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Financial and Price Stability in Emerging Markets: The Role of the Interest Rate

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The Global Financial Crisis opened a heated debate on whether inflation target regimes must be relaxed and allow for monetary policy to address financial stability concerns. Nonetheless, this debate has focused on the ability of the interest rate to "lean against the wind" and, more generally, on the accumulation of systemic risk arising from the macro-financial challenges faced by advanced economies. This paper extends the debate to emerging markets by developing micro-foundations that allow extending a simplified version of the New-Keynesian credit augmented model of Curdia and Woodford (2016) to a small-open economy scenario, and by subsequently using the same empirical strategy as Ajello et al. (2015) to calibrate the model for Mexico. The results suggest that openness in the capital account, and in particular a strong dependence of domestic financial conditions on capital flows, diminishes the effectiveness of monetary policy to lean against the wind. Indeed, in the open-economy with endogenous financial crises, the optimal policy rate is even below the level that would prevail in the absence of endogenous financial crisis and systemic risk.

JEL codes: E52, F32.
Keywords: leaning against the wind, global financial cycle, monetary policy, financial stability.

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1. Introduction

The Global Financial Crisis has shown that financial institutions interact in manners that amplify the risk faced by the system as a whole (systemic risk), even though these actions may not involve greater individual risk-taking. Thus, for instance, excessive credit growth in the upturn of the financial cycle leads financial institutions to deleverage massively in the downturn. This, in turn, generates negative externalities by diminishing asset prices and, therefore, by creating capital losses for several financial institutions (for a similar argument concerning market liquidity rather than leverage, see Adrian and Shin, 2009). Moreover, in this context, macro-prudential regulatory tools may not be efficient enough to fully tackle systemic risk in the sense that they foster shadow banking and that they may be subject to regulatory arbitrage. In the light of these potential flaws in macro-prudential tools, a recent debate has emerged on whether monetary policy must lean against the wind, that is, whether it must dampen the accumulation of imbalances over the financial cycle and, therefore, complement macro-prudential policies in achieving the new financial stability goal (see Section 6 for a review of potential flaws in macro-prudential regulatory tools and capital controls).

Nonetheless, this debate has focused on advanced economies (AE) and, in particular, on the ability of monetary policy to lean against the wind (Borio, Furfine, and Lowe, 2001; Borio and Lowe, 2002; and Van der Ghote, 2016). A salient characteristic of AEs is that they are not strongly reliant on foreign credit (for related evidence, see Section 2). In contrast, possibly because their financial systems are narrower and smaller relative to the capital flows they receive, emerging market economies (EMEs) are more reliant on capital flows and foreign credit, and these factors have traditionally been more relevant in triggering financial crises in these economies. Along these lines, a recent literature argues that this traditional reliance of EMEs on foreign credit has now taken the new form of a global financial cycle, according to which global factors, such as the monetary policy of financial centers and movements in global appetite for risk, affect capital flows and, through this channel, impact domestic financial conditions (Bruno and Shin, 2014; Rey, 2015 and Passari and Rey, 2015). All in all, these considerations highlight the need for setting a debate on monetary policy and financial stability that considers the specific characteristics and financial risks faced by EMEs.

The present paper sets the debate by developing micro-foundations that allow extending the New-Keynesian credit augmented model elaborated by Curdia and Woodford (2016) to a small-open economy case, and by subsequently taking the same strategy as Ajello et al. (2015) when calibrating the resulting setup for Mexico. In our Curdia and Woodford's extended model (2016), an increase in the interest rate will diminish the output gap and the demand for domestic credit, just as it does in the closed-economy framework. However, in the open economy model, the increase in the interest rate will also attract capital flows and, through this channel, fuel the domestic credit supply. That is, the model will feature a unique mechanism through which a contraction in monetary policy will exert an increasing impact on domestic credit growth by attracting capital flows.

Interestingly, this unique mechanism will be sufficiently strong that when calibrating the model the optimal response to a demand shock that inflates credit growth will be to adjust the interest rate by less than in a closed-economy setup with endogenous financial crisis and systemic risk. In other words, openness in the capital account will diminish the ability of monetary policy to dampen imbalances over the financial cycle, suggesting that the prescriptions of the leaning against the wind hypothesis may not be as well-suited for EMEs as they are for AEs.

As noted above, the paper contributes to the literature by developing micro-foundations enabling us to extend the original contribution of Curdia and Woodford (2016) to a small-open economy case. Thus, just as Curdia and Woodford (2016) do, we introduce credit in the model by considering two types of consumers: households with a higher valuation of current consumption will borrow and households with a lower valuation will save. Furthermore, in extending their setup to a small-open economy, we allow for international trade and for capital flows. International trade is modeled in a manner that is close to Gali and Monacelli (2005) and to most contributions in the small-open economy literature, by introducing a domestically-produced good, a foreign-produced good, and home bias. For its part, we model capital flows by introducing domestic savers with access to global financial markets and, therefore, to external credit.[1] Domestic savers will find it optimal to lend domestically some of the financial funds they will borrow abroad, implying that a surge of capital inflows in the model will fuel domestic credit. Indeed, this feature will settle the grounds for the emergence of the unique mechanism mentioned above.

Using this theoretical setup, and given that the paper will follow Ajello et al. (2015) when taking the model to data, it links domestic credit growth to financial crises by using the same reduced-form strategy as they do.[2] In particular, we log-linearize the model and introduce a time-varying endogenous crisis probability that depends on a two-state crisis shock, as well as on domestic credit growth. Precisely, this probability will be increasing in credit growth, representing the idea that the accumulation of imbalances over the financial cycle triggers amplifying effects on systemic risk. Furthermore, in the same manner as they do, we make the transition between states computationally feasible by considering a two-period setup.

The paper then considers three scenarios. First, it considers a closed-economy model with exogenous crisis probability that features a single and domestic good, and allows for the crisis

[1] The assumption is that global markets are incomplete and savers can only trade in a bond paying in foreign currency.

[2] As explained in Section 4, this strategy enables us to overcome the difficulty imposed by the fact that we cannot use either perturbation methods as traditionally done in the DSGE literature or global solution methods.

probability to be independent of credit and exogenous. [3] This scenario can be thought of as representing the world preceding the Global Financial Crisis, in which the concept of systemic risk was not that extended. Second, the paper considers a closed-economy scenario in which the crisis probability responds positively to domestic credit. This scenario can be thought of as representing the current situation for AEs, in which the financial cycle is a significant source of financial risk. Finally, the paper extends this last case to a small open economy framework by letting domestic households derive utility from consumption of both domestic and foreign goods and by letting domestic savers borrow in global financial markets. This scenario must be thought of as representing the case of EMEs, in which the global financial cycle plays an important role.

These three scenarios are subsequently used to undertake the empirical analysis. To this end, the same assumptions as Ajello et al. (2015) are made. In particular, we assume that agents expect that in the second period they will be in a "normal state," and that in this state no financial crisis takes place. Regarding this assumption, it is important to note in the spirit of Shiller (2005; 2006) that, if expectations were modeled as rational, an increase in credit growth would raise the crisis probability, reduce expected future output and inflation and, therefore, diminish output and inflation today. However, this result is inconsistent with much evidence suggesting that in times of buoyant financial conditions agents expect good times to continue going forward.

Under these assumptions, the paper calibrates the model for the three scenarios and obtains the optimal response of monetary policy to a demand shock that inflates credit growth, representing the upturn of the financial cycle. In a closed-economy with exogenous crisis probability, the interest rate is optimally set at a level that completely stabilizes output and inflation. This result, known as the divine coincidence, shows that the demand shock provides a good benchmark for understanding how financial considerations alter optimal monetary policy. Indeed, in the scenario with endogenous crisis, the central bank incorporates the effects of policy choices and credit growth on crisis probability and, thus, sets a higher interest rate than in the absence of systemic risk. That is, systemic risk, represented in the model by endogenous financial crises, forces the policy-maker to incur in welfare losses today to diminish the probability that a financial crisis occurs tomorrow. This conclusion is in line with the prescriptions of the leaning against the wind hypothesis.

However, this result is overturned by openness in the capital account. In the open economy with endogenous crisis, the central bank optimally sets a smaller interest rate than in the remaining scenarios, and this is explained by two factors. First, in the open-economy setup, a contraction in monetary policy further reduces inflation through its impact on the exchange rate. Second, as noted

[3] In other words domestic households' preferences display complete home bias. Of course, once we close the trade balance, also the capital account is closed, due to the accounting relationship between trade deficits/surplus and capital flows.

above, a rise in the interest rate attracts capital flows, fueling credit growth and thus increasing the crisis probability. That is, for a small country, openness in the capital account reduces the optimal policy rate even below the level that prevails in the absence of endogenous crises and systemic risk.

Nonetheless, when interpreting the implications for the leaning against the wind hypothesis, note that the effect of the exchange rate on inflation is not necessarily linked to this hypothesis or the debate that followed the crisis. Hence, the paper further compares two open-economy scenarios, one with exogenous crisis probability and another one with endogenously determined crisis probability. The results show that in the two cases the optimal interest rate is smaller than in the closed-economy with exogenous crisis and, most importantly, even smaller in the open-economy with endogenous crisis. This suggests that the effect of capital flows on credit is sufficiently important that the ability of monetary policy to lean against the wind is diminished. To put it differently, the domestic financial cycle considerations are overpowered by the global financial cycle considerations when it comes to conducting monetary policy in EMEs. As for the quantitative importance of differences in interest rate setting among the three scenarios, we show that when the policy-makers is allowed to have uncertainty on some parameters of the model, these differences are magnified.[4]

Turning back to the literature on the global financial cycle, evidence suggests that global conditions are transmitted to domestic financial variables through their impact on capital flows (see Section 2 for related evidence on the case of Mexico). Moreover, this evidence is based on countries with relatively high exchange rate flexibility, suggesting that not even the adoption of a flexible exchange rate regime is able to fully insulate an economy from external shocks. In this context, several authors have recalled the classic trilemma in international macroeconomics and related the evidence to monetary policy independence. In particular, these authors have argued that, in the presence of the global financial cycle, monetary policy independence can be only regained by using an additional policy instrument, among which macro-prudential policies and capital controls stand out (Fahri and Werning, 2014; Rey, 2015; Obstfeld et al., 2017).

Motivated by the possibility that the global financial cycle diminishes the ability of exchange rate flexibility to insulate an economy from external shocks, and that it increases the need for additional policy instruments, Section 6 considers a simplified version of the model in which domestic prices are fully sticky and, using this simplified version of the model, performs two types of comparisons. First, the section compares an economy with a flexible exchange rate regime to an economy with a rigid exchange rate regime in terms of the policy maker's ability to offset the welfare losses generated

[4] This proof is sent on request. We allow for the possibility that policy-makers have uncertainty on some parameters of the model, i.e., the elasticity of crisis probability to credit and the severity of financial crises, and consider both a Bayesian and a Robust policy-maker in the manner of Ajello et al. (2015). The results show that the uncertainty increases the quantitative differences among the different scenarios considered, a result that resembles the one they obtain for the U.S. economy

by a demand shock. Second, the section compares an economy that features conventional monetary policy to an economy that features, in addition, capital controls. In performing these comparisons, the same three scenarios mentioned above are considered.

Consistent with the classic trilemma in international macroeconomics, the results show that in a setup with exogenous financial crisis, and thus in the absence of the global financial cycle, exchange rate flexibility is preferred over fixed exchange rate regimes and allows driving the welfare losses to zero. Indeed, the result that flexible exchange rate regimes are preferred over more rigid regimes remains robust to the introduction of endogenous financial crises, which is in turn consistent with the evidence presented by Obstfeld et al. (2017), according to which exchange rate flexibility plays an important insulating role, even in the presence of the global financial cycle. Nonetheless, when the financial crisis is endogenously determined, the policy-maker can no longer drive the welfare loss down to zero. In turn, this result is consistent with the modern version of the trilemma that has been mostly pushed by Rey (2015), and according to which in the presence of the global financial cycle exchange rate flexibility is no longer sufficient to fully insulate an economy from external shocks.

As for the exercise about capital controls, the results suggest that they provide the policy-maker with an additional policy instrument, enabling her to drive the welfare losses arising from the demand shock again back to zero. Nonetheless, as noted in Section 6 by a literature review, the application of this result to reality is subject to a policy maker's ability to prevent regulatory arbitrage, as well as to her willingness to accept the associated economic costs.

The paper is also related to a growing literature that studies optimal monetary policy in the presence of financial stability considerations either by providing evidence or setting macro-models augmented to account for financial stability risks (Borio and Lowe, 2002; Adrian and Shin, 2009; Curdia and Woodford, 2016; Svensson, 2012, 2014; Woodford, 2012; Ajello et al., 2015; Brunnermeier and Sannikov, 2016; Collard et al., forthcoming). In contrast with this literature, we address this issue in the context of EMEs which face financial stability risks of a different nature stemming from the direction and volatility of capital flows.

The paper is structured as follows. Section 2 provides conceptual arguments, facts and anecdotal evidence suggesting that the model is better suited for understanding EMEs than any small-open economy, and shows that for the Mexican case the global financial cycle has become particularly relevant since the late 2000s. Section 3 derives the micro-foundations that allow extending Curdia and Woodford's model (2016) to an open-economy setup. Section 4 introduces the log-linear model, makes the same simplifying assumptions as Ajello et al. (2015) and motivates the parameter choice in the calibration exercise. Section 5 presents the results, Section 6 compares exchange rate regimes with a varying degree of flexibility and introduces capital controls. Finally, Section 7 concludes.

2. Importance of capital flows for EMEs

Capital Flows, Foreign Credit and Financial Stability in EMEs

One of the main conclusions in this paper is that monetary policy is less effective in dampening financial imbalances in EMEs than in AEs. Moreover, as noted above, in reaching this conclusion the paper takes global financial conditions as given and builds upon a unique mechanism that works in two steps: (i) capital flows affect credit growth; and through this channel (ii) they also affect the probability that a financial crisis occurs. In this context, one could be tempted to argue that our model's results are applicable to every small-open economy and not only to EMEs. Nonetheless, in this regard, it is important to note that the model's unique mechanism is empirically relevant only in those cases in which both steps (i) and (ii) are quantitatively important.

The implication is that our model is better-suited for EMEs than for AEs provided that the following two relevant points hold true: (a) while EMEs strongly rely on capital flows and thus foreign savings represent a large fraction of total credit in these countries, this is not the case for AEs; in this context, step (i) is only relevant for understanding the trade-off between financial and price stability in EMEs; (b) capital flows and foreign credit are more relevant in triggering financial crises in EMEs than in AEs, suggesting that also step (ii) is more important in the former nations. In the remainder of this subsection, I provide conceptual arguments, facts and anecdotal evidence consistent with (a) and (b) and thus with the fact that our model is better-suited for thinking about monetary policy in EMEs.

Simple arguments in the most standard neoclassical framework suggest that EMEs rely on foreign credit while AEs do not. In a context in which EMEs exhibit smaller capital-to-labor ratios and higher capital investment returns, this framework suggests that, attracted by these higher returns, AEs must invest and EMEs should receive capital inflows. An additional reason for why emerging markets more strongly rely on foreign credit may be related to their smaller efficiency in reallocating financial resources. Along these lines, Mishkin (1996) argues that problems of asymmetric information are deeper in EMEs (see, for instance, Mishkin, 1996) and that, as a result, they exhibit smaller domestic credit levels and have a stronger reliance on foreign credit. Similarly, Claessens and Ghosh (2013) claim that EME's financial systems are smaller and narrower relative to the capital flows they receive and, to support this point, they show that these countries have a greater share of net flows-to-M2.

The present paper argues in the lines of Claessens and Ghosh (2013) by calculating shares for EMEs and for AEs to document that capital flows and foreign credit are more relevant for financing purposes in the former countries. Nonetheless, to be consistent with the model's unique mechanism, we do not use M2; instead, we construct shares by dividing net capital inflows through credit to the non-financial sector and present the results in Table 1. This table excludes the U.S. and China due to the reserve currency nature of the dollar and the FX reserve accumulation policy undertaken by the Asian country and driven by the evidence provided below, according to which the global financial cycle became more relevant in the late 2000s, distinguishes between two periods of time: 2000-2007 and 2008-2016.[5] Notably, the table shows that the share of net capital inflows through credit is significantly greater (and positive) for EMEs in both periods, suggesting that that these countries are indeed more reliant on capital flows. To provide further robustness, Table 4 in the Appendix calculates the same ratio including the U.S. and China and shows that net inflows are higher for EMEs also for the most recent period, 2008-2016.

Table 1. Financial Flows to EMEs

	Net Financial Flows[1/] (% of Credit to Non-Financial Sector)	
	2000-2007	2008-2016
EMEs (exc. China) [2/]	1.14	2.65
AE (exc. USA) [3/]	-0.70	-0.69

1/ The average of the net financial flows for each country group is measured as Net financial capital inflows as percent of the total credit to non-financial sector.
2/ The set of Emerging Market Economies is composed by: Argentina, Brazil, Colombia, Chile, China, India, Indonesia, Mexico, Poland, Turkey and South Africa.
3/ The set for Advanced economies is composed by: Australia, Canada, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Israel, Japan, Korea, Netherlands, Norway, Singapore, Sweden, Switzerland, United Kingdom and United States.
Source: International Monetary Fund (IMF) and Bank of International Settlements (BIS).

Regarding point (b), related to the importance of capital flows for financial stability in emerging markets, anecdotal evidence is strongly supportive of this point. There is an overwhelming larger amount of situations in which capital flows and foreign credit can be related to a financial crisis in EMEs than in AEs. Several of these situations relate to crises that occurred in Latin America (for a recount, see Frankel and Rapetti, 2010). For instance, the external debt crises of the 1980's was preceded by a significant increase in foreign credit over the 1960's and the 1970's, and the currency crises of the late 1990's and the early 2000's relate closely to sudden stops. Beyond Latin America, the Asian and Russian crises of the 1990s provide additional examples that capital flows and external debt are relevant in understanding financial stability in EMEs. The fact that capital flows led to financial instability many more times in EMEs than in AEs makes it hard to argue against point (b).

Yet, formal literature further supports this idea, as shown by the fact that it has traditionally focused on EMEs. Through a common narrative shared by several studies, this literature notes that prolonged

[5] Foreign investment in the US is mainly driven by investors looking for safe assets and liquidity and by the fact that the dollar is the reserve currency. US foreign debt consists mainly of government debt and other safe assets, while the US experience capital outflows if one only considers equity and other risky assets. All in all, the US still earn net positive capital income on its foreign asset position, notwithstanding the current account deficits. Simlarly, the Chinese capital account have been heavily influenced by government policies aimed at accumulating foreign reserves, mainly consisting of US dollars and short term US government debt.

periods of strong capital inflows frequently lead to macro-financial imbalances in EMEs (see Calvo, 1998; Kaminski and Reinhart, 1999; Rodrik and Velasco, 1999; Reinhart and Reinhart, 2009; Korinek and Mendoza, 2014; Caballero, 2016; and Ostry et al., 2012 for conceptual remarks). Thus, for instance, this literature acknowledges that by providing residents with further financing, the afore-mentioned episodes lead to rapid credit growth, asset price misalignments and real currency appreciations. Moreover, as part of the financing is frequently issued in foreign currency, currency mismatches in EMEs also tend to emerge.

Indeed, there is an acknowledgement that these macro-financial imbalances frequently end with capital flow reversals, leading to abrupt and most of the times unexpected reductions in credit supply and asset prices. Moreover, in the literature, this process is described in the context of large nominal depreciations following abandonments of fixed exchange rate regimes, such as those that prevailed during the 1990's (see, for instance, Calvo, 1998; Kaminsky and Reinhart, 1999; Calvo and Reinhart, 2000; Rodrik and Velasco, 1999), as well as in real macroeconomic models and environments featuring flexible regimes (see Ostry et al, 2012; Caballero, 2016 and Tobal, 2017 for differences in flexibility of Latin American exchange rate regimes over time).

In sum, there is strong support that EMEs rely on capital flows for financing purposes but AEs do not, and that these flows are disproportionately more relevant to understand financial stability in the former nations. Indeed, these points suggest that, although our model can be in principle applied to any small-open economy, it is actually better-suited for understanding emerging markets.

Global Financial Cycle: Theory end Evidence

While EMEs have traditionally had a stronger reliance on capital flows and foreign savings than AEs, recent literature acknowledges that this reliance has taken a specific form over the past decade. In particular, a recent strand of the literature argues that there is a global financial cycle according to which movements in capital flows are strongly correlated across countries and that, at the same time, these flows affect domestic financial conditions, particularly in EMEs. Moreover, this literature suggests that, in contrast to what seems to have occurred in the late 1990's and early 2000's, capital flows are currently more strongly driven by global conditions, or "push factors," among which the monetary conditions of global financial centers and appetite for global risk stand out (for a comparison between periods, see Eichengreen and Gupta, 2016). In sum, this literature suggests that monetary policy in the U.S. and Europe, as well as indexes of global uncertainty such as the VIX, co-move strongly with capital flows, leverage, credit growth and asset prices (for instance, see Bruno and Shin, 2014; Rey, 2015 and Passari and Rey, 2015; Obstfeld et al., 2017).

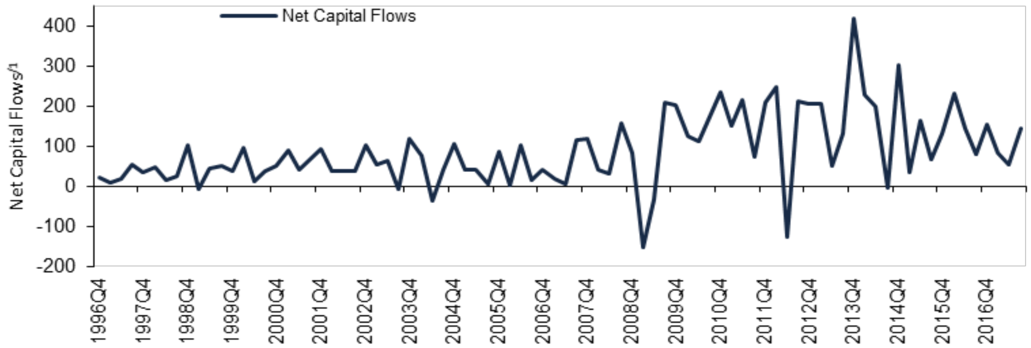
In principle, this evidence seems relevant for understanding domestic financial developments in every type of economy not setting global financial conditions, i.e., small-open economies. Nonetheless, empirically speaking, the case is stronger for EMEs in which capital flows represent a greater proportion of total credit. In this regard, it is also important to note that, for the case of EMEs, the afore-mentioned co-movements in capital flows imply movements in net flows of the same direction, e.g., an increase in global appetite for risk tends to increase net flows to EMEs but to reduce them in AEs. In the remainder of this subsection, the paper provides evidence suggesting that global financial considerations are relevant in Mexico, particularly since the period 2007-2008.

For this purpose, the paper plots capital flows, cyclical components of credit and output gap measures obtained with traditional filters in three figures. Figure 1 documents that there was a substantial increase in the size and the volatility of net capital flows in Mexico over 2007-2008, and that their impacts have remained larger since then. Interestingly, Figure 2 shows that it was exactly over this period when the cyclical component of total credit to the non-financial private sector started to be strongly correlated with smoothed versions of net capital inflows, indicating that credit growth in Mexico started to be particularly fueled by international financial conditions precisely at that time, i.e., as well known series of capital flows are highly volatile and, thus, we take moving averages of the net inflows series. Moreover, the more the net inflow series is averaged, i.e., the lower the frequency we consider for capital flows, the more evident the correlation between the series becomes.

Figures 1 and 2 support the idea that the global financial cycle has become relevant in Mexico. Moreover, by doing so, these figures provide empirical relevance to the unique mechanism described in the theoretical model. As noted above, in our framework a rise in the interest rate affects credit growth not only through its impact on output gap but also through its increasing-effect on net capital inflows. Along these lines, Figures 3 plots the same cyclical component of credit as in Figure 2 along with a measure of output gap obtained with a standard HP filter. This figures notes that precisely since the late 2000's, the cyclical component of total credit does not exhibit a strong correlation with the traditional measure of output gap. This evidence, along with the fact that this cyclical component started to be correlated with net inflows at the same time as noted in Figure 2, suggests that the empirical relevance of the model is even stronger. Precisely, the evidence suggests that credit growth in Mexico is more strongly affected by capital inflows, and through this channel international financial system, than for slackness in the domestic goods and services market.

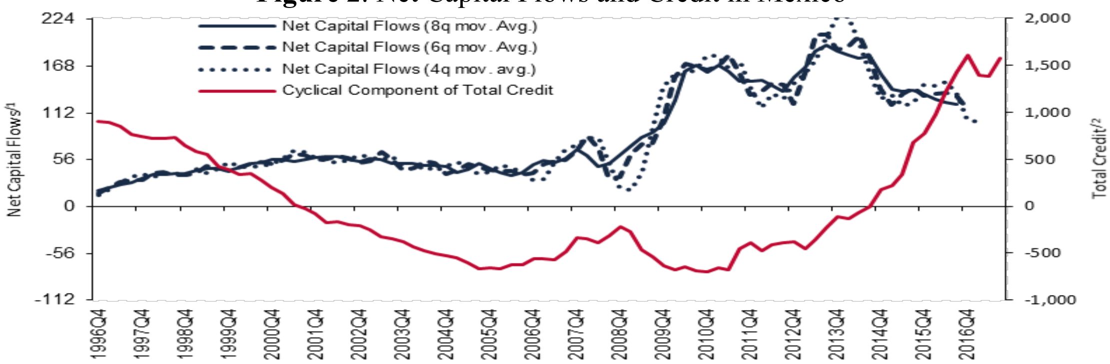
Moreover, beyond the Mexican case, the evidence on the global financial cycle has led to a renewed debate that reconsiders the classic trilemma of international macroeconomics, according to which independent monetary policy is feasible under free capital mobility if and only if exchange rates are floating.

Figure 1. Net Capital Flows in Mexico



Notes: Original figures as of the third quarter of 2017, measured in billions of Mexican pesos.
Net capital flows refer to the balance of the financial account of the balance of payments.
Source: Banco de Mexico.

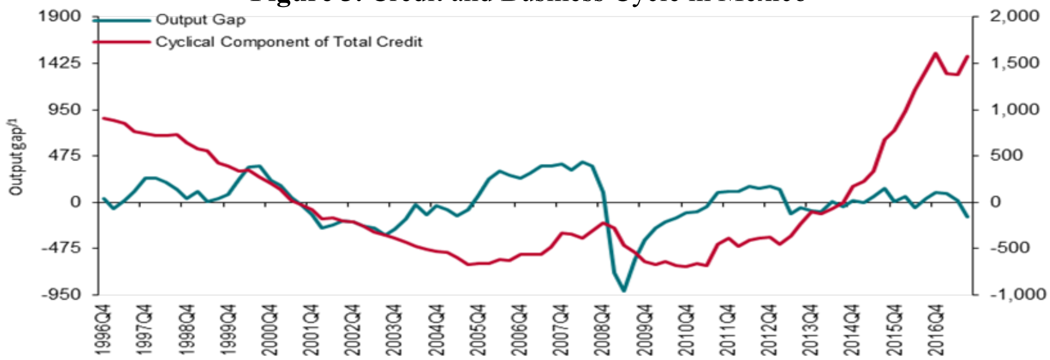
Figure 2. Net Capital Flows and Credit in Mexico



Notes: Original figures as of the third quarter of 2017, measured in billions of Mexican pesos.
1/ Net capital flows refer to the balance of the financial account of the balance of payments. The data on net capital flows were smoothed using a centered moving average of order 4 (4q mov. avg.), of order 6 (6q mov. avg.) and of order 8 (8q mov. avg.).
2/ Total credit refers to total funding to the non-financial private sector. The cyclical component was obtained with a two-tailed HP filter. A signal-to-noise ratio equal to 400,000 was used, as traditionally advised for quarterly disaggregated financial variables.
Source: Authors' calculations with data from Banco de Mexico.

Precisely, in the presence of a global financial cycle, monetary conditions have been shown to be transmitted to EMEs through their impact on capital flows and leverage of global institutions even in relatively flexible exchange rates. Thus, in this context, several authors questions whether exchange rate flexibility is sufficient to insulate economies from the global financial cycle when capital is mobile (see, e.g., Rey, 2015; Obstfeld et al., 2017). Similarly, some authors suggests that additional policy instruments must be considered, among which macro-prudential policies and capital controls stand out (Rey, 2015). Interestingly, both the role of exchange rate flexibility and the potential need for an additional policy instruments are analyzed in more detail in Section 6.

Figure 3. Credit and Business Cycle in Mexico



Notes: Original figures as of the third quarter of 2017, measured in billions of Mexican pesos.
1/ Output gap is measured with the cyclical component of seasonally adjusted real GDP. The cyclical component of real GDP was obtained with a two-tailed HP filter. A signal-to-noise ratio equal to 1,600 was used, as traditionally advised for quarterly disaggregated real variables.
2/ Total credit refers to total funding to the non-financial private sector. The cyclical component of total credit was obtained by applying a two-tailed HP filter. A signal-to-noise ratio equal to 400,000 was used, as traditionally advised for quarterly disaggregated financial variables.
Source: Authors' calculations with data from Banco de Mexico.

3. Model Setup

This section builds the model by extending the original contribution of Curdia and Woodford (2016) to the case of a small-open economy. A salient characteristic of their model is that it augments the basic New-Keynesian setup by allowing for two household types and, through this channel, creates a role for credit. In particular, in Curdia and Woodford (2016), households differ according to their taste for current consumption relative to future consumption and to their elasticity of intertemporal substitution. Under the assumptions that we explain in detail below, the households with a higher valuation of current consumption will borrow and the households with a lower valuation will save, giving rise to domestic credit. Thus, relative to the basic New Keynesian model, the most important innovation of Curdia and Woodford's setup concerns the demand side of the economy and the existence of credit markets.[6] By contrast, the supply side of the economy remains the same as in the basic New-Keynesian model, and is characterized by monopolistic competition and nominal rigidities, as illustrated in detail below. As for the application of these modelling features to our model, it is important to note that domestic credit in our paper can be thought of as being both the result of direct exchanges between different household types, as well as of intermediation by financial intermediaries operating under perfect competition.

Furthermore, in adapting the model to a small open economy setting, the paper allows for imports and exports as well as for international capital flows. Imports and exports are allowed for by letting

[6] As we are interested in studying how credit growth affects crisis probability, and the role of monetary policy therein, and not in how fluctuations in interest rate spreads affect the behavior of the economy, we abstract from the endogenous spread considered by Curdia and Woodford (2016). Actually, the same approach is also the one taken by Ajello et al (2015).

households be interested in consuming two goods, domestically produced goods and foreign goods; just in the same manner as Gali and Monacelli (2005). Global financial markets, in contrast, are modelled by letting domestic savers access a bond that pays in units of foreign currency. Borrowers, instead, can only borrow on domestic financial markets. Since the open economy is small, everyone in this economy takes global interest rates and global prices as given. Furthermore, global financial markets are incomplete, i.e. only one asset paying in units of the foreign currency is traded.[7] This asset is used by domestic savers to lend and borrow in global markets.

Importantly, these feature of the model will generate a mechanism through which capital flows will affect domestic financial conditions and, through this channel, financial risk. In the model, a surge of capital inflows will enhance domestic savers' availability of financial funds and, therefore, fuel domestic credit and leverage in the domestic market. This model is then used in the next section to connect credit to crisis probability.

Households

Having described the main features of the model, let us go now through households. Following Curdia and Woodford (2016), the model assumes that households differ in terms of their utility function and that this function can be summarized as follows:

$$max\tilde{E}_0 \sum_{t=1}^{\infty} \beta^{t-1} \left[\frac{C^{\tau_t^i}}{1-\sigma^{\tau_t^i}} \left(c_t^i\right)^{1-\sigma^{\tau_t^i}} - \frac{\chi^{\tau_t^i}}{2} \left(l_t^i\right)^2 \right], \tag{1}$$

where $\tau_t^i \in \{s, b\}$ indicates household type, c^i is household i's consumption and l^i is household i's worked hours, while indexes s and b identify savers and borrowers, respectively. $\tilde{E}$ is the expectation operator, which is represented with a tilde to highlight the fact that expectations are not completely rational, as in Ajello et al (2015) and for the reasons explained below. Just as in Curdia and Woodford (2016), some households have a lower taste for current consumption (which is obtained by setting $C^s \leq C^b$) and a lower elasticity of intertemporal substitution ($\frac{1}{\sigma^s} \leq \frac{1}{\sigma^b}$) than others. Taste for leisure, $\chi^{\tau_t^i}$, is also allowed to differ between agent types.[8] Type $\tau_t = s$ households represent a share $1 - \pi^b$ of the Home population, and type $\tau_t = b$ a share π^b. β is the subjective discount factor.

[7] Gali and Monacelli (2005) instead assume that global financial markets are complete, i.e. there exists one asset for each state of nature. This allows domestic households to insure against any fluctuation in consumption that is not driven by global shocks. Of course, credit relationships between the domestic and the foreign economy, and hence capital flows, are irrelevant in their framework; given that households can simply trade in contingent assets. Assuming incomplete markets and only one bond traded at the global level allows us to make bond and credit flows relevant.

[8] As we explain in the appendix, this allows to ensure that the two household types work the same number of hours. A similar approach is also used by Curdia and Woodford (2016).

The modelization of domestic financial markets strictly follows Curdia and Woodford (2016). Households are assumed to be able to sign an insurance contract that allows them to share all aggregate and idiosyncratic risk, but they can receive transfers from the insurance agency only infrequently, i.e. in each period with probability $1-\delta$. When it access insurance markets, each household may also switch type, with probability π^b if of type s, and with probability $1-\pi^b$ of type b. In all other points in time, households can only trade one-period credit contracts. As explained by Curdia and Woodford (2016), the objective of these assumptions is to ensure that household heterogeneity is limited to two types, without having to track the entire wealth distribution. Details of this framework are discussed at length in the appendix. Here, it is sufficient to report the budget constraint that they imply for a generic domestic household i:

$$B_t^i + B_t^{fi} = R_{t-1}\frac{B_{t-1}^i}{\pi_t} + \frac{R_{t-1}^f B_{t-1}^{fi} X_t}{X_{t-1}} + w_t l_t^i + D_t - c_t^i - T_t. \tag{2}$$

In the above, R is the nominal domestic interest rate, which is assumed to be under the control of the policy-maker, B^i is the real (per-capita) value of domestic credit, i.e., debt from the point of view of type b households, π is the inflation rate, R^f is the interest rate on the foreign currency bond, B^f is the real (per-capita) value of the foreign currency bonds, and X is the real exchange rate. B^f is constrained to be equal to zero for borrowers, as the latter are assumed not to have access to global financial markets. Further, w is the real wage, D are firm profits,[9] and T are lump-sum taxes.[10]

Households optimize (1) subject to (2), by optimally choosing consumption, worked hours, the quantity of domestic credit (debt for type b households), and the quantity of foreign bonds. The first order conditions with respect to consumption and worked hours are quite standard. In particular, they imply that the marginal utility of consumption, λ, and the labor supply have the same form for both household types:

$$\lambda_t^i = C^{\tau_t^i} c_t^{i^{-\sigma^{\tau_t^i}}};$$
$$w_t = \frac{\chi^{\tau_t^i} l_t^i}{\lambda_t^i}. \tag{3}$$

Of course, the marginal utility of consumption is a decreasing function of consumption. The labor supply condition equalizes the real wage rate to the ratio between the marginal disutility of labor, $\chi^{\tau_t^i} l_t^i$, and the marginal utility of consumption, λ.

[9] In particular, we assume that domestic households are the sole owners of domestic firms. Savers and borrowers own firms in proportion to their share in the population.

[10] More precisely, T is the algebraic sum of lump-sum taxes and insurance agency transfers. The latter are zero for the δ households that do not access insurance markets in the period, while they are different from zero for the other δ households.

The first order conditions with respect to credit differ between the two household types. The one of type s households is the following:

$$\frac{1}{R_t} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)(1-\pi^b)]\lambda^s_{t+1} + (1-\delta)\pi^b \lambda^b_{t+1}}{\lambda^s_t \pi_{t+1}}; \tag{4}$$

while the one of type b households is:

$$\frac{1}{R_t} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)\pi^b]\lambda^b_{t+1} + (1-\delta)(1-\pi^b)\lambda^s_{t+1}}{\lambda^b_t \pi_{t+1}}. \tag{5}$$

Both expressions are Euler equations that equalize the inverse interest rate to the expected growth rate of marginal utility divided by inflation. However, they take into account that households may change type at time $t+1$ if they happen to access insurance markets. For the reasons explained above, such type switching takes place with probability $(1-\delta)\pi^b$ for type s households and with probability $(1-\delta)\left(1-\pi^b\right)$ for type b households.

Moreover, equations (4) and (5) clarify why it is necessary to have time-varying types. As $C^s \leq C^b$ and $\frac{1}{\sigma^s} \leq \frac{1}{\sigma^b}$, type $\tau_t = b$ agents know that they may like consumption less in the future, while type $\tau_t = s$ know that they may like it more.[11] Due to this, in equilibrium, type $\tau_t = b$ agents are borrowers, and type $\tau_t = s$ are savers. The latter agents also optimize with respect to holdings of foreign bonds, which gives rise to the following first order condition:

$$\frac{R_t}{R^f_t} = \tilde{E}_t \frac{X_{t+1}}{X_t} \pi_{t+1}; \tag{6}$$

which is an uncovered interest parity in levels. In fact, it states that the ratio between the domestic and the foreign interest rate is equal to the expected real appreciation times the inflation rate.

As equations (4)-(6) determine equilibrium in both domestic and global financial markets, and such equilibrium is fundamental to understand the results of our paper, it is useful to discuss them more deeply. When these equations are log-linearized and rearranged, under the assumption that $\delta \to 1$,[12] they can be rewritten as follows:[13]

$$\hat{R}_t - \tilde{E}_t \pi_{t+1} = \sigma^b\left(\tilde{E}_t \hat{c}^b_{t+1} - \hat{c}^b_t\right) = \sigma^s\left(\tilde{E}_t \hat{c}^s_{t+1} - \hat{c}^s_t\right) \tag{7}$$

$$\hat{R}^f_t = \sigma^s\left(\tilde{E}_t \hat{c}^s_{t+1} - \hat{c}^s_t\right) - \left(\tilde{E}_t \hat{X}_{t+1} - \hat{X}_t\right) \tag{8}$$

[11] Notice that a different taste for current consumption would be sufficient to ensure this result even if all types had the same elasticity of intertemporal substitution. We allow for different elasticities of intertemporal substitution because, as explained by Curdia and Woodford (2016), this allows to capture the fact that reductions in the interest rate imply higher credit levels.
[12] Curdia and Woodford (2016) calibrate δ close to one, because households shift from being borrowers to being savers (or viceversa) rather infrequently. We use this assumption when log-linearizing the model, as explained in the appendix.
[13] In what follows, hats indicate that the variables are in log-deviations from the steady state.

Equation (7) shows that the existence of a domestic credit market links savers' and borrowers' consumption growth to each other. More precisely, in each point in time, the expected growth rate of savers' consumption must be σ^b/σ^s times the growth rate of borrowers' consumption. In other words, given expectations of future consumption, if savers start consuming more today also borrowers have to consume more, which implies that savers will *increase lending* to borrowers. Equation (8) links savers' expected consumption growth to the foreign interest rate and to the exchange rate. Given future expectations on consumption and on the exchange rate, capital flows to the domestic economy produce both currency appreciation, i.e. X falls, and higher savers' consumption.[14] The latter, through equation (7), implies *higher domestic credit* and higher borrowers' consumption. Through this channel, capital flows end up fuelling domestic credit.

The latter mechanism is key to understand the results of the paper. Capital flows increase the availability of funds in the hands of savers, and the latter use part of such funds to lend to borrowers. Therefore, domestic credit, and crisis probability, increase. Another intuitive way to understand the latter mechanism can be obtained by using equation (2) to get the average consumption of savers and borrowers:[15]

$$c_t^s + \frac{b_t}{(1-\pi^b)} - \frac{\frac{R_{t-1}}{\pi_t}(b_{t-1})}{(1-\pi^b)} + \frac{b_t^f}{(1-\pi^b)} - \frac{\frac{R_{t-1}^f b_{t-1}^f}{(1-\pi^b)}X_t}{X_{t-1}} = w_t l_t^s + D_t - T_t; \tag{9}$$

and

$$c_t^b = \frac{b_t}{\pi^b} - \frac{\frac{R_{t-1}}{\pi_t}(b_{t-1})}{\pi^b} + w_t l_t^b + D_t - T_t;$$

where b and b^f are respectively the total amounts of domestic credit and of foreign assets in the hands of savers. By combining the latter two equations and then log-linearizing, it is possible to obtain the following relationship:[16]

$$\frac{1}{(1-\pi^b)\pi^b}\left[\tilde{b}_t - \frac{1}{\beta}\left(\tilde{b}_{t-1} + b\hat{R}_{t-1}\right)\right] = s^b\hat{c}_t^b - s^s\hat{c}_t^s - \frac{b}{\beta(1-\pi^b)\pi^b}\hat{\pi}_t - \frac{1}{1-\pi^b}\left[\tilde{b}_t^f - \frac{1}{\beta}\tilde{b}_{t-1}^f\right] \tag{10}$$

[14] Capital flows for instance may be caused by a lower $\hat{R}^f$. In the rest of the paper, however, we will assume that they are produced by a domestic demand shock.
[15] The algebra is reported in the appendix.
[16] The relationship is obtained under the assumption that steady state foreign credit is zero.

where s^b, s^s, and b are respectively the steady state consumption level of borrowers, the steady state consumption level of savers, and steady state domestic credit. Equation (10) illustrates neatly the channels that affect credit growth in the model. In practice, three channels can be identified, two of which operate in both the closed-economy and the open-economy model, and one of which is only present in the open-economy model. The first channel, which captures the effect of *demand* on credit, is purely due to the interaction between borrowers and savers in domestic financial markets and is captured by the term $s^b\hat{c}_t^b - s^s\hat{c}_t^s$: if borrowers' consumption grows more than savers', this must be financed by additional domestic credit. The second channel is due to a *Fisher* effect and is captured by the term $-\frac{b}{\beta(1-\pi^b)\pi^b}\hat{\pi}_t$: as credit is nominal, inflation reduces its real value. The third effect, i.e. the one that is only present in the open economy model, is captured by the term $-\frac{1}{1-\pi^b}\left[\tilde{b}_t^f - \frac{1}{\beta}\tilde{b}_{t-1}^f\right]$: if the value of foreign assets held by savers fall, i.e. *capital inflows* take place, domestic credit rises.

Unlike Curdia and Woodford (2016) the consideration of an open economy confronts us with the need of specifying how much of the consumption in the utility function is satisfied with foreign goods and, closely related, how trade balance is determined. Thus, just as in most part of the open economy DSGE literature (see, for instance, the seminal contribution of Gali and Monacelli, 2016), we assume that the consumption basket is composed of home and foreign produced consumption goods (imports), respectively defined as c_H and c_F. [17] In particular, the consumption utility aggregator takes the general CES form for both savers and borrowers and can thus be written as follows

$$c_t^i = \left[(1-\gamma)^{\frac{1}{\eta}}{c_{H,t}^i}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}}{c_{F,t}^i}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}},$$

where γ governs the degree of home bias and η is the elasticity of substitution between home and foreign goods. If domestic households are not interested in consuming foreign goods, which happens for $\gamma = 0$, the model collapses to a closed economy framework. On the contrary, if γ is close to one, the home economy is completely open, in the sense that home produced goods represent a negligible share of the households' consumption basket. Notice that throughout the text, we set η equal to one, which implies that the consumption basket is Cobb-Douglas, and may be rewritten as $c_t^i = K{c_{H,t}^i}^{1-\gamma}{c_{F,t}^i}^{\gamma}$, where K is a constant.

Total expenditure has to satisfy the following equation:

$$c_t^i = p_{H,t}c_{H,t}^i + X_t c_{F,t}^i$$

[17] See De Paoli (2009) and Gali and Monacelli (2005), among others.

where p_H is the real price of the domestic good,[18] while X is the real exchange rate. As standard in the CES model, optimal allocation implies the following conditions:

$$c_{H,t}^{i} = (1-\gamma)\left(p_{H,t}\right)^{-\eta} c_t^i \tag{11}$$

$$c_{F,t}^{i} = \gamma (X_t)^{-\eta} c_t^i. \tag{12}$$

In practice, consumption of the domestic good positively responds to total expenditure, while it responds negatively to higher domestic prices. Similarly, imports responds positively to total expenditure, but they respond negatively to a higher exchange rate. Exports are assumed to be governed by the following equation:

$$EXP_t = \gamma \left(\frac{p_{H,t}}{X_t}\right)^{-\nu}; \tag{13}$$

where ν is the elasticity of exports to the terms of trade. The latter expression for exports could be obtained by assuming that also the foreign consumption basket is CES and that expenditure on domestically produced goods is a negligible share of total expenditure in the foreign economy.[19] Equation (13) implies that the quantity of the domestic good exported is decreasing in the ratio between the price of the domestic good and the exchange rate.[20]

Firms

As noted above, our analytical innovations concern the household side rather than the firm side of the model. In fact, the present paper follows Curdia and Woodford (2016) in modelling firms as in the basic New-Keynesian model. More specifically, intermediate good firms produce differentiated goods under monopolistic competition, and are subject to Rotemberg quadratic price adjustment costs.[21] Differentiated goods are then aggregated by final good firms operating under perfect competition.[22] The problem of intermediate firm producing good j is to maximize

$$\max \tilde{E}_0 \sum_{t=1}^{\infty} \Omega_{t,t+1}\left[p_{j,t} y_{j,t} - (1+\tau) w_t l_{j,t} - \frac{\chi_P}{2}\left(\frac{p_{j,t}}{p_{j,t-1}}\pi_t - 1\right)^2 p_{H,t} y_{H,t}\right]$$

subject to a downward sloping demand function

[18] In other words, p_H is the ratio between the price of the domestically produced good and the price index.
[19] A similar approach is that adopted by Krugman (1999) and by Cespedes et al (2004). More specifically they assume that exports are constant in the foreign currency, which is the case when $\nu = 1$.
[20] Since the price of the foreign good in the foreign currency is constant, this ratio can also be seen as the terms of trade.
[21] Up to first order, Rotemberg quadratic adjustment costs give rise to equilibrium conditions that are the same as in the Calvo framework.
[22] This assumption is equivalent to assuming that households consume a basket of differentiated goods.

$$y_{j,t} = \left(\frac{p_{j,t}}{p_{H,t}}\right)^{-\zeta} y_{H,t}$$

and a linear production function

$$y_{j,t} = l_{j,t}.$$

In the above problem, p_j is the real price of good j, τ is a steady state labor subsidy that is financed through lump-sum taxes on households, y_j and y_H are respectively the production levels of good j and of the final domestically produced good. Ω is a stochastic discount factor, ζ is the elasticity of substitution among differentiated goods, and χ_P is the Rotemberg adjustment cost parameter. In the Rotemberg framework, all firms set the same price and the same production level in equilibrium, i.e. $p_j = p_H$ and $y_j = y_H$.

In the appendix, we show how the first order conditions of the problem of firms give rise to the following Phillips curve relationship:

$$\begin{aligned} w_t = p_{H,t} &+ \frac{\chi_P}{\zeta - 1}(\pi_{H,t} - 1)\pi_{H,t} \\ &- \frac{\chi_P}{\zeta - 1}\tilde{E}_t\Omega_{t,t+1}\left[\frac{(\pi_{H,t+1} - 1)\pi_{H,t+1}p_{H,t+1}y_{H,t+1}}{p_{H,t}y_{H,t}}\right] \end{aligned} \tag{14}$$

In the above equation, $\pi_{H,t} = p_{H,t}/p_{H,t-1}\pi_t$ is domestic price inflation. In the absence of sticky prices, i.e. if Rotemberg adjustment costs are absent ($\chi_P = 0$), (14) would collapse to $w_t = p_{H,t}$, i.e. the real wage (which is also equal to real marginal costs) would be equal to the real price. When prices are sticky, a positive shock to demand, which puts upward pressure on output and inflation, increases the real wage above the real price, because firms find it difficult to raise their price; i.e. mark-ups fall. Instead, if they expect higher demand, and hence higher inflation, tomorrow, they start increasing their price today above the real wage, in order to smooth costly price adjustment over time. This tends to increase mark-ups. Equilibrium in the labor market implies that:

$$y_{H,t} = l_t = (1 - \pi^b)l_t^s + \pi^b l_t^b; \tag{15}$$

while total firm profits are

$$D_t = p_{H,t}y_{H,t} - (1 + \tau)w_t l_t - \frac{\chi_P}{2}(\pi_{H,t} - 1)^2 p_{H,t}y_{H,t}.$$

Aggregation

The Appendix Section shows that the first order conditions and the constraints reported above can be used to obtain the aggregate resource constraint

$$p_{H,t}y_{H,t} = \pi^b c_t^b + (1-\pi^b)c_t^s + p_{H,t}EXP_t - X_t\left[\pi^b c_{F,t}^b + (1-\pi^b)c_{F,t}^s\right] + \frac{\chi_P}{2}\left(\pi_{H,t}-1\right)^2 p_{H,t}y_{H,t}, \tag{16}$$

and the equality between the current account and the capital account:

$$p_{H,t}EXP_t - X_t\left[\pi^b c_{F,t}^b + \left(1-\pi^b\right)c_{F,t}^s\right] + \frac{\left(R_{t-1}^f - 1\right)X_t}{X_{t-1}} b_{t-1}^f = b_t^f - \frac{X_t}{X_{t-1}} b_{t-1}^f. \tag{17}$$

The aggregate resource constraint (16) states that output is equal to consumption plus exports, less imports, all measured in terms of the price of the consumption bundle. As Rotemberg quadratic adjustment costs are present, part of output is wasted due to price adjustment. Equation (17) instead states that the current account, given by the trade balance, $p_{H,t}EXP_t - X_t\left[\pi^b c_{F,t}^b + \left(1-\pi^b\right)c_{F,t}^s\right]$ plus net interest income $\frac{\left(R_{t-1}^f-1\right)X_t}{X_{t-1}} b_{t-1}^f$, must be equal to inverse capital flows, given by the change in domestic holdings of foreign assets, $b_t^f - \frac{X_t}{X_{t-1}} b_{t-1}^f$.

The relationships that we have obtained can be used to get the log-linear model that we discuss in the next section. The model can be described by an IS curve, a Phillips curve, an uncovered interest parity condition, and a credit accumulation equation. The Appendix Section shows how the model can be log-linearized in detail.

Specifically, the IS curve is obtained by considering the demand side of the model that is mostly derived from households' optimization, i.e. by combining the Euler equations of savers and borrowers, (4) and (5), with the aggregate resource constraint (16). The effect of net exports on the IS curve is obtained by considering the equations governing imports and exports, i.e. equations (11), (12), and (13). The log-linear Phillips curve is obtained by considering the supply side of the model that is mostly obtained through the firms' optimization problem. In practice, the firms' production function (15) is combined with the Phillips curve in levels (14); after taking account of households' labor supply (3).The uncovered interest parity condition is easily obtained by simply log-linearizing equation (6). Finally, the credit accumulation equation is obtained by combining the average consumption of savers (9) with the equality between the current account and the capital account (17).

4. Log-Linear Model

The setup presented in the previous section determines the main economic mechanism described in the model and, by doing so, generates the structural relationships that are required for subsequently interpreting the data. However, to finish taking the theoretical model to data, the paper takes additional steps by employing the strategy used by Ajello et al (2015) when they take their own model to data. [23] In particular, Ajello et al (2015) take a standard closed economy New Keynesian model and adopt the following modifications when taking it to the data: i) they reduce the infinite horizon model to a two-period framework; ii) they assume that in period two the economy may be subject to a crisis shock, and that this shock brings it to the crisis state delivering exogenous and adverse effects on output and inflation; in contrast, if such s shock does not take place, the economy is in the normal state, in which no deviation of output and inflation from the steady state occurs; iii) they assume that agents give a fixed subjective probability to the realization of a crisis, independently from the actual crisis probability, i.e. expectations are not rational, i.e. as noted below, this latter finds empirical back-up in evidence provided by Schularick and Taylor (2012), among others. Along the lines of Ajello et al (2015), the present makes the three above-mentioned assumptions.

The reasons for adopting such simplifying assumptions are manifold. Assumptions i) and ii) are connected. The fact that the present paper refers to financial crises that are endogenous and dependent on credit, as assumed according to ii), implies that it cannot use the standard solution perturbation method used in the DSGE literature n. That method in fact only allows for fluctuations driven by exogenous shocks. While it would be possible to solve the model in levels by using global solution methods, the latter cannot be easily utilized except in the simplest cases and the insight given by linearization would be lost. Most importantly, while empirical evidence on the relationship between credit growth and crisis probability is quite strong, agreed-upon and convenient micro-foundations of such relationship still lack. Since the goal of this paper is to take account of this relationship in the data, we think that it is more useful to adopt the reduced form relationship between credit and crisis probability of Ajello et al (2015). The adoption of a two-period framework, as understood by assumption i), allows performing this task in a relatively easy manner.

Regarding assumption iii), i.e. imposing that agents give a fixed subjective probability to a crisis event and do not form expectations rationally in this respect, it allows keeping the model compatible with the evidence. In fact, and as explained by Ajello et al. (2015), if expectations were modeled as being rational, times in which credit growth is high would be associated with reductions of output and inflation, because the increased crisis probability may reduce expected future inflation and output gaps, leading to lower inflation and a lower output gap today. Nonetheless, this result is inconsistent

[23] Notice that, differently from us, Ajello et al. (2015) do not micro-found the credit accumulation equation, and just estimate from the data that credit is increasing in output. Interestingly, when we consider the closed economy version of our micro-founded model, we obtain that credit is in fact increasing in output.

with much empirical evidence suggesting that agents expect good times to continue going forward (see Shiller, 2005; Reinhart and Rogoff, 2009).

Therefore, this section reports the two-period model in log-linear form: the log-linearization of the model presented in section 3 is reported in detail in the appendix. To present our results, the section considers three scenarios: (i) a closed economy in which financial crises are exogenous and; (ii) a closed economy in which this probability increases with credit growth; and (iii) an open economy in which capital flows have an influence on domestic financial conditions.

Closed economy model with exogenous crisis probability

When the model of section 3 is log-linearized under the assumption that $\gamma = 0$ (that is the economy is closed) and that crisis probability is independent of credit, the conditions that determine equilibrium are written as follows:

$$\hat{y}_1 = \tilde{E}_1\hat{y}_2 - \bar{\sigma}\left(\hat{R}_1 - \tilde{E}_1\hat{\pi}_2\right) + \epsilon_1, \tag{18}$$

$$\hat{\pi}_1 = \varphi\frac{\bar{\sigma}+1}{\bar{\sigma}}\hat{y}_1 + \beta\tilde{E}_1\hat{\pi}_2; \tag{19}$$

where ϵ_1 is a normally distributed demand shock. As can be seen from equations (18) and (19), when the economy is closed and crisis probability is exogenous, the model collapses to a standard New-Keynesian model. In this model, Equation (18) is the IS curve according to which output responds positively to expectations about output tomorrow and negatively to the real interest rate, and equation (19) is the Phillips Curve according to which inflation depends positively on expectations of inflation tomorrow and on output today.

Before proceeding, it is useful to express some of the parameters in equations (18) and (19) in terms of deep fundamentals of the model given that this will ease the task of explaining the parametrization in what follows. Hence, we consider the following definitions:

$$\varphi = \frac{\zeta - 1}{\chi_P}$$

and

$$\bar{\sigma} = [\frac{\pi^b s^b}{\sigma^b} + \frac{(1-\pi^b)s^s}{\sigma^s}].$$

Closed economy model with endogenous crisis probability

This subsection augments the model summarized in equations (18) and (19) to make endogenous the probability of transitioning from a normal state to a crisis state. For this purpose, we follow Ajello et al. (2015) in defining the transition probability and the growth rate of credit in real terms as follows

$$P(\tilde{b}_1) = \frac{e^{p+\kappa\tilde{b}_1}}{1 + e^{p+\kappa\tilde{b}_1}} \tag{20}$$

where

$$\tilde{b}_1 - \frac{1}{\beta}\left(\tilde{b}_0 + b\hat{R}_0^d - b\hat{\pi}_1\right) = s_{\aleph}\hat{y}_1; \tag{21}$$

and p and κ are parameters determining the average crisis probability and the elasticity of crisis probability to credit, respectively. Furthermore, we define parameter $s_{\aleph}$, an indicator of credit growth sensitivity to output, as follows:

$$s_{\aleph} = \frac{\pi^b\left(1 - \pi^b\right)\left[\frac{s^b}{\sigma^b} - \frac{s^s}{\sigma^s}\right]}{\bar{\sigma}}.$$

Equation (20) states that the transition probability increases with $\tilde{b}_1$, i.e. domestic credit in real terms and equation (21) defines credit as being an increasing function of output and a decreasing function of inflation. With the exception of the specific functional form chosen by Ajello et al (2015) for the transition probability, the remaining aspects of equations (20) and (21) can be theoretically and empirically founded.

Equation (20) finds empirical support in Schularick and Taylor (2012) and Ajello et al (2015). Assuming that the crisis probability follows a logistic function, they find that real credit growth is a critical predictor of financial crises. Furthermore, this equation is consistent with the idea of systemic risk developed by Borio and Lowe (2002), according to which it is precisely the build-up of imbalances, and particularly the accumulation of leverage during the upturn of the financial cycle, which prompts a financial turmoil. Furthermore, we estimate the equation for a group of Latin American countries in the appendix and use the estimates to calibrate parameters p and κ in our numerical analysis.

As for equation (21), it is derived from the closed economy version of the model of section 3; thus, this equation is theoretically supported by the micro-foundations of the model. To be more precise, equation (21) is another way to illustrate the factors that influence credit accumulation, alternative to equation (10). The term $s_{\aleph}\hat{y}_1$ in (21) captures the same effect as term $s^b\hat{c}_t^b - s^s\hat{c}_t^s$ in (10). In fact, a positive shock to income has a stronger effect on the expenditure decisions of borrowers than on those of savers, and, therefore, makes the former more willing to borrow and the latter willing to lend, thereby raising credit. The Fisher effect is similarly captured by term $\frac{b}{\beta}\hat{\pi}_t$.

Open economy model with endogenous crisis probability

To extend the analysis to the case of a small, open economy, this subsection considers the full model presented in section 3 and derives the following equilibrium conditions:

$$\hat{y}_1 = \tilde{E}_1\hat{y}_2 - \frac{\gamma(\nu-\gamma)}{1-\gamma}\left(\tilde{E}_1\hat{X}_2 - \hat{X}_1\right) - (1-\gamma)\bar{\sigma}(\hat{R}_1 - \tilde{E}_1\hat{\pi}_2) + \epsilon_1, \tag{22}$$

$$\hat{R}_1 - \hat{R}_1^f = \tilde{E}_1\hat{X}_2 - \hat{X}_1 + \tilde{E}_1\hat{\pi}_2, \tag{23}$$

$$\begin{aligned}\hat{\pi}_1 = &-\frac{\gamma}{1-\gamma}\hat{X}_0 + \frac{\gamma}{1-\gamma}\left(1+\beta+\frac{\zeta-1}{\chi_P}\left(2-\frac{(\nu-\gamma)}{(1-\gamma)\bar{\sigma}}\right)\right)\hat{X}_1 \\ &+\frac{\zeta-1}{\chi_P}\frac{(1-\gamma)\bar{\sigma}+1}{(1-\gamma)\bar{\sigma}}\hat{y}_1 + \beta\left[\tilde{E}_1\hat{\pi}_2 - \frac{\gamma}{1-\gamma}\tilde{E}_1\hat{X}_2\right],\end{aligned} \tag{24}$$

$$\tilde{b}_1 - \frac{1}{\beta}\left(\tilde{b}_0 + b\hat{R}_0 - b\hat{\pi}_1\right) = \frac{(1-\gamma)s_{\aleph} + \pi^b\gamma}{1-\gamma}\hat{y}_1 - \frac{\gamma(\nu-\gamma)}{1-\gamma}\frac{s_{\aleph}+\pi^b}{1-\gamma}\hat{X}_1; \tag{25}$$

Equation (22) is the open economy intertemporal IS equation. Just as in the closed economy model, current output gap, $\hat{y}$, depends on its future expectations, and on the real interest rate. In the open economy, current output also depends on the real exchange rate: a real devaluation tends to increase it through higher net exports. Equation (24), the Phillips curve, shows that inflation depends on output and on expected future inflation, as in the closed economy model; while the real exchange rate enters the equation due to openness. In particular, current depreciations tend to increase inflation, while past and expected future depreciations tend to reduce it.[24] It is important to highlight the fact that the modifications to the IS curve and to the Phillips curve that are due to openness affect the benchmark to which the model with endogenous systemic risk is compared, but not the basic result of this paper. In other words, the fact that the IS curve and the Phillips curve are different in an open economy changes the optimal interest rate compared to a closed economy also when systemic risk is exogenous. However, as we show below, results when adding endogenous systemic risk are compared to the different benchmark: in the closed economy model, the interest rate is increased with respect to the closed economy benchmark with exogenous systemic risk, while in the open economy model, the interest rate is reduced, with respect to the different benchmark.

[24] Current depreciations tend to increase inflation due to several mechanisms. It is not fundamental to discuss all of them here, as such effects are not necessary to understand the results. However, one might recall that depreciations increase inflation due to the pass-through of higher import prices to the CPI. Past depreciations are correlated to lower inflation simply due to the fact that they increase past prices, thereby widening the base over which today's inflation is computed. Expected future depreciations reduce current inflation because price adjustment costs only affect domestic prices and so firms do not take account of the future changes in the real exchange rate when setting today's prices.

Equation (25) is also an alternative way to equation (10) to describe credit accumulation in the open economy model. As in the closed economy case, the Fisher effect is captured by $\frac{b}{\beta}\hat{\pi}_t$ and the output term plays the same role as term $s^b\hat{c}_t^b - s^s\hat{c}_t^s$. However, in the open economy credit is more sensitive to output gap, i.e., $\frac{\pi^b\gamma}{1-\gamma}$ is greater than zero. Finally, the term $-\frac{\gamma(\nu-\gamma)}{1-\gamma}\frac{(1-\gamma)s_{\aleph}+\pi^b}{1-\gamma}\frac{s_{\aleph}+\pi^b}{1-\gamma}\hat{X}_1$ plays the same role as $-\frac{1}{1-\pi^b}\left[\tilde{b}_t^f - \frac{1}{\beta}\tilde{b}_{t-1}^f\right]$ in equation (10). In fact, capital inflows cause currency appreciation, i.e. a fall in $\hat{X}$, and higher domestic credit.

The fact that credit growth depends on the real exchange rate (and capital flows) has a relevant implication: a raise in the policy rate is more likely to increase credit rather than reduce it, compared to a closed economy model. In both the open economy and the closed economy model a contractionary monetary policy tends to reduce output and inflation. The fall in output tends to reduce credit, due to the demand effect, and to raise it through the Fisher effect. In our numerical exercise, we will show that higher rates reduce credit in the closed economy, which implies that the demand channel prevails. In the open economy, however, an interest rate hike also generates capital inflows and an appreciating effect on the real exchange rate. Capital inflows, in turn, increase credit. Hence, the effectiveness of monetary policy in controlling credit growth is clearly diminished in the open economy and, thus, interest rate setting is less suited to avoid excessive leverage and to dampen financial risks.

Notice that when parameterizing equation (25), and more generally the model, we depart from Ajello et al (2015) who uses U.S. data to estimate a reduced form relation between credit growth and output. More precisely, we obtain (25) by using the structural model. As a robustness check, the appendix estimates a reduced form relation between domestic credit, output and the real exchange rate for Mexico and shows that actually domestic credit is positively influenced by output growth and negatively influenced by real depreciations.

Parameter Values

In computing optimal monetary policy, we are confronted with the need of choosing a loss function that the policy-maker wants to minimize. Thus, in order to keep consistency with Ajello et al. (2015), the period loss function is assumed take the following form:

$$L(\hat{\pi}_t, \hat{y}_t) = \frac{1}{2}\left(\phi_\pi \hat{\pi}_t^2 + \phi_y \hat{y}_t^2\right),$$

and inflation and output are given the same weight, i.e. $\phi_\pi = \phi_y$. Also in the manner of Ajello et al. (2015), the period two loss is adjusted to take into account that crises can last more than one period in the following manner:

$$L(\hat{\pi}_2(C), \hat{y}_2(C)) = \frac{\frac{1}{2}\left(\phi_\pi \hat{\pi}_2^2(C) + \phi_y \hat{y}_2^2(C)\right)}{1 - \beta\tau}.$$

where the τ parameter can be adjusted to increase or decrease the crisis duration and C identifies the crisis state. Following Ajello et al (2015), it has been assumed that in the normal state (N) no variable deviates from its approximation point, hence $\hat{\pi}_2(N) = \hat{y}_2(N) = \hat{X}_2(N) = \hat{\aleph}_2(N) = 0$. Furthermore, it is assumed that the private sector disregards the possibility of a crisis, given that, as discussed by Ajello et al (2015) and Shiller (2005), credit booms are accompanied by private sector expectations that "good times" will continue going forward.

Table 2 in the appendix Section reports the calibration of the model. The calibration is based on Mexican data when possible, while in all other instances we run a robustness analysis to test the sensitivity of the results. Those parameters that govern the welfare loss due to the realization of the crisis state are set to capture the effects of the Mexican financial crisis of 1994-1995 on macroeconomic variables. On the basis of information provided by the OECD recession dummy for Mexico, it is assumed that the crisis begins on 1994-Q4 and ends on 1995-Q3.[25,26] Over this period, the output gap and inflation averaged -2.4% and 9.1% respectively on a quarterly basis.[27] To set the duration of the crisis to four quarters, τ is calibrated to 0.7537.[28] The discount factor, β, is set to 0.99 to obtain an annualized quarterly steady state real interest rate of 4%, as is standard in the macroeconomic literature. Different values of β however do not change significantly the results.

The baseline value of parameter γ, which governs the degree of home bias, is set to 0.3 to obtain a degree of trade openness, computed as the ratio between the sum of imports and exports and GDP, equal to 60%, consistently with the Mexican figure.[29] However, as the main focus of the analysis concerns the effect of openness on optimal monetary policy, we also consider several other values of γ. The elasticity of exports to the terms of trade, ν, is set to 1, as common in the literature (see Gali and Monacelli, 2005). To assess the robustness of results with respect to this assumption, we also consider values of ν between zero and six.

The ζ and χ_P parameters are set to 6 and 77, respectively, in order to obtain a mark-up of prices over marginal costs of 20% and prices that, if a Calvo model was used instead of a Rotemberg model,

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[25] This data set is obtained from the FRED website.

[26] This amounts to delaying the crisis by one month.

[27] Data on the output gap and inflation are obtained from Banco de Mexico. Potential output is set equal to actual output on 1994-Q3 and is increased at a constant growth rate, calculated as the average growth rate of the Mexican economy between 1993-Q1 and 2015-Q3. The output gap is computed as the difference between actual output and potential output.

[28] Given that $L\left(\hat{\pi}_2(C), \hat{y}_2(C), \hat{\aleph}_2(C)\right)$ is the one period loss, τ can be obtained solving the equation $\frac{L\left(\hat{\pi}_2(C), \hat{y}_2(C), \hat{\aleph}_2(C)\right)}{1-\beta\tau} = L\left(\hat{\pi}_2(C), \hat{y}_2(C), \hat{\aleph}_2(C)\right)[1 + \beta + \beta^2 + \beta^3]$.

[29] Data on exports and imports are obtained from FRED.

would adjust every 4.5 quarters.30 These two parameters govern the steepness of the Phillips curve and hence the relative elasticity of inflation and output to monetary policy. Given the uncertainty surrounding these values for Mexico, we also run robustness checks on them. Following Curdia and Woodford (2016), we set the share of borrowers, π^b, to 0.5 and the ratio between the inverse elasticity of intertemporal substitution of the two types, σ^s/σ^b, to five. Also in this case, several other values are considered as a robustness check. Furthermore, the absolute values of σ^s and σ^b are set such that the slope of the IS curve with respect to the real interest rate, $\bar{\sigma}$, is one. This value is what would be obtained in a representative agent model under log-utility. The share of borrowers' consumption, $\pi^b s^b$ is conventionally set to 0.7, but other values are also considered. We calibrate the steady state domestic credit to output ratio, b to 1.17 consistently with the average Mexican figure.[31]

The p and κ parameters, which govern the relation between domestic credit and crisis probability, are set to -4.1137 and 1.1625, respectively. As explained in the appendix, these values are obtained by running a logistic regression with country fixed effects of four years domestic bank credit growth on crisis probability for a group of Latin American countries. Crisis years are identified using the dataset of Laeven and Valencia (2012). This procedure is the same as the one employed by Ajello et al (2015) to calibrate the parameters governing crisis probability in their paper. In practice, crisis probability is 6.28% on an annual basis on average, higher than the one obtained by Ajello et al (2015) (equal to 3.24%), but its elasticity to credit is lower than the one estimated by Ajello et al (2015) (which is 1.88). In addition, time zero credit and real exchange rate deviation from average are set to zero. However, as crises often strike in periods of high indebtedness, we consider several other values for inherited credit.

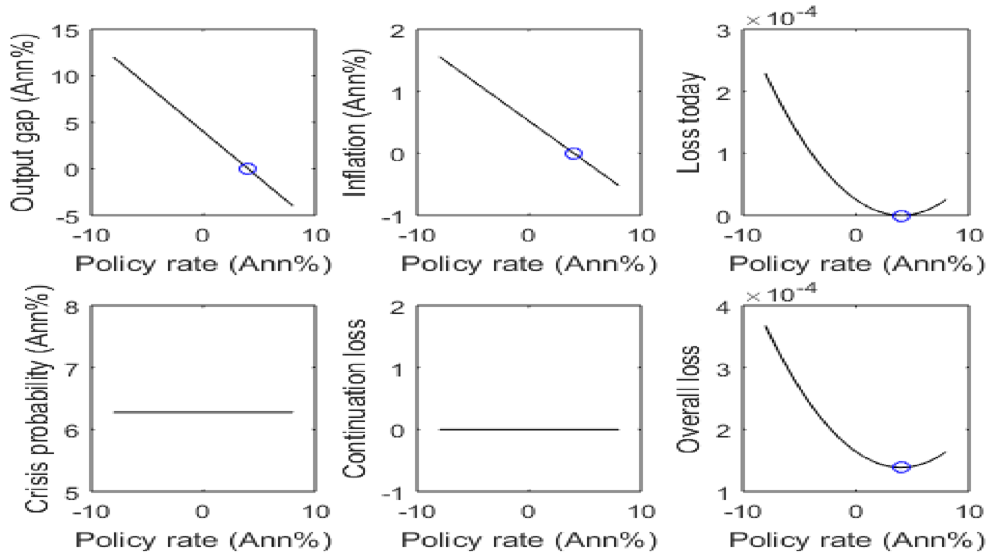
5. Results

Using the parametrization presented in the previous section, we explore the effects of a 1% positive aggregate demand shock in period 1. In the standard New Keynesian framework, monetary policy can fully stabilize output and inflation in response to a demand shock, i.e., this result is frequently referred to as the divine coincidence; thus, this is the type of shock that most clearly exposes how the introduction of financial stability concerns moves the central bank away from its traditional objectives. Figure 4 shows exactly this case. In particular, it shows the output gap, inflation, loss in period one, the continuation loss (i.e. the loss in period two), the total loss and the crisis probability

[30] These values are taken from De Paoli et al. (2010). Keen and Wang (2007) show how to convert a Rotemberg parameter to a Calvo frequency of adjustment.
[31] The b parameter is computed as the ratio between total credit to the non-financial sector and GDP. Data are taken from Banco de Mexico and cover the period 1994-Q4 to 2015-Q3.

as a function of the policy rate in the basic New-Keynesian framework, i.e. the closed economy model with exogenous crisis probability. Both the output gap and inflation are decreasing in the policy rate, while crisis probability and the continuation loss are independent of it. The blue circles indicate the optimal policy, which ensures to completely stabilize both inflation and the output gap; and to set period one loss to zero.

Figure 4. Basic New-Keynesian Model



Notes. Each panel reports the corresponding variable as a function of the policy rate. Blue circles indicate the optimal policy rate and the corresponding value of the variable in the panel. The policy-maker is able to completely stabilize both inflation and the output gap and to set period one loss to zero.

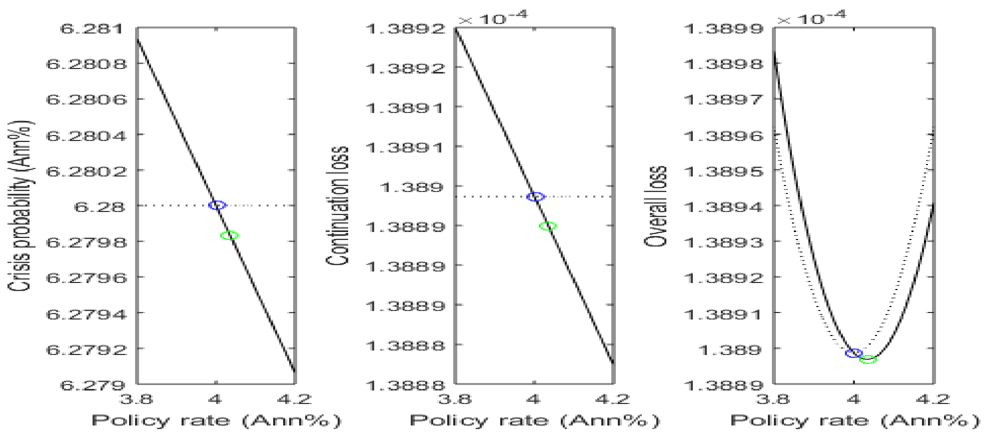
Figure 5 compares the closed economy model with exogenous crisis probability (dotted lines) to the closed economy model with endogenous crisis probability (full line). In that figure, blue circles indicate the optimal policy in the exogenous crisis probability case (which of course are the same as in Figure 4), while green circles indicate the optimal policy in the endogenous crisis case. The comparison between the two closed economies reveals that the results are similar to those obtained by Ajello et al (2015). While crisis probability is independent of the policy rate in the exogenous crisis model, raising this rate reduces output, credit, leverage and therefore, the probability of a crisis in the endogenous crisis model. The implication is that in the latter scenario it is no longer optimal to fully stabilize output and inflation: taking into account the effect of her policy choices on crisis probability, the policy-maker optimally sets a somewhat higher interest rate than in the model with exogenous crisis. However, just as Ajello et al. (2015), we find that the difference in terms of optimal policy between the scenarios is small (around three basis points on an annual basis).

Continuing with the case of a closed economy with endogenous crises, Figure 6 studies the sensitivity of optimal monetary policy to different lagged credit conditions, $b_0 \in [0,0.5]$. Note that a higher level of inherited credit is associated with a higher probability of crisis. This implies that, due to the convexity of the logit function, monetary policy is more efficient in reducing the risk of a crisis and, as a result, the optimal policy rate is higher. Nonetheless, we find again small differences between varying scenarios: for credit levels that are 50% higher than their normal level, the policy rate is increased around 3 basis points on an annual basis.

As for the open economy, openness in the balance-of-payment triggers additional channels through which the interest rate affects the traditional objectives of a central bank, and the crisis probability. Besides affecting inflation and output through its impact on aggregate demand, a rise in the interest rate affects its traditional objectives through its effect on the real exchange rate. This is highlighted in Figure 7 in which we show the effect of the policy rate on the output gap, on inflation, and on period one loss, in the closed economy case (dashed line) and in the open economy case (full line).

A rise in the interest rate produces a reevaluation of the exchange rate, which further compresses exports and, at the same time, diminishes inflation by reducing the domestic prices of imported goods. The fact that inflation is more sensitive to monetary policy implies that, even in the absence of financial stability considerations, the optimal interest rate is smaller in the open economy. In Figure 7 the red circles, which corresponds to the optimal policy in the open economy case, are at lower interest rate levels compared to the green circles, which indicate the optimal policy in the closed economy model.

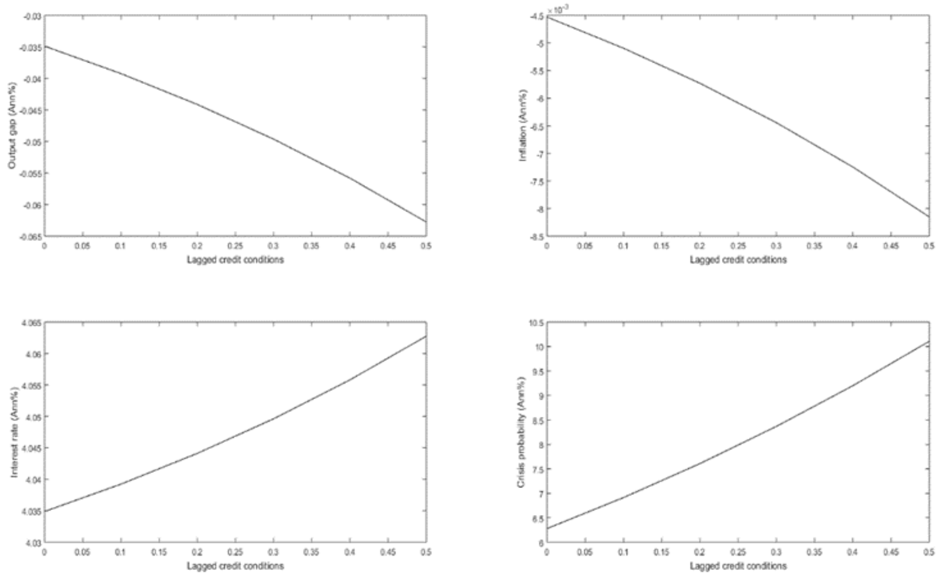
Figure 5. Basic New Keynesian Model and Closed Economy Model with Endogenous Crisis



Notes. Each panel reports the corresponding variable as a function of the policy rate. Blue circles indicate the optimal policy rate and the value of the variable in the panel in the basic New Keynesian case, while green circles refer to the closed economy model with endogenous crisis probability. In the latter case, the optimal policy rate is higher in order to reduce crisis probability and overall loss.

Furthermore, the inclusion of financial stability concerns provides additional incentives for setting a lower interest rate. Just as in the closed economy with endogenous crisis, an increase in the policy rate has a direct and diminishing impact on credit, due to the fall in output, and, therefore, on the crisis probability. Nonetheless, in the open economy, a rise in the interest rate attracts capital flows and, through this channel, fuels domestic credit. Figure 8 that the latter effect overpowers the former effect, so that credit, crisis probability and the continuation loss are increasing in the policy rate, as shown by the full line.[32] In other words, to reduce the probability of a financial crisis, the central bank in a small, open economy must reduce the interest rate below the level that would prevail in the absence of systemic risk. This is precisely the opposite policy perspective from the one supported by the “leaning against the wind” approach proposed for the case of advanced economies.

Figure 6. Optimal Values as a Function of Lagged Credit Conditions in the Closed Economy Model with Endogenous Crisis Probability



Taking into account the considerations we have just made, we compute optimal monetary policy rate for the open economy model, with and without endogenous financial crisis. The optimal rates are equal to 2.18% and 2.24% on an annual basis, respectively, and in both cases smaller than in the corresponding closed economy case. Note that, just as in the closed economy and as in Ajello et al. (2015), the adjustment due to endogenous financial crisis is small. Our main point here, however, is not quantitative, but qualitative. Introducing endogenous crises in the closed economy model implies that interest rates must react more strongly to demand shocks, while the opposite is true in an open economy. Equally important, the next section shows that the effect is quantitatively stronger when the policy-maker is uncertain about the value of some parameters, mimicking the result obtained by Ajello et al. (2015) for the case of a closed economy.

Taking into account the considerations we have just made, we compute optimal monetary policy rate for the open economy model, with and without endogenous financial crisis. The optimal rates are

[32] The figure reports the closed economy model with dotted lines for a comparison. Also in this case, red circles refer to the optimal policy in the open economy model, while green circles refer to the closed economy model.

equal to 2.18% and 2.24% on an annual basis, respectively, and in both cases smaller than in the corresponding closed economy case. Note that, just as in the closed economy and as in Ajello et al. (2015), the adjustment due to endogenous financial crisis is small. Our main point here, however, is not quantitative, but qualitative. Introducing endogenous crises in the closed economy model implies that interest rates must react more strongly to demand shocks, while the opposite is true in an open economy. Equally important, the next section shows that the effect is quantitatively stronger when the policy-maker is uncertain about the value of some parameters, mimicking the result obtained by Ajello et al. (2015) for the case of a closed economy.

6. Role of flexible exchange rates and capital controls in crisis prevention

Flexible vs fixed exchange rates

The classic trilemma claims that in a world with free capital mobility monetary policy independence can be regained by adopting a flexible exchange rate regime. Nonetheless, several authors have recently defied this trilemma by arguing that, when domestic financial variables are strongly determined by global factors such as in a global financial cycle world, exchange rate flexibility is no longer sufficient to ensure that monetary policy is independent (Rey, 2013). In this context, one could be tempted to argue that Section 4's results point towards the exact same direction, i.e., suggesting that exchange rate flexibility is no longer sufficient to ensure monetary policy independence. Nonetheless, before interpreting in such a manner the results, it will be useful to make a distinction between the concept of monetary policy independence and the concept of monetary policy optimality.

Monetary policy independence refers to policy-makers' ability to set their interest rate freely. To illustrate this concept, consider a reference to the trilemma. The argument starts from the observation that no amount of FX market interventions, and therefore no amount of FX reserves, would be able to compensate for a potential difference between domestic and foreign interest rates and, through this channel, sustain a currency peg. That is, as noted by the classic trilemma, monetary policy independence is lost under a fixed exchange rate regime by the need of sustaining the peg. By contrast, monetary policy optimality refers to policy-makers' ability to set the interest rate in such manner that some criterion, possibly social welfare, is maximized. In this regard, note that the concept of optimality is closely connected to the Tinbergen principle, according to which a policy-maker can only reach a certain number of targets if it has at least the same number of independent instruments.

Flexible vs fixed exchange rates - A simplified model

Using these concepts of monetary independence and optimality, this section investigates the role of the exchange rate as a shock absorber, i.e., its ability to insulate the economy from external shocks.

For this purpose, it simplifies the small open economy model of section 4 by assuming that domestic prices are fully sticky for two relevant reasons, i.e., $\chi_p \to \infty$. First, according to Friedman's classic argument, it is exactly in a context with fully sticky prices in which the gains from exchange rate flexibility are maximized, i.e., the context in which nominal flexibility more clearly allows for a rapid adjustment in the real exchange rate. Thus, stickiness allows questioning the role of the exchange rate as a shock absorber in its most favorable framework. Second, perfectly sticky prices allow more safely assuming that the policy-maker does not care about inflation and, therefore, the number of policy objectives becomes two rather than three.[33] This will ensure that when the crisis probability is exogenous, and the policy-maker accordingly has a single objective, exchange rate flexibility is able to drive welfare losses to zero by fully isolating the economy from external shocks.[34] This can be described by the following equations:

$$\hat{y}_1 = \frac{\gamma(\nu - \gamma)}{1-\gamma}\hat{X}_1 - (1-\gamma)\bar{\sigma}\hat{R}_1 + \epsilon_1 + K_1, \quad (26)$$

$$\hat{R}_1 = -\hat{X}_1 + K_2, \quad (27)$$

$$\tilde{b}_1 = \frac{(1-\gamma)s_{\aleph} + \pi^b\gamma}{1-\gamma}\hat{y}_1 - \left(\frac{\gamma(\nu-\gamma)}{1-\gamma}\frac{s_{\aleph}+\pi^b}{1-\gamma} + \frac{1}{\beta}b\frac{\gamma}{1-\gamma}(1+\beta)\right)\hat{X}_1 + K_3; \quad (28)$$

where K_1, K_2 and K_3 are constants, and the interpretation of the equations is the same as noted above.[35] Figure 10 represents the model graphically under any parametrization in which the relationship shown in (28) has a positive slope in the (X, Y) space:[36] Panel (a) shows the IS curve (eq. (26)) in the (Y, R) space; Panel (b) shows the uncovered interest parity condition (eq. (27)) in the (X, R) space; Panel (c) is only useful for graphical purposes and reports the 45 degrees line; and Panel (d) shows equation (28) in the (X, Y) space. In this panel points above the curve represent combinations of output and the exchange rate for which credit levels, and hence crisis probability, are higher; while points below the curve represent combinations of output and the exchange rate for which credit levels, and hence crisis

[33] The consumption price index can still change because of fluctuations in import prices due to innovations in the exchange rate; therefore inflation could still be a policy objective even under perfectly sticky domestic prices. However, we assume in this section that the policy-maker does not care about such fluctuations in order to ensure that output stabilization and reduction of crisis probability remain the only two objectives of policy.

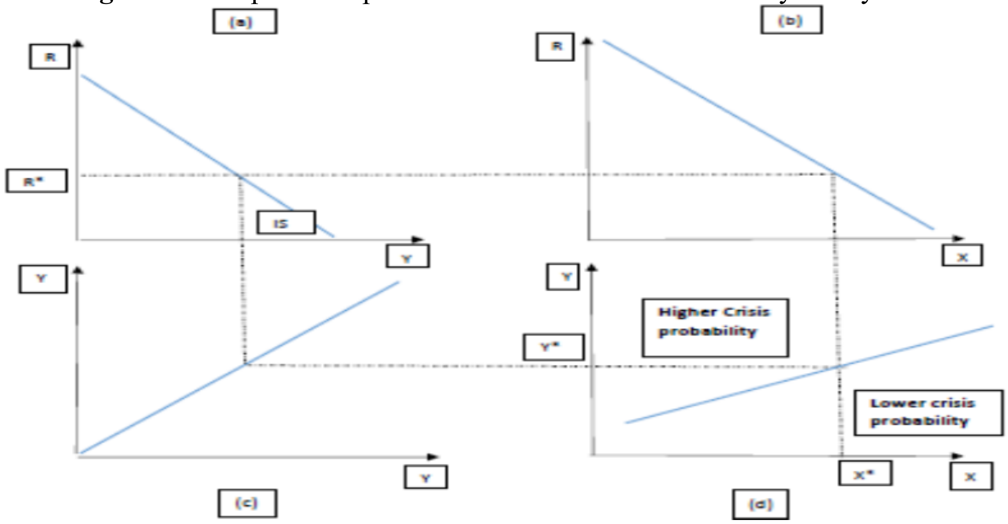
[34] As noted above, completely isolating the domestic economy from outside influence is impossible even under exogenous crisis probability if the policy-maker has both an output and an inflation objective, because the pass-through from the exchange rate to the consumption price index invalidates the divine coincidence result.

[35] Here we use the fact that expectations are assumed to be constant.

[36] The IS curve has a negative slope under any parametrization because γ is between 0 y 1 and the slope of the covered interest rate parity does not depend on parameter values.

probability, are lower. Moreover, the equilibrium of the system, represented by the blue lines, is determined by R^*, the policy maker's choice of the interest rate.

Figure 10. Graphical Representation of the Model with Fully Sticky Prices



Notes: Panel (a) reports the IS curve, equation (26), in the space (Y,R). Panel (b) reports the uncovered interest parity condition (27) in the space (X,R). Panel (c) report the diagonal in the space (Y,Y). Finally, panel (d) reports the combinations of output and of the exchange rate for which credit is constant in the space (X,Y), equation (28).

Flexible vs fixed exchange rates - Exogenous crisis probability

When the crisis probability is exogenous the system in equations (26)-(28) can be thought of as being determined only by (26) and (27) since, in this case, credit is irrelevant for the purpose of output and the exchange rate determination. Having this in mind, we represent the resulting system of equations for both fixed and flexible exchange rate regimes and examine the effects of a demand shock.

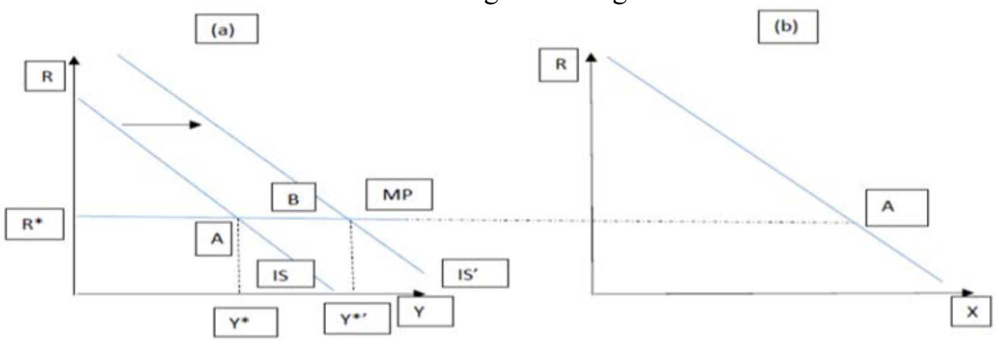
Figure 11 considers the case of a fixed exchange rate. Note in this figure that the demand shock shifts the IS curve to the right, from position IS to position IS'. Yet, to sustain the currency peg, the policy-maker is forced to maintain the interest rate at the same level, as implied by the covered interest rate parity condition in panel (b) and illustrated by the flat policy curve labeled MP. That is, under a fixed exchange rate regime, the policy-maker cannot respond to the demand shock and must, therefore, fully accept its effect on output, which is represented in Figure 11 by the shift from Y^* to $Y^{*\prime}$. Importantly, note this result is compatible with the classic trilemma, according to which in a free capital mobility world monetary policy is not independent.

Moreover, the model is consistent with the classic trilemma in that, under a flexible exchange rate regime, monetary policy regains independence. Note in Figure 12 the policy-maker can increase the interest rate and accept a currency appreciation, i.e., in equilibrium the policy-maker can reach any of the output-interest rate combinations illustrated in Panel b.[37] In this sense, and taking into account

[37] The fixed exchange rate regime can be seen as a specific case of a flexible regime where the interest rate remains constant.

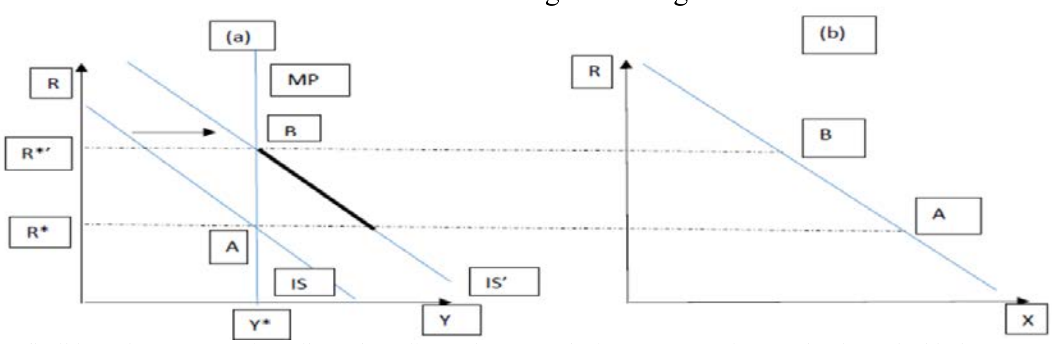
the definition of independence given above, we say that exchange rate flexibility provides independence by allowing the policy-maker to choose any interest rate that she wants, i.e., this is represented in Figure 12 by the fact that the MP curve is vertical. Nonetheless, among all feasible choices, there is a set of interest rates for which the output effect of the shock, and therefore the associated welfare loss, is smaller than under a fixed exchange rate regime; this set is represented by the black segment on the new IS curve. Moreover, within this set, there is only one choice point B in Figure 12 and implies an increase in the interest rate from R^* to $R^{*'}$. Note that in this situation openness in the capital account does not constrain the policy-maker; complete output stabilization is achievable under a flexible exchange rate regime.[38]

Figure 11. Demand Shock in Fully Sticky Prices and Exogenous Crisis Model under a Fixed Exchange Rate Regime



Notes: Equilibrium goes from point A to point B, where output is higher (Y*' rather than Y*), while the interest rate (R*) is constant.

Figure 12. Demand Shock in Fully Sticky Prices and Exogenous Crisis Model under a Flexible Exchange Rate Regime



Notes: A flexible exchange rate regime allows the policy-maker to set the interest rate and output levels on the black curve, on which welfare losses are smaller than under a fixed exchange rate regime. Optimal policy, however, is represented only by a particular flexible exchange rate policy, the one represented by curve MP. The optimal policy implies that equilibrium goes from point A to point B, where output is constant (Y*), while the interest rate grows from R* to R*'.

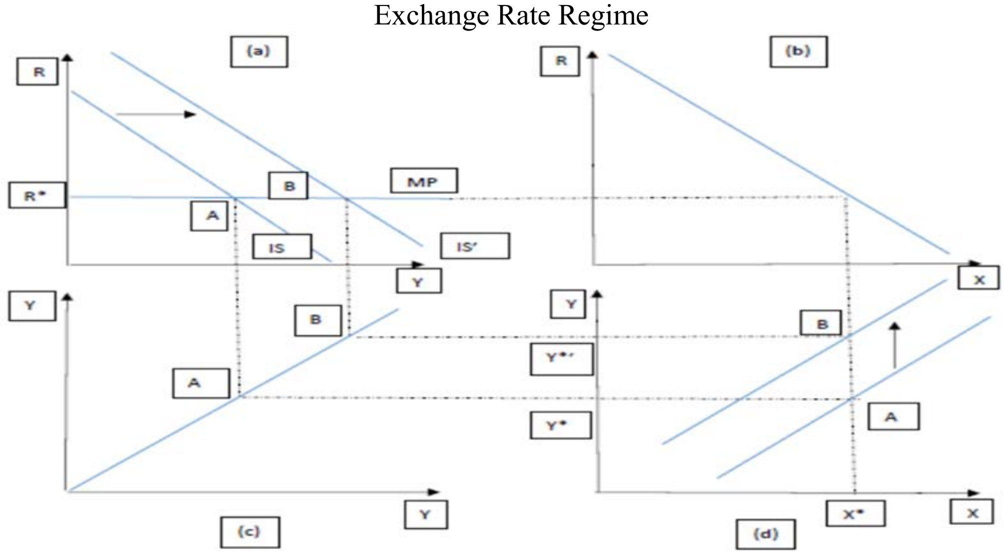
[38] It is maybe easier to understand the fact that the optimal policy insulates the domestic economy from outside influence if one imagines a shock to the foreign interest rate that shifts the uncovered interest parity condition in panel (b) to the right. The currency depreciation shifts also the IS curve to the right, but through a higher interest rate the policy-maker can completely eliminate the effect of the higher demand on output.

Flexible vs fixed exchange rates - Endogenous crisis probability

When crisis probability is endogenous, credit growth affects crisis probability and, through this channel, future expected welfare loss. Hence, in this case, all equations in the system (26)-(28) must be taken into account. The fixed exchange rate regime is portrayed in Figure 13. Of course, also in this case, following the shift of the IS curve to the right, the policy-maker has to keep the interest rate constant so that the currency peg is maintained. Thus, the MP curve is also flat in this case and the policy-maker is unable to stabilize output, which goes from Y^* to $Y^{*\prime}$. Unlike in the case with exogenous crisis probability, in this case it is important to track changes in credit growth since these changes affect the crisis probability. Note in this regard that, as a result of the output increase, the curve describing output-exchange rate combination in panel (d) shifts upwards and to the left. The implication is that in equilibrium there is an additional loss arising from greater credit growth, as well as higher crisis probability. That is, the negative implications of pegging to affixed exchange rate are greater when the financial crisis probability is endogenous.

Figure 14 considers a flexible exchange rate regime in which, just as in the case of Figure 12, the policy-makers can increase the interest rate and accept a currency appreciation. In fact, any point on the black (bold) curve in the figure refers to an output-interest rate combination that is achievable and, at the same time, minimizes welfare losses relative to a fixed exchange rate regime. Note that, among all these choices, the one that keeps output constant was optimal with exogenous crisis probability, i.e., this choice is represented by the vertical policy curve MP and point B in panel (a).

Figure 13. Demand Shock in Fully Sticky Prices and Endogenous Crisis Model under a Fixed Exchange Rate Regime

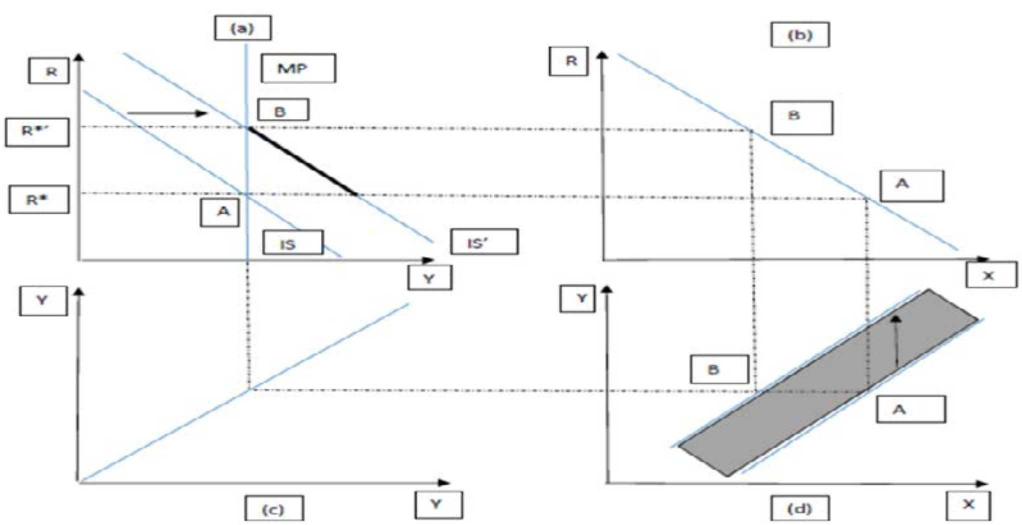


Notes: Equilibrium goes from point A to point B, where output is higher and the interest rate (R*) is constant. In panel (d) the curve shifts upwards because the higher output implies a higher credit level and crisis probability.

Nonetheless, this choice is no longer optimal with endogenous crisis since the interest rate increase required to keep output constant attracts a sufficiently large amount of capital flows that credit, and thus crisis probability, increase by a sufficiently large amount. That is, in the grey shaded area of panel (d) there are output-exchange rate combinations that are feasible and are associated with smaller welfare losses than point B; the optimal choice lies within this area. In terms of the model's results, this implies that the interest rate increases by less than in a case in which there is exogenous crisis and no systemic risk. Most importantly, a main takeaway is that with endogenous crisis probability, exchange rate flexibility diminishes welfare losses but, nonetheless, is unable to fully insulate the economy from external shocks; the exchange rate works only partially as a shock absorber.

As a way of summarizing the results, Figure 15 represents the four cases investigated in the present section. In this figure, the dashed curve represents total welfare loss, comprising both present and future expected losses, for different values of the interest rate in the simplified model with exogenous crisis probability. By the same token, the solid curve represents the same loss in the simplified model with endogenous crisis probability. In both cases, the green circle refers to the interest rate-welfare loss combination prevailing under a fixed exchange rate regime, while the blue circle refers to combination prevailing under optimal policy choice. The remaining points on the curves refer to interest rate-welfare loss combinations that are achievable under a flexible exchange rate regime.

Figure 14. Demand Shock in Fully Sticky Prices and Endogenous Crisis Model under a Flexible Exchange Rate Regime

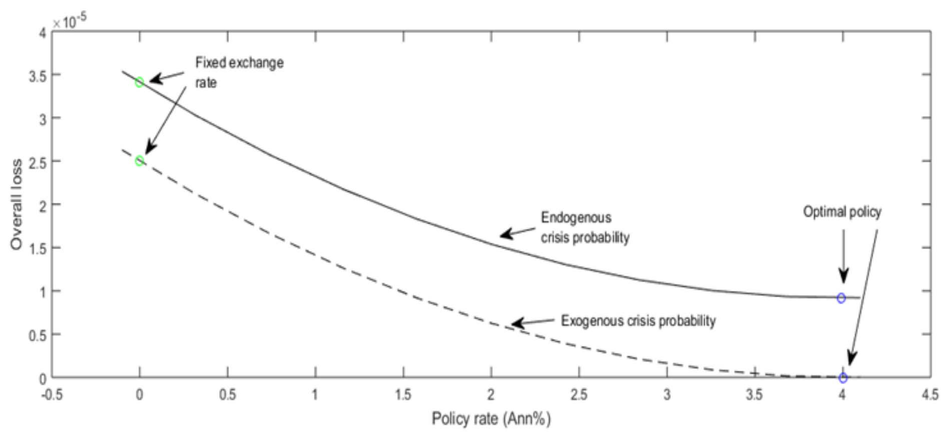


Notes: A flexible exchange rate regime allows the policy-maker to set the interest rate and output levels on the black curve. The policy which completely stabilizes output and which is represented by the curve MP in panel (a) is no longer optimal, because it generates a too strong shift of the curve in panel (d) to the left. In this case the optimal policy is a policy that corresponds to an interest rate-output combination on the black bold curve in panel (a) and an output-exchange rate combination in the grey shaded area in panel (d).

Focusing first on the dashed curve, two remarks deserve to be made. First, as noted above, a flexible exchange rate regime is preferred over a fixed exchange rate regime, and this is because flexible regimes provide monetary policy with enough independence to pick a welfare-improving interest rate. Second, in line with the predictions of the classic trilemma in international macroeconomics, in the absence of financial stability considerations, exchange rate flexibility and the resulting role of the exchange rate as a shock absorber fully insulate the economy from external shocks. In Figure 15, this is represented by the fact that the policy-maker is able to fully accommodate the demand shock by driving welfare losses down to zero.

Regarding the solid curve, the result that exchange rate flexibility is preferred still holds. This result, again, is in line with the prescriptions of the classic trilemma. Moreover, the result is consistent with the evidence provided by Obstfeld et al., (2017), according to which exchange rate flexibility plays a role in insulating an economy from external shocks, even in the presence of the global financial cycle. Nonetheless, when the crisis probability is endogenous and thus financial stability considerations are in place, it is no longer true that welfare losses can be driven down to zero. As noted above, in this case the introduction of endogenous crisis probability distorts the optimal choice of the interest rate relative to a case with exogenous probability of a crisis. Interestingly, the fact that financial stability concerns prevents exchange rate flexibility from fully insulating the domestic economy is line with the perception with the modern version of the trilemma in international economics. This modern version has been mostly pushed by Rey (2015) and claims that in the presence of the global financial cycle the exchange rate does not work fully as a shock absorber.

Figure 15. Loss as a Function of the Interest Rate in the Simplified Model in the Exogenous and in the Endogenous Crisis Case



Notes: The green circle indicates the interest rate-loss combination that prevails under a fixed exchange rate regime, while the blue circle indicates the interest rate-loss combination that prevails under the optimal policy.

Finally, it is important to note that the conclusions of this subsection are even truer in the full model, when prices are not completely sticky and the policy-maker also cares about inflation. In that case in fact, the policy-maker optimally decides to deviate even less from the interest rates prevailing in global financial markets, because doing so produces strong fluctuations in the exchange rate, which in turn pass-through into domestic inflation. As noted, in fact, the optimal interest rate response in a small open economy is lower compared to a closed economy even when crisis probability is exogenous (for proofs on these statements, see the Appendix Section).

Capital controls

According to a recent strand in the literature, the existence of a global financial cycle implies that exchange rate flexibility is no longer sufficient to insulate an economy from external shocks. In turn, this has reopened the debate on the goodness of capital controls and on whether these instruments should be used. The present subsection addresses this debate from two different but complementary analyses. First, the subsection takes an analytical perspective and introduces capital controls in the open economy model and the related simplified version presented above. Second, this analysis is complemented with a conceptual discussion on different determinants of their effectiveness when it comes to implementing them in the real world.

In introducing these controls into the model we assume that they take the form of a tax on foreign debt. As shown in the Appendix, the only linearized equation affected by the introduction of this tax is the uncovered interest parity condition, which is thus written as follows:[39]

$$\hat{R}_1 - \hat{R}_1^f = \tilde{E}_1 \hat{X}_2 - \hat{X}_1 + \tilde{E}_1 \hat{\pi}_2 + \tau_1^X; \tag{29}$$

where τ^X is the tax rate on foreign debt. Note in equation (29) that capital controls introduce a wedge in the uncovered interest parity condition, and that this provides the policy-maker more leeway. In particular, capital controls enable the policy-maker to increase R_1 over the sum of the interest rate differential and the expected depreciation of home currency. In terms of the simplified model with sticky prices shown in (26)-(28), the only equation affected is (27), which is then written as follows

$$\hat{R}_1 = -\hat{X}_1 + \tau_1^X + K_2. \tag{30}$$

Figure 16 the simplified version of the model with foreign debt tax. Note that, unlike in Figure 14, the policy-maker can shift the uncovered interest parity curve in panel (b) and choose its position by manipulating the tax. For instance, an increase in τ^X shifts the curve upwards, indicating that more stringent capital controls are associated with a smaller crisis probability, for given levels of output and exchange rate. That is, the tax gives the policy-maker an additional policy instrument she will use to achieve an additional goal, such as a reduction in the crisis probability.

Figure 16 shows that the additional instrument is indeed used to this end. In particular, note that in the associated equilibrium the policy-maker fully stabilizes output by setting the same interest rate as in the case with no endogenous crisis ($R^{*'}$) and that, at the same time, fully eliminates any impact on

[39] In particular, we assume that the government levies a tax on domestic residents foreign debt (or a pays a subsidy on domestic residents foreign assets) and transfers the revenues to them (or obtain the funding from) lump-sum.

credit and on crisis probability by setting a positive tax. In other words, by giving the policy-maker an additional instrument, capital controls enable her to achieve simultaneously her two goals.

The result that capital controls can improve welfare is not new. Indeed, there is a recent literature claiming that capital controls allow internalizing negative externalities.[40]Using a small open economy New Keynesian model, Fahri and Werning (2014) show that temporary tax/subsidies on capital inflows/outflows allow mitigating exchange rate depreciations, increases in the interest rate, current account reversals and consumption falls during a sudden stops. Heathcote and Perry (2016) use a two-country model to show that capital controls generate favorable behavior of interest rates and terms-of-trade and are, thus, sometimes welfare-improving for individual countries. Moreover, they show that under some circumstances symmetric controls, i.e. imposed in the same way in all countries, are also welfare-improving from a global perspective. Furthermore, after reviewing the literature, Korinek (2011) concludes that capital controls may help counteract pecuniary externalities through which balance sheet effects are amplified during a financial crisis.

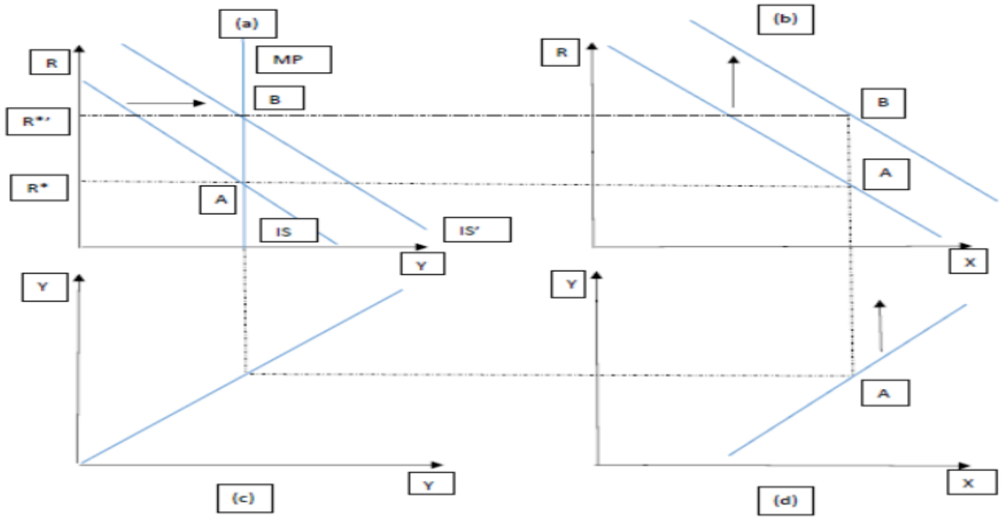
Notwithstanding the fact that capital controls may entail these benefits and the advantages described in Figure 16 several authors note that their goodness depends on policy-makers ability to prevent regulatory arbitrage. Along these lines. Stein (2013) argues that the effectiveness of capital controls depend crucially on their capacity of fully tackling transnational financial investment. Moreover, by definition, prudential measures in general, and capital controls in particular, can only have traction on flows that are intermediated through the regulated financial institutions. Direct borrowing from abroad, through branches of foreign banks, or intermediated by unregulated institutions are not subject to domestic prudential regulations. Moreover, capital controls imposed on domestic banks may cause flows to migrate to unregulated institutions due to regulatory arbitrage. Similarly, Benigno et al (2016) highlight that capital controls may not be the most useful measure in internalizing the external effects of their foreign borrowing. In particular, they argue that consumption taxes, imposed differently on tradable and non-tradable goods, may be preferable.

Moreover, in a similar vein, the empirical evidence on the effectiveness of capital controls is mixed. On the positive side, Ostry et al (2012) find that capital controls can help reduce the riskiness of the external liability structures and the extent of risky foreign-currency borrowing in the economy. Magud et al (2011) find that capital controls are useful to make monetary policy more independent, but they do not seem to be able to reduce net flows. On the negative side, Forbes et al (2015) show that, although capital flow-management measures have significant effects on some variables, which they are intended to influence, most effects are insignificant, small in magnitude, and not robust across

[40] The argument in this paper can be also rationalized in these lines. In the context of our model, the externality would arise from the fact capital flows fuel credit growth and, through this channel raise the crisis probability.

empirical methodologies. Therefore they argue that the apparent lack of effectiveness of capital controls could result from the policies being poorly enforced, poorly calibrated, poorly communicated, poorly timed, or poorly implemented in any other way. In a similar vein, Fernandez et al (2015) find that policy-makers do not adjust capital controls over the business cycle, therefore they fail to adjust them to changes in systemic risk.

Figure 16. Demand Shock for the Endogenous Crisis Model with Capital Controls



Notes: By raising both the interest rate and the foreign debt tax the policy-maker is able to stabilize both output and the exchange rate, eliminating any effect of the shock on crisis probability. The policy-maker is able to reach the first best.

In summary, the existence of regulatory arbitrage, of imperfections in the implementation of capital control policies, and the inability to timely adjust them along the business cycle all suggest that such policies may be ineffective in fully tackling the effect of capital flows on domestic financial variables. In other words, the model presented in this section, in which the foreign debt tax can be used to completely eliminate the effect of capital flows on systemic risk, may overstate the effectiveness of capital controls. In this context, and given that the effectiveness of capital controls seems circumstance-specific, the analysis undertaken in sections 4 and 5 still is of extremely relevance.

7. Conclusions

The financial turmoil of 2007-2008 has renewed policy-makers' and scholars' interest in the relationship between monetary policy and financial stability. According to the "lean against the wind" view, central banks should take into account financial stability concerns when taking monetary policy decisions. In particular, central banks should increase interest rates in the expansionary phases of the financial cycle to reduce the accumulation of financial imbalances and to dampen systemic risk. Ajello et al (2015) show that this is the case in a formal model, even though the adjustment of monetary policy due to financial concerns is quantitatively small.

Most of the literature on the relationship between monetary policy and financial stability has concentrated on advanced economies. However, there are good reasons to think that such relationship is quite different in small open economies subject to important fluctuations in capital flows. In fact, higher interest rates can end up attracting foreign capital and, through this channel, increasing credit availability, leverage and systemic risk. In this paper, we have extended the framework analyzed by Ajello (2015) to a small open economy and, calibrating the model for Mexico, we have obtained that central banks in such economies should reduce rather than increase interest rates during the expansionary phase of the financial cycle. Our results suggest that a "leaning against the wind" policy is not suited for small open economies and may end up worsening rather than improving financial stability.

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Appendix

The model

In this section of the appendix, we describe the model again, providing more detail. We consider a small open economy that takes global interest rates and global demand for its output as given. The domestic economy is modelled following Curdia and Woodford (2016) and there are two types of domestic financial assets in which households can trade. First, households can sign state-contingent contracts that insure them against both aggregate and idiosyncratic risk. However, they can only receive transfers from the insurance agency intermittently, with probability $1-\delta$. At all other points in time, i.e. with probability δ, they can only trade one-period credit contracts. In this sense, domestic financial markets are incomplete.

A market for credit contracts exists because households in the domestic economy are of two types according to the parameterization of their utility function, which allows to ensure that some households want to lend and others want to borrow in domestic financial markets, in a way that is better specified below. Following Curdia and Woodford (2016), we assume that only when they have access to insurance markets, households face a positive probability of switching type, i.e. they can pass from being a borrower to being a saver, or vice versa. Curdia and Woodford (2016) show that under the assumption that initial wealth levels are the same for all households, the optimal insurance contract ensures that all households able to receive transfers from the insurance company at time t will begin time $t+1$ with the same wealth level. This allows to limit heterogeneity to two household types, without tracking the whole wealth distribution. Notice that, contrary to Curdia and Woodford (2016), we assume that there is no friction in domestic financial intermediation, i.e. the interest rate that borrowers pay on the credit contract is equal to the interest rate that savers receive.

The type of household i at time t is identified by the symbol τ_t^i which can be either s, for savers, or b for borrowers. Borrowers represent a share π^b of the population and savers a share $1-\pi^b$. Apart from being able to lend in domestic financial markets, savers also have access to global financial markets. Such markets are also assumed to be incomplete, in that a single bond denominated in foreign currency is traded. Borrowers are assumed to have no access to global financial markets.

Households supply labor and receive profits from domestic intermediate firms.[41] Using these incomes, and inherited wealth, households make their consumption and saving decisions. Both household types choose how to allocate consumption among domestic and foreign goods. Savers choose how to allocate their savings among domestic financial markets, in which they lend to

[41] We assume that labor can be supplied only to domestic firms, i.e. it is immobile across countries. Further, domestic firms are owned by domestic households, i.e. stock markets are country specific and there is no cross-country ownership.

borrowers, and global financial markets, in which they lend or borrow by trading the foreign currency bond.

In order to illustrate the maximization problem of domestic households it is useful to first show formally how their wealth evolves over time. Beginning of period real wealth for a generic household i, W_t^i, is:

$$W_t^i = R_{t-1}\frac{B_{t-1}^i}{\pi_t} + S_t^i + \frac{R_{t-1}^f B_{t-1}^{fi} X_t}{X_{t-1}},$$

where R is the nominal domestic interest rate, B^i is the real value of domestic credit inherited from the past, π is the inflation rate, S^i is the transfer that the household receives from the insurance agency, R^f is the interest rate on the foreign currency bond, B^f is the real value of the foreign currency bonds inherited from the past, and X is the real exchange rate. Of course, both B^i and S^i can be either positive or negative. However, S^i is equal to zero for all households that do not access insurance markets at time t, while it is different from zero for the ones that access them. B^f is equal to zero for households that were borrowers in period $t-1$. Household i's end of period assets, $B^i + B^f$ is:

$$B_t^i + B_t^{fi} = W_t^i + w_t l_t^i + D_t - c_t^i - T_t.$$

where w is the real wage, l^i are worked hours, D are real (per capita) firm profits, c^i is consumption, and T are (real) lump-sum taxes.

Given the description of wealth accumulation described above, we can write the problem of domestic household i as follows:

$$max\tilde{E}_0\sum_{t=1}^{\infty}\beta^{t-1}\left[\frac{C^{\tau_t^i}}{1-\sigma^{\tau_t^i}}\left(c_t^i\right)^{1-\sigma^{\tau_t^i}} - \frac{\chi^{\tau_t^i}}{2}\left(l_t^i\right)^2\right],$$

subject to

$$B_t^i + B_t^{fi} = R_{t-1}\frac{B_{t-1}^i}{\pi_t} + S_t^i + \frac{R_{t-1}^f B_{t-1}^{fi} X_t}{X_{t-1}} + w_t l_t^i + D_t - c_t^i - T_t. \qquad (31)$$

Borrowers, i.e. type $\tau_t = b$ households, also have to respect the following constraint:

$$B_t^{fi} = 0.$$

In the above, utility is increasing in consumption, c, and decreasing in worked hours, l. Parameter $\sigma^{\tau_t^i}$ is the inverse of the intertemporal elasticity of substitution, $C^{\tau_t^i}$ is a parameter that affects taste for current consumption, and $\chi^{\tau_t^i}$ governs taste for leisure. Borrowers are assumed to have a higher taste for current consumption and a higher elasticity of intertemporal substitution than savers. Taste for leisure is assumed to differ between agent types only to ensure that they work the same amount of time in steady state, as in Curdia and Woodford (2016). Indexation by τ_t indicates that these are the parameters that can change value over time for each agent i.

It is important at this point to define total domestic credit, b, as follows:

$$b_t = \int_{\pi^b}^{1} B_t^i di = -\int_{0}^{\pi^b} B_t^i di\,; \tag{32}$$

and the total amount of foreign assets held by savers as:

$$b_t^f = \int_{\pi^b}^{1} B_t^{fi} di. \tag{33}$$

Given the ability of households to sign insurance contracts, Curdia and Woodford (2016) show that all savers hold the same amount of wealth and all borrowers issue the same amount of debt, which implies that:

$$\frac{b_t}{1-\pi^b} = B_t^s; \frac{b_t}{\pi^b} = -B_t^b;$$

and

$$\frac{b_t^f}{1-\pi^b} = B_t^{fs}.$$

The optimality conditions of the problem of households are the following:

$$\lambda_t^i = C^{\tau_t^i} c_1^{i\,-\sigma^{\tau_t^i}};$$

$$w_t = \frac{\chi^{\tau_t^i} l_t^i}{\lambda_t^i};$$

$$\frac{1}{R_t} = \beta \tilde{E}_t \frac{\lambda_{t+1}^i}{\lambda_t^i \pi_{t+1}}. \tag{34}$$

Savers also optimize with respect to foreign asset holdings, which gives rise to the following additional first order condition:

$$\frac{1}{R_t^f} = \beta \tilde{E}_t \left(\frac{\frac{\lambda_{t+1}^i}{\lambda_t^s} X_{t+1}}{X_t} \right). \tag{35}$$

Under the assumption that initial wealth levels are the same for all households, Curdia and Woodford (2016) show that

$$\tilde{E}_t \lambda_{t+1}^i = \tilde{E}_t \{ [\delta + (1-\delta)\pi^b] \lambda_{t+1}^b + (1-\delta)(1-\pi^b) \lambda_{t+1}^s \}$$

for households that are borrowers at time t and

$$\tilde{E}_t \lambda_{t+1}^i = \tilde{E}_t \{ [\delta + (1-\delta)(1-\pi^b)] \lambda_{t+1}^s + (1-\delta)\pi^b \lambda_{t+1}^b \},$$

for households that are savers at time t. Hence, equation (34) can be rewritten as

$$\frac{1}{R_t} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)\pi^b] \lambda_{t+1}^b + (1-\delta)(1-\pi^b) \lambda_{t+1}^s}{\lambda_t^b \pi_{t+1}} \tag{36}$$

for borrowers and as

$$\frac{1}{R_t} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)(1-\pi^b)] \lambda_{t+1}^s + (1-\delta)\pi^b \lambda_{t+1}^b}{\lambda_t^s \pi_{t+1}} \tag{37}$$

for savers. Equation (35) becomes:

$$\frac{1}{R_t^f} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)(1-\pi^b)] \lambda_{t+1}^s + (1-\delta)\pi^b \lambda_{t+1}^b}{\lambda_t^s} X_{t+1}/X_t. \tag{38}$$

Equations (36) and (37) clarify why it is necessary to have time-varying types. As $C^s \leq C^b$ and $\frac{1}{\sigma^s} \leq \frac{1}{\sigma^b}$, type $\tau_t = b$ agents know that they may like consumption less in the future, while type $\tau_t = s$ know that they may like it more.[42] Due to this, in equilibrium, type $\tau_t = b$ agents are borrowers, and type $\tau_t = s$ are savers at time one.

Households choose how to allocate consumption between domestic and foreign goods. The consumption basket for all domestic households is the following:

$$c_t^i = \left[(1-\gamma)^{\frac{1}{\eta}} c_{H,t}^{i \ \frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} c_{F,t}^{i \ \frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}.$$

[42] Notice that a different taste for current consumption would be sufficient to ensure this result even if all types had the same elasticity of intertemporal substitution. We allow for different elasticities of intertemporal substitution because, as explained by Curdia and Woodford (2016), this allows to capture the fact that reductions in the interest rate imply higher credit levels.

If domestic households are not interested in consuming foreign goods, which happens for $\gamma = 0$, the model collapses to a closed economy framework. On the contrary, if γ is close to one, the home economy is completely open, in the sense that home produced goods represent a negligible share of the households' consumption basket. η is the elasticity of substitution between domestic and foreign goods and it is set to one in the main text, which implies that the consumption basket is Cobb-Douglas. Total expenditure has to satisfy the following equation:

$$c_t^i = p_{H,t} c_{H,t}^i + X_t c_{F,t}^i \tag{39}$$

and the optimal allocation implies the following conditions:

$$c_{H,t}^i = (1-\gamma)\left(p_{H,t}\right)^{-\eta} c_t^i \tag{40}$$

and

$$c_{F,t}^i = \gamma (X_t)^{-\eta} c_t^i; \tag{41}$$

where p_H is the real price of the domestic good, i.e. the ratio between the price of the domestically produced good and the price of the consumption basket.

Exports are assumed to be governed by the following equation:

$$EXP_t = \gamma \left(\frac{p_{H,t}}{X_t}\right)^{-\nu}; \tag{42}$$

where ν is the elasticity of exports to the terms of trade.

As in Curdia and Woodford (2016), the firm sector is as in the standard New Keynesian model. There are intermediate firms that produce differentiated goods, indexed by j, under monopolistic competition and final good firms that aggregate such goods to produce the domestic final consumption good, y_H. As is well known, this is equivalent to assuming that households consume a basket of differentiated goods directly. Owners of domestic firms are borrowers and savers in equal shares, which implies that a share $1 - \pi^b$ of firms is owned by savers and a share π^b is owned by borrowers.

Intermediate firms choose the price of their good, labor demand, and production levels. Final good firms choose the amount of each intermediate good to buy and the amount of final good to produce. They take the price of the final good as given, due to perfect competition.

The production function of final good firms is a standard Dixit-Stiglitz aggregator:

$$y_{H,t} = \left[\int_0^1 y_{j,t}^{\frac{\zeta-1}{\zeta}} dj\right]^{\frac{\zeta}{\zeta-1}}$$

where ζ is the elasticity of substitution among differentiated goods. Profit maximization on the part of final good firms gives rise to the following demand for the differentiated good j

$$y_{j,t} = \left(\frac{p_{j,t}}{p_{H,t}}\right)^{-\zeta} y_{H,t} \tag{43}$$

where p_j is the real price of good j and p_H was defined above.

The problem of intermediate good firm j is to choose $p_{j,t}$, $y_{j,t}$ and $l_{j,t}$ to:

$$\max \tilde{E}_0 \sum_{t=1}^{\infty} \Omega_{1,t}\left[p_{j,t}y_{j,t} - (1+\tau)w_t l_{j,t} - \frac{\chi_P}{2}\left(\frac{p_{j,t}}{p_{j,t-1}}\pi_t - 1\right)^2 p_{H,t}y_{H,t}\right] \tag{44}$$

subject to

$$y_{j,t} = l_{j,t} \tag{45}$$

and to equation (43). The term $\frac{\chi_P}{2}\left(\frac{p_{j,t}}{p_{j,t-1}}\pi_t - 1\right)^2 p_{H,t}y_{H,t}$ represents a quadratic Rotemberg price adjustment cost, expressed in real terms. Ω is a stochastic discount factor, whose form is assumed to be $\Omega_{t,t+1} = \frac{\beta\left((1-\pi^b)\lambda_{t+1}^s + \pi^b\lambda_{t+1}^b\right)}{(1-\pi^b)\lambda_t^s + \pi^b\lambda_t^b}$: as firms are owned by both savers and borrowers in shares equal to their proportion over the Home population, an average of their marginal utilities is employed to discount profits. We assume that firms receive an employment subsidy, whose rate is τ, which is financed through lump-sum taxes on households and which eliminates the distortionary effect of monopolistic competition on production in the steady state.[43]

After substituting equation (43) in (44) and in (45), and optimizing with respect to $p_{j,t}$ and to $l_{j,t}$ one gets:

$$(1-\zeta)\frac{p_{j,t}^{1-\zeta}}{p_{H,t}^{-\zeta}} + \mu_t\zeta\frac{p_{j,t}^{-\zeta}}{p_{H,t}^{-\zeta}} - \chi_p\left(\frac{p_{j,t}}{p_{j,t-1}}\pi_t - 1\right)\frac{p_{j,t}}{p_{j,t-1}}\pi_t$$
$$+ \tilde{E}_t\frac{\Omega_{t,t+1}\left(\frac{p_{j,t+1}}{p_{j,t}}\pi_{t+1} - 1\right)\frac{p_{j,t+1}}{p_{j,t}}\pi_{t+1}\left(p_{H,t+1}y_{H,t+1}\right)}{p_{H,t}y_{H,t}} = 0$$

and

[43] This is commonly assumed in the New-Keynesian literature, as for example in Rotemberg and Woodford (1998). This assumption allows to obtain an efficient steady state in which the adverse effect of monopolistic competition on employment is absent. The latter result helps when computing the optimal policy with a micro-founded loss function. Even if we do not need this assumption here, we keep it to remain closer to the literature on optimal monetary policy.

$$(1+\tau)w_t = \mu_t;$$

where μ is the Lagrange multiplier on constraint (45). In a symmetric equilibrium, all firms set the same price and hire the same amount of labor. Combining the two optimality conditions, and taking into account that the subsidy is set in a way that eliminates the effect of monopolistic competition on labor demand, i.e. $\tau = \frac{\zeta-1}{\zeta} - 1$, one obtains:

$$\begin{aligned} w_t = p_{H,t} &+ \frac{\chi_P}{\zeta-1}(\pi_{H,t}-1)\pi_{H,t} \\ &- \frac{\chi_P}{\zeta-1}\tilde{E}_t\Omega_{t,t+1}\left[\frac{(\pi_{H,t+1}-1)\pi_{H,t+1}p_{H,t+1}y_{H,t+1}}{p_{H,t}y_{H,t}}\right] \end{aligned} \tag{46}$$

In equation (46), $\pi_{H,t} = p_{H,t}/p_{H,t-1}\pi_t$ is domestic price inflation. In the absence of sticky prices, (46) would collapse to $w_t = p_{H,t}$, i.e. the real wage (which is also equal to real marginal costs) is equal to the real price. When prices are sticky, a positive shock to demand, which puts upward pressure on output and inflation, increases the real wage above the real price, because firms find it difficult to raise their price. Instead, if they expect higher demand, and hence higher inflation, tomorrow, they start increasing their price today above the real wage, in order to smooth costly price adjustment over time. Aggregation also implies that:

$$y_{H,t} = l_t = (1-\pi^b)l_t^s + \pi^b l_t^b. \tag{47}$$

Total firm profits are

$$D_t = p_{H,t}y_{H,t} - (1+\tau)w_t l_t - \frac{\chi_P}{2}(\pi_{H,t}-1)^2 p_{H,t}y_{H,t}. \tag{48}$$

The home final good market clearing condition implies that:

$$y_{H,t} = \pi^b c_{H,t}^b + (1-\pi^b)c_{H,t}^s + EXP_t + \frac{\chi_P}{2}(\pi_{H,t}-1)^2 y_{H,t}. \tag{49}$$

Multiplying equation (49) on both sides by p_H and taking into account equation (39) one gets

$$\begin{aligned} p_{H,t}y_{H,t} = \pi^b c_t^b &+ (1-\pi^b)c_t^s + p_{H,t}EXP_t \\ &- X_t\left[\pi^b c_{F,t}^b + (1-\pi^b)c_{F,t}^s\right] + \frac{\chi_P}{2}(\pi_{H,t}-1)^2 p_{H,t}y_{H,t}. \end{aligned} \tag{50}$$

Equation (50) is the standard aggregate resource constraint that states that home gross domestic product, $p_H y_H$, is equal to consumption, $\pi^b c^b + (1-\pi^b)c^s$, plus exports, $p_H EXP$, minus imports, $X[\pi^b c_F^b + (1-\pi^b)c_F^s]$, all expressed in real terms. The equation is corrected for the presence of price adjustment costs. For later use, we define real GDP, y, as follows:

$$y_t = p_{H,t} y_{H,t}.$$

Using equations (31), (32), (33), and (50) one can show that:

$$\begin{aligned} p_{H,t}EXP_t - X_t\left[\pi^b c_{F,t}^b + (1-\pi^b)c_{F,t}^s\right] + \frac{\left(R_{t-1}^f - 1\right)X_t}{X_{t-1}} b_{t-1}^f \\ = b_t^f - X_t/X_{t-1} b_{t-1}^f. \end{aligned} \quad (51)$$

Equation (51) states that the current account, given by the sum of the trade balance, $p_{H,t}EXP_t - X_t\left[\pi^b c_{F,t}^b + (1-\pi^b)c_{F,t}^s\right]$, and net interest income from abroad, $\frac{\left(R_{t-1}^f - 1\right)X_t}{X_{t-1}} b_{t-1}^f$, must equal inverse capital flows, given by the change in the value of international bonds held by domestic households, $b_t^f - X_t/X_{t-1} b_{t-1}^f$.

Now, we describe the aggregate demand block of the economy, which will be used to obtain the log-linear IS curve. It is composed of the following equations:

$$\lambda_t^b = C^b c_t^{b^{-\sigma^b}};$$

$$\frac{1}{R_t} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)\pi^b]\lambda_{t+1}^b + (1-\delta)(1-\pi^b)\lambda_{t+1}^s}{\lambda_t^b \pi_{t+1}};$$

$$\lambda_t^s = C^s c_t^{s^{-\sigma^s}}$$

$$\frac{1}{R_t} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)(1-\pi^b)]\lambda_{t+1}^s + (1-\delta)\pi^b \lambda_{t+1}^b}{\lambda_t^s \pi_{t+1}};$$

which are present in both the general (open economy) version of the model and in the closed economy version and which determine how much households value current versus future consumption. The following equations instead are present only in the open economy model:

$$c_{H,t}^i = (1-\gamma)\left(p_{H,t}\right)^{-\eta} c_t^i$$

$$c_{F,t}^i = \gamma (X_t)^{-\eta} c_t^i;$$

$$EXP_t = \gamma \left(\frac{p_{H,t}}{X_t}\right)^{-\nu};$$

and allow to obtain the net-exports contribution to aggregate demand. Finally, the aggregate demand block of the economy is closed by the aggregate resource constraint:

$$p_{H,t}y_{H,t} = \pi^b c_t^b + (1-\pi^b)c_t^s + p_{H,t}EXP_t - X_t\left[\pi^b c_{F,t}^b + (1-\pi^b)c_{F,t}^s\right] + \frac{\chi_P}{2}\left(\pi_{H,t}-1\right)^2 p_{H,t}y_{H,t};$$

which in a closed economy takes the form $y_t = \pi^b c_t^b + \left(1-\pi^b\right)c_t^s + \frac{\chi_P}{2}(\pi_t - 1)^2 y_t$.

The aggregate supply block of the economy, and as a consequence the Phillips curve, can be obtained from the following equations:

$$w_t = \frac{\chi^b l_t^b}{\lambda_t^b} \tag{52}$$

$$w_t = \frac{\chi^s l_t^s}{\lambda_t^s} \tag{53}$$

$$y_{H,t} = l_t = \left(1-\pi^b\right)l_t^s + \pi^b l_t^b$$

which determine the labor supply of households and hence output, and by

$$w_t = p_{H,t} + \frac{\chi_P}{\zeta - 1}\left(\pi_{H,t}-1\right)\pi_{H,t} - \frac{\chi_P}{\zeta-1}\tilde{E}_t\Omega_{t,t+1}\left[\frac{\left(\pi_{H,t+1}-1\right)\pi_{H,t+1}p_{H,t+1}y_{H,t+1}}{p_{H,t}y_{H,t}}\right],$$

which governs the evolution of price mark-ups. In a closed economy the latter equation becomes:

$$w_t = 1 + \frac{\chi_P}{\zeta-1}(\pi_t - 1)\pi_t - \frac{\chi_P}{\zeta-1}\tilde{E}_t\Omega_{t,t+1}\left[\frac{(\pi_{t+1}-1)\pi_{t+1}y_{t+1}}{y_t}\right].$$

In an open economy, it is necessary to add a global financial market block, which is:

$$\frac{1}{R_t^f} = \beta\tilde{E}_t\frac{[\delta + (1-\delta)(1-\pi^b)]\lambda_{t+1}^s + (1-\delta)\pi^b\lambda_{t+1}^b}{\lambda_t^s}X_{t+1}/X_t$$

and which will give rise to an uncovered interest parity condition when log-linearized.

When considering the model versions with endogenous crisis probability, it is also necessary to add a credit accumulation block. The latter is described by

$$c_t^s + \frac{b_t}{(1-\pi^b)} - \delta\frac{\frac{R_{t-1}}{\pi_t}b_{t-1}}{(1-\pi^b)} + \frac{b_t^f}{(1-\pi^b)} - \frac{1-\pi^b+\delta\pi^b}{1-\pi^b}\frac{R_{t-1}^f b_{t-1}^f X_t}{X_{t-1}} = w_t l_t^s + D_t - T_t,$$

which is obtained by summing equation (31) over the interval $(\pi^b, 1]$ and where c^s is the average consumption of savers, and by

$$p_{H,t}EXP_t - X_t\left[\pi^b c_{F,t}^b + \left(1-\pi^b\right)c_{F,t}^s\right] + \frac{\left(R_{t-1}^f - 1\right)X_t}{X_{t-1}}b_{t-1}^f = b_t^f - \frac{X_t}{X_{t-1}}b_{t-1}^f.$$

These equations describe how credit evolves using the average consumption of savers and equality between the current account and capital flows. In a closed economy, the average consumption of savers is sufficient, and has the following form:

$$c_t^s + \frac{b_t}{(1-\pi^b)} - \delta\frac{\frac{R_{t-1}}{\pi_t}b_{t-1}}{(1-\pi^b)} = w_t l_t^s + D_t - T_t.$$

Steady state

The model described in the previous section is non-linear. In order to log-linearize it and obtain a form for the open economy model that is analogous to that employed by Ajello et al (2015), we first have to compute its steady state.

As we show below, the values of the parameters governing taste for leisure, χ^b and χ^s, can be set in such a way to make sure that at the steady state, $\bar{l}_1^b = \bar{l}_1^s = 1$.[44] From the production function (47), we obtain that

$$\bar{y}_H = \bar{l}^s = \bar{l}^b = 1. \tag{54}$$

Assuming that $\bar{b}^f = 0$, i.e. that steady state foreign assets are equal to zero, and using equation (51), one can show that

$$\bar{p}_H\overline{EXP} = \bar{X}\bar{c}_F = \bar{X}\left(\pi^b\bar{c}_F^b + \left(1-\pi^b\right)\bar{c}_F^s\right). \tag{55}$$

where $\bar{c}_F = \pi^b\bar{c}_F^b + \left(1-\pi^b\right)\bar{c}_F^s$ is the total amount of foreign good imported from abroad. We assume that inflation is zero at the steady state, i.e. $\bar{\pi} = 1$. As domestic price inflation is defined as

[44] From now on, variables at the steady state are represented with a bar.

$\pi_{H,t} = p_{H,t}/p_{H,t-1}\pi_t$, in the steady state also $\bar{\pi}_{H,1} = 1$. So, using (55) and equation (50), one can show that

$$\bar{p}_H = \bar{c} = \pi^b \bar{c}^b + \left(1 - \pi^b\right)\bar{c}^s. \quad (56)$$

where $\bar{c} = \pi^b \bar{c}^b + \left(1 - \pi^b\right)\bar{c}^s$ is total consumption. Now, it is possible to combine (56) with (55), which after using (41) and (42) allows to obtain

$$\bar{X} = \bar{p}_H^{-\frac{\nu(1-\eta)}{1-\eta-\nu}}. \quad (57)$$

Substituting (40) and (41) in (39), one gets another relationship between the real exchange rate and the real domestic price:

$$1 = (1-\gamma)\bar{p}_H^{1-\eta} + \gamma \bar{X}^{1-\eta}. \quad (58)$$

The solution of the system of equations (57) and (58) is of course $\bar{p}_H = \bar{X} = 1$. Using equation (56) one obtains that

$$\bar{c} = 1. \quad (59)$$

In the main text, s^s and s^b are respectively defined as the ratios between the consumption of savers and aggregate consumption, and the ratio between the consumption of borrowers and aggregate consumption. Given (59), we get:

$$\bar{c}^s = s^s$$

and

$$\bar{c}^b = s^b.$$

Similarly, from equations (40), (41) and (42), one can obtain:

$$\bar{c}_H^s = (1-\gamma)s^s;$$

$$\bar{c}_F^s = \gamma s^s;$$

$$\bar{c}_H^b = (1-\gamma)s^b;$$

$$\bar{c}_F^b = \gamma s^b;$$

and

$$\overline{EXP} = \gamma.$$

Equation (46) can be used to obtain

$$\bar{w} = \bar{p}_H = 1.$$

As we calibrate the steady state value of domestic credit to $\bar{b}$, we then use the following system of equations

$$\frac{1}{\bar{R}} = \beta \frac{[\delta + (1-\delta)\pi^b]\bar{\lambda}^b + (1-\delta)(1-\pi^b)\bar{\lambda}^s}{\bar{\lambda}^b}$$

$$\frac{1}{\bar{R}} = \beta \frac{[\delta + (1-\delta)(1-\pi^b)]\bar{\lambda}^s + (1-\delta)\pi^b\bar{\lambda}^b}{\bar{\lambda}^s};$$

to solve for $\bar{R}$ and for one parameter among C^b and C^s, while setting the other to one. In fact, only the ratio between the tastes for current consumption of borrowers and of savers matters for the determination of domestic credit levels. In practice, such ratio is set to ensure that the consumption levels of the two household types are equal to the parameterization given by s^s and s^b.

At this point, equations (52) and (53) can be used to obtain

$$\chi^b = C^b {s^b}^{-\sigma^b}$$

$$\chi^s = C^s {s^s}^{-\sigma^b}.$$

Log-Linearization

We log-linearize the model under the assumption that δ is close to one, as this allows to simplify the derivation of the log-linear system. Furthermore, given that our objective is only to use the micro-foundations as a means useful to build an open economy version of the framework employed by Ajello et al (2015), we want to capture the basic structural framework behind the open economy model and not take account of all its details. In fact, δ is calibrated to a number close to one in Curdia and Woodford (2016), which suggests that savers and borrowers switch types infrequently. Ignoring this switch in our two period version of the log-linear model is unlikely to be costly from the point of view of the numerical results and buys us a lot of clarity from the point of view of the intuition behind our log-linear relation.

The first step of the log-linearization is obtaining the IS curve from the aggregate demand block presented in the previous sections. To do so, we first consider equations

$$\lambda_t^b = C^b c_t^{b^{-\sigma^b}};$$

$$\lambda_t^s = C^s c_t^{s^{-\sigma^s}}.$$

Taking logs on both sides and subtracting the log of each variable at the approximation point, on obtains:

$$\hat{\lambda}_t^i = -\sigma^i \hat{c}_t^i, \tag{60}$$

where $i = b, s$ and where for any variable x we have $\hat{x} = \log(\frac{x}{\bar{x}})$. Then, consider the equations

$$\frac{1}{R_t} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)(1-\pi^b)]\lambda_{t+1}^s + (1-\delta)\pi^b \lambda_{t+1}^b}{\lambda_t^s \pi_{t+1}}$$

$$\frac{1}{R_t} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)\pi^b]\lambda_{t+1}^b + (1-\delta)\left(1-\pi^b\right)\lambda_{t+1}^s}{\lambda_t^b \pi_{t+1}};$$

Their log-linear versions, under the assumption that $\delta \to 1$, are:

$$-\hat{R}_t = \tilde{E}_1 \hat{\lambda}_{t+1}^s - \hat{\lambda}_t^s - \tilde{E}_t \hat{\pi}_{t+1}. \tag{61}$$

and

$$-\hat{R}_t = \tilde{E}_t \hat{\lambda}_{t+1}^b - \hat{\lambda}_t^b - \tilde{E}_1 \hat{\pi}_{t+1}. \tag{62}$$

Under the assumption that initial wealth levels are equal for all agents, equations (61) and (62) imply that the marginal utilities of the two agent types are always equal:

$$\hat{\lambda}_t^b = \hat{\lambda}_t^s. \tag{63}$$

Hence, we can drop the type index, and simply refer to $\hat{\lambda}$ as marginal utility. Given the latter fact, equation (61) can be re-written as follows:

$$\hat{\lambda}_t = \tilde{E}_t \hat{\lambda}_{t+1} + \hat{R}_t - \tilde{E}_t \hat{\pi}_{t+1}. \tag{64}$$

The next step is the log-linearization of the aggregate resource constraint (50), which after combining it with equations (41) and (42), can be re-written as:

$$y_t = (1-\pi^b)c_t^s + \pi^b c_t^b + \gamma p_{H,t}^{1-\nu} X_t^{\nu} - \gamma X_t^{1-\eta}\left((1-\pi^b)c_t^s + \pi^b c_t^b\right) + \frac{\chi_P}{2}\left(\pi_{H,t}-1\right)^2 y_t;$$

Now, we assume that the domestic consumption basket is Cobb-Douglas, i.e. $\eta = 1$, which allows to obtain:

$$y_t = (1-\gamma)\left((1-\pi^b)c_t^s + \pi^b c_t^b\right) + \gamma p_{H,t}^{1-\nu} X_t^{\nu} + \frac{\chi_P}{2}\left(\pi_{H,t}-1\right)^2 y_t.$$

The above equation can be log-linearized to obtain:

$$\hat{y}_t = (1-\gamma)\left(\pi^b s^b \hat{c}_t^b + (1-\pi^b)s^s \hat{c}_t^s\right) + \gamma\left((1-\nu)\hat{p}_{H,t} + \nu \hat{X}_t\right).$$

Consider now equation (58), which in log-linear terms can be written as $\hat{p}_{H,t} = -\frac{\gamma}{1-\gamma}\hat{X}_t$. Given this, the above equation can be written as follows

$$\hat{y}_t = (1-\gamma)\left(\pi^b s^b \hat{c}_t^b + (1-\pi^b)s^s \hat{c}_t^s\right) + \frac{\gamma(\nu-\gamma)}{1-\gamma}\hat{X}_t.$$

Then, using equations (60) and (63), we can write:

$$y_t = -(1-\gamma)\left(\frac{\pi^b s^b}{\sigma^b} + \frac{(1-\pi^b)s^s}{\sigma^s}\right)\hat{\lambda}_t + \frac{\gamma(\nu-\gamma)}{1-\gamma}\hat{X}_t. \tag{65}$$

So, defining the additional parameter:

$$\bar{\sigma} = \left[\frac{\pi^b s^b}{\sigma^b} + \frac{(1-\pi^b)s^s}{\sigma^s}\right],$$

equation (65) can be written as:

$$\hat{\lambda}_t = -\frac{1}{(1-\gamma)\bar{\sigma}}\hat{y}_t + \frac{1}{(1-\gamma)\bar{\sigma}}\frac{\gamma(\nu-\gamma)}{1-\gamma}\hat{X}_t. \tag{66}$$

Combining the above equation with (64), delivers

$$-\frac{1}{(1-\gamma)\bar{\sigma}}\hat{y}_t+\frac{1}{(1-\gamma)\bar{\sigma}}\frac{\gamma(\nu-\gamma)}{1-\gamma}\hat{X}_t$$
$$=\tilde{E}_1\left[-\frac{1}{(1-\gamma)\bar{\sigma}}\hat{y}_{t+1}+\frac{1}{(1-\gamma)\bar{\sigma}}\frac{\gamma(\nu-\gamma)}{1-\gamma}\hat{X}_{t+1}\right]+\hat{R}_t-\tilde{E}_1\hat{\pi}_{t+1}$$

Rearranging the equation above, we obtain the IS curve:

$$\hat{y}_t=\tilde{E}_1\hat{y}_{t+1}-\frac{\gamma(\nu-\gamma)}{1-\gamma}\left(\tilde{E}_1\hat{X}_{t+1}-\hat{X}_t\right)-(1-\gamma)\bar{\sigma}\left(\hat{R}_t-\tilde{E}_1\hat{\pi}_{t+1}\right). \tag{67}$$

To obtain the closed economy version of (67), it is sufficient to set $\gamma=0$:

$$\hat{y}_t=\tilde{E}_1\hat{y}_{t+1}-\bar{\sigma}\left(\hat{R}_t-\tilde{E}_1\hat{\pi}_{t+1}\right).$$

To obtain the Phillips curve, we now switch to the aggregate supply block of the model. It is useful to begin with the labor supplies:

$$w_t=\frac{\chi^b l_t^b}{\lambda_t^b}$$

$$w_t=\frac{\chi^s l_t^s}{\lambda_t^s}$$

which in log-linear terms are:

$$\hat{l}_t^i=\hat{\lambda}_t^i+\hat{w}_t; \tag{68}$$

where $i=b,s$. Next, consider the production function

$$y_{H,t}=l_t=\left(1-\pi^b\right)l_t^s+\pi^b l_t^b;$$

which in log-linear terms is:

$$\hat{y}_{H,t}=\hat{l}_t=\left(1-\pi^b\right)\hat{l}_t^s+\pi^b\hat{l}_t^b. \tag{69}$$

From equation (68) and (63), it is easy to see that $\hat{l}_t^b=\hat{l}_t^s$, and so we will drop the type index and refer to labor supply simply as $\hat{l}_t$. The following step is the log-linearization of the pricing equation:

$$w_t=p_{H,t}+\frac{\chi_P}{\zeta-1}\left(\pi_{H,t}-1\right)\pi_{H,t}-\frac{\chi_P}{\zeta-1}\tilde{E}_1\Omega_{t,t+1}\left[\frac{\left(\pi_{H,t+1}-1\right)\pi_{H,t+1}p_{H,t+1}y_{H,t+1}}{p_{H,t}y_{H,t}}\right].$$

The above equation in log-linear terms is:

$$\hat{w}_t = \hat{p}_{H,t} + \frac{\chi_P}{\zeta - 1}\hat{\pi}_{H,t} - \beta\frac{\chi_P}{\zeta - 1}\tilde{E}_t\hat{\pi}_{H,t+1}.$$

Using (68) and (69), the latter equation can be re-written as:

$$\hat{y}_{H,t} - \hat{\lambda}_t = \hat{p}_{H,t} + \frac{\chi_P}{\zeta - 1}\hat{\pi}_{H,t} - \beta\frac{\chi_P}{\zeta - 1}\tilde{E}_t\hat{\pi}_{H,t+1}.$$

Using (66), adding $\hat{p}_{H,t}$ on both sides and taking into account that $\hat{p}_{H,t} = -\frac{\gamma}{1-\gamma}\hat{X}_t$, the above equation becomes:

$$\hat{y}_t + \frac{1}{(1-\gamma)\bar{\sigma}}\hat{y}_t - \frac{1}{(1-\gamma)\bar{\sigma}}\frac{\gamma(\nu-\gamma)}{1-\gamma}\hat{X}_t = -2\frac{\gamma}{1-\gamma}\hat{X}_t + \frac{\chi_P}{\zeta - 1}\hat{\pi}_{H,t} - \beta\frac{\chi_P}{\zeta - 1}\tilde{E}_t\hat{\pi}_{H,t+1}.$$

Rearranging it, one obtains:

$$\hat{\pi}_{H,t} = \frac{\zeta - 1}{\chi_P}\frac{\gamma}{1-\gamma}\left(2 - \frac{(\nu-\gamma)}{(1-\gamma)\bar{\sigma}}\right)\hat{X}_t + \frac{\zeta - 1}{\chi_P}\frac{(1-\gamma)\bar{\sigma}+1}{(1-\gamma)\bar{\sigma}}\hat{y}_t + \beta\tilde{E}_t\hat{\pi}_{H,t+1} \qquad (70)$$

Now, recall that the relationship between inflation, the real domestic price and domestic price inflation is $\pi_{H,t} = p_{H,t}/p_{H,t-1}\pi_t$, which in log-linear terms becomes $\hat{\pi}_{H,t} = \hat{p}_{H,t} - \hat{p}_{H,t-1} + \hat{\pi}_t$. Using this relationship and recalling that $\hat{p}_{H,t} = -\frac{\gamma}{1-\gamma}\hat{X}_t$, equation (70) becomes

$$\hat{\pi}_t = \frac{\gamma}{1-\gamma}\left(\hat{X}_t - \hat{X}_{t-1}\right) + \frac{\zeta - 1}{\chi_P}\frac{\gamma}{1-\gamma}\left(2 - \frac{(\nu-\gamma)}{(1-\gamma)\bar{\sigma}}\right)\hat{X}_t + \frac{\zeta - 1}{\chi_P}\frac{(1-\gamma)\bar{\sigma}+1}{(1-\gamma)\bar{\sigma}}\hat{y}_t$$
$$+ \beta\left[\tilde{E}_t\hat{\pi}_{t+1} - \frac{\gamma}{1-\gamma}\left(\tilde{E}_t\hat{X}_{t+1} - \hat{X}_t\right)\right].$$

Rearranging the latter equation, and defining $\varphi = \frac{\zeta-1}{\chi_P}$ delivers the Phillips curve:

$$\hat{\pi}_t = -\frac{\gamma}{1-\gamma}\hat{X}_{t-1} + \frac{\gamma}{1-\gamma}\left(1 + \beta + \varphi\left(2 - \frac{(\nu-\gamma)}{(1-\gamma)\bar{\sigma}}\right)\right)\hat{X}_t$$
$$+ \varphi\frac{(1-\gamma)\bar{\sigma}+1}{(1-\gamma)\bar{\sigma}}\hat{y}_t + \beta\left[\tilde{E}_t\hat{\pi}_{t+1} - \frac{\gamma}{1-\gamma}\tilde{E}_t\hat{X}_{t+1}\right]. \qquad (71)$$

In a closed economy, (71) collapses to:

$$\hat{\pi}_t = \varphi\frac{\bar{\sigma}+1}{\bar{\sigma}}\hat{y}_t + \beta[\tilde{E}_t\hat{\pi}_{t+1}].$$

The financial block of the economy can be obtained using the following equation:

$$\frac{1}{R_t^f} = \beta \tilde{E}_t \frac{[\delta + (1-\delta)(1-\pi^b)]\lambda_{t+1}^s + (1-\delta)\pi^b \lambda_{t+1}^b}{\lambda_t^s} X_{t+1}/X_t;$$

combining it (38), and recalling that $\delta \to 1$, one gets:

$$\frac{R_t}{R_t^f} = \tilde{E}_1 \left(\frac{X_{t+1}}{X_t \pi_{t+1}} \right).$$

Log-linearizing the latter equation gives:

$$\hat{\mathrm{R}}_{\mathrm{t}} - \hat{R}_t^f = \tilde{E}_t \hat{X}_{t+1} - \hat{X}_t + \tilde{E}_t \hat{\pi}_{t+1}; \tag{72}$$

which is the uncovered interest parity condition, in which the interest rate differential between the domestic and the foreign economy is equal to the expected nominal depreciation or, equivalently, to the expected real depreciation plus the expected inflation rate.

When crisis probability is endogenous, it is necessary to obtain the credit accumulation equation. To do this, start from the average consumption of savers, in which we substitute for equation (48). Recalling again that $\delta \to 1$:

$$c_t^s + \frac{b_t}{(1-\pi^b)} - \frac{\frac{R_{t-1}}{\pi_t}(b_{t-1})}{(1-\pi^b)} + \frac{b_t^f}{(1-\pi^b)} - \frac{\frac{R_{t-1}^f b_{t-1}^f}{(1-\pi^b)} X_t}{X_{t-1}}$$
$$= w_t l_t^s + y_t - (1+\tau_t) w_t l_t - \frac{\chi_P}{2}\left(\pi_{H,t} - 1\right)^2 y_t - T_t.$$

Using the fact that the subsidy is financed with taxes, i.e. $T_t = -\tau_t w_t l_t$, the above equation can be written as

$$c_t^s + \frac{b_t}{(1-\pi^b)} - \frac{\frac{R_{t-1}}{\pi_t}(b_{t-1})}{(1-\pi^b)} + \frac{b_t^f}{(1-\pi^b)} - \frac{\frac{R_{t-1}^f b_{t-1}^f}{(1-\pi^b)} X_t}{X_{t-1}}$$
$$= w_t l_t^s + y_t - w_t l_t - \frac{\chi_P}{2}\left(\pi_{H,t} - 1\right)^2 y_t. \tag{73}$$

Using the current account equals inverse capital flows condition, i.e.

$$p_{H,t} EXP_t - X_t\left[\pi^b c_{F,t}^b + \left(1-\pi^b\right) c_{F,t}^s\right] + \frac{\left(R_{t-1}^f - 1\right) X_t}{X_{t-1}} b_{t-1}^f = b_t^f - \frac{X_t}{X_{t-1}} b_{t-1}^f$$

and equation (50), equation (73) becomes

$$c_t^s + \frac{b_t}{(1-\pi^b)} - \frac{\frac{R_{t-1}}{\pi_t}(b_{t-1})}{(1-\pi^b)} + \frac{1}{1-\pi^b}(y_t - c_t) = w_t l_t^s + y_t - w_t l_t - \frac{\chi_P}{2}\left(\pi_{H,t}-1\right)^2 y_t.$$

After log-linearization, the latter equation becomes:

$$s^s \hat{c}_t^s + \frac{1}{1-\pi^b}\left(\tilde{b}_t - \frac{1}{\beta}\left(\hat{b}_{t-1} + b\hat{R}_{t-1} - b\hat{\pi}_t\right) + \hat{y}_t - \hat{c}_t\right) = \hat{y}_t; \tag{74}$$

Where we used the fact that $\hat{l}_t^b = \hat{l}_t^s = \hat{l}_t$. Further, we defined $b = \bar{b}$ and used the fact that $\bar{R} = 1/\beta$. Notice that domestic credit $\tilde{b}$ is represented with a tilde instead that with a hat because it is reported in deviations rather than log-deviations from the approximation point.

Rearranging equation (74), one can get:

$$\tilde{b}_t - \frac{1}{\beta}\left(\tilde{b}_{t-1} + b\hat{R}_{t-1} - b\hat{\pi}_t\right) = -\pi^b(\hat{y}_t - \hat{c}_t) - \left(1-\pi^b\right)(s^s\hat{c}_t^s - \hat{c}_t).$$

Using the fact that $\hat{c}_t = \left(1-\pi^b\right)s^s\hat{c}_t^s + \pi^b s^b \hat{c}_t^b$, the above equation can be rewritten as follows:

$$\begin{aligned}\tilde{b}_t - \frac{1}{\beta}&\left(\tilde{b}_{t-1} + b\hat{R}_{t-1} - b\hat{\pi}_t\right) \\ &= -\pi^b\left(\hat{y}_t - \left(1-\pi^b\right)s^s\hat{c}_t^s - \pi^b s^b \hat{c}_t^b\right) - \pi^b\left(1-\pi^b\right)\left(s^s\hat{c}_t^s - s^b\hat{c}_t^b\right).\end{aligned}$$

Using (60), the latter equation becomes:

$$\tilde{b}_t - \frac{1}{\beta}\left(\tilde{b}_{t-1} + b\hat{R}_{t-1} - b\hat{\pi}_t\right) = -\pi^b\left(\hat{y}_t + \bar{\sigma}\hat{\lambda}_t\right) - (1-\pi^b)\pi^b\left(\frac{s^b}{\sigma^b} - \frac{s^s}{\sigma^s}\right)\hat{\lambda}_t. \tag{75}$$

Now, one can use equation (66) to write:

$$\begin{aligned}\tilde{b}_t - \frac{1}{\beta}\left(\tilde{b}_{t-1} + b\hat{R}_{t-1} - b\hat{\pi}_t\right) &= -\pi^b\hat{y}_1 + \pi^b\bar{\sigma}\left(\frac{1}{(1-\gamma)\bar{\sigma}}\hat{y}_1 - \frac{1}{(1-\gamma)\bar{\sigma}}\frac{\gamma(\nu-\gamma)}{1-\gamma}\hat{X}_1\right) \\ &+ (1-\pi^b)\pi^b\left(\frac{s^b}{\sigma^b} - \frac{s^s}{\sigma^s}\right)\left(\frac{1}{(1-\gamma)\bar{\sigma}}\hat{y}_1 - \frac{1}{(1-\gamma)\bar{\sigma}}\frac{\gamma(\nu-\gamma)}{1-\gamma}\hat{X}_1\right).\end{aligned}$$

Rearranging, and defining the parameter

$$s_{\aleph} = \frac{\pi^b\left(1-\pi^b\right)\left[\frac{s^b}{\sigma^b} - \frac{s^s}{\sigma^s}\right]}{\bar{\sigma}};$$

we obtain:

$$\tilde{b}_t - \frac{1}{\beta}\left(\tilde{b}_{t-1} + b\hat{R}_{t-1} - b\hat{\pi}_t\right) = \frac{(1-\gamma)s_{\aleph} + \pi^b\gamma}{1-\gamma}\hat{y}_t - \frac{\gamma(\nu-\gamma)}{1-\gamma}\frac{s_{\aleph} + \pi^b}{1-\gamma}\hat{X}_t. \quad (76)$$

The closed economy version of the credit accumulation equation (76) is obtained by setting $\gamma = 0$:

$$\tilde{b}_t - \frac{1}{\beta}\left(b\hat{R}_{t-1} + \tilde{b}_{t-1} - b\hat{\pi}_t\right) = s_{\aleph}\hat{y}_t.$$

Optimization problem

As we explain in the main text, before solving the optimal policy problem, we reduce the model to a two-period framework. Hence, the policy-maker solves the following minimization problem:

$$\min \frac{1}{2}\left(\phi_y\hat{y}_1^2 + \phi_\pi\hat{\pi}_1^2\right) + \frac{1}{2}\beta P\left(\tilde{b}_1\right)\left(\phi_y\hat{y}_2(C)^2 + \phi_\pi\hat{\pi}_2(C)^2\right)/(1-\beta\tau)$$

subject to

$$\hat{y}_1 = \tilde{P}\left(\tilde{b}_1\right)\hat{y}_2(C) - \frac{\gamma(\nu-\gamma)}{1-\gamma}\left[\tilde{P}\left(\tilde{b}_1\right)\hat{X}_2(C) - \hat{X}_1\right] - (1-\gamma)\bar{\sigma}\left[\tilde{P}\left(\tilde{b}_1\right)\hat{X}_2(C) - \hat{X}_1\right] + \epsilon_1,$$

$$\hat{\pi}_1 = -\frac{\gamma}{1-\gamma}\hat{X}_0 + \frac{\gamma}{1-\gamma}\left(1 + \beta + \varphi\left(2 - \frac{(\nu-\gamma)}{(1-\gamma)\bar{\sigma}}\right)\right)\hat{X}_1 + \varphi\frac{(1-\gamma)\bar{\sigma}+1}{(1-\gamma)\bar{\sigma}}\hat{y}_1$$
$$+ \beta\left[\tilde{P}\left(\tilde{b}_1\right)\hat{\pi}_2(C) - \frac{\gamma}{1-\gamma}\tilde{P}\left(\tilde{b}_1\right)\hat{X}_2(C)\right],$$

$$\tilde{b}_1 - \frac{1}{\beta}\left(\tilde{b}_0 + b\hat{R}_0 - b\hat{\pi}_1\right) = \frac{(1-\gamma)s_{\aleph} + \pi^b\gamma}{1-\gamma}\hat{y}_1 - \frac{\gamma(\nu-\gamma)}{1-\gamma}\frac{(1-\gamma)s_{\aleph} + \pi^b}{1-\gamma}\hat{X}_1.$$

Notice that the first constraint is obtained after substituting the uncovered interest parity condition (72) in the IS curve (67). The second and third constraint are respectively the Phillips curve (71) and the credit accumulation equation (76). Given our assumptions about expectations of second period variables, for any variable x_2, $E_1x_2 = P\left(\tilde{b}_1\right)x_2(C) + \left(1 - P\left(\tilde{b}_1\right)\right)x_2(N) = P\left(\tilde{b}_1\right)x_2(C)$.

While the policy maker is assumed to know the real probability of the realization of the crisis state, $P\left(\tilde{b}_1\right)$; the private sector has a distorted perception of such probability, $\tilde{P}\left(\tilde{b}_1\right)$. In the main text we assume that $\tilde{P}\left(\tilde{b}_1\right) = 0$, which allows us to rewrite the problem of the policy-maker as follows:

$$\min \frac{1}{2}\left(\phi_y\hat{y}_1^2 + \phi_\pi\hat{\pi}_1^2\right) + \frac{1}{2}\beta P\left(\tilde{b}_1\right)\left(\phi_y\hat{y}_2(C)^2 + \phi_\pi\hat{\pi}_2(C)^2\right)/(1-\beta\tau)$$

subject to

$$\hat{y}_1 = \left(\frac{\gamma(\nu-\gamma)}{1-\gamma} + (1-\gamma)\bar{\sigma}\right)\hat{X}_1 + \epsilon_1,$$

$$\hat{\pi}_1 = -\frac{\gamma}{1-\gamma}\hat{X}_0 + \frac{\gamma}{1-\gamma}\left(1+\beta+\varphi\left(2-\frac{(\nu-\gamma)}{(1-\gamma)\bar{\sigma}}\right)\right)\hat{X}_1 + \varphi\frac{(1-\gamma)\bar{\sigma}+1}{(1-\gamma)\bar{\sigma}}\hat{y}_1$$

$$\tilde{b}_1 - \frac{1}{\beta}\left(\tilde{b}_0 + b\hat{R}_0 - b\hat{\pi}_1\right) = \frac{(1-\gamma)s_{\aleph} + \pi^b\gamma}{1-\gamma}\hat{y}_1 - \frac{\gamma(\nu-\gamma)}{1-\gamma}\frac{s_{\aleph}+\pi^b}{1-\gamma}\hat{X}_1.$$

Parameter τ takes values between zero and one, and is meant to capture the effect of the duration of financial crises on the welfare loss. When τ is equal to zero, the welfare loss is equivalent to that that would be obtained when the crisis lasts only one period; while when τ is one, the welfare loss is equivalent to that that would be obtained when the crisis lasts forever. Intermediate values allows to obtain crises whose durations are higher than one period but not infinite.

The Lagrangian of the problem is:

$$\begin{aligned}
L = &-\frac{1}{2}\left(\phi_y\hat{y}_1^2 + \phi_\pi\hat{\pi}_1^2\right) - \frac{1}{2}\beta P\left(\tilde{b}_1\right)\left(\phi_y\hat{y}_2(C)^2 + \phi_\pi\hat{\pi}_2(C)^2\right)/(1-\beta\tau) \\
&+ \lambda_1\left\{\left(\frac{\gamma(\nu-\gamma)}{1-\gamma} + (1-\gamma)\bar{\sigma}\right)\hat{X}_1 - \hat{y}_1 + \epsilon_1\right\} \\
&+ \lambda_2\left\{-\frac{\gamma}{1-\gamma}\hat{X}_0 + \frac{\gamma}{1-\gamma}\left(1+\beta+\varphi\left(2-\frac{(\nu-\gamma)}{(1-\gamma)\bar{\sigma}}\right)\right)\hat{X}_1 + \varphi\frac{(1-\gamma)\bar{\sigma}+1}{(1-\gamma)\bar{\sigma}}\hat{y}_1\right. \\
&\left. - \hat{\pi}_1\right\} \\
&+ \lambda_3\left\{\frac{(1-\gamma)s_{\aleph} + \pi^b\gamma}{1-\gamma}\hat{y}_1 - \frac{\gamma(\nu-\gamma)}{1-\gamma}\frac{s_{\aleph}+\pi^b}{1-\gamma}\hat{X}_1 - \tilde{b}_1 + \frac{1}{\beta}\left(\tilde{b}_0 + b\hat{R}_0^d - b\hat{\pi}_1\right)\right\}
\end{aligned}$$

The first order conditions with respect to output, inflation, the real exchange rate and domestic credit are, respectively:

$$-\phi_y\hat{y}_1 - \lambda_1 + \varphi\frac{(1-\gamma)\bar{\sigma}+1}{(1-\gamma)\bar{\sigma}}\lambda_2 + \frac{(1-\gamma)s_{\aleph} + \pi^b\gamma}{1-\gamma}\lambda_3 = 0, \tag{77}$$

$$-\phi_\pi\hat{\pi}_1 - \lambda_2 - \frac{b}{\beta}\lambda_3 = 0, \tag{78}$$

$$\left[\frac{\gamma(\nu-\gamma)}{1-\gamma}+(1-\gamma)\bar{\sigma}\right]\lambda_1+\frac{\gamma}{1-\gamma}\left(1+\beta+\varphi\left(2-\frac{(\nu-\gamma)}{(1-\gamma)\bar{\sigma}}\right)\right)\lambda_2 \\ -\frac{\gamma(\nu-\gamma)}{1-\gamma}\frac{s_{\aleph}+\pi^b}{1-\gamma}\lambda_3=0 \tag{79}$$

and

$$-\frac{\frac{1}{2}\beta\left(\phi_y\hat{y}_2(C)^2+\phi_\pi\hat{\pi}_2(C)^2\right)P_b\left(\tilde{b}_1\right)}{1-\beta\tau}-\lambda_3=0; \tag{80}$$

where $P_b\left(\tilde{b}_1\right)$ the derivative of crisis probability with respect to credit. Equations (77)-(80) represent the general case, i.e. the open economy model with endogenous crisis probability. The closed economy model with exogenous crises can be obtained by setting $\gamma=0$ and $P_b\left(\tilde{b}_1\right)=0$, which deliver:

$$-\phi_y\hat{y}_1+\varphi\frac{\bar{\sigma}+1}{\bar{\sigma}}\lambda_2=0,$$

$$-\phi_\pi\hat{\pi}_1-\lambda_2=0,$$

$$\lambda_1=0$$

and

$$\lambda_3=0.$$

The closed economy with endogenous crisis probability instead deliver the following optimality conditions:

$$-\phi_y\hat{y}_1+\varphi\frac{\bar{\sigma}+1}{\bar{\sigma}}\lambda_2+s_{\aleph}\lambda_3=0$$

$$-\phi_\pi\hat{\pi}_1-\lambda_2-\frac{b}{\beta}\lambda_3=0,$$

$$\lambda_1=0,$$

and

$$-\frac{\frac{1}{2}\beta\left(\phi_y\hat{y}_2(C)^2+\phi_\pi\hat{\pi}_2(C)^2\right)P_b\left(\tilde{b}_1\right)}{1-\beta\tau}-\lambda_3=0.$$

Calibration

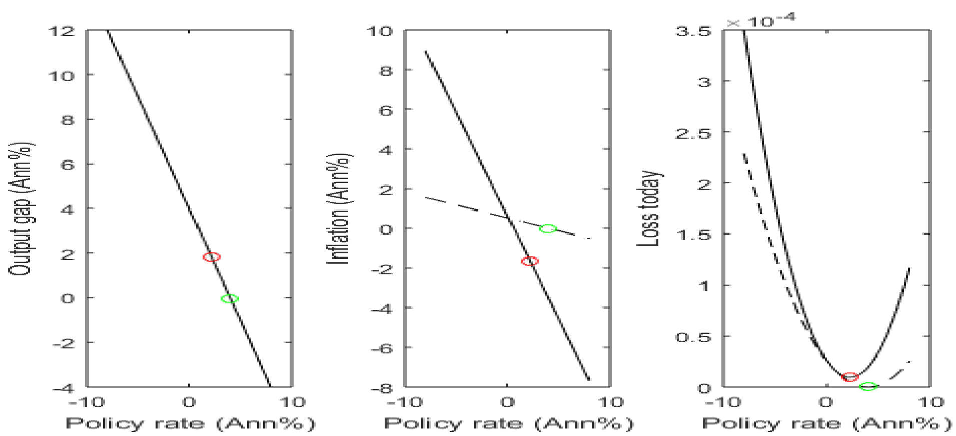
Table 2. Calibration

	Parameter Value	Description
$\hat{y}_2(C)$	-2.4% (-9.6% annualized)	Crisis State Output Gap
$\hat{\pi}_2(C)$	9.1% (36.4% annualized)	Crisis State Inflation
ζ	6	Elasticity of Substitution Among Home Goods
χ_P	77	Rotemberg Parameter
γ	0.3	Home Bias
ν	0-6	Elasticity of Exports
π^b	0.5	Share of Borrowers
β	0.99	Discount Factor
σ^b	Set to obtain $\bar{\sigma}=1$	Inverse Intertemporal Elasticity of Subs. of Borrowers
σ^s	$5\sigma^b$	Inverse Intertemporal Elasticity of Subs. of Savers
s^b	1.4	Expenditure Share of Borrowers
s^s	0.6	Expenditure Share of Savers
b	1.17	Steady State Debt

p	-4.1137	Coefficient on Crisis Probability
κ	1.1625	Coefficient on Crisis Probability
ϕ_y	1/2	Loss Function Coefficient on Output Gap
ϕ_π	1/2	Loss Function Coefficient on Inflation
τ	0.7537	Coefficient to Set Crisis Duration

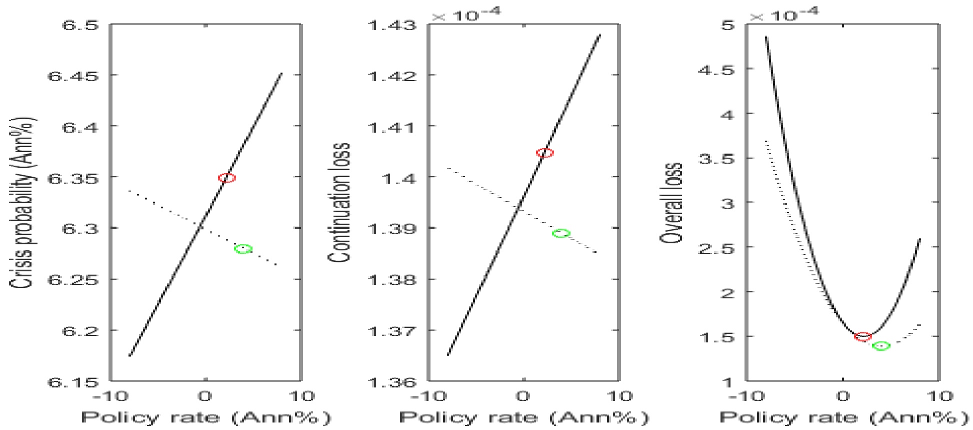
Figures 7-9.

Figure 7– Closed economy model (dashed line) and open economy model (full line).



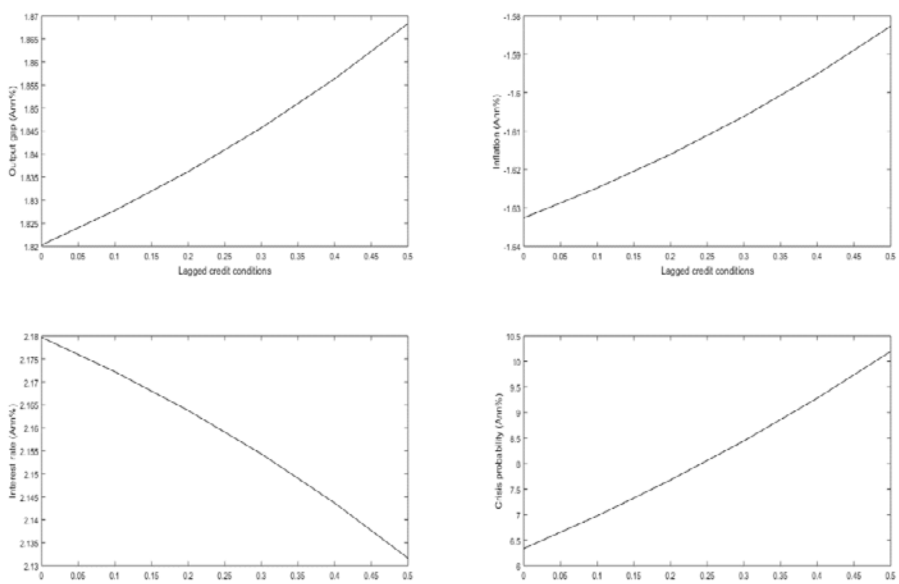
Notes: Each panel reports the corresponding variable as a function of the policy rate. Green circles indicate the optimal policy rate and the corresponding value of the variable in the panel in the closed economy model, while red circles refer to the open economy model. In the latter case, the optimal policy rate is lower, due to the fact that inflation is more responsive to the policy rate when the economy is open.

Figure 8. Closed economy model (dashed line) and open economy model (full line), both in the endogenous crisis case.



Each panel reports the corresponding variable as a function of the policy rate. Green circles indicate the optimal policy rate and the corresponding value of the variable in the panel in the closed economy model, while red circles refer to the open economy model. In the latter case, the optimal policy rate is lower, due to the fact that lowering the policy rate reduces crisis probability.

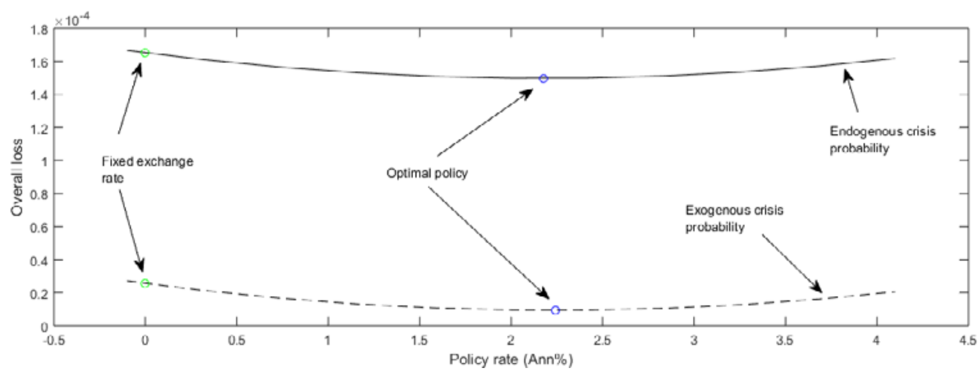
Figure 9- Optimal values as a function of lagged credit conditions in the open economy model



Flexible vs fixed exchange rate in the full model

In the main text we showed that in the simplified model with fixed prices, any flexible exchange rate policy is preferable to a fixed exchange rate regime, even though the loss cannot be brought to zero when financial crises are endogenous. Figure shows that this is the case also under the baseline calibration of the model. The only difference with respect to the simplified model is that in the full model the loss cannot be brought to zero even when financial crises are exogenous because, for the reasons discussed in the main text, the divine coincidence does not hold.

Figure 17 - Loss as a function of the interest rate in the full model in the exogenous (dashed line) and in the endogenous crisis (full line) case



The green circle indicates the interest rate-loss combination that prevails under a fixed exchange rate regime, while the blue circle indicates the interest rate-loss combination that prevails under the optimal policy.

Capital controls

In this section we show how capital controls can be introduced in the model. For instance, one can assume that a tax is imposed on foreign debt (or equivalently foreign asset holdings are subsidized), so that the budgets constraint of domestic households (31) becomes:

$$B_t^i + (1 - \tau_t^x) B_t^{fi} = R_{t-1} \frac{B_{t-1}^i}{\pi_t} + S_t^i + \frac{R_{t-1}^f B_{t-1}^{fi} X_t}{X_{t-1}} + w_t l_t^i + D_t - c_t^i - T_t$$

where τ^x is the tax rate. Revenues from this tax are assumed to be handed back to households lump-sum, thereby aggregate resource constraints are unaffected. The only equilibrium condition that changes with respect to the baseline model is the first order condition of savers with respect foreign asset holdings, which becomes:

$$\frac{(1 - \tau_t^x) R_t}{R_t^f} = \frac{X_{t+1}}{X_t} \pi_{t+1}.$$

Log-linearizing the above equation one gets equation (29):

$$\hat{R}_1 - \hat{R}_1^f = \tilde{E}_1 \hat{X}_2 - \hat{X}_1 + \tilde{E}_1 \hat{\pi}_2 + \tau_1^X.$$

Parameters governing the effect of credit on crisis probability

Following Schularick and Taylor (2012) and Ajello et al (2015), we model crisis probability for country i as a logistic function of predictor X_t^i:

$$P(X_t^i) = \frac{e^{X_t^i}}{1 + e^{X_t^i}}.$$

The predictor X_t is assumed to be a function of the four year cumulated credit growth and of country fixed effects:

$$X_t^i = h_0 + h_i + h_1 L_t$$

To obtain h_0 and h_1, that in fact correspond to p and κ in the model, we follow an approach similar to that used by Ajello et al (2015) and apply it to a group of Latin American countries. In practice, we take IFS data on bank credit and the CPI index for Brazil, Colombia, Costa Rica, Ecuador, Mexico, Peru and Uruguay over the period 1980:Q1-2008:Q4. Given these data, we compute the cumulative four years growth of real bank credit for each country i:

$$L_t^i = \sum_{s=0}^{4} \left(\log\left(\frac{B_{t-s}^i}{P_{t-s}^i}\right) - \log\left(\frac{B_{t-s-1}^i}{P_{t-s-1}^i}\right) \right).$$

Crisis years for each country are identified using the dataset of Laeven and Valencia. We set the country fixed effect for Mexico to zero for identification purposes and run a logistic regression. The results of the regression are reported in Table 3.

Table 3 – Logistic regression results

Equation	Variables
h_1	1.1625 * (0.6409)
h_0	-2.7032*** (0.7655)
Observations	168

The estimation reported in Table implies that when $L_t = 0$, the probability of a crisis is 6.28% on an annual basis. The annual crisis probability is converted to a quarterly crisis probability using the following equation:

$$P_Q = 1 - (1 - P_A)^{\frac{1}{4}},$$

where P_Q and P_A are respectively the quarterly and the annual crisis probability. We obtain $P_Q = 1.61\%$. Then the value of parameter p is obtained as follows:

$$p = \log\left(\frac{P_Q}{1 - P_Q}\right).$$

Parameter h_1 governs the response of crisis probability to credit.

A reduced form credit accumulation equation for Mexico

As mentioned in section 0, differently from Ajello et al (2015) we obtain the credit accumulation equation (76) from the structural model. In this section of the appendix, we estimate a reduced form credit accumulation equation for Mexico relating domestic bank credit to output and to the real exchange rate. Real domestic bank credit is obtained from IFS data dividing nominal credit by the CPI index. Real output and the real exchange rate are obtained from Banco de Mexico and are available beginning in 1993:Q1. We run the regression of bank credit quarterly growth rate on the log-deviations of output and the real exchange rate from a HP trend over the period 1993:Q1-2008:Q4:

$$\Delta Credit_t = \beta_0 + \beta_1 Output_t + \beta_2 RealExchangeRate_t + \epsilon_t$$

Results are reported in Table 3 . Credit growth is significantly positively correlated to output and negatively to a depreciation of the real exchange rate, similarly to what is obtained in the structural model.

Table 3 – Credit accumulation regression results

Variables	$\Delta Credit$
β_0	0.00228 (0.0075)
β_1	0.79454** (0.37389)
β_2	-0.1944* (0.10707)
Observations	63
R-squared	0.242

Additional Tables

Table 4. Financial Flows to EMEs including China

	Net Financial Flows[1/] (% of Credit to Non-Financial Sector)	
	2000-2007	2008-2016
EMEs[2/]	-0.82	0.07
AE[3/]	0.42	0.00

1/ The Average of the net financial flows for each country group is measured as Net financial capital inflows as percent of the total credit to non-financial sector

2/ The set of Emerging Market Economies is composed by: Argentina, Brazil, Colombia, Chile, China, India, Indonesia, Mexico, Poland, Turkey and South Africa

3/ The set for Advanced economies is composed by: Australia, Canada, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Israel, Japan, Korea, Netherlands, Norway, Singapore, Sweden, Switzerland, United Kingdom and United States.

Source: International Monetary Fund (IMF) and Bank of International Settlements (BIS).

Additional figures

Figure 1 - Optimal values for different values of γ.

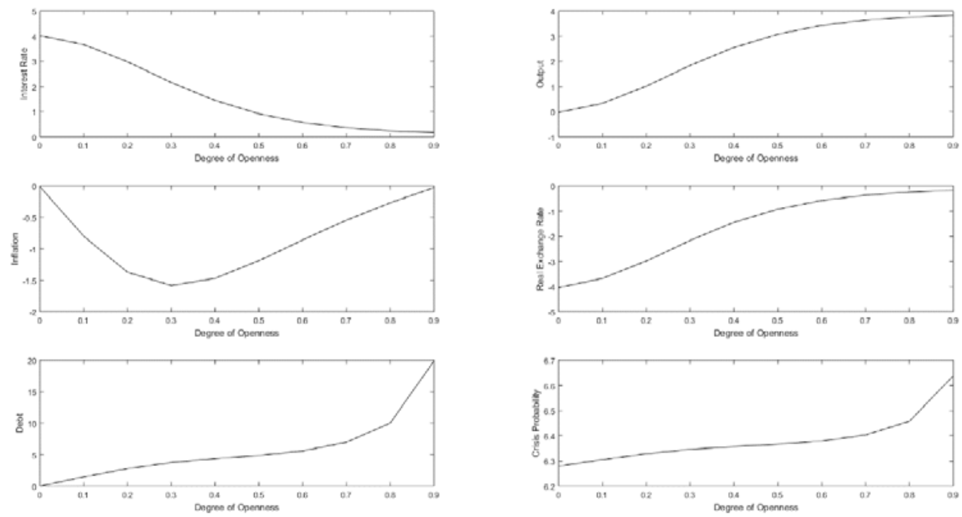


Figure 2 - Optimal values for different values of ν.

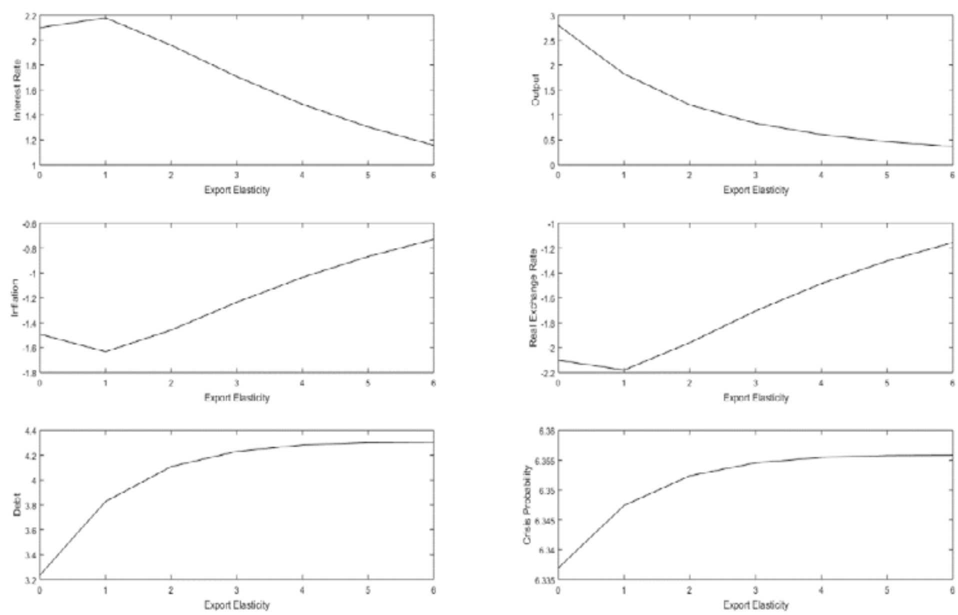


Figure 20- Optimal values for different values of $\frac{\sigma^s}{\sigma^b}$.

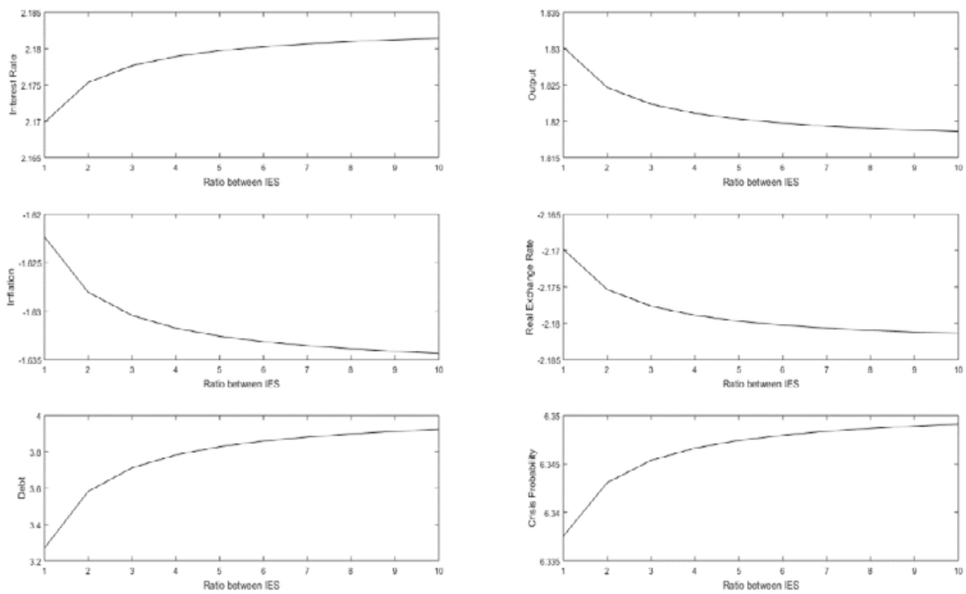


Figure 21 – Optimal values for different values of χ_P

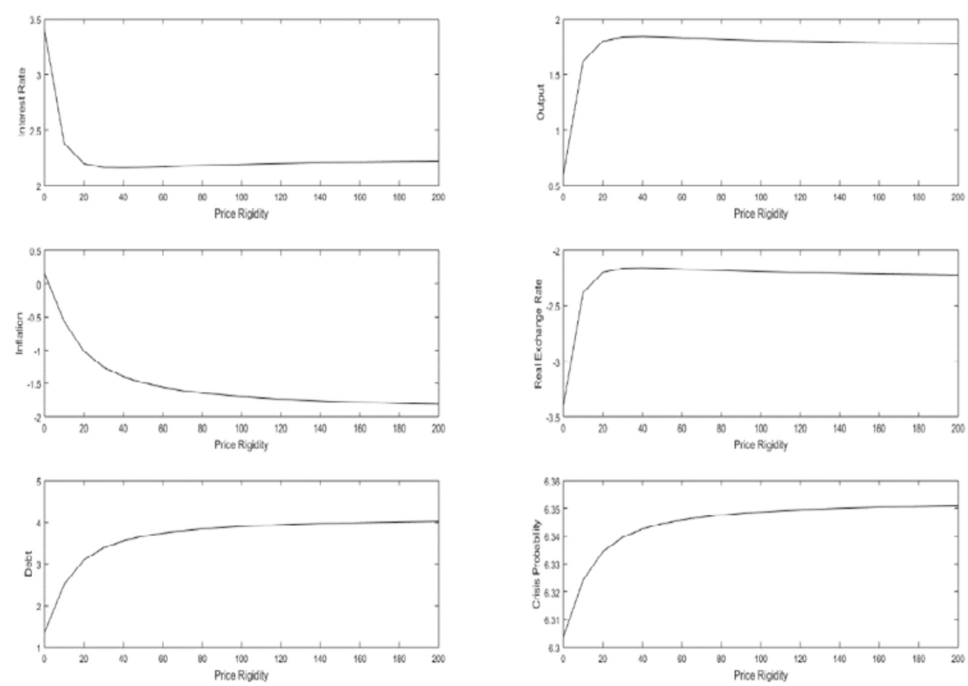
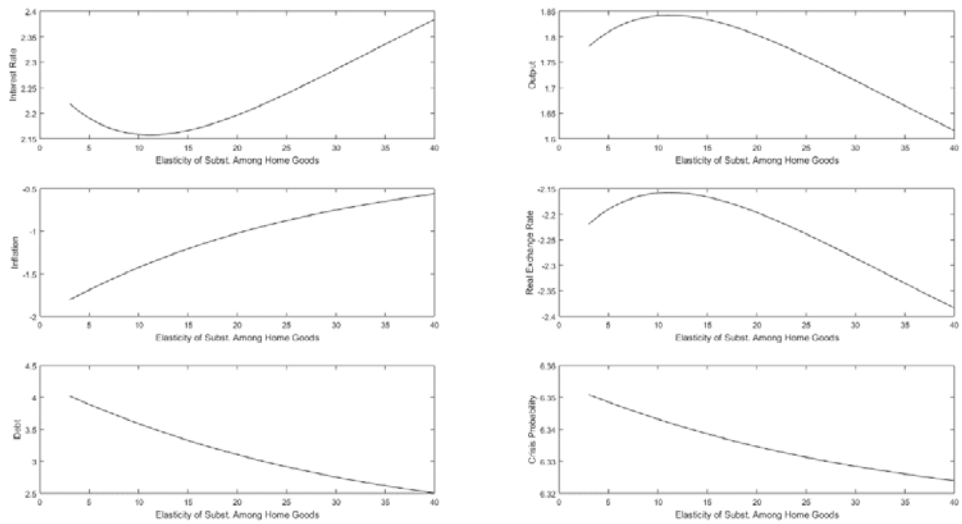


Figure 3 – Optimal values for different values of ζ



Among the above figures, the most interesting is probably Figure 2. It considers the effect of higher export elasticities on the optimal interest rate (and the other macroeconomic variables). The higher is the elasticity of exports, the lower the optimal interest rate. In fact, higher export elasticities are reflected into higher elasticities of capital flows to the interest rate differential between the home and the foreign economy. It is easy to see that the higher is ν the more important is the real exchange rate in influencing credit accumulation. A reduction of the nominal interest rate produces a stronger capital outflow when export is very elastic because foreign households are eager to exploit the possibility of borrowing cheaper (or lending less because of the lower interest rate) from (to) domestic households to increase their consumption of the domestic good. The strong capital outflow reduces domestic credit more, making interest rate cuts more effective at diminishing crisis probability. Going from $\nu = 1$ to $\nu = 6$, the optimal policy rate falls from around 2.2% to around 1.7%, a reduction of fifty basis points. Notice that also in this case the crisis probability is higher the higher is ν. Here again the high elasticity of capital flows makes sure that a small increase in the interest rate attracts a great amount of additional foreign credit which in turn increases domestic credit. When $\nu = 6$, domestic credit increases by around 8%; compared to around 3% when $\nu = 1$, even though the policy rate is raised more in the latter case.

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