,$$

$$Y_P^s = \left(\frac{\circ}{1-\circ}\right)\frac{Y^s}{P^D} > 0, \quad Y_A^s = \left(\frac{\circ}{1-\circ}\right)\frac{Y^s}{A} > 0.$$

An increase in the price of domestic goods, or a positive productivity shock, lead, as before, to an expansion in employment and output.

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

$$I = I(i^L - \pi^e), \tag{3.6}$$

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

Thus, total loans, L, are given by

$$L = L_0 + P^D I,$$

where L_0 is the beginning-of-period stock of loans.

3.2.2. Households

Households supply labour inelastically and consume the domestic and foreign goods.[2] They hold three categories of imperfectly substitutable financial assets: currency (which bears no interest), domestic-currency deposits with the domestic banking system, and foreign-currency deposits held abroad. They also hold real, physical assets, in the form of land (equivalently, housing or real estate). Foreigners do not hold domestic assets.

Portfolio Allocation

As before, portfolio decisions follow a two-stage process. In the first stage, households allocate their financial wealth, F^H, defined now as:

$$F^H = M + D + ED^*, \tag{3.7}$$

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

2 Given that labour demand is determined by firms and that the nominal wage is fixed, the assumption that labour supply is inelastic implies again (as discussed in chapter 2) that unemployment may emerge in equilibrium.

This equation can be rewritten as

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

that is,

$$F^H = F_0^H + (E - E_0)D_0^*, \tag{3.8}$$

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

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

$$\frac{D}{M} = \nu(i^D), \tag{3.9}$$

where $\nu' > 0$.

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

$$\frac{ED^*}{D} = \chi i^D - (i^* + \varepsilon)], \tag{3.10}$$

where $\chi' < 0$.

Substituting (3.9) and (3.10) in (3.7) yields

$$\frac{D}{F^H} = \frac{\nu}{1 + (1 + \chi)\nu} = d(i^D; i^* + \bullet), \tag{3.11}$$

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

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

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

Using (3.11) to substitute out for D yields the demand for cash as

$$\frac{M}{F^H} = \frac{1}{1 + (1 + \chi)\nu} = m(i^D; i^* + \bullet), \tag{3.12}$$

where

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

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

To ensure that a higher domestic deposit rate also lowers the relative demand for cash, in addition to increasing the deposit-cash ratio, that is, $m_{i^D} < 0$, the following restriction is imposed:

$$\nu' i^D / \nu > -\chi' i^D / (1 + \chi).$$

This condition requires the elasticity of the domestic deposits-cash ratio to be sufficiently high. It essentially means that the increase in domestic deposits resulting from a rise in its own rate of return is large enough to ensure that it is accommodated not only by a reduction in foreign deposits but also by lower holdings of cash.

From (3.10) and (3.11), the demand for foreign-currency deposits is given by

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

that is, using (3.11),

$$\frac{ED^*}{F^H} = \frac{\nu\chi}{1+(1+\chi)\nu} = d^*(i^D; i^* + \bullet), \tag{3.13}$$

where

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

Thus, while an increase in the return on foreign deposits has the expected (positive) effect, an increase in the domestic rate of return has in general an ambiguous effect. Intuitively, the reason is that it may lower the demand for cash so much that both types of bank deposits may increase. It is assumed in what follows that a higher rate of return on domestic deposits lowers the demand for foreign deposits, that is, $d^*_{i^D} < 0$. In turn, to ensure that $d^*_{i^D} < 0$, it must be that $\chi\nu' + \chi'\nu(1+\nu) < 0$, or equivalently

$$\nu' i^D / \nu < -\chi'(1+\nu) i^D / \chi.$$

This condition imposes an upper bound as well on the elasticity of the domestic deposits-cash ratio.

Comment 3.2. From (3.11), (3.12), and (3.13), it can be established that the standard portfolio restrictions $m_i + d_i + d^*_i = 0$, with $i = i^D, i^*$, hold.

As in the previous chapter, total household wealth, A^H, is defined as

$$A^H = F^H + P^H h_0, \tag{3.14}$$

where h_0 is the quantity of land (equivalently, housing or real estate) and P^H the nominal price of land, which is fully flexible and adjusts instantaneously to equilibrate supply and demand.

In the second stage of the portfolio allocation process, household determine their demand for land, which is given by

$$\frac{H}{P^D} = h(i^D - \pi^e, i^* + \bullet - \pi^e, \pi^{H,e}, Y^s), \tag{3.15}$$

where $\pi^{H,e}$ is the expected rate of increase in land prices and $h_{i^D}, h_{i^*+\bullet} < 0$, $h_{\pi^{H,e}}, h_{Y^s} > 0$. 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 (as noted in the previous chapter) the well-documented procyclical relationship between house prices and economic activity.

Consumption

Real consumption expenditure, 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 have no direct effect on spending.

Thus, the consumption function takes now the form:

$$C = c_0 + c_1(Y^s - T) - c_2[(i^D - \pi^e) + (i^* + \varepsilon - \pi^e)] + c_3(\frac{A^H}{P^D}), \tag{3.16}$$

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

The positive effect of disposable income on consumption is, again, consistent with the evidence regarding the pervasiveness of liquidity constraints on households. The positive effect of financial and housing wealth on consumption is also well-documented. The negative effect of the expected real returns on domestic and foreign deposits captures an intertemporal substitution effect – even though the model is not explicitly intertemporal. When the (expected) real interest rate on either type of deposits increases, households have an incentive to save more and to reduce current consumption. For simplicity, the marginal effects of each rate of return are assumed to be the same, c_2.

3.2.3. Commercial Banks

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

$$L + RR + B^{CB} = D + L^B + EL^*. \tag{3.17}$$

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

$$RR = \mu D, \tag{3.18}$$

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

The deposit market is competitive and banks view domestic-currency deposits and loans from the central bank as perfect substitutes. Thus, as in Chapter 2, 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:

$$i^D = (1-\mu)i^R. \tag{3.19}$$

The (investment) loan market is monopolistically competitive. The loan rate is now defined as

$$i^L = i^R + \theta + \gamma\tau^L - \varkappa(\frac{B^{CB}}{L_0}), \tag{3.20}$$

where θ is the default premium (or premium, for short), $\tau^L \in (0,1)$ a macroprudential tax on loans, $\gamma > 0$, and $\varkappa \geq 0$. [3]

First, consider the term i^R, the refinance rate. As in the previous chapter, it represents the marginal cost of borrowing from the central bank.

Second, consider the term θ, the default premium. 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, h_0, which is given, times P^H, the nominal price of land) net of initial liabilities (that is, the beginning-of-period stock of loans, L_0):

$$\theta = \theta(\kappa P^H h_0 - L_0), \tag{3.21}$$

where $\kappa \in (0,1)$ is the proportion of assets that can effectively be used or pledged as collateral and $\theta' < 0$. Thus, the higher the value of collateralizable wealth, $\kappa P^H h_0$, net of initial liabilities, L_0, 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 h_0 and L_0 are predetermined, the premium varies inversely with the price of land.

Third, consider the macroprudential tax rate, τ^L. As discussed in the previous chapter, 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.

3 See Agénor (2021, Appendix A) and the Appendix to the next chapter for a discussion of the micro-foundations of this specification.

Fourth, consider the term $-\varkappa B^{CB}/L_0$. 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.[4] The negative effect of the change in sterilization bonds on the loan rate is also consistent with the empirical evidence on the impact of official foreign exchange purchases on market interest rates provided by Garcia (2012), for instance, for Brazil.

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

$$\frac{EL^*}{L_0^B} = f^F[(1+\tau^B)i^* + \varepsilon - i^R], \tag{3.22}$$

where $\tau^B \in (0,1)$ is the capital controls levy and $f^{F\prime} < 0$. Thus, as in Agénor and Jia (2020), for instance, bank foreign borrowing is subject to a tax that increases proportionally its direct cost.[5] The tax is macroprudential in the sense that it aims fundamentally to promote financial stability by dampening excessive bank borrowing, but just like conventional capital controls, it also affects cross-border financial transactions, and thus the balance of payments and the exchange rate.

The demand function for central bank bonds is given by

$$\frac{B^{CB}}{L_0} = f^B(i^{CB} - i^R), \tag{3.23}$$

where $f^{B\prime} > 0$. Thus, the demand for central bank bonds is positively related to the differential between the return on these bonds and the marginal cost of borrowing, that is, the refinance rate. A portfolio equation essentially similar to (3.23) is formally derived in Agénor et al. (2020), under the assumption of economies of scope in banking and a premium that depends on how much banks borrow on world capital markets.[6]

Given the interest rate-setting behaviour of commercial banks, 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 (3.17).

3.2.4. Central Bank and Financial 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 operates a managed float regime and sells its own bonds to banks, to sterilize its intervention operations.[7]

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:

$$E_0 R^* + L^B = M + RR + B^{CB}. \tag{3.24}$$

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

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

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

[6] Note also that in (3.23), as in (3.20), the stock of loans is measured at the beginning of period. The same assumption is made in (3.22) with respect to central bank borrowing.

[7] The assumption that sterilization bonds are held only by commercial banks helps to sharpen the focus of the analysis on the bank portfolio channel associated with sterilized intervention.

Foreign reserves are adjusted through the rule

$$R^* - R_0^* = -\ldots^E \left(\frac{E - E_0}{E_0}\right), \tag{3.25}$$

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

The spot intervention rule (3.25) captures a *leaning against the wind* objective. It is consistent with the evidence (alluded to earlier) which suggests that MICs tend to intervene frequently, and systematically, in the foreign exchange market to stabilize large currency fluctuations – even those operating an inflation targeting regime.

A nominal depreciation, for instance, induces the central bank to sell foreign exchange to strengthen the domestic currency. As a result, its stock of reserves falls. When $\ldots = 0$ the exchange rate is fully flexible (with official reserves constant at R_0^*), whereas when $\ldots^E \to \infty$ the exchange rate is fixed at E_0.

Comment 3.3. The case where the central bank operates a fixed exchange rate regime is discussed in Agénor and Montiel (2015, Chapter 6) and Agénor (2020, Chapter 7), whereas the case of a fully flexible exchange rate regime is studied in Agénor and Montiel (2015, Chapter 6) and Agénor (2020, Chapter 7; 2021).

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

$$B^{CB} - B_0^{CB} = \ldots^S E_0 (R^* - R_0^*), \tag{3.26}$$

where B_0^{CB} is the beginning-of-period value of B^{CB} and $\ldots^S \in (0,1)$ measures the degree of sterilization.[8] Substituting (3.25) in (3.26) therefore yields

$$B^{CB} - B_0^{CB} = -\ldots^S \ldots^E (E - E_0). \tag{3.27}$$

Further, substituting (3.27) in (3.24) gives the change in the money supply as

$$M - M_0 = -(1 - \ldots^S) \ldots^E (E - E_0) + (L^B - L_0^B) - (RR - RR_0). \tag{3.28}$$

Thus, if the exchange rate is fully flexible ($\ldots^E = 0$), or if full sterilization prevails ($\ldots^S = 1$), exchange rate fluctuations have no effect on domestic liquidity. If intervention is unsterilized, $\ldots^E > 0$ and $\ldots^S = 0$, which implies from (3.26) that $B^{CB} = B_0^{CB}$ and from (3.28) that changes in official reserves fully affect money supply.

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

3.2.5. Prices and the Real Exchange Rate

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

$$P = (P^D)^{1-\delta} E^{\delta}. \tag{3.29}$$

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

$$z = \frac{E}{P^D}. \tag{3.30}$$

8 Unsterilized intervention corresponds therefore to $\ldots^S = 0$, in which case $B^{CB} = B_0^{CB}$.

3.2.6. Market-Clearing Conditions

There are now 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.

Once again, 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 (3.23) and (3.26), so that

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

Substituting the intervention rule (3.25) for the change in reserves in this expression yields

$$f^B(i^{CB} - i^R) = \frac{B_0^{CB}}{L_0} - \frac{\dots^{S} \dots^{E}}{L_0}(E - E_0). \tag{3.31}$$

This equation can be solved for the equilibrium value of the central bank bond rate, 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:

$$Y^s - X(z; Y^*) = (1 - \delta)C + I + G, \tag{3.32}$$

where G denotes government spending, $X(z)$ exports, both measured in terms of the price of the domestic good, Y^* foreign output, and $(1- \ \ )C$ is consumption spending on domestic goods. Exports are positively related to the real exchange rate and foreign output, so that X_z, $X_{Y^*} > 0$. 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

$$E^{-1}P^D[X(z) - \delta C] + i^*(D_0^* + R_0^* - L_0^*) \tag{3.33}$$

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

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

Given that from (3.30) $E / P^D = z$, condition (3.33) can also be written as

$$z^{-1}[X(z) - \delta C] + (1 + i^*)F_0^* - F^* = 0, \tag{3.34}$$

where $F^* = D^* + R^* - L^*$ is the economy's net stock of foreign assets. Importantly, whether or not the central bank intervenes, the nominal exchange rate adjusts instantaneously – it can always jump to ensure that the foreign exchange market is in equilibrium, as captured in compact form in (3.34).

As noted earlier, the supply of land is fixed at h_0. The equilibrium condition of the land market is therefore given by

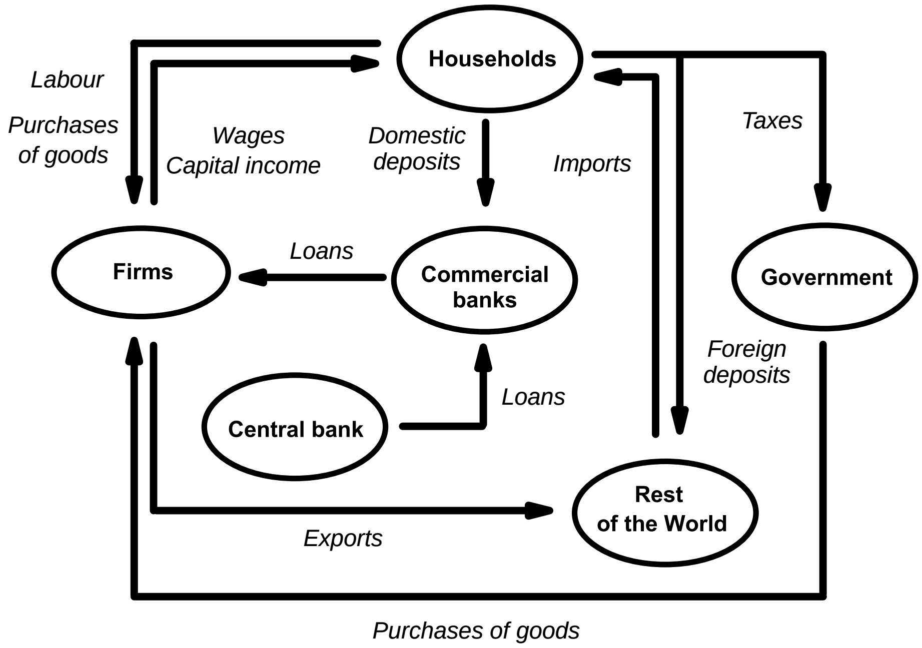
$$\frac{H}{P^D} = \frac{P^H h_0}{P^D}. \tag{3.35}$$

The last equilibrium condition relates to the market for cash, and involves (3.12) and (3.24). But by Walras law that condition can be eliminated once again.[9]

9 See Chapter 2. As before, because household consumption depends on beginning-of-period nominal cash balances, changes in that variable do not affect directly the economy's equilibrium.

FF-GG-XX Model of an Open Economy: Main Real and Financial Linkages

Figure 3.1



The main real and financial linkages between agents are shown in Figure 3.1, whereas Table 3.1 summarizes the list of variables and their definitions.

3.3. Macroeconomic Equilibrium

To establish macroeconomic equilibrium requires combining and condensing the market equilibrium conditions described earlier to bring them down to two conditions: an *internal balance* condition, which combines the equilibrium conditions of the land market, the credit market, and the goods market; and an *external balance* condition, which relates to the equilibrium condition of the foreign exchange market. In doing so, the expected rates of inflation and depreciation, π^e, $\pi^{H,e}$, and $\bullet$, are all assumed constant and normalized to zero.[10]

3.3.1. Internal balance

The internal balance curve is derived in three steps: *a*) solution of the market for land; *b*) solution of the financial sector equilibrium; and *c*) combining the solutions for the real price of land and the loan rate to the equilibrium solution of the goods market.

Step 1

Using (3.15), and setting $h_0 = 1$, the equilibrium condition of the land market (3.35) can be solved for the real price of land, p^H:

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

that is, using (3.5) and (3.19) to substitute out for Y^s and i^D,

$$p^H = p^H(P^D; i^R, \mu, i^* + \bullet), \tag{3.36}$$

where

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

[10] Endogenous price expectations were discussed in chapter 2. The case of an endogenous expected depreciation rate is considered later.

Variable Names and Definitions	Table 3.1
Variable	Definition
Firms	
Y	Aggregate output
N	Employment
K_0	Capital stock (beginning of period)
P^D	Price of domestic good
W	Nominal wage
I	Investment
X	Exports
Households	
C	Expenditure
A^H	Total wealth
F^H	Financial wealth
M	Currency holdings (cash)
D	Domestic deposits
D^*	Foreign deposits (foreign-currency terms)
h_0	Real assets (land)
P^H	Nominal price of land
Commercial banks	
L	Loans to firms
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
Government	
G	Government spending
Central bank, regulator	
i^R	Refinance rate
μ	Required reserve ratio
R^*	Foreign reserves (foreign-currency terms)
τ^B	Capital controls levy on banks
τ^L	Macroprudential tax rate
Other variables	
E	Nominal exchange rate
z	Real exchange rate
P	Cost-of-living index
π^e	Expected inflation rate
ε	Expected depreciation rate
Y^*	Foreign output
i^*	Foreign interest rate

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

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

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

An increase in domestic prices, by reducing wages and stimulating output, raises income and the demand for land as well as its real price. An increase in the refinance rate, by raising the return on domestic deposits, lowers the demand for land and its price. A rise in the rate of return on foreign deposits has a similar effect. An increase in the required reserve ratio, by reducing the return on domestic deposits, raises the demand for land as well as its price.

Step 2

Consider the financial market equilibrium condition. Rather than solving for the equilibrium value of the central bank bond rate, i^{CB}, ,using (3.31), it can be noted that by substituting (3.23) for B^{CB}/L_0 in (3.20), the fourth term in the latter expression becomes $-\varkappa f^B(i^{CB}-i^R)$; this implies therefore an inverse relationship between the loan rate and the central bank bond rate. Further, using (3.31) to substitute out for $f^B(i^{CB}-i^R)$ gives the loan rate as

$$i^L = i^R + \theta + \gamma\tau^L - \varkappa(\frac{B_0^{CB}}{L_0}) + \varkappa\frac{\ldots^S \ldots^E}{L_0}(E - E_0). \tag{3.37}$$

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

Next, let us combine the land market and financial sector equilibrium conditions. Noting that $E = zP^D$ from (3.30) while $P^H = P^D p^H$, and substituting (3.36) in (3.21) and the result in (3.37) for θ, yields

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

that is,

$$i^L = FF(P^D, z; i^R, \mu, \tau^L, i^*), \tag{3.38}$$

where

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

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

$$FF_{iR} = 1 + \theta' P^D p^H_{iR}\kappa > 0,$$

$$FF_\mu = \theta' P^D p^H_\mu \kappa < 0,$$

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

$$FF_{i^*} = \theta' P^D p^H_{i^*}\kappa > 0.$$

Equation (3.38) defines the *financial sector equilibrium* condition, which also implicitly account for the equilibrium of the market for land.

An increase in the price of domestic goods, P^D, has in general an ambiguous effect on the loan rate. On the one hand, it lowers real wages and stimulates activity, thereby raising the demand for land and its price. This, in turn, raises the value of firms' collateralizable assets relative to their outstanding stock of loans. Banks therefore demand a lower premium and reduce the loan rate. This channel is the key source of the *financial amplification 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 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 $\ldots^E$, or the degree of sterilization, as measured by $\ldots^S$, are relatively small, or if $|\theta'|$ is sufficiently large, the first effect dominates and $FF_{pD} < 0$. Otherwise, $FF_{pD} \gtrless 0$. Put differently, the sign of FF_{pD} captures a key difference between fully flexible exchange rates and a managed float regime (the existence of an exchange rate channel), as well as, in the latter case, a difference in the strength of financial frictions.

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

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

An increase in the required reserve ratio, μ, lowers the deposit rate, which tends to increase the demand for land as well as its price. The resulting increase in collateral values tends to lower the premium and the loan rate ($FF_\mu < 0$).[11] 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 ($FF_{i^*} > 0$).

Step 3

Consider now the equilibrium condition of the domestic goods market. Substituting the supply equation (3.5) and the investment function (3.6), together with the consumption function (3.16), after incorporating (3.8) and (3.14) for real wealth, as well as (3.19) for the domestic deposit rate, in condition (3.32), together with the equilibrium condition of the housing market (3.36) for the real price of land, and (3.30) for the nominal exchange rate, gives

$$Y^s(P^D;\cdot) = (1-\delta)\Big\{c_0 + c_1 Y^s(P^D;\cdot) - c_2[(1-\mu)i^R + i^*] - \quad (3.39)$$

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

Further, substituting the financial sector-land market equilibrium condition (3.38) in (3.39) yields

$$Y^s(P^D;\cdot) = (1-\delta)\Big\{c_1 Y^s(P^D;\cdot) - c_2[(1-\mu)i^R + i^*] - \quad (3.40)$$

$$+c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D} + p^H(P^D; i^R, \mu, i^*)]\Big\}$$

$$+I[FF(P^D, z; i^R, \mu, \tau^L, i^*)] + G + X(z, Y^*).$$

Differentiating totally this equation yields

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

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

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

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

$$+dG + X_z dz + X_{Y^*} dY^*,$$

which can be rearranged and written as, in functional form,

$$z = FG(P^D; G, i^R, \mu, \tau^L, i^*, Y^*). \quad (3.41)$$

where, noting that $F_0^H - E_0 D_0^* = M_0 + D_0$, and setting $f = 1 - (1-\delta)c_1 < 1$,

$$FG_{P^D} = \frac{1}{/}\Big\{f\, Y^s_{P^D} + \frac{(1-\delta)c_3}{(P^D)^2}(M_0 + D_0) - (1-\delta)c_3 p^H_{P^D} - I' FF_{P^D}\Big\},$$

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

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

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

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

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

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

$$FG_{Y^*} = -\frac{X_{Y^*}}{\Delta},$$

$$\Delta = (1-\delta)c_3 D^*_0 + I'FF_z + X_z.$$

Equation (3.41) is the *internal balance condition*, which combines the equilibrium conditions of the real (goods and land) markets and the financial (credit and deposit) markets, as a relationship between the real exchange rate and the price of domestic goods.

Consider first the term Δ, which measures the total effect of a real depreciation on excess demand for domestic goods. It is the sum of a wealth effect on consumption, $(1-\delta)c_3 D^*_0$, a financial sector effect, $I'FF_z$, related to the impact of sterilized intervention, and a competitiveness (or relative price) effect on exports, X_z. In particular, the wealth effect arises from the fact that, holding the price of domestic goods constant, a real exchange rate depreciation is equivalent to a *nominal* depreciation. This creates a capital gain on foreign-currency deposits, which induces households to increase spending. While the first and third effects are positive, the second is negative. It will be assumed in what follows that $\Delta > 0$. Thus, a real exchange-rate depreciation, all else equal, creates *excess demand* for domestic goods on the domestic market.[12]

The partial derivatives in (3.41) can now be explained as follows.

1. An increase in the price of domestic goods, P^D, has an ambiguous effect on the goods market and the equilibrium real exchange rate. The first term, $f\,Y^s_{P^D} = [1-(1-\delta)c_1]Y^s_{P^D}$, 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 $(1-\delta)c_1 Y^s_{P^D}$. Because $(1-\delta)c_1 \in (0,1)$, this effect is positive and tends therefore to create *excess supply.*

The second and third terms, $(1-\delta)c_3(M_0 + D_0)/(P^D)^2$ and $-(1-\delta)c_3 p^H_{P^D}$, capture a wealth effect on consumption, the first operating through real money balances and the second through real house prices. These effects operate in opposite directions: higher domestic prices reduce real money balances, thereby lowering consumption and creating excess supply; at the same time, they increase real house prices, which has the opposite effect on consumption and excess supply. As in the previous chapter, it will be assumed once again that $p^H_{P^D}$ (or, more specifically, h_{Y^s} in (3.36)) is small enough to ensure that the net wealth effect is negative. It therefore also contributes to a reduction in aggregate demand and creates *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 amplification 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 $\varkappa$, $..^E$, or $..^S$, 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 assets, thus lowering the loan rate and stimulating investment. This, in turn, tends to create *excess demand* for domestic goods.

[12] Note that there is no relative price effect on *imports* in the expression for Δ; the reason is the assumption that δ is fixed. This issue is discussed later on.

Thus, there are two cases to consider: first, the case where the strength of the financial amplification effect is such that it mitigates, but does not reverse, the excess supply associated with the net supply and wealth effects discussed earlier, so that (given that ⁄ > 0) $FG_{p^D} > 0$, regardless of the sign of FF_{p^D};[13] 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 $FG_{p^D} < 0$.

2. 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, $FG_G < 0$.

3. An increase in the refinance rate, i^R, leads to a contraction in 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.[14] Thus, an increase in the policy rate creates excess supply on the domestic goods market. To restore equilibrium, holding the price of domestic goods constant, the real (and thus nominal) exchange rate must depreciate to stimulate exports, reduce domestic sales, and increase aggregate demand through a positive wealth effect on consumption. Thus, $FG_{i^R} > 0$.

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

5. 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, $FG_{\tau^L} > 0$.

6. 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). All these effects combine to generate excess supply of goods at the initial level of prices, thereby requiring a depreciation to reduce home sales of domestic goods, by raising exports; thus, $FG_{i^*} > 0$.

7. Finally, an increase in foreign output, Y^*, raises exports and reduces local sales of the domestic good. This creates therefore excess demand. To restore equilibrium, sales on the domestic market must increase; and with domestic prices, P^D, given, this requires an appreciation of the exchange rate to mitigate the initial increase in exports. Thus, $FG_{Y^*} < 0$.

3.3.2. External balance

The external balance curve is also 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.

Step 1

Using (3.8), the demand function for foreign deposits, equation (3.13), can be written as

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

13 When $\varkappa$, $..^E$, and $..^S$ are all positive, a weak financial accelerator effect may also ensure that $FF_{p^D} > 0$, in which case the condition $FG_{p^D} > 0$ always holds.

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

where, as shown earlier, $d^*_{i^D} < 0$ and $d^*_{i^*} > 0$. Given that, from (3.30), $E = zP^D$, and noting again that $F^H_0 - E_0 D^*_0 = M_0 + D_0$, the above expression can be written as

$$D^* = \frac{d^*(i^D; i^*)}{zP^D}(M_0 + D_0 + zP^D D^*_0). \tag{3.42}$$

Differentiating totally this equation yields, using (3.19) to substitute out for i^D,

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

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

Noting that

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

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

the expression above for dD^* becomes

$$dD^* = -\frac{d^*}{(zP^D)^2}(M_0 + D_0)(zdP^D + P^D dz)$$
$$+ \frac{(M_0 + D_0 + zP^D D^*_0)}{zP^D}[d^*_{i^D}\{(1-\mu)di^R - i^R d\mu\} + d^*_{i^*} di^*],$$

which can be written in functional form as

$$D^* = D^*(z, P^D; i^R, \mu, i^*), \tag{3.43}$$

where

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

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

$$D^*_{i^R} = \frac{(M_0 + D_0 + zP^D D^*_0)}{zP^D} d^*_{i^D}(1-\mu) < 0,$$

$$D^*_\mu = -\frac{(M_0 + D_0 + zP^D D^*_0)}{zP^D} d^*_{i^D} i^R > 0,$$

$$D^*_{i^*} = \frac{(M_0 + D_0 + zP^D D^*_0)}{zP^D} d^*_{i^*} > 0.$$

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

Step 2

Using (3.22), (3.25), (3.30), and (3.43), net foreign assets, $F^* = D^* + R^* - L^*$, can be written as

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

so that

$$F^* = F^*(z, P^D; i^R, \mu, \tau^B, i^*), \tag{3.44}$$

where, recalling from (3.22) that $f^{F\prime} < 0$,

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

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

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

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

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

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

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

Step 3

Consider the equilibrium condition of the market for foreign exchange, equation (3.34). Using again the consumption function (3.16), and (3.19) to substitute out for the deposit rate, together with the equilibrium condition of the market for land (3.36), that equation can be written as

$$z^{-1}X(z, Y^*) - z^{-1}\delta\Big\{c_1 Y^s(P^D; \cdot) - c_2[(1-\mu)i^R + i^*] \tag{3.45}$$

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

Substituting (3.44) for F^* in that equation yields

$$z^{-1}X(z, Y^*) - z^{-1}\delta\Big\{c_1 Y^s(P^D; \cdot) - c_2[(1-\mu)i^R + i^*] + c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D} \tag{3.46}$$

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

Differentiating totally this expression yields

$$z^{-1}(X_z - \frac{X-\delta C}{z})dz + z^{-1}X_{Y^*}dY^* - z^{-1}\delta c_1 Y^s_{P^D}dP^D$$

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

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

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

which can be rearranged to give, in functional form,

$$z = XX(P^D;G,i^R,\mu,\tau^L,\tau^B,i^*,Y^*), \tag{3.47}$$

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

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

$$XX_G = 0,$$

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

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

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

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

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

$$XX_{Y^*} = \Omega^{-1}(-z^{-1}X_{Y^*}),$$

$$\Omega = z^{-1}(X_z - \frac{X-\delta C}{z}) - z^{-1}\delta\alpha_3 D_0^* - F_z^*.$$

Equation (3.47) represents the *external balance condition*, which relates again the real exchange rate and the price of domestic goods.

Consider first Ω, which measures the total effect of a change in the real exchange rate on the balance of payments. This expression consists of four terms. The first term, $z^{-1}X_z - z^{-2}(X-\delta C)$, 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 $z^{-1}X_z - z^{-2}(X-\delta C) > 0$. In turn, for this condition to hold, the initial trade surplus cannot be too large ($X - \delta C < zX_z$) or, equivalently, the sensitivity of the country's exports to the real exchange rate, X_z must be sufficiently high. Thus, a depreciation improves the trade balance.

Comment 3.4. 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. In the present setting, with δ constant, and for a given level of total consumption, the price elasticity of import demand is zero. Thus, if trade is in equilibrium initially ($X = \delta C$), the condition for the trade balance to improve is simply $X_z > 0$, which always holds. The case where δ depends on relative prices is discussed later.

The second term, $-z^{-1}\delta\alpha_3 D_0^*$, captures an expenditure-increasing effect, which results from a positive wealth effect associated with a depreciation-induced capital gain on foreign deposits. The resulting increase in consumption translates into a rise in imports, which causes the trade balance to deteriorate.

The third term, $-F_z^*$, is positive (given that $F_z^* < 0$, as shown earlier) and arises from the combination of valuation and intervention effects associated with an exchange rate change.

In what 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 $z^{-1}X_z - F_z^*$) is large enough to dominate the expenditure-reducing effect (given by $-z^{-1}\delta\alpha_3 D_0^*$) and ensure that $\Omega > 0$.

The partial derivatives in (3.47) can now be explained as follows.

1. 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, $z^{-1}\delta\alpha_1 Y_{P^D}^s$, captures the positive effect of income on consumption and imports, which translates into a deterioration of the trade balance and the balance of payments. The second and third terms, $-z^{-1}\delta\alpha_3(P^D)^{-2}(M_0 + D_0)$ and $z^{-1}\delta\alpha_3 p_{P^D}^H$, capture the expenditure-reducing effect of an increase in the price of domestic goods operating – directly and indirectly, in the latter case through house prices – through a negative net wealth effect, on the trade balance. These effects are the same as those described in the derivation of the FG curve. The reduction in consumption spending implies a contraction in imports, which therefore improves the balance of payments. The last term, $F_{P^D}^*$, is also similar to what was discussed earlier in deriving the effects of a real exchange rate depreciation. This time, an increase in P^D, holding z constant, implies a concomitant nominal depreciation and a *reduction* in the economy's net foreign assets ($F_{P^D}^* < 0$). 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 reduce exports, in particular) to maintain equilibrium. Thus, $XX_{P^D} < 0$.

2. 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 ($XX_G = XX_{\tau^L} = 0$).

3. An increase in the refinance rate, i^R, has four effects on the balance of payments. First, it raises the domestic deposit rate, as measured by $-z^{-1}\delta\alpha_2(1-\mu)$, thereby lowering expenditure across the board (on both domestic and imported goods) as a result of intertemporal substitution. Second, 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 $z^{-1}\delta\alpha_3 p_{i^R}^H$. Third, by raising the domestic 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 ($XX_{i^R} < 0$).

4. An increase in the required reserve ratio, μ, lowers the domestic deposit rate, which stimulates consumption and imports *both* through the intertemporal substitution effect and a wealth effect (the latter operating again through land prices). These effects are captured by the terms $z^{-1}\delta\alpha_2 i^R$ and $z^{-1}\delta\alpha_3 p_\mu^H$, respectively. The reduction in the domestic deposit rate also contributes to an increase in holdings of foreign-currency deposits ($F_\mu^* > 0$). All these effects operate in the same direction: they contribute to a deterioration of the current account and the balance of payments. Thus, the real exchange rate must depreciate to maintain external equilibrium ($XX_\mu > 0$).

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

6. An increase in the world interest rate, i^*, leads to an improvement in the current account through both the intertemporal and wealth effects (as measured by $-z^{-1}\delta c_2$ and $z^{-1}\delta c_3 p_{i^*}^H$), which combine to lower consumption and imports. There is also a positive effect on interest payments, as measured by $-F_0^*$. Moreover, the capital account deteriorates, as households increase their holdings of foreign deposits; this effect is measured by $F_{i^*}^*$. Thus,

two cases may occur: the improvement in the current account dominates and the real exchange rate must appreciate to maintain external equilibrium, so that $XX_{i^*} < 0$; or capital outflows are large enough to ensure that the real exchange rate must depreciate, in which case $XX_{i^*} > 0$. In what follows the focus will be on the first scenario, which is consistent with the evidence on the negative correlation between changes in world interest rates, capital flows, and the real exchange rate.[15]

7. Finally, an increase in world output, Y^*, raises exports, which improves the current account and the balance of payments. To maintain external balance, the real exchange rate must appreciate. Thus, $XX_{Y^*} < 0$.

In sum, the model collapses to two equations – an *internal balance condition*, (3.41), which describes equilibrium in domestic real and financial markets, and an *external balance condition*, (3.47), which describes balance-of-payments equilibrium. These two conditions can be solved, analytically and graphically, in terms of the real exchange rate, z, and the price of domestic goods, P^D.[16]

Comment 3.5. After substituting out for the equilibrium price of land, p^H, in (3.37), the model could have been solved (perhaps more transparently) in terms of *three* variables: the banks' lending rate, i^L, the price of domestic goods, P^D, and the real exchange rate, z, by solving jointly for equations (3.38), (3.39), and (3.47). However, working with three variables would make it impossible to use two-dimensional diagrams to characterize the equilibrium and conduct policy analysis. Substituting (3.38) for i^L in (3.39) – given that (3.47) relates z to P^D only, and therefore does not depend directly on i^L – was an essential step to bring the model down to two equilibrium conditions.

3.3.3. Graphical Illustration

Figures 3.2 and 3.3 present the determination of macroeconomic equilibrium under two alternative assumptions about the slope of the internal balance curve, as discussed earlier: the case where the financial amplification effect is relatively weak, so that $FG_{P^D} > 0$, and the case where this effect is strong enough to ensure not only that $FF_{P^D} < 0$ but also $FG_{P^D} < 0$. By contrast, the external balance curve, XX, always has a negative slope, given that $XX_{P^D} < 0$. A rise in domestic prices lowers the demand for imports (through a negative net wealth effect on total consumption) and improves the trade balance, requiring therefore a real appreciation to maintain equilibrium.

Consider first the case where $FG_{P^D} > 0$, that is, the case where the financial amplification effect mitigates, but does not reverse, the increase in excess supply of goods sold on the home market – resulting from the combination of a (positive) net supply effect and a (negative) net wealth effect – induced by higher domestic prices. As noted earlier, the real exchange rate must depreciate to stimulate consumption and exports, and restore equilibrium. Both curves are depicted in Figure 3.2. The economy's equilibrium is determined at point E. Given these solutions, the equilibrium values of other variables, such as the nominal exchange rate (given that $E = zP^D$) sales of domestic goods on the local market, $Y^s(P^D; A) - X(z, Y^*)$, investment, consumption, and so on, can be derived.

The case where $FG_{P^D} < 0$, that is, the case where the financial amplification effect is relatively strong, is depicted in Figure 3.3. Curve FG is now also downward-sloping, just like curve XX. To determine which curve is steeper – a crucial step for understanding the comparative statics properties of the model and the adjustment process to shocks – *Samuelson's correspondence principle*, which involves (as discussed in Chapter 2) analysing the local stability of the dynamic system associated with (3.41) and (3.47), can be used again. As shown in the Appendix to this chapter, stability implies that XX be steeper than FG (that is, $|XX_{P^D}| > |FG_{P^D}|$), as displayed in the figure.

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.[17] Of course, given the static nature of the model, this gradual adjustment process does not involve explicitly an element of time, as would be the case in a full-blown dynamic setting. Nevertheless, as discussed later on, it helps significantly in explaining in intuitive terms the transmission of policy and exogenous shocks to the economy and the shift between the initial equilibrium and the post-shock equilibrium.

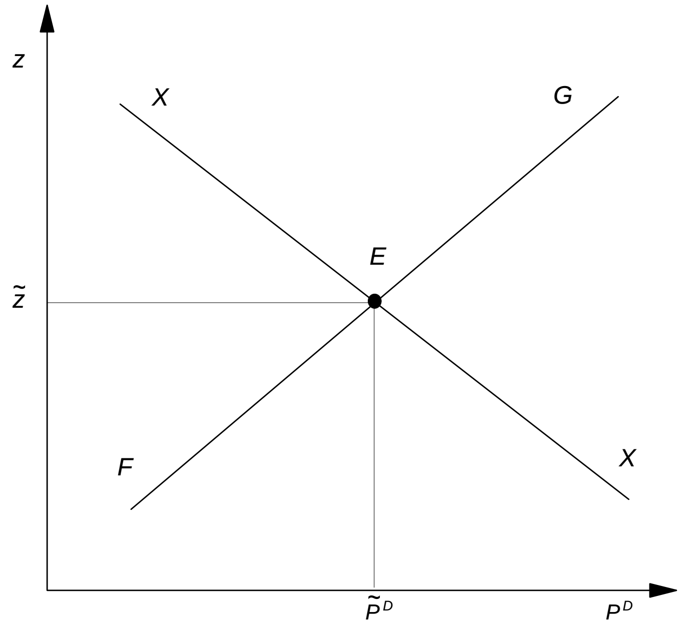
15 See Agénor et al. (2014, 2018) and the references therein.

16 In effect, given that $z = E / P^D$, the solutions for z and P^D give implicitly the solution for the *nominal* exchange rate.

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

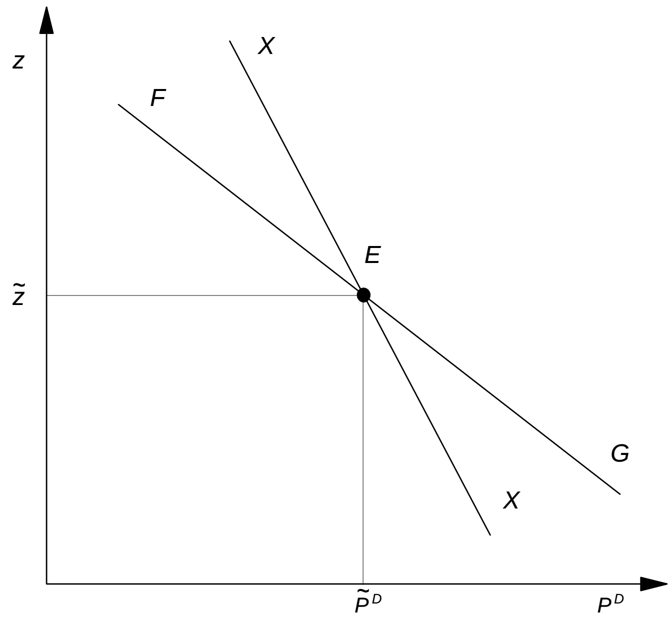
Macroeconomic Equilibrium: Weak Financial Amplification

Figure 3.2



Macroeconomic Equilibrium: Strong Financial Amplification

Figure 3.3



3.4. Macro-Financial Policy Analysis

In what follows, the macroeconomic effects of changes in five types of macro-financial policies are considered: fiscal policy (in the form of an increase in government spending), monetary policy (an increase in the refinance rate), macro-prudential regulation (a rise in the macroprudential tax rate), discretionary intervention in the foreign exchange market, and capital controls (in the form of an increase in the tax on bank foreign borrowing).[18] As discussed in Chapter 1, and

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

later on in Chapter 6, in recent years economic management in MICs has relied heavily on all of these instruments. In particular, many of these countries have relied on macroprudential regulation as a tool to manage credit and asset price fluctuations driven by large capital inflows and to safeguard financial stability, as documented by Bruno et al. (2017), Ghosh et al. (2017), Aguirre et al. (2018), Aldasoro et al. (2020), Frost et al. (2020), Coman and Lloyd (2022), and Bergant et al. (2023). Aguirre et al. (2018), for instance, found that macroprudential policies – especially those targeted at financial institutions – helped to mitigate the impact of capital inflows in developing economies by dampening fluctuations in credit and leverage. In addition, the evidence suggests that some of these tools may operate through similar channels.[19] Studying analytically their transmission process is thus important to determine the degree to which they are complementary, or substitutes, in responding to particular shocks.

3.4.1. Fiscal Policy

Consider an increase in government spending, *G*. The equilibrium response of the real exchange rate and domestic prices can be evaluated by differentiating totally (3.41) and (3.47), holding ι^R, μ, τ^L τ^B, and i^* constant, to give

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

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

or, in matrix form,

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

This system can be solved using Cramer's rule to give

$$\frac{dz}{dG} = \frac{-\overset{(-)}{FG_G}\,\overset{(-)}{XX_{pD}}}{\underset{(?)}{FG_{pD}} - \underset{(-)}{XX_{pD}}} < 0, \quad \frac{dP^D}{dG} = \frac{-\overset{(-)}{FG_G}}{\underset{(?)}{FG_{pD}} - \underset{(-)}{XX_{pD}}} > 0. \tag{3.48}$$

Comment 3.6. For a brief characterization of Cramer's rule, see Comment 2.12.

With $FG_{pD} > 0$, an increase in government spending leads unambiguously to a real appreciation and higher domestic prices. With $FG_{pD} < 0$, because (as discussed earlier) the slope of XX is steeper than the slope of FG in absolute terms, $-FG_{pD} < -XX_{pD}$, or equivalently, $FG_{pD} - XX_{pD} > 0$. Thus, the same results hold in that case as well.

Figure 3.4 illustrates these effects under both assumptions about the slope of FG. Intuitively, an increase in government spending creates excess demand at the initial levels of domestic prices and production. The real exchange rate (and thus the nominal exchange rate) should therefore appreciate to reduce exports and increase sales on the domestic market, $Y^s - X$, to restore equilibrium. Indeed, as shown in (3.41), $FG_G < 0$. Thus, while curve XX does not move (it does not depend directly on government spending), curve FG shifts downward to $F'G'$ in both panels. The real exchange rate should appreciate from *E* to *B* to restore internal equilibrium.

However, as noted earlier, the exchange rate adjusts instantaneously – whether or not the central bank intervenes – to maintain *external* equilibrium. Thus, the jump to *B* is hypothetical; 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) translates into lower consumption and imports. As a result, there is a current account surplus. To maintain external balance, and regardless of the strength of the financial amplification effect, the real exchange rate appreciates from E to E', the new equilibrium point, to reduce exports – regardless of the strength of the financial accelerator effect.[20]

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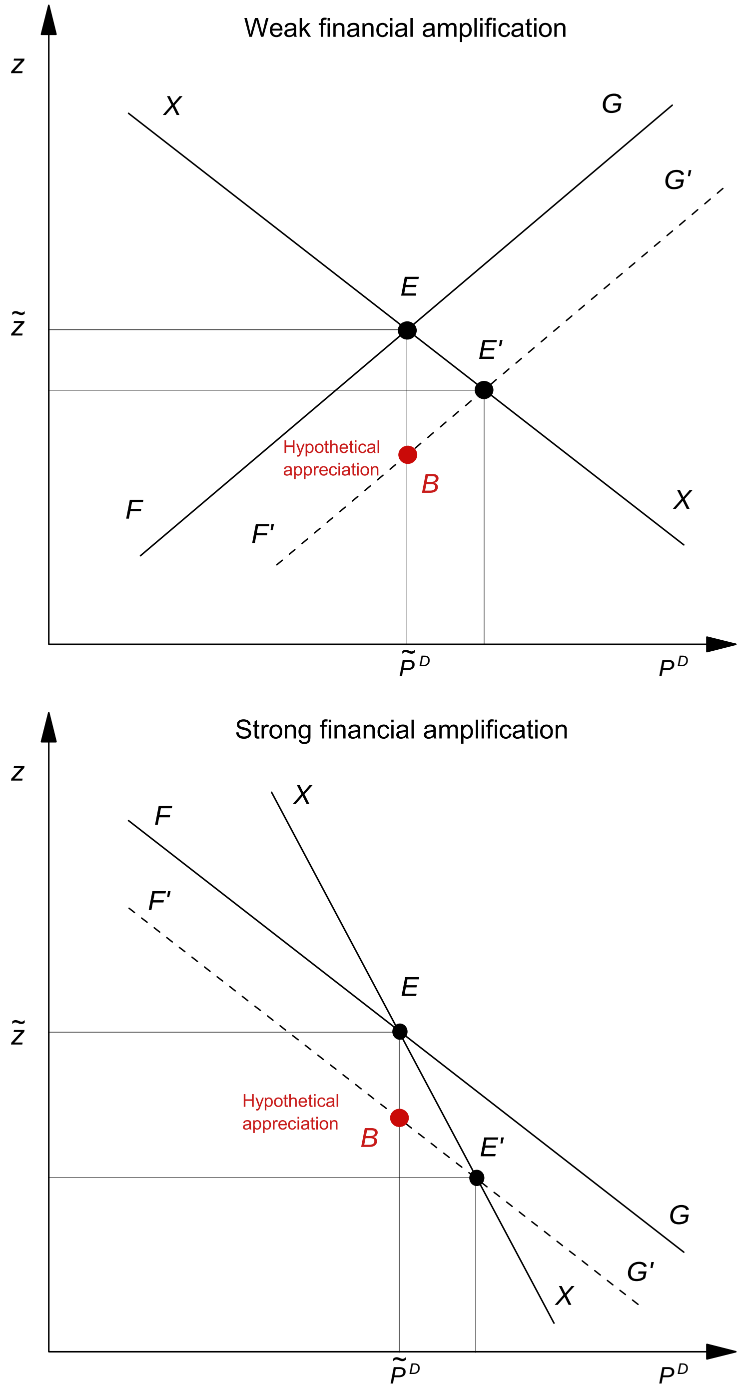
19 Kim and Mehrotra (2022), for instance, found that the effects of macroprudential policy shocks on output, prices and credit are very similar to those of monetary policy shocks. However, they also argued that there are differences in the transmission mechanism of these shocks: while macroprudential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

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

Increase in Government Spending

Figure 3.4



During the transition, the increase in domestic prices stimulates output (by lowering real wages) and raises the price of land, which reduces the premium and therefore the loan rate. Lower borrowing costs stimulate investment. At the new equilibrium, exports are lower, as a result of the real appreciation. The combination of a higher P^D and a more appreciated (lower) z ensures that domestic sales, $Y^s(P^D) - X(z)$, unambiguously increase – and so does domestic absorption, as implied by the goods market equilibrium condition (3.32). By contrast, the equilibrium effect on private consumption cannot be ascertained a priori; although the increase in income raises household spending, the increase in domestic prices means that real financial wealth falls. As noted earlier, despite the positive effect of higher land prices, the net wealth effect is negative. Thus, the impact on consumption can be either positive or negative, depending on coefficients c_1 and c_3. If private consumption falls, government spending generates a crowding-out effect.

In sum, the equilibrium effects of government spending on prices, the real exchange rate, and the balance of payments are all consistent with textbook open-economy models of the Mundell-Fleming variety.[21] At the same time, what the analysis makes clear is that the effects of fiscal policy depend not only on its direct impact on aggregate demand (in standard Keynesian fashion) but also on its indirect effects operating through the financial system and financial frictions, which affect the pricing of bank loans.

3.4.2. Monetary Policy

Consider an increase in the central bank refinance rate, i^R. Differentiating (3.41) and (3.47), holding G, μ, τ^L, τ^B, and i^* constant, gives

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

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

or, in matrix form,

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

Solving this system using Cramer's rule gives

$$\frac{dz}{di^R} = \frac{\overset{(-)}{XX_{i^R}}\,\overset{(?)}{FG_{P^D}} - \overset{(+)}{FG_{i^R}}\,\overset{(-)}{XX_{P^D}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}}, \quad \frac{dP^D}{di^R} = \frac{\overset{(-)}{XX_{i^R}} - \overset{(+)}{FG_{i^R}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}}. \tag{3.49}$$

Thus, equation (3.49) gives $dz / di^R \gtrless 0$ and $dP^D / di^R < 0$ when $FG_{P^D} > 0$, and $dz / di^R > 0$ and $dP^D / di^R < 0$ when $FG_{P^D} < 0$. With a weak financial amplification effect, the impact on domestic prices is negative, whereas the impact on the real exchange rate is ambiguous; with strong amplification, the impact on prices is again negative, but the real exchange rate definitely depreciates.

An increase in the refinance rate operates directly through changes in both the deposit and loan rates. By raising the deposit rate, the policy induces households to save more and reduce current spending. In addition, the increase in the refinance rate is passed on fully to the loan rate, which reduces investment. There is therefore a contraction in aggregate demand and excess supply prevails. To maintain internal balance at an unchanged value of P^D, as noted earlier, the real exchange rate should depreciate ($FG_{i^R} > 0$), to increase exports and reduce domestic sales. Curve FG shifts upward and z should (hypothetically) jump, from *E* to *B*, as illustrated in the upper panels of Figures 3.5 and 3.6.

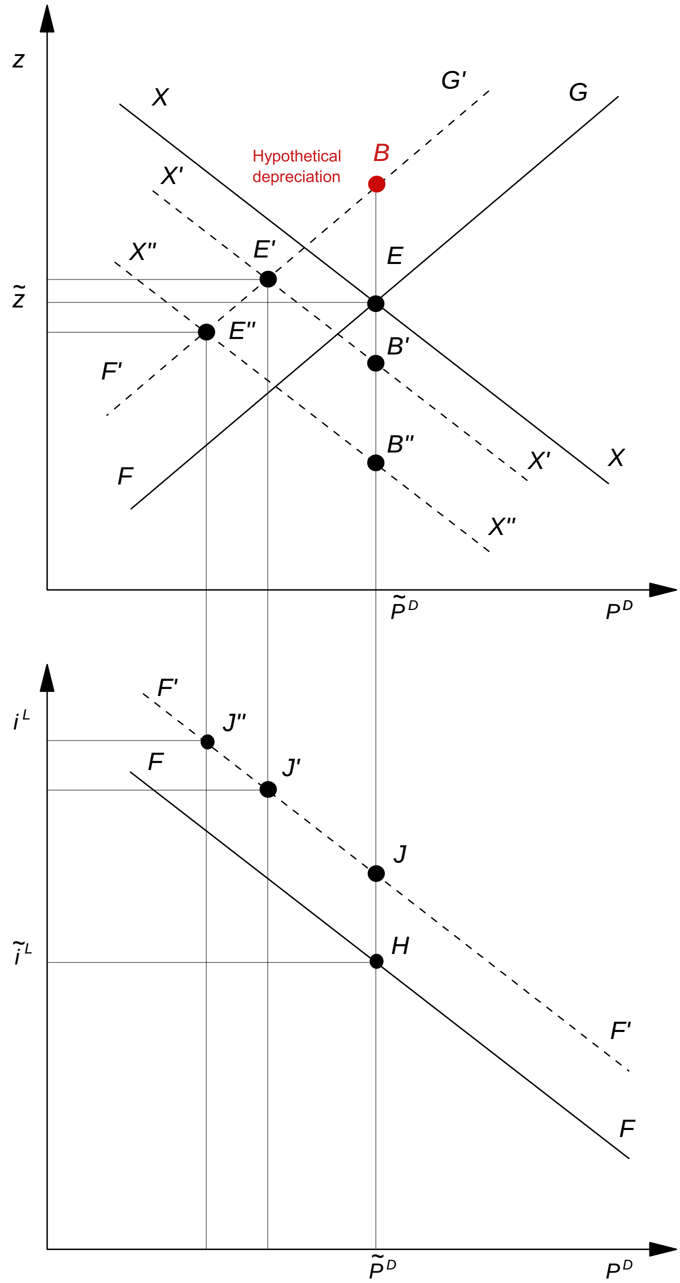
At the same time, an increase in the refinance rate has two effects on the external balance condition. First, through its adverse impact on household spending (related to the intertemporal effect discussed earlier), it lowers imports and leads to an improvement in the current account. Second, the higher 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 (or to the left) in the upper panels of Figures 3.5 and 3.6, and *z* jumps from *E* to B' or B'' (Figure 3.5), or from E to B' (Figure 3.6), given that the exchange rate adjusts instantaneously to maintain external equilibrium.

The implication of these shifts is that, regardless of the strength of the financial amplification effect, in the new equilibrium the price of the domestic good definitely falls – a contractionary monetary policy is always deflationary – but the impact of this policy on the real exchange rate cannot be ascertained a priori when the financial amplification effect is weak. As shown in the upper panel of Figure 3.5, depending on the magnitude of the shift in *XX*, for a given shift in FG, the economy may move from the initial position E to an equilibrium point such as E' (corresponding to a real depreciation) or E'' (corresponding to a real appreciation). By contrast, when the financial amplification effect is strong, as shown in the upper panel of Figure 3.6 the real exchange rate always depreciates, regardless of the magnitude of the shift in either curve.

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

Increase in Refinance Rate: Weak Financial Amplification

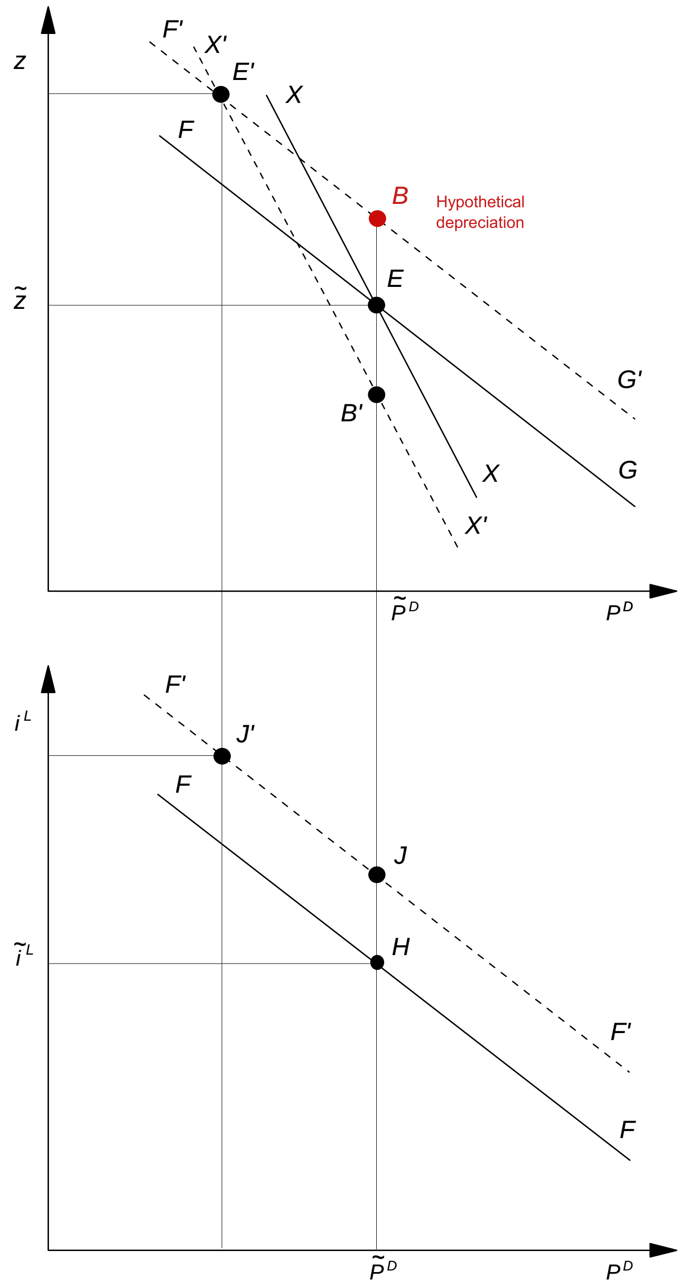
Figure 3.5



The lower panel in Figures 3.5 and 3.6 shows movements in the financial equilibrium curve *FF*, which relates the loan rate and domestic prices (see (3.38)). The initial effect of the increase in the refinance rate is an outward shift in *FF*; at the initial level of domestic prices the loan rate increases on impact. In both figures, this corresponds to the movement from *H* to *J*. Because domestic prices (and thus the real price of land) fall continuously during the transition, the loan rate continues to increase. By implication, investment falls continuously throughout the adjustment process. The movement in the loan rate from J to J' (or J'' in Figure 3.5) corresponds to the financial amplification effect. While domestic production definitely contracts (the drop in domestic prices raises the product wage), the fact that the equilibrium effect on the real exchange is ambiguous when $FG_{P^D} > 0$ means that the impact on exports is also ambiguous – and so is the net effect on sales of domestic goods on the domestic market, $Y^s - X$. By contrast, when $FG_{P^D} < 0$, exports unambiguously increase, so domestic sales are definitely lower, given that production falls. Again, whether consumption of domestic goods increases or falls cannot be determined a priori: the fall in domestic prices generates a positive wealth effect, but the contraction in output lowers income, which compounds the initial drop in spending to intertemporal substitution.

Increase in Refinance Rate: Strong Financial Amplification

Figure 3.6



3.4.3. Macroprudential Policy

Consider an increase in the macroprudential tax rate, τ^L. Differentiating (3.41) and (3.47), holding G, i^R, μ, τ^B, and i^* constant, gives

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

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

or, in matrix form,

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

Solving this system gives

$$\frac{dz}{d\tau^L} = \frac{-\overset{(+)}{FG_{\tau^L}}\ \overset{(-)}{XX_{pD}}}{\underset{}{\overset{(?)}{FG_{pD}}} - \overset{(-)}{XX_{pD}}} > 0,\ \frac{dP^D}{d\tau^L} = \frac{-\overset{(+)}{FG_{\tau^L}}}{\overset{(?)}{FG_{pD}} - \overset{(-)}{XX_{pD}}} < 0. \tag{3.50}$$

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

Figure 3.7 illustrates these effects. Intuitively, an increase in the macroprudential tax rate raises the loan rate and lowers investment, thereby creating excess supply at the initial level of domestic prices. Given that $FG_{\tau^L} > 0$, the real (and, again, nominal) exchange rate should depreciate (hypothetically from *E* to *B* in both panels) to restore internal equilibrium, by expanding exports and reducing domestic sales. Thus, curve *FG* shifts upward, to *F'G'*. Because the macroprudential tax operates directly only through the loan rate, curve *XX* does not shift.

Once again, because the (nominal) exchange rate adjusts instantaneously to maintain external equilibrium, the real exchange rate remains at *E* when the shock occurs. At the same time, excess supply of goods on the home market puts downward pressure on domestic prices, which in turn (through a positive net wealth effect) raises consumption and imports. The current account therefore deteriorates. During the transition, and regardless of the strength of the financial amplification effect, the real exchange rate must depreciate, from *E* to *E'*, to maintain external balance. In the new equilibrium, because domestic prices are lower (implying that the product wage is higher) and the real exchange rate has depreciated, both output and domestic sales are also lower. The drop in collateral values is associated with a higher loan rate and a contraction in investment. By contrast, the impact on consumption remains ambiguous, for the same reasons as discussed earlier – the conflict between income and wealth effects.

3.4.4. Foreign Exchange Intervention

As noted earlier, under a managed float the central bank intervenes systematically to stabilize the exchange rate, through the rule specified in (3.25). One way to study the role of foreign exchange intervention would therefore consist of looking at changes in the parameter $..^E$ in rule (3.25), possibly coupled with a change in the degree of sterilization, as given by $..^S$ in (3.26).[22] However, changes in these parameters entail changes in the slopes of *FG* and *XX*, which are not particularly informative, given the qualitative focus of the paper; to illustrate the role of foreign intervention in the model, it is more instructive to consider the case where intervention is *discretionary* and responds to an exogenous shift in capital flows. In line with the evidence discussed earlier, the focus is on the case of full sterilization.

Accordingly, consider an autonomous inflow of foreign exchange, due to either an autonomous reduction in household deposits held abroad or an increase in foreign bank borrowing, which translates on impact into a reduction in the initial stock of net foreign assets, $/\ F^* < 0$. [23] For simplicity, intervention and sterilization operations are assumed to take place *before* this inflow affects spending and portfolio decisions.[24] Treating F^* as an exogenous variable in (3.45), 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 both panels of Figure 3.8.

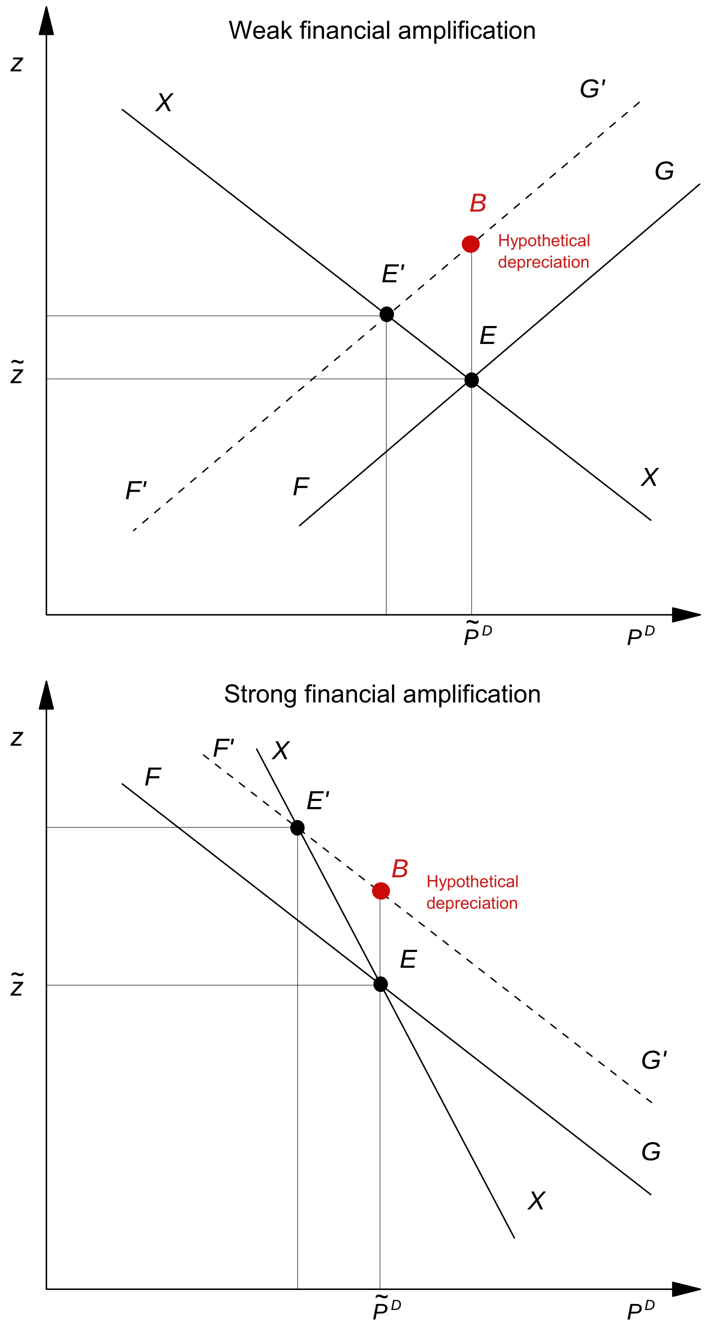
22 In more elaborate models, both $..^E$ and $..^S$ can be viewed as policy instruments, chosen to optimize with respect to a particular objective. See Agénor et al. (2020), for instance.

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

24 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.

Increase in macroprudential Tax Rate

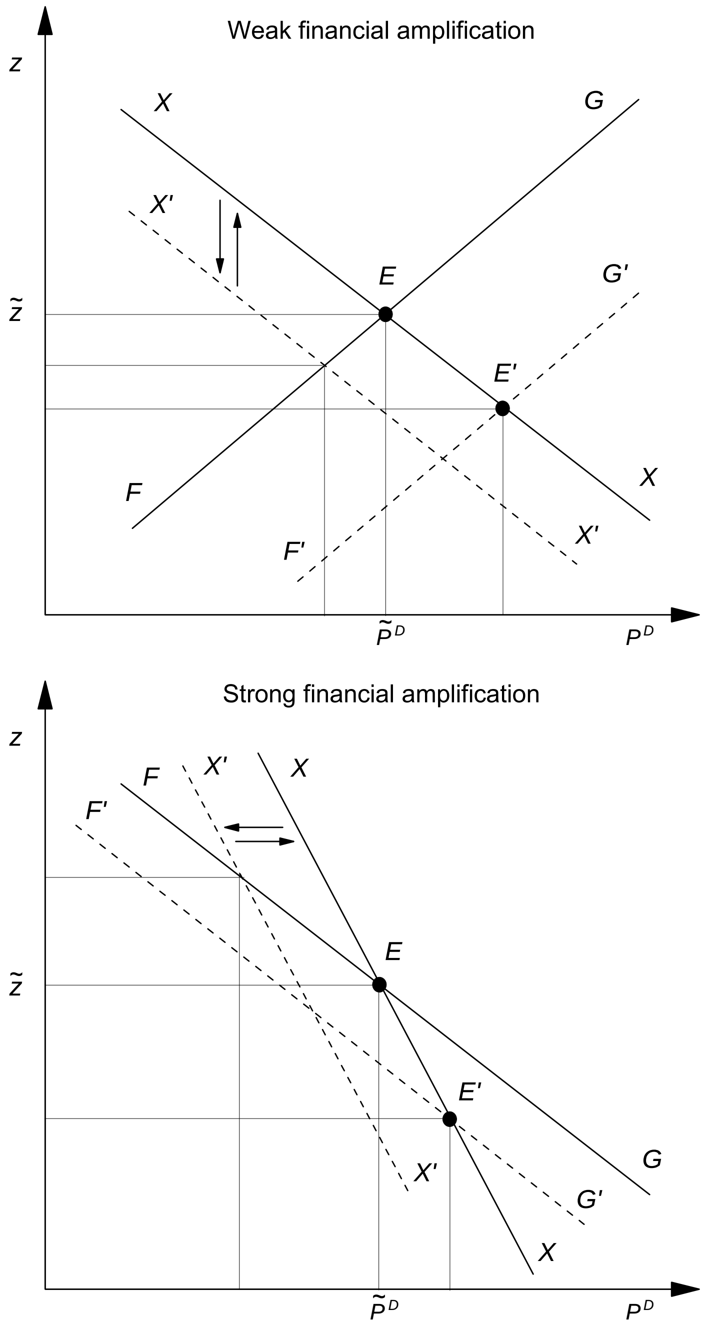
Figure 3.7



Now, sterilized intervention in this setting involves two simultaneous operations. First, discretionary intervention – the central bank purchases instantaneously all the inflow of foreign currency, thereby increasing its stock of foreign reserves, $/ R^*$, and issues domestic currency in return; from (3.28), holding all other balance sheet items constant, $/ M = E_0/ R^*$. As a result of the intervention, F^* increases back to its original value (so that $/ F^* = 0$), 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, $/ B^{CB} = E_0/ R^*$ and $/ M = 0$. If there is no bank portfolio channel (that is, no economies of scope in banking, $\varkappa = 0$), nothing else happens; curve XX shifts right back to its initial position and the equilibrium remains at E^0, which implies that sterilized intervention has no effect on the exchange rate or prices.

Discretionary Sterilized Intervention

Figure 3.8



However, if the bank portfolio channel is present ($\varkappa > 0$), the adjustment process does not stop there. Given that $/ B^{CB} = E_0 / R^*$, from (3.20) and (3.38) $FF_{R^*} = -\varkappa < 0$. Using this result, from (3.39) $FG_{R^*} = -I'FF_{R^*} = I'\varkappa < 0$. Thus, an increase in reserves, holding domestic prices constant, induces also a downward shift in FG if $\varkappa > 0$, as shown in both panels of Figure 3.8. The loan rate falls on impact, thereby stimulating investment and aggregate demand. To restore equilibrium, sales of the domestic good must increase; in turn, this requires a drop in exports and therefore a real appreciation. Thus, FG shifts downward, to $F'G'$. The new equilibrium would therefore be at E', characterized by higher domestic prices and a real appreciation. Put differently, if the bank portfolio channel prevails, a fully sterilized intervention is expansionary. By implication, it will also affect the exchange rate.

Comment 3.7. The early empirical literature, as reviewed in Agénor and Pereira da Silva (2019), for instance, provided mixed evidence on whether sterilized intervention affects the exchange rate. However, more recent studies, including Kuersteiner et al. (2018), Fratzscher et al. (2019), and especially Arango-Lozano et al. (2022) – who conducted a meta-analysis of 279 estimations conducted across five decades – provide more robust evidence of a significant effect.

It is worth noting also that, in the model, while unsterilized foreign exchange intervention does affect liquidity ($E_0 R^* \neq M$, as noted earlier), its conventional effects on market interest rates and (by implication) other macroeconomic aggregates do not operate. The first reason is that interest rates are set by banks, rather than market forces. Changes in liquidity therefore have no direct effect on the opportunity cost of holding cash or the incentives to save – and, consequently, household spending decisions. The second reason is that, in the model, consumption is assumed to depend on beginning-of-period financial wealth. As a result, changes in the money supply do not play a direct role in the determination of macroeconomic equilibrium, and sterilized intervention in the absence of the bank portfolio channel generates the same outcomes as unsterilized intervention: in both cases the equilibrium remains at point E.

However, what would happen if changes in the money stock had a direct impact on consumption is intuitively clear: with no sterilization (and thus no effect on investment), the increase in the money supply induced by foreign exchange intervention would lead to an expansion in aggregate demand. With unsterilized intervention, although XX would still shift back to its initial position, FG would shift downward, so in the new equilibrium domestic prices would be higher and the real exchange rate would appreciate – just as illustrated in Figure 3.8. But with sterilized intervention *and* the bank portfolio channel present, FG would shift downward by *more*, because the policy would now lead to an expansion not only in consumption but also in investment.

3.4.5. Capital Controls

Consider an increase in the capital controls levy on banks, τ^B. Differentiating (3.41) and (3.47), holding G, i^R, μ, τ^L, and i^* constant, gives

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

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

or, in matrix form,

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

Solving this system gives

$$\frac{dz}{d\tau^B} = \frac{\overset{(+)}{XX_{\tau^B}} \overset{(?)}{FG_{P^D}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} \gtrless 0, \quad \frac{dP^D}{d\tau^B} = \frac{\overset{(+)}{XX_{\tau^B}}}{\underset{(?)}{FG_{P^D}} - \underset{(-)}{XX_{P^D}}} > 0. \tag{3.51}$$

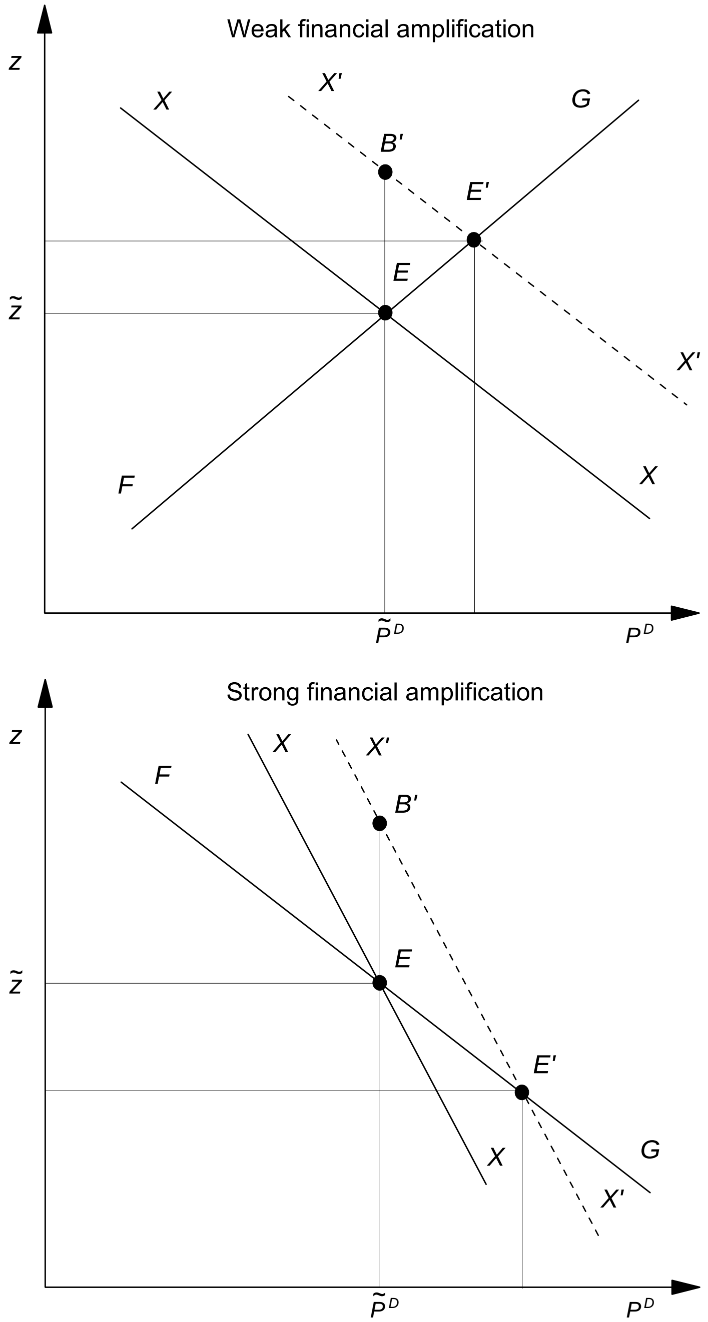
Thus, an increase in the capital controls levy always leads to an increase in domestic prices, regardless of the sign of FG_{P^D} (given again that the condition $FG_{P^D} - XX_{P^D} > 0$ always holds), but its impact on the real exchange rate is in general ambiguous. With a weak financial amplification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

Figure 3.9 illustrates these effects. Intuitively, an increase in the capital controls levy induces banks to borrow less abroad. This dampens capital inflows and leads to a deterioration of the balance of payments. Holding domestic prices constant, the real exchange rate must depreciate on impact to maintain external equilibrium. Graphically, curve FG does not change – capital controls operate only through the cost of foreign borrowing for banks, which does not directly affect the equilibrium conditions of the financial and goods markets – whereas curve XX shifts upward to $X'X'$.[25] The real exchange rate jumps from E to B' on impact.

[25] The key reason why the cost of foreign borrowing does not influence curves FF and FG is that, as shown in (3.20), the *marginal* cost of funding for banks is the refinance rate, i^R.

Increase in Capital Controls Levy

Figure 3.9



However, the initial depreciation raises exports and reduces local sales of the domestic good. There is therefore excess demand initially, and this leads to a gradual increase in domestic prices, a reduction in the product wage, and an expansion of output. As shown in Figure 3.9, and regardless of the strength of the financial amplification effect, the initial depreciation is followed by a subsequent appreciation to help restore internal balance at point *E′*. The equilibrium depreciation is smaller than the initial depreciation, and there is therefore real exchange rate overshooting. During the transition, while domestic prices increase continuously, exports fall, whereas domestic output increases. The increase in goods and land prices lead to a lower premium, which induces an expansion in investment. Thus, the financial amplification 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 on banks 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 control, 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 amplification effect; if this effect is weak, the expansionary effect of capital controls will be significantly mitigated. In addition, as the cost of funding abroad increases, banks borrow less on world capital markets and more from the central bank – with no effect on the refinance rate. However, had it be assumed that the cost of accessing central bank liquidity increases with the amount borrowed, for instance, the downward impact of the financial amplification effect on the loan rate would be highly mitigated and possible reversed, in which case capital controls could have either no effects on the economy or even a contractionary effect, in line with some of the evidence.

It is also important to keep in mind that the model does not capture the typical problems that policymakers must address in practice when implementing capital controls, namely, the possibility of leakages if controls are not tight or comprehensive enough, the possibility of substitution between flows at different maturities, and the risk of adverse signaling effects about the government's intentions regarding capital account openness, which could lead to abrupt shifts in market perceptions.

Table 3.2 summarizes the impact of fiscal policy, monetary policy, macroprudential regulation, and capital controls on key macroeconomic variables.

3.5. External Financial Shock

Suppose now that the economy is subject to an external financial shock, namely, a reduction in the world interest rate, i^*. As documented extensively in the literature, this type of shocks has often created major challenges for economic management in MICs.[26] In this context, there are two issues to consider. The first is how this shock is transmitted. The second is to what extent the different policy instruments discussed earlier should be combined, to return the economy to its initial equilibrium position.

Intuition suggests that the coordinated use of (some of) these tools could indeed increase policy space, while maximising their effectiveness and limiting their unintended consequences.[27] For instance, monetary policy and (sterilized) foreign exchange intervention could complement each other during capital inflow episodes, if purchases of foreign currency provide more scope for central banks to adjust domestic interest rates in response to inflationary pressures. Moreover, as illustrated in the foregoing discussion, each policy instrument affects a wide range of real and financial variables. Thus, they could be deployed together, to support a single objective (such as output stability), or separately, with each instrument targeting a specific objective – such as price stability or financial stability. The issue, therefore, is to what extent the various policy instruments considered earlier should be used in a complementary manner (although not necessarily in the same direction) to achieve joint objectives, or independently in pursuit of separate objectives. However, before addressing these issues, it is useful to first characterize the macroeconomic and financial effects of a reduction in the world interest rate.

Differentiating (3.41) and (3.47), holding G, i^R, μ, τ^L, and τ^B constant, gives

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

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

or, in matrix form,

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

26 See Agénor and Montiel (2015) and Agénor (2020, Chapter 1), for instance, for a more detailed discussion. In practice, changes in world interest rates are often driven by US monetary policy shocks, as documented by Friedrich and Guérin (2020), among others.

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

Impact of Macro-Financial Policies under a Managed Float: Summary			Table 3.2
	Variable	Strength of financial frictions	
		Weak	Strong
Increase in government spending, G			
Output supply	Y^s	+	+
Domestic sales	$Y^s - X$	+	+
Private consumption	C	?	?
Investment	I	+	+
Domestic absorption	$(1-\delta)C + I + G$	+	+
Exports	X	–	–
Loan premium	θ	–	–
Loan rate	i^L	–	–
Price of domestic good	P^D	+	+
Real price of land	p^H	+	+
Real exchange rate	z	–	–
Increase in refinance rate, i^R			
Output supply	Y^s	– / ?	– / ?
Domestic sales	$Y^s - X$	? / ?	– / ?
Private consumption	C	? / ?	? / ?
Investment	I	– / –	– / ?
Domestic absorption	$(1-\delta)C + I + G$	? / ?	– / ?
Exports	X	? / –	+ / –
Loan rate	i^L	+ / +	+ / ?
Loan premium	θ	+ / ?	+ / ?
Price of domestic good	P^D	– / ?	– / ?
Real price of land	p^H	– / ?	– / ?
Real exchange rate	z	? / –	+ / –
Increase in macroprudential tax, τ^L			
Output supply	Y^s	–	–
Domestic sales	$Y^s - X$	–	–
Private consumption	C	?	?
Investment	I	–	–
Domestic absorption	$(1-\delta)C + I + G$	–	–
Exports	X	+	+
Loan rate	i^L	+	+
Loan premium	θ	+	+
Price of domestic good	P^D	–	–
Real price of land	p^H	–	–
Real exchange rate	z	+	+
Sterilized intervention ($\varkappa > 0$)			
Output supply	Y^s	+	+

Impact of Macro-Financial Policies under a Managed Float: Summary			Table 3.2 (concluded)
	Variable	Strength of financial frictions	
		Weak	Strong
Private consumption	C	?	?
Investment	I	+	+
Domestic absorption	$(1-\delta)C+I+G$	+	+
Exports	X	–	–
Loan premium	θ	–	–
Loan rate	i^L	–	–
Price of domestic good	P^D	+	+
Real price of land	p^H	+	+
Real exchange rate	z	–	–
Increase in capital controls tax rate, τ^B			
Output supply	Y^s	+	+
Domestic sales	Y^s-X	?	+
Private consumption	C	?	?
Investment	I	+	+
Domestic absorption	$(1-\delta)C+I+G$	?	+
Exports	X	+	–
Loan premium	θ	–	–
Loan rate	i^L	–	–
Price of Domestic good	P^D	+	+
Real price of land	p^H	+	+
Real exchange rate	z	+	–
Increase in required reserve ratio, μ			
Output supply	Y^s	+	+
Domestic sales	Y^s-X	?	+
Private consumption	C	?	?
Investment	I	+	+
Domestic absorption	$(1-\delta)C+I+G$	?	+
Exports	X	?	–
Loan premium	i^L	–	–
Loan rate	θ	–	–
Price of domestic good	P^D	+	+
Real price of land	p^H	+	+
Real exchange rate	z	?	–

Notes: 1. From (3.32), absorption, $(1-\delta)C+I+G$, is equal to domestic sales, Y^s-X. Thus, they have the same sign. 2. For the increase in the refinance rate, the first sign in the table refers to the equilibrium effect when the cost channel is weak, and the second to the equilibrium effect when the cost channel is strong.

Solving this system gives the equilibrium responses of the real exchange rate and domestic prices:

$$\frac{dz}{di^*} = \frac{\overset{(+)}{XX_{i^*}}\,\overset{(?)}{FG_{pD}} - \overset{(+)}{FG_{i^*}}\,\overset{(-)}{XX_{pD}}}{\underset{(?)}{FG_{pD}} - \underset{(-)}{XX_{pD}}} \gtrless 0, \tag{3.52}$$

$$\frac{dP^D}{di^*} = \frac{\overset{(+)}{XX_{i^*}} - \overset{(+)}{FG_{i^*}}}{\underset{(?)}{FG_{pD}} - \underset{(-)}{XX_{pD}}} \gtrless 0.$$

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

Figure 3.10 illustrates these effects. Both FG and XX shift downward, regardless of the strength of the financial amplification effect. As noted earlier, $FG_{i^*} > 0$ (see (3.41)), which indicates that holding domestic prices constant, the real exchange rate should appreciate (from E to B) to maintain internal equilibrium. Because $XX_{i^*} > 0$ (see (3.47)), the real exchange rate actually appreciates, from E to either B' or B''. In both panels the new equilibrium point is at E' or E'', characterized by a more appreciated real exchange rate but either lower or higher domestic prices.[28]

Intuitively, a reduction in the world interest rate generates initially (as in the case of an increase in the refinance rate) an intertemporal effect, which leads to higher consumption. It also leads to an increase in the demand for, and the price of, land, which raises on impact collateral values and lowers the premium. This raises investment initially. Both effects combine to create excess demand on the home market for domestic goods. Holding domestic prices constant, this would require a real appreciation (from E to B) to reduce exports and increase domestic sales, $Y^s - X$.

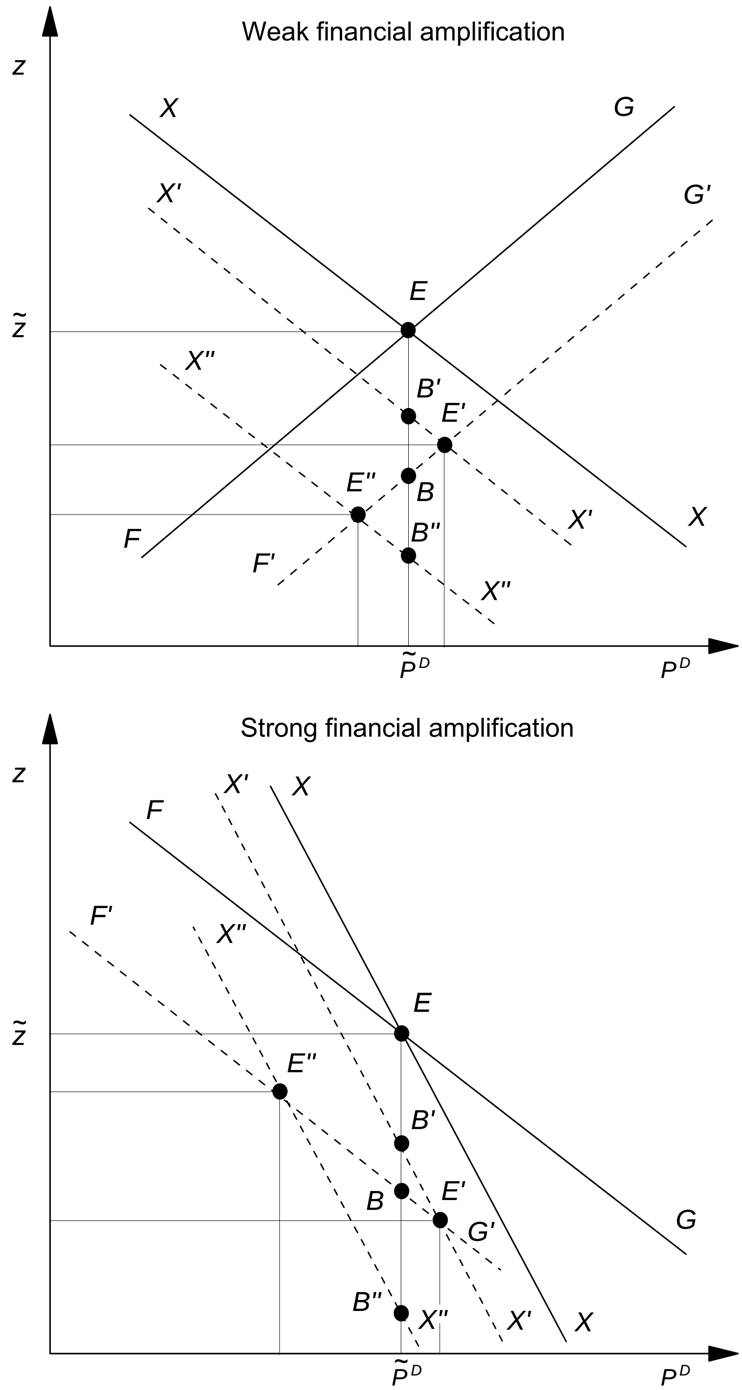
At the same time, the initial effect on the balance of payments is ambiguous. On the one hand, a lower world interest rate reduces interest income on net foreign assets, which worsens the current account; on the other, it generates a capital inflow (due to a reduction in deposits held abroad), which improves the capital account. If the latter effect dominates, the real exchange rate appreciates on impact, to either B' or B'', depending on the magnitude of the shift in XX. If XX does not shift much (which occurs, in particular, if the price sensitivity of exports, X_z, is relatively large) the real exchange rate must appreciate (from E to B') to maintain external equilibrium and will continue to do so (from B' to E), as domestic prices increase to eliminate excess demand for goods. By contrast, if the shift in XX is relatively large, following the initial appreciation (from E to B'') the real exchange rate must depreciate (from B'' to E''), while prices fall to eliminate excess supply. Thus, there is overshooting in the second case.

In addition, despite falling initially due to higher collateral values, the behaviour 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.

28 Again, with strong amplification, the impact on the real exchange rate is also indeterminate; the real appreciation shown in the figure is for illustrative purposes.

Reduction in Foreign Interest Rate

Figure 3.10



In sum, the model is able to reproduce the main stylized facts associated with capital inflows induced by *push factors*, namely, a real appreciation, a current account deficit, pressures on asset prices, and an expansion in credit and aggregate demand.[29] The key channels through which these effects operate are the portfolio effect of reductions in world interest rates and the financial amplification effect, which reflects changes in collateral values.

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

3.6. Policy Combinations

The question now is – how should the policy instruments discussed earlier, be combined, if at all, in managing external financial shocks and associated capital flows? To illustrate the analysis, the focus is on the case of a weak financial amplification effect.[30] Moreover, the case considered is only the one 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, the initial equilibrium is assumed to be at E^0, corresponding to the intersection of curves F^0G^0 and X^0X^0 in Figures 3.11 to 3.17. As discussed previously, a reduction in the world interest rate leads to downward shifts in the internal and external balance conditions, from F^0G^0 to F^1G^1 and from X^0X^0 to X^1X^1. The new equilibrium is at E^1, which corresponds to E' in Figure 3.10. The issue, therefore, is how policies can be combined to bring about a reduction in domestic prices and a real depreciation – the two fundamental variables of the model, from which all other endogenous variables can be derived – in order to return the economy from E^1 to its initial position, E^0. For that to happen, naturally, curve FF 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.[31] Given that there are two objectives, the *Tinbergen rule* (defined in the previous chapter) suggests that two instruments may be necessary.

Therefore, the following combinations are considered in turn: *a*) monetary and fiscal policies; *b*) monetary policy and sterilized foreign exchange intervention; *c*) monetary and macroprudential policies; *d*) monetary policy and capital controls; *e*) macroprudential policy and capital controls; *f*) macroprudential policy and sterilized intervention; and *g*) sterilized intervention and capital controls. While combinations involving more than two policies (as has often been the case in practice, documented in Chapter 6) could also be studied, graphical representations would become too opaque; for expositional clarity, instruments are therefore only considered in pairs.

3.6.1. Monetary and Fiscal Policies

Figure 3.11 illustrates outcomes when policy authorities combine monetary and fiscal policies. The transmission mechanism of these policies is as discussed earlier and represented in the upper panels of Figures 3.4 and 3.5.

The upper panel of Figure 3.11 shows what happens when the refinance rate, i^R, is *increased*. Curve XX shifts downward, from X^1X^1 to X^2X^2, whereas curve FG shifts upward, from F^1G^1 to F^2G^2. This is consistent with the outcomes illustrated in Figure 3.5. The upshot is that the policy, through a contraction in aggregate demand, does reduce domestic prices; at point E^2, prices are actually back to their original level. However, at the same time, higher domestic interest rates lead to more capital inflows; thus, although at E^2 domestic prices are the same as at E^0, the real exchange rate is more appreciated.

In a second step, in an attempt to return z to its initial value, the authorities can calibrate a reduction in government spending, *G*, so as to ensure that curve FG shifts further upward from F^2G^2 to F^3G^3, which coincides exactly with the initial curve F^0G^0. Thus, starting at E^2, the reduction in government spending induces a real depreciation and a drop in domestic prices (as in Figure 3.4). But even if curve FG shifts back to its original position, rather than E^0 the new equilibrium would be at E^3, the point of intersection of X^2X^2 and F^0G^0, characterized by lower domestic prices and a more appreciated real exchange rate than at the initial equilibrium. The implication, therefore, is that this policy combination (higher refinance rate, cut in government spending) cannot take the economy back to its initial position. The reason, fundamentally, is that an increase in the policy rate, by raising domestic deposit rates, exacerbates capital inflows. As a result, curve XX shifts in a direction opposite to what would be required.

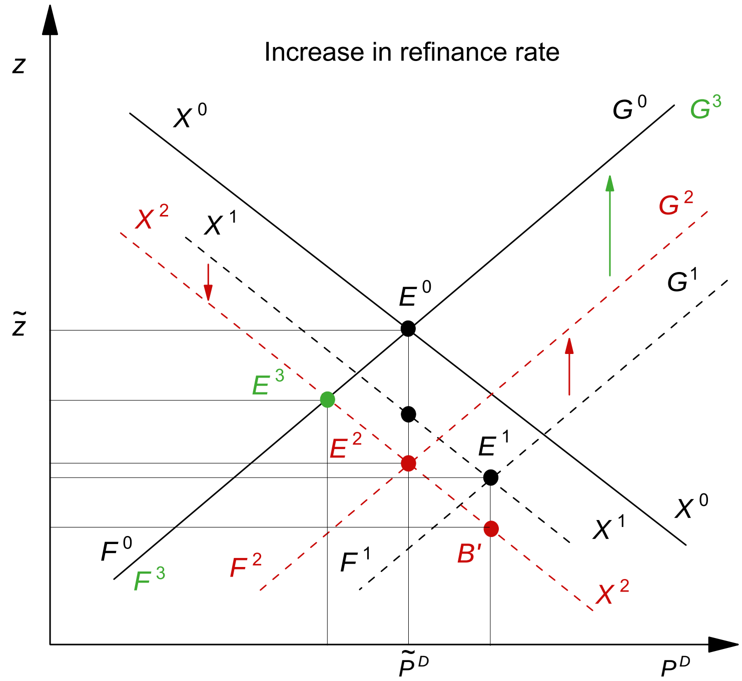
Suppose instead that the authorities, in a first step, decide to *reduce* the refinance rate. This is illustrated in the lower panel of Figure 3.11. In that case, the internal and external balance conditions move in the opposite direction: X^1X^1 shifts upward to X^2X^2, whereas F^1G^1 shifts downward to F^2G^2. By reducing the attractiveness of domestic bank deposits, a monetary policy tightening mitigates the inflow of capital. In fact, the increase in the refinance rate can be calibrated in such a way that the upward shift in X^2X^2 takes XX back exactly to its original position, X^0X^0; this is the case illustrated in the figure. However, the new equilibrium, if no other action is taken,

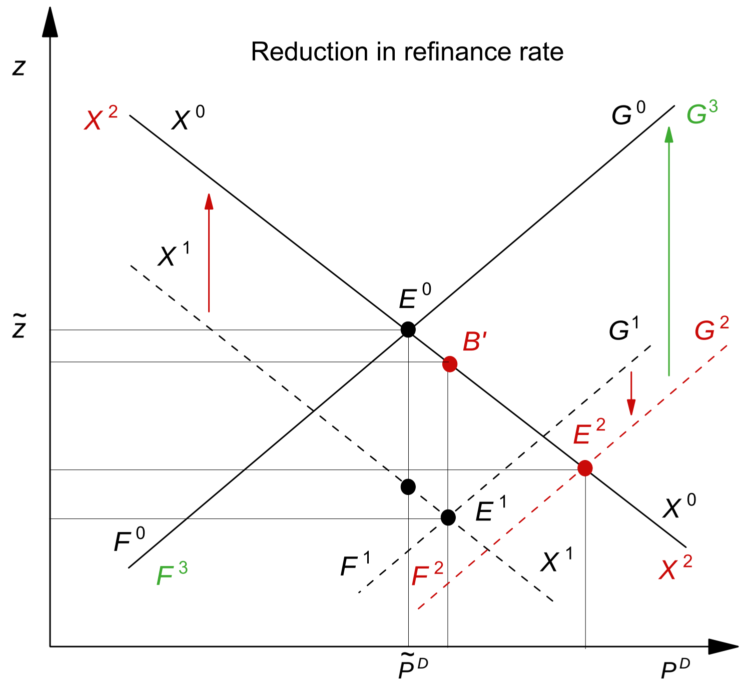
30 The case of strong financial amplification can be studied in the same manner and is left to the interested reader.

31 Note that, using (3.30), the cost-of-living index (3.29) can be written as $P = P^D z^\delta$. Thus, when P^D and *z* move in opposite directions in response to exogenous or policy shocks, the net effect on *P* is in general ambiguous. However, if, as assumed here, the goal of policy authorities is to stabilize *both* the price of the domestic good and the real exchange rate, by definition they will also stabilize the cost-of-living index – a more common objective in practice.

Policy Combination: Fiscal and Monetary Policies (Weak Financial Amplification Effect)

Figure 3.11





would be at E^2, characterized by higher prices and a more appreciated exchange rate compared to E^0. The reason, this time, is that the cut in the refinance rate is expansionary. The fact that an increase, or a reduction, in policy interest rates cannot by itself restore the initial equilibrium illustrates well the dilemma that central banks are typically faced with in managing capital flows with a single policy instrument.

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

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.[32]

3.6.2. Monetary Policy and Sterilized Intervention

The case where monetary policy is combined with discretionary, sterilized intervention (as defined earlier) is illustrated in Figure 3.12, in the presence and the 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 point E^1 (as in Figure 3.11), an *increase* in the policy rate has the same effects as before: a downward shift in XX from X^1X^1 to X^2X^2, and an upward shift in FG from F^1G^1 to F^2G^2. However, rather than calibrating the increase in the refinance rate to restore domestic prices to their original level (as in the previous case), suppose instead that the authorities do so to create a contraction in aggregate demand that is large enough to ensure that FG shifts upward from F^1G^1 to F^2G^2, corresponding to the initial curve F^0G^0. If so, and nothing else happens, the new equilibrium would be at E^2, characterized by lower domestic prices and a more appreciated real exchange rate than at E^0.

At the same time, the central bank can intervene at its discretion 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 and remains at F^0G^0. Thus, this time, the combination of an *increase* in the policy interest rate (which is essentially geared towards achieving internal balance, that is, 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 operates ($\varkappa > 0$). This case is illustrated in the lower panel of Figure 3.12. The first step (the increase in the refinance rate) is the same, and so is the subsequent upward shift in XX associated with intervention (from X^2X^2 to $X^3X^3 = X^0X^0$). 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.[33] Then, when intervention occurs, the expansionary effect translates into a downward shift from F^2G^2 to $F^3G^3 = F^0G^0$, with the XX curve shifting upward from X^2X^2 to $X^3X^3 = X^0X^0$.

However, if the bank portfolio effect is *not* internalized, and the interest rate adjustment in the first step is only large enough to shift FG from F^1G^1 to $F^2G^2 = F^0G^0$ (as in the case discussed earlier), sterilized intervention in a second step would lead to a *downward* shift in FG, in addition to the shift in XX back to its original position. The new equilibrium would be at a point like E^3 rather than E^0, characterized by higher domestic prices and a more appreciated real exchange rate relative to the economy's initial equilibrium. Put differently, to restore the initial equilibrium, internalizing the bank portfolio effect when sterilized intervention is expansionary means that monetary policy must be tighter than otherwise (the increase in the refinance rate must be *larger*), to accommodate the subsequent downward shift in the internal balance equilibrium curve when sterilized intervention is implemented.[34]

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

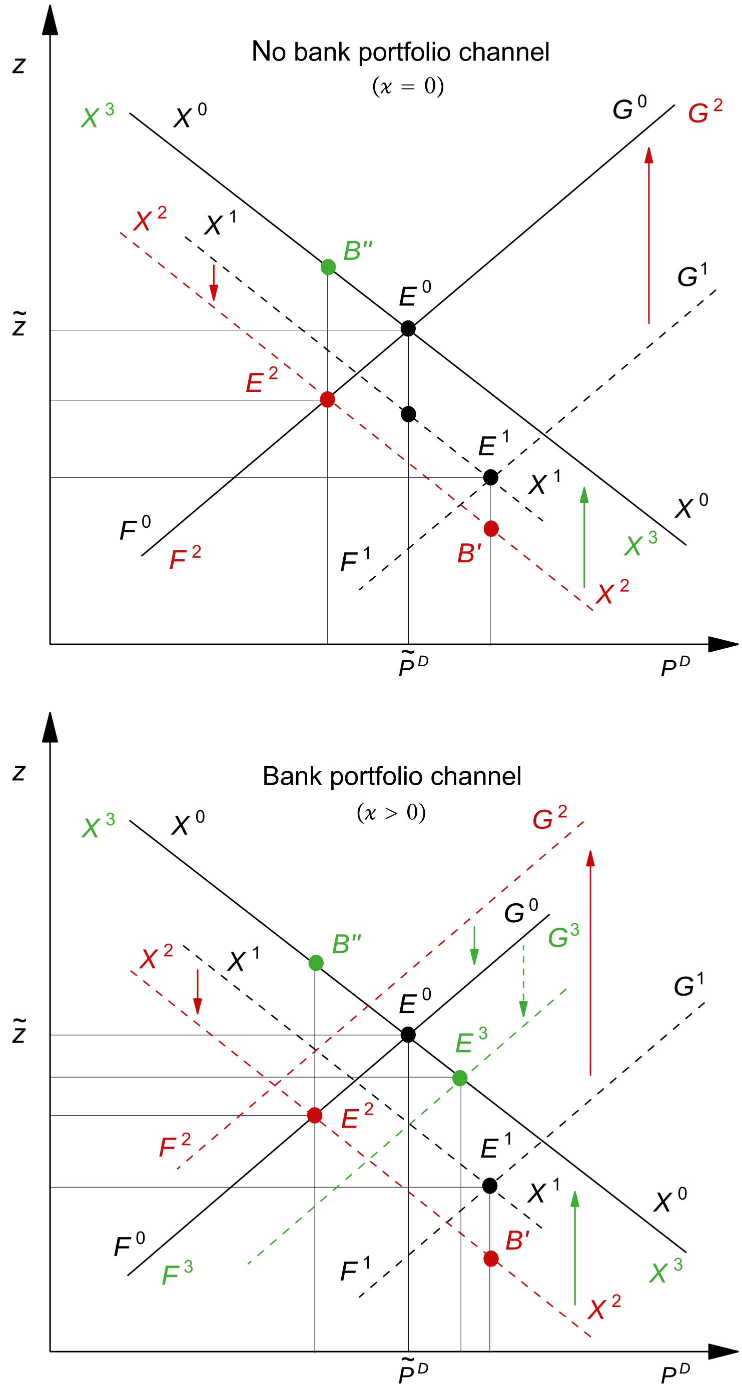
32 Ghosh et al. (2017), for instance, found no evidence of a systematic use of countercyclical fiscal policy in the face of capital inflows. In turn, this may be due to either an inherent lack of flexibility in public budgets (due to widespread earmarking of outlays, for instance) or the existence of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

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

34 The reverse sequence of policies, involving sterilized intervention first and a policy rate adjustment, can be analysed along the same lines.

Policy Combination: Monetary Policies and Sterilized Intervention (Weak Financial Amplification Effect)

Figure 3.12



The thrust of the 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 MICs. At the same time, the analysis also illustrates the importance of a careful calibration of the change in the policy rate and, to that effect, of using an operational model that accurately captures the key features of the financial system.

3.6.3. Monetary and Macroprudential Policies

The case where policy authorities combine monetary policy and macroprudential regulation is illustrated in Figure 3.13.

First, consider the case where, as in the upper panel of the figure, the refinance rate is *increased*. As in Figures 3.5, 3.11 and 3.12, the external balance curve shifts downward, from X^1X^1 to X^2X^2, whereas the internal balance curve shifts upward, from F^1G^1 to F^2G^2. The assumption in the figure is again that the increase in the policy rate is calibrated so that, at E^2, prices (viewed as the main target variable of monetary policy) are back to their original level. But at E^2, the real exchange rate is more appreciated than at E^0 (even though less so than at E^1). A well-calibrated increase in the macroprudential tax rate, τ^L (a contractionary policy as well, given that it induces an increase in the loan rate) shifts the internal balance curve from F^2G^2 to F^3G^3, which coincides with F^0G^0. The policy induces therefore a real depreciation and a drop in domestic prices, as illustrated earlier in Figure 3.7. But again the new equilibrium would be at E^3, the point of intersection of X^2X^2 and F^0G^0, characterized by lower domestic prices and a more appreciated real exchange rate than at E^0. The implication, therefore, is that this policy combination (increases in both the refinance rate and the macroprudential tax rate) cannot restore the initial equilibrium, because a higher policy rate amplifies the inflow of capital and upward pressures on the real exchange rate. It induces a shift in XX that goes in the opposite direction of what is desirable.

Second, suppose that, in an initial step, the authorities *reduce* the refinance rate. As shown in the lower panel of Figure 3.13, the external balance curve shifts now upward from X^1X^1 to X^2X^2, whereas the internal balance curve shifts further downward from F^1G^1 to F^2G^2. Now, the increase in the refinance rate can be calibrated so that X^1X^1 shifts back to $X^2X^2 = X^0X^0$; without any other policy change, the new equilibrium would therefore be at E^2, located to the southeast of E^0. In a second step, the increase in the macroprudential tax rate can be calibrated in such a way that the internal balance condition shifts as before upward from F^2G^2 all the way to $F^3G^3 = F^0G^0$, thereby restoring the initial equilibrium E^0. Again, the combination of a reduction in the policy interest rate (which, in effect, targets external balance) and a tightening of macroprudential regulation (which targets internal balance) generates the desired result. This policy mix is consistent with the evidence, alluded to earlier, which suggests that macroprudential policy has indeed been used repeatedly in recent years, in combination with monetary policy, to manage capital inflows.

3.6.4. Monetary Policy and Capital Controls

Consider now the combination of monetary policy and capital controls, which is illustrated in Figure 3.14.

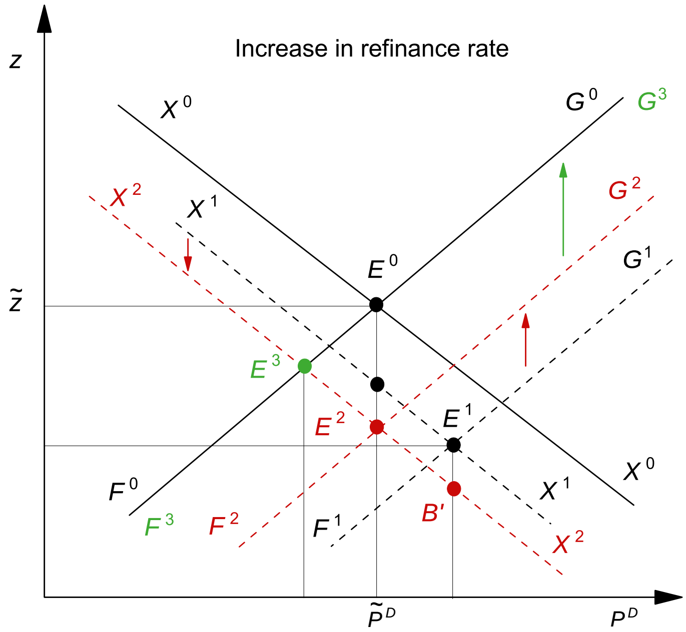
Suppose again that the first step involves an *increase* in the refinance rate, which is calibrated to restore domestic prices to their initial value. Curve FG shifts upward from F^1G^1 to F^2G^2, which is located below F^0G^0, whereas curve XX shifts further downward from X^1X^1 to X^2X^2. At point 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.

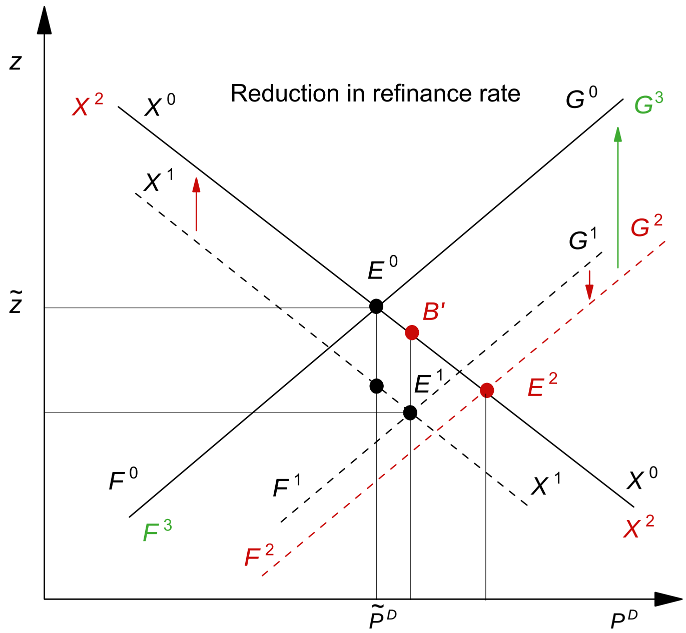
Now, suppose that, in a second step, the capital controls levy, τ^B, is increased in such a way that the external balance curve shifts from X^2X^2 to X^3X^3, which corresponds exactly to X^0X^0. However, because the tightening of capital controls has no effect on the position of FG, the internal balance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

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

Policy Combination: Monetary ans Macroprudential Policies (Weak Financial Amplification Effect)

Figure 3.13

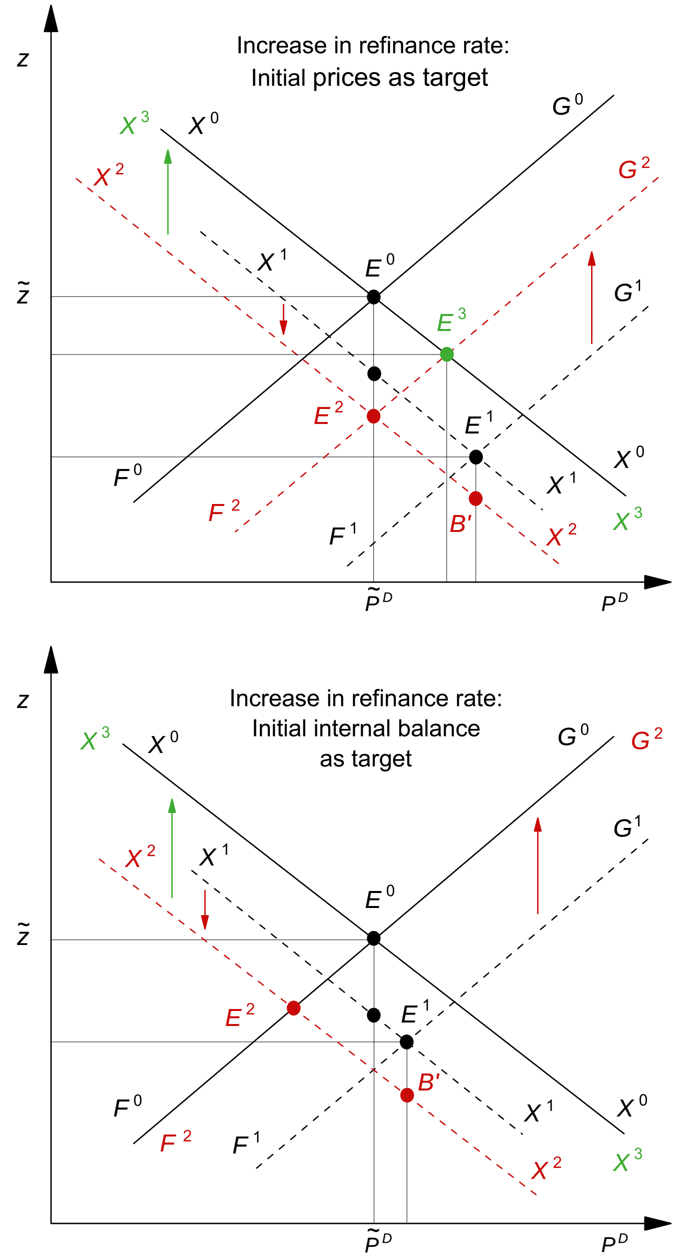




It is also worth noting that a *reduction* in the refinance rate (as in the lowers panels of Figures 3.11 and 3.13), combined with a tightening of capital controls, would *not* be an effective policy combination. The key reason is that while a large enough cut in interest rates could shift XX from X^1X^1 all the way back to X^0X^0, it would also push FG further *downward*, compared 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) implies a monetary stance that is *opposite* to the combination that works best when, for instance, government spending is the other available tool (an expansionary monetary policy and a spending cut).

Policy Combination: Monetary Policy and Capital Controls (Weak Financial Amplification Effect)

Figure 3.14



3.6.5. Macroprudential Policy and Capital Controls

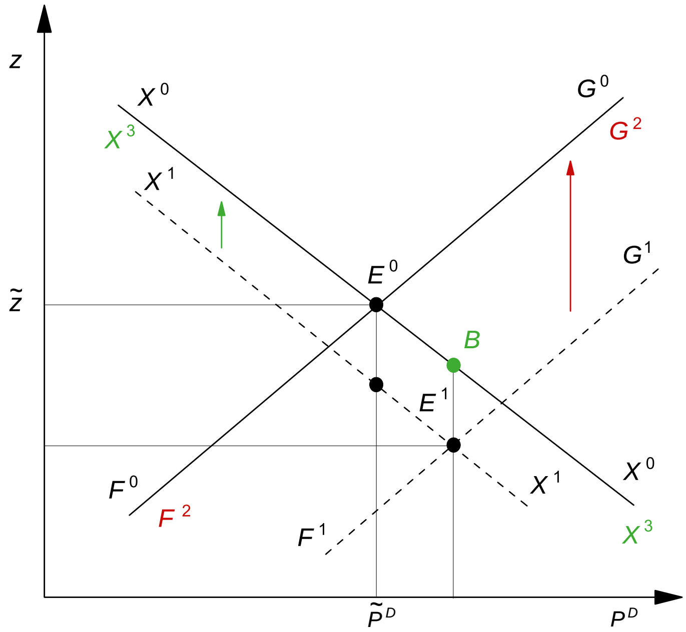
Consider the case where the only tools available are the macroprudential tax rate and the capital controls levy. This case is illustrated in Figure 3.15.

The results are a straightforward combination of Figures 3.6 and 3.9; the reason is that each policy affects one, and only one, of the equilibrium curves. Indeed, starting at E^1, a sufficiently large increase in the macroprudential tax rate can shift the internal balance curve from F^1G^1 to $F^2G^2 = F^0G^0$, whereas a sufficient tightening of capital controls can shift the external balance curve from X^1X^1 to $X^3X^3 = X^0X^0$. The equilibrium is thus restored at E^0. Again, this combination of tools has also been used in practice, although less frequently 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.[35]

35 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.

Policy Combination: Macroprudential Policy and Capital Controls (Weak Financial Amplification Effect)

Figure 3.15



3.6.6. Macroprudential Policy and Sterilized Intervention

The case where policy authorities combine macroprudential policy and sterilized intervention is illustrated in Figure 3.16. Each policy, as noted earlier, affects only one of the equilibrium curves.

Consider first the case where there is no bank portfolio channel ($\varkappa = 0$), which is displayed in the upper panel. In that case, an increase in the macroprudential tax rate can be calibrated to shift the internal balance curve upward from F^1G^1 to exactly $F^2G^2 = F^0G^0$, whereas sterilized intervention can be used to shift the external balance curve upward from X^1X^1 to $X^3X^3 = X^0X^0$, therefore restoring the initial equilibrium at E^0.

If there is a bank portfolio channel ($\varkappa > 0$), the policy responses are qualitatively the same. However, the macroprudential policy tightening must be stronger, to account for the fact that sterilization is expansionary. As shown in the lower panel of Figure 3.16, the increase in τ^L must be large enough for FG to shift from F^1G^1 to F^2G^2, located *above* F^0G^0. Sterilized intervention leads in turn not only to an upward shift in XX, X^1X^1 to $X^3X^3 = X^0X^0$, but also to a downward shift in FG, from F^2G^2 to exactly $F^3G^3 = F^0G^0$. Put differently, macroprudential policy must be more aggressive in order to offset the expansionary effect of sterilization on investment. If this expansionary effect is not internalized, and the tax rate is set so as to return FF to F^0G^0 (as in the case where $\varkappa = 0$), the new equilibrium would be at a point located to the southeast of E^0, characterized by higher prices and a more appreciated real exchange rate than initially.

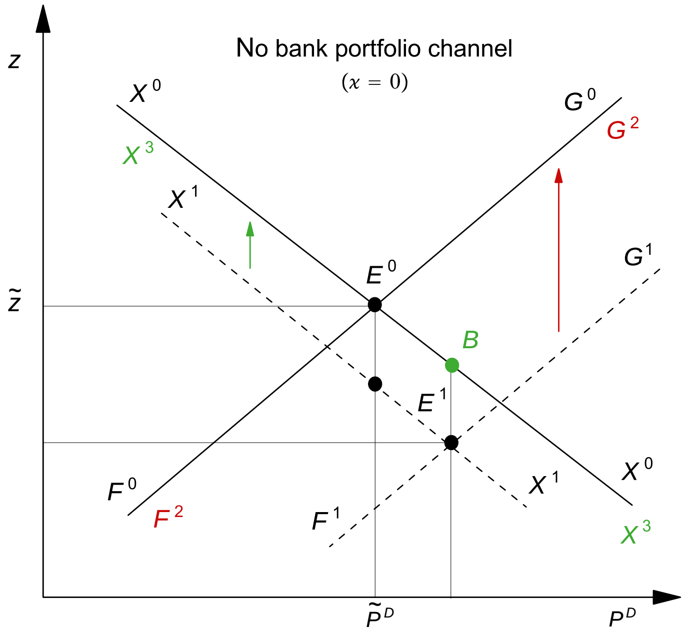
Among MICs, a number of countries have combined sterilized intervention and macroprudential policy (see Chapter 6). What the foregoing discussion brings to the fore is, once again, the fact that when sterilized intervention is used in combination with other instruments, the possibility that it may generate expansionary effects must be internalized in setting the instrument, or instruments, that it is used in combination with.

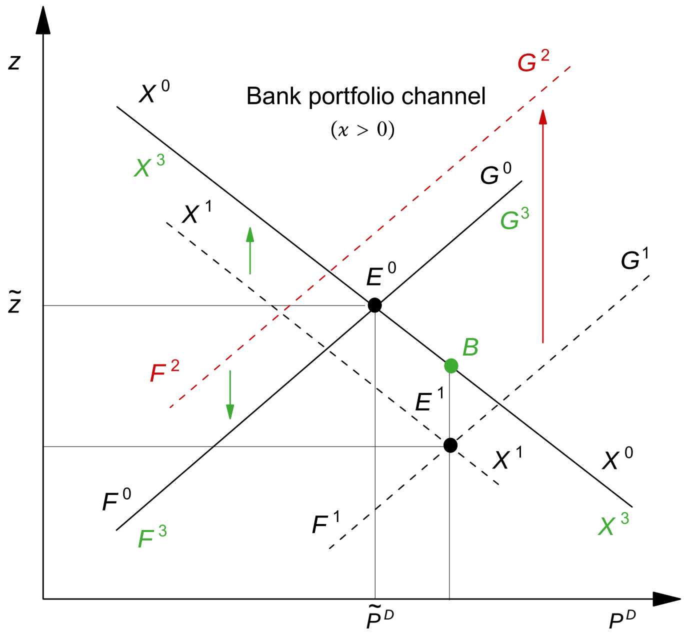
3.6.7. Sterilized Intervention and Capital Controls

Finally, it is readily apparent that, in this model, the combination of sterilized intervention and capital controls would *not* be a judicious policy combination to return the economy to its equilibrium. The reason is that, as can be inferred from Figures 3.8 and 3.9, both policies operate by inducing a shift in XX only. In fact, if sterilized intervention is expansionary, the combination of these two instruments could make matters *worse*, in the sense that it could induce a shift in the internal balance curve that operates in the *wrong direction*, that is, a shift in FG that moves it further away from F^0G^0, relative to F^1G^1. From that perspective, the two instruments are more substitutes than complements and are better used in combination with other policies that can influence internal balance, such as monetary and macroprudential policies, as discussed earlier.

Policy Combination: Macroprudential Policy and Sterilized Intervention (Weak Financial Amplification Effect)

Figure 3.16





3.6.8. Summary

The main results of the analysis of policy combinations 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 equilibrium effects are generally not affected.[36] 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 depends on which other instrument, or instruments, policymakers have at their disposal to engage in countercyclical responses. 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 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).

36 In a related analysis, Agénor and Pereira da Silva (2023) showed that this is not the case when monetary policy is used and the cost channel, associated with bank borrowing to finance working capital needs, is present.

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 an effective policy mix to respond to capital inflows driven by *push* factors.

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 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 best policy mix. This combination is effective even in the presence of a bank portfolio channel – with the caveat that, in that case, the change in interest rates must be carefully calibrated.

The fact that an effective policy mix may involve higher, rather than lower, interest rates, depending on the other instrument 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 cost-based macroprudential tax (targeted at internal balance) and temporary capital controls on bank foreign borrowing (targeted at external balance), or macroprudential and sterilized intervention (provided that expansionary effects are properly accounted for) are also potent policy combinations to manage capital inflows. By contrast, combining sterilized intervention and capital controls is an ineffective policy response.

While these results are obviously dependent on the model's structure, the nature of the shock under consideration, and the assumed objectives of policymakers (returning the economy to its initial position, following an external financial shock) they illustrate fairly well the insights that can be gained into the joint performance of macro-financial policy instruments. Moreover, depending on the range of tools available, different combinations may achieve the same result. At the same time, not all combinations are equally feasible; for instance, lack of fiscal space, and political constraints, often makes fiscal policy difficult to implement in the short term. Concerns about adverse signaling effects may also give policymakers pause in activating capital controls, even if these are viewed as temporary.

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

3.7. Extensions

The model presented earlier can be extended in a number of directions. In what follows, five of them are briefly considered: physical capital as collateral, working capital needs, reserve requirements, intratemporal substitution, and endogenous depreciation expectations.[37]

3.7.1. Physical Capital as Collateral

As in chapter 2, in the foregoing discussion collateral was assumed to take the form of land. Once again, an alternative specification is to assume that firms pledge physical collateral to secure loans. Thus, equation (3.21) can be replaced by

$$\theta = \theta(\kappa P^D K_0 - L_0), \tag{3.53}$$

where again $\kappa \in (0,1)$ is the proportion of assets that can be pledged as collateral and $\theta' < 0$.

This alternative specification of the premium does not affect the fundamental property of the model – the financial amplification effect. The reason again is that, the equilibrium real price of land is positively correlated to domestic prices (see equation (3.36)), through their effect on income. Thus, having domestic prices enter directly

[37] Other extensions include accounting for unemployment, as discussed in Chapter 2, and bank capital regulation, as discussed by Agénor and Pereira da Silva (2012) in a closed-economy setting.

in the premium through the value of the capital stock as in (3.53) does not affect the qualitative features of the equilibrium. The key difference is that now, changes in some variables no longer affect the premium and the loan rate through their impact on the real price of land. Indeed, the following partial derivatives in the financial sector equilibrium condition (3.38) are now

$$/FF_{i^R} = 1, \; FF_z = FF_\mu = FF_{i^*} = 0.$$

Thus, while the effect of changes in the refinance rate remain qualitatively the same, productivity shocks and changes in the required reserve ratio, the real exchange rate, and the world interest rate have no longer a direct effect on financial equilibrium. At the same time, FF_{pD} remains negative (as before) if θ' is sufficiently large, which implies that the financial amplification effect functions in the same manner as described earlier.

With the premium determined as in (3.53), the derivatives of the internal balance condition FG in (3.41) with respect to i^R, μ, and i^* become

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

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

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

$$/ = (1-\delta)c_3 D_0^* + X_z > 0.$$

These derivatives retain the same sign; the transmission channel of these variables through the internal equilibrium condition remains therefore the same. Regarding the derivative with respect to P^D, the same ambiguities described earlier (regarding, specifically, the strength of the financial amplification mechanism) remain.[38] Thus, it is still the case that

$$FG_{pD} = \frac{1}{/}\left\{ f\,Y^s_{pD} + \frac{(1-\delta)c_3}{(P^D)^2}(M_0 + D_0) - (1-\delta)c_3 p^H_{pD} - I'FF_{pD} \right\} \gtreqless 0.$$

As noted in Chapter 2, a further simplification, when specification (3.53) is adopted, is to abstract entirely from the existence of land as a portfolio asset. In such conditions, equations (3.14) and (3.15) can be ignored, and equation (3.16), with $\pi^e = \varepsilon = 0$, can be replaced by

$$C = c_0 + c_1(Y^s - T) - c_2(i^D + i^*) + c_3\left[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D}\right], \tag{3.54}$$

where parameters are as defined before. By implication, in (3.41),

$$FG_{i^R} = \frac{(1-\delta)c_2(1-\mu) - I'}{/},$$

$$FG_\mu = -\frac{(1-\delta)c_2 i^R}{/} < 0, \; FG_{i^*} = \frac{(1-\delta)c_2}{/} > 0,$$

with $/ = (1-\delta)c_3 D_0^* + X_z$ now, and the derivative of the internal balance condition FG with respect to P^D simplifies to become

$$FG_{pD} = \frac{1}{/}\left\{ f\,Y^s_{pD} + \frac{(1-\delta)c_3}{(P^D)^2}(M_0 + D_0) - I'FF_{pD} \right\} \gtreqless 0.$$

[38] In particular, assuming that the sensitivity of the demand for land to income is small enough to ensure that the *net wealth effect* is to reduce consumption, as in the closed-economy setting, is no longer sufficient to ensure that FG_{pD} is unambiguous.

This derivative remains ambiguous, due to the financial amplification effect alluded to earlier. Thus, once again, the qualitative features of the transmission mechanism, as described earlier, are not affected.[39]

3.7.2. Working Capital Needs

As in Chapter 2, let the wage bill, inclusive of borrowing costs, be defined as $(1-\psi_W)WN + \psi_W(1+i^R)WN = (1+\psi_W i^R)WN$, where $\psi_W \in (0,1)$ is the fraction of wage costs financed by bank loans. Profits are therefore given by, instead of (3.2),

$$\Pi = P^D A N^{\alpha} K_0^{1-\alpha} - (1+\psi_W i^R)WN. \tag{3.55}$$

The first-order condition of firms' maximisation problem with respect to N is now

$$\alpha P^D A N^{\alpha-1} K_0^{1-\alpha} - (1+\psi_W i^R)W = 0,$$

which yields the demand for labour as, with again $W = \bar{W} = 1$,

$$N^d = (\frac{\alpha P^D A}{1+\psi_W i^R})^{1/(1-\alpha)} K_0. \tag{3.56}$$

This equation can be substituted in the production function (3.1) to give

$$Y^s = (\frac{\alpha P^D A}{1+\psi_W i^R})^{\alpha/(1-\alpha)} K_0. \tag{3.57}$$

Thus the demand for labour and the supply of domestic goods are now inversely related to the *effective* cost of labour, $(1+\psi i^R)/P^D$, which accounts not only for the direct cost of employing workers, but also for the cost of borrowing to pay wages at the beginning of the production process. These equations can be written as

$$N^d = N^d(P^D; A, i^R), \quad Y^s = Y^s(P^D; A, i^R), \tag{3.58}$$

with $N^d_x, Y^s_x > 0$, $x = P^D, A$, as before, as well as

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

An increase in the refinance rate exerts a contractionary effect on employment and output.

The main implication of this extension relates to curve GG, where the derivative with respect to i^R is now given by[40]

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

An increase in the refinance rate, i^R, has now, in general, an ambiguous effect on the equilibrium 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.[41]

Two cases must therefore be considered. The first is 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

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39 This version of the model is also studied more extensively in Agénor (2020, chapter 7) and can be analyzed graphically as well using the Excel simulation tool circulated in parallel with this Manual.

40 As noted in the previous chapter, in principle to be consistent with the timing of transactions only wage income should appear in the consumption function. However, using (3.16) simplifies the derivations without affecting qualitatively the results.

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

dominates the supply-side effect. Thus, an increase in the policy rate creates excess supply on the domestic goods market. To restore equilibrium, holding the price of domestic goods constant, the real (and thus nominal) exchange rate must depreciate to stimulate exports and reduce domestic sales. Thus, $FG_{i^R} > 0$. The second case corresponds to the situation where the cost channel is strong, that is, ψ_W, and thus $Y^s_{i^R}$ in absolute terms, are sufficiently large, given c_2 and c_3, to ensure that $FG_{i^R} < 0$.

If ψ_W, the proportion of wage costs financed by bank credit, is small enough to ensure that $FG_{i^R} > 0$, then the case considered previously ($\psi_W = 0$) continues to prevail. Thus, a weak cost channel makes no substantive difference to the analysis. By contrast, if the cost channel of monetary policy is strong ($FG_{i^R} < 0$) there may be, as noted in Chapter 2, *stagflation* – a restrictive monetary policy may lead not only to a contraction in output but also an increase in domestic prices.

Formally, the impact of an increase in the refinance rate on the real exchange rate and domestic prices is now, instead of (3.49),

$$\frac{dz}{di^R} = \frac{\overset{(-)}{XX_{i^R}}\,\overset{(?)}{FG_{p^D}} - \overset{(?)}{FG_{i^R}}\,\overset{(-)}{XX_{p^D}}}{\underset{(?)}{FG_{p^D}} - \underset{(-)}{XX_{p^D}}}, \quad \frac{dP^D}{di^R} = \frac{\overset{(-)}{XX_{i^R}} - \overset{(?)}{FG_{i^R}}}{\underset{(?)}{FG_{p^D}} - \underset{(-)}{XX_{p^D}}}. \tag{3.59}$$

Thus, one must now distinguish not only with respect to the strength of the financial amplification effect (that is, the sign of FG_{p^D}), but also the strength of the cost channel (as measured by the sign of FG_{i^R}).

As shown earlier, regardless of whether FG_{p^D} is positive or negative, $FG_{p^D} - XX_{p^D} > 0$. Thus, with a weak cost channel ($FG_{i^R} > 0$), equation (3.59) gives $dz/di^R \gtreqless 0$ and $dP^D/di^R < 0$ when $FG_{p^D} > 0$, as well as $dz/di^R > 0$ and $dP^D/di^R < 0$ when $FG_{p^D} < 0$. With a weak financial amplification effect, the impact on domestic prices is negative, whereas the impact on the real exchange rate is ambiguous; with a strong amplification effect, the impact on prices is again negative, but the real exchange rate definitely depreciates. These results correspond exactly, and not surprisingly, to those displayed in Figures 3.5 and 3.6, which correspond to the case where $\psi_W = 0$, that is, no bank financing of labour costs.

Consider now the case of a strong cost channel ($FG_{i^R} < 0$). Solution (3.59) now gives $dz/di^R < 0$ and $dP^D/di^R \gtreqless 0$ when $FG_{p^D} > 0$, as well as $dz/di^R \gtreqless 0$ and $dP^D/di^R \gtreqless 0$ when $FG_{p^D} < 0$. With weak financial amplification, the real exchange rate always appreciates, but the impact on domestic prices is now ambiguous; with strong amplification, both effects are ambiguous.

These results are illustrated in Figure 3.17. The aggregate demand effects are the same as before; on impact, consumption and investment both fall in response to an increase in the refinance rate. However, the contraction in aggregate supply (due to the increase in the effective product wage) is large enough to lead, at the initial level of prices, to a situation of excess *demand*. The real exchange rate should therefore appreciate, from *E* to *B*, to lower exports, increase domestic sales, and restore internal equilibrium. Thus, curve FG now shifts downward, regardless of the strength of the financial amplification effect. At the same time, as before XX shifts downward to either $X'X'$ or $X''X''$, requiring an actual appreciation on impact (from E to B' or B'') to maintain external equilibrium. If the shift in XX is not too large (to, say, $X'X'$), domestic prices *increase* in the new equilibrium (point E'), again regardless of the strength of the financial amplification effect. However, when the shift of XX is relatively large, to, say, $X''X''$, prices in the new equilibrium (point 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.[42]

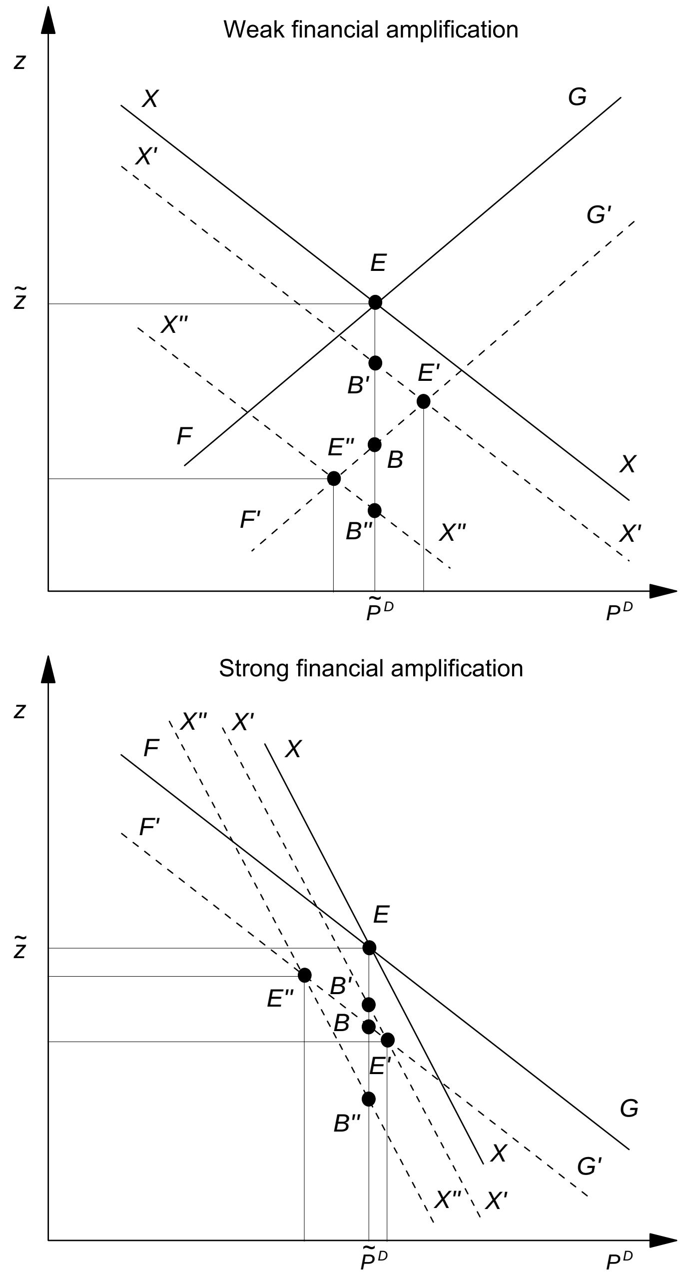
In addition, at the new equilibrium (E' or E'') the real exchange rate always appreciates when the financial amplification effect is weak (upper panel of the figure), in contrast to what occurs with a weak cost channel (see Figure 3.5). And when financial amplification is strong, the effect on the real exchange rate is in general ambiguous, while it always depreciates with a weak cost channel (see Figure 3.6). In the case shown in the lower panel of Figure 3.17, the real exchange rate appreciates – whether prices increase or fall.[43] Consequently, exports are also

42 This point is important because most of the existing literature on the price puzzle associated with the cost channel, which includes Henzel et al. (2009), dwells on closed-economy New Keynesian models.

43 With a larger downward shift in *XX*, or a smaller downward shift in *FG*, compared to what is shown in the figure, the real exchange rate would depreciate in the new equilibrium.

Increase in Refinance Rate: Strong Cost Channel

Figure 3.17



lower. But the impact on output, and thus domestic sales, remains ambiguous and depends on whether a price puzzle exists or not. For the same reason, the impact on consumption, the loan rate, and investment, are also in general ambiguous. In addition, when domestic prices are lower in the new equilibrium (at E''), the real exchange rate *overshoots* – the real appreciation on impact (from E to B'') is larger than the equilibrium effect (the vertical distance between E and E''), regardless of the strength of the financial amplification effect.

The upshot of this analysis is that, to evaluate the macroeconomic effects of monetary policy, determining how significant the cost channel is may be as important as assessing the strength of the financial amplification effect. This is consistent with the large literature on the implications of bank financing of working capital needs for business cycles in MICs and some advanced economies.[44] Even though the mere presence of a cost channel does not necessarily affect the transmission mechanism of monetary policy – the fact that a monetary contraction may raise production costs does not imply that the policy is stagflationary – the possibility that output and prices may move in opposite directions in response to changes in interest rates means that policy trade-offs may be

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

exacerbated. Addressing these trade-offs may require greater coordination in policy responses. In addition, the fact that, depending on the strength of financial frictions, the real exchange rate may either appreciate or depreciate in response to a contractionary monetary policy is consistent with the predictions of more complex models.[45]

3.7.3. Reserve Requirements

As in Chapter 2, consider the case of a increase in the required reserve ratio, μ. As discussed by Agénor and Pereira da Silva (2016), for instance, this instrument has been used quite extensively in Latin America to respond to domestic and external shocks – although, at times, as a substitute for monetary policy, rather than a tool of financial regulation.[46]

Differentiating (3.41) and (3.47), holding the other policy instruments constant, gives

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

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

or, in matrix form,

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

Solving this system gives

$$\frac{dz}{d\mu} = \frac{\overset{(+)}{XX_{\mu}}\,\overset{(?)}{FG_{pD}} - \overset{(-)}{FG_{\mu}}\,\overset{(-)}{XX_{pD}}}{\underset{(?)}{FG_{pD}} - \underset{(-)}{XX_{pD}}} \gtrless 0, \quad \frac{dP^D}{d\mu} = \frac{\overset{(+)}{XX_{\mu}} - \overset{(-)}{FG_{\mu}}}{\underset{(?)}{FG_{pD}} - \underset{(-)}{XX_{pD}}} > 0. \tag{3.60}$$

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

These effects are illustrated in Figure 3.18.[47] First, an increase in the required reserve ratio lowers the deposit rate and induces households to spend more today. Second, the reduction in the deposit rate generates a shift away from deposits and into other assets – foreign deposits and land. The increase in the demand for land raises its price, which in turn at first exerts a positive wealth effect on consumption and raises collateral values. This tends to lower the loan rate – given that $FF_{\mu} < 0$, as can be inferred from (3.38) – and to stimulate investment, in line with the financial amplification effect. The combination of these effects on consumption and investment creates excess demand and, at the initial level of domestic prices, the real exchange rate should appreciate (from E to B) to restore internal equilibrium ($FG_{\mu} < 0$ in (3.41)). Graphically, FG shifts downward to $F'G'$. Third, higher consumption spending raises imports, whereas the reduction in the domestic deposit rate induces households to increase their holdings of foreign deposits. The combination of a worsening current account and a capital outflow means that the real exchange rate must depreciate to maintain external equilibrium ($XX_{\mu} > 0$). Thus, XX shifts upward to $X'X'$ in both panels of Figure 3.16, and the real exchange rate jumps from E to B' or B'', depending on the magnitude of the shift in XX. Subsequently, it appreciates, to either E' or E''. With a weak amplification effect, while output and investment unambiguously increase, changes in exports, domestic sales, consumption and domestic absorption are ambiguous. With a strong amplification effect, output and investment change in the same manner, but now exports are unambiguously lower (given the real appreciation), whereas domestic sales and domestic absorption are unambiguously higher.

The key point of this analysis is that an increase in reserve requirements has an expansionary effect on output (as well as, possibly, domestic sales) and raises domestic prices. By implication, with a weak financial amplification effect, while an increase in reserve requirements may help in terms of mitigating the effects of a reduction in the world interest rate when it comes to the real exchange rate – if it is associated with a depreciation, which is not guaranteed – it could magnify inflationary pressures (see the upper panel of Figure 3.10).

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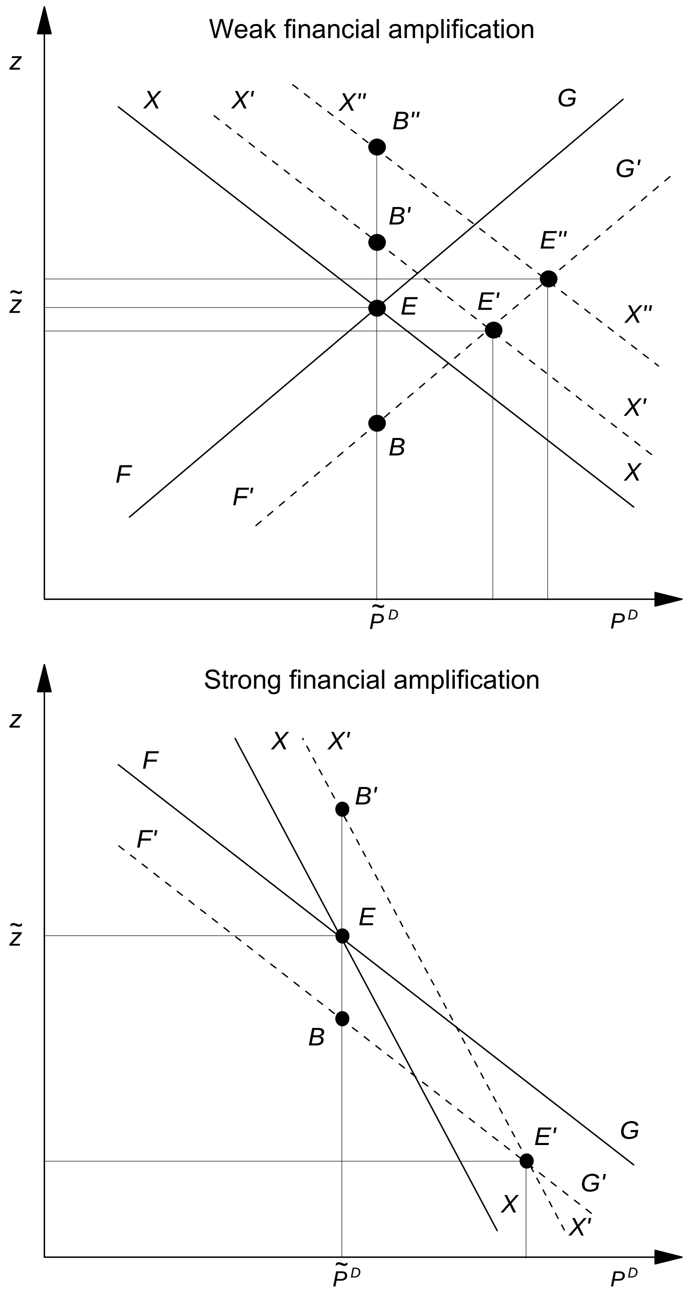
45 See, for instance, Devereux et al. (2006).

46 See Cordella et al. (2014), Glocker and Towbin (2015), Coman and Lloyd (2019), and Fabiani et al. (2021) for formal empirical evidence.

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

Increase in the Required Reserve Ratio

Figure 3.18



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

An alternative, but fundamentally similar, approach is to consider the case where, as in Agénor and Pereira da Silva (2017), for instance, economies of scope prevail with respect to deposits and loans. Consequently, the loan rate equation (3.20) is generalized to

$$i^L = i^R + \theta + \gamma\tau^L - \varkappa\left(\frac{B^{CB}}{L_0}\right) - \varkappa_D\left(\frac{D}{L_0}\right), \tag{3.61}$$

where $\varkappa_D > 0$.[48] From the portfolio equation (3.11), $D = F_0^H d(i^D; i^* + \bullet)$, where $d_{i^D} > 0$. Combined with (3.19) for the deposit rate, equation (3.61) implies that an increase in the required reserve ratio would tend to raise the loan rate. Again, if this effect is relatively large, investment will fall. In addition, if the contraction in investment is large relative to the expansionary effect on consumption, aggregate demand will fall and in so doing put downward pressure on domestic prices.[49] In such conditions, increases in the required reserve ratio can play an effective role in responding to the macroeconomic and financial effects associated with a drop in the world interest rate – possibly, as discussed earlier, in combination with other instruments.

3.7.4. Intratemporal Substitution

In the foregoing discussion, it was assumed that the share of spending on imports, δ, is constant, and corresponds to the weight of foreign prices in the cost-of-living index (see (3.29)). However, as the relative price of imports (the real exchange rate) changes, *intratemporal* substitution should induce changes in the allocation of total household spending between domestic and imported goods. For instance, a depreciation of the real exchange rate (a rise in z) makes imported goods more expensive domestically; households therefore have incentives to consume less of these goods and more of domestic goods. This relative price effect is generally referred to as the *intratemporal substitution effect* and can be captured by defining δ as

$$\delta = \delta(z), \tag{3.62}$$

where $\delta' < 0$. At the same time, to avoid complicating the analysis unduly, it is convenient to keep the weight used in the price index (3.29) to a base period value, say, δ_0.

To illustrate how the analysis changes as a result of endogenizing δ, note that the internal balance equation, equation (3.40), takes now the form

$$Y^s(\cdot) = [1-\delta(z)]\Big\{c_0 + c_1 Y^s(\cdot) - c_2[(1-\mu)i^R + i^*]-$$

$$+c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D} + p^H(\cdot)]\Big\} + I[FF(P^D, z; \cdot)] + G + X(z; \cdot).$$

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

$$/ = -\delta' C + (1-\delta)c_3 D_0^* + I' FF_z + X_z.$$

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

Similarly, the external balance condition, equation (3.46), is now

$$z^{-1}X(z;\cdot) - z^{-1}\delta(z)\Big\{c_1 Y^s(\cdot) - c_2[(1-\mu)i^R + i^*]$$

$$+c_3[\frac{F_0^H + (zP^D - E_0)D_0^*}{P^D} + p^H(\cdot)]\Big\} + (1+i^*)F_0^* - F^*(z;\cdot) = 0.$$

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

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

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

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

49 Graphically, curve *FG* would now shift *upward* in Figure 3.18, rather than downward. Even then, the possibility that domestic prices increase also in that case cannot be ruled out. For prices to fall, the drop in investment must be large enough to outweigh the increase in consumption (due to the intertemporal and wealth effects) and create excess supply initially.

3.7.5. Endogenous Depreciation Expectations

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

In the static framework considered here it is not easy to provide a fully satisfactory treatment of expectations. However, suppose that exchange rate expectations are extrapolative, so that the expected depreciation rate is given by

$$\bullet = -\left(\frac{E - E_0}{E_0}\right), \tag{3.63}$$

where $- > 0$. Thus, a depreciation today (an increase in E) induces agents to expect the exchange rate to depreciate further tomorrow. In that case, equation (3.42) becomes, noting that $E = zP^D$,

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

The partial derivatives d_z^* and $d_{P^D}^*$ in (3.43) are now given by

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

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

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

In addition, and as can be inferred from (3.36), which defines the equilibrium price of land, the endogenous treatment of expectations as in (3.63) creates another channel through which exchange rate fluctuations directly affect domestic lending conditions. However, depending on the shock, and on the structural features of the economy, this channel may operate either procyclically or countercyclically.

Consider, for instance, an increase in the refinance rate. As noted earlier, the result may be either a possible appreciation (weak financial amplification, see Figure 3.5) or a definite depreciation (strong financial amplification, see Figure 3.6). With endogenous expectations specified as in (3.63), a depreciation raises the rate of return on foreign assets, thereby lowering the demand for, and thus the price of, land, given that $p_{i^*+\bullet}^H < 0$. In turn, this tends to reduce collateral values and to raise the loan rate. The opposite occurs when the real exchange rate appreciates.[50] How strong this channel is depends therefore on the sensitivity of the demand for land with respect to the rate of return on foreign-currency assets.

[50] Similarly, with specification (3.63), a reduction in the world interest rate would now also have an indirect effect on the equilibrium price of land and domestic lending conditions, through its impact on the nominal exchange rate.

Appendix

Local Stability Analysis and the Slopes of *FG* and *XX* when $FG_{P^D} < 0$

As noted in the chapter, $XX_{P^D} < 0$. Thus, when $FG_{P^D} < 0$, both FG and XX have a negative slope. The question that arises then is: how steep is FG relative to XX? The answer, which is crucial for understanding the comparative statics properties of the model and the adjustment process to shocks, can be provided by relying once again on Samuelson's correspondence principle, which essentially involves analysing the local stability of the dynamic system associated with the model.[51]

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

In continuous time, the first dynamic equation is

$$\frac{dz}{dt} = XX(P^D;\cdot) - z, \tag{3.1}$$

where $XX()$ is the equilibrium value of z given by the external sector equilibrium condition (3.47). The second dynamic equation is

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

or, using the internal sector equilibrium condition (3.40), and noting that $F_0^H - E_0 D_0^* = M_0 + D_0$,

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

$$\text{-} + c_3 p^H(P^D;\cdot)\Big\rangle + I[FF(P^D, z;\cdot)] + G - Y^s(P^D;\cdot) + X(z)\Big\}, \tag{3.2}$$

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

Linearizing equations (3.1) and (3.2) in the vicinity of the steady state yields, with a "126" denoting a steady-state value,

$$\begin{bmatrix} dz/dt \\ dP^D/dt \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ \lambda_G a_{21} & \lambda_G a_{22} \end{bmatrix} \begin{bmatrix} z - \tilde{z} \\ P^D - \tilde{P}^D \end{bmatrix}, \tag{3.3}$$

and

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

$$a_{12} = XX_{P^D} < 0,$$

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

[51] See Agénor (2020, Chapter 2) for a more detailed discussion.

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

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

The real exchange rate is a jump variable, whereas the domestic price level is a state variable. Saddlepath stability of the dynamic system (3.3) requires therefore that the two eigenvalues be of opposite sign. A necessary and sufficient condition for that to occur is that the matrix of coefficients of the linearized system (or Jacobian), **A**, which is equal to the product of the roots, has a negative determinant:

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

For this condition to hold, it must therefore be that

$$\frac{a_{22}}{a_{21}} < \frac{a_{12}}{a_{11}}. \tag{3.4}$$

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

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

and, given the definition of FG_{pD} provided in the text (see below (3.41)),

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

Thus, condition (3.4) can also be written as

$$-FG_{pD} < -XX_{pD}, \tag{3.5}$$

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

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

Chapter 4. A DSGE Model with a Managed Float Regime

The static models presented in the previous chapters provided a simple, tractable framework for studying the transmission of macro-financial policies in closed and open bank-dependent economies with financial frictions. It also helped to provide an intuitive discussion of the benefits (or lack thereof) of alternative combinations of a broad range of policy instruments. However, to address some of the key challenges that policymakers in these economies face, especially in managing external shocks, a more elaborate open-economy model, which can be calibrated and used to provide quantitative answers to the type of policy questions that policymakers are confronted with, is needed.

Accordingly, this chapter presents a dynamic stochastic general equilibrium (DSGE) model with a managed float regime. On the financial side, its core assumptions are fundamentally similar to those discussed in previous chapters.[1] At the same time, it provides a more rigorous (microfounded) characterization of some of its structural features. Monopolistic price setting in the real sector, as well as interest rate and foreign exchange intervention rules, are explicitly accounted for. Thus, the model incorporates a range of nominal, real and financial frictions, most of them consistent with those considered in previous chapters, which are empirically relevant for policy analysis.

The remainder of this chapter is organized as follows. Section 1 summarizes the key assumptions of the model, and section 2 provides its formal description. The equilibrium and some key features of the steady state are discussed in section 3. A benchmark parameterisation is presented in section 4. This parameterisation falls well short of a calibration for a particular country; rather, it is designed to reproduce the main stylized facts associated with various policy and exogenous shocks, including, and especially, episodes of large capital inflows induced by a drop in world interest rates, as discussed earlier: a real appreciation, a current account deficit, lower domestic interest rates, a credit boom, an aggregate demand expansion, and asset price pressures. The solution of the model is also discussed. Sections 5 and 6 illustrate its properties by considering the macroeconomic and financial effects of a range of policy instruments, as well as domestic and foreign exogenous shocks. In both sections, the focus is mainly on the *qualitative* features of the results, and their consistency with well-established "stylized" facts, rather than the magnitude of these effects *per se*. To conclude the analysis, three extensions, related to reserve requirements, wage rigidity (as in Chapters 2 and 3), and heterogeneous inflation expectations, are briefly considered.

4.1. Core Assumptions

The model presented in this chapter shares the same core features of the closed- and open-economy models studied in the previous chapters. In particular, the loan rate is set as a premium over the cost of borrowing from the central bank, and the premium itself is a function of borrowers' collateralizable net worth. The supply of loans to firms and the provision of liquidity by the central bank to commercial banks are perfectly elastic at prevailing interest rates. Households hold foreign-currency deposits, which are imperfect substitutes for domestic deposits. Capital mobility is imperfect, implying that domestic interest rates are determined by domestic conditions, rather than developments abroad.

The central bank operates a managed float and intervenes on the spot market for foreign exchange to smooth fluctuations in the exchange rate. Intervention is sterilized by issuing bonds, which are held by commercial banks. Macroprudential policy takes again the form of a tax on loans and reserve requirements. Also as before, capital controls take the form of a tax on bank foreign borrowing. Naturally, the dynamic nature of the model presented in this chapter changes in fundamental ways how these features interact and affect the equilibrium of the economy.

In addition, the open-economy DSGE model presented in this chapter has the following characteristics. First, household decisions are based on an explicit intertemporal optimisation problem. The production structure now involves several types of goods – a final good, intermediate goods, and capital goods – and producers, who also solve optimisation problems. While the market for the final good is competitive, monopolistic competition prevails in the market for domestic intermediate goods.

Banks also solve an explicit optimisation problem, but while perfect competition prevails in the market for deposits, they compete in monopolistic fashion in the market for loans. Finally, the central bank operates an explicit

[1] The analysis dwells significantly on Agénor et al. (2014*a*, 2018*a*, 2020) and Agénor and Jia (2020).

interest rate rule, which in its basic form (referred to as a standard *Taylor rule*) relates changes in the refinance rate to deviations in inflation from its target and fluctuations in output.

4.2. The Model

Consider a small open economy populated by eight categories of agents: a continuum of households with unit mass; a continuum of intermediate goods-producing (IG) firms, or wholesalers, indexed by $j \in (0,1)$; a continuum of final good (FG) producers, or retailers, with unit mass; a continuum of capital good (CG) producers with unit mass; a continuum of commercial banks, indexed by $i \in (0,1)$; the government; the central bank; and a financial regulator. For simplicity, each household is matched to an IG producer, a CG producer, and a bank, and receives profits (if any) from them in lump-sum fashion.

The country produces a continuum of intermediate goods, which are imperfect substitutes for a continuum of imported intermediate products, using capital and labour. These goods are aggregated to produce a homogeneous, tradable final good. The treatment of imports as consisting only of intermediate goods is in line with the approach proposed by McCallum and Nelson (2000), as discussed in Chapter 1, and in line with the evidence on the role of global value chains in international trade. Capital and labour are not mobile internationally.

The final good is consumed by households and the government, used for investment (subject to additional costs) by CG producers, or exported. Monopolistic competition prevails in the market for domestic intermediate goods and each intermediate good is either produced or imported by a single firm. Producers of final goods and capital operate in competitive markets.

While the deposit market is competitive, monopolistic competition prevails in the credit market. This helps to illustrate, as in Chapters 2 and 3, how the possibility of default affects the pricing of loans. Specifically, the loan rate set by commercial banks incorporates a premium, above and beyond the marginal cost of funding from the central bank. In turn, the premium depends once again on collateral values (which fluctuate with real house prices) but also on cyclical output (which affects unit monitoring costs). Thus, through both channels, the model captures some of the financial amplification effects discussed in previous chapters. Domestic banks can borrow abroad (subject to a tax), but domestic firms can only borrow from domestic banks; they have no direct access to world capital markets.

4.2.1. Households

The representative household consumes the final good, demands housing services, supplies labour, and holds imperfectly substitutable domestic assets (cash, deposits, and government bonds) as well as non-contingent foreign bonds. The household's objective is to maximise

$$U_t = \mathbb{E}_t \sum_{s=0}^{\text{€}} f^{s} \left\{ \frac{C_{t+s}^{1-\varsigma^{-1}}}{1-\varsigma^{-1}} - \eta_N \frac{(\int_0^1 N_{t+s}^j dj)^{1+\psi_N}}{1+\psi_N} + \ln x_{t+s}^{\eta_x} + \ln H_{t+s}^{\eta_H} \right\}, \tag{4.1}$$

where C_t is final good consumption, N_t^j the number of hours of labour provided to IG producer j, x_t a composite index of real monetary assets, H_t the stock of housing, $\Lambda \in (0,1)$ the subjective discount factor, $\varsigma > 0$ the intertemporal elasticity of substitution in consumption, ψ_N the inverse of the Frisch elasticity of labour supply, and $\eta_N, \eta_x, \eta_H > 0$ are preference parameters.

Comment 4.1. As noted in Chapter 2, there is significant evidence that households may face liquidity constraints and therefore be unable to smooth consumption over time. DSGE models that account for liquidity-constrained (or *rule-of-thumb*) consumers include Gal 13053′f et al. (2004), Agénor et al. (2013), and Mohimont (2022).

The composite monetary asset is defined as a geometric average of real cash balances, m_t, and real bank deposits, d_t, both of which provide liquidity services:

$$x_t = m_t^{\nu} d_t^{1-\nu}, \tag{4.2}$$

where $\nu \in (0,1)$. Both m_t and d_t are measured in terms of the price of domestically produced final goods sold at home, P_t^D.

Comment 4.2. Both deposits and cash are accounted for in the model. Deposits are a key source of funding for banks, whereas (as discussed later on) the bond rate is solved from the equilibrium condition of the money market.

The household's flow budget constraint is

$$m_t + d_t + b_t + z_t B_t^F + p_t^H/ H_t \tag{4.3}$$

$$= \omega_t N_t - T_t - C_t + \frac{m_{t-1}}{1+\pi_t} + (\frac{1+i_{t-1}^D}{1+\pi_t})d_{t-1} + (\frac{1+i_{t-1}^B}{1+\pi_t})b_{t-1}$$

$$+(1+i_{t-1}^{FB})z_t B_{t-1}^F + J_t^B + J_t^I + \Omega_t^H,$$

where $N_t = \int_0^1 N_t^j dj$ is total labour hours, $z_t = E_t / P_t^D$ is the real exchange rate (with E_t the nominal exchange rate), p_t^H the real price of housing, $1+\pi_t = P_t^D / P_{t-1}^D$, b_t (B_t^F) real (foreign-currency) holdings of one-period, non-contingent domestic (foreign) government bonds, i_t^D the interest rate on bank deposits, i_t^B and i_t^{FB} interest rates on domestic and foreign government bonds, respectively, ω_t the economy-wide real wage (measured in terms of the price of final goods sold domestically), T_t real lump-sum taxes, and J_t^B and J_t^I profits (if any) of the matched IG producer and commercial bank, respectively. For simplicity, housing does not depreciate and domestic government bonds are held only at home.

Comment 4.3. The definition of the real exchange rate assumes that the foreign-currency price of final goods sold on markets abroad is normalized to unity. Note also that B_t^F is measured in foreign-currency terms.

The rate of return on foreign bonds (measured in foreign-currency terms) is defined as

$$1+i_t^{FB} = (1+i_t^*)(1-\theta_t^{FB}), \tag{4.4}$$

where i_t^* is the risk-free world interest rate and θ_t^{FB} a financial intermediation cost (which may also reflect official restrictions on cross-border financial transactions), defined as

$$\theta_t^{FB} = \frac{\theta_0^{FB}}{2} B_t^F, \tag{4.5}$$

with $\theta_0^{FB} > 0.$ Thus, the cost of acquiring foreign bonds is increasing in the amount of bonds held.[2]

Comment 4.4. Gabaix and Maggiori (2015), Cavallino (2019), and Itskhoki and Mukhin (2021) have developed more elaborate micro-founded models of the foreign exchange market in the presence of financial frictions. In these models, intermediaries are credit constrained, as creditors recognize the possibility that financiers may divert funds. Adrian et al. (2022*a*) also adopt a related specification.

The representative household chooses sequences of consumption, $\{C_{t+s}\}_{s=0}^{€}$, labour, $\{N_{t+s}^j\}_{s=0}^{€}$, $j \in (0,1)$, cash, $\{m_{t+s}\}_{s=0}^{€}$, deposits, $\{d_{t+s}\}_{s=0}^{€}$, domestic bonds, $\{b_{t+s}\}_{s=0}^{€}$, foreign bonds, $\{B_{t+s}^F\}_{s=0}^{€}$, and housing services, $\{H_{t+s}\}_{s=0}^{€}$, so as to maximise (4.1) subject to (4.2) to (4.5), taking the path of domestic interest rates (i_t^B and i_t^D), the world risk-free rate (i_t^*), prices and inflation (ω_t, p_t^H, z_t, and $_t$), and all lump-sum transfers and taxes (J_t^B, J_t^I, J_t^K, and T_t), as given. The Lagrangian for this problem, $\mathcal{L}_t^H$, can be written as:

$$\mathcal{L}_t^H = \mathbb{E}_t \sum_{s=0}^{€} f^s \left\{ \frac{C_{t+s}^{1-\varsigma^{-1}}}{1-\varsigma^{-1}} - \frac{\eta_N}{1+\psi_N}(\int_0^1 N_{t+s}^j dj)^{1+\psi_N} + \ln x_{t+s}^{\eta_x} + \ln H_{t+s}^{\eta_H} \right.$$

$$-\lambda_{t+s}\left[m_{t+s} + d_{t+s} + b_{t+s} + z_{t+s}B_{t+s}^F + p_{t+s}^H/ H_{t+s} - \omega_{t+s}N_{t+s} \right.$$

$$+T_{t+s} + C_{t+s} - \frac{m_{t+s-1}}{1+\pi_{t+s}} - (\frac{1+i_{t+s-1}^D}{1+\pi_{t+s}})d_{t+s-1} - (\frac{1+i_{t+s-1}^B}{1+\pi_{t+s}})b_{t+s-1}$$

[2] It is also assumed implicitly that this cost is rebated to households through a lump-sum transfer and thus do not represent a resource cost to the economy.

$$-(1+i^*_{t+s-1})z_{t+s}[B^F_{t+s-1}-\frac{\theta_0^{FB}}{2}(B^F_{t+s-1})^2]-J^B_{t+s}-J^I_{t+s}-J^K_{t+s}\Bigg]\Bigg\},$$

where λ_t is the Lagrange multiplier associated with the household budget constraint, which is equivalent to the marginal utility of an additional unit of resources.

The first-order conditions are

$$\frac{\partial \mathcal{L}_t^H}{\partial C_t}: C_t^{-1/\varsigma}-\lambda_t=0, \tag{4.6}$$

$$\frac{\partial \mathcal{L}_t^H}{\partial N_t^j}: \eta_N(N_t^j)^{\psi_N}=\lambda_t\omega_t, \quad \forall j\in(0,1) \tag{4.7}$$

$$\frac{\partial \mathcal{L}_t^H}{\partial m_t}: \frac{\eta_x\nu}{m_t}-\lambda_t+f\,\mathbb{E}_t(\frac{\lambda_{t+1}}{1+\pi_{t+1}})=0, \tag{4.8}$$

$$\frac{\partial \mathcal{L}_t^H}{\partial d_t}: \frac{\eta_x(1-\nu)}{d_t}-\lambda_t+f\,\mathbb{E}_t\left\{\lambda_{t+1}(\frac{1+i_t^D}{1+\pi_{t+1}})\right\}=0, \tag{4.9}$$

$$\frac{\partial \mathcal{L}_t^H}{\partial H_t}: \frac{\eta_H}{H_t}-\lambda_t p_t^H+f\,\mathbb{E}_t(\lambda_{t+1}p_{t+1}^H)=0, \tag{4.10}$$

$$\frac{\partial \mathcal{L}_t^H}{\partial b_t}: -\lambda_t+f\,\mathbb{E}_t\left\{\lambda_{t+1}(\frac{1+i_t^B}{1+\pi_{t+1}})\right\}=0, \tag{4.11}$$

$$\frac{\partial \mathcal{L}_t^H}{\partial B_t^F}: -\lambda_t z_t+(1+i_t^*)f\,\mathbb{E}_t[\lambda_{t+1}z_{t+1}(1-\theta_0^{FB}B_t^F)]=0, \tag{4.12}$$

for $t=0,1,...€$ and $\forall j\in(0,1)$, together with the sequence of budget constraints (4.5) and the transversality conditions

$$\lim_{s\to\infty}\mathbb{E}_{t+s}f^{\,s}\lambda_{t+s}b_{t+s}=\lim_{s\to\infty}\mathbb{E}_{t+s}f^{\,s}\lambda_{t+s}B^F_{t+s}=0.$$

From (4.11),

$$\lambda_t=f\,\mathbb{E}_t[\lambda_{t+1}(\frac{1+i_t^B}{1+\pi_{t+1}})]. \tag{4.13}$$

Combining equations (4.6) and (4.13) yields the standard Euler equation:

$$C_t^{-1/\varsigma}=f\,\mathbb{E}_t\left\{C_{t+1}^{-1/\varsigma}(\frac{1+i_t^B}{1+\pi_{t+1}})\right\}, \tag{4.14}$$

which states that, at the optimum, households cannot gain from shifting consumption across periods. A one-unit reduction in period-t consumption lowers utility by $C_t^{-1/\varsigma}$. The same unit saved in period t can be converted through the bond market into $\mathbb{E}_t(1+i_t^B)/(1+\pi_{t+1})$ of period-$t+1$ consumption, raising utility by $\mathbb{E}_t[(1+i_t^B)(1+\pi_{t+1})^{-1}C_{t+1}^{-1/\varsigma}]$; this is discounted back to the present by f.

Using (4.6) to substitute out for λ_t in (4.7) yields, in a symmetric equilibrium,

$$N_t=(\frac{\omega_t C_t^{-1/\varsigma}}{\eta_N})^{1/\psi_N}, \tag{4.15}$$

which relates labour supply positively to the real wage and negatively to consumption.

Substituting (4.6) and (4.11) in (4.8) and (4.9) yields the demand functions for cash and deposits:

$$m_t = \frac{\eta_x \nu C_t^{1/\varsigma}(1+i_t^B)}{i_t^B}, \tag{4.16}$$

$$d_t = \frac{\eta_x (1-\nu) C_t^{1/\varsigma}(1+i_t^B)}{i_t^B - i_t^D}. \tag{4.17}$$

Similarly, substituting (4.6) in (4.10) yields the intertemporal condition for housing services:

$$\frac{p_t^H}{C_t^{1/\varsigma}} = \frac{\eta_H}{H_t} + f\,\mathbb{E}_t\left(\frac{p_{t+1}^H}{C_{t+1}^{1/\varsigma}}\right), \tag{4.18}$$

which indicates that, at the margin, the benefit from consuming a flow of housing services must equate the cost in terms of foregone consumption.

Ignoring covariance terms, equation (4.13) can be written as

$$\mathbb{E}_t\left(\frac{f\lambda_{t+1}}{\lambda_t}\right) \simeq \mathbb{E}_t\left(\frac{1+\pi_{t+1}}{1+i_t^B}\right). \tag{4.19}$$

At the same time, equation (4.12) can be written as

$$1 = (1+i_t^*)\mathbb{E}_t\left[\left(\frac{f\lambda_{t+1}}{\lambda_t}\right)\left(\frac{z_{t+1}}{z_t}\right)(1-\theta_0^{FB}B_t^F)\right],$$

so that, substituting (4.19), and given the definition of z_t,

$$1 \simeq (1+i_t^*)\mathbb{E}_t\left[\left(\frac{1+\pi_{t+1}}{1+i_t^B}\right)\left(\frac{E_{t+1}}{P_{t+1}^D}\frac{P_t^D}{E_t}\right)(1-\theta_0^{FB}B_t^F)\right],$$

or again, given that $1+\pi_{t+1} = P_{t+1}^D / P_t^D$,

$$1+i_t^B \simeq (1+i_t^*)\mathbb{E}_t\left[\frac{P_{t+1}^D}{P_t^D}\left(\frac{E_{t+1}}{P_{t+1}^D}\frac{P_t^D}{E_t}\right)(1-\theta_0^{FB}B_t^F)\right].$$

This expression can be written as

$$1+i_t^B \simeq (1-\theta_0^{FB}B_t^F)(1+i_t^*)\mathbb{E}_t\left(\frac{E_{t+1}}{E_t}\right),$$

which relates the expected marginal rates of return on domestic and foreign assets under the assumption of imperfect world capital markets. It can be rearranged to give the demand for foreign bonds as

$$B_t^F \simeq \frac{(1+i_t^*)\mathbb{E}_t(E_{t+1}/E_t) - (1+i_t^B)}{\theta_0^{FB}(1+i_t^*)\mathbb{E}_t(E_{t+1}/E_t)}. \tag{4.20}$$

Equation (4.20) shows that optimal holdings of foreign bonds is a function of the difference between the expected, depreciation-adjusted world safe interest rate, and the domestic bond rate. Perfect capital mobility prevails when $\theta_0^{FB} \to 0$, in which case

$$1+i_t^B \simeq (1+i_t^*)\mathbb{E}_t(E_{t+1}/E_t).$$

This equation corresponds to the standard uncovered interest parity condition under risk neutrality.

4.2.2. Final Good Producers

The representative FG producer imports a continuum of differentiated intermediate goods from the rest of the world and combines them with a similar continuum of domestically produced intermediate goods to generate a final good, in quantity Y_t, which is sold both at home and abroad:

$$Y_t = [f_I (Y_t^I)^{(\eta-1)/\eta} + (1-f_I)(Y_t^F)^{(\eta-1)/\eta}]^{\eta/(\eta-1)}, \tag{4.21}$$

where Y_t^I (Y_t^F) is a quantity index of domestic (imported) intermediate goods, $\Lambda_I \in (0,1)$ a measure of home bias (with $\Lambda_I \to 1$ corresponding to an economy closed to trade), and $\eta > 0$ the elasticity of substitution between baskets of domestic and imported composite intermediate goods. These baskets are defined as

$$Y_t^h = \left\{ \int_0^1 (Y_t^{h,j})^{(\theta_h - 1)/\theta_h} dj \right\}^{\theta_h/(\theta_h - 1)}, \quad h = I, F. \tag{4.22}$$

where $\theta_h > 1$ is the elasticity of substitution between intermediate domestic goods among themselves ($h = I$), and imported goods among themselves ($h = F$), and $Y_t^{h,j}$ is the quantity of type-j intermediate good of category h (domestic or imported), with $j \in (0,1)$.

Comment 4.5. For simplicity, the number of domestic and imported intermediate goods is the same and normalized to unity. For a more general specification of the production of final goods, which nests the Dixit-Stiglitz specification used in (4.21) as a special case, see Adrian et al. (2022).

FG producers sell their output at a perfectly competitive price. In the first stage, the representative producer solves for the demand functions for each variety of domestic and imported intermediate goods, $Y_t^{h,j}$, taking as given their domestic-currency price $P_t^{h,j}$, as well as the aggregate quantities of these goods, Y_t^h, and their domestic-currency prices, P_t^h, for $h = I, F$.

Let profits be defined as $P_t^h Y_t^h - \int_0^1 P_t^{h,j} Y_t^{h,j} dj$; using (4.22), the solution of the first-stage problem is thus determined by

$$Y_t^{h,j} = \operatorname{argmax} \left[P_t^h \left\{ \int_0^1 (Y_t^{h,j})^{(\theta_h - 1)/\theta_h} dj \right\}^{\theta_h/(\theta_h - 1)} - \int_0^1 P_t^{h,j} Y_t^{h,j} dj \right],$$

which gives the demand functions for each variety of both types of intermediate goods:

$$Y_t^{h,j} = \left(\frac{P_t^{h,j}}{P_t^h}\right)^{-\theta_h} Y_t^h, \quad h = I, F. \tag{4.23}$$

Competition implies that FG producers make zero profits; thus,

$$P_t^h Y_t^h = \int_0^1 P_t^{h,j} Y_t^{h,j} dj. \tag{4.24}$$

Inserting (4.24) in (4.23) yields the price indices for domestically produced and imported intermediate goods:

$$P_t^h = \left\{ \int_0^1 (P_t^{h,j})^{1-\theta_h} dj \right\}^{1/(1-\theta_h)}. \quad h = I, F. \tag{4.25}$$

In the second stage, the representative FG producer chooses the aggregate quantities of each type of intermediate goods, Y_t^h, so as to maximise its profits:

$$Y_t^I, Y_t^F = \operatorname{argmax}(P_t Y_t - P_t^I Y_t^I - P_t^F Y_t^F),$$

where P_t is the price of final output. Using (4.21), the allocation of total demand between domestic and foreign goods is thus given by

$$Y_t^I = f_I^{\eta} \left(\frac{P_t^I}{P_t}\right)^{-\eta} Y_t, \quad Y_t^F = (1-f_I)^{\eta} \left(\frac{P_t^F}{P_t}\right)^{-\eta} Y_t. \tag{4.26}$$

Given perfect competition, the zero-profit condition is now $P_tY_t = P_t^IY_t^I + P_t^FY_t^F$. Substituting (4.26) in that expression and simplifying gives

$$P_t = f_I^{\eta}\frac{(P_t^I)^{1-\eta}}{P_t^{-\eta}} + (1-f_I)^{\eta}\frac{(P_t^F)^{1-\eta}}{P_t^{-\eta}},$$

which, after rearranging, gives the price of the final good as

$$P_t = [f_I^{\eta}(P_t^I)^{1-\eta} + (1-f_I)^{\eta}(P_t^F)^{1-\eta}]^{1/(1-\eta)}. \tag{4.27}$$

Producer currency pricing prevails; prices are therefore set in the sellers' currency. The domestic-currency price of imports of intermediate good j is thus given by

$$P_{jt}^F = E_t^{\mu^F}E_{t-1}^{1-\mu^F}WP_{jt}^F, \tag{4.28}$$

where WP_{jt}^F is the foreign-currency price of imported good j, assumed exogenous. Imperfect exchange rate pass-through is accounted for in simple fashion by introducing in (4.28) a weighted average of the exchange rate at t and $t-1$, with $\mu^F \in (0,1)$. Thus, $\mu^F = 1$ corresponds to complete pass-through. Regardless of the value of μ^F, in the long run full pass-through occurs and the law of one price holds.

Comment 4.6. A more rigorous (micro-founded) specification to account for imperfect exchange rate pass-through is to introduce a group of retail firms (importers), who buy differentiated intermediate goods on world markets at competitive prices and operate domestically as monopolistic competitors. Importers would then choose their prices in local currency, subject to an adjustment cost. Market power in that sector would result in incomplete pass-through. See, for instance, Monacelli (2005) and Christiano et al. (2011).

The volume of goods sold abroad, Y_t^X, depends on the domestic-currency price of exports of the final good on world markets, P_t^X, relative to the price of domestic goods sold at home:

$$Y_t^X = \left(\frac{P_t^X}{P_t^D}\right)^{\varkappa_X}, \tag{4.29}$$

where $\varkappa_X > 0$. In similar fashion to (4.28), the domestic-currency price of exports is given by

$$P_t^X = E_t^{\mu^X}E_{t-1}^{1-\mu^X}WP_t^X, \tag{4.30}$$

where $\mu^X \in (0,1)$ and WP_t^X denotes the foreign-currency price of exports. As in (4.28), to capture imperfect pass-through the domestic-currency price of exports is assumed to depend on both the current and past values of the nominal exchange rate.

Total output in volume terms is also given by

$$Y_t = Y_t^D + Y_t^X, \tag{4.31}$$

where Y_t^D denotes the volume of domestically-produced final goods sold at home or, equivalently, domestic absorption.

4.2.3. Intermediate Goods Producers

Domestic IG firms, indexed by $j \in (0,1)$, produce intermediate goods by combining labour, N_t^j, and capital, K_t^j,

$$Y_t^{I,j} = \varepsilon_t^I(N_t^j)^{1-\alpha}(K_t^j)^{\alpha}, \tag{4.32}$$

where $\alpha \in (0,1)$ and ε_t^I is a common technology shock, which follows a stationary log-linear first-order autoregressive process:

$$\ln\varepsilon_t^I = \rho^I\ln\varepsilon_{t-1}^I + \xi_t^I, \tag{4.33}$$

with $\rho^I \in (0,1)$ and $\xi_t^I \sim iid(0,\sigma_{\xi^I}^2)$.

Comment 4.7. The analysis could be extended to account for the fact that the production of domestic intermediates also requires the use of imported intermediate goods, such as oil and gas.

Each IG producer rents capital from a randomly matched CG producer, at the rate r_t^K. In addition, a fraction $\psi_W \in (0,1)$ of wages must be paid in advance. To do so firm j borrows the amount $l_t^{W,j}$ from banks. The amount borrowed is therefore equal to

$$l_t^{W,j} = \psi_W \omega_t N_t^j. \tag{4.34}$$

Working capital loans contracted do not carry any risk, and are made (as in previous chapters) at a rate that reflects only the marginal cost of borrowing from the central bank, i_t^R. Total labour costs are thus $\psi_W i_t^R \omega_t N_t^j + (1-\psi_W)\omega_t N_t^j = (1+\psi_W i_t^R)\omega_t N_t^j$, and total costs of firm j in period t, TC_t^j, are given by

$$TC_t^j = (1+\psi_W i_t^R)\omega_t N_t^j + r_t^K K_t^j.$$

IG producers solve a two-stage problem. In the first stage, taking input prices as given, they rent labour and capital in perfectly competitive factor markets so as to minimize the real cost of producing one unit of good. Thus, this static optimisation problem can be specified as

$$N_t^j, K_t^j = \text{argmin}[(1+\psi_W i_t^R)\omega_t N_t^j + r_t^K K_t^j],$$

subject to (4.32) with $Y_t^j = 1$.

The Lagrangian for this problem can be written as

$$\mathcal{L}_t^I = (1+\psi_W i_t^R)\omega_t N_t^j + r_t^K K_t^j + \lambda_t^I[1 - A_t^I (K_t^j)^{\alpha} (N_t^j)^{1-\alpha}],$$

where λ_t^I is the Lagrange multiplier associated with (4.32). The first-order conditions equate the marginal product of capital and labour to their relative price, $\forall j$:

$$\frac{\partial \mathcal{L}_t^I}{\partial N_t^j} : (1-\alpha)\frac{Y_t^j}{N_t^j}\lambda_t^I = (1+\psi_W i_t^R)\omega_t, \tag{4.35}$$

$$\frac{\partial \mathcal{L}_t^I}{\partial K_t^j} : \alpha \frac{Y_t^j}{K_t^j}\lambda_t^I = r_t^K. \tag{4.36}$$

Dividing (4.35) by (4.36) yields

$$N_t^j = \left(\frac{1-\alpha}{\alpha}\right)\left[\frac{r_t^K}{(1+\psi_W i_t^R)\omega_t}\right] K_t^j. \tag{4.37}$$

Substituting this result in the constraint $Y_t^j = 1$ yields, using (4.32),

$$A_t^I \left(\frac{1-\alpha}{\alpha}\right)^{1-\alpha} \left\{\left[\frac{r_t^K}{(1+\psi_W i_t^R)\omega_t}\right] K_t^j\right\}^{1-\alpha} (K_t^j)^{\alpha} = 1,$$

which can be solved for K_t^j:

$$K_t^j = \frac{1}{A_t^I}\left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha}\left[\frac{(1+\psi_W i_t^R)\omega_t}{r_t^K}\right]^{1-\alpha}. \tag{4.38}$$

In turn, substituting this result in (4.37) gives

$$N_t^j = \frac{1}{A_t^I}\left(\frac{\alpha}{1-\alpha}\right)^{-\alpha}\left[\frac{(1+\psi_W i_t^R)\omega_t}{r_t^K}\right]^{-\alpha}. \tag{4.39}$$

Dividing (4.38) by (4.35) shows that the optimal capital-labour ratio varies inversely with the effective wage-capital rental rate ratio:

$$\frac{K_t^j}{N_t^j} = \left(\frac{\alpha}{1-\alpha}\right)\left[\frac{(1+\psi_W i_t^R)\omega_t}{r_t^K}\right]. \tag{4.40}$$

Marginal cost can be defined as

$$mc_t^j = \frac{(1+\psi_W i_t^R)\omega_t N_t^j + r_t^K K_t^j}{Y_t^j}.$$

Substituting for Y_t^j from (4.32) yields

$$mc_t^j = \left\{(1+\psi_W i_t^R)\omega_t \left(\frac{K_t^j}{N_t^j}\right)^{-\alpha} + r_t^K \left(\frac{K_t^j}{N_t^j}\right)^{1-\alpha}\right\}\frac{1}{A_t^j},$$

that is, using (4.40), and rearranging,

$$mc_t^j = \frac{1}{A_t^j}\left(\frac{r_t^K}{\alpha}\right)^{\alpha}\left[\frac{(1+\psi_W i_t^R)\omega_t}{1-\alpha}\right]^{1-\alpha}. \tag{4.41}$$

In the second stage, each IG producer chooses a sequence of prices $P_t^{I,j}$ so as to maximise discounted real profits. As in Rotemberg (1982), they all incur a cost in adjusting prices, of the form

$$PAC_t^j = \frac{\phi_I}{2}\left(\frac{P_t^{I,j}}{P_{t-1}^{I,j}} - 1\right)^2 Y_t, \tag{4.42}$$

where $\phi_I \geq 0$ is an adjustment cost parameter, or, equivalently, a measure of the degree of price stickiness. The price adjustment cost makes each IG producer's problem dynamic; rather than maximising its profits period-by-period, each firm acts to maximise its total market value. At the same time, specification (4.42) ensures that this cost is zero in the steady state, when $P_t^{I,j} = P_{t-1}^{I,j}$.

Comment 4.8. An alternative approach to formalizing price stickiness in DSGE models is the Calvo-Yun approach. See, for instance, Christiano et al. (2010*b*) for a discussion, and Agénor (2020, Chapter 4) for a comparison with the Rotemberg approach.

Real profits of IG producer j, $J_t^{I,j}$, can be defined as

$$J_t^{I,j} = \left(\frac{P_t^{I,j}}{P_t^I}\right)Y_t^{I,j} - mc_t^j Y_t^{I,j} - PAC_t^j,$$

where $mc_t^j Y_t^j$ represents total production costs.

The dynamic, second-stage optimisation problem is thus

$$\{P_{t+s}^j\}_{s=0}^{\infty} = \arg\max \mathbb{E}_t\left[\sum_{s=0}^{\infty} \beta^s \lambda_{t+s} J_{jt+s}^{I,j}\right],$$

subject to constraint (4.23) with $h = I$ on $Y_t^{I,j}$.

Comment 4.9. Because IG firms are owned by households (to whom they transfer their profits, if any), the firm's discount factor for period-$t+s$ profits is $\beta^s \lambda_{t+s}$, where from (4.6) $\lambda_{t+s} = C_{t+s}^{-1/\varsigma}$ can be viewed as the marginal utility value (in terms of consumption of the final good) of an additional currency unit of profits at $t+s$.

Taking $\{mc_{t+s}\}_{s=0}^{\infty}$, $\{P_{t+s}^I\}_{s=0}^{\infty}$, and $\{Y_{t+s}^D\}_{s=0}^{\infty}$ as given, and using (4.23) with $h = I$, the first-order condition for this maximisation problem is:

$$(1-\theta_I)(\frac{P_t^{I,j}}{P_t^I})^{-\theta_I} Y_t^I + \theta_I (\frac{P_t^{I,j}}{P_t^I})^{-\theta_I - 1} mc_t Y_t^I$$

$$-\phi_I \left\{ (\frac{P_t^{I,j}}{P_{t-1}^{I,j}} - 1) \frac{1}{P_{t-1}^{I,j}} \right\} Y_t + f\, \phi_I \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} (\frac{P_{t+1}^{I,j}}{P_t^{I,j}} - 1) \frac{P_{t+1}^{I,j}}{(P_t^{I,j})^2} Y_{t+1} \right\} = 0,$$

which determines the adjustment process of the nominal price $P_t^{I,j}$.

In a symmetric equilibrium, IG firms are identical; they produce the same output and choose the same price. Thus, $P_t^{I,j} = P_t^I$, for all $j \in (0,1)$. Equation (4.41) becomes, with $1+\pi_t^I = P_t^I / P_{t-1}^I$,

$$1-\theta_I + \theta_I mc_t - \phi_I \pi_t^I (1+\pi_t^I) + f\, \phi_I \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \pi_{t+1}^I (1+\pi_{t+1}^I)(\frac{Y_{t+1}}{Y_t}) \right\} = 0, \tag{4.43}$$

which determines the path of inflation in domestic intermediates. Note that inflation at t depends on its expected value at $t+1$. The reason is that a choice for $P_t^{I,j}$ today affects the menu costs that firms will incur tomorrow.

4.2.4. Capital Good Producers

The representative CG producer buys an amount I_t of the final good and combines it with the existing capital stock to produce new capital goods, K_{t+1}, which are leased to a randomly matched IG producer at the rate r_{t+1}^K. Capital accumulates as follows:

$$K_{t+1} = I_t + (1-\delta_K) K_t, \tag{4.44}$$

where $\delta_K \in (0,1)$ is the depreciation rate.

Investment goods are paid for in advance. To do so the representative CG producer borrows from banks, at the rate i_t^L, the amount

$$l_t^K = I_t. \tag{4.45}$$

Let $\kappa = \int_0^1 \kappa^i di \leq 1$, where $\kappa^i \in (0,1)$ is the fraction of the housing stock pledged as collateral to each bank *i*, and let $q_t \in (0,1)$ denote the repayment probability. Thus, if loans are repaid in full, an event that occurs with probability $q_t \in (0,1)$, the total cost faced by the CG producer at the end of period   is $(1+i_t^L) l_t^K$, whereas if there is default, which occurs with probability $1-q_t$, the CG producer loses the collateral that it pledged to secure the loan, $\kappa \mathbb{E}_t p_{t+1}^H H_t$; lenders have no claim on the residual income (if any) of the borrower.

Using these definitions, expected profits are defined as

$$\mathbb{E}_t J_{t+1}^K = \mathbb{E}_t (r_{t+1}^K K_{t+1}) - q_t (1+i_t^L) I_t \tag{4.46}$$

$$-(1-q_t)\kappa \mathbb{E}_t p_{t+1}^H H_t - \frac{-_K}{2} (\frac{I_t - \delta_K K_t}{K_t})^2 K_t,$$

where the last term is an increasing and convex capital adjustment cost, which depends on *net* investment, $I_t - \delta_K K_t$, and is measured in terms of units of current capital, with the parameter $-_K > 0$.

Comment 4.10. A specification of investment adjustment costs similar to the expression that appears in (4.46) is used in a number of contributions, including, for instance, Christensen and Dib (2008), Bailliu et al. (2015), De la Peña (2021), and Bahadir and Gumus (2022). However, several alternative specifications of these costs are also common, and the choice between them is not completely innocuous, in terms of its implications for the economy's response to shocks.

The representative CG firm chooses the level of investment, I_{t+s} and capital, K_{t+s+1}, $s = 0,...\text{€}$, so as to maximise the value of the discounted present value of profits, subject to (4.44), and taking $\{i^L_{t+s}\}^{\text{€}}_{s=0}$, $\{p^H_{t+s+1}\}^{\text{€}}_{s=0}$, $\{q_{t+s}\}^{\text{€}}_{s=0}$, and $\{r^K_{t+s+1}\}^{\text{€}}_{s=0}$ as given.[3] The Lagrangian for this problem can be written as

$$\mathcal{L}^K_t = \mathbb{E}_t \left\{ \sum_{s=0}^{\text{€}} f^s \lambda_{t+s} \left\{ r^K_{t+s+1} K_{t+s+1} - q_{t+s}(1+i^L_{t+s}) I_{t+s} - \right.\right.$$

$$-(1-q_{t+s})\kappa p^H_{t+s+1} H_{t+s}$$

$$\left.\left. -\frac{-_K}{2}\left(\frac{I_{t+s}}{K_{t+s}} - \delta_K\right)^2 K_{t+s} - p^K_{t+s}[K_{t+s+1} - (1-\delta_K)K_{t+s} - I_{t+s}] \right\}\right\},$$

where λ_{t+s} is defined in (4.6) and p^K_{t+s} is the shadow price of capital or, equivalently, the Lagrange multiplier on the period $t+s$ capital accumulation equation (4.44).

The first-order conditions are given by

$$\frac{\partial \mathcal{L}^K_t}{\partial I_t} : -\lambda_t q_t (1+i^L_t) - \lambda_t -_K \left(\frac{I_t}{K_t} - \delta_K\right) + \lambda_t p^K_t = 0,$$

$$\frac{\partial \mathcal{L}^K_t}{\partial K_{t+1}} : \lambda_t \mathbb{E}_t r^K_{t+1} - \lambda_t p^K_t + f\,\mathbb{E}_t \left\{ \lambda_{t+1} \left[-\frac{-_K}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta_K\right)^2 \right.\right.$$

$$\left.\left. --_K \left(\frac{I_{t+1}}{K_{t+1}} - \delta_K\right) K_{t+1} \left(-\frac{I_{t+1}}{K^2_{t+1}}\right) + p^K_{t+1}(1-\delta_K) \right]\right\} = 0.$$

These conditions can be rewritten as

$$p^K_t = q_t(1+i^L_t) + -_K\left(\frac{I_t}{K_t} - \delta_K\right), \tag{4.47}$$

$$\lambda_t \mathbb{E}_t r^K_{t+1} - \lambda_t p^K_t + f\,\mathbb{E}_t \left\{ \lambda_{t+1} \left[-\frac{-_K}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta_K\right)^2 \right.\right. \tag{4.48}$$

$$\left.\left. + -_K \left(\frac{I_{t+1}}{K_{t+1}} - \delta_K\right)\left(\frac{I_{t+1}}{K_{t+1}}\right) + p^K_{t+1}(1-\delta_K) \right]\right\} = 0.$$

Now, note that

$$-\frac{-_K}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta_K\right)^2 + -_K\left(\frac{I_{t+1}}{K_{t+1}} - \delta_K\right)\left(\frac{I_{t+1}}{K_{t+1}}\right)$$

$$= -\frac{-_K}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta_K\right)\left[\left(\frac{I_{t+1}}{K_{t+1}} - \delta_K\right) - 2\left(\frac{I_{t+1}}{K_{t+1}}\right)\right]$$

$$= \frac{-_K}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta_K\right)\left(\frac{I_{t+1}}{K_{t+1}} + \delta_K\right) = \frac{-_K}{2}\left[\left(\frac{I_{t+1}}{K_{t+1}}\right)^2 - \delta_K^2\right].$$

Thus, condition (4.48) can also be written as

$$p^K_t = \mathbb{E}_t r^K_{t+1} + \mathbb{E}_t \left\{ \frac{f\,\lambda_{t+1}}{\lambda_t} \left[\frac{-_K}{2}\left[\left(\frac{I_{t+1}}{K_{t+1}}\right)^2 - \delta_K^2\right] + p^K_{t+1}(1-\delta_K) \right] \right\}.$$

3 Holding the loan rate constant implies that the CG producer does not internalize the fact that the provision of collateral, all else equal, may reduce the cost at which it borrows. As a result, there is no "demand" for collateral *per se*. However, as shown next, the (expected) loan rate, which depends on collateral values, does affect the incentives to invest.

Further, from (4.13), $\mathbb{E}_t(f\lambda_{t+1}/\lambda_t) \simeq \mathbb{E}_t[(1+\pi_{t+1})/(1+i_t^B)]$. Substituting this result in the above expression yields

$$p_t^K \simeq \mathbb{E}_t r_{t+1}^K + \mathbb{E}_t\left\{(\frac{1+\pi_{t+1}}{1+i_t^B})\left[-_K[(\frac{I_{t+1}}{K_{t+1}})^2 - \delta_K^2] + p_{t+1}^K(1-\delta_K)\right]\right\}. \tag{4.49}$$

Equation (4.47) relates the investment-capital ratio, net of depreciation, to the shadow price of capital and today's expected loan rate. Equation (4.49) relates tomorrow's expected rate of return on capital to the current and future prices of capital, the expected future value of the investment-capital ratio, and the expected real bond rate.

Comment 4.11. Abstracting from borrowing in advance and (uncertain) repayment, and with no adjustment costs ($-_K = 0$), the shadow price of capital is $p_t^K = 1$, $\forall t$.[4] The rate of return to capital would then be $1 \simeq \mathbb{E}_t r_{t+1}^K + (\mathbb{E}_t\pi_{t+1} - i_t^B) + 1 - \delta_K$, or equivalently $\mathbb{E}_t r_{t+1}^K - \delta_K \simeq i_t^B - \mathbb{E}_t\pi_{t+1}$, which implies that the CG firm invests up to the point where the (expected) rental rate of the resulting capital, adjusted for depreciation, is equal to the opportunity cost of investing, as measured by the (expected) real interest rate on government bonds.

4.2.5. Commercial Banks

Banks borrow not only from the central bank (as in previous chapters) but also on world capital markets. Due to "original sin" (see Eichengreen et al. (2007)) they can only borrow in foreign currency, and there are no markets that allow them to hedge against the foreign exchange risk that they incur as a result. At the end of each period, banks receive interest income from IG and CG producers, repay with interest household deposits and the liquidity borrowed from the central bank, and redeem in full their foreign debt. All profits (if any) are then distributed, books are closed, and operations start anew at the beginning of the next period.

Bank i's balance sheet is thus

$$l_t^i + b_t^{CB,i} + RR_t^i = d_t^i + z_t L_t^{FB,i} + l_t^{B,i} + V_t^i, \tag{4.50}$$

where l_t^i represents total loans, $b_t^{CB,i}$ holdings of sterilization bonds issued by the central bank, $L_t^{FB,i}$ foreign borrowing (in foreign-currency terms), V_t^i bank capital, and RR_t^i denotes required reserves held at the central bank, which do not pay interest and are set as a fraction of deposits:

$$RR_t^i = \mu d_t^i, \tag{4.51}$$

where $\mu \in (0,1)$ is again the required reserve ratio. Total loans consist of investment and working capital loans:

$$l_t^i = l_t^{K,i} + l_t^{W,i}. \tag{4.52}$$

Capital requirements are a fixed fraction of investment loans (the only type of risky assets in this setting), so that

$$V_t^i = \rho^D l_t^{K,i}, \tag{4.53}$$

where $\rho^D \in (0,1)$ represents the capital adequacy ratio.

Comment 4.12. Explicit accounts in medium-scale DSGE models of bank capital requirements, the channels through which bank capital affects the supply of credit, countercyclical capital buffers (in line with the Basel III arrangement), and interactions between the optimal setting of these buffers and monetary policy are discussed in a number of contributions, including Agénor et al. (2012, 2013), Cozzi et al. (2021), and Agénor and Jackson (2022).

The market for deposits is competitive, and deposits and central bank liquidity are perfect substitutes. This ensures therefore that, $\forall i$, the following no-arbitrage condition holds:

$$i_t^{D,i} = (1-\mu)i_t^R, \tag{4.54}$$

where i_t^R is the refinance rate.

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[4] Abstracting from borrowing and (uncertain) repayment, but with $-_K > 0$, the first term in equation (4.47) would be replaced by 1. The equation could therefore be rewritten as $I_t / K_t = \delta_K + -_K^{-1}(p_t^K - 1)$, which is a standard result.

By contrast, monopolistic competition prevails in the loan market. Specifically, the amount borrowed by the representative capital good producer, l_t^K, is a Dixit-Stiglitz basket of differentiated loans, each supplied by a bank i, with an elasticity of substitution $\zeta^L > 1$:

$$l_t^K = [\int_0^1 (l_t^{K,i})^{(\zeta^L-1)/\zeta} di]^{\zeta^L/(\zeta^L-1)}.$$

The demand for type-i loan, $l_t^{K,i}$, is thus given by the downward-sloping curve

$$l_t^{K,i} = (\frac{1+i_t^{L,i}}{1+i_t^L})^{-\zeta^L} l_t^K, \tag{4.55}$$

where $i_t^{L,i}$ is the rate on the loan extended by bank i, and the aggregate loan rate is defined as

$$1+i_t^L = [\int_0^1 (1+i_t^{L,i})^{1-\zeta^L} di]^{1/(1-\zeta^L)}.$$

Bank i's expected profits at end of period t (or beginning of $t+1$) are defined as

$$\mathbb{E}_t J_{t+1}^{B,i} = q_t^i(1+i_t^{L,i})(1-\tau_t^C)l_t^{K,i} + (1-q_t^i)\kappa^i \mathbb{E}_t p_{t+1}^H H_t \tag{4.56}$$

$$+(1+i_t^{CB})b_t^{CB,i} + \mu d_t^i - (1+i_t^{D,i})d_t^i - (1+i_t^R)l_t^{B,i} - (1+i_t^{FC,i})\mathbb{E}_t(\frac{E_{t+1}}{E_t})z_t L_t^{FB,i}$$

$$-\Gamma(l_t^{K,i}, b_t^{CB,i}) + \Omega_t^{C,i} - x_t^{M,i},$$

where i_t^{CB} is the interest rate on central bank bonds, $\tau_t^C \in (0,1)$ the tax rate on the gross value of domestic loans imposed for macroprudential reasons, and $i_t^{FC,i}$ the cost of borrowing on world capital markets, which is defined as

$$1+i_t^{FC,i} = (1+\tau_t^B)(1+i_t^*)(1+\theta_t^{FB,i}), \tag{4.57}$$

with $\tau_t^B \in (0,1)$ a capital control (or prudential tax) imposed by the central bank and $\theta_t^{FC,i}$ a financial intermediation cost which increases with the foreign-currency value of the amount borrowed:

$$\theta_t^{FC,i} = \frac{\theta_0^{FC}}{2} L_t^{FB,i}, \tag{4.58}$$

and with $\theta_0^{FC} > 0$.

Equation (4.58) defines expected profits as the difference between expected bank revenues, given by the sum of repayments on investment loans if there is no default, $q_t^i(1+i_t^{L,i})l_t^{K,i}$, the expected value of collateral seized in case of default, $(1-q_t^i)(\kappa^i \ {}_t p_{t+1}^H H_t)$, augmented by the income from holdings of central bank bonds and the value of reserves held at the central bank, μd_t^i, and bank expenses, given by the sum of interest payments on deposits, $(1+i_t^{D,i})d_t^i$, central bank borrowing, $(1+i_t^R)l_t^{B,i}$, and foreign borrowing, $(1+i_t^{FC,i})\mathbb{E}_t(E_{t+1}/E_t)z_t L_t^{FB,i}$, with the latter accounting for expected depreciation. The term $\Gamma(l_t^{K,i}, b_t^{CB,i})$ in that equation measures the nonseparable cost of managing loans and central bank bonds. The term $\Omega_t^{C,i}$ in (4.56) represents the proceeds of the loan tax and capital controls; in order to abstract from the fiscal effects of these policies, these proceeds are assumed to be rebated to banks in lump-sum fashion. The last term in that equation, $-x_t^{M,i}$, captures the (non-contingent) monitoring cost faced by bank i.

The function $\Gamma(l_t^{K,i}, b_t^{CB,i})$ is assumed to be strictly increasing and quasi-convex in its two arguments, so that $\Gamma_{l^K}, \Gamma_{b^{CB}} > 0$, $\Gamma_{l^K l^K}, \Gamma_{b^{CB} b^{CB}} \geq 0$; in addition, it is also assumed to be linearly homogeneous. By implication of linear homogeneity, $\Gamma_{l^K b^{CB}} \leq 0$, that is, higher holdings of central bank bonds lowers the cost of lending. There is therefore *cost complementarity* or *economies of scope*, that is, lower costs of managing assets than the sum of costs incurred when managing them individually.

As in Vargas et al. (2013), and Agénor et al. (2020), the function $\Gamma()$ is represented by the Diewert cost function:

$$\Gamma(l_t^{K,i}, b_t^{CB,i}) = \gamma_B b_t^{CB,i} + \gamma_L l_t^{K,i} - 2\gamma\sqrt{b_t^{CB,i} l_t^{K,i}}, \tag{4.59}$$

where $\gamma_B, \gamma_L, \gamma > 0$. To ensure that Γ_{l^K} and $\Gamma_{b^{CB}}$ are both positive requires that γ be less than γ_B and γ_L.

Each bank can affect the repayment probability on its loan to the representative CG producer, q_t^i, by expending effort; the higher the monitoring effort, the safer the loan.[5] As in Allen et al. (2011) and Dell'Ariccia et al. (2014), for instance, the probability of repayment itself, rather than monitoring effort *per se*, is taken to be the choice variable. Accordingly, the monitoring cost is defined as an increasing function of the repayment probability:

$$x_t^{M,i} = \Phi_t \frac{(q_t^i)^2}{2} l_t^{K,i}, \tag{4.60}$$

where Φ_t is a unit cost parameter, which itself depends on the economy's *average* collateral-loan ratio and the economy's cyclical output, $Y_t / \tilde{Y}$ (with $\tilde{Y}$ denoting the steady-state value of final production), and is therefore taken as given by each individual bank:

$$\Phi_t = (\frac{\kappa \mathbb{E}_t p_{t+1}^H / \tilde{p}^H}{l_t^K / \tilde{l}^K})^{-\Phi_1} (\frac{Y_t}{\tilde{Y}})^{-\Phi_2}, \tag{4.61}$$

with $\Phi_1, \Phi_2 > 0$, and a tilde (126) is used to denote steady-state values. Both variables have a negative effect on monitoring costs. First, a higher collateral-loan ratio mitigates moral hazard problems and induces borrowers to take less risk and exert more effort in ensuring that their investments are successful; in addition, it may induce them to be more compliant with bank monitoring requirements. There is therefore a negative relationship between collateral and a borrower's risk. Second, in boom times, when profits and cash flows are high, (unit) monitoring costs tend to fall, because borrowers are more diligent and the risk of default abates.[6]

Each bank determines the lending rate, the intensity of monitoring (or, equivalently, the repayment probability), foreign borrowing, and holdings of central bank bonds, so as to maximise expected profits (4.56) subject to (4.50)-(4.55), and (4.57)-(4.60). As shown in the Appendix to this chapter, the solution of the bank's optimisation problem in a symmetric equilibrium is

$$1 + i_t^L = \frac{\zeta^L}{(\zeta^L - 1)(1 - \tau_t^C) q_t} \left\{ 1 + i_t^R + \gamma_L - \gamma (\frac{b_t^{CB}}{l_t^K})^{0.5} \right\}, \tag{4.62}$$

$$l_t^{FB} = \frac{1 + i_t^R - (1 + \tau_t^B)(1 + i_t^*) \mathbb{E}_t (E_{t+1} / E_t)}{\theta_0^{FC} (1 + \tau_t^B)(1 + i_t^*) \mathbb{E}_t (E_{t+1} / E_t)}, \tag{4.63}$$

$$q_t = (\frac{\kappa \mathbb{E}_t p_{t+1}^H \bar{H}}{l_t^K})^{\Phi_1} (\frac{Y_t}{\tilde{Y}})^{\Phi_2} [(1 - \tau_t^C)(1 + i_t^L) - (\frac{\kappa \mathbb{E}_t p_{t+1}^H \bar{H}}{l_t^K})], \tag{4.64}$$

$$\frac{b_t^{CB}}{l_t^K} = \frac{\gamma^2}{(i_t^R + \gamma_B - i_t^{CB})^2}, \tag{4.65}$$

Equation (4.62) shows that the loan rate depends negatively on the repayment probability, and positively on the marginal cost of borrowing from the central bank and the macroprudential tax rate, τ .

Equation (4.63) states that foreign borrowing is decreasing in the (expected) cost of borrowing abroad, which accounts for the capital controls tax rate τ_t^B, and increasing in the cost of borrowing domestically from the central bank.

Equation (4.64) shows that, all else equal, a higher (tax-adjusted) loan rate, or a higher level of cyclical output, tends to increase incentives to monitor borrowers. Intuitively, as in Allen et al. (2011), for instance, a higher loan rate increases incentives to monitor because it raises the bank's pay-off if there is no default. Equation (4.64) also shows that the collateral-loan ratio exerts conflicting effects on monitoring effort and the repayment proba-

5 Importantly, monitoring is also desirable from the borrower's perspective.

6 See Agénor (2020, Chapter 4) for a further discussion.

bility. On the one hand, there is a negative, *hedging effect*, due to the fact that, by mitigating the loss that banks incur in case of default, collateral can induce them to monitor less – thereby reducing the probability of repayment. On the other, there is a positive, *disciplining effect*, which takes the form of reduced incentives for borrowers to take risks; this, in turn, tends to lower unit monitoring costs. In what follows, and consistent with the evidence that highlights the existence of a negative correlation between collateral and a borrower's risk, it is assumed that the latter effect dominates. Thus, the net effect of an increase in the collateral-loan ratio is to raise the probability of repayment.

Equation (4.65) shows that the ratio of central bank bonds over investment loans varies inversely with the differential between the refinance rate (augmented with the cost parameter γ_B) and the rate of return on these bonds. If economies of scope do not exist ($\gamma = 0$), $\tau_t^C = 0$, and ζ^L is large enough, equation (4.62) gives $q_t(1+i_t^L) \simeq 1+i_t^R+\gamma_L$, whereas equation (4.65) yields $i_t^{CB} = i_t^R + \gamma_B$; combining these two expressions yields $1+i_t^{CB}-\gamma_B = q_t(1+i_t^L)-\gamma_L$, which indicates that cost-adjusted, expected rates of return on loans and central bank bonds must be equal.[7] Thus, bank loans and holdings of central bank bonds are perfect substitutes and their ratio is indeterminate. As discussed further later on, in such conditions the bank portfolio channel is inoperative.

For the numerical analysis later on in this chapter and next, a more tractable specification of equation (4.64) is used. Specifically, it is replaced by

$$q_t = \varphi_0\left(\frac{\kappa \mathbb{E}_t p_{t+1}^H \bar{H} / \tilde{p}^H}{l_t^K / \tilde{l}^K}\right)^{\varphi_1}\left(\frac{Y_t}{\tilde{Y}}\right)^{\varphi_2}\left[\frac{(1-\tau_t^C)(1+i_t^L)}{1+\tilde{i}^L}\right]^{\varphi_3}, \tag{4.66}$$

where $\varphi_0 \in (0,1)$ and $\varphi_i \geq 0$, $i = 1,2,3$. This equation shows again that the repayment probability depends positively on the expected value of collateral relative to the volume of loans, the cyclical position of the economy, and the loan rate.

As in previous chapters, borrowing from the central bank, $l_t^{B,i}$, is determined residually from the balance sheet constraint of commercial banks, in this case equation (4.50).

4.2.6. Central Bank

As in previous chapters, the central bank supplies liquidity to commercial banks through a standing facility. It also operates a managed float regime and engages in sterilized intervention. Its balance sheet is given by

$$z_t R_t^F + l_t^B = m_t^s + b_t^{CB} + RR_t + nw_t, \tag{4.67}$$

where R_t^F denotes international reserves (measured in foreign-currency terms), m_t^s the supply of cash, b_t^{CB} bond liabilities, and nw_t the central bank's net worth.

As in Agénor et al. (2020), the intervention rule is specified as

$$R_t^F = (R_{t-1}^F)^{\varphi_1^R}\left[R_m^F\left(\frac{E_t}{E_t^T}\right)^{-\varphi_2^R}\right]^{1-\varphi_1^R}, \tag{4.68}$$

where $R_m^F > 0$ is an exogenous lower bound on official reserves, $\varphi_1^R \in (0,1)$ is the degree of persistence and $\varphi_2^R \geq 0$ the degree of exchange rate smoothing with respect to the target exchange rate, E_t^T.

Comment 4.13. As in Agénor et al. (2018), the intervention rule (4.68) could also depend on a reserve target, R_t^{FT}, which could be related to "trade" and "financial" motives and with self-insurance against trade shocks captured through an import coverage ratio, and to the *expected* exchange rate, $\mathbb{E}_t E_{t+1}$, rather than the current exchange rate.

Rule (4.68) combines two motives that are common in practice: leaning against exchange rate misalignment (given that in our parameterisation the steady-state exchange rate ensures current account equilibrium), and *leaning against the wind*. It is consistent with the evidence (discussed in previous chapters) which shows that MICs tend to intervene frequently and systematically in the foreign exchange market to stabilize currency fluctuations

[7] If the cost parameters are the same, this condition takes the standard form $1+i_t^{CB} = q_t(1+i_t^L)$.

– even under an inflation targeting regime, under which in principle the exchange rate should be allowed to float freely to avoid calling into question the preeminence and credibility of the inflation target.

The target exchange rate is defined as

$$E_t^T = E_{t-1}^{\phi^E} \tilde{E}^{1-\phi^E}, \tag{4.69}$$

where $\phi^E \in (0,1) > 0$ and $\tilde{E}$ is the steady-state value of the nominal exchange rate. A nominal depreciation, for instance, for a given target exchange rate, induces the central bank to sell foreign currency in the market for foreign exchange to strengthen the domestic currency. As a result, its stock of reserves falls. In the particular case where $\varepsilon_1^R = 1$, the stock of reserves remains constant over time and the exchange rate is fully flexible.

Comment 4.14. As in Lama and Medina (2020) and Adrian et al. (2022*b*), for instance, the intervention rule (4.68) and the exchange rate target (4.69) could be specified in terms of the *real* exchange rate, instead of the nominal rate.

The central bank adjusts its stock of bonds to sterilize the effects of its foreign exchange operations on the supply of cash:

$$b_t^{CB} - \frac{b_{t-1}^{CB}}{1+\pi_t} = \kappa^F z_t \Delta R_t^F, \tag{4.70}$$

where $\kappa^F \in (0,1)$ measures the degree of sterilization. Unsterilized intervention corresponds therefore to $\kappa^F = 0$.

Substituting (4.68) in (4.70), and the result in the loan rate equation (4.62), shows that sterilized intervention, in the presence of economies of scope, creates a channel through which exchange rate fluctuations may affect credit market conditions.

The interest income earned by the central bank is transferred in its entirety to the government. Thus, changes in the nominal value of the central bank's net worth, NW_t, depend only on capital gains associated with exchange rate depreciation ($\Delta NW_t = \Delta E_t R_t^F$). Using this result, taking first differences of (4.67), expressed in nominal terms, and substituting (4.70) in the resulting expression yields

$$m_t^s = \frac{m_{t-1}^s}{1+\pi_t} + (1-\kappa^F) z_t \Delta R_t^F + \left(l_t^B - \frac{l_{t-1}^B}{1+\pi_t}\right) - \left(RR_t - \frac{RR_{t-1}}{1+\pi_t}\right), \tag{4.71}$$

which shows that, with full sterilization ($\kappa^F = 1$), changes in the domestic-currency value of foreign-exchange reserves have no direct effect on the supply of cash.

Comment 4.15. In nominal terms, equation (4.67) can be written as $E_t R_t^F + L_t^B = M_t^s + B_t^{CB} + NW_t$. Taking first differences of this expression gives $\Delta E_t R_t^F + E_t \Delta R_t^F + \Delta L_t^B = \Delta M_t^s + \Delta B_t^{CB} + \Delta NW_t$. Setting $\Delta NW_t = \Delta E_t R_t^F$, and dividing by P_t^D yields $z_t \Delta R_t^F + \Delta L_t^B / P_t^D = (\Delta M_t^s + \Delta B_t^{CB}) / P_t^D$. Using (4.70), $P_{t-1}^D / P_t^D = 1/(1+\pi_t)$, and $\Delta X_t / P_t^D = x_t - (X_{t-1}/P_t^D)$ $= x_t - x_{t-1}/(1+\pi_t)$, for $X = L^B, M^s$, yields equation (4.71).

Comment 4.16. Because sterilization involves issuing high-yielding domestic liabilities while the foreign reserves that are accumulated as a counterpart earn typically a lower yield (the world risk-free interest rate), the central bank incurs a *quasi-fiscal cost* when it engages in sterilized operations. See Agénor et al. (2020) for a discussion.

The refinance rate is set through a Taylor-type rule with inertia:

$$\frac{1+i_t^R}{1+\tilde{i}^R} = \left(\frac{1+i_{t-1}^R}{1+\tilde{i}^R}\right)^{\chi^R} \left\{ \left(\frac{1+\pi_t}{1+\pi^T}\right)^{\varepsilon_1} \left(\frac{Y_t}{\tilde{Y}}\right)^{\varepsilon_2} \right\}^{1-\chi^R} \varepsilon_t^R, \tag{4.72}$$

where $\tilde{i}^R$ is the steady-state value of the refinance rate, $\pi^T \geq 0$ the central bank's inflation target, $\chi^R \in (0,1)$ a persistence parameter, $\varepsilon_1, \varepsilon_2 > 0$, and ε_t^T is a stochastic shock that follows a stationary log-linear first-order autoregressive process,

$$\ln \varepsilon_t^R = \rho_{\zeta R} \ln \varepsilon_{t-1}^R + \xi_t^R, \tag{4.73}$$

where $\rho_{\zeta R} \in (0,1)$ and $\xi_t^R \sim iid(0, \sigma_{\xi R}^2)$ is a serially uncorrelated random shock with zero mean.[8]

Comment 4.17. The output term in the Taylor rule (4.72) could take the form of the growth rate of output, Y_t / Y_{t-1}, which is commonly referred to as a *speed limit* policy.

4.2.7. Government

The government purchases the final good and issues nominal riskless one-period bonds, in quantity b_t, to finance its deficit; it does not borrow abroad. In addition to lump-sum taxes, it also receives the interest income collected by the central bank on its foreign reserves and its loans to commercial banks. It pays interest on the share of government debt held by the private sector. Its budget constraint is given by

$$b_t - \frac{b_{t-1}}{1+\pi_t} = G_t - T_t + \frac{i_{t-1}^B b_{t-1}}{1+\pi_t} \tag{4.74}$$

$$-z_t i_{t-1}^* R_{t-1}^F - \left(\frac{i_{t-1}^R l_{t-1}^B - i_{t-1}^{CB} b_{t-1}^{CB}}{1+\pi_t}\right) + \Gamma(l_t^K, b_t^{CB}),$$

where $z_t i_{t-1}^* R_{t-1}^F + (1+\pi_t)^{-1}(i_{t-1}^R l_{t-1}^B - i_{t-1}^{CB} b_{t-1}^{CB})$ the real value of net interest income earned by the central bank (transferred entirely to the government), and G_t real expenditure, which represents a fraction $\psi^G \in (0,1)$ of output of the final good:

$$G_t = \psi^G Y_t. \tag{4.75}$$

The intermediation cost $\Gamma(l_t^{K,i}, b_t^{CB,i})$ also appears in equation (4.74) because it is assumed to be a private resource cost for the banks, not a social cost. This assumption helps to keep the focus on the distortions introduced by economies of scope.

In what follows, it will be assumed that the government keeps its real stock of debt constant ($b_t = b$, for all t) and balances its budget by adjusting lump-sum taxes.

4.2.8. Financial Regulator

The financial regulator sets both the macroprudential tax rate, τ_t^L, and the capital controls levy, τ_t^B. Both are time-varying and defined in terms of a simple implementable rule.

Specifically, the macroprudential tax rate is related to an *operational target* for systemic risk, the credit growth rate. The focus on that variable is consistent with the evidence, discussed in Chapter 1, which suggests that fast credit expansions often lead to excessive leverage (by both lenders and borrowers), making the economy more vulnerable to negative shocks and fueling financial instability. It also reflects the assumption that inefficient credit fluctuations are not directly observable, which implies that, in practice, regulators can only adopt policies that are based on noisy indicators of financial risks. Specifically,

$$\frac{1+\tau_t^L}{1+\tilde{\tau}^L} = \left(\frac{1+\tau_{t-1}^L}{1+\tilde{\tau}^L}\right)^{\chi_1^L} Z_t^{\chi_2^L(1-\chi_1^L)}, \tag{4.76}$$

where $\chi_1^L \in (0,1)$ is a persistence parameter, $\chi_2^L > 0$ the response parameter to the trigger variable Z_t, which can be defined as either the credit growth rate or deviations in the loan-to-output ratio:[9]

$$Z_t = \frac{l_t^K}{l_{t-1}^K}, \quad Z_t = \frac{l_t^K / \tilde{l}^K}{Y_t / \tilde{Y}}.$$

8 Because (as noted in Chapter 1) sterilized intervention is the main instrument used by central banks in MICs to mitigate exchange rate fluctuations, the case where the exchange rate is targeted through an augmented interest rate rule is not considered. See Agénor and Pereira da Silva (2019, pp. 39-40) for a discussion of the evidence on this issue.

9 As is clear from (4.76), the response parameters do not affect the steady-state level of the macroprudential tax rate, only its cyclical properties.

Thus, from (4.62) and (4.76), borrowing is more costly when credit is growing (either in absolute terms or as a ratio to output), and this in turn helps to mitigate risks to financial stability.

Note that, in either definition of the trigger variable, what appears is not total credit but investment loans only, which contribute in the present setting to aggregate demand fluctuations, as opposed to working capital loans, which affect the supply side.[10] In addition, both definitions of the trigger variable imply that in equilibrium the macroprudential tax rate is constant at $\tilde{\tau}^L$.

Comment 4.18. In the model, households do not borrow directly from the banking system. Macroprudential policies taking the form of restrictions on borrowing (such as loan-to-value or debt-to-income ratios) cannot be analysed.

As in Agénor and Jia (2020), the countercyclical rule for the capital controls levy, τ_t^B, is defined as

$$\frac{1+\tau_t^B}{1+\tilde{\tau}^B} = (\frac{1+\tau_{t-1}^B}{1+\tilde{\tau}^B})^{\chi_1^B} \left\{ (\frac{L_t^{FB}}{L_{t-1}^{FB}})^{\chi_2^B} \right\}^{1-\chi_1^B}, \tag{4.77}$$

where $\chi_1^C \in (0,1)$ is a persistence parameter and $\chi_2^C \geq 0$ is the response parameter to changes in banks' foreign borrowing.

Specification (4.77) shows therefore that the purpose of capital controls is to *lean against* a buildup of foreign debt by domestic banks. It provides a useful benchmark for a normative analysis of the benefits associated with market-based restrictions on cross-border bank-related capital flows, using simple, implementable rules. Note also that, to the extent that it dampens the growth and volatility in banks' foreign-currency liabilities, and thus financial volatility, the tax is macroprudential in nature.

The main real and financial flows between agents are summarized in Figure 4.1.

4.2.9. Market-Clearing Conditions

In this economy, equilibrium conditions must be satisfied for the credit, deposit, final good, cash, labour, and housing markets. To ensure equilibrium in the final good market, sales at home of the domestically produced final good must be equal to domestic absorption, inclusive of price adjustment costs:

$$Y_t^D = C_t + G_t + I_t + \frac{-_K}{2}(\frac{I_t}{K_t} - \delta_K)^2 K_t + \frac{\phi_I}{2}(\frac{P_t^I}{P_{t-1}^I} - 1)^2 Y_t^I, \tag{4.78}$$

with the price of sales on the domestic market, P_t^D, determined through the identity

$$P_t Y_t = P_t^D Y_t^D + P_t^X Y_t^X. \tag{4.79}$$

Government bonds are in zero net supply and the equilibrium condition of the currency market is given by

$$m_t = m_t^s. \tag{4.80}$$

The equilibrium condition of the housing market is

$$\frac{H_t}{P_t^D} = \frac{P_t^H \bar{H}}{P_t^D}, \tag{4.81}$$

where $\bar{H}$ is the fixed supply of housing.

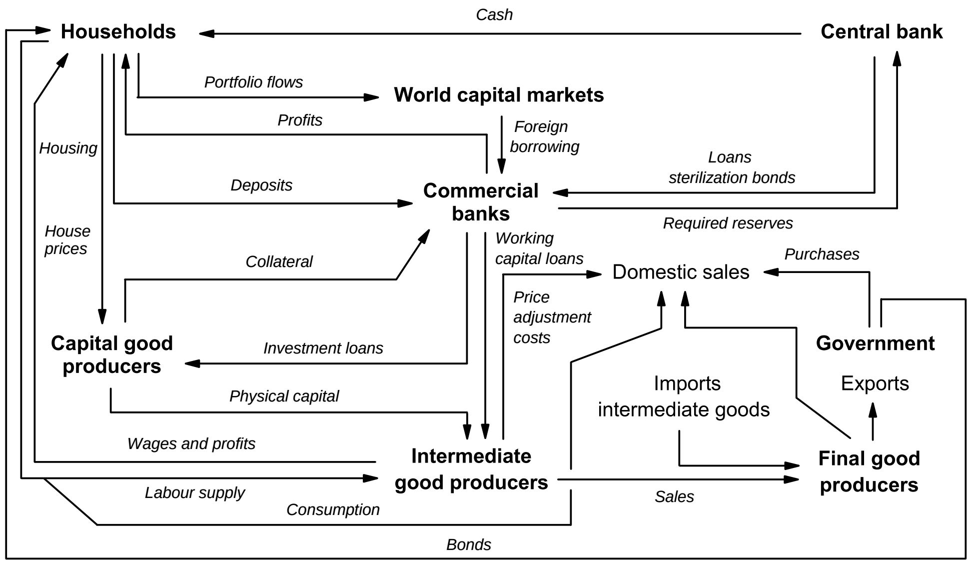
The equilibrium condition of the labour market is

$$(\frac{\omega_t C_t^{-1/\varsigma}}{\eta_N})^{1/\psi_N} = (\frac{\circ}{1-\alpha})^{-\circ}[\frac{(1+\psi_W i_t^R)\omega_t}{r_t^K}]^{-\circ}. \tag{4.82}$$

[10] In the benchmark parameterisation discussed later on, there are no working capital needs ($\psi_W = 0$); there is therefore no distinction between investment loans and total loans.

Structure of the DSGE Model with Managed Float

Figure 4.1



Source: Adapted from Agénor (2020, Chapter 7).

Finally, the balance of payments (or the equilibrium condition of the market for foreign exchange) is given by

$$WP_t^X Y_t^X - WP_t^F Y_t^F + i_{t-1}^* F_{t-1} - \theta_{t-1}^{FB} B_{t-1}^F - \theta_{t-1}^{FC} L_{t-1}^{FC} - / \ F_t = 0, \tag{4.83}$$

where $F_t = R_t^F + B_t^F - L_t^{FC}$ is the economy's net foreign asset position.

4.3. Equilibrium and Steady State

The key features of the steady-state solution of the model are as follows. Steady-state values are again denoted by tildes.

The monetary policy rule (4.72) implies that, in the steady state, inflation must be equal to its target value:

$$\tilde{\pi} = \pi^T.$$

Assuming that the target rate of inflation π^T is zero implies also that $\tilde{\pi} = 0$.

The steady-state value of the bond rate is determined by setting $C_t = C_{t+1}$ and $\tilde{\pi} = 0$ in (4.14). This gives

$$\tilde{i}^B = f^{-1} - 1. \tag{4.84}$$

To ensure that in equilibrium banks have no incentives to borrow from the central bank to purchase government bonds, the steady-state refinance rate must be equal to the bond rate:

$$\tilde{i}^R = \tilde{i}^B. \tag{4.85}$$

From (4.15), (4.16), (4.17), (4.18), and (4.20), the representative household's labour supply and demand for real cash balances, bank deposits, housing services, and foreign bonds are given by

$$\tilde{N} = (\frac{\tilde{\omega}(\tilde{C}^{-1/\varsigma}}{\eta_N})^{1/\psi_N},$$

$$\tilde{m} = \frac{\eta_x \nu \tilde{C}^{1/\varsigma}(1+\tilde{i}^B)}{\tilde{i}^B},$$

$$\tilde{d} = \frac{\eta_x(1-\nu)\tilde{C}^{1/\varsigma}(1+\tilde{i}^B)}{\tilde{i}^B - \tilde{i}^D},$$

$$\tilde{p}^H\bar{H} = \frac{{}_H\tilde{C}^{1/}}{1-f}.$$

$$\tilde{B}^F = \frac{\tilde{i}^* - \tilde{i}^B}{\theta_0^{FB}(1+\tilde{i}^*)}.$$

The last result implies that the steady-state value of the stock of foreign bonds held by the representative household is positive as long as the world risk-free interest rate exceeds the domestic bond rate. The greater the degree of imperfections on the world capital markets (the higher θ_0^{FB} is), the lower household holdings of foreign bonds are.

From (4.23) and (4.26)-(4.31), steady-state values of the demand for domestic and foreign intermediate goods, the price of final output, the price of foreign imported intermediate goods, the export price, exports, and production of the domestic final good are given by

$$\tilde{Y}^I = f_I^{\eta}(\frac{\tilde{P}^I}{\tilde{P}})^{-\eta}\tilde{Y}, \quad \tilde{Y}^F = (1-f_I)^{\eta}(\frac{\tilde{P}^F}{\tilde{P}})^{-\eta}\tilde{Y},$$

$$\tilde{P} = [f_I^{\eta}(\tilde{P}^I)^{1-\eta} + (1-f_I)^{\eta}(\tilde{P}^F)^{1-\eta}]^{1/(1-\eta)},$$

$$\tilde{P}^F = \tilde{E}WP^F,$$

$$\tilde{Y}^X = (\frac{\tilde{P}^X}{\tilde{P}^D})^{\varkappa},$$

$$\tilde{P}^X = \tilde{E}WP^X,$$

$$\tilde{Y} = \tilde{Y}^D + \tilde{Y}^X.$$

From (4.32), steady-state output of intermediate goods is given by

$$\tilde{Y}^I = \tilde{N}^{1-\circ}\tilde{K}^{\circ}.$$

From (4.34), the steady-state level of borrowing for working capital needs is

$$\tilde{l}^W = \psi_W\tilde{\omega}\tilde{N},$$

whereas from (4.40) the steady-state value of the capital-labour ratio is

$$\frac{\tilde{K}}{\tilde{N}} = (\frac{\circ}{1-\circ})[\frac{(1+\psi_W\tilde{i}^R)\tilde{\omega}}{\tilde{r}^K}].$$

By construction, price adjustment costs (as defined in (4.42)), are zero in the steady state. From the price adjustment equation (4.43),

$$1-\theta_I + \theta_I\widetilde{mc} - \phi_I\tilde{\pi}^I(1+\tilde{\pi}^I) + f\,\phi_I\tilde{\pi}^I(1+\tilde{\pi}^I) = 0,$$

which can be solved for the steady-state value of marginal cost:

$$\widetilde{mc} = \frac{\theta_I - 1}{\theta_I}. \tag{4.86}$$

This equation relates marginal cost to the inverse of the markup, $\theta_I/(\theta_I-1)$, imposed by IG producers. As θ_I increases, the mark-up falls, and in the limit case of $\theta_I \to \infty$, both the markup and marginal cost tend to unity. The parameter θ_I is thus a measure of the steady-state distortion arising from monopolistic competition.

In the steady state, $K_{t+1} = K_t$; equation (4.44) implies therefore that steady-state investment is

$$\tilde{I} = \delta_K \tilde{K}, \tag{4.87}$$

so that capital adjustment costs, as defined in (4.46), are zero.

From (4.45), the equilibrium amount of loans demanded by CG producers is

$$\tilde{l}^K = \tilde{I}.$$

From the optimality conditions (4.47) and (4.49), given (4.84) and (4.87),

$$\tilde{p}^K = \tilde{q}(1+\tilde{i}^L),$$

$$\tilde{p}^K = \tilde{r}^K + f\,\tilde{p}^K(1-\delta_K)],$$

which can be combined to give

$$\tilde{r}^K = \tilde{q}(1+\tilde{i}^L)[1-f(1-\delta_K)]. \tag{4.88}$$

Equation (4.88) relates the steady-state rental rate of capital to the expected cost of borrowing and the bond rate.

Comment 4.19. If CG producers do not need to borrow in advance to finance investment, the no-arbitrage condition $\tilde{r}^K - \delta_K = f^{-1} - 1$ would holds. It indicates that, in equilibrium, the capital rental rate (adjusted for depreciation) must be equal to the real bond rate.

From (4.54), the steady-state deposit rate is

$$\tilde{i}^D = (1-\mu)\tilde{i}^R,$$

which implies, given that $\tilde{i}^R = \tilde{i}^B$, that $\tilde{i}^B > \tilde{i}^D$. Intuitively, the return on bonds must be higher than the return on deposits to compensate for the fact that bonds, unlike deposits, do not provide liquidity services.

With $\tilde{\tau}^B = \tilde{\tau}^C = 0$, as noted earlier, using (4.62) to (4.64), the steady-state values of the loan rate, bank foreign borrowing, and the repayment probability are given by

$$1+\tilde{i}^L = \frac{\zeta^L}{(\zeta^L-1)\tilde{q}}\left\{1+\tilde{i}^R+\gamma_L-\gamma\left(\frac{\tilde{b}^{CB}}{\tilde{l}^K}\right)^{0.5}\right\},$$

$$\tilde{L}^{FB} = \frac{\tilde{i}^R-\tilde{i}^*}{\theta_0^{FB}(1+\tilde{i}^*)},$$

$$\tilde{q} = \varphi_0\kappa^{\cdot\cdot 1},$$

and, by inverting the demand function for central bank bonds (4.65),

$$\tilde{i}^{CB} = \tilde{i}^R + \gamma_B - \gamma\left(\frac{\tilde{l}^K}{\tilde{b}^{CB}}\right)^{0.5}.$$

From (4.50) and (4.51), the steady-state level of bank borrowing from the central bank is

$$\tilde{l}^B = \tilde{I} + \tilde{b}^{CB} - \rho^D\tilde{l}^K - \tilde{z}\tilde{L}^{FB} - (1-\tilde{\mu})\tilde{d}.$$

Equations (4.74) and (4.75) give the steady-state value of lump-sum taxes, $\tilde{T}$. The equilibrium condition of the final good market, equation (4.78), together with (4.75), and given that price adjustment costs are zero in equilibrium, yields the steady-state level of domestic output sales:

$$\tilde{Y}^D = \frac{\tilde{C}+\tilde{I}}{1-\psi_G},$$

with the price of these sales given by, from (4.79),

$$\tilde{P}^D = (\tilde{P}\tilde{Y} - \tilde{P}^X\tilde{Y}^X) / \tilde{Y}.$$

From (4.80), (4.81), and (4.82), the steady-state equilibrium conditions of the currency, housing and labour markets are given by

$$\tilde{m} = \tilde{m}^s,$$

$$\tilde{p}^H = \frac{\eta_H \tilde{C}^{1/\varsigma}}{(1-f)\bar{H}},$$

$$\tilde{\omega}^{\alpha+\psi_N^{-1}} = (\frac{\eta_N}{\tilde{C}^{-1/\varsigma}})^{1/\psi_N}(\frac{\circ}{1-\circ})^{-\circ}(\frac{1+\psi_W \tilde{i}^R}{\tilde{r}^K})^{-\circ}.$$

Finally, the steady-state equilibrium condition of the market for foreign exchange, equation (4.81), yields

$$WP^X\tilde{Y}^X - WP^F\tilde{Y}^F + \tilde{i}^*\tilde{F} + \tilde{\theta}^{FB}\tilde{B}^F - \tilde{\theta}^{FC}\tilde{L}^{FC} = 0,$$

whereas $\tilde{F}$ is the economy's steady-state net foreign asset position, defined as

$$\tilde{F} = \tilde{R}^F + \tilde{B}^F - \tilde{L}^{FC}.$$

The above equations form a static system that defines the nonstochastic steady state of the model. It can be solved numerically, based on the parameterisation provided next. This solution is obtained under the assumption that policymakers have no access to lump-sum subsidies to correct the distortions created by monopolistic competition and financial frictions. In that sense, the nonstochastic steady state is inefficient. Although not without its problems – it rules out achieving the first-best allocation – this assumption is fairly common in the DSGE literature.[11]

4.4. Parameterisation

The model is parameterised for a representative bank-dependent middle-income economy, using as a starting point the parameter values discussed in Agénor (2020, chapters 4 and 7), Agénor et al. (2014, 2018) and Agénor et al. (2020), which themselves rely on a wide range of studies. Some sensitivity analysis is also reported later on.

The discount factor f is set at 0.95, which gives a steady-state annualized interest rate (real and nominal, given zero steady-state inflation) of 5.3 percent – a fairly common value for studies focusing on developing countries.[12] The intertemporal elasticity of substitution, ς, is set at 0.5, in line with estimates for MICs (see Agénor and Montiel (2015, Chapter 2)). The Frisch elasticity of labour supply is set at 0.71, which implies that $\psi_N = 1.4$, as in Akinci (2021), for instance. It is also within the range of values estimated by Dogan (2019). The relative weight of labour in the utility function, η_N, is solved backwards, from the first-order condition (4.15), to ensure that in the steady state households devote one third of their time endowment (itself normalized to unity) to market activity – a common benchmark in the literature, for both developed and developing countries (see, for instance, Christoffel and Schabert (2015) and Boz et al. (2015)). The resulting value is $\eta_N = 21.8$. The parameter for composite monetary assets, η_x, is set at a low value, 0.001, to capture the view that the direct utility benefit of holding money is fairly small – again, a common assumption in the literature (see, for instance, Chang et al. (2015)). The housing preference parameter, η_H is set at a low value as well, 0.02, for the same reason. The share parameter in the index of money holdings, ν, which corresponds to the relative share of cash in narrow money, is set at 0.35. Thus, the case considered is that of an economy where the use of cash remains widespread. The sensitivity of the spread to household holdings of foreign bonds, θ_0^{FB}, is set at 0.2, as in Agénor et al. (2020). This helps to ensure that the steady-state domestic bond rate departs significantly from the rate of return on foreign assets, as implied by imperfect capital mobility.

Regarding firms, the share of capital in output of intermediate goods, $\circ$, is set at 0.35, a fairly standard value. The adjustment cost parameter for prices of intermediate goods, ϕ_I, is set at 50, to capture a relatively low

11 See Agénor (2020, Chapter 4) for a discussion.

12 For some of the experiments reported later on, a higher discount factor, $f = 0.97$ (corresponding to a real interest rate of 3.1 percent) is used to better match well-established facts associated with some specific shocks.

degree of persistence in price stickiness in developing economies, as documented in some studies (see Kiley (2000) and Klenow and Malin (2011)). The rate of depreciation of private capital, δ_K, is set equal to 0.025, a fairly standard value as well for both developed and developing countries (see, for instance, Jin and Ziong (2022)), which implies an annualized depreciation rate of 10.4 percent. The adjustment cost incurred by CG producers for transforming investment into capital, $-_K$, is set at 0.26, the value estimated by De la Peña (2021) for Mexico. The share of labour costs financed in advance, ψ_W, is set initially at 0.0 to study the behaviour of the model in the absence of a cost channel. The case where ψ_W is positive will also be examined later on.

The distribution parameter between domestic and imported intermediate goods in the production of the final good, f_I, is set at 0.7, as in Hwang (2012), Medina and Roldós (2018), Lama and Medina (2020), and De la Peña (2021), for instance, to capture the case of a country where imports are about a third of final output. This corresponds also to the import share estimated by Jin and Xiong (2023) for a sample of 38 developing and emerging economies. Thus, there is home bias in final good production. The elasticity of substitution between baskets of domestic and imported composite intermediate goods, η, is set at 1.5, a fairly standard value used, for instance, by Anand et al. (2015), Cuadra and Nuguer (2018), and Dogan (2019). It implies that these goods are substitutes in the production of the final good.[13] The elasticities of substitution between intermediate domestic goods among themselves, θ, and imported goods among themselves, θ_F, are set equal to the same value, 6, as in Demirel (2010), Rhee and Turdaliev (2012), and De la Peña (2021), for instance. This gives a steady-state markup rate, $\theta_I / (\theta_I - 1)$, equal to 20 percent. The exchange rate pass-through to the domestic-currency price of imports is assumed instantaneous, so $\mu^F = 1.0$, which is consistent with the estimate for Turkey, for instance, obtained by Bussière et al. (2014, fig. 1). Similarly, the degree of pass-through to export prices, μ^X, is set at 1.0. Thus, only the current exchange rate affects the domestic-currency price of exports. The price elasticity of exports, $\varkappa_X$, is set equal to 0.9, which is close to the value used by Gertler et al. (2007) for South Korea, for instance, and consistent with the estimates obtained by Ahmed et al. (2015) for a broad sample of countries.

With respect to commercial banks, consistent with the evidence on the legal hurdles that creditors face in trying to seize collateral in MICs (see Chapter 1), the effective collateral-loan ratio, κ, is set at 0.2. The elasticity of substitution between differentiated loans, ζ^L, is set at 4.5, to obtain a spread between the refinance rate and the loan rate consistent with the evidence. The elasticities of the repayment probability with respect to the effective collateral-loan ratio, and deviations in output from its steady state, are set at $.._1 = 0.05$ and $.._2 = 0.4$, respectively, whereas the elasticity with respect to the (tax-adjusted) loan rate, $.._3$ is set to 0.[14] Parameter θ_0^{FC}, which determines the sensitivity of bank foreign borrowing to the differential in the cost of domestic and foreign loans, is set at 0.2, to obtain (as discussed later) a ratio of bank foreign liabilities to output in line with actual data. The parameters of the cost function, γ_B, γ_L, and γ, are set at 1, 0.1, and 0.1, respectively. The first two values ensure that, given the steady-state values of l^K and b^{CB} (as discussed next), marginal costs are positive, whereas the third ensures that the bank portfolio effect, as captured by γ, is relatively weak initially. The capital adequacy ratio, ρ^D, is set at 0.12, consistent with the evidence on actual capital-asset ratios in middle-income countries (see World Bank (2020)).

Regarding the central bank, the required reserve ratio μ is set at 0.2, consistent with the data reported by Cordella et al. (2014) for a group of large economies in Latin America. Responses of the refinance rate to inflation and output deviations, $\bullet_1$ and $\bullet_2$, and the degree of persistence in the central bank's policy rate, χ^R, are set at 1.5, 0.4, and 0.85, respectively. These values are consistent with estimates of Taylor-type rules for MICs, including those of Moura and Carvalho (2010).[15] The degree of persistence in the foreign exchange intervention rule, $.._1^R$, is set to 0.8. The parameter characterizing the degree of exchange rate smoothing in the foreign reserves targeting rule, $.._2^R$, is set at 0.0 in the benchmark case, to reflect full exchange rate flexibility. The sterilization coefficient, κ^F, is also set at 0.0 initially, given that there is no intervention, and thus no sterilization, in the benchmark experiments. The case of intervention, sterilized and unsterilized, is discussed later on. The lower bound on official reserves, R_m^F, is set to 6 percent of output.

Finally, the share of noninterest government spending in output, ψ_G, is set at 0.18, a value consistent with the evidence for a number of large MICs (see, for instance, Carvalho and Castro (2016)).

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13 By contrast, Medina and Roldós (2018), for instance, use a value of $= 0.5$, which implies that home and foreign intermediate goods are complements.

14 The assumption that $.._3 = 0$, shuts down the feedbak effect of the loan rate on the repayment probability. However, given that the loan rate itself is inversely related to the repayment probability, it is inconsequential as long as $.._3 < 1$.

15 By way of comparison, estimates for Mexico by Cermeño et al. (2012) for the period 1998-2008 give $\bullet_1 = 2.31$, $\bullet_2 = 0.47$, and $\chi = 0.52$. More recent estimates for the same country by Zamarripa (2021) give mean values of $\bullet_1 = 2.31$, $\bullet_2 = 0.47$, and $\chi = 0.52$. Both studies also find evidence of a significant – but declining over time, in the second study – policy response to the nominal exchange rate.

Parameter values are summarized in Table 4.1, whereas initial steady-state values are displayed in Table 4.2. Most of the aggregate ratios are broadly consistent with the data. Steady-state investment, for instance, is close to the value calculated for Brazil by Divino and Haraguchi (2022, Table 1). Interest rates on central bank borrowing, government bonds, and sterilization bonds are all equal (as noted earlier) and given by $\tilde{\imath}^R = \tilde{\imath}^B = \tilde{\imath}^{CB} = 5.3$ percent. The deposit rate is $\tilde{\imath}^D = 4.2$ percent, whereas the loan rate is $\tilde{\imath}^L = 9.5$ percent. Thus, these values satisfy the steady-state restrictions $\tilde{\imath}^L > \tilde{\imath}^R > \tilde{\imath}^D$.

The initial stock of sterilization bonds is set at a relatively small value, at $b^{CB} = 0.021$, implying a bank loans-sterilization bonds ratio of 4.8. With the world risk-free interest rate $\tilde{\imath}^W$ set equal to 1.0 percent, $\theta_0^{FB} = 0.2$, and the steady-state bond rate $\tilde{\imath}^B$ equal again to 5.3 percent, the steady-state value of the stock of foreign assets held by households is equal to $\tilde{B}^F = (\tilde{\imath}^W - \tilde{\imath}^B)/[\theta_0^{FB}(1+\tilde{\imath}^W)] = -21.1$ percent of final output. Thus, households are net debtors in the initial steady state. With $\theta_0^{FC} = 0.2$, and with the same values of $\tilde{\imath}^W$ and $\tilde{\imath}^B$, the ratio of bank foreign debt to final output $\tilde{L}^{FC} = (\tilde{\imath}^B - \tilde{\imath}^W)/[\theta_0^{FC}(1+\tilde{\imath}^W)]$ is 21.1 percent. By implication, with the initial level of foreign reserves $\tilde{R}_m^F = 0.05$ percent of output, the economy's net stock of foreign assets, $\tilde{F} = \tilde{R}^F + \tilde{B}^{FP} - \tilde{L}^{FB}$, is initially negative, at –37.2 percent of final output. Thus, the country is a net debtor in the initial steady state. The initial steady-state values of the macroprudential and capital controls tax rates are both set to $\tilde{\tau}^B = \tilde{\tau}^C = 0$.

4.5. Macro-Financial Policy Analysis

To study the properties of the model, impulse response functions associated with several policy experiments are computed: fiscal policy (an increase in government expenditure), monetary policy (an increase in the refinance rate), a more aggressive sterilization policy, a tightening of the macroprudential tax, and a tightening of capital controls on banks. In addition, the behaviour of the model in response to several temporary domestic and external shocks are considered: a positive domestic productivity shock, a positive domestic financial shock, and a negative shock to the world interest rate. The last exercise is particularly important from the perspective of MICs and sets the stage for the discussion of policy responses, and policy combinations, in the next chapter. Although in the real world, shocks often occur concurrently (making them therefore difficult to disentangle), to understand how they are transmitted it is naturally easier to study them independently. All of these experiments are conducted under a fully flexible exchange rate, that is, with no intervention in the foreign exchange market and therefore no sterilization operations.[16]

To calculate the impulse response functions, in standard fashion the model is solved using a first-order perturbation approach. This requires linearization or log-linearization of the system of equations (see Fernández-Villaverde et al. (2016)). For reasons that have been discussed extensively in the literature, second-order local approximations are used for welfare evaluation, as discussed in the next chapter.

4.5.1. Fiscal Policy

Consider a temporary increase in the share of government spending in output, as measured by the parameter ψ^G, which is now assumed to follow a stationary log-linear first-order autoregressive process:

$$\ln\left(\frac{\psi_t^G}{\psi^G}\right) = \rho^G \ln\left(\frac{\psi_{t-1}^G}{\psi^G}\right) + \xi_t^G,$$

where $\rho^G \in (0,1)$ and the serially uncorrelated innovation ξ_t^G is normally distributed with mean zero and standard deviation σ_{ξ^G}, that is, $\xi_t^G \sim iid(0, \sigma_{\xi^G}^2)$. For this experiment, the autocorrelation coefficient ρ^G is set at 0.0 and σ_{ξ^G} at 0.01.

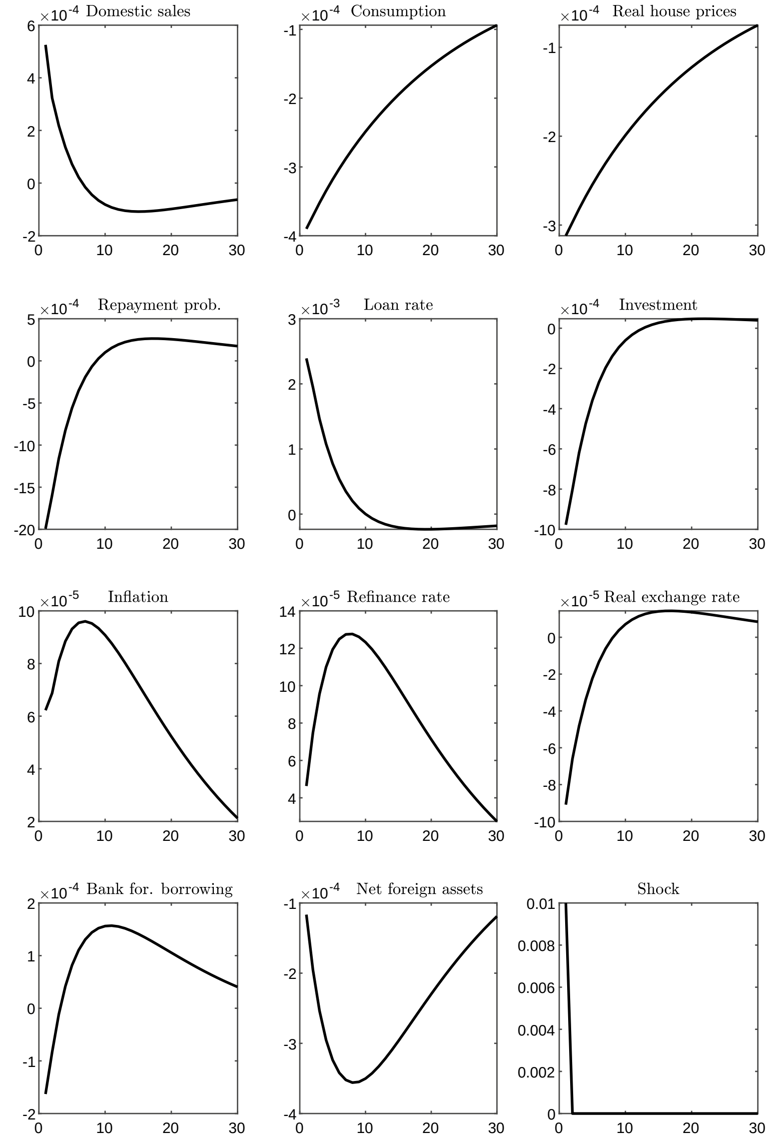
The impulse response functions associated with this experiment are displayed in Figure 4.2, for a set of key macroeconomic and financial variables: sales of final goods at home, consumption, real house prices, the repayment probability, the loan rate, investment, inflation, the refinance rate, the real exchange rate, bank foreign borrowing, and net foreign assets.

[16] Because the stock of central bank bonds is not zero in the steady state, in all of these experiments the ratio of these bonds to bank loans in the loan rate equation (4.62) is kept constant at its initial steady-state value. Thus, the effect of changes in the bond sterilization rate on the loan rate is fully neutralized. Of course, when the case of intervention with sterilization is discussed later on, that ratio is endogenized. With $\gamma > 0$, this also allows the model to capture the potential expansionary effect of sterilization.

Open-Economy DSGE Model: Benchmark Parameterisation		Table 4.1
Parameter	Value	Description
Household		
f	0.95	Discount factor
ς	0.5	Elasticity of intertemporal substitution
η_N	21.8	Relative weight of labour in utility function
ψ_N	1.4	Inverse of Frisch elasticity of labour supply
η_x	0.001	Preference parameter for money holdings
η_H	0.002	Preference parameter for housing
ν	0.35	Share parameter in index of money holdings
θ_0^{FB}	0.2	Sensitivity of premium, household holdings of foreign bonds
Production		
f_I	0.7	Distribution parameter, final good
η	1.5	Elasticity of substitution, baskets of intermediate goods
μ^F	1.0	Exchange rate pass-through, imported goods
μ^X	1.0	Exchange rate pass-through, exports
$\varkappa_X$	0.9	Price elasticity of exports
θ_I, θ_F	6.0	Elasticity of demand within groups, intermediate goods
$\circ$	0.35	Share of capital, domestic intermediate goods
ϕ_I	50	Adjustment cost parameter, domestic IG prices
δ_K	0.025	Depreciation rate of capital
$-_K$	0.26	Adjustment cost parameter, investment
ψ_W	0.0	Share of labour costs financed in advance
Commercial banks		
κ	0.2	Effective collateral-loan ratio
$\cdot\cdot_1$	0.05	Elasticity of repayment probability, collateral
$\cdot\cdot_2$	0.4	Elasticity of repayment probability, cyclical output
Parameter	Value	Description
ζ^L	4.5	Elasticity of substitution, loans to CG producers
θ_0^{FC}	0.2	Sensitivity of premium, bank foreign borrowing
γ_B	1.0	Direct cost parameter, sterilization bonds
γ_L	0.1	Direct cost parameter, loans
γ	0.1	Joint cost parameter, sterilization bonds and loans
Central bank		
μ	0.2	Required reserve ratio
χ^R	0.85	Degree of interest rate smoothing
$\bullet_1$	1.5	Response of refinance rate to inflation deviations
$\bullet_2$	0.4	Response of refinance rate to output deviations
$\cdot\cdot_1^R$	0.8	Persistence parameter, foreign reserves rule
$\cdot\cdot_2^R$	0.0	Exchange rate smoothing parameter, foreign reserves rule
$\cdot\cdot\cdot^E$	1.0	Weight of the lagged exchange rate in the target rate
κ^F	0.0	Sterilization coefficient
Government		
ψ_G	0.18	Share of government spending in domestic output sales

Impulse Response Functions: Positive Government Spending Shock (Deviations from steady state)

Figure 4.2



Note: Responses of domestic sales, consumption, investment, real house prices, bank foreign borrowing, net foreign assets, and the real exchange rate, are expressed as percent deviations from their steady-state values. The responses of the loan rate, the refinance rate, the repayment probability, and the inflation rate, are expressed as absolute deviations (or percentage points) from these values.

On impact, the increase in government spending raises aggregate demand and output. Inflation rises, and so does the refinance rate. The loan rate therefore increases, thereby leading to a contraction in investment, which mitigates the initial increase in output. At the same time, the nominal bond rate (which follows the same path as the refinance rate) also increases, by more than the (one-period ahead) inflation rate, which induces households to reduce spending today and shift consumption to the future. Thus, increased government expenditure generates a crowding-out effect on private spending.

Note also that the drop in consumption is associated with a reduction in the demand for housing, thereby putting downward pressure on their price. Thus, there are two conflicting effects on the repayment probability: on the one hand, higher output tends to increase it; on the other, lower collateral values tend to lower it. Although investment (and thus loan demand) falls as well, the net effect on the collateral-loan ratio is negative. Given the parameter values used in the simulations, the overall effect is a reduction in the repayment probability, which magnifies the rise in the loan rate. This is consistent with the financial amplification mechanism discussed in previous chapters. Finally, the increase in domestic prices is associated with a real appreciation, consistent with other theoretical studies of the impact of positive shocks to government spending.

Initial Steady-State Values: Key Variables (In proportion of final output, unless indicated otherwise)		Table 4.2
Variable	Description	Value
C	Household consumption	0.6
$I = l^K$	Investment loans to CG producers	0.1
l^W	Working Capital loans to IG producers	0.0
K	Capital stock	4.0
r^K	Rental rate of capital (percent)	0.076
$K\ N$	Employment (proportion of time endowment)	0.315
$K\ G$	Public expenditure	0.18
$K\ q$	Repayment probability, investment loans to CG producers (percent)	0.93
i^B, i^R	Government bond rate, central bank refinance rate (percent)	0.053
i^D	Bank deposit rate (percent)	0.042
i^L	Loan rate, investment lending to CG producers (percent)	0.095
V / l^K	Capital-loan ratio (or capital adequacy ratio)	0.12
i^{FB}	Cost of foreign borrowing (percent)	0.031
L^{FC}	Foreign borrowing, commercial banks	0.211
R^F	Foreign reserves, central bank	0.05
F	Net foreign assets	–0.372

4.5.2. Monetary Policy

Consider a temporary 1 percentage point reduction in the refinance rate, as captured by a shock to ξ in (4.73). For this experiment, the autocorrelation coefficient ρ^R is set at 0.3 and σ_{ξ^R} at 0.01.[17]

The impulse response functions associated with this experiment are displayed in Figure 4.3, with and without financial amplification, that is, with the repayment probability determined endogenously as implied by (4.64), and with that variable kept at its initial steady-state value given in Table 4.2.

Consider first the case where the repayment probability is endogenous. The immediate effect of this shock is a concomitant fall in the deposit rate, which lowers the demand for bank deposits and raises the demand for cash and bonds. With zero net supply of bonds, the nominal bond rate must fall as well. At the same time, the reduction in the refinance rate directly lowers the loan rate, which leads to an expansion of investment. Thus, aggregate demand increases, which puts upward pressure on prices. The rise in expected (one-period ahead) inflation, combined with the fall in the nominal bond rate, results in a reduction in the expected real bond rate. This induces households to save less and spend more today, thereby contributing to a further expansion in aggregate demand and output. At the same time, the increase in consumption prompts households to supply less labour, which puts upward pressure on wages, marginal cost, and inflation. It is also associated with higher house prices; in turn, higher prices, combined with a positive movement in cyclical output, lead to an increase in the repayment probability and therefore a further reduction in the loan rate. Thus, the two channels through which financial amplification occurs operate in the same direction: they both combine to increase the repayment probability or, equivalently, to reduce the premium that banks impose on borrowers.

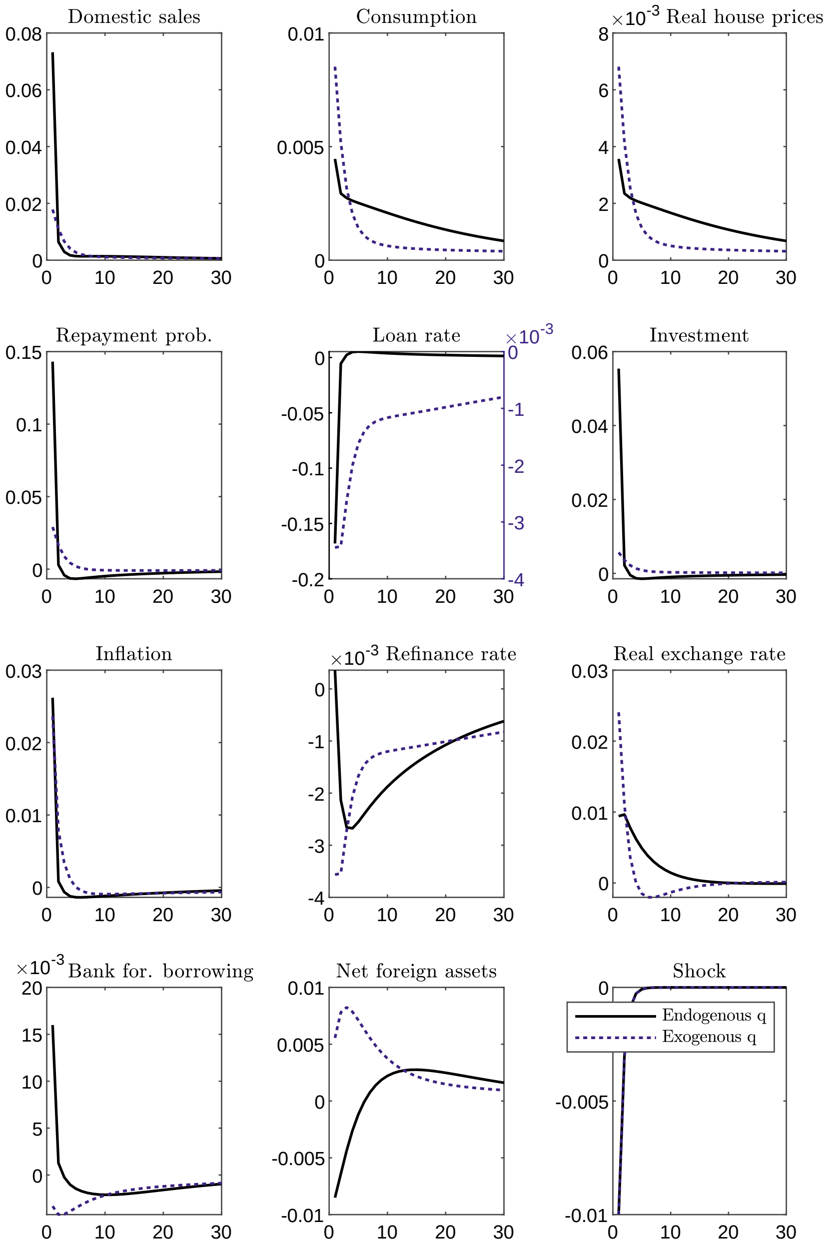
The rise in inflation induces an endogenous response of the refinance rate, which is large enough to lead to a small net positive effect on that variable. The higher cost of borrowing at home induces banks to borrow more on world capital markets, and this leads to a fall in net foreign assets.

Consider next the case where amplification effects are absent, that is, the repayment probability is held constant at its steady-state value. The results are shown as the dotted lines in Figure 4.3. Essentially, without amplification effects (associated with the increases in the collateral-loan ratio and cyclical output), the response of the loan rate and investment are muted – and so is the initial expansionary effect on output. Inflation increases by a slightly smaller amount as well. This time, the net effect on the refinance rate is negative. The nominal bond rate falls as well and, combined with the increase in inflation, induces a larger drop in the (expected) real bond rate and

[17] For this experiment, a value of $f = 0.97$ is also used, to better match the evidence associated with transitory monetary policy shocks.

Impulse Response Functions: Negative Refinance Rate Shock (Deviations from steady state)

Figure 4.3



Note: See Note to Figure 4.2.

a larger increase in current consumption, through intertemporal substitution. Nevertheless, this increase is not large enough to offset the sharp reduction in investment. Consequently, output increases significantly less, compared to the case where financial amplification effects are present. The drop in the cost of domestic borrowing induces banks to reduce their foreign borrowing. At the same time, lower domestic interest rates lead households to increase their holdings of foreign bonds. The net effect is an increase in the economy's net foreign assets.

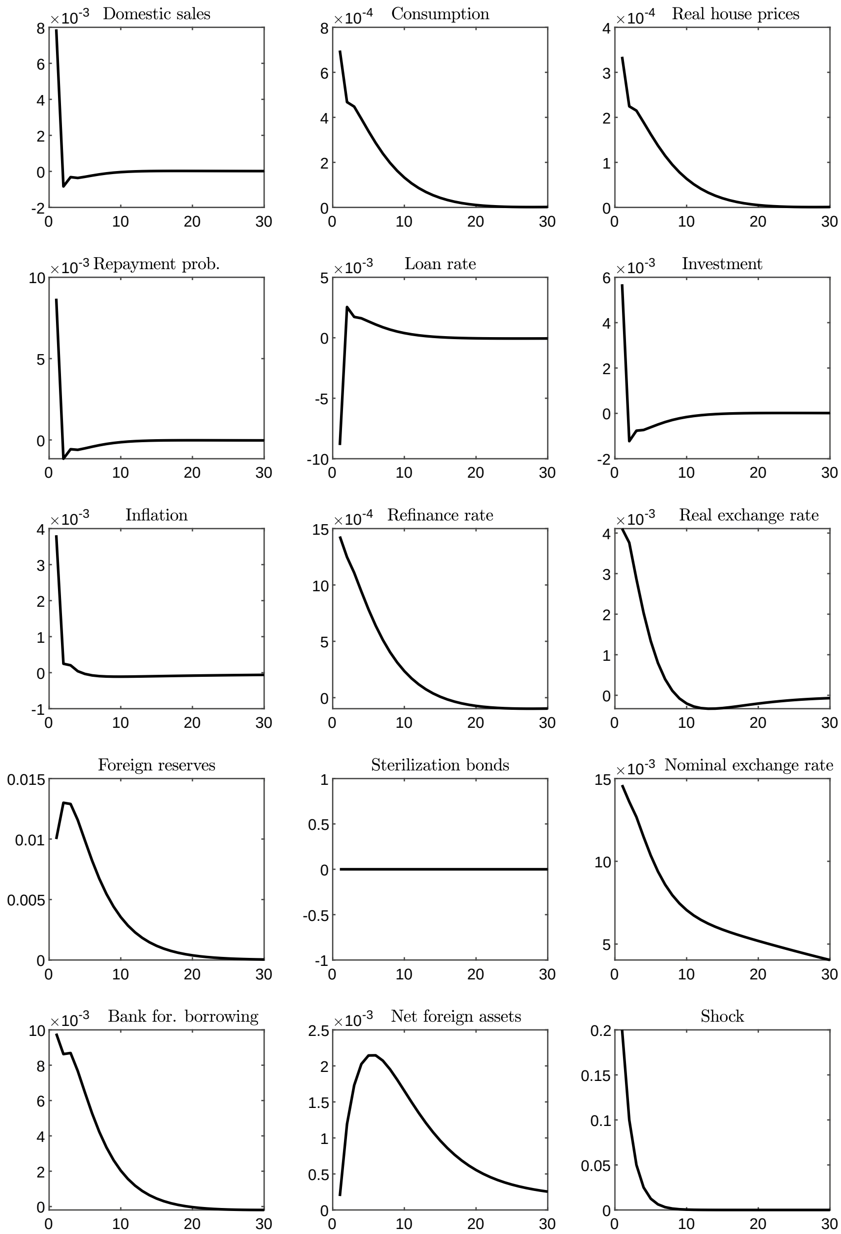
4.5.3. Foreign Exchange Intervention

Consider a transitory increase in the central bank's foreign reserves, corresponding to a 1 percentage point of GDP. This is implemented by adding a multiplicative stochastic disturbance ϵ_t^F to (4.68),

$$R_t^F = (R_{t-1}^F)^{\chi_1^R}[R_m^F(\frac{E_t}{E_t^T})^{-\chi_2^R}]^{1-\chi_1^R}\exp(\epsilon_t^F),$$

Impulse Response Functions: Temporary Purchase of Foreign Reserves (Deviations from steady state)

Figure 4.4



Note: See Note to Figure 4.2.

where ε_t^F is assumed to follow a stationary log-linear first-order autoregressive process:

$$\ln \varepsilon_t^F = \rho^F \ln \varepsilon_{t-1}^F + \xi_t^F,$$

with $\rho^F \in (0,1)$ and $\xi_t^F \sim iid(0, \sigma^2_{\xi^F})$. For this experiment, the persistence parameter ρ^F is set at 0.5 and σ_{ξ^F} at 0.01. This shock can be interpreted as a transitory purchase of foreign exchange through intervention in the foreign exchange market. The intervention is assumed to be unsterilized ($\kappa^F = 0$).

The impulse response functions associated with this experiment are displayed in Figure 4.4.

The purchase of foreign exchange induces a (real and nominal) currency appreciation and an expansion of the money supply. In turn, the currency depreciation raises inflation, which induces the central bank to tighten monetary policy. At the same time, the increase in domestic liquidity requires a drop in the nominal bond rate to induce households to hold more cash and maintain equilibrium of the money market. The combination of a fall in the nominal bond rate and an increase in inflation leads to a fall in the expected real bond rate; households therefore shift spending to the present and consumption increases, thereby stimulating output. In turn, higher output raises the repayment probability. There are therefore conflicting effects on the loan rate: on the one hand, a higher refinance rate tends to increase it; on the other, a higher repayment probability tends to lower it. The net effect, as shown in Figure 4.4, is a reduction in the market cost of borrowing, which stimulates investment and contributes to a further expansion in aggregate demand and added pressures on inflation. Thus, consistent with the empirical evidence, an unsterilized reserve purchase is both expansionary and inflationary.

4.5.4. Macroprudential Policy

Consider a temporary increase in the macroprudential tax rate, τ_t^L, which, instead of (4.76), is assumed to follow a stationary log-linear first-order autoregressive process:

$$\ln(\frac{1+\tau_t^L}{1+\tilde{\tau}^L}) = \rho^L \ln(\frac{1+\tau_{t-1}^L}{1+\tilde{\tau}^L}) + \xi_t^L,$$

where $\tilde{\tau}^L$ is the initial steady-state value, set at 0, $\rho^L \in 0,1)$, and $\xi_t^L \sim iid(0,\sigma_{\xi^L}^2)$. For this experiment, the autocorrelation coefficient ρ^L is set at 0.3.

The impulse response functions associated with this experiment are displayed in Figure 4.5.

On impact, the increase in the macroprudential tax rate raises the loan rate, thereby inducing a contraction in investment and output. The fall in aggregate demand puts downward pressure on inflation. The combination of lower output and inflation leads to a fall in the refinance rate, which mitigates the increase in the loan rate. Because the nominal bond rate also falls, the net effect on the (expected) real bond rate is ambiguous in general; given the parameter values selected, the net effect is negative, thereby inducing households to increase spending today. But this effect is not large, compared to the contraction in investment.

The demand for housing and real house prices increase in line with consumption, thereby unambiguously raising (given the drop in lending) the collateral-loan ratio. However, the contraction in output dominates and induces a drop in the repayment probability, thereby amplifying the initial increase in the loan rate. The fall in inflation is associated with a real depreciation. The reduction in the marginal cost of borrowing from the central bank induces banks to borrow less abroad. As a result, net foreign assets increase. Thus, while macroprudential policy tightening operates through a standard *leverage channel* (a contraction in lending), there is no *composition channel,* as in some contributions (see, for instance, Jin and Xiong (2023)). Indeed, although the increase in the macroprudential tax rate raises the loan rate, the reduction in inflation drives the domestic refinance rate down, which induces banks to borrow less abroad. Put differently, because of the endogenous response of monetary policy, the effectiveness of macroprudential policy is not hindered by financial openness.

4.5.5. Capital Controls

Consider a temporary increase in the capital controls tax rate, τ^B, which, instead of (4.77), is assumed to follow a stationary log-linear first-order autoregressive process:

$$\ln(\frac{1+\tau_t^B}{1+\tilde{\tau}^B}) = \rho^B \ln(\frac{1+\tau_{t-1}^B}{1+\tilde{\tau}^B}) + \xi_t^B,$$

where $\tilde{\tau}^B$ is the initial steady-state value of τ^B, set at 0, $\rho^B \in (0,1)$, and $\xi_t^B \sim iid(0,\sigma_{\xi^B}^2)$. For this experiment, the autocorrelation coefficient ρ^B is set at 0.3 and σ_{ξ^B} at 0.01.

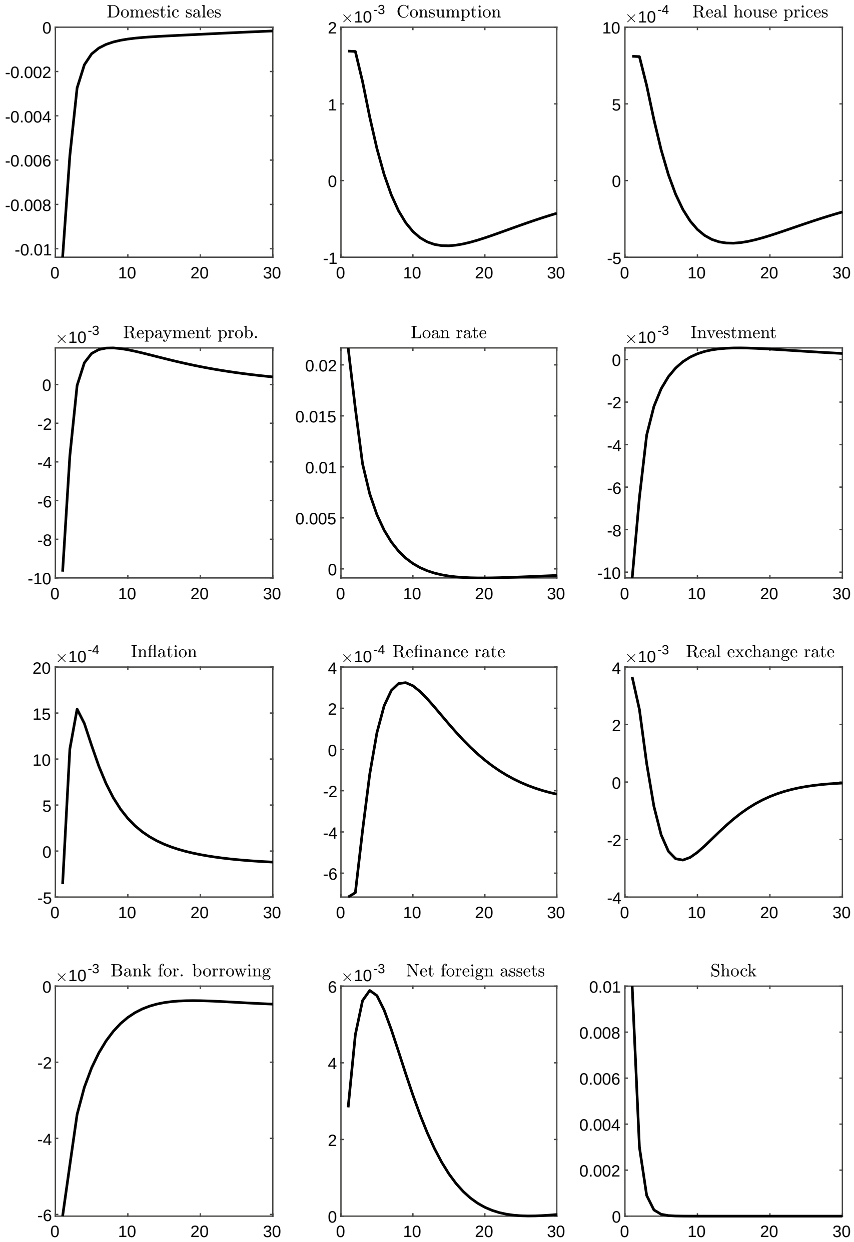
The impulse response functions associated with this experiment are displayed in Figure 4.6.

The increase in the capital controls tax rate raises the cost of foreign borrowing abroad for banks. In turn, the drop in bank foreign borrowing mitigates capital inflows, which implies a depreciation of the nominal and real exchange rates.[18] However, the depreciation raises the inflation rate, which translates into an increase in the refinance rate. At the same time, the increase in inflation lowers the (expected) real bond rate, which induces

[18] Note that, despite the drop in foreign borrowing, net foreign assets fall slightly on impact. The reason is that the (expected) depreciation rate increases and raises the return on foreign bonds, thereby inducing an offsetting capital outflow.

Impulse Response Functions: Positive Macroprudential Tax Rate Shock (Deviations from steady state)

Figure 4.5



Note: See Note to Figure 4.2.

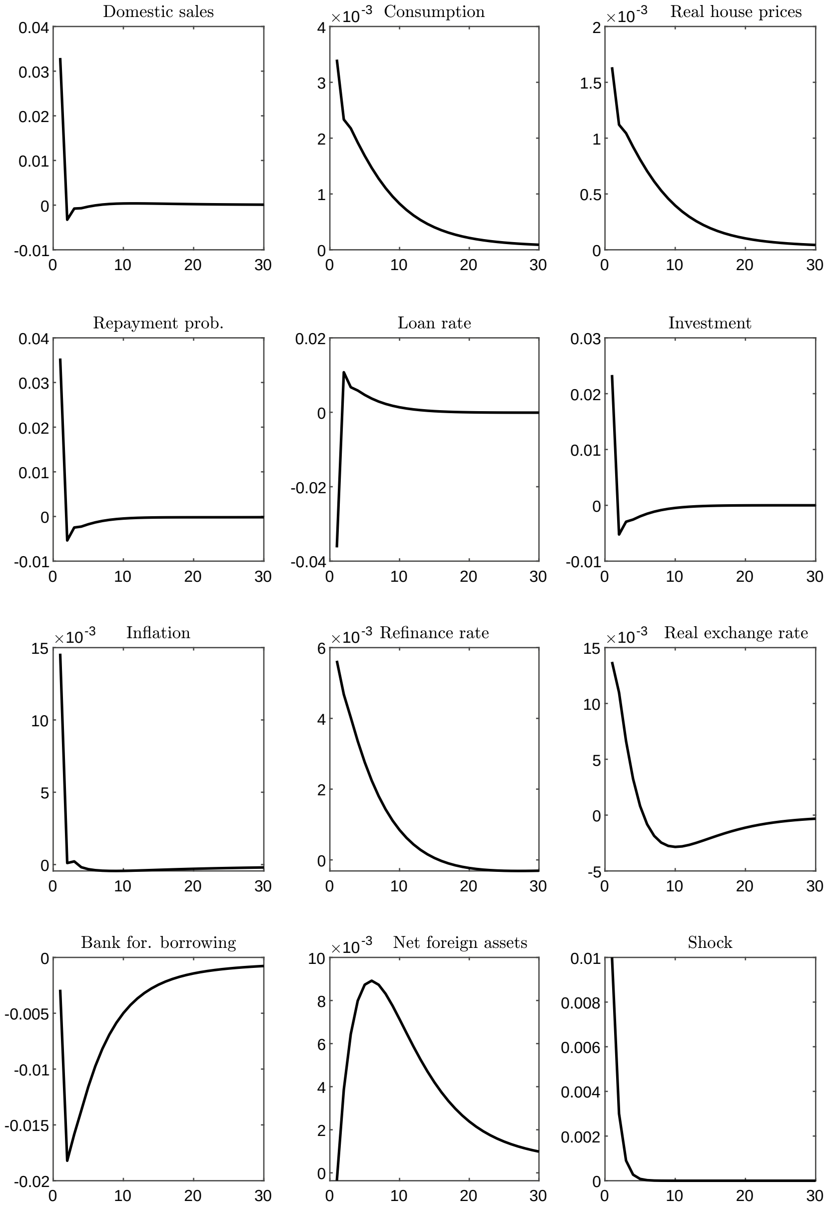
households to spend more today. The increase in aggregate demand and higher house prices combine to generate an increase in the repayment probability. Thus, there are conflicting effects on the loan rate: the increase in the refinance rate tends to raise it, whereas the increase in the repayment probability tends to reduce it. The net effect is negative, which translates into an expansion in investment, thereby compounding the consumption-induced increase in aggregate demand and further raising inflationary pressures.

4.6. Domestic and External Shocks

To further illustrate the workings of the model, both domestic and external shocks are analysed. Two types of domestic shocks, real and financial, are first considered. A shock to the world risk-free rate – a critical experiment in the context of this Manual – is then studied.

Impulse Response Functions: Positive Capital Controls Tax Rate Shock (Deviations from steady state)

Figure 4.6



Note: See Note to Figure 4.2.

4.6.1. Productivity Shock

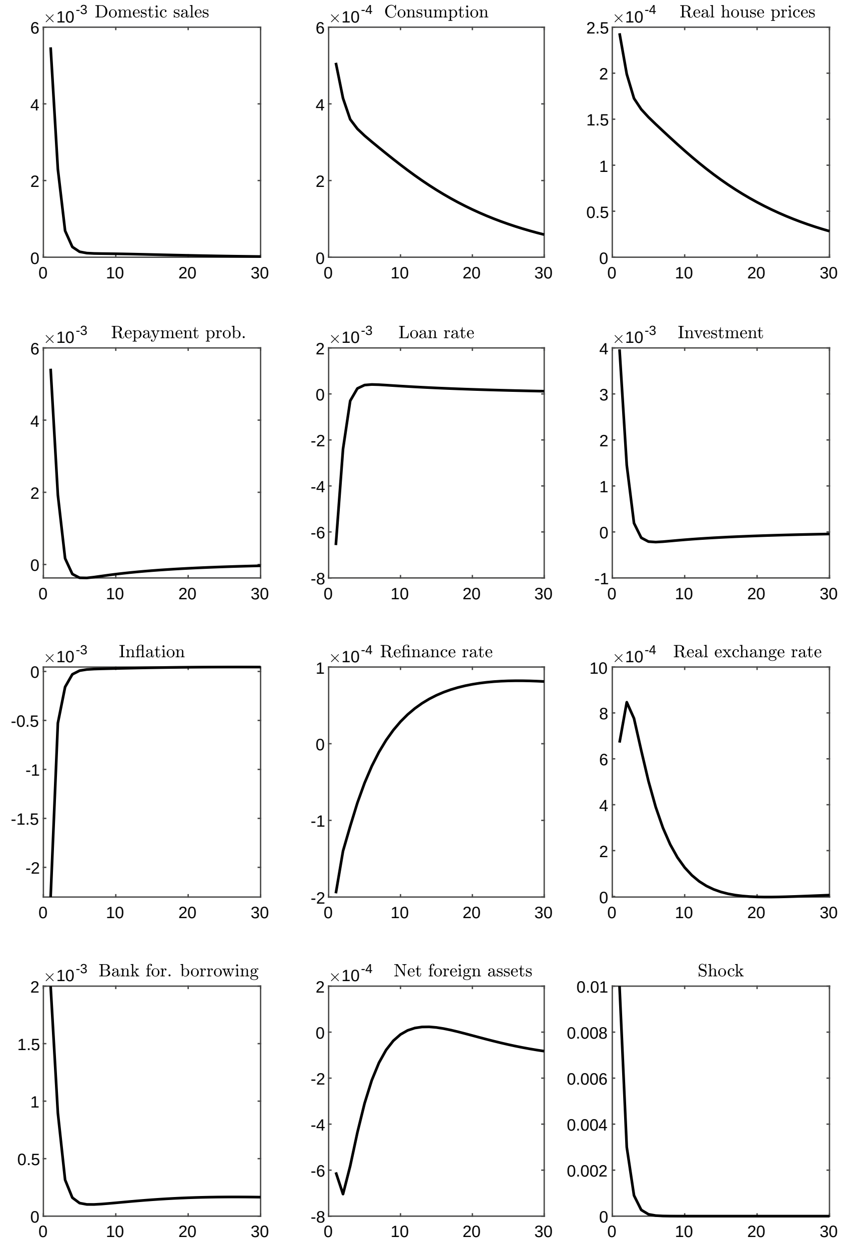
Consider a temporary 1 percentage point increase in the productivity parameter, as captured by a shock to ξ_t^A in (4.33). For this experiment, the autocorrelation coefficient ρ^A is set at 0.3 and σ_{ξ^A} at 0.01.

The impulse response functions associated with this experiment are displayed in Figure 4.7.

The productivity shock expands the production frontier and lowers marginal cost. Its direct effect is thus a higher level of output. This raises the repayment probability and lowers the loan rate, which in turn stimulates investment. The reduction in marginal cost also tends to lower inflation on impact. Thus, as is generally the case with supply shocks, the central bank faces a trade-off in adjusting interest rates, due to conflicting movements in output and inflation. But given the preeminence of the price stability objective (which is captured through the parameters $\bullet_1$ and $\bullet_2$ in the Taylor-type rule (4.72)), the net effect is a reduction in the refinance rate. The drop in the market cost of borrowing is thus magnified, thereby stimulating further investment and aggregate demand. Over time, this tends to mitigate the initial drop in inflation.

Impulse Response Functions: Positive Productivity Shock (Deviations from steady state)

Figure 4.7

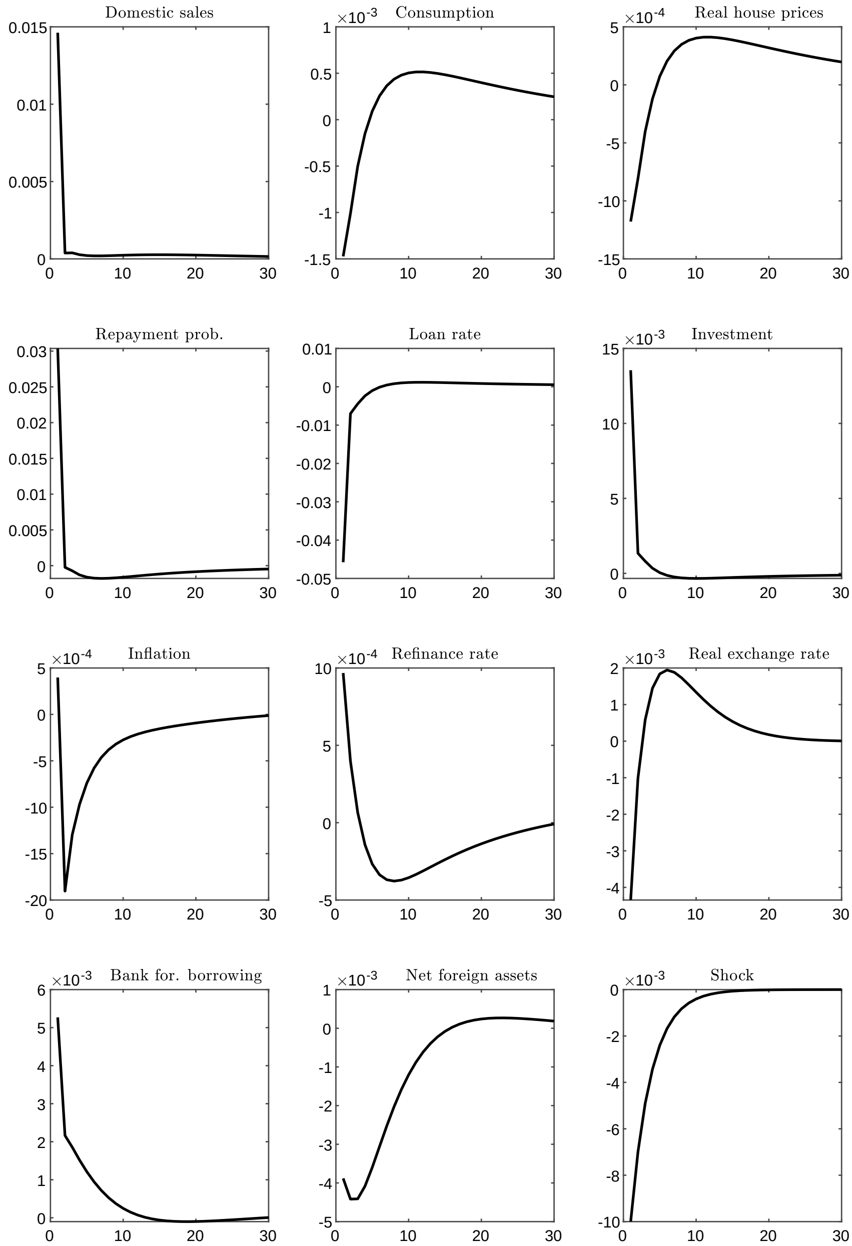


Note: See Note to Figure 4.2.

The lower refinance rate also translates into a lower deposit rate, which in turn reduces the demand for domestic deposits by households and raises the demand for cash and government bonds. With a zero net supply, the nominal bond rate therefore must fall as well. At the same time, the drop in (expected) inflation is smaller than the fall in the nominal bond rate, which translates therefore into a reduction in the (expected) real bond rate. Through intertemporal substitution, this induces households to consume more today. The increase in consumption compounds the positive effect of higher investment on aggregate demand. It also raises the demand for leisure and leads to a reduction in labour supply, which puts upward pressure on wages and mitigates the initial drop in inflation. In addition, the expansion of consumption is associated with higher demand for housing services, which tends to raise their price. In turn, higher house prices raise collateral values and induce a further increase in the repayment probability and downward pressure on the loan rate, which magnifies the increase in investment. Once again, and consistent with the intuition gathered from using the simple models of the previous chapters, frictions in the pricing of bank loans create a financial amplification effect which shapes the transitional dynamics associated even with real shocks.

Impulse Response Functions: Negative Financial Shock (Deviations from steady state)

Figure 4.8



Note: See Note to Figure 4.2.

4.6.2. Domestic Financial Shock

Consider a temporary, negative shock to the loan rate, i_t^L. This is implemented by adding a multiplicative stochastic disturbance ε_t^L to (4.62), where ε_t^L is assumed to follow a stationary log-linear first-order autoregressive process:

$$\ln \varepsilon_t^L = \rho^L \ln \varepsilon_{t-1}^L + \xi_t^L,$$

where $\rho^L \in (0,1)$ and $\xi_t^L \sim iid(0, \sigma^2_{\xi^L})$. For this experiment, the autocorrelation coefficient ρ^L is set at 0.7 and σ_{ξ^Q} at 0.01. The shock can be interpreted as a transitory reduction in the perceived likelihood of default on the part of borrowers.[19]

The impulse response functions associated with this experiment are displayed in Figure 4.8.

19 It is also similar to the markup shock implemented in Angelini et al. (2014).

The reduction in the loan rate stimulates investment, aggregate demand and domestic sales. The resulting increase in inflation induces the central bank (which faces no trade-off between its policy objectives) to raise the refinance rate. There are therefore two conflicting, indirect effects on the loan rate: on the one hand, the higher cost of borrowing from the central bank tends to mitigate its initial drop, due to the shock; on the other, the increase in the repayment probability associated with the positive output effect tends to amplify it. The net effect on the loan rate is negative.

The nominal bond rate increases, in line with the refinance and deposit rates, by an amount that exceeds the increase in the (one-period ahead) inflation rate; as a result, the real (expected) bond rate rises as well, thereby inducing households to reduce consumption today. This reduction also lowers the demand for housing services and real house prices, which lowers collateral values and mitigates the increase in the repayment probability resulting from higher output. The increase in the marginal cost of borrowing at home induces banks to borrow more abroad, thereby leading to an exchange rate appreciation and a fall in the economy's net foreign assets.

4.6.3. World Interest Rate Shock

Finally, suppose that the risk-free world interest rate follows a stationary log-linear first-order autoregressive process:

$$\ln\left(\frac{1+i_t^*}{1+\tilde{i}^*}\right) = \rho^W \ln\left(\frac{1+i_{t-1}^*}{1+\tilde{i}^*}\right) + \xi_t^W,$$

where $\rho^W \in (0,1)$ and $\xi_t^W \sim iid(0,\sigma_{\xi^W}^2)$. For this experiment, the autocorrelation coefficient ρ^W is set at 0.8 and σ_{ξ^W} and 0.01.

To illustrate the impact of external financial shocks on capital flows and domestic economic fluctuations, consider a temporary drop in the world risk-free interest rate by 1 percentage point.[20]

The results of this experiment are shown in Figures 4.9, 4.10, and 4.11. Four cases are considered: *a*) fully flexible exchange rate (no intervention, and thus no sterilization involved); *b*) intervention with no sterilization; *c*) intervention and sterilization, with low γ (essentially, no bank portfolio channel); and *d*) intervention and sterilization, with high γ. For the three cases involving foreign exchange intervention, the weight of the lagged exchange rate in the target rate, φ^E, is also set at 0.8, consistent with greater emphasis on *leaning against the wind*. In addition, the parameter that captures the degree of intervention, φ_2^R, is set at 12, to capture a relatively strong incentive to smooth exchange rate changes.[21] Finally, in the two cases involving sterilization, the parameter κ^F is set at 0.8.

Flexible exchange rate

Consider first the case where the exchange rate is fully flexible, as displayed in Figure 4.9. On impact, the shock lowers both the return on foreign assets and the bank's cost of borrowing abroad. Thus, households' net holdings of foreign bonds decline, whereas foreign borrowing by banks increases. These effects combine to generate an inflow of capital (a reduction in the economy's net foreign assets), which leads to a nominal appreciation. The domestic-currency price of imported intermediate goods falls as a result, thereby raising the demand for these goods. At the same time, the nominal appreciation lowers inflation (measured in terms of the price of domestic sales) initially. Thus, there are conflicting movements in output and inflation, and this creates a trade-off for the central bank in adjusting interest rates. But given the preeminence of the price stability objective, the net effect is a reduction in the refinance rate. As a result, the loan rate also falls, thereby stimulating investment. Because domestic prices are sticky, the nominal appreciation translates on impact into a real appreciation.

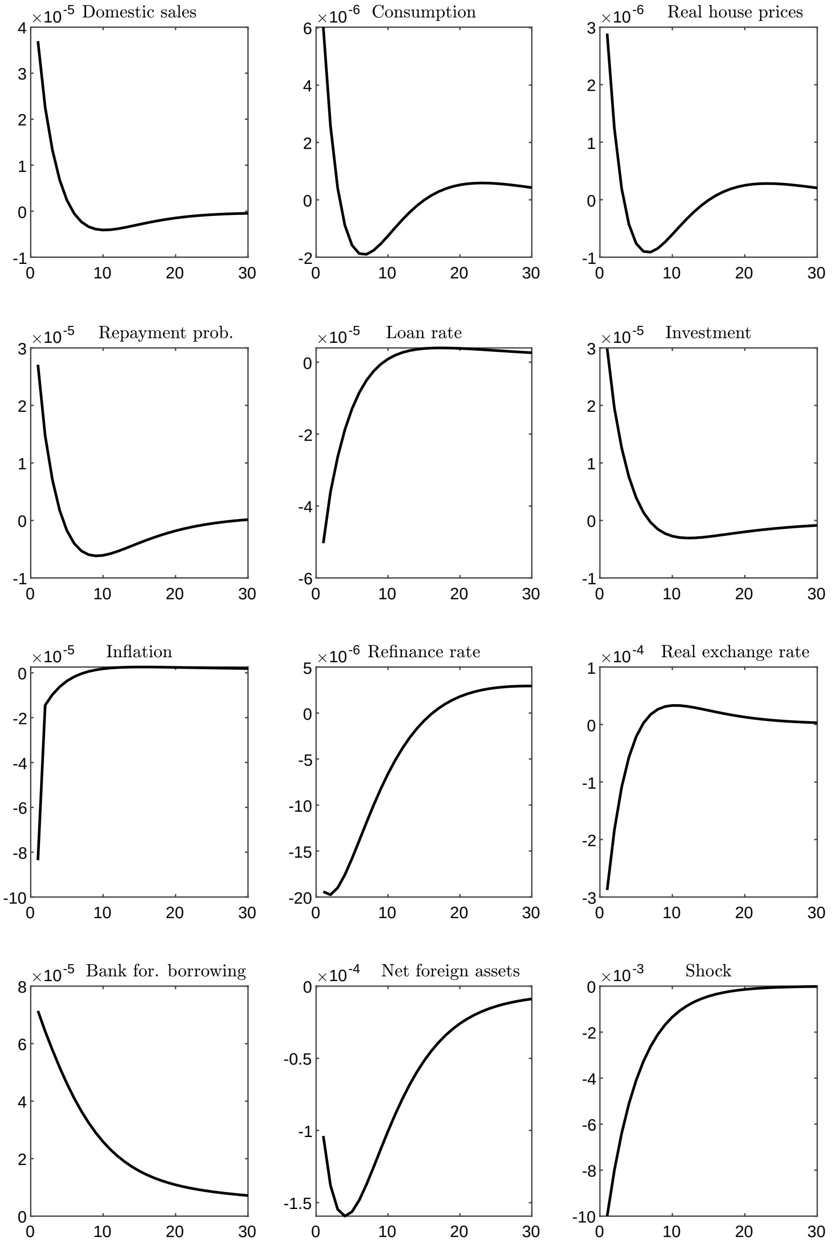
The reduction in net holdings of foreign bonds by domestic households leads also to higher demand for domestic cash and bonds, given that the deposit rate falls in response to the reduction in the refinance rate. Thus, the nominal bond rate also falls and, despite the drop in inflation on impact, the expected real bond rate falls as well. The weaker incentive to save induces households to consume more today. In turn, the increase in consumption is accompanied by a reduction in the supply of labour (given that the marginal utility of leisure rises) and greater demand for housing services, which puts upward pressure on their price and increases the value of the collateral that firms can pledge to secure investment loans. Although the collateral-loan ratio *falls* initially – the reduction in the cost of borrowing raises investment by more than the increase in the value of collateral – the repayment

[20] In analyzing the effects of this shock, the fact that changes in foreign interest rates could affect foreign output, and thus domestic exports, is not accounted for. This helps to isolate the pure financial effects of the shock.

[21] By way of comparison, Benes et al. (2015) used a value of 6 in their experiments.

Impulse Response Functions: Negative World Interest Rate Shock (Deviations from steady state)

Figure 4.9



Note: See Note to Figure 4.2.

probability increases on impact as a result of the positive effect of the increase in cyclical output. Consequently, the reduction in the loan rate is magnified and so is the expansion in investment. Domestic absorption increases unambiguously on impact. At the same time, the real appreciation translates into a reduction in exports, which also contributes to the expansion of sales of the final good on the domestic market.

The results of this experiment show therefore that, consistent with the evidence, external shocks that lead to large inflows of capital (a *sudden flood*, as discussed in Chapter 1) generate a domestic boom characterized by a credit expansion, asset price pressures, increases in aggregate demand, and an expansion in output. Although the boom in domestic activity tends to raise the refinance rate, the drop in inflation induced by the exchange rate appreciation tends to reduce it. Given the relative weights of inflation and output deviations in the Taylor rule, the net effect is a reduction in the refinance rate. This, in turn, reduces the cost of borrowing for banks and their customers, and contributes to the expansion in investment and output.

Unsterilized Foreign Exchange Intervention

Consider next the case of unsterilized foreign exchange intervention. The results are shown in Figure 4.10. For comparative purposes, the results displayed in Figure 4.9 are also reported. In addition, the behaviour of two additional variables is shown: the central bank's foreign reserves and the nominal exchange rate.[22]

The qualitative features of the transmission mechanism are fundamentally the same; the key difference is that the central bank intervenes in the foreign exchange market by buying foreign currency to mitigate the nominal appreciation. Its foreign reserves therefore increase on impact. Because intervention is not sterilized, the money supply expands as a result; to maintain equilibrium of the money market, the nominal bond rate must fall to increase the demand for cash. As a result, compared to the case of fully flexible exchange rate, the (expected) real bond rate falls by more, thereby inducing households to spend even more today. The result is higher output, a larger increase in the repayment probability, and therefore a more significant reduction in the loan rate and a larger expansion in investment. Given the degree of price stickiness, the impact on inflation is muted; but because of the stronger expansion in output, the drop in the refinance rate is unambiguously smaller. Overall, and consistent with the evidence, while unsterilized intervention stabilizes the exchange rate (ever so slightly here) , it ends up being more expansionary through its impact on domestic liquidity.

Sterilization, with and without Bank Portfolio Channel

Finally, consider the case of sterilized intervention, with weak ($\gamma = 0.05$) and strong bank ($\gamma = 0.1$) portfolio channels. The results are shown in Figure 4.11.

A comparison of Figures 4.10 and 4.11 shows that sterilized intervention (with no bank portfolio channel) stabilizes the economy compared to unsterilized intervention. However, when the bank portfolio channel is present and sufficiently strong, sterilized intervention is expansionary an magnifies macroeconomic fluctuations. The reason is that, when that channel is present, the loan rate falls by significantly more on impact, and the expansion in investment and output are stronger. Although the impact effect on consumption is weaker, it is also more persistent.

4.7. Extensions

To conclude, a few extensions of the analysis can be briefly considered. The first three extensions are related to issues raised in the previous chapters: *a*) physical capital as collateral; *b*) reserve requirements; and c) nominal wage rigidity. The last extension, which relates to the treatment of inflation expectations, is specific to dynamic models.

4.7.1. Physical Capital as Collateral

In the foregoing discussion, as in previous chapter, it was assumed that collateral consists of housing or land. Alternatively, and more in line with models with financial frictions in the tradition of Bernanke et al. (1999), it could be assumed that firms can pledge physical capital, K_t, to secure loans. Thus, equation (4.66), which relates to the repayment probability, would be replaced by

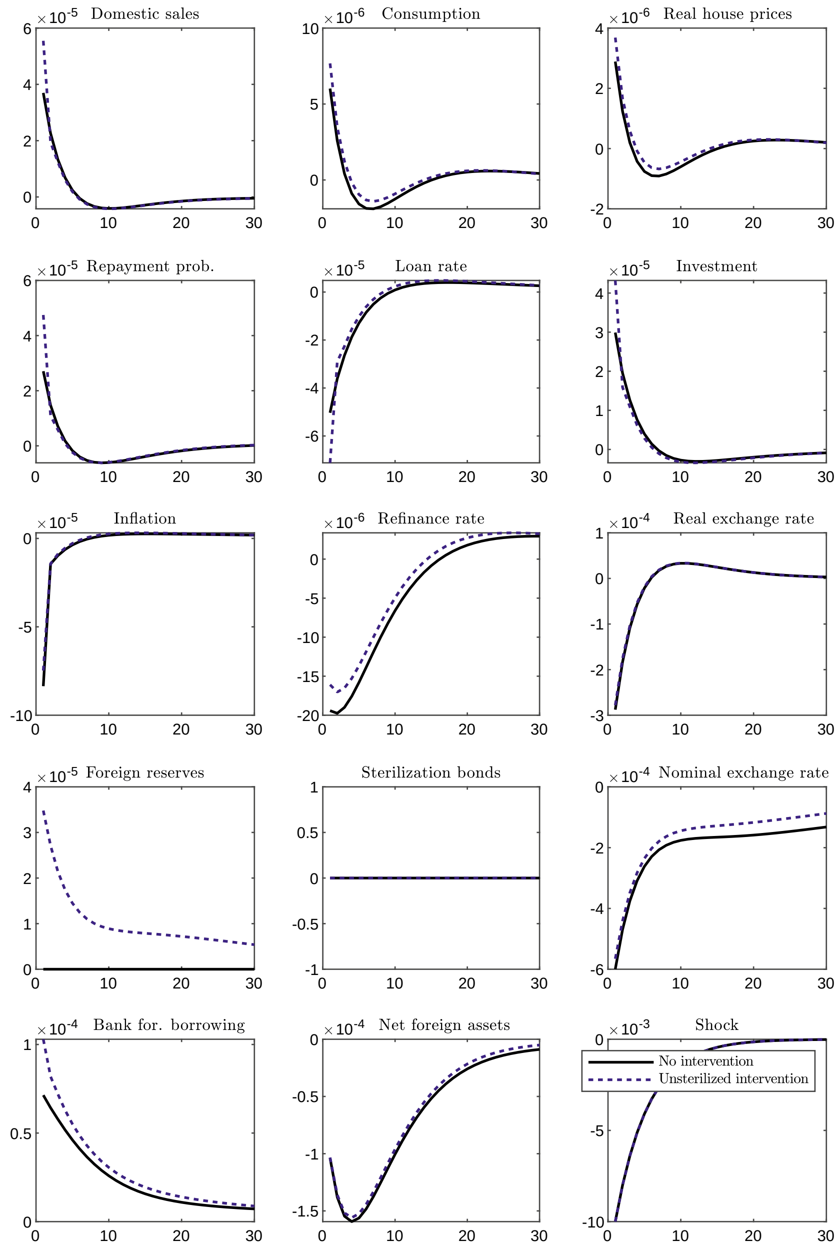
$$q_t = \varphi_0 \left(\frac{\kappa \mathbb{E}_t p^K_{t+1} K_t / \tilde{p}^K \tilde{K}}{l^K_t / \tilde{l}^K}\right)^{\varphi_1} \left(\frac{Y_t}{\tilde{Y}}\right)^{\varphi_2} \left(\frac{1+i^L_t}{1+\tilde{i}^L}\right)^{\varphi_3}.$$

As discussed in the closed economy static model, using physical capital as collateral did not change fundamentally the properties of the model, with respect to the financial amplification effects associated with core shocks. In the results presented by Agénor (2020, Chapter 4), based on a closed-economy DSGE model with financial frictions similar to those discussed earlier, this is also the case.

[22] Deviations in the stock of sterilization bonds is also represented, although it does not change in the cases considered.

Impulse Response Functions: Negative World Interest Rate Shock (Deviations from steady state)

Figure 4.10



Note: See Note to Figure 4.2.

4.7.2. Reserve Requirements

As noted in previous chapters, imperfect substitutability between (domestic) funding sources for commercial banks is a necessary condition for reserve requirements to be effective as a countercyclical instrument. Suppose indeed that deposits and central bank borrowing are not perfect substitutes from the perspective of the monetary authority. Specifically, the actual cost of borrowing from the central bank is now i_t^C, given by

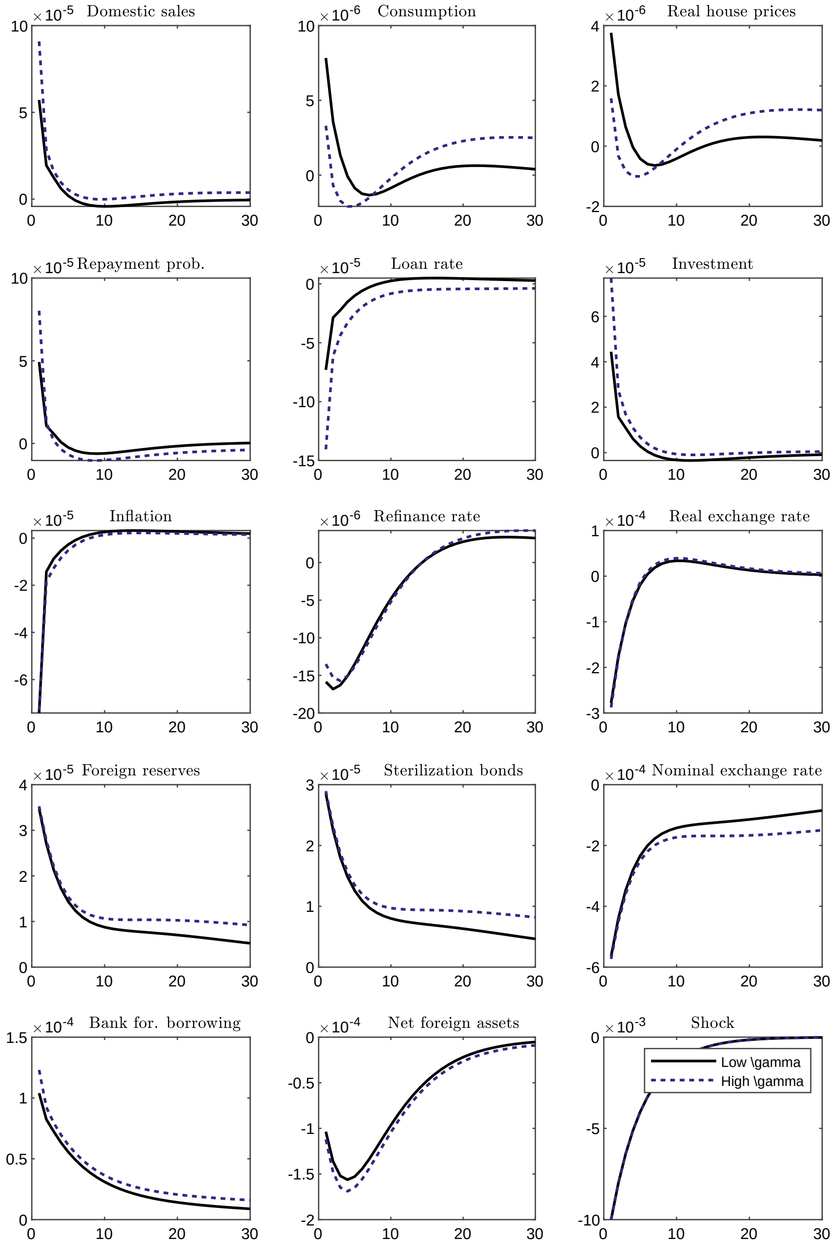
$$1 + i_t^C = (1 + i_t^R)(1 + \theta_t^{C,B}), \tag{4.89}$$

where $\theta_t^{C,B}$ represents a penalty rate, which is positively related to the ratio of central bank borrowing to deposits:

$$\theta_t^{C,B} = \theta_0^{C,B}\left(\frac{l_t^{C,B}}{d_t}\right), \tag{4.90}$$

Impulse Response Functions: Negative World Interest Rate Shock (Deviations from steady state)

Figure 4.11



Note: See Note to Figure 4.2.

with $\theta_0^{C,B} > 0$. At the same time, the no-arbitrage condition between the deposit rate and the marginal cost of central bank liquidity, equation (4.54), becomes

$$i_t^{D,i} = (1-\mu_t)i_t^C, \tag{4.91}$$

where μ_t is now a time-varying policy instrument, whereas equation (4.62) has now i_t^C as a measure of the marginal cost of domestic funding:

$$1+i_t^L = \frac{\zeta^L}{(\zeta^L-1)(1-\tau_t^C)q_t}\left\{1+i_t^C+\gamma_L-\gamma\left(\frac{b_t^{CB}}{l_t^K}\right)^{0.5}\right\}. \tag{4.92}$$

Equation (4.89) shows that the rate at which commercial banks can borrow from the central bank incorporates a penalty rate, above and beyond the refinance rate, determined through the Taylor rule (4.72). Equation (4.90) indicates that the penalty rate increases with the amount borrowed domestically and falls with the level of deposits.

From (4.91), an increase in the required reserve ratio lowers the deposit rate as well as deposits. All else equal, the penalty rate rises, and so do the marginal cost of domestic borrowing and the loan rate, as implied by (4.89) and (4.92). Thus, the policy is countercyclical. A thorough numerical analysis of how this policy operates in related DSGE models is provided in Agénor (2020, Chapters 5 and 9) and Agénor et al. (2018).[23]

4.7.3. Nominal and Real Wage Rigidity

In the simple models presented in Chapters 2 and 3, the nominal wage was assumed to be fixed. By contrast, in the foregoing discussion, it was assumed that the real wage is fully flexible. As implied by the first-order condition (4.15), in a frictionless, perfectly competitive labour market, the wage adjusts to equate the marginal rate of substitution between consumption and leisure and the marginal product of labour.

There is an extensive literature dealing with ways of introducing nominal and real wage rigidity in DSGE models. A particularly simple specification to introduce wage rigidity in the foregoing analysis is to rewrite condition (4.15) as

$$W_t = W_{t-1}^{\delta^W}(P_t \eta_N N_t^{\psi_N} C_t^{1/\varsigma})^{1-\delta^W}, \tag{4.93}$$

where $\delta^W \in (0,1)$. Thus, the case of full flexibility considered earlier corresponds to $\delta^W = 0$. By contrast, if $\delta^W = 0$, then $W_t = W_{t-1}$, and the nominal wage is constant. Similarly, as in Blanchard and Gal13053’f (2007, eq. 15), real wage rigidity can be captured by replacing (4.93) by $\omega_t = \omega_{t-1}^{\delta^W}(\eta_N N_t^{\psi_N} C_t^{1/\varsigma})^{1-\delta^W}$.

Other commonly used specifications in DSGE models involve wage norms (discussed by Christoffel and Linzert (2010, eq. 23) and Krause and Lubik (2007, eq. (33), for instance), search and matching frictions (as in Blanchard and Gal13053’f (2010), Heer and Schubert (2012), Boz et al. (2015), and Sheen and Wang (2016), for instance), bargaining, between either firms and workers or firms and trade unions (as in Christofffel and Linzert (2010), for instance), and efficiency wages. A common result in the literature is that more rigid wages (a higher δ^W) translates into more persistent fluctuations in output and inflation. In addition, wage rigidity can generate frictional unemployment.[24]

4.7.4. Inflation Expectations

In the model presented earlier, both inflation and exchange rate expectations are forward-looking and fully rational, and the inflation target is fully credible. However, it could be assumed that credibility of the target is imperfect, and that inflation expectations adjust gradually, based on the ability of the central bank to achieve its target. A simple specification along these lines is to specify the evolution of the expected inflation rate, denoted $\pi_{t+1|t}^e$ rather than $\mathbb{E}_t \pi_{t+1}$, in the form

$$\pi_{t+1|t}^e = \theta_t \pi^T + (1-\theta_t)\pi_{t-1}, \tag{4.94}$$

where the parameter $\theta_t \in (0,1)$ is updated through a Bayesian rule related to deviations of actual inflation from target, so that $\theta_t = f(\pi_t - \pi^T)$, with $f' < 0$. Such a function may also take an asymmetric form, if overshooting the target is viewed as more costly than undershooting.[25] The implications of replacing the rational expectation $\mathbb{E}_t \pi_{t+1}$ by a specification such as (4.94), or by a convex combination of $\mathbb{E}_t \pi_{t+1}$ and $\pi_{t+1|t}^e$, is that it would likely generate greater persistence in economic fluctuations – without, however, necessarily affecting qualitatively the results discussed earlier.

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23 See also Lama and Medina (2020), who also consider (as is done in Chapter 5) the optimal combination of foreign exchange intervention and reserve requirements rules.

24 See Gal (2010) for a discussion of the literature.

25 Alternatively, Adrian et al. (2022*a*, 2022*b*) defined the degree of inertia in inflation expectations in terms of the values of the parameters that determine the degree of nominal price rigidity.

Appendix

The Bank Optimisation Problem

As noted in the text, bank i 's balance sheet, equation (4.50), can be used to determine residually how much it borrows from the central bank:

$$l_t^{B,i} = l_t^{K,i} + b_t^{CB,i} - z_t L_t^{FB,i} - d_t^i, \tag{4.1}$$

with the demand for loans from bank i, $l_t^{K,i}$, given by the downward-sloping curve (4.55).

Each bank sets the repayment probability, its (gross) loan rate, foreign borrowing, and holdings of central bank bonds, in order to maximise its end-of-period expected real profits, $\mathbb{E}_t J_{t+1}^{B,i}$:

$$q_t^i, 1+i_t^{L,i}, L_t^{FB,i}, b_t^{CB,i} = \text{argmax}\, \mathbb{E}_t J_{t+1}^{B,i},$$

where $\mathbb{E}_t J_{t+1}^{B,i}$ is defined in equation (4.56), reproduced here for convenience:

$$\mathbb{E}_t J_{t+1}^{B,i} = q_t^i (1+i_t^{L,i})(1-\tau_t^C) l_t^{K,i} + (1-q_t^i)\kappa^i \mathbb{E}_t p_{t+1}^H H_t \tag{4.2}$$

$$+(1+i_t^{CB}) b_t^{CB,i} + \mu d_t^i - (1+i_t^{D,i}) d_t^i - (1+i_t^R) l_t^{B,i} - (1+i_t^{FC,i}) \mathbb{E}_t (\frac{E_{t+1}}{E_t}) z_t L_t^{FB,i}$$

$$-\Gamma(l_t^{K,i}, b_t^{CB,i}) + \Omega_t^{C,i} - x_t^{M,i},$$

subject to the downward-sloping loan demand curve of the representative CG producer (4.55), the balance sheet constraint (4.1), the cost of foreign borrowing (4.57)-(4.58), and monitoring costs (4.60).

Substituting (4.57) for $1+i_t^{FC,i}$ and (4.1) for $l_t^{B,i}$ in (4.2), and using (4.58) and (4.60) to substitute out for $\theta_t^{FC,i}$, and $x_t^{M,i}$, respectively, yields

$$\mathbb{E}_t J_{t+1}^{B,i} = q_t^i (1+i_t^{L,i})(1-\tau_t^C) l_t^{K,i} + (1-q_t^i)\left(\kappa^i \mathbb{E}_t p_{t+1}^H H_t\right) + (1+i_t^{CB}) b_t^{CB,i} \tag{4.3}$$

$$-(1+i_t^{D,i}) d_t^i - (1+i_t^R)(l_t^{K,i} + b_t^{CB,i} - z_t L_t^{FB,i} - d_t^i)$$

$$-(1+\tau_t^B)(1+i_t^*)(1+\frac{\theta_0^{FB}}{2} L_t^{FB,i}) \mathbb{E}_t (\frac{E_{t+1}}{E_t}) z_t L_t^{FB,i} - \Gamma(l_t^{K,i}, b_t^{CB,i}) + \Omega_t^{B,i} - \Phi_t \frac{(q_t^i)}{2} l_t^{K,i}.$$

Taking as given the macroprudential tax rate τ_t^C, the value of collateral $\mathbb{E}_t p_{t+1}^H H_t$, the deposit and refinance rates and i_t^R, the rate of return on central bank bonds i_t^{CB}, the real exchange rate z_t, and the world interest rate i_t^*, the lump-sum transfer $\Omega_t^{C,i}$, and the unit monitoring cost parameter Φ_t, maximisation of (4.3) with respect to q_t^i, $1+i_t^{L,i}$, $L_t^{FB,i}$, and $b_t^{CB,i}$ yields the first-order conditions:

$$(1+i_t^{L,i})(1-\tau_t^C) l_t^{K,i} - \kappa^i \mathbb{E}_t p_{t+1}^H H_t - \Phi_t q_t^i l_t^{K,i} = 0, \tag{4.4}$$

$$q_t^i (1-\tau_t^C) l_t^{K,i} + q_t (1+i_t^{L,i})(1-\tau_t^C) \frac{\partial l_t^{K,i}}{\partial (1+i_t^{L,i})} - (1+i_t^R) \frac{\partial l_t^{K,i}}{\partial (1+i_t^{L,i})} \tag{4.5}$$

$$-\Gamma_{l^K}(l_t^{K,i}, b_t^{CB,i}) \frac{\partial l_t^{K,i}}{\partial (1+i_t^{L,i})} = 0,$$

$$(1+i_t^R) z_t - (1+\tau_t^B)(1+i_t^*) \mathbb{E}_t (\frac{E_{t+1}}{E_t}) z_t (1+\theta_0^{FC} L_t^{FB,i}) = 0, \tag{4.6}$$

$$1+i_t^{CB} - (1+i_t^R) - \Gamma_{b^{CB}}(l_t^{K,i}, b_t^{CB,i}) = 0. \tag{4.7}$$

Consider first condition (4.4). Using (4.61), it can be rearranged to give, in a symmetric equilibrium,

$$q_t = (\frac{\kappa \mathbb{E}_t p^H_{t+1} \bar{H}}{l^K_t})^{\Phi_1} (\frac{Y_t}{\tilde{Y}})^{\Phi_2} [(1-\tau^C_t)(1+i^L_t) - (\frac{\kappa \mathbb{E}_t p^H_{t+1} \bar{H}}{l^K_t})]. \tag{4.8}$$

Consider next condition (4.5). From (4.55), $l^{K,i}_t = [(1+i^{L,i}_t)/(1+i^L_t)]^{-\zeta^L} l^K_t$; thus

$$\frac{\partial l^{K,i}_t}{\partial (1+i^{L,i}_t)} = -\zeta^L (\frac{1+i^{L,i}_t}{1+i^L_t})^{-\zeta^L - 1} (\frac{l^K_t}{1+i^L_t}). \tag{4.9}$$

Substituting (4.55) and (4.9) in (4.5), and noting that $\Gamma()$ is linearly homogeneous, yields

$$q^i_t (1-\tau^C_t)(\frac{1+i^{L,i}_t}{1+i^L_t})^{-\zeta^L} l^K_t - q^i_t (1+i^{L,i}_t)\zeta^L (\frac{1+i^{L,i}_t}{1+i^L_t})^{-\zeta^L-1}(\frac{l^K_t}{1+i^L_t})$$

$$+(1+i^R_t)\zeta^L (\frac{1+i^{L,i}_t}{1+i^L_t})^{-\zeta^L-1}(\frac{l^K_t}{1+i^L_t})$$

$$-\Gamma_{l^K}(\frac{l^{K,i}_t}{b^{CB,i}_t},1)[-\zeta^L (\frac{1+i^{L,i}_t}{1+i^L_t})^{-\zeta^L-1}(\frac{l^K_t}{1+i^L_t})] = 0.$$

In a symmetric equilibrium, $i^{L,i}_t = i^L_t \ \forall i$, and this expression gives

$$q_t(1-\tau^C_t) l^K_t - q_t(1+i^L_t)\zeta^L (\frac{l^K_t}{1+i^L_t}) + (1+i^R_t)\zeta^L (\frac{l^K_t}{1+i^L_t}) + \Gamma_{l^K}(\frac{l^K_t}{b^{CB}_t},1)\zeta^L (\frac{l^K_t}{1+i^L_t}) = 0.$$

Multiplying both sides by $-(1+i^L_t)/l^K_t$ yields

$$q_t(1-\tau^C_t)(1+i^L_t) - q_t(1+i^L_t)\zeta^L + (1+i^R_t)\zeta^L + \Gamma_{l^K}(\frac{l^K_t}{b^{CB}_t},1)\zeta^L = 0,$$

which gives the equilibrium loan rate as

$$1+i^L_t = \frac{\zeta^L}{(\zeta^L-1)q_t(1-\tau^C_t)} \left\{ 1+i^R_t + \Gamma_{l^K}(1,\frac{b^{CB}_t}{l^K_t}) \right\}. \tag{4.10}$$

Now, as noted in the text (equation (4.59)), suppose that $\Gamma(l^K_t, b^{CB}_t)$ can be represented by the Diewert cost function:

$$\Gamma(l^K_t, b^{CB}_t) = \gamma_B b^{CB}_t + \gamma_L l^K_t - 2\gamma \sqrt{l^K_t b^{CB}_t},$$

where $\gamma_B, \gamma_L, \gamma > 0.$ It can be shown that[26]

$$\Gamma_{l^K} = \gamma_L - \frac{\gamma b^{CB}_t}{\sqrt{l^K_t b^{CB}_t}} = \gamma_L - \gamma(\frac{b^{CB}_t}{l^K_t})^{0.5},$$

$$\Gamma_{b^{CB}} = \gamma_B - \frac{\gamma l^K}{\sqrt{l^K_t b^{CB}_t}} = \gamma_B - \gamma(\frac{l^K_t}{b^{CB}_t})^{0.5}.$$

Substituting these results in equations (4.7) and (4.10) yields

$$1+i^L_t = \frac{\zeta^L}{(\zeta^L-1)q_t} \left\{ 1+i^R_t + \gamma_L - \gamma(\frac{b^{CB}_t}{l^K_t})^{0.5} \right\}, \tag{4.11}$$

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26 Note that while we always have $\Gamma_{ii} > 0$, and $\Gamma_{ij} < 0$, for $i = l^K, b^{CB}$, to ensure that $\Gamma_i > 0$ requires appropriate restrictions on γ_B and γ_L. These restrictions are checked when calibrating and solving the model.

$$\frac{b_t^{CB}}{l_t^K} = \frac{\gamma^2}{(i_t^R + \gamma_B - i_t^{CB})^2}. \tag{4.12}$$

Finally, consider the first-order condition with respect to $L_t^{FB,i}$, equation (4.6). It can be rearranged to give

$$1 + i_t^R - (1 + \tau_t^B)(1 + i_t^*)\mathbb{E}_t(\frac{E_{t+1}}{E_t})(1 + \theta_0^{FC} L_t^{FB,i}) = 0,$$

so that, in a symmetric equilibrium,

$$L_t^{FB} = \frac{1 + i_t^R - (1 + \tau_t^B)(1 + i_t^*)\mathbb{E}_t(E_{t+1} / E_t)}{\theta_0^{FC}(1 + \tau_t^B)(1 + i_t^*)\mathbb{E}_t(E_{t+1} / E_t)}. \tag{4.13}$$

Equations (4.8), (4.11), (4.12), and (4.13) correspond to those reported in the text.

Note also that with b_t^{CB} set by the central bank through its intervention rule, equation (4.12) can be inverted to solve for i_t^{CB}:

$$i_t^{CB} = i_t^R + \gamma_B - \gamma(\frac{l_t^K}{b_t^{CB}})^{0.5}, \tag{4.14}$$

as stated in the text.

Chapter 5. Policy Responses to External Financial Shocks: Numerical Experiments

One of the key numerical experiments reported in the previous chapter focused on the transmission of world interest rate shocks to small open economies. The results were shown to be consistent with some of the well-documented facts (as discussed in Chapter 1) pertaining to the transmission of these shocks to developing countries: a surge in capital inflows, exchange rate appreciation, widening current account deficits, asset price increases, a credit expansion, aggregate demand pressures, and, despite these pressures, no discernible (or even a negative) impact on inflation, due to exchange rate appreciation putting downward pressure on the prices of imported goods. Today, the challenges associated with capital flows triggered by "push" factors remain as pressing as they have ever been for policymakers in middle-income countries.

This chapter uses the DSGE model presented in Chapter 4 to discuss policy responses to external financial shocks. As was done in Chapter 3, in a simpler setting, both individual and combinations of policies are considered. From the perspective of monetary policy (which, as noted previously, may lose its effectiveness), the issue is whether responding to fluctuations in macroeconomic and financial variables – above and beyond a "normal" response through a standard Taylor rule – is possible, without exacerbating movements in capital flows. In addition, the issue is whether other instruments, used either individually or in combinations, can be used to manage capital flows and mitigate the potential risks that they may cause. Indeed, if financial imbalances are related to excessive credit growth, and if credit growth is fuelled by large capital inflows, a comprehensive policy response may well require, for instance, the use of both macroprudential tools and foreign exchange intervention. In that context, the cost of instrument manipulation (which was not explicitly considered in Chapter 3) may also be an important consideration.

This chapter considers the effectiveness of fiscal policy, monetary policy (in the form of an augmented Taylor rule), sterilized intervention, macroprudential regulation, and capital controls in response to external financial shocks. As noted in the previous chapter, the distortion that macroprudential regulation and capital controls are aimed at correcting relates fundamentally to the fact that the financial system may behave procyclically in response to these shocks. Both policies, which essentially operate as a tax, may therefore help to mitigate these risks by, in the first place, dampening the increase in bank foreign borrowing. More generally, the issue of substitutability and complementarity between policy instruments can also be addressed in this setting.

The remainder of this chapter is organized as follows. Section 1 discusses alternative ways of conducting policy evaluation, that is, the definition of the "metric" used to determine instrument settings optimally and assess their performance. section 2 considers individual optimal responses for the set of policy instruments referred to earlier. section 3 considers optimal combinations of these instruments, based on simple implementable rules. In both sections the focus is on responses to a negative shock to the world risk-free interest rate, as discussed in the previous chapter. The last section considers some extensions, namely, the comparison between independent policymaking and cooperation (that is, the gains from coordination), the case of constrained coordination, and the case of biased policy preferences, which represent an alternative metric for the evaluation of optimal policy and performance.

5.1. Policy Evaluation

Three approaches are commonly used in the DSGE literature to study optimal policies.[1]

The first focuses on using simple, implementable rules – that is, rules whereby macro-financial policy instruments are set (without violating standard nonnegativity constraints) on the basis of a few observable, aggregate variables – to minimise a policy loss function, based on an institutional mandate attributed to policymakers.

Comment 5.1. The set of policy rules that can be deemed to be "simple" and "implementable" may be fairly broad. In particular, credit conditions can be measured either by credit growth, the credit-to-output ratio, the risky credit-to-bank capital ratio, credit spreads, total credit or only *uncollateralized* credit (conceptually a more relevant indicator of financial fragility), and so on, all in terms of deviations from a reference value or benchmark. Which indicator, and which reference value, is chosen could significantly affect the performance of any particular rule. However, in this Manual, the focus will be on either credit-to-output or credit growth only.

[1] See also Agénor (2020, Chapter 5) for a discussion. In what follows, and as in Svensson (2010), for instance, the term "optimal" is used to refer in general to optimization-based policies.

The second consists of again choosing simple instrument rules to maximise social welfare, often defined in terms of the utility function of the representative household.[2] In the first case a linear approximation of the model is sufficient, whereas in the second a second-order approximation is necessary. The third approach is the Ramsey optimal policy (or Ramsey policy, for short), under which a social planner directly sets the path of some policy instrument, or instruments, so as to maximise social welfare, subject to the constraints imposed by the competitive market equilibrium. However, although the Ramsey policy provides a rigorous and conceptually sound approach to policy evaluation, it is often difficult to derive in richer models – the so-called *curse of dimensionality*.

There are pros and cons to all of these approaches. In what follows an explicit characterization of the first two approaches is provided.[3] In addition, a fourth approach, proposed by Agénor and Flamini (2022), which involves combining the first two, is also presented.

5.1.1. Policy Loss Minimisation

The first approach typically involves, for the central bank, minimising an intertemporal loss function, defined as a discounted sum of current and expected future losses, with a quadratic period loss function in terms of (squared) inflation and (squared) output, both as deviations from a target or reference value. The underlying rationale is that the central bank has a *dual institutional mandate*, or an *extended simple mandate*, with inflation stability taking precedence over output stability as an objective. This is captured by imposing a greater weight on the former relative to the latter.[4]

Consider first the case where the central bank is concerned with macroeconomic stability and the regulator with financial stability. Macroeconomic (in)stability is defined in terms of a *macroeconomic stability index*, which is specified as a weighted average of the asymptotic conditional variances (that is, subject to the initial state of the economy being the nonstochastic steady state) of inflation deviations, σ_π^2, and cyclical output deviations, σ_Y^2:

$$\mathcal{LF}_t^M = \sigma_\pi^2 + \gamma^Y \sigma_Y^2, \tag{5.1}$$

where $\gamma^Y > 0$ is the weight on output deviations.

Similarly, financial (in)stability is defined in terms of a *financial stability index*. This index can be defined in *narrow* terms, denoted $\mathcal{LF}_t^{F,N}$, on the basis of the asymptotic variance of the ratio of investment loans to output, l_t^K / Y_t.[5] Alternatively, it can be defined in terms of a *broad* index, denoted $\mathcal{LF}_t^{F,B}$, specified on the basis of a weighted average of the asymptotic variances of the investment loan-to-output ratio and the variance of real house prices, p_t^H. Thus,

$$\mathcal{LF}_t^F = \begin{cases} \mathcal{LF}_t^{F,N} = \sigma_{l^K/Y}^2 \text{ Narrowindex} \\ \mathcal{LF}_t^{F,B} = \gamma^F \sigma_{l^K/Y}^2 + (1-\gamma^F)\sigma_{p^H}^2 \text{ Broadindex}' \end{cases} \tag{5.2}$$

where $\gamma^F \in (0,1)$.

As in Agénor et al. (2014, 2018) for instance, a composite *economic stability index*, $\mathcal{LF}_t^E$, which combines the objectives of the central bank and the regulator, can be defined as a weighted average of the two indexes,

$$\mathcal{LF}_t^E = \gamma^E \mathcal{LF}_t^M + (1-\gamma^E)\mathcal{LF}_t^F, \tag{5.3}$$

where $\gamma^E \in (0,1)$. In what follows, the case in which the central bank focuses only on macroeconomic stability (thereby minimising $\mathcal{LF}_t^M$) and the case in which it focuses on both macroeconomic and financial stability (in which case it minimises the composite index $\mathcal{LF}_t^E$) will both be considered. In the latter case, two scenarios can be addressed: the scenario in which macroeconomic stability is the main concern, so that $\gamma^E = 0.8$, and the scenario in which both objectives have equal weights, $\gamma^E = 0.5$. As for the financial regulator, it will be assumed that its only goal, as delegated by society, is to promote financial stability; its objective is therefore to minimise $\mathcal{LF}_t^F$ only.

2 In models where there are several categories of households, and possibly entrepreneurs who also consume, the welfare criterion is generally based on a weighted average of each group's utility function.

3 A comparison with the Ramsey policy is not provided, due to the difficulty of solving for it in relatively large models.

4 See Debortoli et al. (2019) for a discussion.

5 The volatility of credit growth is also used in a number of contributions.

There is also some evidence that central banks – even in those countries that have adopted an inflation targeting framework, as discussed in previous chapters – are also systematically concerned about exchange rate fluctuations, possibly as a result of financial stability considerations (see the discussion later on). Evidence to that effect is provided by estimating augmented Taylor rules (as in Aizenman et al. (2011), for instance) or assessing relative policy preferences (as in Gómez et al. (2019) and McKnight et al. (2020) for Latin America). If so, the index of macroeconomic stability (5.1) could be defined as

$$\mathcal{LF}_t^M = \sigma_\pi^2 + \gamma^Y \sigma_Y^2 + \gamma^z \sigma_z^2,$$

with $\gamma^z > 0$, if the policy concern is in terms of real exchange rate volatility. However, there is also some evidence to suggest that stabilizing the exchange rate is often a *sporadic*, not a systematic, objective of central banks.

5.1.2. Welfare Maximisation

Alternatively, policymakers' objective may be to maximise social welfare, defined in terms of the utility of the representative household. To do so welfare calculations must be based on a second-order approximation to the household's period utility function and the model characterizing the economy (see Benigno and Woodford (2005)).

From equation (1) in Chapter 4, the present discounted value of the household's expected utility function is

$$U_t = \mathbb{E}_t \sum_{s=0}^{\text{€}} f^{s} u_{t+s}, \tag{5.4}$$

where u_t is the period utility function defined as

$$u_t = u(C_t, N_t, x_t) = \frac{C_t^{1-\varsigma^{-1}}}{1-\varsigma^{-1}} - \eta_N \frac{(\int_0^1 N_t^j dj)^{1+\psi_N}}{1+\psi_N} + \ln x_t^{\eta_x} + \ln H_t^{\eta_H}, \tag{5.5}$$

and all variables and parameters are as defined previously.

Given that the housing market is always in equilibrium, and that the supply of housing is constant, the utility benefit from housing services is also constant and can be ignored. The period utility function can therefore be written as

$$u_t = u(C_t, N_t, x_t) = \frac{C_t^{1-\varsigma^{-1}}}{1-\varsigma^{-1}} - \eta_N \frac{N_t^{1+\psi_N}}{1+\psi_N} + \eta_x \ln x_t. \tag{5.6}$$

Taking a second-order approximation to $u()$ in the vicinity of the initial, deterministic steady state and noting that all cross-derivatives are zero yields

$$u_t \simeq \tilde{u} + u_C(\tilde{C},\tilde{N},\tilde{x})(C_t - \tilde{C}) + u_N(\tilde{C},\tilde{N},\tilde{x})(N_t - \tilde{N}) + u_x(\tilde{C},\tilde{N},\tilde{x})(x_t - \tilde{x})$$

$$+ \frac{u_{CC}(\tilde{C},\tilde{N},\tilde{x})}{2}(C_t - \tilde{C})^2 + \frac{u_{NN}(\tilde{C},\tilde{N},\tilde{x})}{2}(N_t - \tilde{N})^2 + \frac{u_{xx}(\tilde{C},\tilde{N},\tilde{x})}{2}(x_t - \tilde{x})^2 + \mathcal{O}(3),$$

where

$$\tilde{u} = \frac{\tilde{C}^{1-\varsigma^{-1}}}{1-\varsigma^{-1}} - \frac{\eta_N \tilde{N}^{1+\psi_N}}{1+\psi_N} + \eta_x \ln \tilde{x},$$

and $\mathcal{O}(3)$ denotes terms of third order or higher. Ignoring these higher-order terms, this approximation can be rewritten as

$$u_t \simeq \tilde{u} + \tilde{C}^{-\varsigma^{-1}}(C_t - \tilde{C}) - \eta_N \tilde{N}^{\psi_N}(N_t - \tilde{N}) + \frac{\eta_x}{\tilde{x}}(x_t - \tilde{x})$$

$$- \frac{\tilde{C}^{-\varsigma^{-1}-1}}{2\varsigma}(C_t - \tilde{C})^2 - \eta_N \psi_N \frac{\tilde{N}^{\psi_N - 1}}{2}(N_t - \tilde{N})^2 - \eta_x \frac{\tilde{x}^{-2}}{2}(x_t - \tilde{x})^2,$$

or again

$$u_t \simeq \tilde{u} + \tilde{C}^{1-\varsigma^{-1}}(\frac{C_t - \tilde{C}}{\tilde{C}}) - \eta_N \tilde{N}^{\psi_N}(\frac{N_t - \tilde{N}}{\tilde{N}}) + \eta_x(\frac{x_t - \tilde{x}}{\tilde{x}})$$

$$-\frac{\tilde{C}^{1-\varsigma^{-1}}}{2\varsigma}(\frac{C_t - \tilde{C}}{\tilde{C}})^2 - \eta_N \psi_N \frac{\tilde{N}^{1+\psi_N}}{2}(\frac{N_t - \tilde{N}}{\tilde{N}})^2 - \frac{\eta_x}{2}(\frac{x_t - \tilde{x}}{\tilde{x}})^2.$$

Equivalently, defining the log-deviation of C_t from its steady-state value as $\hat{C}_t = \ln(C_t / \tilde{C}) \simeq (C_t - \tilde{C}) / \tilde{C}$, and similarly for $\hat{N}_t$ and $\hat{x}_t$, the above expression becomes

$$u_t \simeq \tilde{u} + \tilde{C}^{1-\varsigma^{-1}}\hat{C}_t - \eta_N \tilde{N}^{1+\psi_N}\hat{N}_t + \eta_x \hat{x}_t - \frac{\tilde{C}^{1-\varsigma^{-1}}}{2\varsigma}\hat{C}_t^2 - \eta_N \psi_N \frac{\tilde{N}^{1+\psi_N}}{2}\hat{N}_t^2 - \frac{\eta_x}{2}\hat{x}_t^2.$$

The conditional expectation of log-deviations from the steady state is zero, that is, $\mathbb{E}_t(\hat{C}_t) = \mathbb{E}_t(\hat{N}_t) = \mathbb{E}_t(\hat{x}_t) = 0$. Thus, the conditional expectation of the present discounted value of the household's expected utility function can be approximated by

$$\mathcal{U}_t \simeq \frac{1}{1-f}\left\{\tilde{u} - \frac{\tilde{C}^{1- \ -1}}{2\varsigma}\text{Var}(\hat{C}_t) - \eta_N \psi_N \frac{\tilde{N}^{1+ \ N}}{2}\text{Var}(\hat{N}_t) - \frac{x}{2}\text{Var}(\hat{x}_t)\right\}, \tag{5.7}$$

where $\text{Var}(\hat{y}_t)$ denotes the conditional variance of $\hat{y}_t$, calculated from period t to infinity.

5.1.3. Two-Stage Welfare Analysis

The loss function and social welfare approaches are not necessarily incompatible. In some models, and under certain conditions, a loss function similar to equation (5.1) can be formally derived from a second-order approximation to a representative household utility function, with the relative weight of the output term being a function of the underlying deep parameters in the economy – such as those governing the degree of price stickiness. In that sense, simple loss functions for central banks can be viewed as parsimonious approximations to social welfare (Debortoli et al. (2019)). Broader loss functions can be derived in a similar fashion. For instance, De Paoli (2009) showed that in an open economy the utility-based loss function can be written as a quadratic expression of domestic inflation, the output gap, and the real exchange rate.

However, depending on the model (in particular, whether financial frictions are accounted for), loss functions that are explicitly derived as approximations to social welfare may account for the volatility of variables that are not necessarily easy to interpret. Andrés et al. (2013), for instance, in a model with (constrained) borrowers and savers, showed that the micro-founded loss function accounts not only for inflation and output gap volatility but also for additional terms, which capture aspects of heterogeneity between households. These terms include a *housing gap* and a *consumption gap*, with the former measuring the distortion in the distribution of collateralizable assets between household groups (savers and borrowers) and the latter measuring the gap between the consumption of these groups. These gaps are not particularly intuitive from a practical policy standpoint. More generally, such approximations of household welfare remain to a very significant extent *model dependent* and reflect the particular distortions assumed in any given model. The resulting loss functions – if they can be derived at all – may end up being relatively complex, especially when financial frictions are introduced.

A third approach, proposed by Agénor and Flamini (2022), combines the policy loss minimisation and the welfare maximisation approaches in a two-stage process. In a first stage, the optimal parameters of the policy rule are solved for using a loss function approach, consistent with a narrow institutional mandate defined in terms of inflation and output stability for the central bank, and in terms of an operational target for financial stability (mitigating credit fluctuations) for the financial regulator. In a second stage, the performance of the rule is evaluated in terms of household welfare. Thus, compared to the standard welfare maximisation approach, the two-stage procedure brings together both the positive and the normative aspects of policy evaluation. Formally, Stage 1 involves minimising either (5.1), (5.2) or (5.3), and Stage 2 involves inserting the solution values for the volatility of consumption, employment, and money into the second-order approximation (5.7), and calculating welfare, which can then be compared across policy regimes.

5.1.4. Accounting for Instrument Adjustment Costs

The objective functions defined earlier can all be amended to account for the cost of instrument manipulation. For the case of policy loss minimisation, assuming that the instrument is the refinance rate for the central bank and the tax on loans for the regulator, equations (5.1) and (5.2) can be replaced by

$$\mathcal{LF}_t^M = \sigma_\pi^2 + \gamma^Y \sigma_Y^2 + \varkappa_C \sigma^2_{\Delta i^R}, \tag{5.8}$$

$$\mathcal{LF}_t^F = \begin{cases} \mathcal{LF}_t^{F,N} = \sigma^2_{l^K/Y} + \varkappa_R \sigma^2_{\Delta \tau^L} & \text{Narrow index} \\ \mathcal{LF}_t^{F,B} = \gamma^F \sigma^2_{l^K/Y} + (1-\gamma^F)\sigma^2_{p^H} + \varkappa_R \sigma^2_{\Delta \tau^L} & \text{Broad index} \end{cases}, \tag{5.9}$$

where $\varkappa_C, \varkappa_R \geq 0$ are cost parameters. The composite stability index remains, of course, as defined in (5.3).

For the welfare approach, the objective of the central bank is now no longer to maximise U_t but to maximise instead

$$U_t^C = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s u_{t+s} - \varkappa_C \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s (i^R_{t+s} - i^R_{t+s-1})^2, \tag{5.10}$$

whereas for the regulator, the objective becomes,

$$U_t^R = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s u_{t+s} - \varkappa_R \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s (\tau^L_{t+s} - \tau^L_{t+s-1})^2. \tag{5.11}$$

Using the second-order approximation of discounted utility (5.7), and using the approximation

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s (i^R_{t+s} - i^R_{t+s-1})^2 \simeq \frac{\text{Var}(\Delta i^R_t)}{1-\beta},$$

the adjusted welfare function of the central bank is now given by, instead of (5.7),

$$\mathcal{U}_t^C \simeq \mathcal{U}_t - \frac{\varkappa_C}{1-\beta} \text{Var}(\Delta i^R_t). \tag{5.12}$$

Similarly, given (5.7) and the approximation

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s (\tau^L_{t+s} - \tau^L_{t+s-1})^2 \simeq \frac{\text{Var}(\Delta \tau^L_t)}{1-\beta},$$

the adjusted welfare objective of the regulator is

$$\mathcal{U}_t^R \simeq \mathcal{U}_t - \frac{\varkappa_R}{1-\beta} \text{Var}(\Delta \tau^L_t). \tag{5.13}$$

Thus, while under the loss minimisation approach the two authorities have objectives that differ both in terms of their mandate and in the specification of instrument adjustment costs, under the welfare maximisation approach the difference is only in terms of the latter. In the absence of these costs ($\varkappa_C = \varkappa_R = 0$), the objective function is the same. For the two-stage approach, the difference is in terms of the function used in both stages.[6]

5.1.5. Instrument Complementarity and Substitutability

Given that the joint performance of multiple instruments is considered later on, it is important to define at the outset the notions of *complementarity* and *substitutability*. A common view in the literature is the Tinbergen rule, as defined in Chapter 2: if there are *n* policy objectives, *n* instruments (at least) must be deployed to achieve them. For instance, to achieve price stability and financial stability, policy authorities must use both the refinance and a

6 As discussed later on, different welfare objectives could be related to biased preferences among policymakers, themselves related to differences in institutional mandates.

macroprudential instrument. In that sense, instruments are necessarily *complements*. This rule was well illustrated in the specific examples that were provided in Chapters 2 and 3.

In the above definition, the *direction* in which instruments are adjusted does not matter; depending on the shock, the instruments may be both countercyclical or procyclical, or adjusted in opposite directions. An alternative view in the literature is that, with respect to a *single* objective, two instruments are *complementary* if they must be used together in the *same direction* (say, in countercyclical fashion) and they are substitutes if either one of them can be used to achieve that objective. For instance, achieving price stability following a positive aggregate demand shock can be achieved by either a contractionary monetary policy (a higher refinance rate) *or* a tightening of macroprudential policy. In that sense, the two instruments are substitutes. However, if output depends on credit (through, say, working capital needs), stabilizing output *and* prices (that is, achieving two objectives) may require combining a contractionary monetary policy (to keep aggregate demand in check) with an offsetting loosening of macroprudential policy (to keep credit flowing). Thus, two instruments can be complementary even if they are adjusted in opposite directions. This was well illustrated in Chapters 2 and 3, with respect to several instrument combinations.

A common criticism of the Tinbergen rule is that it holds only if targets must be achieved precisely. In practice, policymakers often aim to minimise deviations from their targets, rather than achieve them exactly and continuously. Moreover, it is possible that each instrument may affect several targets in the same direction. As a result, instruments may not be complements but could instead be substitutes. Conversely, even if there is a single objective (policy loss minimisation, or welfare maximisation), it may be optimal to combine instruments – especially if the cost of using a particular instrument increases rapidly due to decreasing marginal returns.

The view that complementarity depends only on whether (say) two policy instruments should be used together, regardless of the direction of use, is also problematic. It means that, with simple policy rules of the type discussed earlier, the response parameters of the two rules be non-zero – their sign doesn't matter. In that sense, there is no obvious definition of substitutability between policy instruments.

The definition used in this Manual is predicated on the fact that policymakers optimise an objective function using both individual instruments and two-way combinations. Two instruments are deemed to be complements when both of them must be used to achieve the policy objective (policy loss minimisation, welfare maximisation), that is, in terms of the simple policy rules defined earlier, when the response parameters to changes in the trigger variable embedded in both rules are non-zero. By contrast, two instruments are substitutes when the same outcome can be achieved by using either one of them, and adding the other instrument does not improve over that outcome.

The foregoing definition does not involve any statement about the *direction* in which instruments are changed. When instruments are used jointly (as is the case under coordination agreements between separate policy entities), it can be complemented by defining the concepts of *burden sharing* and *burden deepening*. In a setting with two policymakers and two instruments, *burden sharing* exists if one instrument is used less aggressively, while the other is used either with the same intensity or more aggressively, both compared to when they are used alone, to achieve the policy objective. By contrast, *burden deepening* exists if one instrument is used more aggressively, and the other at least the same, both compared to when they are used alone. Put differently, *burden sharing* is a situation where one policy authority reacts *less* when there is a joint response, compared to when it acts alone (which may entail a zero response parameter), whereas *burden deepening* is a situation in which both policymakers react more aggressively than when acting alone.[7] Thus, *burden sharing* can be viewed as a situation where instruments are *substitutes* (at the margin), and *burden deepening* as a situation where they are *complements* (at the margin).

In general, whether two instruments are complements or substitutes (in the sense of whether they are used together or not), and whether their joint use entails *burden sharing* or *burden deepening* (in the sense that greater use of one may lead or not, at the margin, to greater use of the other) depends on *a*) the nature of the policymakers' objective function; *b*) the nature of the shock that policymakers must respond to; *c*) the transmission mechanism of the various instruments; and *d*) the cost of instrument manipulation.[8] The next sections illustrate these different dimensions.

7 See Agénor (2020, Chapter 5) for a more detailed discussion. Note that these two notions are not necessarily related to the previous definition of complementarity; the reason is that the optimal response parameters, when instruments are used either individually or jointly, can be zero.

8 See, for instance, Cecchetti and Kohler (2014) for a simple example of how the policy objective function affects the extent to which instruments are substitutes or complements.

5.2. Optimal Simple Rules

In this section, the performance of individual policies is examined, in response to a reduction in the world interest rate. To assess the performance of each policy, the model is first solved without an active policy rule – a case referred to as *no activism*. The model is then solved with the relevant endogenous rule, and the optimal degree of aggressiveness of the rule is solved for by using either *a*) the policy minimisation approach, with the objective function being either (5.1) or (5.2), or alternatively (5.8) or (5.9), with or without instrument cost, or *b*) the welfare maximisation function, with the objective being either (5.7), (5.12) or (5.13), without or with instrument cost, or the two-stage approach.

5.2.1. Assessing the Gain from Activism

To calculate the relative gain from an activist response relative to no activism proceeds as follows.

Policy Loss Approach

With the policy loss approach, let $\mathcal{LF}$ denote the value of the loss function under no activism, and let $\mathcal{LF}^c$ denote the value of that function with an active response. Activism is thus preferable if $\mathcal{LF}^c < \mathcal{LF}^b$. In percentage terms, the gain (a *reduction* in the policy loss) can therefore be defined as $\mathcal{LF}^c / \mathcal{LF}^b - 1$.

Standard and Two-Stage Welfare Approaches

With the standard and two-stage welfare approaches, two approaches can be used to quantify the gain associated with pursuing a given policy relative to no intervention: the relative welfare approach, and the equivalent variations approach.

Relative welfare approach. Let $\mathcal{U}^b$ and $\mathcal{U}^c$ denote the values of the welfare function under no activism and activism, respectively. Activism is preferable if $\mathcal{U}_t^c > \mathcal{U}_t^b$, and the gain (an *increase* in welfare) can be measured as $\mathcal{U}_t^c / \mathcal{U}_t^b - 1$. The same approach can be used for the second step of the two-stage approach.

Equivalent variations approach. This approach is based on calculating the percentage of the consumption stream under no activism that ensures that households are as well off under no policy intervention than under activism.

Specifically, consider the welfare gain under an active countercyclical rule of the type (5.17) below, for instance, associated with $\chi_2^G > 0$, relative to the case where no countercyclical policy is implemented, so that $\chi_2^G = 0$. This gain can be calculated as the percentage change in consumption along its path under the status quo that would leave the representative household indifferent between living in an economy where the countercyclical policy rule is under operation, $\chi_2^G > 0$, and an economy with no policy activism. Thus, using the utility function (5.4), the welfare gain associated with intervention relative to no activism is measured by the constant β, which is solved from the condition:

$$\mathbb{E}_t \sum_{s=0}^{€} f^s u[(1+\beta)C_{t+s}^b, N_{t+s}^b, x_{t+s}^b] = \mathbb{E}_t \sum_{s=0}^{€} f^s u(C_{t+s}^c, N_{t+s}^c,, x_{t+s}^c), \tag{5.14}$$

or equivalently, using (5.5),

$$\mathbb{E}_t \sum_{s=0}^{€} f^s \left\{ \frac{[(1+\beta)C_{t+s}^b]^{1-\varsigma^{-1}}}{1-\varsigma^{-1}} - \frac{\eta_N (N_{t+s}^b)^{1+\psi_N}}{1+\psi_N} + \eta_x \ln x_{t+s}^b \right\} \tag{5.15}$$

$$= \mathbb{E}_t \sum_{s=0}^{€} f^s \left\{ \frac{(C_{t+s}^c)^{1-\varsigma^{-1}}}{1-\varsigma^{-1}} - \frac{\eta_N (N_{t+s}^c)^{1+\psi_N}}{1+\psi_N} + \eta_x \ln x_{t+s}^c \right\},$$

where $\{C_{t+s}^h\}_{s=0}^{€}$, $\{N_{t+s}^h\}_{s=0}^{€}$ and $\{x_{t+s}^h\}_{s=0}^{€}$ are solution paths under the status quo ($h = b$) and activism ($h = c$).

The fraction β can be computed from the solution of the second-order approximation to the utility function, given in (5.7), and the model's equilibrium around the deterministic steady state. From (5.7) and (5.15),

$$\frac{1}{1-f}\left\{ \tilde{u} - (1+\beta)^{1- \;\; -1} \frac{\tilde{C}^{1- \;\; -1}}{2\varsigma} \text{Var}(\hat{C}_t^b) - \eta_N \psi_N \frac{(\tilde{N})^{1+ \;\; N}}{2} \text{Var}(\hat{N}_t^b) - \frac{x}{2} \text{Var}(\hat{x}_t^b) \right\}$$

$$= \frac{1}{1-f}\left\{\tilde{u} - \frac{\tilde{C}^{1-\varsigma^{-1}}}{2\varsigma}\text{Var}(\hat{C}_t^c) - \eta_N \psi_N \frac{\tilde{N}^{1+\psi_N}}{2}\text{Var}(\hat{N}_t^c) - \frac{\eta_x}{2}\text{Var}(\hat{x}_t^c)\right\},$$

or again

$$(1+\beta)^{1-\varsigma^{-1}}\frac{\tilde{C}^{1-\varsigma^{-1}}}{2\varsigma}\text{Var}(\hat{C}_t^b) + \eta_N \psi_N \frac{\tilde{N}^{1+\psi_N}}{2}\text{Var}(\hat{N}_t^b) + \frac{\eta_x}{2}\text{Var}(\hat{x}_t^b)$$

$$= \frac{\tilde{C}^{1-\varsigma^{-1}}}{2\varsigma}\text{Var}(\hat{C}_t^c) + \eta_N \psi_N \frac{\tilde{N}^{1+\psi_N}}{2}\text{Var}(\hat{N}_t^c) + \frac{\eta_x}{2}\text{Var}(\hat{x}_t^c),$$

equivalently

$$(1+\beta)^{1-\varsigma^{-1}}\Gamma^C\text{Var}(\hat{C}_t^b) + \Gamma^N\text{Var}(\hat{N}_t^b) + \Gamma^x\text{Var}(\hat{x}_t^b)$$

$$= \Gamma^C\text{Var}(\hat{C}_t^c) + \Gamma^N\text{Var}(\hat{N}_t^c) + \Gamma^x\text{Var}(\hat{x}_t^c),$$

where the weights on the variances of consumption and employment are, respectively,

$$\Gamma^C = \frac{\tilde{C}^{1-\varsigma^{-1}}}{2\varsigma}, \quad \Gamma^N = \eta_N \psi_N \frac{\tilde{N}^{1+\psi_N}}{2}, \quad \Gamma^x = \frac{\eta_x}{2}.$$

This expression can be solved for β:

$$\beta = \left\{\frac{\Gamma^C\text{Var}(\hat{C}_t^c) + \Gamma^N[\text{Var}(\hat{N}_t^c) - \text{Var}(\hat{N}_t^b)] + \Gamma^x[\text{Var}(\hat{x}_t^c) - \text{Var}(\hat{x}_t^b)]}{\Gamma^C\text{Var}(\hat{C}_t^b)}\right\}^{1/(1-\varsigma^{-1})} - 1. \tag{5.16}$$

Thus, a positive value of β denotes a welfare gain.[9]

In what follows, all experiments are conducted under the assumption that the instrument manipulation costs are zero for all instruments, that is, $\varkappa_C = \varkappa_R = 0$ in (5.8) to (5.13). This provides a useful benchmark because, for arbitrarily high values of these parameters, there may be a bias toward generating zero optimal response coefficients. The grid search for optimal parameter values is conducted at one decimal point, that is, a step of 0.1, and in the interval $(-4,+4)$ for fiscal and macroprudential policies; a step of 0.01, and in the interval (0.04), for the degree of *leaning against the wind* in monetary policy; a step of 0.1 and in the interval (0.1) for the degree of sterilization; and a step of 0.1 and in the interval $(-1,+1)$ for the capital controls tax rate. The persistence parameter in each simple rule is set at 0.8, except for monetary policy, where a value of 0.85, consistent with the value used in the previous chapter, is used. For some experiments, graphs are also used to illustrate the results.[10] Under both the standard and the two-stage welfare approaches, relative welfare is used to calculate the gain from activism.

5.2.2. Fiscal Policy

Consider the simple implementable fiscal rule, based on the share of government spending in output:

$$\frac{\psi_t^G}{\psi^G} = \left(\frac{\psi_{t-1}^G}{\psi^G}\right)^{\chi_1^G}\left[\left(\frac{Y_t}{\tilde{Y}}\right)^{\chi_2^G}\right]^{1-\chi_1^G}, \tag{5.17}$$

where $\chi_1^G \in (0,1)$ is a persistence parameter and $\chi^G \leq 0$. Fiscal policy responds therefore in countercyclical fashion to deviations in output. The issue is to solve for the optimal value of χ_2^G, holding χ_1^G constant at 0.8.[11]

9 It can be established that, when the utility function is log-linear in consumption (or, equivalently, when $\varsigma \to 1$ in equation (5.5)), the relative welfare and the equivalent variations approaches yield similar results.

10 Graphs are not used systematically because in a number of experiments the lower or upper bounds for searching for response parameters are reached. As a result, displays of relative gains or losses are not particularly informative.

11 An alternative rule is to account for the *growth rate* of output in the spending rule, as in Jones and Rabanal (2021), for instance.

The loss function used to evaluate this policy assumes that the fiscal authority is only concerned about output; it therefore takes the form[12]

$$\mathcal{LF}_t^G = \sigma_Y^2. \tag{5.18}$$

For the welfare approach, equation (5.7) is used, whereas for the two-stage approach both (5.18) and (5.7) are used.

The results are presented in Table 5.1. For the policy loss and two-stage approaches, they show that the optimal response parameter, χ_2^G, hits the lower limit of –4. Thus, the policy is countercyclical. But while the policy loss is significantly lower (compared to no activism) under the policy loss approach, welfare deteriorates under the two-stage approach. Put differently, how the policy is evaluated matters for whether it improves performance.

Under the standard welfare approach, the optimal response coefficient now hits the upper limit of 4. Thus, the policy is now *procyclical*, a rather surprising result at first sight. However, recall that as shown in the previous chapter, an increase in government spending leads to a crowding-out effect on private consumption. Thus, following a shock that leads to an expansion in household spending (as is the case here, see Chapter 4), stabilizing consumption means *increasing* public expenditure. The policy also leads to a welfare gain, relative to no activism.

5.2.3. Augmented Monetary Policy

The augmented Taylor rule, specified in terms of the loan-to-output ratio, takes the form

$$\frac{1+i_t^R}{1+\tilde{i}^R} = \left(\frac{1+i_{t-1}^R}{1+\tilde{i}^R}\right)^{\chi^R} \left\{\left(\frac{1+\pi_t}{1+\pi^T}\right)^{\bullet_1}\left(\frac{Y_t}{\tilde{Y}}\right)^{\bullet_2}\left(\frac{l_t^K/Y_t}{\tilde{l}^K/\tilde{Y}}\right)^{\bullet_3}\right\}^{1-\chi^R}, \tag{5.19}$$

where $\bullet_3 \geq 0$ is solved for optimally.

Alternatively, the augmented Taylor rule can be specified in terms of the credit growth rate:

$$\frac{1+i_t^R}{1+\tilde{i}^R} = \left(\frac{1+i_{t-1}^R}{1+\tilde{i}^R}\right)^{\chi^R} \left\{\left(\frac{1+\pi_t}{1+\pi^T}\right)^{\bullet_1}\left(\frac{Y_t}{\tilde{Y}}\right)^{\bullet_2}\left(\frac{l_t^K}{l_{t-1}^K}\right)^{\bullet_3}\right\}^{1-\chi^R}, \tag{5.20}$$

Comment 5.4. The policy rule can be further augmented to account for *leaning against the wind* of exchange rate fluctuations, in line with the evidence discussed earlier on augmented Taylor rules.

Using either (5.19) or (5.20), the issue is to solve for the optimal value of $\bullet_3$, holding $\bullet_1$, $\bullet_2$ and χ^R constant at the values discussed in the previous chapter.

The loss function used to evaluate this policy is the *composite stability index*, defined in (5.3), which consists of the weighted averages of the partial stability indexes defined in (5.1) and (5.2). The weight γ^E is set at 0.8, which indicates that the central bank, despite being concerned with financial stability considerations, continues to attach a significantly higher weight to macroeconomic stability.[13] The weight γ^Y on cyclical output in the macroeconomic stability index defined in (5.1) is set at 0.3, consistent with the evidence on central bank preferences documented by Palma and Portugal (2014) for Brazil and within the range of values estimated by Gómez et al. (2019, Table 6) and McKnight et al. (2020, Table 5) for a large group of Latin American countries. For the welfare approach, equation (5.7) is used. The two-stage approach involves therefore using both (5.3) and (5.7).

The results, using the credit growth-based rule (5.20), are shown in Table 5.1 and Figure 5.1. Under the policy loss and two-stage approaches, the optimal response parameter, $\bullet_3$, is small and positive, 0.09. Thus, the policy is countercyclical – it stabilizes output and inflation by mitigating credit growth and investment. An interior solution is obtained because, at first, increasing $\bullet_3$ dampens volatility in output and inflation; but as the policy becomes more aggressive, it exacerbates volatility. As the policy rate increases, so do market interest rates; as a result, bank foreign borrowing and capital inflows are magnified. The optimal value is thus the point at which the

12 Alternatively, it could be assumed that the fiscal authority also cares somewhat about inflation, in which case a macroeconomic stability index similar to (5.1) could be used, with a weight $\gamma^M > 1$.

13 As noted earlier, an alternative case would be to set $\gamma^E = 0.5$, which implies that macroeconomic stability and financial stability are given equal weights by the central bank. However, this is a less plausible case in practice, and is therefore ignored to save space.

Negative Shock to World Interest Rate: Optimal Responses of Individual Policies and Gain Relative to No Activism ($\varkappa_C = \varkappa_R = 0.0$)	Table 5.1
Fiscal policy	
Optimal response parameter, χ_2^G	
Policy loss approach	–4.0
Two-stage welfare approach	–4.0
Welfare approach	4.0
Gain relative to no activism	
Policy loss approach	–0.081
Two-stage welfare approach	–0.011
Welfare approach	0.010
Monetary policy	
Optimal response parameter, $^{o}_{3}$	
Policy loss approach	0.09
Two-stage welfare approach	0.09
Welfare approach	0.0
Gain relative to no activism	
Policy loss approach	–0.001
Two-stage welfare approach	–0.135
Welfare approach	0
Macroprudential regulation	
Optimal response parameter, χ_2^C	
Policy loss approach	4.0
Two-stage welfare approach	4.0
Welfare approach	–0.1
Gain relative to no activism	
Policy loss approach	–0.917
Two-stage welfare approach	–0.953
Welfare approach	0.076

policy loss is minimised. Nevertheless, while the relative policy loss is slightly lower under the policy loss approach (as expected), welfare deteriorates significantly under the two-stage approach. Again, the criterion used to evaluate policy performance matters.

Under the standard welfare approach, it is optimal for the central bank not to react; consequently, welfare does not change relative to no activism. Intuitively, trying to stabilize credit growth by raising the refinance rate by more than the standard Taylor rule would require leads to an increase in the volatility of domestic interest rates (including the real bond rate) and thus the volatility of consumption; thus, the best response is not to depart from the standard policy response in the first place. Importantly, this result obtains even if there are no costs to manipulating policy interest rates.

The fact that the optimal response to credit fluctuations – above and beyond what a standard Taylor rule would call for – is fairly weak under the policy loss and two-stage approaches, and nonexistent under the standard welfare approach, is consistent with the widely-held view that in an economy with an open capital account monetary policy loses much of its effectiveness in terms of managing external financial shocks. Indeed, to the extent that it contributes to higher domestic interest rates, it may exacerbate the macroeconomic effects of lower world interest rates on capital inflows. This issue is further discussed, from an empirical perspective, in the next chapter.

5.2.4. Macroprudential Policy

As discussed in Chapter 4, the simple implementable rule for the macroprudential tax rate, τ_t^L, can be defined in terms of an *operational target* for systemic risk, the loan-to-output ratio:

$$\frac{1+\tau_t^L}{1+\tilde{\tau}^L} = \left(\frac{1+\tau_{t-1}^L}{1+\tilde{\tau}^L}\right)^{\chi_1^L} \left\{\left(\frac{l_t^K / Y_t}{\tilde{l}^K / \tilde{Y}}\right)^{\chi_2^L}\right\}^{1-\chi_1^L}, \tag{5.21}$$

Negative Shock to World Interest Rate: Optimal Individual Policies and Gain Relative to No Activism ($\varkappa_C = \varkappa_R = 0.0$)	Table 5.1 (concluded)
Sterilization (low γ)	
Optimal response parameter, κ^F	
Policy loss approach	0.0
Two-stage welfare approach	0.0
Welfare approach	0.9
Gain relative to no activism	
Policy loss approach	0.0
Two-stage (hybrid) approach	0.0
Welfare approach	0.222
Sterilization (high γ)	
Optimal response parameter, κ^F	
Policy loss approach	0.0
Two-stage welfare approach	0.0
Welfare approach	0.5
Gain relative to no activism	
Policy loss approach	0.0
Two-stage welfare approach	0.0
Welfare approach	0.246
Capital controls	
Optimal response parameter, χ_2^B	
Policy loss approach	0.6
Two-stage welfare approach	0.6
Welfare approach	0.3
Gain relative to no activism	
Policy loss approach	–0.311
Two-stage welfare approach	–0.887
Welfare approach	0.401

Notes: see the text for the definitions of the loss function used for each instrument. Under the welfare approach, the objective function is a second-order approximation of household utility. The two-stage (hybrid) approach combines these two objective functions. A negative entry indicates a gain for the policy loss approach and a loss for the other approaches.

where χ_1^L ° (0,1) and $\chi_2^L \geq 0$. This rule could also be specified in terms of the credit growth rate:

$$\frac{1+\tau_t^L}{1+\tilde{\tau}^L} = (\frac{1+\tau_{t-1}^L}{1+\tilde{\tau}^L})^{\chi_1^L} \left\{ (\frac{l_t^K}{l_{t-1}^K})^{\chi_2^L} \right\}^{1-\chi_1^L}, \tag{5.22}$$

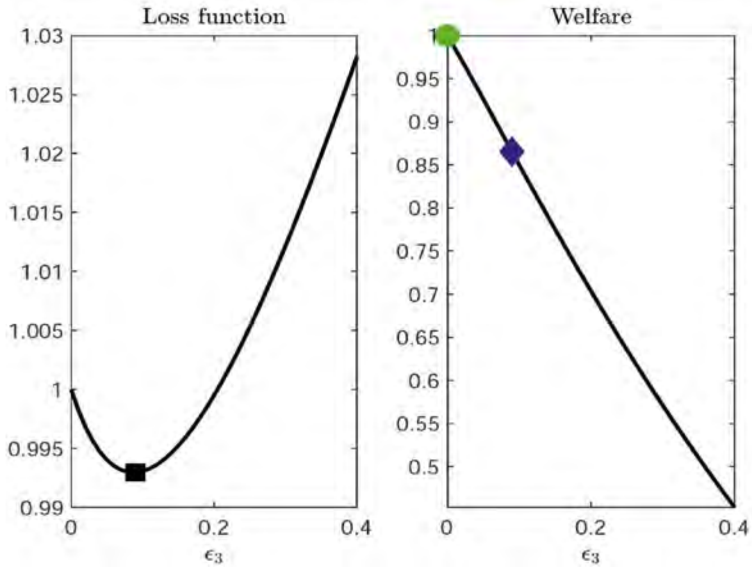
Thus, borrowing is more costly during periods of credit booms and this may help to smooth macroeconomic and financial fluctuations. Using either (5.21) or (5.22), the issue is to solve for the optimal value of χ_2^L, holding χ_1^L constant.

The loss function used to evaluate this policy is the *financial stability index*, defined in (5.2). To focus the discussion, the narrow index $\mathcal{LF}_t^{F,N} = \sigma^2_{l^K/Y}$ is used. As before, for the welfare approach, equation (5.7) – evaluated using a second-order approximation of the model – is used, whereas for the two-stage approach, both (5.2) and (5.7) are used.

The results, using the credit growth-based rule (5.22), are reported in Table 5.1. Under the policy loss and two-stage approaches, the optimal policy calls for setting the response parameter, χ_2^C, to the highest positive value allowed numerically, +4. The policy is unambiguously countercyclical – it stabilizes the loan rate, investment, as well as output and inflation (see Chapter 4). Given how aggressive the policy is, the reduction in the policy loss (relative to no activism) is quite dramatic; however, under the two-stage welfare approach, the policy generates an equally large loss. The reason is that stabilizing inflation does little to stabilize the real bond rate. Again, the criterion used to evaluate policy performance matters.

Negative World Interest Rate Shock: Optimal Monetary Policy Response, Alternative Policy Evaluation Approaches

Figure 5.1



Note: the left-hand side panel, the (black) square correponds to the optimal response under the loss function approach. On the right-band side panel, the (blue) diamond corresponds to the welfare function approach and the (green) circle to the two-stage approach.

Under the standard welfare approach, it is optimal for the regulator to respond *procyclically*. Intuitively, by lowering the macroprudential tax rate, the loan rate falls further and investment increases, thereby increasing the volatility of both variables. However, because inflation falls by less (as noted in Chapter 4), the (expected) real bond rate becomes less volatile – and so does consumption. This raises welfare, relative to activism.

5.2.5. Sterilized Intervention

To study the use of sterilized intervention in response to external financial shocks, for a given foreign exchange intervention rule, the parameter $\kappa^F \in (0,1)$ in the sterilization rule defined in Chapter 4, is solved for optimally.[14] For convenience, this expression is repeated here:

$$b_t^{CB} - \frac{b_{t-1}^{CB}}{1+\pi_t} = \kappa^F z_t / R_t^F . \tag{5.23}$$

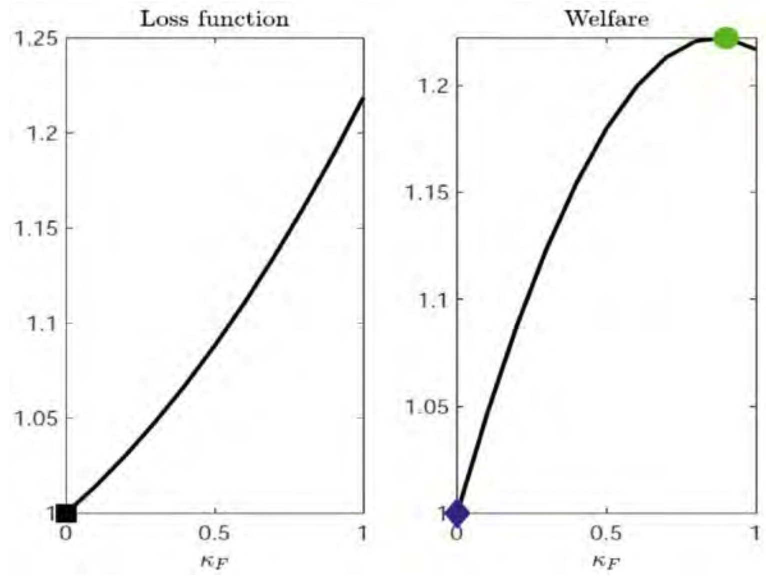
The loss function used to evaluate this policy is again the *composite stability index*, defined in (5.3). The weight γ^E is also set at 0.8, which indicates that the central bank, despite being concerned by financial stability considerations, continues to attach a significantly higher weight to macroeconomic stability. For the welfare approach, equation (5.7) is used. The two-stage approach involves using both (5.3) and (5.7). To assess the role of the bank portfolio channel (as discussed in Chapter 4), both low and high values of γ (0.05 and 0.1, respectively) are used.

The results are shown in Table 5.1 and Figure 5.2. Regardless of the value of γ, they indicate a sharp contrast between the different policy evaluation criteria. Under the policy loss and two-stage approaches, the optimal policy calls for setting the degree of sterilization, κ^F, to 0. Intuitively, in the presence of a bank portfolio channel (weak or strong), sterilization is procyclical; thus, to stabilize output and inflation, in response to an expansionary shock, it is optimal not to sterilize. By implication, there are no gains, in either case, relative to no activism. By contrast, under the standard welfare approach, it is optimal for the central bank to sterilize aggressively ($\kappa^F = 0.9$) if the bank portfolio channel is weak ($\gamma = 0.05$). The reason is that even though the policy is procyclical, it mitigates the drop in inflation; as a result, it stabilizes the (expected) real bond rate as well as consumption. Almost full sterilization is therefore optimal and a source of welfare gain relative to no policy intervention. By contrast, when the bank portfolio channel is stronger ($\gamma = 0.1$), the optimal sterilization coefficient drops to $\kappa^F = 0.5$. The reason, as discussed in detail in Chapter 4, is that the bank portfolio channel makes sterilized intervention more expansionary – therefore amplifying the effects of the initial external shock.

14 The numerical analysis ensures that the solution for κ^F is bounded.

Negative World Interest Rate Shock: Optimal Degree of Sterilization, Alternative Policy Evaluation Approaches

Figure 5.2



Note: See Note to Figure 5.1.

5.2.6. Capital Controls

As defined in the previous chapter, the rule for the capital controls tax (which can also be viewed as a macroprudential tax) is defined as

$$\frac{1+\tau_t^B}{1+\tilde{\tau}^B} = \left(\frac{1+\tau_{t-1}^B}{1+\tilde{\tau}^B}\right)^{\chi_1^B} \left\{ \left(\frac{L_t^{FB}}{L_{t-1}^{FB}}\right)^{\chi_2^B} \right\}^{1-\chi_1^B}, \tag{5.24}$$

where $\chi_1^B \in (0,1)$ and $\chi_2^B \geq 0$.

The loss function used to evaluate this policy is the narrow *financial stability index*, defined in (5.2), as well as an alternative measure, which also accounts for the volatility of the real exchange rate, with a weight $\gamma^Z \geq 0$:

$$\mathcal{LF}_t^{F,N} = \gamma^Z \sigma_{l^K/Y}^2 + \sigma_z^2. \tag{5.25}$$

As before, for the welfare approach, equation (5.7) is used, whereas for the two-stage approach, both (5.25) and (5.7) are used. In what follows, $\gamma^Z = 0.2$ is used for illustration. Thus, the regulator, although concerned with exchange rate volatility, attaches a larger weight to credit fluctuations.

The results are displayed in Table 5.1. Under all approaches to policy evaluation, it is optimal for the central bank to raise the capital controls tax rate, χ_2^B, in response to increases in bank foreign borrowing. By doing so the cost of borrowing abroad rises, thereby mitigating capital inflows and the resulting real appreciation. Consequently, inflation falls by less than under no policy intervention and this stabilizes the real bond rate and household consumption. The response is more aggressive under the policy loss and two-stage approaches. However, while there is a significant gain, relative to no activism, under the policy loss and standard welfare approaches, welfare deteriorates significantly under the two-stage approach.

5.3. Optimal Combinations of Simple Rules

Rather than individual policies, it is instructive to examine the performance of combinations of macro-financial policy instruments in response to the same shock to the world risk-free interest rate. As in the simple models of Chapters 2 and 3, these combinations are studied in pairs, for greater intuition. The seven combinations considered are: fiscal and monetary policies; monetary policy and sterilized intervention; monetary and macroprudential policies; monetary policy and capital controls; macroprudential regulation and sterilized intervention; macroprudential policy and capital controls; and capital controls and sterilization.[15] These combinations cover a wide range of policy mixes implemented in MICs in recent years, as discussed in Chapter 1 and further explored in Chapter 6. Optimal policy and performance are studied using the three approaches highlighted earlier, loss function minimisation, welfare maximisation, and a two-stage welfare evaluation approach.

By definition, some policy combinations (involving, for instance, fiscal policy and macroprudential regulation) require coordination between policymakers (in this case, the fiscal authority and the financial regulator). Such coordination raises well-known issues of feasibility and benefits (relative to acting independently), which have been addressed in the literature.[16] These issues are briefly discussed at the end of this chapter. For the time being, it is assumed that coordination entails no costs.

5.3.1. Fiscal and Monetary Policies

This combination involves coordination between the fiscal authority and the central bank, and requires solving jointly for the optimal values of χ_2^G in (5.17) and $\bullet_3$ in (5.19) or (5.20).

Under the loss function approach, the criterion used is the *macroeconomic stability index*, defined in (5.1). As before, for the welfare approach, equation (5.7) is used, whereas for the two-stage approach, both (5.1) and (5.7) are used.

The results are reported in Table 5.2, using the credit growth-based rule (5.20). In this case, the optimal policy response is a combination of the individual policies discussed earlier; both are countercyclical under the policy loss and two-state welfare approaches, whereas under the standard welfare approach the optimal policy mix involves a procyclical fiscal policy response and no response by monetary policy to credit fluctuations. But again, while the policy loss and the standard welfare approaches generate a gain, the two-stage approach entails a significant loss. In addition, when these two instruments are used, the response of monetary policy is less aggressive under the policy loss and two-stage approaches than when it is used alone ($\bullet_3 = 0.03$ in Table 5.2, compared to $\bullet_3 = 0.09$ in Table 5.1), whereas the fiscal policy response is the same; thus, based on the definition provided earlier, there is no *burden sharing*.

5.3.2. Monetary Policy and Sterilization

This combination involves the central bank setting jointly the optimal values of $\bullet_3$, using either (5.19) or (5.20), and the degree of sterilization κ^F in (5.23), for a given degree of foreign exchange intervention. As was done previously, when discussing sterilization, it is useful to consider separately the cases of weak and strong bank portfolio channels ($\gamma = 0.05$ and $\gamma = 0.1$, respectively).

The loss function used to evaluate this policy mix is the *composite stability index*, defined in (5.3), with again $\gamma^E = 0.8$. For the welfare approach, equation (5.7) is used. The two-stage approach involves using both (5.3) and (5.7).

5.3.3. Monetary and Macroprudential Policies

This combination involves the central bank jointly setting the optimal values of $\bullet_3$, using either (5.19) or (5.20), and the response parameter χ_2^C in the countercyclical rule (5.21) or (5.22). The loss function used to evaluate this policy mix is also the *composite stability index*, defined in (5.3), with $\gamma^E = 0.8$. For the welfare approach, equation (5.7) is used. The two-stage approach involves using both (5.3) and (5.7).

The results are shown in Table 5.2, using the credit-growth based rules (5.20) and (5.22). They are substantially different from those obtained under the individual policies. Under the policy loss and two-stage welfare approaches, the response of monetary policy to credit is significantly stronger, whereas the optimal macroprudential policy response works in the opposite direction to stabilize credit and investment. In that sense, the instruments can again be viewed as *complements*, even though they operate in opposite directions. In contrast with the results of the individual policies, compared to no activism the economy is better off under all three approaches, and substantially so when welfare is used to evaluate performance. Moreover, under the policy loss and two-stage welfare approaches, monetary policy is more aggressive whereas macroprudential policy is less aggressive ($\bullet_3 = 0.09$ and $\chi_2^C = 4.0$ in Table 5.1, and $\bullet_3 = 0.37$ and $\chi_2^C = -0.4$ in Table 5.2). Thus, there is *burden sharing*.

15 Other combinations (such as fiscal policy and capital controls) are theoretically possible, but they are also less plausible in practice.

16 See, for instance, Angelini et al. (2014), De Paoli and Paustian (2017), Agénor and Flamini (2022), and Agénor and Jackson (2022), as well as the literature review in the last two contributions.

Negative Shock to World Interest Rate: Optimal Policy Combinations and Gain Relative to No Activism ($\varkappa_C = \varkappa_R = 0.0$)

Table 5.2

Fiscal and monetary policies	
Optimal response parameters, χ_2^G, ε_3	
Policy loss approach	–4.0, 0.03
Two-stage welfare approach	–4.0, 0.03
Welfare approach	4.0, 0.0
Gain relative to no activism	
Policy loss approach	–0.003
Two-stage welfare approach	–0.052
Welfare approach	0.010
Monetary policy and sterilization (low γ)	
Optimal response parameters, $\bullet_3, \kappa^F$	
Policy loss approach	0.15, 0.0
Two-stage welfare approach	0.15, 0.0
Welfare approach	0.05, 1.0
Gain relative to no activism	
Policy loss approach	–0.029
Two-stage welfare approach	–0.216
Welfare approach	0.261
Monetary policy and sterilization (high γ)	
Optimal response parameters, $\bullet_3, \kappa^F$	
Policy loss approach	0.12, 0.0
Two-stage welfare approach	0.12, 0.0
Welfare approach	0.03, 0.5
Gain relative to no activism	
Policy loss approach	–0.018
Two-stage (hybrid) approach	–0.167
Welfare approach	0.255
Monetary and macroprudential policies	
Optimal response parameters, ε_3, χ_2^C	
Policy loss approach	0.37, –0.4
Two-stage (hybrid) approach	0.37, –0.4
Welfare approach	0.33, –0.4
Gain relative to no activism	
Policy loss approach	–0.021
Two-stage welfare approach	0.111
Welfare approach	0.208

Negative Shock to World Interest Rate: Optimal Responses of Policy Combinations and Gain Relative to No Activism ($\varkappa_C = \varkappa_R = 0.0$)	Table 5.2 (conluded)
Monetary policy and capital controls	
Optimal response parameters, ε_3, χ_2^B	
Policy loss approach	0.4, 0.4
Two-stage welfare approach	0.4, 0.4
Welfare approach	0.08, 0.3
Gain relative to no activism	
Policy loss approach	–0.261
Two-stage welfare approach	0.337
Welfare approach	0.458
Macroprudential regulation and sterilization (low γ)	
Optimal response parameters, χ_2^C, κ^F	
Policy loss approach	0.5, 0.0
Two-stage welfare approach	0.5, 0.0
Welfare approach	0.0, 0.9
Gain relative to no activism	
Policy loss approach	–0.041
Two-stage welfare approach	–0.561
Welfare approach	0.222
Macroprudential regulation and capital controls	
Optimal response parameters, $^{o}{}^{C}_{2}, ^{o}{}^{B}_{2}$	
Policy loss approach	4.0, 0.5
Two-stage welfare approach	4.0, 0.5
Welfare approach	0.1, 0.3
Gain relative to no activism	
Policy loss approach	–0.318
Two-stage welfare approach	–0.434
Welfare approach	0.418
Capital controls and sterilization (low γ)	
Optimal response parameters, χ_2^B, κ^F	
Policy loss approach	0.2, 0.0
Two-stage (hybrid) approach	0.2, 0.0
Welfare approach	0.1, 0.6
Gain relative to no activism	
Policy loss approach	–0.065
Two-stage welfare approach	0.234
Welfare approach	0.287

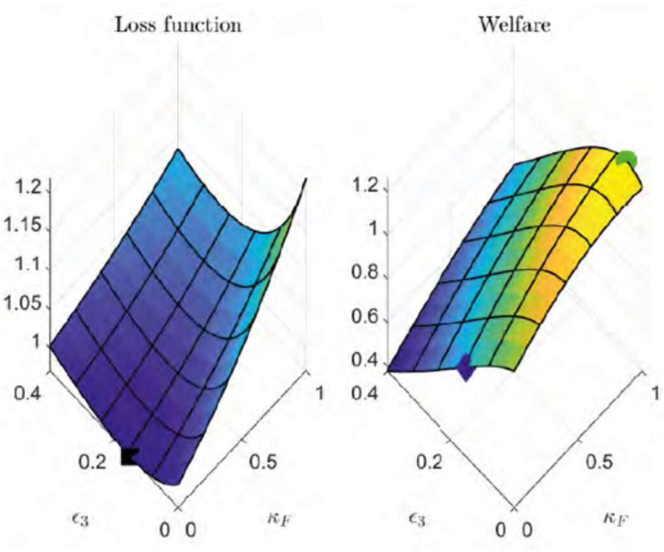
5.3.4. Monetary Policy and Capital Controls

This combination involves the central bank jointly setting the optimal values of ε_3, using either (5.19) or (5.20), and the response parameter $^{o}{}^{B}_{2}$ in the countercyclical rule (5.24). The loss function used to evaluate this policy mix is once again the *composite stability index*, defined in (5.3), with $\gamma^E = 0.8$. [17] For the welfare approach, equation (5.7) is used. The two-stage approach involves using both (5.3) and (5.7).

[17] An extension would be to also include the volatility of the real exchange rate, in a similar fashion to (5.25).

Negative World Interest Rate Shock: Optimal Monetary Policy Response and Degree of Sterilization, Alternative Policy Evaluation Approaches

Figure 5.3



Note: See Note to Figure 5.1.

The results are shown in Table 5.2, using the credit growth-based rule (5.20). Once again, they are quite different from those established earlier with individual policies; under all three approaches to policy evaluation, *both* instruments are now countercyclical. The response of monetary policy is also more aggressive. Consequently, relative to no activism, there is a significant policy gain under all three approaches. The instruments are again complements and operate this time in the same direction. Moreover, under the policy loss and two-stage welfare approaches, monetary policy is more aggressive whereas capital controls are less aggressive ($\bullet_3 = 0.09$ and $\chi_2^B = 0.6$ in Table 5.1, and $\bullet_3 = 0.4$ and $\chi_2^B = 0.4$ in Table 5.2). Thus, there is *burden sharing*. A similar result holds with respect to the standard welfare approach ($\bullet_3 = 0.0$ and $\chi_2^B = 0.3$ in Table 5.1, and $\bullet_3 = 0.08$ and $\chi_2^B = 0.3$ in Table 5.2).

5.3.5. Macroprudential Policy and Sterilization

This combination involves the central bank and the regulator jointly setting the response parameter χ_2^C in the rule (5.21) or (5.22), and the degree of sterilization κ^F in (5.23). The loss function used to evaluate this policy mix is also the *composite stability index*, defined in (5.3), with $\gamma^E = 0.8$. [18] For the welfare approach, equation (5.7) is used. The two-stage approach involves using both (5.3) and (5.7).[19]

The results are shown in Table 5.2, using the credit-growth rule (5.22), for a weak portfolio channel ($\gamma = 0.05$). The results are similar to those obtained with the individual policies; under the policy loss and two-stage welfare approaches, it is optimal for macroprudential policy alone to respond, regardless of the value of γ. By contrast, if the bank portfolio channel is weak, it is optimal to sterilize aggressively if the policy performance is evaluated using the standard welfare approach. With a strong portfolio channel ($\gamma = 0.1$, not reported to save space), it is optimal to sterilize less under the welfare approach – without, however, relying more on macroprudential policy. In that sense, the two instruments are not complements. Moreover, under the policy loss and two-stage welfare approaches, macroprudential policy is less aggressive whereas the degree of sterilization remains the same ($\chi_2^C = 4.0$ and $\kappa^F = 0.0$ in Table 5.1, and $\chi_2^C = 0.5$ and $\kappa^F = 0.0$ in Table 5.2). Thus, there is neither *burden sharing* nor *burden deepening*.

18 Again, an extension would be to also include the volatility of the real exchange rate, in a similar fashion to (5.25).

19 The case where capital controls, in the form again of a tax on banks' foreign borrowing, and the degree of sterilization are solved for jointly is discussed in Agénor and Jia (2020). They show that, with endogenous reserves and a managed float, the optimal degree of sterilization is unity. By helping to insulate the money supply from the behavior of foreign reserves, sterilized intervention helps to stabilize movements in the exchange rate, market interest rates, and by implication, capital flows. This generates significant benefits in terms of financial stability and, to a lesser extent, macroeconomic stability.

5.3.6. Macroprudential Policy and Capital Controls

The combination of macroprudential regulation and capital controls involves the central bank and the regulator jointly setting the response parameter χ_2^C in rule (5.21) or (5.22) and the response parameter χ_2^B in rule (5.24).[20] The loss function used to evaluate this policy mix is again the *composite stability index*, defined in (5.3), with $^{\circ E} = 0.8$.[21] For the welfare approach, equation (5.7) is used. The two-stage approach involves using both (5.3) and (5.7).

The results are shown in Table 5.2, using the credit growth-based rule (5.22). Under all three approaches to policy evaluation, macroprudential policy and capital controls are used jointly, and in the same countercyclical direction. Under the policy loss and two-stage welfare approaches, the response of the macroprudential tax on loans is as strong as allowed in the experiment, while the adjustment in the capital controls tax rate is moderate. However, while there is a substantial gain (compared to no activism) with the policy loss and standard welfare approaches, the economy is significantly worse off under the two-stage approach.

Under the policy loss and two-stage welfare approaches, macroprudential policy is equally aggressive, whether it is used alone or in combination, whereas the response of the capital controls tax rate is less aggressive, compared to when it is used alone ($\chi_2^C = 4.0$ and $\chi_2^B = 0.6$ in Table 5.1, and $\chi_2^C = 4.0$ and $\chi_2^B = 0.5$ in Table 5.2). In that sense, there is *burden sharing*.[22]

5.3.7. Sterilization and Capital Controls

Finally, the combination of sterilization and capital controls involves jointly setting the degree of sterilization κ^F in (5.23) and the response parameter χ_2^B in rule (5.24). The loss function used to evaluate this policy mix is also the *composite stability index*, defined in (5.3), with $^{\circ E} = 0.8$.[23] For the welfare approach, equation (5.7) is used. The two-stage approach involves using both (5.3) and (5.7).

The results are shown in Table 5.2, for a weak bank capital channel ($^{\circ} = 0.05$). Under the loss function and two-stage approaches, it is optimal to impose capital controls only, which mitigate directly bank-related capital inflows. By contrast, under the standard welfare approach, the use of both instruments ($\chi_2^B = 0.1$, $\kappa^F = 0.6$), in countercyclical fashion, is optimal. In that sense, the instruments are complements and operate in the same direction. Under all three approaches, there is a substantial policy or welfare gain relative to no activism. With a strong capital channel ($^{\circ} = 0.1$, not reported to save space), a result similar to the one seen before is obtained: it is optimal to sterilize less under the standard welfare approach ($\kappa^F = 0.3$), but without relying more on capital controls ($\chi_2^B = 0.1$ again).

Moreover, under the policy loss and two-stage welfare approaches, capital controls are less aggressive when used in combination, whereas the optimal degree of sterilization does not change ($\chi_2^B = 0.6$ and $\kappa^F = 0.0$ in Table 5.1, and $\chi_2^B = 0.2$ and $\kappa^F = 0.0$ in Table 5.2). In that sense, there is *burden sharing*. Similarly, under the standard welfare approach, both policies become less aggressive when used in combination ($\chi_2^B = 0.3$ and $\kappa^F = 0.9$ in Table 5.1, and $\chi_2^B = 0.1$ and $\kappa^F = 0.6$ in Table 5.2). Once again, there is *burden sharing*.

Comment 5.5. The foregoing results are based on the assumption that instrument manipulation entails no cost. In addition, the analysis does not consider the fact that sterilization may entail a quasi-fiscal cost (see Agénor et al. (2020)). Accounting for these features would help to provide a more thorough assessment of the benefits of sterilization policies.

To conclude, it is also worth noting that while there are policy combinations for which the three evaluation approaches to policy evaluation give conflicting results (both in terms of instrument choice and benefits compared to no activism), there are also cases where they are consistent – in the sense that, for the optimal setting of instruments, all three approaches show a gain relative to no response. For instance, there is a conflict between the welfare effects when using the two-stage welfare approach compared to the standard welfare approach for the following policy combinations: fiscal and monetary policies; monetary policy and sterilization; macroprudential policy and

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20 The case where the required reserve ratio is the instrument of macroprudential policy, and is combined with capital controls, is discussed in Agénor and Jia (2020).

21 As noted earilier, an extension would be to also include the volatility of the real exchange rate, in a similar fashion to (5.25).

22 Acosta-Henao et al. (2020) found that when the use of macroprudential instruments is strengthened, the intensity of capital controls falls, suggesting therefore that the two instruments are substitutes.

23 Again, an extension would be to also include the volatility of the real exchange rate, in a similar fashion to (5.25).

sterilization; and macroprudential policy and capital controls. By contrast, and even if the optimal policy response parameters are not the same, there are gains (relative to no activism) under *both* approaches for the following policy mixes: monetary and macroprudential policies; monetary policy and capital controls; and capital controls and sterilization.[24] Moreover, differences in gains may actually not be that large. This is an important consideration for policymakers confronted with the practical issue of choosing between instrument combinations.

5.4. Extensions

The foregoing evaluation of policy performance (whether of individual policies or policy combinations) can be extended in several directions. To conclude this chapter, two issues are briefly considered: independent policy-making vs cooperation; and the explicit account of biased preferences, when the objective function of policymakers is, to start with, household welfare.

5.4.1. Independent Policymaking vs Cooperation

A key issue in a world with several policymakers (say, a central bank and a financial regulator) is the gains (or lack thereof) associated with coordination. In the previous sections, the discussion largely assumed that, when a policymaker (say, the central bank) acts independently, it ignores how the other (say, the regulator) behaves. However, accounting explicitly for strategic interactions is important. In this case, one must solve for the Nash equilibrium, which requires the reaction functions to be consistent. The gain from coordination between policymakers can then be based on comparing outcomes under the Nash equilibrium and outcomes under the cooperative solution, in which (as discussed earlier) they act jointly. More formally, under uncoordinated policymaking, each policymaker independently sets its policy instrument so as to minimise its own policy loss or maximise its own welfare, taking the choice of instrument by the other policymakers as given. The resulting policy outcomes typically fail to fully account for *policy externalities*, generated by exogenous or policy shocks. In contrast, if policymakers coordinate their choices by jointly determining instrument settings with a view to minimising a weighted sum of their policy loss functions, or maximising a common welfare function, the policy spillovers each of them is confronted with would be internalized. As a consequence, and depending on the nature of the externality, coordination may enable all policymakers to attain lower policy losses or higher social welfare.

5.4.2. Biased Policy Preferences

Another direction in which policy evaluation can be extended is to consider *biased preferences* among policymakers, that is, the case where policy objective functions account not only for household welfare but also for a narrow and specific institutional mandate bestowed by society to each authority (say, price stability for the central bank, and financial stability for the regulator).[25] Two issues of importance in this context are, first, the extent to which the degree of bias in preferences affects the gains from cooperation, relative to either no activism or a setting where policymakers can act strategically (as noted earlier). A second issue is how society should set *optimal* institutional mandates, in the sense of determining the optimal degree of bias in the objective functions of the central bank and the regulator, and how the optimal mandate depends on the cost of instrument manipulation. Accounting for biased preferences offers an alternative to the two-stage approach to policy evaluation discussed earlier. This issue is further discussed by Agénor and Jackson (2022), who show in particular that biased preferences play a significant role in determining whether there are gains from policy coordination and how large these gains can be.

24 Under the loss function approach, there is always a gain (relative to no activism) for all the policy combinations displayed in Table 5.2.
25 Bodenstein et al. (2019) were the first to consider the case of biased policy preferences, in a setting with multiple policymakers.

Chapter 6. Policy Responses to External Financial Shocks: Country Experiences

In order to illustrate the workings of the models presented in the previous chapters, this chapter reviews the experience of 11 middle-income countries (MICs), six in Asia and five in Latin America, with managing external financial shocks related to capital flows since 2000.[1] This sample consists of countries with different macroeconomic characteristics: some have recorded sustained current account surpluses and others have shown recurrent dependence on external financing. Some had to manage rapid increases in domestic credit, frequently coinciding with real estate and consumption booms, and some not. Yet, in all of these countries, and consistent with the evidence discussed in Chapter 1, financial intermediation occurs mainly through the banking system, rather than capital markets, and bank credit remains the dominant mode of financing.

Another common feature of the countries in the sample is that most of them experienced frequent periods of macroeconomic volatility. Latin America experienced chronic episodes of macroeconomic imbalances in the 1970s and 1980s, often due to unsustainable fiscal expansion and culminating in currency, banking and sovereign debt crises. Massive capital outflows, large output losses and slow growth resulted, making the 1980s a so-called *lost decade*. In the case of Asian economies, the 1996-97 Asian financial crisis was a turning point. The major feature of the macroeconomic policy regime then was the reliance on fixed or pegged exchange rates, which became unsustainable due to the accumulation of foreign debt. The ensuing financial crisis spurred the adoption of flexible exchange rate regimes, and the accumulation of foreign exchange reserves as one of the main protection against the gyrations of global capital flows. Subsequently, many countries in the region improved their policy regimes in pursuit of macroeconomic and financial stability, including through greater reliance on macroprudential instruments. In effect, countries in *both* regions adopted rather similar strategies, based on three pillars, to strengthen their macroeconomic and financial stabilization policies in the last decades.

First, as of mid-1990s, central banks were granted independence, *de jure* or *de facto*. Coupled with legal rules banning the monetization of public debt and deficits, this allowed most central banks, notably in Latin America, to focus on the primary objective of controlling inflation. Second, at the same time or soon after, following a global trend, many central banks in both regions opted for inflation targeting (IT) regimes and flexible exchange rate regimes, which helped consolidate the anchoring of expectations of low inflation among the general public. Brazil, Chile and Colombia adopted inflation targeting in 1999, and Mexico and Peru in 2000. In Asia, inflation targeting was adopted in Korea, Thailand, Indonesia and the Philippines in 1999, 2000, 2001, and 2002, respectively. India adopted an inflation target in 2015.[2] Third, and more recently, the very success of IT regimes in many MICs brought new challenges related to their growing integration in international capital markets. More stable macroeconomic environment created opportunities for financial integration but also the need to handle larger and potentially more volatile capital flows. Therefore, central banks in MICs increasingly combined monetary policy with a toolkit of other instruments aimed at promoting stability. In particular, countries in the two regions have used foreign exchange interventions (FXI) and various macroprudential instruments, and many also resorted to capital controls or – as generally referred to nowadays by the International Monetary Fund (2022) – capital flow management policies (CFMs).

The chapter describes the circumstances in which these instruments and the broader set of policy tools discussed in the previous chapters were deployed in Asia and Latin America. After experiencing specific external financial shocks that are discussed later on (large capital inflows, changes in the global interest rate), the attempt to return to the initial equilibrium for the real exchange rate and inflation in these regions was achieved by using additional policy instruments, rather than monetary and/or fiscal policies alone. Accordingly, at least two policy instruments were combined when available to the policymaker as discussed in Chapters 3, 4 and 5.

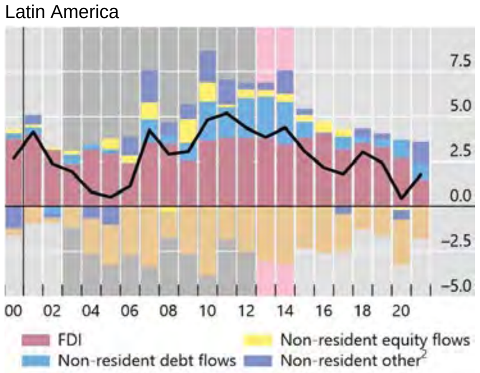
The chapter is organized as follows. Section 1 examines three major episodes of large capital flows: *a*) a *sudden flood* of inflows (2003-07), which compounded currency appreciation linked to a commodity super-cycle; *b*) a *search for yield* inflow (2009-12) due to the post-global financial crisis (GFC) low interest rate environment in advanced economies; and *c*) a *sudden stop* of capital flows (2013), linked to the US Federal Reserve's announcement of a gradual narrowing of its policy of quantitative easing. Section 2 analyses how and when at least two policy instruments were used in combination to re-establish internal and external equilibria during these episodes. Sections 3 and 4 examine in more detail the cases of two countries, one in each region: Brazil and Malaysia. These countries, despite significant differences between them in terms of in policy institutions, illustrate the combinations of instruments that policymakers can deploy to address the risks to macroeconomic and financial stability

[1] These countries are Brazil, Chile, Colombia, India, Indonesia, Korea, Malaysia, Mexico, Peru, the Philippines, and Thailand.

[2] See Agénor and Pereira (2019) for an overview of the adoption of IT regimes across the world.

Asia and Latin America: Capital flows, 2000-21 (As a percentage of GDP)

Figure 6.1



[1] Vertical line represents the year China was included into the WTO (2001). Latin America include Brazil, Chile, Colombia, Mexico and Peru. Asia includes India, Indonesia, Korea, Malaysia, the Philippines and Thailand. [2] Other is a residual category that includes non-resident flows other than those included in FDI, equity and debt flows.

Source: IMF, *International Financial Statistics*; BIS calculations.

created by short-term capital flows. Section 5 provides an analytical interpretation of their experience, using the simple open-economy model developed in Chapter 3, and discusses the role of implementation lags and instrument manipulation costs.

6.1. Three Episodes of Capital Flows into MICs

This section discusses three distinct episodes of capital flows experienced by MICs in Latin America and Asia. These episodes are illustrated in Figure 6.1. The first, in 2003-2007, follows the strengthening of macroeconomic policy regimes including successes with inflation targeting. These developments prompted a large inflow of foreign direct investment, which resulted in a strong currency appreciation in recipient countries. A China-related commodity price boom also contributed to these developments. The second, in 2009-12, took the form of large inflows, of non-resident debt and equity capital flows resulting from a *search for yield*, induced by the implementation of unconventional monetary policies in advanced economies. The third episode in 2013, is the *sudden stop* of capital flows due to the announcement (*taper tantrum*) by the US Federal Reserve of the future reduction of its quantitative easing policy. That produced a surge in U.S. Treasury yields that resulted in capital outflows from many MICs.[3]

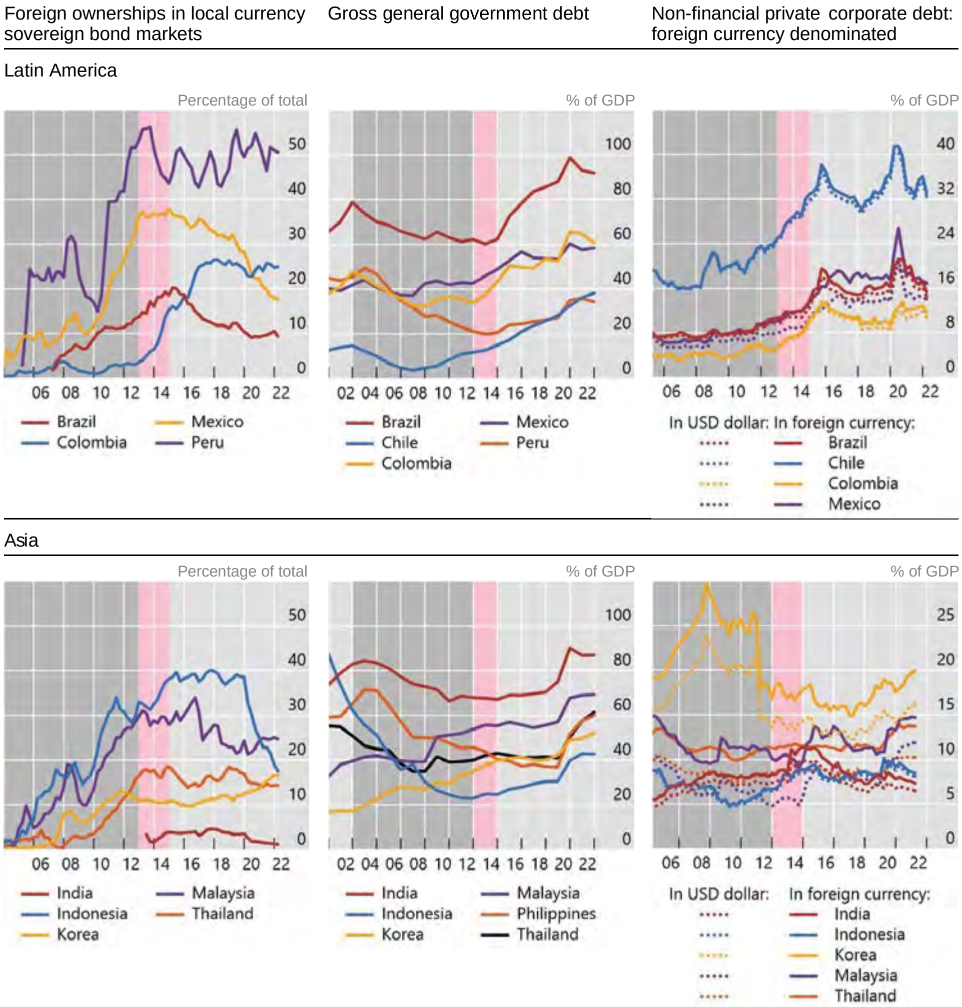
As these episodes unfolded, there were facilitating institutional and market factors at play as well, namely the development of local currency markets, especially for sovereign debt, and the increased participation of foreign investors until the mid-2010s (Figure 6.2, left-hand side). Indeed, Aguilar et al. (2021) stressed that, along with greater international risk appetite, institutional developments played an important role. The latter comprised removing administrative barriers for investors to enter and exit local markets, including to foreign exchange markets, and the development of derivatives markets to allow for the possibility of hedging positions. In several cases, greater accessibility was rewarded with credit rating upgrades and with the inclusion of local instruments in global bond indices, which attracted further investments from abroad.

As argued by the Bank for International Settlements (2019*a*, Chapter 2), the greater diversification of capital flows represented a positive development overall as it helped deepen local financial markets and reduce the currency mismatches that amplified previous crises. At the same time, however, the greater presence of portfolio investors exposed MICs to new risks. Passive investment strategies and other practices by asset managers can lead to herding behaviour and contagion. Foreign ownership of bonds, even when they are denominated in domestic currency, may give rise to adverse feedback loops between yields and exchange rates and exacerbate the transmission of global shocks.

[3] The episode of 2008 and 2009 due to the GFC itself is not discussed here. The MICs central banks reduced interest rates, both in Asia and in Latin America, while at the same time used their forex reserves and relaxed macroprudential measures. Such a combination of instruments also took place in 2020, in response to the Covid crisis.

Asia and Latin America: Financial indicators, 2001-22

Figure 6.2



Sources: IMF, *World Economic Outlook*; Institute of International Finance.

6.1.1. *Trade-induced Currency Appreciation, 2003-07*

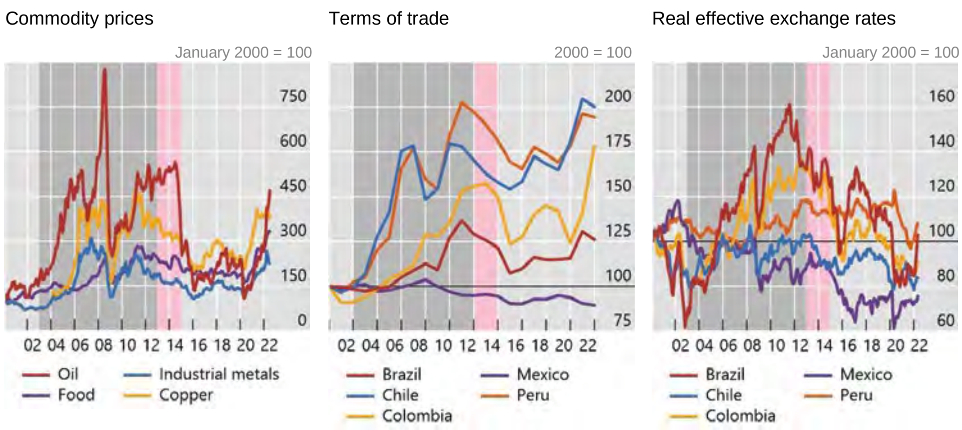
The first episode of capital flows in 2003-07 was influenced by several factors starting, as alluded to earlier, with the strengthening of their macroeconomic policy regimes. The credibility gain that the adoption of inflation targeting provided was compounded in many MICs by an exogenous positive shock: a significant improvement in their terms of trade, linked to the onset of a commodity super cycle that lasted from 2003 until 2014-15 (Figure 6.3, left-hand panel). The key factor behind this improvement was the expansion in world trade, itself related to China's admission to the World Trade Organization in 2001. It led to a strengthening of commodity exporters' currencies between 2002 and 2012 (Figure 6.3, right-hand panel), which contributed to making them more attractive to foreign investors and promoted capital inflows into these countries.

6.1.2. Search for Yield, *2009-12*

After the GFC, central banks in large advanced economies expanded their supply of liquidity massively, keeping rates at historically low levels and in turn feeding a global *search for yield* (Aizenman et al. (2016)). This time, capital flows were larger and more volatile than in the wave experienced prior to the GFC. As illustrated in Figure 6.1, their composition also changed. The share of debt, equity and other portfolio investment increased further for commodity exporters and others, whereas foreign direct investment flows remained stable, both as a share of GDP and as a share of total capital inflows.

Commodity prices, terms of trade and exchange rates, 2001-22

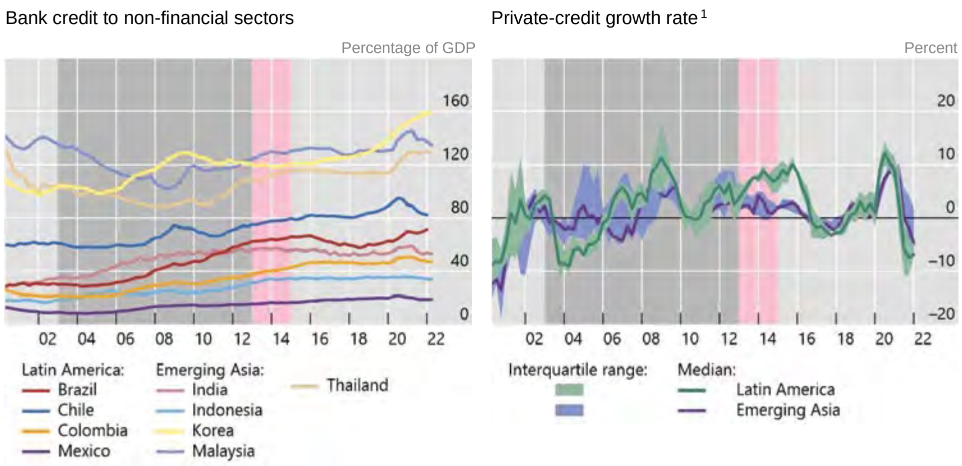
Figure 6.3



Source: IMF, *World Economic Outlook*; national data; BIS calculations.

Asia and Latin America: Credit developments, 2000-22[1]

Figure 6.4



[1] Latin America includes Brazil, Chile, Colombia and Mexico; Asia includes India, Indonesia, Korea, Malaysia and Thailand.

Source: national date; BIS calculations.

Commodity exporters once again experienced an improvement in their terms of trade, as well as large and persistent currency appreciation, which coincided with stronger growth in investment, output and domestic credit (Figure 6.4). As a mirror image, the terms of trade of commodity importers deteriorated.

Large capital inflows and the currency appreciation in commodity-exporting countries produced well-known collateral effects, tantamount to a relaxation in domestic financial conditions. However, in the years that followed the GFC, MICs took advantage of these more favorable global conditions to de-lever their financial systems and accumulate international reserves. Public debt to GDP ratios typically stabilized or declined thanks to rapid growth in nearly all of the sample countries (Figure 6.2, centre panel). And several of these countries, all five in Latin America, as well as Indonesia and Thailand, accumulated foreign reserves. However, non-financial corporations increased foreign borrowing, across the board in Latin America as well as in India, Malaysia and to a lesser extent in Thailand. At the same time, the growth of private domestic credit was sustained, most markedly in Latin America but also in Asia (Figure 6.2, right-hand panels).

6.1.3. Taper Tantrum*, 2013*

The same forces that spilled over from easy global financial conditions to domestic ones, work in the opposite direction when capital flows reverse. This is precisely what happened for many MICs during the 2013 *taper tantrum* episode. As global investors expected that the tightening cycle of the Federal Reserve would bring about higher returns in dollars, the exposure to MICs risks shrunk abruptly. As a result, several currencies depreciated significantly during the period 2013-16 (Figure 6.3, right-hand panel). In particular, the nominal exchange rate depreciated by more than 20 percent in Brazil and Mexico, and by more than 10 percent in Colombia, Indonesia and Malaysia. But the depreciation would have been much larger if MICs had not accumulated foreign exchange reserves in good times prior to the taper tantrum. This allowed some of them to use these reserves to intervene in the foreign exchange market and *lean against the wind* of currency depreciation.

6.2. Policy Responses

There are two broad types of external financial shocks described in the previous section: those resulting in large capital inflows and those leading to large capital outflows, induced by changes in world capital markets. In standard policy responses, the expansionary (respectively, contractionary) consequence of these shocks is dealt with using monetary and fiscal policies in a countercyclical manner. But beyond that, and in particular when financial transmission is explicitly taken into account, the models in Chapters 3 and 4 have shown analytically the channels through which these external financial shocks can be amplified, especially changes in asset prices and collateral values, and how they affect the premium embedded in the cost of borrowing from domestic banks.

The case in which fiscal and monetary policies are used to respond to an expansion in aggregate demand and inflationary pressures associated with large capital inflows triggered by external shocks was discussed in both Chapter 3 (in a simple analytical framework) and Chapter 4 (using a full-blown DSGE model). However, in practice, the use of fiscal policy as a countercyclical tool may be hampered by the lack of fiscal space, which constrains (as noted in previous chapters) the ability to adjust government spending and taxes to stabilize the economy.[4] In addition, the countercyclical use of monetary policy poses a key challenge. If inflation is already close to target, and inflation expectations well anchored, inflation targeting central banks may face a trade-off in raising interest rates. By contrast, higher interest rates may cool domestic demand and mitigate inflationary pressures; on the other, they may exacerbate exchange rate appreciation, which in turn could attract additional capital flows and further ease domestic financial conditions. The financial effects of the exchange rate may therefore significantly dampen the intended impact of tighter monetary policy conditions on output and prices, while debt and other measures of financial vulnerability continue to deteriorate.[5]

The case in which fiscal and monetary policies are used to manage the macroeconomic effects associated with large outflows, entailing in particular a tightening of domestic financial conditions, is the reverse of the previous one. The scope for using fiscal policy may be limited due to fiscal rigidities. There too, the countercyclical use of monetary policy faces a trade-off: while a tightening of interest rates may mitigate the currency's depreciation, if it is large and long lasting it may generate a contraction in output that may be deemed excessive. By contrast, although a reduction in policy rates during an episode of large outflows may prevent a contraction in economic activity, it may also accelerate the depreciation of the exchange rate, which in turn may weaken the balance sheets of indebted borrowers (thereby raising risk premia) and feed into higher prices if the pass-through effect is sufficiently strong.

The upshot of this analysis is therefore that, to stabilize the economy, policymakers may face practical difficulties if the only instruments at their disposal are monetary and fiscal policies. In reality, to manage the consequences of external financial shocks, central banks in MICs have used (as discussed in previous chapters) several other instruments in addition to these policies, namely, FXI, macroprudential policies, and CFMs. Using multiple instruments was not new to them – having been employed also in the early stages of inflation targeting – but their systematic use increased in intensity over the first two episodes of capital flows alluded to earlier (Figure 6.5*a* and 6.5*b*). The issue that is considered next is the performance of all of these instruments.

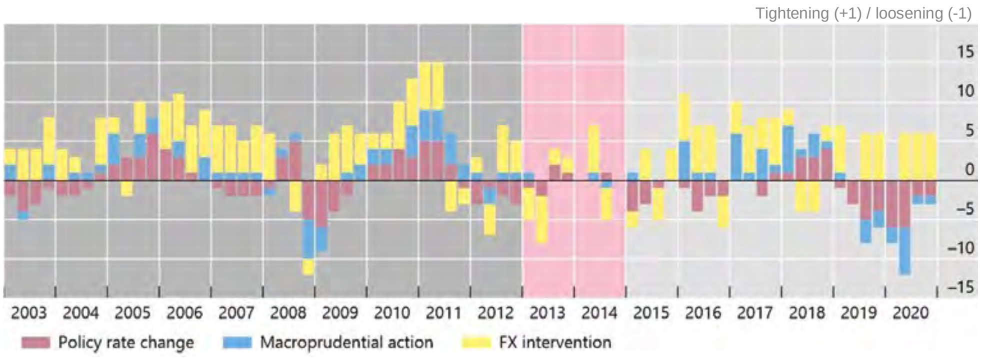
4 Fiscal policy may even turn procyclical during periods of large appreciation, thereby exacerbating financial amplification effects.

5 The strength of these effects depends on the size of foreign-currency denominated debt and how large is the presence of foreign investors in local currency markets. In the presence of foreign-currency denominated debt, an appreciation of the exchange rate can improve the balance sheet of borrowers and lenders, leading to greater credit availability and narrower credit spreads. Similarly, an appreciating currency normally makes local currency bonds more attractive to foreign investors. See, for instance, Bank for International Settlements (2019*b*), Carstens and Shin (2019), and Hofmann et al. (2020).

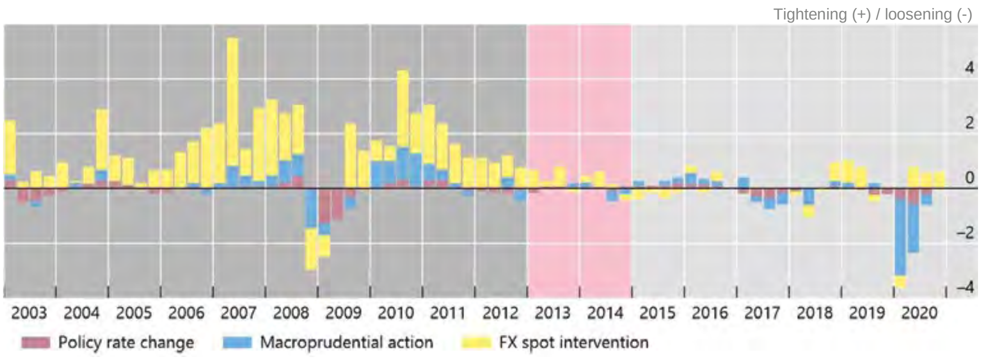
Selected MICs: Joint use of monetary, macroprudential and exchange rate policies, 2003-20[1]

Net number of MICs that tightened or loosened policy instruments | Figure 6.5a

Six Asian economies[2]



Five Latin America economies[3] | Figure 6.5b



[1] Policy rate change = average quarterly change in the policy rate in percentage points across countries divided by 50 basis points; macroprudential action = average number of the sum of tightening (+1) or loosening (-1) actions by a country across the countries; FX spot intervention = average value of the percentage change in total FX reserve assets in US dollars excluding gold across countries normalised by its standard deviation, where a positive value means purchasing foreign currency and selling local currency and a negative value selling foreign currency and purchasing local currency. [2] ID, IN, KR, MY, PH and TH. [3] BR, CL, CO, MX and PE.

Sources: authors' calculations, based on various sources.

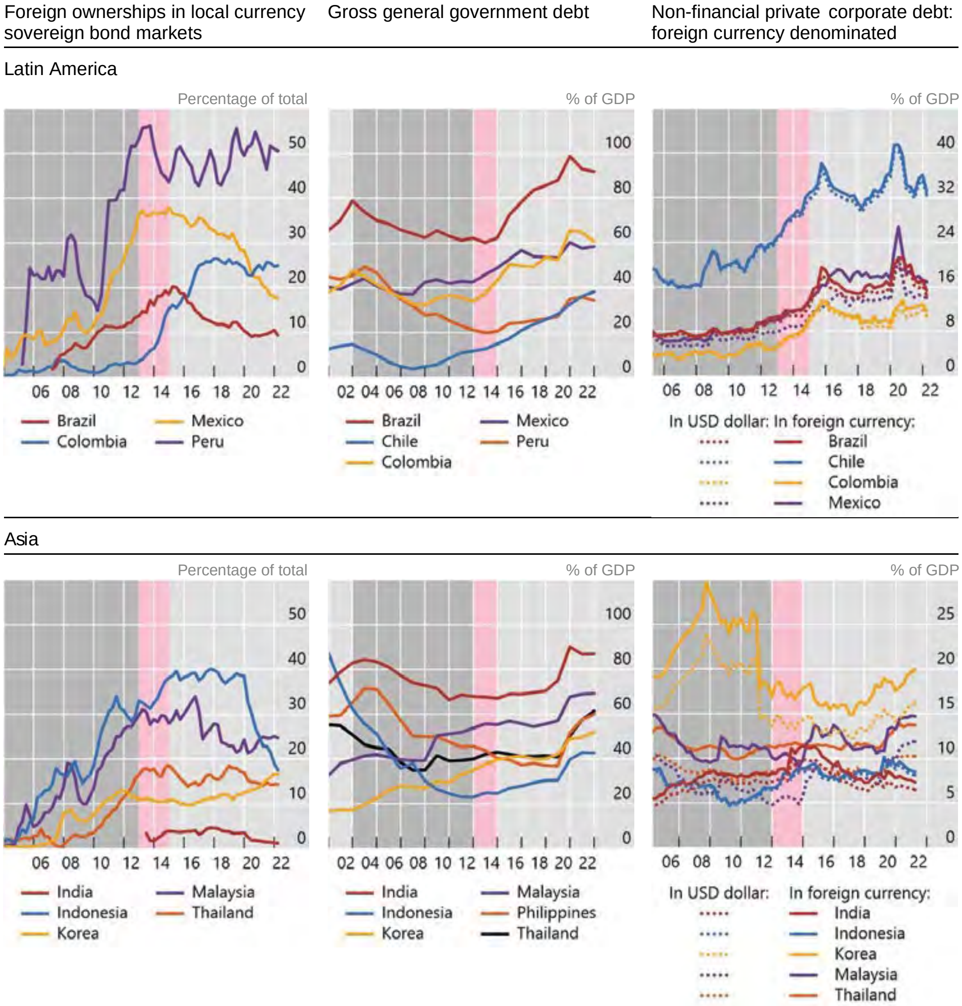
6.2.1. Trade-induced Currency Appreciation, 2003-07

Facing appreciating currencies and capital inflows, together with significant inflationary pressures, central banks used monetary policy countercyclically. As shown in Figure 6.6 (centre panels), for most countries, with the exception of Brazil, policy rates increased at a moderate pace or remained broadly stable. Foreign exchange intervention also played an important role (see red and yellow bars in Figures 6.5*a* and 6.5*b*) and was in most cases coupled with sterilization, as discussed in Chapter 5. Central banks conducted FXI with two main motives in mind: to increase international reserves and to smooth excess exchange rate volatility.[6] For instance, the Philippines increased its foreign exchange reserves by 10 percent of GDP between 2010 and 2013 and Thailand by 20 percent of GDP between 2006 and 2012. In Latin America, the rate at which reserves were accumulated was more sustained from the early 2000s to 2022. The use of sterilized intervention, in combination with monetary policy, helps to explain why interest rate increases remained moderate during the 2003-07 period.

[6] International reserves constitute an important backstop that contributes to improve investors' confidence and reduce both the probability and the adverse effects of a sharp tightening in external financial conditions.

Asia and Latin America: International reserves, policy rates, and capital-to-risk weighted assets, 2000-22

Figure 6.6



[1] Peru's 2021 observation from the Central Reserve Bank of Peru.

Sources: IMF, *World Economic Outlook*; Institute of International Finance; national data.

6.2.2. Search for Yield, *2009-12*

Facing large inflows related to the *search for yield episode* and lower inflationary pressures, from 2009 to 2012, central banks lowered (or maintained) policy rates but also increased their recourse to macroprudential measures (see Figures 6.5*a* and 6.5*b*).[7] These measures were complemented by foreign exchange interventions to smooth volatility and lean against excessive appreciation without abandoning the flexible exchange rate regime. For instance, measures were aimed at reducing financial institutions' exposures to exchange rate risks and fast-growing segments of the domestic credit market. These tools were used not only to improve the resilience of the financial system but, in some cases, also in an attempt to contain or smooth financial booms. The tools most frequently deployed, especially in Brazil, Colombia and Peru, were reserve requirements on deposits, often differentiated according to maturity and currency of denomination. In addition, intervention increasingly occurred through foreign exchange derivatives markets – which reflected the development of these more sophisticated markets, notably in Latin America – and the significant increase in the demand for hedges, especially in the nonfinancial corporate sector. These policies were discussed analytically in Chapter 5.

[7] In the aftermath of the GFC, new *structural* micro and macroprudential regulataroy reforms were introduced to strengthen the resilience of financial sectors. These reforms frequently went beyond the minimum tightening of regulatory standards required by Basel III standards so as to address each country's needs. In particular, many MICs introduced more stringent reporting requirements relating to derivatives positions of corporates, after having learned with the highly destabilising experience of pervasive use of knock-in/knock out (KiKo) foreign exchange options at the onset of the GFC.

At a more structural level, and although the objectives pursued by central banks did not fundamentally change in most countries, the organization of central banks was generally modified to reflect their greater emphasis on monitoring financial stability risks. There was also greater emphasis on ensuring that measures regarding financial stability were implemented and communicated to the public more effectively. To that effect, financial stability committees and divisions were created or strengthened. Financial stability reports were introduced or became more analytical, with a greater focus on *macro*prudential regulation and systemic risk. And, in several countries, inter-agency arrangements between the central bank, other financial authorities and relevant government ministries were established to improve coordination of policy decisions. For instance, Bank Negara Malaysia (BNM thereafter) created a Joint Policy Committee in 2009. While this committee has no fixed schedule, it can convene the Monetary Policy and the Financial Stability committees on an *ad hoc* basis to decide on policies that matter both for macroeconomic stability and financial stability. Another example is the Financial Stability Committee created by Central Bank of Brazil in 2011. The creation of these committees, both independently and in coordination with monetary policy, facilitated more transparency and effectiveness in the implementation of macroprudential policies.

6.2.3. Taper Tantrum*, 2013*

In response to the large capital outflows caused by the *taper tantrum*, and the resulting exchange rate depreciation and increase in risk premia, central banks combined monetary policy action (see Figures 6.5a, 6.5*b*, and 6.6, centre panels) with foreign exchange intervention. This is well illustrated by the drop in international reserves displayed in Figure 6.6 (left panels). Such intervention aimed at leaning against excessive depreciation and volatility, reducing market disruptions, and adjusting the supply of liquidity.[8] Among these three objectives, limiting exchange rate volatility was the most prominent.

The combination of monetary policy and foreign exchange intervention during that episode was considered successful in a number of Asian countries (see Bank for International Settlements (2019*b*)). Indeed, despite the magnitude of the external financial shock that the *taper tantrum* represented, intervention allowed MICs to maintain flexible exchange rate regimes while mitigating financial stability risks and dampening the impact of currency fluctuations on prices. As the adverse effects of large swings in the exchange rates on the financial system and on inflation were reduced, exchange rates were able to play their traditional stabilizing role through their impact on trade and output.

6.2.4. A Synoptic View of Policy Responses

In addition to Figures 6.5a and 6.5.b, which illustrate for selected MICs the joint use of monetary, macroprudential and exchange rate policies during the three episodes analysed in this chapter, Table 6.1 provides more specific details, for all countries and for each episode, of the respective policy stance for all of the five instruments considered earlier.

For the 2003-07 "trade-induced currency appreciation" and the 2009-12 "search for yield" episodes, both with large capital inflows, most countries engaged in systematic foreign exchange intervention, leading to a large accumulation of foreign reserves. In terms of the other instruments, there was mostly a tightening of the macroprudential stance, restrictive fiscal and monetary policies, and a limited usage of capital controls.

For the 2013-15 "taper tantrum" episode, systematic foreign exchange intervention also took place – but in most cases in the opposite direction, sometimes using derivatives and interventions in futures markets. The general stance of both fiscal and monetary policies also became (with some exceptions) expansionary, and the macroprudential policy stance was tightened. Most countries also loosened capital controls.

Table 6.1 confirms that, when faced with large swings in capital flows that affect their domestic and external equilibrium, MICs have used a variety of instruments, some systematically, others more sporadically. In addition, the combinations reported in the table (although not by pairs of instruments) are consistent with the analytical approach taken in the previous chapters. This is illustrated in more detail in the case studies of Brazil and Malaysia that are presented in the next sections.

8 Among the motives for intervening in foreign exchange markets, restoring orderly market functioning remains, in general, the most important (Bank for International Settlements (2021)). Both the size and type of intervention are generally adopted after a diagnosis of the source of pressure in the foreign exchange market, and adapted to the specific type of investor or flows associated with it. For temporary or seasonal needs for liquidity in foreign exchange, for instance, central banks used repo operations, while for more permanent changes in foreign exchange liquidity, they favoured outright sales in the spot market.

Macro financial policy mix across 11 EMEs for three phases of large capital flows

Table 6.1

	BR	CL	CO	MX	PE	ID	IN	KR	MY	PH	TH
2003-2007											
Fiscal policy stance[1]	restrictive	restrictive	restrictive	restrictive	restrictive	restrictive	expansive	restrictive	expansive	restrictive	restrictive
Monetary policy[2]	expansive	restrictive	restrictive	expansive	restrictive	restrictive	restrictive	restrictive	restrictive	neutral	restrictive
FX Int stance[3]	Intervention buying	Intervention selling	Intervention buying*	Intervention buying	Intervention buying	Intervention buying	Intervention buying	No interven-tion*	Intervention buying*	Intervention buying*	Intervention buying*
CFMs stance[4]	loosen	na	na	tighten	na	tighten	loosen	loosen	na	na	na
Macroprudential stance[5]	neutral	neutral	loosen	tighten	tighten	neutral	tighten	tighten	tighten	tighten	tighten
2009-2012											
Fiscal policy stance[1]	restrictive	neutral	neutral	neutral	restrictive	neutral	expansive	neutral	expansive	restrictive	neutral
Monetary policy[2]	expansive	restrictive	restrictive	neutral	restrictive	restrictive	restrictive	restrictive	restrictive	neutral	restrictive
FX Int stance[3]	Intervention buying*	Intervention buying	Intervention buying	Intervention buying	Intervention buying	Intervention buying	Intervention selling*	Intervention buying*	Intervention buying*	Intervention buying*	Intervention buying*
CFMs stance[4]	tighten	na	na	loosen	na	tighten	loosen	tighten	na	na	na
Macroprudential stance[5]	tighten	na	tighten	tighten	tighten	tighten	tighten	tighten	tighten	tighten	tighten
2013-2015											
Fiscal policy stance[1]	expansive	neutral	neutral	expansive	neutral	expansive	expansive	neutral	expansive	restrictive	neutral
Monetary policy[2]	restrictive	expansive	expansive	expansive	expansive	restrictive	neutral	expansive	neutral	neutral	expansive
FX Int stance[3]	Intervention selling*	No Interven-tion	Intervention buying	Intervention buying	Intervention selling*	Intervention selling*	Intervention buying*	Intervention buying*	Intervention selling*	No interven-tion*	Intervention selling*
CFMs stance[4]	loosen	na	na	loosen	na	loosen	loosen	tighten	na	na	na
Macroprudential stance[5]	tighten	tighten	neutral	tighten	tighten	tighten	tighten	tighten	tighten	tighten	neutral

[1] Fiscal policy stance according to the cyclically adjusted primary balance (capb): capb higher than 1% of GDP (restrictive), capb lower than -1% of GDP (restrictive) and the range between them (neutral). [2] Monetary policy stance based on the average change in policy rates during the mentioned periods: positive change (restrictive), no change (neutral) and negative change (expansive). [3] The net stance of FX interventions is reported by considering spot and derivatives FX interventions. * denotes the presence of FX interventions in the derivatives markets. [4] Capital flows measures stance based on the net numbers of CFMs between tighten (+1) and loosen measures (-1). Na = does not apply. [5] Macroprudential measures stance based on the net numbers of macroprudential policy measures between tighten (+1) and loosen measures (-1).
Sources: IMF; national data; BIS.

6.3. The Case of Brazil

The experience of Brazil described in this section is used to illustrate two of the three episodes discussed earlier (see Pereira da Silva and Harris (2012)). After a period of crises and macroeconomic instability, for almost two decades in the 1980s and 1990s, Brazil implemented a new macroeconomic policy framework centered on inflation targeting, a floating exchange rate, and explicit fiscal rules. Combined with the adoption of other public policies, this enabled the country to resume a process of sustainable and more inclusive growth, after two decades of sluggish and irregular performance. Brazil benefited from the commodity boom of 2003-07 and became a more attractive destination for foreign capital, with investment opportunities in numerous areas. Those opportunities brought significant inflows in the post-GFC (2009-12) period. But like many MICs, Brazil also had to deal with episodes of *sudden stops* and loss of confidence. This occurred in 2013 and compounded the volatility associated with the *taper tantrum*. These two episodes are examined in turn.

6.3.1. Managing the Search for Yield*, 2009-12*

The strong recovery of the Brazilian economy in the aftermath of the GFC in 2008-09 (see Figure 6.7), together with higher interest rate differentials and excessive global liquidity, triggered large, short-term foreign inflows, domestic currency appreciation, and an acceleration of the expansion of domestic credit. In 2010, net capital inflows amounted to USD 125 billion (5.6 percent of GDP), compared to about USD 80 billion in 2009 (4.7 percent of GDP). Brazil had a historically large amount of equity issuance, totalling Brazilian Reais (BRL) 146 billion. External debt issuance rose by another USD 48 billion, approximately. Net inflows of foreign direct investment amounted to USD 38 billion.

Brazil managed those large inflows first by allowing its floating exchange rate to play its role through currency appreciation, while smoothing excesses through sterilized reserve accumulation. However, Brazil's credit market was boosted by these capital inflows. Therefore, a set of macroprudential measures was adopted in a second stage. Multiple sources of foreign funding were transmitted into local credit markets, in addition to the confidence factors that are associated with periods of abundant liquidity. External funding at low cost, despite tighter domestic prudential rules, created incentives to increase risk taking and exacerbated asset price increases, including the exchange rate – despite some volatility. Increases in collateral values also contributed to the rapid pace of domestic credit growth, which fuelled excess demand and inflationary pressures (see Figure 6.7).

The central bank relied on a comprehensive toolkit of policy measures to deal with emerging macroeconomic and financial instability at the end of 2010 and early 2011. Standard aggregate demand management was conducted using fiscal and monetary policies. On the fiscal front, in 2010 (respectively, 2011), the targeted primary fiscal surplus was increased from 2.5 percent of GDP to 3.1 percent (respectively, 3 percent) and actual outcomes were slightly lower but in line with objectives, despite the inherent difficulty in Brazil of using fiscal policy as a countercyclical instrument. The actual primary fiscal surplus increased from 2.0 percent of GDP in 2009 to 2.7 percent in 2010 and 3.1 percent in 2011. Regarding monetary policy, the policy rate was raised on average in 2010 (respectively until August 2011) by about 100 basis points each period to help dampen internal imbalances.

Macroprudential measures – in the form of increases in capital requirements for consumer loans, reserve requirements on demand and term deposits and a tax rate on consumer credit – were also adopted to reduce systemic financial risks stemming from rapid credit growth and large short-term capital inflows. Overall, the set of monetary and macroprudential policies that were adopted in 2010 and 2011 were successful in slowing down the growth of household credit to a more sustainable pace. These measures affected not only the volume of new loans, but also their rates and average maturities.

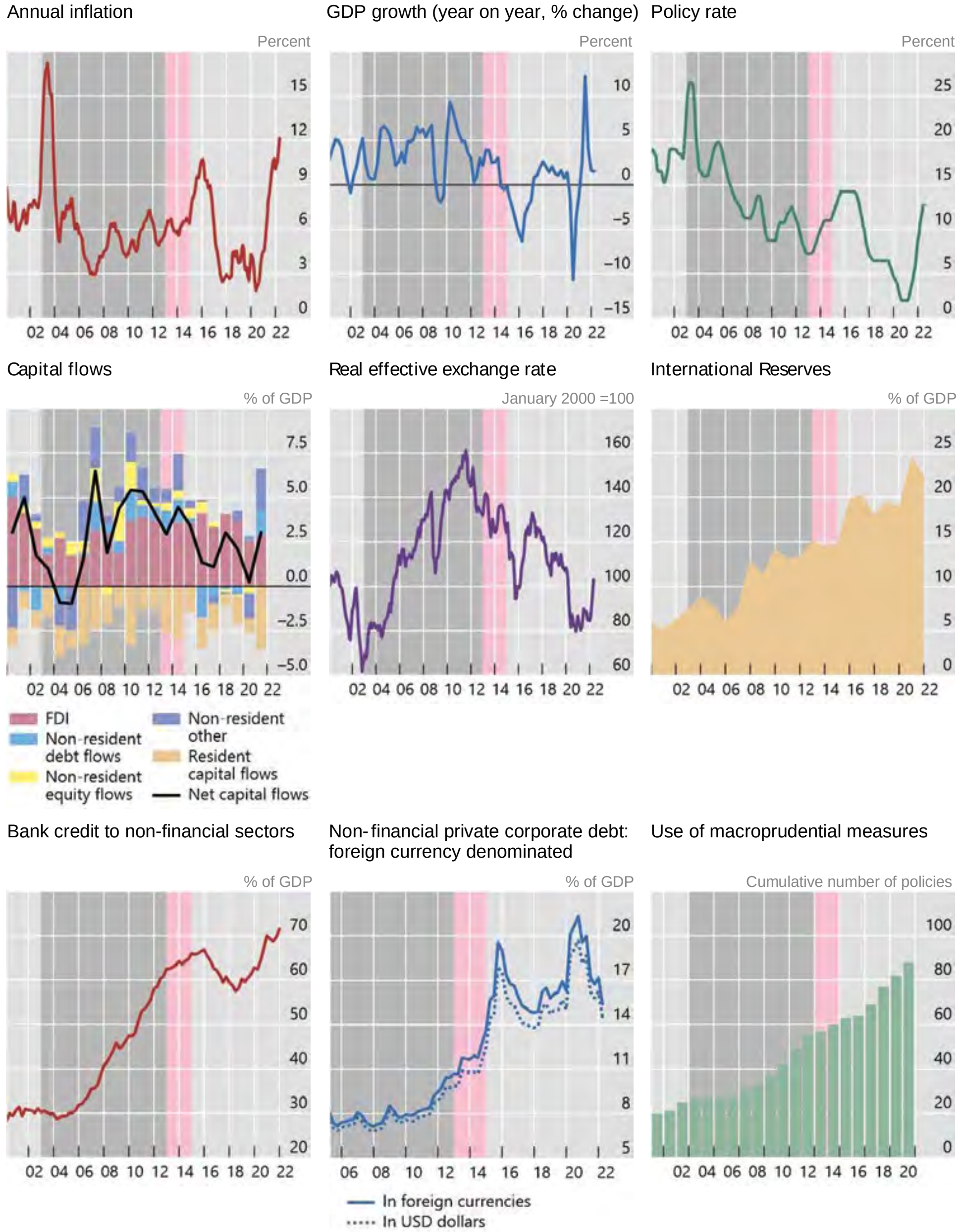
CFMs were also used. Beginning in October 2010, a tax on financial transactions (IOF) for non-residents' portfolio investment in fixed income instruments was raised from 2 percent to 6 percent.[9] This was aimed at curbing excessive short-term and speculative capital inflows, by discouraging short-term carry trades. These were putting pressure on the domestic currency to appreciate. The net foreign inflows to fixed income stabilized first and then declined (see Figure 6.7, right middle panel). This happened despite the fact that the interest rate differential between the domestic policy interest rate (Selic) to Libor (as a proxy for external funding costs), and the return on a government bond by a foreign investor subject to the IOF would break even at a holding period of around nine months.[10]

9 See Benelli et al. (2014). The IOF is applicable to several operations, such as credit, foreign exchange, securities and insurance transactions. Each tax origin is based on a different trigger; in the case of a foreign exchange transaction, it is the settlement of the respective foreign exchange contract.

10 Although the flat one-time IOF hurdle is relatively less penalizing of returns on investments held for longer terms, the tax rate hike affected the liquidity of the primary market at the long end of the yield curve, where foreign investors are usually more active.

Brazil: Macroeconomic developments, 2000-22

Figure 6.7



Sources: IMF, *Balance of Payments, Integrated Macroprudential Policy (iMaPP) Database*; national data; BIS calculations.

Overall, this combination of monetary policy with other policy instruments (foreign exchange intervention, macroprudential regulation, CFMs and, to a less significant extent, fiscal policy) achieved the stabilization of the economy. There was a slowdown in economic growth but not at the expense of an excessive fall in employment. There was a further accumulation of international reserves and moderation of capital inflows. Domestic credit expanded, but at a decelerating pace at the end of 2011 (to an annual growth rate of 18.8 percent) from its peak at the end of 2010 (an annual growth rate of 21 percent). Inflation remained within the tolerance band of the central bank (albeit at the upper limit) and there was a depreciation of the real exchange rate.

6.3.2. Managing the Taper Tantrum*, 2013*

Following its successful management of capital flows during the *search for yield* episode, Brazil encountered more difficult times in 2012-13 in the years preceding the presidential election of 2014. A loss of confidence, social tensions and commodity prices falling from record highs were heightened by markets' perception of an excessive expansion of public sector credit to boost investment. A more vulnerable fiscal picture was compounded by entrenched pressure on fiscal spending (in particular, rigid earmarking and social security commitments) that necessitated a higher tax burden and were accompanied by interventions in energy sector pricing. At the same time, fiscal rigidities limited the country's ability to use fiscal policy as part of the mix of instruments that could be deployed to respond to domestic and external shocks.

Because the previous episode has already illustrated the combination of monetary policy with foreign exchange intervention, more detail is provided in this episode on the specific form of intervention. Monetary policy was tightened to fend off persistent inflationary pressures and to counteract a more lax fiscal policy stance. The policy rate (Selic) was raised by 375 basis points to 11 percent between April 2013 and April 2014. In addition, the central bank intervened in the foreign exchange market. But this time intervention took a different form: the objective was to limit volatility after the Federal Reserve's taper announcement by meeting the demand for hedging. The Central Bank of Brazil launched a large intervention program combining an allotment of non-deliverable-forwards (NDFs), the so called "swaps" in Brazil, with repos.

Brazil's swap program to cope with the taper tantrum shows that foreign exchange intervention can take several forms but follows some basic rules. First, it was a sizeable program, with pre-announced (albeit adjustable over time) allotments of both swaps and repos. The challenges for the foreign exchange market in Brazil were lasting (they were on and off for about three years) and the circumstances behind those challenges evolved from global to domestic and transitioned from monetary policy normalization to the collapse of commodity prices and to heightened domestic political and policy uncertainty.

At the launch of the program in August 2013, it was clear that the demand for hedging was generating perverse dynamics. The price of foreign exchange in Brazil is formed in the futures markets, which is deeper and more liquid, while fully connected with the spot market through arbitrage. As agents with unhedged exposure tried to cover themselves, they exerted undue pressure in the market, which fuelled further depreciation and higher demand for protection in a downward spiral. The central bank identified an *ex ante* gap in corporate hedging of about USD 70 billion and sized the program accordingly. The announcement of a sizeable program unfolding over several months allowed for the interventions to be spread over time. The overall size of the program, with clear rules and a precise schedule, precluded the need to be more aggressive immediately. The additional use of repos was designed to provide liquidity to the market as needed, preempting liquidity stresses and the widening of the *cupom cambial*.[11]

At that point in time, it was only the beginning of a worsening of the political scene, which continued to deteriorate and culminated with the impeachment of the President in 2016. On top of the *taper tantrum*, the sequence of shocks and the pervasive loss of trust in political institutions kept the currency under pressure for most of the period from mid-2013 through the beginning of 2016. At its peak, the accumulated total notional swap position of the central bank reached USD 115 billion. Although the NDF is settled in Brazilian real, the underlying asset controlled by the central bank, namely the international reserves position, plays a critical role in providing credibility to the instrument. At the end of the day, the instrument holds if markets believe that there are no convertibility risks. The increasing use of the concept of reserves net of swaps was an indication that the ratio of swaps to international reserves was hovering around a reasonable limit – a rule of thumb of a ratio of 1/3 total NDF position over total international reserves.

While the build-up of the swap positions followed a pre-announced schedule, which was adjusted over time, the recoiling of the liabilities was opportunistic. The goal was not to maximise the central bank profits, but to withdraw the hedge as soon as it was no longer needed. Still, such movement allowed the recovery of a substantial part of the cost incurred in the previous phase. The experience of Brazil shows that this type of foreign exchange intervention can be very effective at fostering macroeconomic and financial stability when confronted with the ebbs and flows of global capital movements.

6.4. The Case of Malaysia

Malaysia had remarkably stable growth and fairly stable trend inflation from the aftermath of the 2008 GFC until the COVID crisis in 2020. As a small open economy, it is naturally subject to the shocks that shape the global economy and global trade, including, in the last two decades, the GFC, the 2011-14 European sovereign debt crisis, the 2015-16 slowdown in China and, of course, the COVID pandemic. Turning to external financial shocks, and similarly to other MICs, Malaysia saw a fast increase in portfolio inflows during the *search for yield* episode, before

11 *Cupom Cambial* can be understood as the yield on a synthetic dollar-denominated investment in the local market.

experiencing – just like Brazil and many other MICs – large capital outflows in the aftermath the 2013 *taper tantrum* episode.

Malaysia addressed these episodes with a mix of monetary, foreign exchange reserves management and macroprudential policies. This multipronged approach proved capable of insulating the domestic economy and keeping it on a steady growth path throughout. The main challenges resided in mitigating the impact of the sterilization of capital flows on domestic liquidity, and scaling up macroprudential policies in light of the rapid growth of domestic credit in the period (see Figure 6.8, bottom panels).

6.4.1. Managing the Search for Yield*, 2009-12*

After the GFC, domestic economic contraction reached a trough in the first quarter of 2009 before rebounding in the fourth quarter of that year. Economic activity grew steadily thereafter. However, this recovery was accompanied by a sharp rebound in private credit, which increased from 100 to 120 percent of GDP between 2008 and 2010, and an increase in portfolio inflows, which resulted from abundant global liquidity and a search for higher yields in MICs by global investors. Non-resident debt inflows rose from a negative value in 2008 to nearly 5 percent of GDP per annum for four years in a row, between 2009 and 2012. Non-resident equity flows were also significant in 2010 and 2012 (see Figure 6.8).

Because of the increasing risks to financial stability posed by these inflows, BNM followed a multi-pronged approach. First, it implemented financial sector regulatory reforms: it liberalized the country's foreign exchange administration rules to facilitate greater two-way flows, with the goal of deepening the ringgit (MYR) exchange rate market in the medium to long term. Second, BNM increased interest rates to normalize monetary policy stance after the 2009 recession. The policy rate was raised in four steps in March, May, July 2010 and May 2011, by 25 basis points each time. Then, on the macroprudential front, it increased its statutory reserve requirement from 1 to 4 percent in three 1 percentage point increases in March, May and July 2011. In addition, BNM issued notes to absorb liquidity to the tune of MYR 100 billion by end of 2011, reaching a peak at 162 MYR billion in December 2012 (approximately USD 42 billion or 11 percent of the country's GDP in 2012).

Moreover, given that the main destabilizing channel of capital inflows was the acceleration of domestic credit and housing prices, BNM's Joint Policy Committee implemented further macroprudential measures.[12] In November 2010, a 70 percent maximum loan-to-value (LTV) ratio became applicable on the third and subsequent house financing of any borrower. In December 2011, the maximum LTV ratio on house purchases by non-individuals was set at 30 percent. In December 2012, banks were required to step up their assessment of borrowers' creditworthiness, and a maximum loan maturity of nine years on the purchase of cars, and 35 years for houses, were set. Finally, on the fiscal front, the government increased the real property tax gains to 10 percent for sales within two years and 5 percent for those within 2 to 5 years of the purchases.

Interestingly, the very large capital inflows did not translate into a build-up of foreign exchange reserves. This reflected in part the cost of carry trade, due to the return difference between domestic rates and interest rates in reserve currencies. Reserves remained relatively stable at about 40 percent of GDP from 2010 to 2013.

6.4.2. Managing the Taper Tantrum*, 2013*

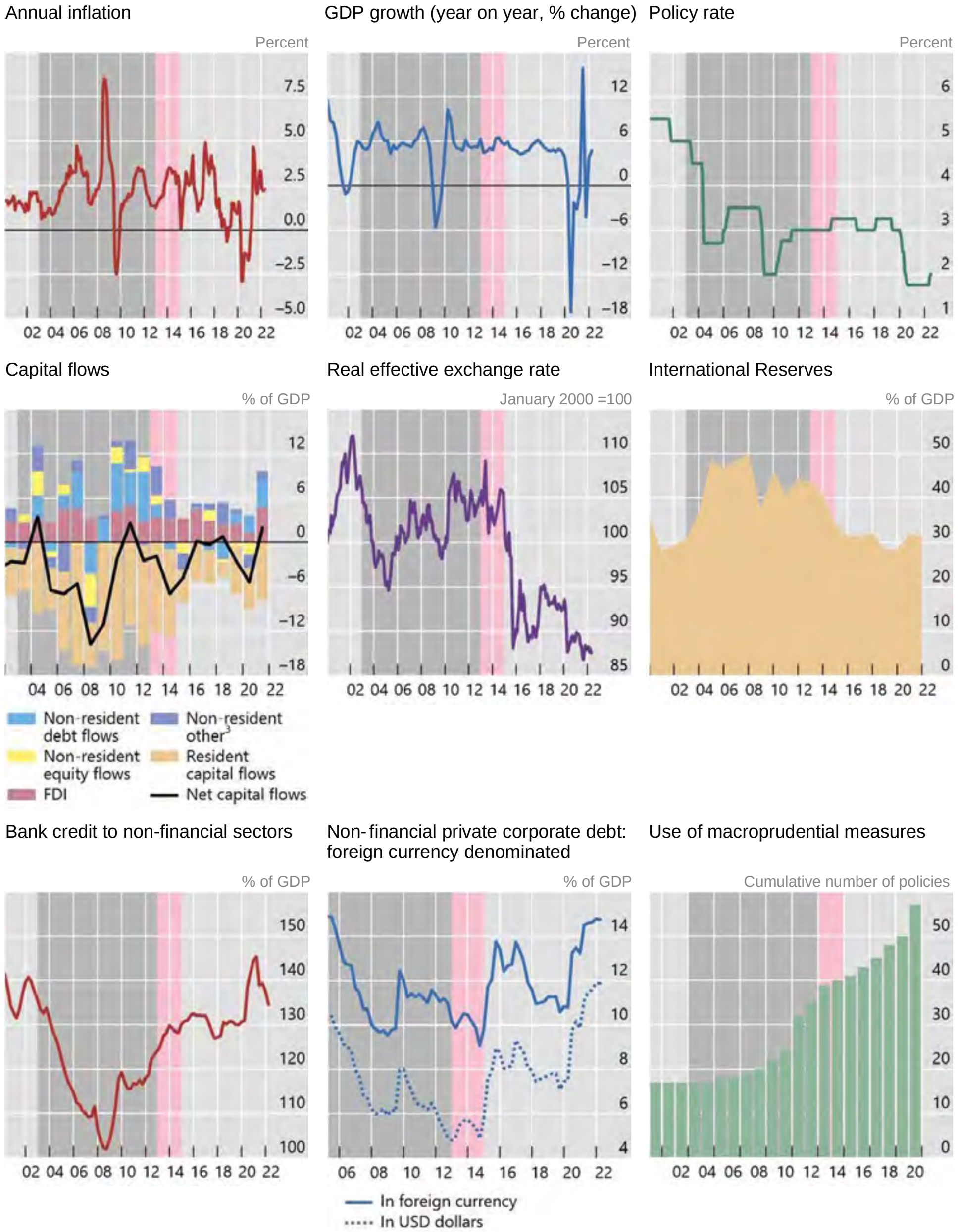
Following the *taper tantrum* of 2013, non-resident debt flows declined in 2014 and turned into net capital outflows in 2015. Resident flows shrunk abruptly, and foreign exchange reserves declined by more than 10 percent of GDP (see Figure 6.8). The real effective exchange rate weakened by 15 percent, after an initial depreciation of over 20 percent in 2015.[13] This episode was managed using a combination of tighter fiscal and monetary policies, together with interventions in the foreign exchange market.

12 The Committee comprises members from both the MPC and the Financial Stability Committee (FSC), with some overlaps in membership and therefore recognition that there could be risks to the separation of both mandates, and hence the efforts to "integrate" only when necessary.

13 This large depreciation was also due in part to the downward phase of the commodity super cycle, as global investors perceived Malaysia as highly dependent on exporting oil and other commodities.

Malaysia: Macroeconomic developments, 2000-22

Figure 6.8



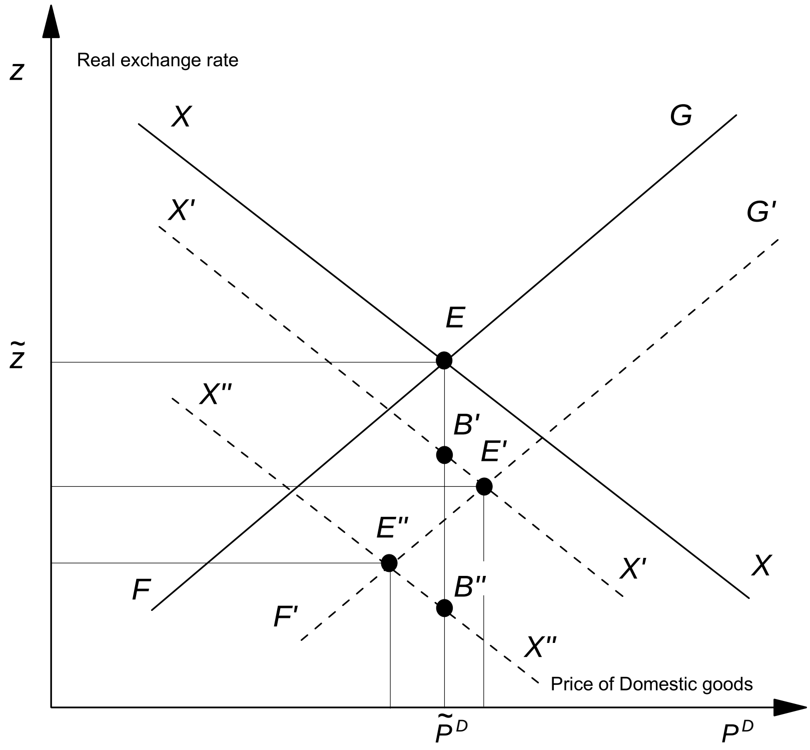
Sources: IMF, *Balance of Payments, Integrated Macroprudential Policy (iMaPP) Database*; national data; BIS calculations.

With respect to fiscal policy, the government introduced a 6 percent tax on goods and services (the equivalent of a value added tax) in April 2015 to restore more balance in public finances. This improved market sentiment. Regarding monetary policy, the policy rate was increased in 2015 and BNM operations were able to maintain liquidity in the money market, as well as a balance between treasuries and BNM notes.[14] Overall, this policy mix was successful in maintaining macroeconomic and financial stability. The tightening of fiscal conditions helped to keep aggregate demand and inflationary pressures under control, and obviated the need for larger increases in interest rates.

14 For instance, in the first part of 2015, BNM reduced its issuance of notes when nonresidents increased their holdings of Malaysian government securities (MGS). Conversely, BNM increased its issuance of notes in September and October of that year, after nonresidents sold off their MGSs in August and September. In addition, BNM shortened the maturity of its monetary operations to accommodate the demand for such maturity by Malaysian banks. The average duration of liquidity absorption operations decreased from 56 days at the end of 2014 to 34 days at the end of 2015.

Reduction in the Risk-Free World Interest Rate

Figure 6.9



Sources: Chapter 3.

6.5. Analytical Interpretation of Policy Responses

In this section the models of Chapters 3 and 4, and the results of the policy combinations studied in Chapter 5, are used to analytically interpret the policy combinations implemented in Brazil and Malaysia, and their outcomes. As discussed earlier, the experience of these two countries illustrate the challenges created by episodes of capital inflows associated with external financial shocks.

6.5.1. Equilibrium after Large Capital Inflows

In the case of both Brazil and Malaysia, the large episodes of capital inflows associated with the *sudden flood* (2003-07) or *search for yield* (2009-12) episodes can be related to the policy experiment of a fall in the risk-free world interest rate, analysed in Chapters 3 and 4. Indeed, the latter episode in particular corresponds to a reduction of foreign interest rates during the post-GFC booms that led to massive inflows of capital into MICs. Using the simple model of Chapter 3, an analytical interpretation of these episodes is provided in Figure 6.9.[15]

A lower world interest rate triggers capital inflows and stimulates domestic consumption. It also increases the demand for, and the price of, land, which raises collateral values and lowers the cost of borrowing, thereby raising investment. The increase in consumption and investment combine to generate excess demand at the initial level of prices. The real exchange rate also appreciates, thereby inducing a contraction of exports. These outcomes are broadly consistent with the experience of Brazil and Malaysia during recent episodes of large inflows of capital. Indeed, in both countries the effect of the shock was to increase capital inflows, which in turn induced a real exchange rate appreciation. At the same time, there was a build-up of inflationary pressures, as a consequence of excess domestic demand.[16]

15 Given the illustrative purpose of this analysis, the focus is on the case of weak financial amplification. Qualitatively similar results can be established with strong financial amplification.

16 Over time, as a result of higher inflation, the domestic policy rate increased, thereby contributing to macroeconomic stability. In the static model of Chapter 3 the policy rate is exogenous, so this effect is not captured; but it is accounted for in the DSGE model of Chapter 4, because of an explicit Taylor-type rule.

As shown in Figure 6.9, both the internal equilibrium curve FG and the external equilibrium curve XX shift downward, to $F'G'$ and $X'X'$, respectively. In the new equilibrium, the real exchange rate (variable z) has appreciated, whereas the domestic price level (variable P^D) can be either higher (at E') or lower (at E'').[17] In the cases of Brazil and Malaysia, a lower global interest rate reduced the holdings of foreign assets by residents and increased domestic demand and imports (as a result of higher household expenditure), thereby creating inflationary pressures. In both countries there was an appreciation of the real exchange rate and inflationary pressures. This was indeed the situation that both countries were in around 2009-10, as described in the previous sections. Thus, the case that corresponds to the experience of these two countries is the new equilibrium point E' in Figure 6.9 (lower z and higher P^D). Using E' as a starting point, the model can be used to illustrate how policies can be combined (consistent with the actual policy mix used by these countries) to restore the initial equilibrium. For clarity, combinations of pairs of instruments are considered.

6.5.2. Getting Back to Initial Equilibrium

Monetary policy tightening and foreign exchange intervention

Consider Figure 6.10, where a reduction in the world interest rate has shifted the equilibrium from the original point E^0, to one with real exchange rate appreciation and higher prices, E^1 (which corresponds to E' in Figure 6.9), at the intersection of F^1G^1 and X^1X^1. This is the typical situation in which MICs such as Brazil and Malaysia find themselves after episodes of large capital inflows induced by reductions in global rates of return.

One possible response to this shock is a standard policy prescription – an increase in the policy rate only. This policy (an increase in the refinance rate in the model) illustrates the case of Brazil, at least initially. As shown in Figure 6.10 (and in line with the discussion of Figure 3.5), a higher policy rate results in a further downward shift of the external equilibrium curve to X^2X^2 (which induces a further appreciation due to higher domestic interest rates) and an upward shift of internal equilibrium curve to F^2G^2 (which induces a contraction in aggregate demand).[18] Therefore, the equilibrium would move from E^1 to E^2. Indeed, lower inflation is achieved, but at the expense of a more appreciated real exchange rate than in the initial equilibrium. In fact, the increase in the policy rate could be calibrated exactly to ensure that the upward shift in FG from F^1G^1 to F^2G^2 intersects the new X^2X^2 curve exactly at the initial level of domestic prices (as in Figure 6.11), but the real exchange rate would still have appreciated more than at the initial equilibrium.

However, suppose that at the same time the central bank combines a contractionary monetary policy with discretionary, sterilized intervention. Indeed, it can intervene in the foreign exchange market to absorb the inflow of foreign exchange, thus neutralizing the effect on the appreciation of the real exchange rate. This is what Brazil did eventually. As illustrated in Figure 6.10, in a first stage the increase in the policy rate can be calibrated so as to initiate a shift in the internal equilibrium curve FG from F^1G^1 to F^2G^2, which coincides with the initial curve F^0G^0. In a second stage, intervention translates into an upward shift in the external equilibrium curve XX, from X^1X^1 to X^3X^3, which coincides with X^0X^0. The initial equilibrium is restored at E^0. Thus, the combination of a tighter policy interest rate (geared towards attaining internal balance) and (sterilized) foreign exchange intervention (geared towards restoring external balance), which broadly corresponds to the strategy pursued by Brazil in the period 2009-12, provides an effective policy mix to stabilize the economy.[19]

Monetary policy tightening and CFMs

Another way for Brazil and Malaysia to move from E^1 back to the initial equilibrium E^0 with two instruments has been to combine monetary and CFMs, which as in the models of Chapters 3 and 4, can also be interpreted as macroprudential policies.[20] Indeed, as discussed earlier, both central banks also combined the increase of their policy rates with tighter CFMs and macroprudential policies.

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17 The reason why domestic prices can be higher or lower in the new equilibrium was discussed in Chapter 3.

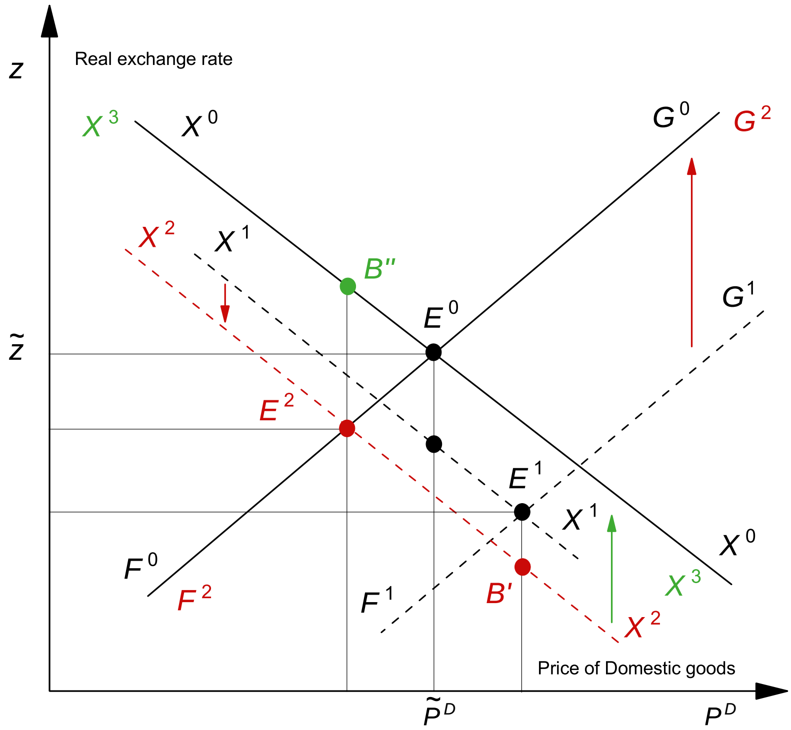
18 As shown in the figure, the upward shift in FG to F^2G^2 is shown to bring the curve back to its initial position, F^0G^0. In general, of course, this does not need to be the case.

19 This policy mix becomes somewhat more complicated to implement if sterilized intervention can be expansionary. However, as discussed in Chapter 3, this would not change the main policy implications.

20 In Brazil, as documented earlier, CFMs took the form of a tax on financial transactions imposed on non-residents' portfolio investment in fixed income instruments. Although this tax does not correspond to the tax on foreign bank borrowing incorporated in the models of the previous chapters, the goal is fundamentally the same-to mitigate capital flows and exchange rate pressures. The use of the results obtained for changes in τ^B is thus sufficient for illustrative purposes.

Policy Response to Capital Inflows Causing Real Appreciation and Inflation, using Monetary Policy and Foreign Exchange Intervention

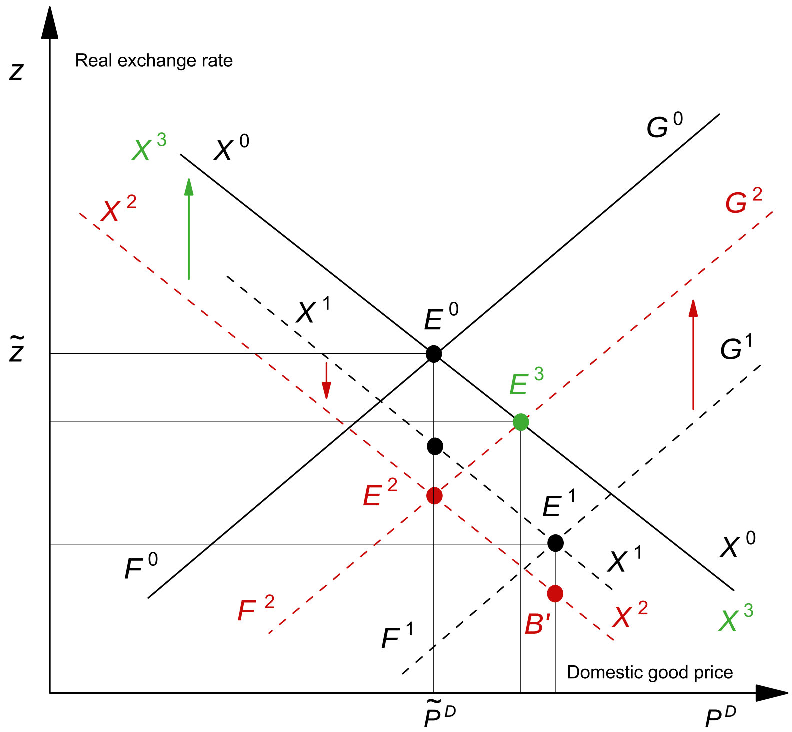
Figure 6.10



Sources: Chapter 3.

Policy Response to Capital Inflows Causing Real Appreciation and Inflation, using Monetary Policy and Capital Controls

Figure 6.11



Sources: Chapter 3.

To illustrate how this policy combination operates, consider Figure 6.11, whichcorresponds to the upper part of Figure 3.14, and once again assume (for illustrative purposes) the case of weak financial amplification. An increase in the policy rate alone results, as before, in the external balance condition shifting downward, from X^1X^1 to X^2X^2, and the internal balance condition shifting upward, from F^1G^1 to F^2G^2. This increase, again, can be calibrated so as to restore domestic prices exactly to their original level, corresponding to the initial equilibrium E^0. But at this new equilibrium, E^2, the real exchange rate remains more appreciated than at E^0.

A better policy response therefore is, in a first stage, to calibrate the increase in the policy rate so that curve FG shifts from F^1G^1 all the way back to F^0G^0. In a second stage, because the policy leads to a further downward shift in XX (because it exacerbates capital inflows and magnifies the real appreciation), the central bank may now combine the increase in the policy rate with a well-calibrated increase in the capital controls tax rate (τ^B, in the notation of the previous chapters). This raises the cost of foreign borrowing and now mitigates capital inflows – in such a way that the external balance curve shifts from X^2X^2 to X^3X^3, coinciding with X^0X^0, with no effect on the position of the internal balance curve *FG*. In a sense, this policy mix involves assigning monetary policy to internal balance, and capital controls to external balance.

Note also that, on the basis of the discussion in Chapter 3 (Figure 3.13), the best policy mix to restore the original equilibrium would be the combination of a *reduction* in the policy rate, coupled with an increase in the macroprudential tax rate. The key reason is that a change in the macroprudential tax rate affects only the position of *FG*, not *XX*; as a result, monetary policy must be assigned to restoring *external* balance, and macroprudential policy to restoring internal balance. The policy assignment is the exact opposite of the case considered earlier; the target to which instruments should be assigned to depends on which instruments policymakers have at their disposal, in addition to the nature of the shock. In particular, while monetary policy should be tightened when the other instrument available is capital controls in the form of a tax on bank foreign borrowing (which can also be viewed as macroprudential in nature), in line with the standard prescription, it should instead be *loosened* when the other instrument available is a macroprudential instrument that directly affects the cost of domestic borrowing.[21]

Another possibility to illustrate these two episodes is to use the DSGE model presented in Chapter 4, which provides a more complete view of the transmission process of the various policies discussed earlier, as well as their dynamics and effects on expectations. The DSGE model captures the effects of the same *sudden flood* of capital: external financial shocks (large inflows of capital) generate a domestic credit boom and an over-valuation of domestic asset prices, boosts aggregate demand, triggering inflationary pressures. The endogenous response of monetary policy due to the boom in domestic demand raises the refinance rate, but exchange rate appreciation tends to dampen inflation and it might result in a reduction in the policy rate. That, in turn, reduces bank loan rates, which contributes to the expansion in investment and output. The central bank is thus confronted with the same problem to get back to the initial equilibrium. The discussion in Chapter 5 is in line with the policies that Brazil and Malaysia implemented: a combination of monetary policy, sterilized foreign exchange intervention, macroprudential policies, and capital controls, using these instruments as complements. The key point of that analysis, as noted earlier in the context of the simple model presented in Chapter 3, is that the target to which each instrument should be assigned depends on the nature (as well as, in a dynamic setting, the degree of persistence) of the shocks impinging on the economy and on which instruments policymakers can deploy to respond to these shocks.

6.5.3. Implementation Lags and Instrument Costs

Other important considerations when choosing between policy combinations are the existence of implementation lags and instrument manipulation costs. Implementation lags relate to the delay between the moment when policymakers recognize the need for action and the moment when a change in policy instrument is initiated.[22] Instrument adjustment costs relate to the perceived side effects (in particular, on forward-looking expectations) of abrupt changes in policy tools.

Instrument adjustment costs were explicitly considered in Chapter 5, but the discussion throughout the manual (including in this chapter) has essentially abstracted from them. This may be a sensible way to proceed

[21] It is also worth noting that the policy mix used by Malaysia during the *taper tantrum* episode, a tightening of fiscal conditions and a moderately contractionary monetary policy, is broadly consistent with the scenario considered in Chapter 3. Indeed, in that scenario, a tight fiscal policy (a cut in government spending, which targets internal balance), combined with a reduction in the policy interest rate (which, in effect, targets external balance) can be effective in terms of restoring the initial equilibrium. Although the discussion in that chapter was in terms of lower government spending, rather than higher taxes, the argument is fundamentally similar.

[22] Thus, implementation lags are distinct from *transmission* lags—the delay between a change in a policy instrument and its ultimate effect on the variable(s) of interest—which are generally well captured in dynamic models.

analytically, at least as a first step. However, in practice, policymakers may face sizable costs in changing instruments; as a result, they may choose to adjust them only gradually, or not use them at all, depending on the shock that they must respond to and its degree of persistence. For instance, abrupt changes in policy interest rates may destabilize markets, especially in countries where expectations are not well anchored and policy credibility is imperfect – possibly because the objective function of the authorities is not well understood by the public. As a result, the central bank may find it preferable, in normal times, to adjust them only by small increments.

The existence of implementation lags may also play a significant role in choosing which instruments to use and how much to adjust them. A key advantage of monetary policy – despite being a fairly blunt instrument – is that it can be implemented right away, once the decision to use it is taken. Similarly, intervention in the foreign exchange market can occur as soon as the decision to do so is made. The same is also true for some types of countercyclical capital controls – provided that there are no frictions between the institutional responsibilities of monetary and fiscal authorities. However, this is usually not the case for fiscal policy (whether it takes the form of changes in government spending or tax rates) or macroprudential regulation. In particular, while required reserve ratios can be adjusted at once for either macroeconomic or prudential reasons, changes in macroprudential instruments that have a direct impact on the cost of borrowing (such as capital requirements or dynamic provisions) may need to be implemented gradually, to provide financial institutions sufficient time (up to a year, in practice) to adjust their balance sheets. This may explain why, in the real world, countries have often relied more heavily on changes in reserve requirements than on countercyclical capital buffers to mitigate credit growth, associated or not with capital inflows (see the previous section and Borio et al. (2022)). Indeed, to maintain macroeconomic stability, or to mitigate financial risks, a long implementation lag may make the use of these instruments unwise when shocks are sizable. Moreover, the amount of time necessary for implementation may be *state contingent* – it may depend on which phase of the business cycle the economy is in. For instance, at the beginning of a recession banks may be able to raise capital only at a prohibitive cost; to adjust their capital-asset ratios they may instead choose to cut lending, thereby amplifying the downturn.

Thus, while several policy combinations may appear to be equally effective when implementation lags and instrument manipulation costs are ignored (as illustrated in this chapter and previous ones), it may well be that only a more narrow set is actually *feasible*, when these lags and costs are taken into account. At the same time, of course, assessing the length of these lags and the magnitude of these costs, and how they vary over time, may be difficult in practice and may involve a judgement call by policymakers. These difficulties therefore compound the well-known challenges associated with assessing the extent to which shocks are transitory or permanent, and the degree of instability of the economy's behavioral parameters, which may create uncertainty about the transmission mechanism of various policies.

Challenges going Forward

The models of Chapters 3 and 4, the experiments reported in Chapter 5, and the country experiences in Asia and Latin America (especially Brazil and Malaysia) discussed in Chapter 6 provide a strong case for policymakers to consider all available instruments to stabilize the economy, following external financial shocks. They also highlight the benefits of coordinating these policies, and the decision-making process that underlies their implementation, under a variety of policy objectives. Indeed, and given fiscal rigidities, a policy mix involving monetary policy, sterilized intervention (aiming at moderating exchange rate volatility and threats to financial instability), and countercyclical macroprudential regulation (aiming at moderating the growth of domestic credit) may be particularly effective. Capital controls, which have been deployed sparingly in practice, to both lengthen the maturity of inflows and to reduce balance sheet vulnerabilities, may also prove useful in combination with these other policies. At the same time, the *direction* in which some of these instruments should be adjusted depends on which other tools policymakers have at their disposal.

Current practices have indeed evolved accordingly. Since the global financial crisis, the policy responses of the central banks in the main Asian and Latin American countries have successfully evolved and expanded their toolkits to deal with larger and more volatile capital flows driven by developments in commodity markets, unconventional monetary policies in major advanced economies, and periods of financial turmoil, such as the *taper tantrum*. Should this become the new operational way to deal with external financial shocks? To some extent it already has in these countries, and in many small advanced open economies as well. Nevertheless, there are caveats.

First, it is worth noting that even independent central banks face a number of political economy and institutional constraints when implementing policies. In many cases the instruments that are discussed in the previous chapters (especially macroprudential policies and capital controls) are dependent on decisions by broader committees that may include the Ministry of Finance or other government institutions. Second, in many cases the decision to activate a specific policy may depend on passing regulations that might be subject to approval by a legislative body. Third, the models used to analyze the two policy episodes described above assumed for tractability the utilization of pairs of instruments only, used with the proper coordination and optimal sequence which is not necessarily the actual practice of central banks for obvious reasons. Indeed, as discussed earlier in the cases of Brazil and Malaysia, multiple instruments are often used simultaneously – usually under emergency circumstances and not necessarily with the optimal sequence.

Policy responses must also continue to evolve in the face of new challenges. The first is institutional. As discussed in previous chapters, in the last decade or so, the monetary policy regime in many MICs has evolved de facto towards a flexible inflation targeting involving the combination of instruments listed and discussed in this Manual. At the same time, there has been an evolution of the institutional set-up in many of these countries, with the creation of financial stability committees with explicit mandates, and formal interactions with monetary policy committees, sometimes under the single authority of the central bank. One issue moving forward is whether there will be at some point, an explicit formal denomination of a new policy regime, either under some form of an integrated policy framework, an integrated inflation targeting regime (as advocated in Agénor and Pereira da Silva (2019, 2022*b*)) or a macro-financial stability framework. Denominations are sometimes a useful device to anchor a practice into guidelines and rules that are easily understood, verifiable and therefore can be used – with the necessary idiosyncratic local circumstances – by any member of the central banking community without constant attrition with market perceptions and interpretations.

Such an evolution might help to address another issue: communication. A major challenge for central banks in MICs when deploying several policy instruments is how to communicate their use effectively to the public. Deploying more instruments makes the central bank's policy decisions more difficult to explain. Following an approach in line with the Tinbergen rule of one instrument per objective may help to simplify communication, but it is not satisfactory. As made abundantly clear in the previous chapters, instruments interact with each other and a single instrument can influence several objectives.

A third, but no less important, challenge for central banks is how monetary policy should interact with fiscal policy. In principle, by lowering risk premia and improving macroeconomic stability, a strong monetary policy framework should help to promote fiscal sustainability. But so far, monetary and fiscal policies have not necessarily supported each other. Indeed, in many MICs fiscal policy has often tilted towards a procyclical bias. Thus, its capacity to support contractionary monetary policy, when needed, has been limited. A strong fiscal framework, consisting of fiscal rules and a stabilization fund – even in countries that are not highly exposed to commodity price shocks, as advocated in Agénor and Pereira da Silva (2019, 2022*b*) – would help to create fiscal space and increase the scope for using fiscal policy as a countercyclical instrument.

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