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FIRM BALANCE SHEETS AND THE SECTORAL STRUCTURE

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Financial fragility in small open economies: firm balance sheets and the sectoral structure

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Résumé

Les épisodes de fortes entrées de capitaux dans les petites économies ouvertes vont souvent de pair avec un déplacement des ressources du secteur exposé vers le secteur abrité, et se terminent parfois en crise de balance des paiements. Cet article construit un modèle dynamique à deux secteurs pour étudier l'évolution de la structure sectorielle et son impact sur la fragilité financière. Le modèle intègre un mécanisme statique de crise de balance des paiements, qui produit des équilibres multiples lorsque le secteur abrité est suffisamment grand par rapport au secteur exposé. L'article étudie la dynamique provoquée par un accroissement de l'ouverture financière. Il montre que la taille relative du secteur abrité sur-réagit, ce qui rend l'économie davantage susceptible d'être financièrement fragile pendant la dynamique transitoire. Une analyse quantitative réalisée à l'aide d'une extension du modèle montre que ce mécanisme rend bien compte de plusieurs épisodes de fortes entrées de capitaux qui ont mené à des crises financières.

Mots-clés : modèles à deux secteurs, libéralisation du compte de capital, crises de balance des paiements, dette en monnaie étrangère, contrainte d'endettement, crise de la zone euro

Codes JEL : E44, F32, F34, F43, O41

Abstract

Episodes of large capital inflows in small open economies are often associated with a shift of resources from the tradable to the non-tradable sector and sometimes lead to balance-of-payments crises. This paper builds a two-sector dynamic model to study the evolution of the sectoral structure and its impact on financial fragility. The model embeds a static mechanism of balance-of-payments crisis which produces multiple equilibria within a single time period when the non-tradable sector is large enough compared to the tradable sector. The paper studies the dynamics induced by an increase in financial openness. It shows that the relative size of the non-tradable sector overshoots, which makes the economy more likely to be financially fragile during the transitory dynamics. Using an extended version of the model, the paper conducts a quantitative analysis and shows that this mechanism accounts well for several episodes of large capital inflows that led to financial crises.

Keywords: two-sector models, capital account liberalization, balance-of-payments crises, foreign currency debt, borrowing constraint, euro area crisis

JEL Classification: E44, F32, F34, F43, O41

Non-technical summary

In the last three decades, both developing and developed economies have experienced boom-and-bust cycles ending with severe financial crises. Those events share a common pattern. The boom typically follows financial or capital account liberalization: capital flows in, financing growing current account deficits and a domestic credit boom. The bust features both a sudden reversal of capital flows and a banking crisis: a *twin crisis*. Examples of such episodes include the Nordic crises of the late eighties, the Asian crisis of 1997, and crises in Latin America in the late nineties. More recently, similar boom-and-bust cycles took place in the periphery countries of the euro area as they joined the currency union and fully integrated their interbank markets.

A full understanding of these crises requires identifying factors of fragility that build up during booms. This is important since most of the large crises of the past decades, including recent events in the periphery of the euro area, were preceded by a (sometimes long) period during which fundamentals were apparently good. Past research has already pointed at high leverage, excessive growth of domestic credit, and large current account deficits as important factors increasing the likelihood of a financial crisis. This paper focuses on another factor: sectoral dynamics. It argues that large capital inflows trigger a re-allocation of resources from sectors producing tradable goods (exporting and import-competing sectors) to sectors producing non-tradable goods (sectors sheltered from international competition, such as construction and a large part of services); and it shows that such a change in the sectoral structure is an important source of financial fragility.

The paper provides a new stylized fact: the size of the non-tradable sector relative to that of the tradable sector—the non-tradable to tradable (N-to-T) ratio—increases above its trend in the first few years of an episode of large capital inflows. In a sample of 40 countries between 1970 and 2010, including 47 episodes of large capital inflows and 21 twin crises, the relative deviation of the N-to-T ratio from its trend is found to peak at about +4% four years after the onset of the boom. These dynamics are especially striking for the periphery countries of the euro area in the years 2000.

The N-to-T ratio is then found to be a good predictor of twin crises: a larger relative deviation of the N-to-T ratio from its trend is associated with a higher probability that a twin crisis occurs in the next few years. For example, in a typical emerging economy three years before a twin crisis, the probability of a crisis occurring in the next three years would increase from 13% with the N-to-T ratio at its trend to 42% with a N-to-T ratio 10% above trend.

The paper then builds a model to account for those two facts. The model shows how an increase in financial openness leads to a persistent appreciation of the real exchange rate and a persistent increase of the N-to-T ratio. Intuitively, financial openness decreases the cost of capital and leads to a higher level of production. This implies a higher demand for inputs. While inputs from tradable sectors can be imported, inputs from non-tradable sectors can only be produced domestically: a higher demand for the latter leads to an increase in their relative price, that is, a real appreciation. Resources then re-allocate into non-tradable sectors, increasing the N-to-T ratio. An important feature of the model underlying this result is the slow re-allocation of factors between sectors.

In economies where private debt contracts are denominated in foreign currency (or, as in the case of the euro area, in members of currency unions whose private debts are not indexed on domestic inflation) and in the presence of borrowing constraints, this higher N-to-T ratio can lead to self-fulfilling crises. In a crisis, borrowing constraints limit the demand for inputs from non-tradable sectors. In turn, this reduces their relative price and the real exchange rate depreciates. A larger supply of non-tradable sectors leads to a lower relative price and a more depreciated real exchange rate. This hurts the balance sheets of the non-tradable sectors which borrow in foreign currency, leading to widespread defaults and a financial crisis.

An extended version of the model is used to conduct a quantitative analysis. The mechanism of sectoral change triggered by financial openness is shown to account well for several episodes of large capital inflows that led to twin crises.

1 Introduction

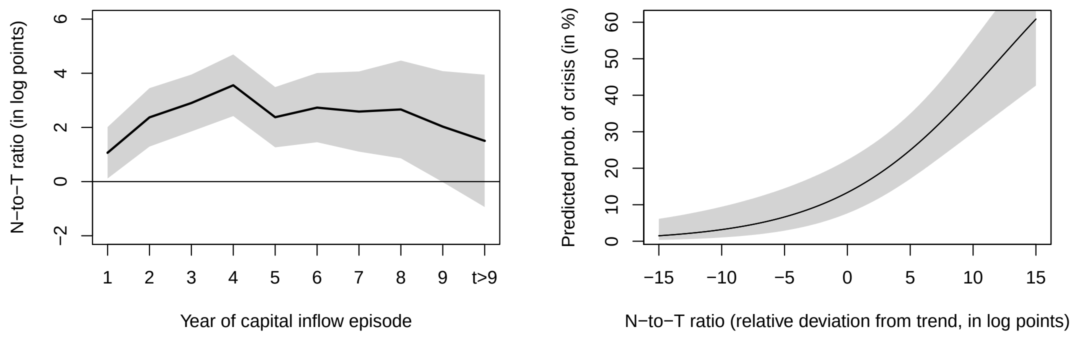
Capital inflows can have substantial effects on the sectoral allocation of resources. The opening of developing economies to foreign capital flows in the last three decades was followed in a number of cases by a shift of resources from the tradable to the non-tradable sector. The same phenomenon took place in the periphery countries of the euro area as they joined the currency union and fully integrated their interbank markets. As documented below, in the first few years of such episodes of capital inflows, the size of the non-tradable sector, relative to that of the tradable sector, increased on average by about 4% above normal times. During the same period many economies experienced financial and balance-of-payments crises. In addition to the different factors of fragility identified by the empirical literature, sectoral factors also seemed to have played a role. As documented below, crises took place in countries and in times where the non-tradable sector was larger than usual compared to the tradable sector. It is tempting to see a link between these two facts. Do episodes of large capital inflows lead to financial fragility through the channel of sectoral change?

The paper presents a framework to address this question. It builds a two-sector dynamic model of a small open economy where balance-of-payments crises can happen within single time periods. The model shows that an increase in financial openness resulting in capital inflows is followed by an increase in the relative size of the non-tradable sector, and that this change in the sectoral structure can make crises possible.

The paper starts by documenting two stylized facts related to capital flows, sectoral dynamics, and financial fragility. First, the size of the non-tradable sector relative to that of the tradable sector—the non-tradable to tradable (N-to-T) ratio—increases above its trend in the first few years of an episode of large capital inflows. Figure 1a summarizes an event study using yearly data on 40 countries between 1970 and 2010. In this sample, 47 episodes of large capital inflows are identified. The figure shows the result of a panel regression of the N-to-T ratio on time dummies indicating the number of years since the beginning of the episode. The relative deviation of the N-to-T ratio from its trend is found to peak at about 4% after four years. This dynamics holds for both emerging and advanced economies, including periphery countries of the euro area, and for both pegs and floating exchange rates.

Second, the relative size of the non-tradable sector is a good predictor of twin crises, defined as the joint occurrence of sudden stops and banking crises. There are 21 such crises in the sample. Using a discrete-choice model, the probability that a twin crisis will take place within the next three years is found to be positively correlated with the relative deviation of the N-to-T ratio from its trend, with a coefficient both statistically and economically significant. Figure 1b shows how the predicted probability of crisis substantially increases with the N-to-T ratio in an emerging economy, keeping other variables at their mean three years before a crisis.

To reproduce these two stylized facts, the paper embeds a static model of self-fulfilling balance-sheet crisis into a dynamic two-sector model. A key feature of the dynamic model is the slow reallocation of factors between sectors. First, production takes time, which prevents sectoral reallocation of resources within a single time period. Second, firms operate with de-



(a) Event study of large capital inflows episodes

(b) Logit model of twin crises

Figure 1: (a) Evolution of the N-to-T ratio during an episode of large capital inflows. Horizontal axis: time dummies indicating the number of years since the start of the episode. The solid line plots point estimates (in log points) in a panel regression of the N-to-T ratio on the time dummies. (b) Predicted probability of a twin crisis in the coming three years as a function of the (detrended) N-to-T ratio, for an emerging economy, keeping other variables at their mean three years before a crisis. Shaded areas represent 95% confidence bands.

creasing returns to scale, which deters entrepreneurs from increasing production too quickly. Another important feature is the fact that production of both goods requires non-tradable goods as an input. With those assumptions, an increase in financial openness (modeled as a permanently lower real interest rate) leads to a persistent overshooting of the real exchange rate and the N-to-T ratio. Intuitively, a lower interest rate increases the desired scale of production in both sectors and therefore the demand for non-tradable inputs. With predetermined supply, the relative price of non-tradable goods—the real exchange rate—initially appreciates. Because of decreasing returns to scale, it is not optimal for the non-tradable sector to expand quickly, which makes this overshooting persistent. Since the relative marginal productivity of inputs in both sectors depends on the relative price of the non-tradable good, the N-to-T ratio follows a similar dynamics, with a persistent increase above its steady state value.

This dynamics can be interrupted by self-fulfilling crises, modeled as in Krugman (1999), Aghion, Bacchetta & Banerjee (2004), and Schneider & Tornell (2004). As in these papers, the crisis mechanism relies on two frictions: borrowing constraints and the absence of a market for bonds denominated in non-tradable goods. The latter gives rise to a currency mismatch in the non-tradable sector. With these two frictions, there can be a second within-period equilibrium, corresponding to a crisis, in addition to the normal time equilibrium. This crisis equilibrium is shown to only exist when the non-tradable sector is large enough in relative terms. This implies that crises are more likely to take place in the medium run after an increase in financial integration, when the N-to-T ratio is large. The intuition is the following. In a crisis equilibrium, binding borrowing constraints limit the demand for non-tradables, which reduces their relative price—the real exchange rate depreciates. The larger the supply of non-tradables, the lower their relative price. Because of the currency mismatch, this hurts the balance sheet of the non-tradable sector. With a sufficiently large supply of non-tradables, this balance-sheet effect is strong enough to make borrowing constraints bind in the first place, yielding a self-fulfilling crisis. In the model, the two financial frictions are only important in times of crisis: the analysis of the no-crisis dynamics is carried out with the assumption that the borrowing constraint does not bind, which makes balance-sheet variables and currency mismatches irrelevant in normal times.

Those results are first derived analytically in a simple version of the model. The model is then extended to a more realistic set-up to conduct a quantitative analysis. The results derived in the simple model are first shown to carry over to the extended set-up. Then, the model is used to shed light on several known episodes of large capital inflows that led to twin crises. These episodes cover four waves of large financial crises: the Nordic crises of the late eighties, the Asian crisis of 1997, crises in Latin America in the late nineties, and recent crises at the periphery of the euro area. Using bayesian methods, I decompose the observed dynamics of GDP, the current account, and the N-to-T ratio during those episodes into movements of a financial transaction cost and two productivity shocks. The observed current account and sectoral dynamics are found to be largely driven by a decrease in the financial transaction cost, which in the model corresponds to financial integration. Finally, the implication for financial fragility and crises is worked out, focusing on the example of Thailand in the nineties. I look at the impact on financial fragility of the lower cost of financing backed out from the data. Financial fragility is found to be more likely to obtain during the transition to the new steady state, supporting the theoretical finding of the simple model. I also show that the model matches the behavior of several key variables during the crisis, in particular the real exchange rate, investment, and employment.

A key innovation of this paper is to connect the literature studying the sectoral evolution of open economies to the literature on emerging market crises. While the crisis literature has extensively studied mechanisms at play during crises, little is known about the dynamics that precedes those events. On the other hand, a long tradition in international macroeconomics has tried to explain sectoral change in two-sector open economies, but these works have not explored the implications for financial fragility. In this paper I show how an episode of capital inflows triggered by financial liberalization endogenously leads to a build-up of financial fragility through the channel of sectoral change. This link between financial liberalization, pre-crisis sectoral dynamics, and crisis times offers a new perspective compared to the existing literature.

The paper also contributes to the empirical literature by documenting the link between capital inflows, the sectoral allocation of resources, and crises. To the best of my knowledge, this empirical evidence is novel. It suggests that sectoral dynamics were important both for emerging market crises of the past decades and for the more recent crises in the periphery of the euro area, thus contributing to a better understanding of those events.

As regards the literature on sectoral dynamics, several works studied how the discovery of natural resources affects the allocation of resources between the tradable and non-tradable sectors, the so-called *Dutch disease*. The reader may for example refer to Corden & Neary

(1982), Bruno & Sachs (1982), and van Wijnbergen (1984). In the present paper, the shift of resources towards the non-tradable sector is triggered instead by a permanent decrease in the domestic interest rate resulting from financial integration, as in de Cordoba & Kehoe (2000) who study the effect of capital account liberalization in Spain with a two-sector model. By contrast, Benigno & Fornaro (2014) study a consumption boom triggered by a temporarily lower interest rate in a model with perfect factor mobility across sectors. The resulting sectoral dynamics is simply driven by the transitory consumption boom. Because of increasing returns in the tradable sector, this dynamics is inefficient, but it does not lead to a severe financial crisis as in the present paper. Similarly, Caballero & Lorenzoni (2007) study the optimal policy response to episodes of temporary but persistent appreciations which, together with a financial friction, move resources away from the export sector to the non-tradable sector.

An alternative candidate for the shock triggering the sectoral dynamics could be the exchange rate-based stabilization plans that were implemented in several developing countries.[1] These plans consisted in stabilizing inflation by anchoring the domestic currency through an exchange-rate peg. Several papers have shown, both empirically and theoretically, that they have led to real appreciations and current account deficits. The effect of the reform is generally equivalent to a decrease of the domestic real rate of interest and plays the same role as financial integration in my model.[2] Interestingly, the idea that there could be "possible links between the dynamics of exchange rate-based stabilizations and balance-of-payments crises" has been mentioned (Calvo & Vegh 1999, p. 1535) but has not been studied formally, and no clear mechanism has been identified. This paper provides such a mechanism. Another difference is that the literature on stabilization episodes has focused on real exchange rate dynamics, not on sectoral dynamics as the present paper does. While some works hint at the initial boom in non-tradables (Rebelo & Vegh 1995, footnote 3), it has not been empirically documented. Several papers use two-sector models to quantitatively reproduce observed real exchange rate movements (Rebelo & Vegh 1995, Uribe 1997, Burstein et al. 2003) but do not compare the resulting dynamics of the N-to-T ratio with the data. On the empirical side, I show that the sectoral reallocation observed in the data is still present in a subsample that excludes capital inflow episodes coinciding with known stabilization plans, calling for a more general explanation.

The existing literature using two-sector models has long recognized the need to assume some restriction to factor mobility in order to get realistic dynamics. For instance, Rebelo & Vegh (1995) assume a fixed factor of production in the non-tradable sector (land) and adjustment costs to capital in the tradable sector; Uribe (1997) assumes adjustment costs and gestation lags in the accumulation of sector-specific capital; and de Cordoba & Kehoe (2000) assume adjustment frictions for both capital and labor at the sectoral level. In the present paper,

[1] I am grateful to Pierre-Olivier Gourinchas and an anonymous referee for suggesting this.

[2] See Rebelo & Vegh (1995) and Calvo & Vegh (1999) for a review. The main mechanisms proposed by the literature have been inflation inertia, which temporarily decreases the real rate of interest, and the lack of credibility of the reform, which induces a consumption boom as households expect a temporary decrease in the opportunity cost of holding money for transactions. In Rebelo & Vegh (1995), Uribe (1997), and Burstein, Neves & Rebelo (2003), inflation acts as a tax on transactions and creates a wedge between the return on capital and the foreign interest rate.

the assumption that production is decided one period in advance and that firms operate with decreasing returns to scale plays a similar role. It produces a persistent overshooting of the N-to-T ratio without having to resort to adjustment costs. An appealing feature of this assumption is that decreasing returns to scale have empirical support from firm-level evidence, which can be used in a calibration exercise, whereas there is a large uncertainty on parameters governing adjustment costs.

The paper also borrows ingredients from the literature on balance-of-payments crises: namely borrowing constraints and currency mismatches. The interplay between those two ingredients gives rise to a balance-sheet effect in the corporate sector, which has been shown to generate multiple equilibria (Krugman 1999, Aghion et al. 2004, Schneider & Tornell 2004), amplify otherwise small shocks (Mendoza 2002), and lead to inefficient overborrowing ex ante (Bianchi 2011). I follow the former set of papers closely. Most of this literature is primarily concerned with modeling the crisis itself and discussing policy options but not with understanding the dynamics that possibly leads to it. An exception is Schneider & Tornell (2004) who study the growth of the non-tradable sector during a transitory lending boom and show that a large enough boom can lead to a self-fulfilling crisis. I follow their methodology of inserting a static crisis mechanism into a dynamic framework, but my paper differs substantially from theirs in important ways. First, they focus on the non-tradable sector alone while I study the allocation of resources between the tradable and non-tradable sectors, which are therefore modeled explicitly and in a symmetric way. Second, their dynamics of non-tradables is driven by a binding borrowing constraint which, together with a linear technology, leads to the cumulative growth of internal funds, investment, and the price of non-tradables.[3] In the present paper, on the contrary, the mechanism of sectoral reallocation does not rely on financial frictions: since borrowing constraints do not bind in normal times, the pre-crisis dynamics reduces to a standard neoclassical two-sector model. This is appealing given that the sectoral reallocation is observed in both emerging and advanced economies, as I document below, whereas binding borrowing constraints are more likely to be a feature of emerging economies with underdeveloped financial markets. In addition, leverage, an important variable to determine financial fragility, is endogenous and not pinned down by the borrowing constraint: this allows me to distinguish the effect of a larger non-tradable sector (with respect to the tradable sector) from that of a more indebted non-tradable sector, in line with the empirical evidence which shows that both credit and the N-to-T ratio are good predictors of crises. Third, while their model has a finite number of periods, the present paper considers an infinite time horizon, which makes it possible to study the effect of financial openness both during the transitory phase of sectoral change and in the new steady state. Finally, their model focuses on the theoretical mechanisms while I also conduct a quantitative analysis.

The link between crisis time and pre-crisis dynamics has been recently studied in another context—the real estate boom and bust in the US—by Mian & Sufi (2009, 2010). Using cross-sectional regional data, they show how the strength of the 2007–2009 recession is related to

[3] This requires a high enough expected future price of non-tradables, induced for example by a reform that is believed to increase the future demand for non-tradable goods.

increases in household leverage in previous years, and provide suggestive evidence that the expansion in mortgage credit might be due to a positive credit supply shock. In my analysis, leverage also plays a role, as shown both by the empirical evidence and the theoretical results, and financial integration in the model is equivalent to a positive credit supply shock. Complementary to leverage, I stress the importance of sectoral reallocation as a key factor of fragility to twin crises. Whether sectoral factors have played a similar role in the US housing boom is an open question: according to Mian & Sufi's (2010) results, there is no clear correlation between the strength of the recession and sectoral shares of employment *at the onset of* the bust. However, sectoral asymmetries *during* the bust have been documented (Mian & Sufi 2011) and can be accounted for by quantitative models (Philippon & Midrigan 2011, Kehoe, Midrigan & Pastorino 2014). These models rely on a borrowing constraint which depends on the price of housing. This plays a role similar to the borrowing constraint depending on the real exchange rate used in my paper, which I borrow from the literature on balance-of-payments crises cited above.

The paper is organized as follows. Section 2 documents the two stylized facts. A simple version of the model is presented in section 3. Section 4 extends the model to a more realistic set-up and uses it to shed light on several historical episodes of large capital inflows leading to twin crises. Section 5 concludes.

2 Empirical evidence

This section documents the two empirical facts mentioned in the introduction: sectoral dynamics during episodes of large capital inflows and the link between the sectoral structure and crises.

I use yearly data for 40 countries (24 emerging and 16 advanced economies) covering the period 1970-2010 (see Appendix C.1 for details on sources). I use a de facto measure of net capital inflows to identify episodes of large capital inflows: these episodes are defined by a large and persistent drop in the current account (Appendix C.2). The sample has 47 episodes with an average duration of 8 years. All the episodes are represented graphically by the shaded areas in Figures C.1 and C.2 of Appendix C, with the current account represented by a dashed line. Many episodes coincide with known financial or capital account liberalizations, e.g. in the Southern cone countries in the nineteen-seventies, the Nordic countries in the late nineteen-eighties, or Latin American and Asian countries in the nineteen-nineties.[4] More recently, the creation of the euro area, which resulted in the full integration of interbank markets, was also associated with several episodes in periphery countries.

Next, I define twin crises as events featuring simultaneously a sudden stop and a banking crisis. Sudden stops are defined as current account reversals and are identified with the criterion used by Ferretti & Razin (2000). Banking crises are taken from Valencia & Laeven (2012). A twin crisis is defined as a sudden stop and a banking crisis that take place in the same year or in two consecutive years (in the latter case, the crisis date is the year of the second event).

[4]See Kaminsky & Schmukler (2003) for de jure indices of liberalization.

There are 21 twin crises in the sample (corresponding to an unconditional probability of 1.7%), reported in Table C.1 of Appendix C. Out of those, 15 take place at the end of an episode of capital inflows: almost a third of capital inflows episodes finish with a crisis (see Figures C.1 and C.2, where crises are represented by a black triangle). Most of the well-known twin crises are captured by the definition: the Nordic crises of the early nineteen-nineties, the Asian crisis, the Mexican and Argentinean crises, as well as the recent crises of the euro area periphery.

2.1 Sectoral dynamics during episodes of large capital inflows

The first empirical fact that motivates the paper, the link between large capital inflows and sectoral dynamics, is illustrated by Figure 1a. The figure summarizes an event study using the data described above.[5] The logarithm of the non-tradable to tradable ratio (measured in constant price value added) is regressed on time dummies indicating the number of years since the beginning of the episode, followed by a dummy indicating all remaining years of the episode. The panel regression uses a GLS estimator to allow for country-specific heteroskedasticity and autocorrelation, controls for a linear trend interacted with country dummies and for the occurrence of twin crises[6] (see Appendix C.3 for details).

Figure 1a reports results for the whole sample. The non-tradable to tradable ratio is found to increase above its trend at the beginning of the episode, peaking at about 4% after four years. Several individual episodes feature much larger increases as can be seen from Figures C.1 and C.2 in Appendix C, where the (detrended) N-to-T ratio for all 40 countries is plotted by a solid line.

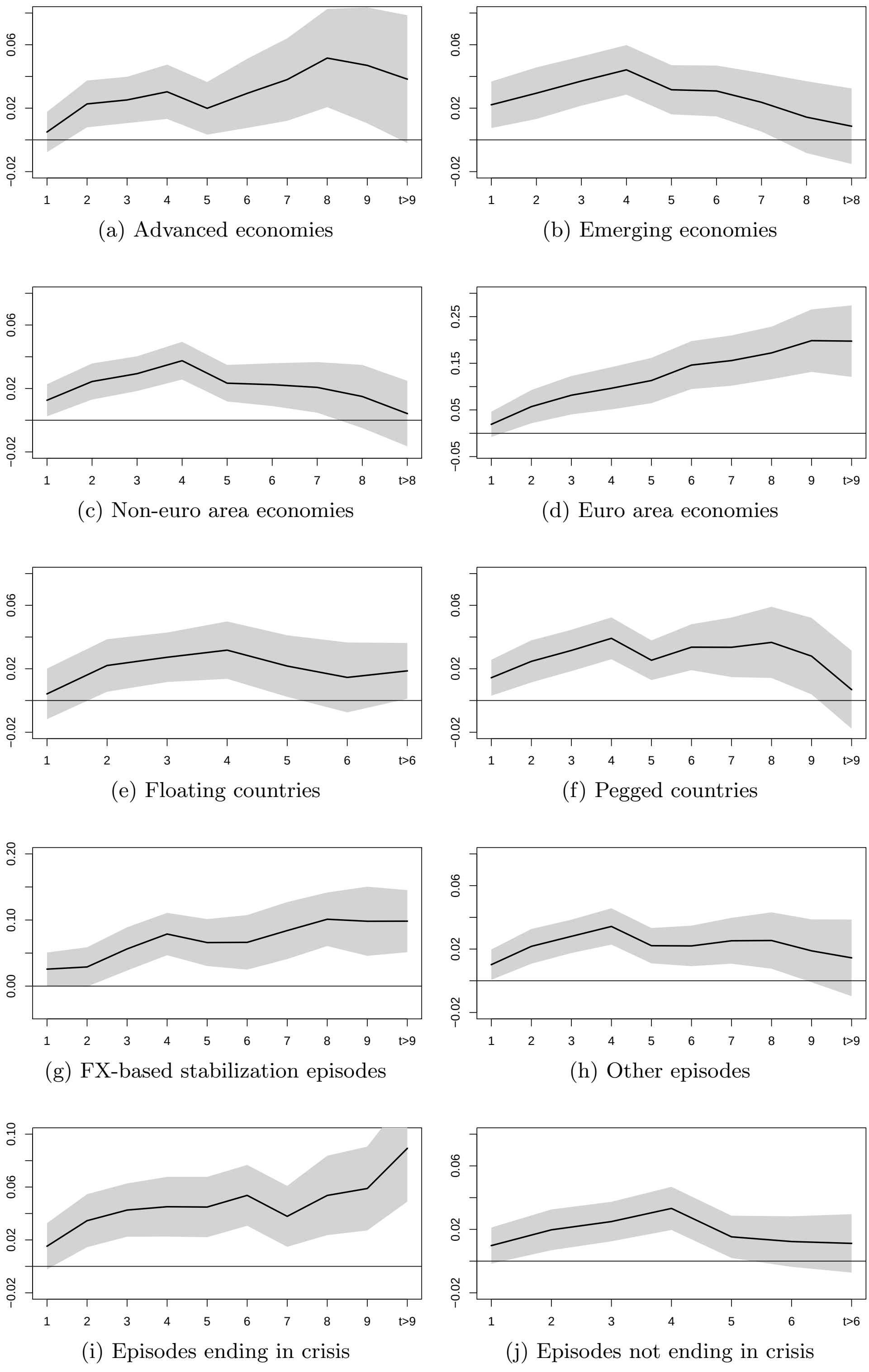
Figure 2 reports robustness checks obtained by splitting the set of episodes in different subsets. Panels (a) and (b) consider separately advanced and emerging countries. Panels (c) and (d) split episodes between non-euro area economies and euro area economies.[7] The N-to-T ratio increases in all subsamples. The episodes corresponding to the creation of the euro are particularly strong and long-lasting, and were not over yet in 2007, the end of the time sample. Panels (e) and (f) split the sample depending on the exchange rate regime. Episodes in both floating and pegged countries feature an increase in the N-to-T ratio. Panels (g) and (h) isolate episodes coinciding with exchange rate-based stabilization plans. There are four such episodes in the sample.[8] As explained in the introduction, these stabilization plans could be an alternative explanation for the non-tradable boom. Indeed, Panel (g) shows a large and sustained increase of the N-to-T ratio in those episodes. However, the stylized fact stays valid for the remaining episodes, suggesting that this sectoral dynamics is driven by a more general mechanism. Finally, Panels (i) and (j) shows that the N-to-T ratio increases regardless of whether the episode ends with a twin crisis. However, the increase is stronger in the episodes ending with a twin crisis.

[5] Data availability restricts the sample to 1974–2007 and the number of large capital inflows episodes to 45.

[6] Tornell & Westermann (2002) find that the production of non-tradable goods falls with respect to that of tradable goods during twin crises.

[7] Episodes in euro area economies are episodes in countries that joined the euro before the end of the episode.

[8] The list of exchange-rate based stabilization plans is taken from Calvo & Vegh (1999). The four episodes in the sample are Argentina in 1985 and 1991, Brazil in 1986, and Mexico in 1987.



(a) Advanced economies
(b) Emerging economies
(c) Non-euro area economies
(d) Euro area economies
(e) Floating countries
(f) Pegged countries
(g) FX-based stabilization episodes
(h) Other episodes
(i) Episodes ending in crisis
(j) Episodes not ending in crisis

Figure 2: Evolution of the N-to-T ratio during an episode of large capital inflows. Horizontal axis: time dummies indicating the number of years since the start of the episode. The solid line plots point estimates (in log) in a panel regression of the N-to-T ratio on the time dummies. The shaded area represents the 95% confidence interval. See Appendix C.3 for details.

This last result suggests that sectoral factors are likely to play a role in twin crises, the second empirical fact that motivates the paper.

2.2 Sectoral structure and twin crises

To document the role of sectoral factors in twin crises, I estimate a discrete-choice logit model of crisis, in the tradition of the early-warning literature.[9] Table 1 presents a benchmark regression on pooled data. The dependent variable is the probability that a twin crisis occurs within a 1, 2, or 3 year window. Columns (1), (3) and (5) report results for a standard model using the current account, private credit, GDP growth, the real effective exchange rate, reserves and an emerging economy dummy as predictors of crisis. The probability of twin crises is higher when current account deficits are large and private credit is booming, and crises are more likely in emerging economies. Columns (2), (4), and (6) complement this model with sectoral variables: the (detrented) N-to-T ratio and the (detrended) relative price of non-tradables. The N-to-T ratio is statistically significant at the 5% level with a positive sign: a larger N-to-T ratio is associated with a higher probability of future crisis.

Table 1: Logit model of the probability of a twin crisis

	1 year		2 years		3 years	
	(1)	(2)	(3)	(4)	(5)	(6)
N-to-T ratio		12.7^{**}		14.1^{***}		15.4^{***}
		(5.7)		(4.0)		(3.3)
Relative price N/T		2.8		3.4		3.9^{*}
		(3.5)		(2.6)		(2.2)
Current account	-4.0	-2.5	-11.7^{**}	-10.2^{**}	-14.7^{***}	-12.6^{***}
	(7.6)	(8.2)	(4.8)	(5.2)	(4.0)	(4.3)
Credit/GDP	9.3^{***}	6.5^{***}	9.9^{***}	6.9^{***}	9.7^{***}	6.8^{***}
	(2.1)	(2.5)	(1.6)	(1.8)	(1.3)	(1.5)
GDP growth	-12.8^{*}	-14.5^{*}	-6.4	-7.8	3.1	3.6
	(7.6)	(8.3)	(6.2)	(6.5)	(5.4)	(5.8)
REER	-0.9	-2.3	0.2	-1.2	0.7	-0.5
	(1.8)	(1.9)	(1.3)	(1.4)	(1.1)	(1.2)
Reserves/GDP	-11.1^{**}	-8.1	-10.6^{***}	-7.6^{**}	-10.4^{***}	-7.9^{**}
	(5.6)	(5.4)	(3.9)	(3.8)	(3.2)	(3.1)
Emerging country	2.9^{***}	2.8^{***}	2.4^{***}	2.4^{***}	1.9^{***}	1.9^{***}
	(1.0)	(1.0)	(0.6)	(0.7)	(0.5)	(0.5)
N	40	40	40	40	40	40
$N \times T$	894	894	894	894	894	894

Logit model on pooled data. Dependent variable: probability that a twin crisis takes place in a 1, 2, or 3 year window. The N-to-T ratio, the relative price of non-tradables, and the real effective exchange rate (REER) are in logarithm. All three variables and credit/GDP are deviations from a linear trend. Standard errors are reported in parenthesis.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Tables C.2 to C.4 in Appendix C.4 show that these results are robust to controlling for country fixed effects (by using a conditional logit estimator) and for several other factors (fiscal

[9] Data availability restricts the sample to 1975–2007 and the number of twin crises to 18.

variables, domestic inflation and interest rates, external shocks, the external balance-sheet of the country, and the exchange rate regime).

The N-to-T ratio is also economically important. In all regressions, it has a large coefficient, comparable in size to those of the current account and credit/GDP, two well-known predictors of crises (in the benchmark regression in Column (6) of Table 1, a 1% increase in the N-to-T ratio is associated with a 15% increase in the odd-ratio of a crisis taking place within the next 3 years). To get a sense of its economical importance, set all other variables at their mean value 3 years before a crisis. In an emerging economy, according to the model estimated in Column (6) of Table 1, the probability that a twin crisis takes place within the next three years would be 13% if the N-to-T ratio is at its trend, 25% if it is 5% above its trend, and 42% if it is 10% above its trend. Figure 1b illustrates this result. In an advanced economy, the corresponding probabilities are respectively 2%, 5%, and 10%.

Table 2 reports the result of a counterfactual exercise for a set of selected twin crises using the benchmark model described above. I compute the probability of a crisis in the coming three years that would have prevailed if the N-to-T ratio had been at its trend instead of being high above its trend. As the table makes clear, according to the model, probabilities of a twin crisis would have been substantially lower without the boom in non-tradables.

Table 2: Counterfactual probability of crises without the N-to-T boom

Country	Year	N-to-T	Predicted	Counterfactual
Nordic crisis				
Finland	1992	0.11	0.13	0.03
Sweden	1993	0.14	0.20	0.03
Asian crisis				
Malaysia	1998	0.06	0.43	0.22
Thailand	1997	0.15	0.78	0.25
Latin America				
Argentina	2001	0.05	0.25	0.14
Colombia	1999	0.07	0.19	0.08
Euro area crisis				
Spain	2009	0.16	0.52	0.09
Greece	2010	0.17	0.63	0.12

Counterfactual exercise for selected twin crises. The third column reports the N-to-T ratio 3 years before a crisis (log deviation from trend). The fourth column reports the predicted probability of a crisis within 3 years using the model of Table 1, Column (6). The fifth column reports the counterfactual probability of crisis had the N-to-T ratio been at its trend 3 years before the crisis.

Those results are consistent with Tornell & Westermann (2002) who show that the relative size of the non-tradable sector usually increases before twin crises in middle-income countries. Calvo, Izquierdo & Mejía (2004) also find that the probability of a sudden stop is higher in economies where the production of tradable goods is small compared to the pre-crisis current-account deficit, a variable that partly captures the sectoral structure.

3 A simple framework

This section considers a simple framework with no labor, no capital, and where the non-tradable good is only used as an intermediate input. This makes it possible to solve the model analytically and to study the mechanism of sectoral reallocation in a transparent way. These assumptions will be relaxed in Section 4 which studies a more realistic setup where production also requires the use of capital and labor, and the non-tradable good enters in the composition of consumption, investment, and intermediate goods.

3.1 The set-up

Consider a small open economy. Time is discrete. There are two types of goods: a tradable good T and a non-tradable good N. The tradable good T is chosen as the numeraire. Denote p_t the relative price of the non-tradable good in period t. The relative price p_t is a measure of the real exchange rate. A high value of p_t corresponds to an appreciated real exchange rate.

Production

The tradable good T is produced by a tradable sector (sector T). It can also be imported and any excess production of tradable goods can be exported. The non-tradable good N is exclusively produced by a domestic non-tradable sector (sector N) and the whole production has to be used domestically.

Each sector is composed of a continuum of firms of measure one. Production uses an intermediate input Z with decreasing returns to scale. Inputs have to be purchased one period before production can be sold. A firm in sector s buys a quantity z^s_{t+1} of inputs in period t and produces a quantity $(z^s_{t+1})^\theta$ sold in period $t+1$, where $\theta \in (0,1)$ measures returns to scale.

The intermediate good Z itself is produced by a competitive intermediate sector with a Cobb-Douglas production function: $y^Z_t = \left(\frac{x^T_t}{1-\mu}\right)^{1-\mu}\left(\frac{x^N_t}{\mu}\right)^{\mu}$, where x^T_t (x^N_t) is the input of tradables (non-tradables) used in the production of intermediate goods Z. Denote p^Z the price of good Z.

Agents

There are three kinds of agents: entrepreneurs, foreign lenders, and intermediate firms. Entrepreneurs and foreign lenders derive utility from the consumption of tradable goods and are risk neutral with a common discount factor β.

Entrepreneurs run firms. They are specialized in one sector, tradable or non-tradable. They belong to families with a measure one continuum of members and are entitled with equal shares of the family's wealth. At the end of each period, members get their share of the family's wealth and leave to an isolated production site. At the beginning of the next period, a fraction $1-\gamma$ of members exits the economy. The remaining comes back to the family where a measure $1-\gamma$ of new members are born. Members only consume when they exit. Since they are isolated on their production site, exiting members have no choice but to consume their profits. If $\mathcal{W}^s_t$ denotes the beginning-of-period wealth of a family in sector s, consumption is then equal to $(1-\gamma)\mathcal{W}^s_t$

and internal funds m_t^s available to start production in period t are equal to $\gamma \mathcal{W}_t^s$ plus some possible subsidy from the Government, to be detailed later. Production decisions are taken by a representative entrepreneur who maximizes utility, defined as the discounted sum of expected future consumptions of the family $U_t = \mathrm{E}_t \sum_{s \geq 0} \beta^{s+1} C_{t+s+1}$.

Foreign lenders receive a large enough endowment of tradable goods in each period to provide an infinitely elastic supply of funds at the rate of return $1/\beta$.

Intermediate firms maximize profits $p_t^Z y_t^Z - p_t x_t^N - x_t^T$.

Financial contracts

Entrepreneurs finance the purchase of inputs out of their internal funds and by issuing one-period bonds. I assume that bonds can only be denominated in tradable goods. Bonds issued in period t by sector s promise a rate of return r_t^s. When the proceeds from the sales of a firm fall short of the promised repayment to bondholders, debt cannot be fully paid back and the entrepreneur is forced to default.

Entrepreneurs are subject to a borrowing constraint. An entrepreneur with internal funds m_t^s can borrow at most

$$p_t^Z z_{t+1}^s - m_t^s \leq (\lambda - 1) m_t^s \qquad s = N, T, \tag{1}$$

where $\lambda \geq 1$ is the financial multiplier of internal funds.

To model the degree of financial openness, I assume that there is an iceberg cost $\tau_t^* > 1$ to international financial transactions. When a foreign lender lends τ_t^* units of tradable good to a domestic agent, the domestic agent only gets 1 unit.

Similarly, domestic agents face an iceberg cost τ when making loans. I assume that $\tau > \tau_t^*$ and that τ/τ_t^* is large enough, due to inefficient domestic financial intermediation, so that it is never optimal for an entrepreneur to hold bonds.

Crises

A balance-of-payments crisis in this model is defined as the occurrence of widespread defaults in the non-tradable sector. This happens when $p_t (z_t^N)^\theta < r_{t-1}^N (p_{t-1}^Z z_t^N - m_{t-1}^N)$, that is for a depreciated enough real exchange rate. Defaults are possible in the non-tradable sector because of the currency mismatch generated by the fact that debt is denominated in tradable goods. This makes balance-sheets of non-tradable firms fragile to unexpected decreases in the relative price. By contrast, firms in the tradable sector are not affected by unexpected price changes and never default.

During crisis times, the Government intervenes to bail out firms producing non-tradable goods, thus preventing the non-tradable sector from completely disappearing (with zero internal funds and a binding borrowing constraint, defaulting entrepreneurs would not be able to start production at all). Entrepreneurs in sector N receive a subsidy $S_t^N > 0$, financed by a lump-sum tax on entrepreneurs in sector T. The subsidy is supposed to be small enough to make the borrowing constraint bind in sector N.

Market-clearing conditions

The total supply of intermediate goods is equal to the demand for inputs by both sector N and sector T:

$$y_t^Z = z_{t+1}^N + z_{t+1}^T. \tag{2}$$

Non-tradable goods are only used as an input in the production of intermediate goods:

$$(z_t^N)^\theta = x_t^N. \tag{3}$$

Discussion of the set-up

The model makes two important technological assumptions. First, production takes time. Second, production has decreasing returns to scale with respect to the intermediate input Z. This second assumption requires that entrepreneurs are specialized in their sector. Allowing them to choose their sector would amount to assuming constant returns to scale with respect to both the intermediate input and "entrepreneurial skill." These two assumptions are the only ingredients needed for the sectoral dynamics of the model.

The model also assumes two financial frictions: the absence of bonds denominated in non-tradable goods and borrowing constraints. These frictions will not play any role in the sectoral dynamics but are crucial to get crises. They are common in models of emerging market crises. The fact that the domestic agents of a developing country are unable to issue debt denominated in foreign currency on international financial markets has been dubbed the *Original Sin* (Eichengreen & Hausmann 1999).[10] A similar situation arises in a currency union, since the nominal exchange rate is fixed and nominal debt in the common currency is not contingent to the national price level. Borrowing constraints that introduce a limit on leverage have become common in the macroeconomic literature (Mendoza 2002, Antras & Caballero 2009) and several microfoundations have been developed that could be easily embedded in the current paper (Schneider & Tornell 2004, Aghion, Banerjee & Piketty 1999, Antras & Caballero 2009).

The assumption that entrepreneurs enter and exit the economy is usual in models with borrowing constraints (as in Bernanke, Gertler & Gilchrist 1999). In my case, this demographic structure makes it possible to consider steady states corresponding to different degrees of financial openness, as internal funds converge to a finite value whatever the level of the real interest rate.[11]

Finally, the model considers a real economy without nominal frictions. The analysis then abstracts from the exchange rate regime. This assumption is supported by the evidence of Section 2 that the sectoral reallocation takes place in floating as well as in pegged countries

[10] Alternatively, several authors have proposed arguments to explain why domestic firms *choose* to take a risky position by issuing debt denominated in foreign currency (Schneider & Tornell 2004, Caballero & Krishnamurthy 2000, Jeanne 2000, Jeanne 2003).

[11] The assumption that entrepreneurs only consume when they exit is a minor restriction. It can be shown that, in any steady state, entrepreneurs would endogenously choose not to consume when they do not exit.

(Figure 1a) and that the exchange rate regime does not predict twin crises (Table C.4 of the Appendix). The case of a fixed exchange rate regime with nominal rigidities will be discussed later.

3.2 Equilibrium

Solution concept

In general, the model can have multiple market-clearing prices inside a single time period, corresponding to normal times and crisis times. It is then possible to construct sunspot-driven equilibrium paths with self-fulfilling crises, where the equilibrium outcome in each period depends on the realization of an exogenous sunspot variable.

For the sake of simplicity, my strategy is to focus on perfect foresight equilibria with no uncertainty and zero-probability crises only. In addition, I will look at equilibrium paths where borrowing constraints do not bind. This reduces the model to a simple two-sector small open economy with no financial frictions and makes it easy to study the dynamics. Then, I will ask whether there exists a second market-clearing price, corresponding to a crisis, in a given time period along that perfect-foresight no-crisis dynamics.

Optimization problems

I now describe in more details the optimization problems of the different agents.

Because of their large endowments, foreign lenders set the rate of return in the model. Given the iceberg cost τ_t^*, the riskless borrowing rate in the domestic economy is

$$r_t = \tau_t^* / \beta \,. \tag{4}$$

With no uncertainty and no crisis, the rates of return on bonds are simply given by $r_t^N = r_t^T = r_t$.

The representative entrepreneur of sector N makes production decisions to maximize the discounted sum of expected future consumptions of the family, given the borrowing constraint (1). The value function of this optimization program is:[12]

$$\begin{aligned} V_t^N(m_t^N) = \max_{z_{t+1}^N} \beta \, \mathrm{E}_t \Big[(1-\gamma) \mathcal{W}_{t+1}^N + V_{t+1}^N \Big(\gamma \mathcal{W}_{t+1}^N \Big) \Big] \\ \text{with} \quad \mathcal{W}_{t+1}^N = p_{t+1} (z_{t+1}^N)^\theta - r_t (p_t^Z z_{t+1}^N - m_t^N) \,, \\ \text{and s. t.} \quad p_t^Z z_{t+1}^N \leq \lambda m_t^N \,, \end{aligned}$$

for internal funds m_t^N and beginning-of-period wealth at $t+1$ $\mathcal{W}_{t+1}^N$. The expected value has two terms: the consumption of the $1-\gamma$ exiting family members next period and the continuation value of the measure one family. A similar value function can be written for the representative entrepreneur of sector T with $\mathcal{W}_{t+1}^T = (z_{t+1}^T)^\theta - r_t(p_t^Z z_{t+1}^T - m_t^T)$. When borrowing constraints

[12]For expositional convenience, I assume that entrepreneurs do not buy bonds. As noted earlier, this is optimal for a high enough iceberg cost on domestic finance, τ.

are non-binding, the optimal decision does not depend on internal funds and reduces to a simple first-order condition for each sector:

$$r_t = \frac{\theta\,\mathrm{E}_t[p_{t+1}](z^N_{t+1})^{\theta-1}}{p^Z_t} = \frac{\theta(z^T_{t+1})^{\theta-1}}{p^Z_t}\,. \tag{5}$$

The marginal rate of return on intermediate inputs in each sector equals the gross rate of return on bonds.

Profit maximization with respect to non-tradable inputs by intermediate firms yields

$$p_t x^N_t = \mu p^Z_t y^Z_t \tag{6}$$

and the first-order condition with respect to tradable inputs, together with the zero profit condition, implies

$$p^Z_t = (p_t)^\mu\,. \tag{7}$$

Internal funds are simply given by:

$$m^N_t = \gamma\big[p_t(z^N_t)^\theta - r_{t-1}(p^\mu_{t-1}z^N_t - m^N_{t-1})\big]\,, \tag{8}$$

$$m^T_t = \gamma\big[(z^T_t)^\theta - r_{t-1}(p^\mu_{t-1}z^T_t - m^T_{t-1})\big]\,. \tag{9}$$

Sectoral dynamics

The dynamics of the no-crisis equilibrium path with non-binding borrowing constraints reduces to:

$$z^N_{t+1} = \Big[\frac{\theta}{p^\mu_t r_t}\,\mathrm{E}_t[p_{t+1}]\Big]^{\frac{1}{1-\theta}}\,, \tag{10a}$$

$$z^T_{t+1} = \Big[\frac{\theta}{p^\mu_t r_t}\Big]^{\frac{1}{1-\theta}}\,, \tag{10b}$$

$$p_t(z^N_t)^\theta = \mu p^\mu_t\big(z^N_{t+1} + z^T_{t+1}\big)\,. \tag{10c}$$

The scales of production in both sectors, z^N_t and z^T_t, are predetermined, while the real exchange rate p_t is determined in period t. Equations (10a) and (10b) directly derive from the first-order conditions (5) together with (7). Equation (10c) comes from the market-clearing conditions (2) and (3), together with (7) and the first-order condition of intermediate firms (6). Internal funds are then given by (8) and (9). I only need to keep track of them to make sure that borrowing constraints are not binding.

Definition 1 (No-crisis equilibrium path)**.** *Given initial conditions z^N_0, z^T_0, m^T_0, an initial debt repayment b^N_0 in sector N, and a deterministic exogenous path for the riskless gross interest rate $\{r_t\}_{t\geq 0}$, a no-crisis equilibrium path is a sequence $\{z^N_t, z^T_t, p_t, m^N_t, m^T_t\}_{t\geq 0}$ that satisfies* (10a)*,* (10b)*,* (10c)*,* (8)*, and* (9)*, such that the borrowing constraints* (1) *do not bind, and $m^N_0 = \gamma[p_0(z^N_0)^\theta - b^N_0]$.*

The following proposition establishes the conditions under which there exists a no-crisis equilibrium steady state with strictly positive debt (the proofs of all propositions are in the Appendix).

Proposition 1. *Suppose $\theta > \gamma$.*

For $\lambda \geq 1$ and $r > 1$ such that $\max(\frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}, 1) < r < \frac{\theta}{\gamma}$, there is a unique no-crisis equilibrium steady state where entrepreneurs have a strictly positive debt and borrowing constraints do not bind. In this steady state, the debt repayment-to-internal funds ratio, an indicator of leverage, decreases with the gross interest rate r. The relative size of both sectors is given by $z^N/z^T = m^N/m^T$ and is decreasing in r.

The proof consists in first constructing the no-crisis steady state (under the assumption that borrowing constraints do not bind) and then deriving parameter restrictions under which it exists (this includes the fact that borrowing constraints should be non-binding) and debt is strictly positive. One of the conditions of existence is that borrowing constraints (1) are slack, *i.e.* $p^\mu z^s < \lambda m^s$ for $s = N, T$. With $m^s = (\frac{1}{\theta} - 1)\frac{\gamma r}{1-\gamma r}p^\mu z^s$ in the steady state, this requires $r > \frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}$. Debt is strictly positive for $r < \theta/\gamma$. For debt to be positive at positive interest rates (*i.e.* with $r > 1$) one has to assume that $\theta > \gamma$.

I now turn to the transitory dynamics that follows a permanent increase in financial openness, that is, a permanent decrease in the iceberg cost τ^* and the domestic riskless rate r.

Proposition 2. *Consider an economy in a no-crisis equilibrium steady state corresponding to $r_0 = \bar{r}$ at $t = 0$, hit by an unexpected and permanent negative shock $r_\infty < r_0$ at $t = 1$. Suppose λ is large enough so that borrowing constraints always remain slack. Then,*

- *the real exchange rate p overshoots: it appreciates on impact at $t = 1$ and depreciates thereafter (for $t \geq 2$),*
- *the scale of production in sector N, z^N, increases starting at $t = 2$,*
- *the relative size of sector N, measured by z^N/z^T, overshoots: it increases at $t = 2$ and decreases thereafter (for $t \geq 3$),*
- *if $\gamma\bar{r}$ is not too close to either 0 or 1, the ratio of sectoral internal funds, m^N/m^T, overshoots with a hump-shaped response starting at $t = 1$.*

To prove the proposition, the dynamics described in equations (10) are reduced to a two-dimensional system (z_t^N, p_t), where z_t^N is a predetermined state variable (similar to a capital stock), while p_t is a non-predetermined *jump* variable that contemporaneously reacts to unexpected shocks. This system is log-linearized and shown to have saddle-path dynamics, as illustrated by the phase diagram of Figure 3a. The permanent decrease from r_0 to r_∞ moves the saddle-path to the north-east in the (z_t^N, p_t) plane, leading to an overshooting real exchange rate as shown in Figure 3b.

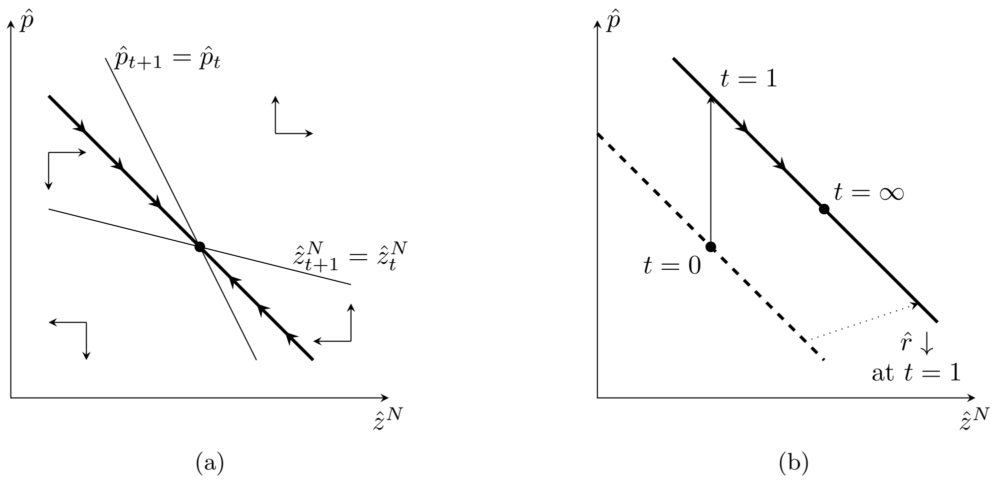


Figure 3: Log-linearized dynamics ($\hat{x}_t$ denotes the log-difference between x_t and its value in a given steady state). (a) Phase diagram. (b) Dynamics following an unexpected and permanent increase in financial openness.

Figure 4 illustrates the transitory dynamics after an increase in financial openness.[13] Intuitively, as domestic entrepreneurs have suddenly access to cheaper foreign loans to finance their purchases of inputs at $t = 1$, they are induced to increase their scale of production. With a predetermined supply, the higher induced demand for non-tradable goods bids up the relative price p in the period of the shock.[14] In the long run, however, the scale of production in sector N, z^N, adjusts to accommodate this larger demand and the real exchange rate subsequently depreciates. Therefore, the real exchange rate overshoots when the shock hits. An important result of the model is that this overshooting lasts for an extended period of time after the shock hits. Indeed, increasing next period's supply of non-tradable goods pushes down their relative price in the next period: from equation (10a), this implies a lower optimal scale of production, slowing down the increase. With a slow increase in z^N_t, the decrease in p_t from $t = 2$ on has to be gradual.

As for the evolution of the sectoral structure, the appreciated real exchange rate hurts the tradable sector by raising the price of the input (in terms of tradable goods) whereas in the non-tradable sector this higher cost of inputs is offset by a high expected future price of outputs. So, the relative size of both sectors, measured by their input purchases or by their internal funds, first evolves in a direction favorable to the non-tradable sector until the tradable sector catches up.

The important feature to get these results is the imperfect mobility of factors. The real exchange rate overshoots when the shock hits because production takes time and cannot adjust instantaneously. The overshooting lasts for many periods because entrepreneurs are specialized in their sector. If they could, they would switch from the tradable to the non-tradable sector

[13]The calibration is described in Section 4.2. The simulation is performed using Dynare. See Juillard (1996) for details on the relaxation algorithm used.

[14]In equation (10c), p_t increases with $z^N_{t+1} + z^T_{t+1}$.

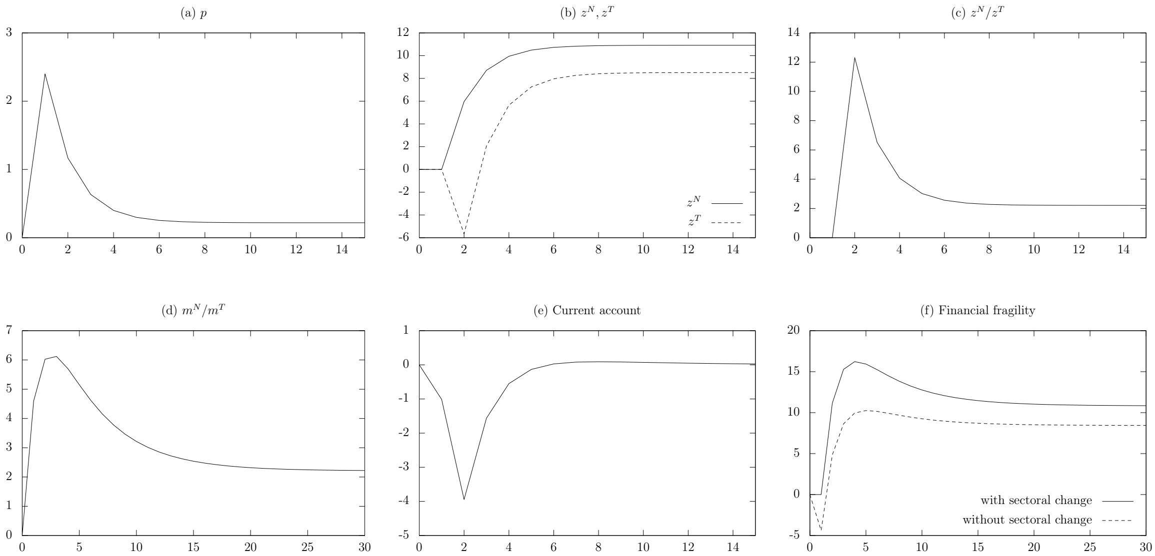


Figure 4: No-crisis equilibrium. Financial openness permanently increases at $t = 1$ by 1 percentage point. Variables are expressed as a percentage deviation from the initial steady state. The current account is normalized by the value of production and expressed as an absolute deviation from the initial steady state, in percentage points. (f) Contribution of sectoral change to financial fragility; solid line: $r_{t-1}(p^{\mu}_{t-1} z^N_t - m^N_{t-1})/m^T_t$; dashed line: $r_{t-1}(p^{\mu}_{t-1} z^N_t - m^N_{t-1})/m^N_t \times (m^N/m^T)_{\text{constant}}$ where m^N/m^T is kept constant at its initial value.

until the expected relative price $\mathrm{E}_1[p_2]$ was back to its steady state level. The real exchange rate and the relative size z^N/z^T would overshoot for a single time period. Appendix B.1 formally derives this result.

3.3 Financial fragility and crises

I now look for a second market-clearing price corresponding to a crisis, along the no-crisis equilibrium path. In this equilibrium, the price of non-tradables is too low to cover the debt repayment (denominated in tradables) promised by firms producing non-tradables. Entrepreneurs of sector N default, their beginning-of-period wealth is zero, and exiting members of the family do not consume.

Proposition 3. *Consider an economy following a no-crisis equilibrium path. If*

$$\frac{r_{t-1}(p^{\mu}_{t-1} z^N_t - m^N_{t-1})}{\gamma\left[(z^T_t)^{\theta} - r_{t-1}(p^{\mu}_{t-1} z^T_t - m^T_{t-1})\right]} > \mu\lambda\,, \tag{11}$$

then there exists a second market-clearing price $p^{crisis}_t < p_t$ at which non-tradable firms default. A necessary condition for the existence of two market-clearing prices is

$$\mu\gamma\lambda > 1\,. \tag{12}$$

An equilibrium path is said to be *financially fragile* in period t when condition (11) is satisfied.

Then, a crisis can be triggered by a non-anticipated expectational shock that makes agents coordinate on the lower market-clearing price. Of course, by definition of the no-crisis equilibrium path, crises are zero-probability events and they remain in the background of the dynamics. Along a no-crisis equilibrium path, condition (11) can be rewritten

$$\frac{r_{t-1}(p^{\mu}_{t-1}z^N_t - m^N_{t-1})}{m^T_t} = \underbrace{\frac{r_{t-1}(p^{\mu}_{t-1}z^N_t - m^N_{t-1})}{m^N_t}}_{\substack{\text{financial}\\ \text{structure of N}}} \times \underbrace{\frac{m^N_t}{m^T_t}}_{\substack{\text{sectoral}\\ \text{structure}}} > \mu\lambda\,. \tag{11'}$$

A no-crisis equilibrium path is financially fragile when the product of two factors is large enough. The first factor relates debt service to internal funds and reflects the financial structure of balance sheets in sector N. As debt is denominated in tradable goods, it also measures the extent of the currency mismatch. The second factor describes the relative size of both sectors, measured by their internal funds, and is an indicator of the sectoral structure of the whole economy.[15]

The steady state value of both factors decreases in r (see Proposition 1). In the long run, more financially opened economies are more leveraged and have a larger non-tradable sector.[16] The following proposition shows under what condition this is enough to make the steady state financially fragile.

Proposition 4. *Suppose $\mu\gamma\lambda > 1$. There is a unique r_{frag} in $\left(\max(\frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}, \theta\mu), \frac{\theta}{\gamma}\right)$ such that $\frac{r(p^{\mu}z^N - m^N)}{m^T} > \mu\lambda$ if and only if $r < r_{frag}$. If $r_{frag} > 1$, a no-crisis equilibrium steady state is financially fragile for all r in $(1, r_{max})$. A sufficient condition for $r_{frag} > 1$ is $\theta > \frac{\lambda}{(\lambda-1+1/\gamma)}$.*

After a permanent decrease in the transaction cost τ^*, leverage in sector N, as measured by the ratio of debt repayment to internal funds, increases to its higher new steady state value.[17] Proposition 2 showed that the ratio of internal funds m^N_t/m^T_t displays a hump-shaped dynamics for a wide range of parameters. As a result, the financial fragility ratio $r_{t-1}(p^{\mu}_{t-1}z^N_t - m^N_{t-1})/m^T_t$ can overshoot in the medium run, as shown in Figure 4f (solid line). This makes it more likely for the economy to become financially fragile during the transition to a more open capital account.

As the financial structure of sector N and the sectoral structure enter multiplicatively in the financial fragility ratio, the two factors reinforce each other. By how much does each factor contribute to financial fragility? Figure 4f shows the evolution of $r_{t-1}(p^{\mu}_{t-1}z^N_t - m^N_{t-1})/m^T_t$ with (solid line) and without (dashed line) changes in m^N/m^T. In the long run the larger value of the ratio mainly comes from a higher leverage but the overshooting of relative internal funds does significantly affect the transitory dynamics.

[15] In condition (11'), m^N and m^T correspond to normal-time internal funds.

[16] The monotonicity of m^N/m^T in r depends on the simplifying assumption that the non-tradable good is only used as an input. It does not generalize to the case when it also enters the consumption basket. In such a case, however, $r(p^Z z^N - m^N)/m^T$ would still be strictly decreasing in r.

[17] The leverage ratio in sector N actually decreases when the shock hits since debt service is predetermined while internal funds increase with the real appreciation. It only starts increasing in the following period. Convergence can be monotonic or slightly hump-shaped, depending on parameter values.

3.4 Discussion of the results

Sectoral dynamics Sectoral dynamics are entirely driven by the technological assumptions. In particular, the demand side of the model plays no role in these dynamics. By definition of the no-crisis equilibrium path, financial frictions play no role either in the transitory dynamics. This suggests that booms in the non-tradable sectors should be observed during episodes of large capital inflows regardless of the degree of financial development, that is, both in emerging and advanced economies. This is consistent with the empirical evidence presented in Section 2.

The role of financial frictions Financial frictions are however important for financial fragility. This is consistent with the logit estimations of Section 2.2, which show that emerging countries, who arguably face stronger borrowing constraints, have a higher probability of crises. As in Krugman (1999), Aghion et al. (2004), and Schneider & Tornell (2004), the crisis mechanism relies on the interplay between currency mismatches and borrowing constraints. Borrowing constraints are in particular necessary to limit the demand for non-tradable goods during crises, not only in sector N but also in sector T: a larger financial multiplier in sector T would weaken the case for financial fragility.[18]

However, the financial multiplier cannot be too small: borrowing constraints have to remain slack, at least in sector N, so that a normal-time equilibrium exists, a result similar to Aghion et al. (2004) and Schneider & Tornell (2004). More precisely, the financial multiplier λ that enters condition (12) is that of sector N. As regards sector T, the definition of a no-crisis equilibrium path can be easily extended to allow for a binding constraint: this would simply slow down growth in the tradable sector during its catching-up phase.

The role of the sectoral structure in financial fragility Condition (11') shows that a sectoral structure largely oriented toward the production of non-tradable goods favors the possibility of crises. Intuitively, when borrowing is constrained, the sectoral structure is what determines the level of the real exchange rate needed to adjust the lower demand for non-tradable goods. Then, for a large enough (foreign currency) debt in sector N—the first factor in condition (11')—this depreciated level of the real exchange rate leads to defaults and a crisis.

Anticipated crises To model anticipated crises, a predictable selection rule should be introduced to coordinate agents across the two possible outcomes when both exist at the same time. Suppose, as Cole & Kehoe (2000), that there is an exogenous sunspot variable independently and uniformly distributed on the interval $[0, 1]$ and denote π the probability of a crisis in a period where a crisis is possible. A possible selection rule could be to coordinate on the crisis-time real exchange rate when (a) it exists, (b) it was predicted to exist with probability π in the previous period, and (c) the sunspot variable is lower than π. The probability of crisis would

[18] If entrepreneurs in sector T were not subject to the constraint at all, they would take advantage of the low price of inputs to increase their production during crises. Their higher demand for inputs would partly make up for the lower demand from sector N, dampening the effect of the crisis, or even making it impossible for a crisis to take place at all.

then be endogenous: equal to 0 or π depending on whether the economy is financially fragile or not. When this probability is non-zero, entrepreneurs of sector N would have to pay a higher rate of return $r_t^N > r_t$ for foreign lenders to break even: $r_t = (1-\pi)r_t^N + \pi\frac{p_{t+1}^{\text{crisis}}(z_{t+1}^N)^\theta}{p_t^\mu z_{t+1}^N - m_t^N}$.[19] The no-crisis equilibrium path studied in this paper corresponds to the limit $\pi \to 0$. By continuity, results concerning financial fragility when $\pi = 0$ should also be valid when $\pi > 0$ provided that the probability of crisis π is low enough.[20]

Crises triggered by shocks on fundamentals So far, crises were supposed to be triggered by self-fulfilling purely expectational shocks. An alternative is to consider unexpected negative shocks on λ. If $\lambda < 1/(\mu\gamma)$ when (11) holds, the normal-time within-period equilibrium disappears and the economy jumps to the remaining crisis-time within-period equilibrium.[21]

Crises in economies with a fixed exchange rate regime As explained earlier, the exchange rate regime does not seem to matter for the sectoral reallocation or the occurence of twin crises. However, it plays an important role during crises. Empirically, large real depreciations have taken the form of nominal depreciations. By contrast, crisis countries in the periphery of the euro area, where such an adjustment is impossible, have experienced limited real depreciation so far. Some form on nominal rigidity is needed to account for this different behavior. Denote p^T (p^N) the nominal price in the tradable (non-tradable) sector. By the law of one price, we have $p^T = e$ where e is the nominal exchange rate.[22] The relative price of non-tradables is then $p = p^N/e$. Equilibria described in the model obtain if either the nominal exchange rate or the price of non-tradables is fully flexible. This is not the case in an economy with nominal rigidities and a fixed exchange rate regime. Appendix B.2 develops such a framework with monopolist competition and pre-set prices in the non-tradable sector. Production in that sector is now given by $u_t(z_t^N)^\theta$, where u_t is the rate of capacity utilization. Entrepreneurs decide at the end of period $t-1$ how much to produce in period t. At the beginning of period t, after shocks on exogenous variables are known but before they know whether a self-fulfilling crisis occurs, they set their prices. When they know whether a crisis occurs or not, they set capacity utilization. Under these assumptions, the dynamics of the no-crisis equilibrium path is unchanged. During a crisis, the relative price of non-tradables, p_t, takes its pre-set normal-time value and adjustment comes from capacity utilization u_t instead. Entrepreneurs in sector N default, not because they sell their goods at a lower price, but because they sell less of them. The sufficient condition of financial fragility (11) still holds.

[19] If τ/τ_t^* is large enough, entrepreneurs of sector N still find it optimal to invest all their internal funds in production.

[20] One advantage of studying this limiting case is that the dynamics converges to a steady state, which is not necessarily true when $\pi > 0$. If the steady state of the no-crisis equilibrium path is financially fragile, equilibrium paths with a small enough $\pi > 0$ never converge to a steady state: instead, convergence is repeatedly interrupted by crises each time the economy is financially fragile and the sunspot is lower than π.

[21] When (11) does not hold, a shock on λ has no effect if the constraints remain slack or triggers a real depreciation if they start binding, but not enough to provoke defaults in sector N.

[22] The price of foreign tradables has been normalized to 1.

4 Quantitative analysis

4.1 The model

A more realistic set-up

To explore the quantitative features of the model, the mechanism has to be embedded into a richer set-up. In the simple framework studied so far, the focus was exclusively on risk-neutral entrepreneurs, intermediate goods were the only factor of production, and the final good consumed by agents was only made of tradable goods. In this section, three additional elements are introduced: (i) there is a standard representative household with concave utility, (ii) the final good is made of both tradable and non-tradable goods, and (iii) production now requires the use of labor and capital, providing new adjustment margins. This more realistic framework will be used to shed light on several episodes of large capital inflows identified in Section 2.1.

Preferences To embed the simple framework of Section 3 into a conventional macroeconomic model, I consider a representative household modeled as in Gertler & Karadi (2011), where members randomly switch between four possible occupations. More specifically the household has a fraction f^N of entrepreneurs in sector N, a fraction f^T of entrepreneurs in sector T, a fraction f^F of financial intermediaries, and a fraction $1 - f^N - f^T - f^F$ of workers. All members benefit from full consumption insurance within the household. Workers supply labor L_t and return their wage w_t to the household. Entrepreneurs are modeled as in the simple set-up of Section 3: they engage in production, issue debt and accumulate internal funds. Instead of exiting the economy with probability $1 - \gamma$, they now return to the household with probability $1 - \gamma$ to become new workers, bringing their share of net wealth back to the household as dividends. They are replaced by members previously employed as workers. Denote div_t^s the dividends brought back by exiting entrepreneurs of sector $i = N, T$, denominated in final goods (see below). Financial intermediaries are similar to entrepreneurs but instead of engaging in production they accumulate capital K which they finance out of their internal funds m_t^F and by issuing bonds. They are also endowed with $L^F = 1$ unit of specialized labor and receive a wage w_t^F which they use to increase their internal funds. Denote div_t^F the dividend they return to the household when they exit financial intermediation. The total income of the household is the sum of wages from workers and dividends from entrepreneurs and financial intermediaries: $w_t L_t + \sum_{i=N,T,F} p_t^F \text{div}_t^i$ where p_t^F is the price of final goods.

The household has Greenwood-Hercowitz-Huffman (GHH) preferences given by utility $U_t = \mathrm{E}_t \sum_{s\geq 0} \beta^s u(c_{t+s} - h(L_{t+s}))$, where c is the consumption of final goods by the household and L the labor supplied by workers. Entrepreneurs and financial intermediaries maximize

$$\mathrm{E}_t \sum_{s\geq 0} M_t^{t+s+1} \text{div}_{t+s+1}^i \qquad i = N, T, F,$$

where

$$M_t^{t+s+1} = \beta^{s+1} \frac{u'(c_{t+s+1} - h(L_{t+s+1}))}{u'(c_t - h(L_t))}$$

is the stochastic discount factor of the household.

Technology As in Section 3, entrepreneurs use an input Z to produce tradable and non-trabable goods. The production of non-tradable goods is $(z_t^N)^\theta$, as before. The production of tradable goods is $e^{a_{t-1}^T}(z_t^T)^\theta$, where a^T is an efficiency wedge between the tradable and non-tradable sectors, which I will refer to as sector-T productivity. The two goods are used to produce a final good with a Cobb-Douglas production function: $y_t^F = \left(\frac{x_t^T}{1-\mu}\right)^{1-\mu}\left(\frac{x_t^N}{\mu}\right)^\mu$, where x_t^T (x_t^N) is the input of tradables (non-tradables) used in the production of the final good F. The input Z is now produced by a competitive sector using intermediate goods J, capital K, labor from workers L, and labor from financial intermediaries L^F:

$$y_t^Z = e^{a_t^Z} J_t^\eta [K_t^\alpha (L_t^F)^\epsilon L_t^{1-\alpha-\epsilon}]^{1-\eta},$$

where a^Z measures the efficiency of production and is similar to total factor productivity (TFP) in one-sector models.[23] Capital depreciates at rate δ. The production of new capital goods and the repair of depreciated capital goods is carried out by a competitive sector of capital producers. Repairing depreciated capital only requires a corresponding amount of final goods. New capital goods K_{t+1} are produced using the existing stock of capital and an amount $K_{t+1} - K_t$ of final goods. In addition, there is an installation cost $\Phi(K_{t+1}, K_t)$ in final goods, where Φ is homogeneous of degree one. New capital goods produced in period t can be rented to both sector Z and capital producers from period $t+1$ on, with respective rental rates ρ_t^Z and ρ_t^K. Denote q_t the price of capital goods in period t.

Financial frictions The iceberg costs and financial frictions described in Section 3.1 for entrepreneurs still apply. In addition, financial intermediaries are also subject to a borrowing constraint similar to (1): their investment expenditures (both the purchase of new capital goods and the repair of depreciated ones) are limited by a multiple of their internal funds m_t^F:

$$q_t(K_{t+1} - K_t) + \delta p_t^F K_t \leq \lambda m_t^F \,. \tag{13}$$

As entrepreneurs, they have limited liability and default when debt falls short of the value of their capital stock $(q_t + \rho_t^Z + \rho_t^K - \delta p_t^F)K_t$. In that case, debt is renegotiated down to the value of capital. Finally, households are also subject to a borrowing constraint: they cannot issue debt. Thus, if B_t denotes the bonds held by households at the end of period t (paying a return $r_t B_t$ in $t+1$), the constraint is

$$B_t \geq 0 \,. \tag{14}$$

[23]The simple framework of Section 3 corresponds to the case $\eta = 1$.

Market clearing The market-clearing condition for intermediate inputs Z and non-tradable goods N are unchanged and given by Equations (2) and (3). In addition, the market for final goods clears. The supply of final goods is equal to the sum of household consumption, intermediate goods and investment:

$$y_t^F = c_t + J_t + K_{t+1} - (1-\delta)K_t + \Phi(K_{t+1}, K_t)\,. \tag{15}$$

Equilibrium

As in Section 3.2, I focus on no-crisis equilibrium paths where entrepreneurs and financial intermediaries face non-binding constraints and do not default. Given stochastic processes for the exogenous variables $\{\tau_t^*, z_t^T, a_t^T\}_{t\geq 0}$, with $r_t = \tau_t^*/\beta$, a no-crisis equilibrium is then defined by a stochastic sequence of allocations $\{z_t^N, z_t^T, y_t^Z, y_t^F, K_t, L_t, J_t, c_t, B_t, m_t^N, m_t^T, m_t^F\}_{t\geq 0}$ and a stochastic sequence of prices $\{p_t, p_t^Z, p_t^F, \rho_t^Z, \rho_t^K, w_t, w_t^F\}_{t\geq 0}$ that solve the optimization problems of all agents and firms, satisfy market clearing conditions for intermediate inputs, non-tradables, and final goods, and such that borrowing constraints for entrepreneurs (1) and financial intermediaries (13) do not bind. Compared to Definition 1, a no-crisis equilibrium now allows for stochastic changes in exogenous variables and includes the evolution of final good production y_t^F, capital K_t, labor L_t, intermediate goods J_t, household bond holdings B_t, prices of inputs p_t^Z, final goods p_t^F and capital q_t, rental rates ρ_t^Z and ρ_t^K, and wages w_t and w_t^F.

Most of the optimality conditions of the model are standard and detailed in Appendix B.3. Here, I just present the first-order conditions specific to the framework developed in this paper.

Households choose their consumption c_t, labor supply L_t and bond holdings B_t to maximize their intertemporal utility under the borrowing constraint (14) and the following budget constraint: $p_t^F c_t + \tau B_t = r_{t-1}B_{t-1} + w_t L_t + p_t^F \sum_{i=N,T,F} \mathrm{div}_t^i$. The first-order condition with respect to B_t is

$$\tau \Delta_t = \beta r_t \,\mathrm{E}_t\, \frac{p_t^F}{p_{t+1}^F} \Delta_{t+1} + \Gamma_t\,, \tag{16}$$

where $\Delta_t = u'(c_t - h(L_t))$ is the marginal utility of consumption and Γ_t/p_t^F is the Lagrange multiplier associated to the borrowing constraint (14). Since $\beta r_t = \tau_t^*$ and $\tau > \tau_t^*$, this multiplier is strictly positive in the vicinity of any steady state and the borrowing constraint (14) binds. I assume τ/τ_t^* is large enough so that this is also the case in any equilibrium considered. Because domestic finance is less efficient than foreign finance, households do not extend any loans to domestic entrepreneurs and financial intermediaries. They simply consume their entire income, consisting of both wages and dividends paid by entrepreneurs and financial intermediaries.[24]

The value function of entrepreneurs of sector N is similar to the one presented in the simple

[24] However, the household still has positive wealth since it owns firms and financial intermediaries.

model. Assuming their borrowing constraint does not bind, it is given by

$$V_t^N\left(\tfrac{m_t^N}{p_t^F}\right) = \max_{z_{t+1}^N} \mathrm{E}_t\, M_t^{t+1}\Big[(1-\gamma)\tfrac{\mathcal{W}_{t+1}^N}{p_{t+1}^F} + V_{t+1}^N\Big(\gamma\tfrac{\mathcal{W}_{t+1}^N}{p_{t+1}^F}\Big)\Big]$$
$$\text{with}\quad \mathcal{W}_{t+1}^N = p_{t+1}(z_{t+1}^N)^\theta - r_t(p_t^Z z_{t+1}^N - m_t^N)\,.$$

Dividends paid to the household are $\mathrm{div}_t^N = (1-\gamma)\frac{\mathcal{W}_{t+1}^N}{p_{t+1}^F}$. The associated first-order condition is

$$\mathrm{E}_t\, M_t^{t+1}\tfrac{\Lambda_{t+1}}{p_{t+1}^F}\big[\theta p_{t+1}(z_{t+1}^N)^{\theta-1} - r_t p_t^Z\big] = 0\,, \tag{17}$$

where Λ_t is the marginal value of beginning-of-period wealth given by

$$\Lambda_t = 1-\gamma+\gamma\,\mathrm{E}_t\, M_t^{t+1}\frac{r_t p_t^F}{p_{t+1}^F}\Lambda_{t+1}.$$

A similar condition holds for entrepreneurs of the tradable sector.

The value function of financial intermediaries is

$$V_t^F\left(\tfrac{m_t^F}{p_t^F}\right) = \max_{K_{t+1}} \mathrm{E}_t\, M_t^{t+1}\Big[(1-\gamma)\tfrac{\mathcal{W}_{t+1}^F}{p_{t+1}^F} + V_{t+1}^F\Big(\tfrac{\gamma\mathcal{W}_{t+1}^F + w_{t+1}^F}{p_{t+1}^F}\Big)\Big]$$
$$\text{with}\quad \mathcal{W}_{t+1}^F = (q_{t+1}+\rho_{t+1}^Z+\rho_{t+1}^K-\delta p_{t+1}^F)K_{t+1} - r_t(q_t K_{t+1} - m_t^F)$$

and $\mathrm{div}_t^F = (1-\gamma)\frac{\mathcal{W}_{t+1}^F}{p_{t+1}^F}$. The first-order condition is similar to the one of entrepreneurs:

$$\mathrm{E}_t\, M_t^{t+1}\tfrac{\Lambda_{t+1}}{p_{t+1}^F}\big[q_{t+1}+\rho_{t+1}^Z+\rho_{t+1}^K-\delta p_{t+1}^F - r_t q_t\big] = 0\,. \tag{18}$$

The rest of the equilibrium is described in Appendix B.3.

Financial fragility in this extended model is defined as the existence of a second market-clearing price such that both financial intermediaries and entrepreneurs of sector N default and all borrowing constraints bind. As in the simple model, financial fragility takes place when the financial fragility ratio $r_{t-1}(p_{t-1}^Z z_t^N - m_{t-1}^N)/m_t^T$ exceeds some threshold. See Appendix B.3 for a formal derivation.

To compare the output of the model with macroeconomic data, I define sectoral GDP as the (vertically integrated) value of production net of the consumption of intermediate goods, with inventories valued at current prices:

$$\mathrm{GDP}_t^N = p_t(z_t^N)^\theta + p_t^Z(z_{t+1}^N - z_t^N) - \eta p_t^Z z_{t+1}^N$$

and similarly for sector T.[25] Real sectoral GDP, denoted rGDP_t^N and rGDP_t^T, are computed by keeping prices constant at their value in the initial steady state.

[25] Sectoral GDP is equal to the sales of N or T goods plus the change in inventories of Z minus the intermediate goods J used in the production of Z. I have used the fact that in equilibrium the value spent on intermediate goods is equal to a share η of the value of inputs Z produced.

Discussion of the extended set-up

As in the simple framework, I focus on no-crisis transition dynamics where borrowing constraints on investment and production do not bind. Therefore, the behavior of the model is close to a conventional one. The only friction is the binding borrowing constraint on consumption. This assumption has two advantages. First, it closes this small open economy model in the sense of Schmitt-Grohe & Uribe (2003) as it prevents it from having a unit root in the evolution of the net foreign position. Second, it is necessary to model crises and financial fragility. Notice that investment and production decisions are not subject to this constraint, since they are taken by financial intermediaries and entrepreneurs who can borrow on financial markets. If anything, relaxing the borrowing constraint on consumption would reinforce the results on sectoral dynamics: as financial openness increases, households would want to consume now part of their higher future income, appreciating the real exchange rate even more and leading to a larger increase in the N-to-T ratio.

Other borrowing constraints, which only bind during crises, are a necessary ingredient to get financial fragility. A crisis in this model requires a low demand for non-tradable goods. As in the simple model, purchases of intermediate inputs by entrepreneurs is limited by their borrowing constraint. In the extended model, a similar constraint applies to financial intermediaries in charge of the investment decision, another component of demand. The borrowing constraint on consumption described earlier sets an upper bound on household consumption, the third component of demand.

With GHH preferences, labor supply does not react to changes in the level of consumption, making employment very procyclical. This specification is often used in models of small open emerging economies.[26] Neumeyer & Perri (2005) show that GHH preferences are essential to get the negative correlation between GDP and the real interest rate that is present in the data.

Financial intermediaries are endowed with labor so that they can start accumulating wealth. Without this assumption, they would not have any internal funds to begin investing. This is particularly the case during crises when they default and lose their accumulated wealth. The same assumption is made for instance by Bernanke et al. (1999).

4.2 Sectoral dynamics during episodes of large capital inflows

I now use this extended framework to study the effect of financial integration on sectoral dynamics and financial fragility. First, I show that the extended model behaves similarly to the simple framework of Section 3. Then, I look at the extent to which this mechanism might have played a role in several historical episodes of large capital inflows that have led to twin crises. Finally, I look at the implication for financial fragility and crises.

[26] See for instance Mendoza (1991), Mendoza & Smith (2006), Christiano, Gust & Roldos (2004), Garcia-Cicco, Pancrazi & Uribe (2010).

Calibration

The model is calibrated on a typical small open economy subject to large capital inflows leading to a twin crisis. More specifically, I will focus on the countries of Table 2: Finland, Malaysia, Thailand, Argentina, Colombia, Greece, and Spain, which include four well-known sets of crises: the Nordic crisis, the Asian crisis, crises in Latin America, and crises at the periphery of the euro area.[27]

The time period is set to 6 months. I choose the following functional forms for the utility function, the disutility of labor and the installation cost of capital: $u(x) = \frac{x^{1-\sigma}}{1-\sigma}$, $h(L) = \frac{\chi}{1+\chi} L^{\frac{1+\chi}{\chi}}$, and $\Phi(K_{t+1}, K_t) = \frac{1}{2}\varphi K_t(\frac{K_{t+1}}{K_t} - 1)^2$. The calibration of the model's parameters is reported in Table 3.

Table 3: Calibration.

Parameter	Value
Discount factor	$\beta = 0.99$
Relative risk aversion	$\sigma = 2$
Frisch elasticity	$\chi = 1$
Capital share	$\alpha = 0.37$
Depreciation rate of capital	$\delta = 0.06$
Installation cost of capital	$\varphi = 1$
Initial iceberg cost	$\tau_0^* = 1.033$
Degree of decreasing returns	$\theta = 0.90$
Share of intermediate goods	$\eta = 0.54$
Share of financial intermediation	$\epsilon = 0.05$
Share of non-tradable goods	$\mu = 0.65$

Most of the parameters are standard in the business cycle literature. The discount factor β is set to match a world real interest rate of 2.7% per year, which is the average real interest rate on 10-year US Treasury bonds (defined as the nominal rate minus current inflation) for the period 1970–2010. The coefficient of relative risk aversion is set to $\sigma = 2$ and the Frisch elasticity of labor to $\chi = 1$, two conventional values in business cycle models. The coefficient α is set to match a capital share of 0.35.[28] This is the average found by Bernanke & Gurkaynak (2001) on a large sample of countries, using the method of Gollin (2002) who argued that there is little variation across countries once the income of independent workers is properly accounted for. The depreciation rate δ is set to match a steady state investment rate of 24% at the world interest rate. This is the average in the seven countries after the beginning of the episode of large capital inflows and until the end of the sample. Finally, the coefficient of installation costs φ is set to 1 following the discussion in Gilchrist, Sim & Zakrajsek (2010).

The parameters specific to this paper are the level of iceberg costs in the initial steady state τ_0^*, the degree of decreasing returns to scale θ, the share of intermediate goods in production η, the share of labor by financial intermediaries ϵ, the share of non-tradable goods μ, and the survival rate of entrepreneurs and financial intermediaries γ.

[27] I exclude Sweden, due to the short duration of the episode (3 years).

[28] Capital income includes the interest rate received by entrepreneurs on inventories.

The initial iceberg cost τ_0^* corresponds to the spread between the domestic marginal return on capital and the world interest rate before financial integration. In emerging markets, this spread, as measured by the EMBI, was around 1000 basis points in 1990, prior to capital account liberalization; it increased above 1000 basis points in 1995 and 1998, two periods of financial stress during which many countries lost market access, and to 700 basis points in the recent global liquidity crisis of 2008. In the recent crisis of the euro area, the sovereign bond spread against Germany increased to around 500 basis points in Spain and Italy as capital stopped flowing to these countries. On the light of this evidence, I set τ_0^* to match a spread of 700 basis points per year.

The degree of decreasing return to scale θ is chosen to be consistent with the literature on firm dynamics. For example, Atkeson & Kehoe (2005) argue that a value of 0.95 is appropriate for the degree of decreasing returns at the plant level based on a survey of the large existing empirical literature; taking into account the effect of imperfect competition, they retain a lower effective value of 0.85. I set θ to the mean of these two values. Cagetti & De Nardi (2009) obtains the same value of 0.9 when they calibrate their model of entrepreneurship to match US data.

The parameter η is set to match a share of intermediate goods in total production of 46%, as recommended by Jones (2013). The share of financial services ϵ is calibrated from input-output data to match a share of inputs from finance and real estate in production equal to 4 percent on average for Finland, Argentina, Greece, and Spain.[29] The share of non-tradable goods μ in consumption, investment, and intermediate goods can also be measured in input-output tables. It is equal to 61% on average for those countries. The true share could be even higher: Burstein, Eichenbaum & Rebelo (2005) argue that some goods traditionally classified as tradables are in fact local goods sheltered from foreign competition. In the case of Argentina, they suggest that local goods could represent up to 22% of tradable consumption goods. Applying this correction raises the share of non-tradable goods to 69%. However, investment and intermediate goods are likely to have a lower share of local goods than consumption goods. Therefore, I make a conservative choice and set μ to the average of the two values, 65%.

Finally, γ is estimated separately for each episode of large capital inflows (see below).

Dynamics in the quantitative model

I run the same simulation as in Section 3.2 and Figure 4. At $t = 0$, the economy is in the initial steady state corresponding to $\tau^* = \tau_0^*$. At $t = 1$, τ^* unexpectedly and permanently decreases by 1 percentage point (which approximately corresponds to 200 basis point annually). I use the value of γ estimated for the capital inflow episode of Thailand in the nineteen-nineties, $\gamma = 0.77$ (see below). The resulting dynamics is displayed in Figure 5.

As can be seen, the mechanism studied in the simple model carries over to the more realistic set-up. Indeed, the dynamics of Figure 5 is qualitatively similar to the dynamics of Figure 4. The evolution of the N-to-T ratio measured by constant price sectoral GDP follows the one

[29] I use OECD input-output tables. Tables for the remaining countries are not available.

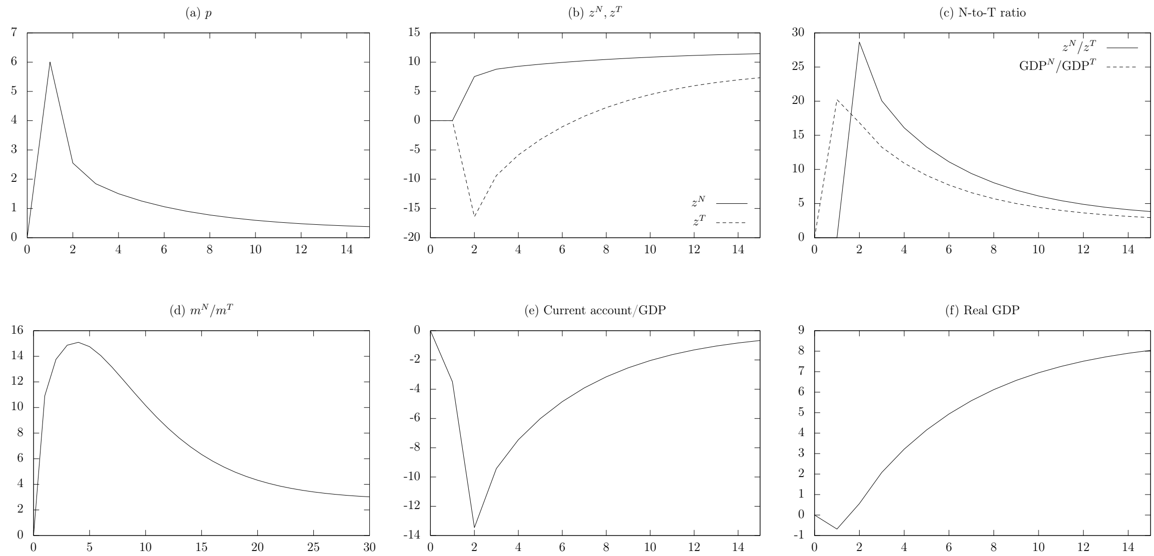


Figure 5: No-crisis equilibrium for $\gamma = 0.77$ (value estimated for Thailand). Financial openness permanently increases at $t = 1$ by 1 percentage point. Variables are expressed as a percentage deviation from the initial steady state, except the current account to GDP ratio which is in absolute deviation from the initial steady state, in percentage points.

of relative purchases of inputs z^N/z^T (Figure 5c).[30] Figure 5f shows how real GDP gradually increases after the shock as capital accumulates because of the lower interest rate.[31]

Understanding historical episodes of large capital inflows

I now confront the model with the data to see if the mechanism described might have played a role during the seven episodes of large capital inflows mentioned above: Finland, Malaysia, Thailand, Argentina, Colombia, Greece, and Spain.

For each episode, I decompose the observed dynamics of the main variables in movements due to several wedges in the spirit of Chari, Kehoe & McGrattan (2007). In addition to the main exogenous variable considered in the paper, the iceberg cost τ_t^* which sets the cost of borrowing r_t, I also consider two wedges introduced in the quantitative model: the multisector efficiency wedge a^Z, akin to a TFP shock, and the efficiency wedge between the tradable and non-tradable sectors, a^T, akin to sector-T productivity. I use three observables: the current account and the N-to-T ratio, which are key to the mechanism studied, and real GDP, which is needed to identify movements in the efficiency wedges. Introducing the efficiency wedge a^Z is important since changes in TFP are likely to affect the current account and the N-to-T ratio through their effect on both the supply of output and the demand for inputs. The sectoral wedge a^T is important since it can directly account for movements in the N-to-T ratio.

More specifically, I assume the following stochastic processes for the three exogenous vari-

[30]The ratio $\mathrm{GDP}^N/\mathrm{GDP}^T$ reacts one period before z^N/z^T because of the timing convention.

[31]At impact, GDP decreases slightly. This is because wages increase by less than the price of the final good, resulting in a lower real wage that decreases labor supply.

ables:

$$\tau_t^* = \tau_{t-1}^* + \epsilon_t^\tau , \tag{19}$$
$$a_t^Z = \rho^Z a_{t-1}^Z + \epsilon_t^Z , \tag{20}$$
$$a_t^T = \rho^T a_{t-1}^T + \epsilon_t^T . \tag{21}$$

I follow closely the theoretical part and assume that the iceberg cost is subject to permanent shocks. The two productivity shocks follow autoregressive processes. The innovations ϵ_t^τ, ϵ_t^Z, and ϵ_t^T are normally distributed with mean 0 and standard deviations σ^τ, σ^Z, and σ^T, respectively. I use the same yearly data as in Section 2. For each episode, the data sample starts one year before the beginning of the episode and stops one year after its end.[32] The decomposition is carried out using a diffuse Kalman filter. I assume that the iceberg cost τ^* is initially equal to τ_0^* and that shocks ϵ_t^τ only start at the beginning of the episode (*i.e.* one year after the beginning of the time sample). The parameters of the shock processes and the survival rate γ are estimated for each episode using bayesian techniques. The priors for the shock processes are the same as in Rabanal (2009). They are reported in Table C.5.

To set a prior for the survival rate γ, I use the fact that this parameter is related to the steady state debt-to-equity ratio. Denote $(D/E)_0$ the debt-to-equity ratio in the initial steady state. Then $(D/E)_0 + 1 = [\theta/(1-\theta)][\beta/(\gamma\tau_0^*) - 1]$. Firm-level data provide some information about possible values for $(D/E)_0$. Booth, Aivazian, Demirguc-Kunt & Maksimovic (2001) report debt-to-equity ratios around 50 percent for Latin American countries and between 70 and 100 percent for Asian countries in the late eighties; de Haas & Peeters (2006) report debt-to-equity ratios from 30 to 60 percent for East European emerging economies in the mid-nineties, and 150 percent for European advanced economies. Accordingly, I set a relatively diffuse prior with a Gamma distribution of mean 100 percent and standard deviation 70 percent. This prior is consistent with calibrations of existing models of financial frictions. Steady state debt-to-equity ratios are equal to 100 percent in Bernanke et al. (1999), 160 percent in Carlstrom & Fuerst (1997), and 110 percent in Gertler, Gilchrist & Natalucci (2007). The posterior means are reported in Table C.6 and vary from 70 to 113 percent. The corresponding survival rates γ vary from 0.77 to 0.80. Further details on the estimation method are given in Appendix C.5.

Figure C.3 in the Appendix displays the resulting shock decomposition of the three observable variables, as well as the estimated decrease in the borrowing rate for all seven countries. In general, TFP and sector-T productivity shocks (blue and light blue bars, respectively) are necessary to account for the dynamics of GDP, but most of the dynamics of the current account and the N-to-T ratio is accounted for by negative shocks to the iceberg cost (dark blue bars) which substantially decrease the cost of financing.

Figures 6 and 7 look in more details at the case of Thailand. According to the empirical evidence of Section 2, Thailand experienced an episode of large capital inflows starting in 1990, which ended up in a twin crisis in 1997. The beginning of the episode of capital inflows coincides

[32] In the case of Finland, where the episode is short, I start the sample two years before the beginning of the episode.

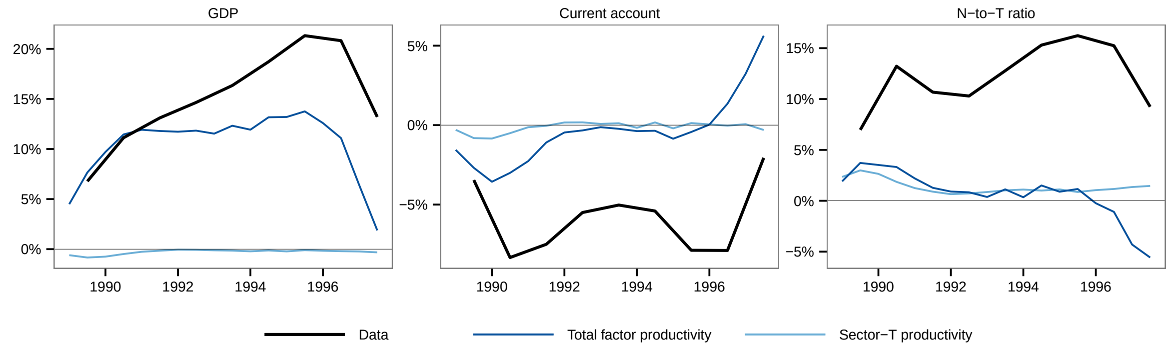


Figure 6: Counterfactuals for Thailand: simulations with one productivity shock only.

with the date of (partial) liberalization of financial markets as documented by Kaminsky & Schmukler (2003), that is, January 1990. In Figure 6, the model is simulated with only one shock, TFP or sector-T productivity respectively. Figure 7 then compares the evolution of the economy when the model is fed with both productivity shocks at the same time and when the only shock is the iceberg cost. The productivity shocks account for most of the increase in GDP above its trend, but explain only a small fraction of movements in the current account and the N-to-T ratio. In particular, with productivity shocks only, both variables quickly revert to their steady state after their initial response. The decrease in the iceberg cost, on the contrary, fits well the observed dynamics of these two variables.

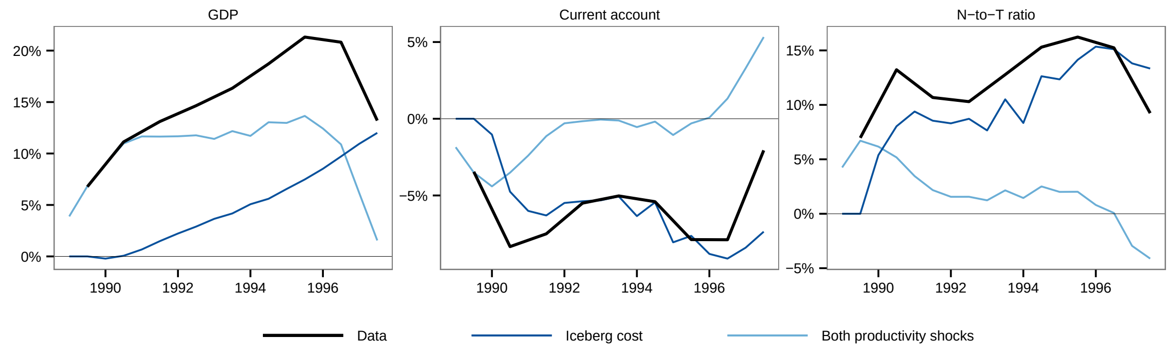


Figure 7: Counterfactuals for Thailand: simulations with the shock on the iceberg cost only and with both productivity shocks at the same time.

The intuition of these results is the following. As explained above, a decrease in the iceberg cost leads to both a persistent increase in the N-to-T ratio and a persistent current account deficit (Figure 5), consistent with the behavior of these two variables during the episodes of large capital inflows.

By contrast, Figure 8 shows the response of the model to innovations in TFP and sector-T productivity in the case of Thailand. A positive TFP shock also leads to a persistent increase in the N-to-T ratio (Figure 8c): as a_t^Z increases, intermediate inputs Z become cheaper and it is optimal for entrepreneurs to increase their scale of production as they would do it with a lower cost of financing. However, the resulting current account deficit is short-lived (Figure 8b): with a higher production, the need to import tradable goods is reduced. TFP shocks, then, do not account well for the persistence of the current account dynamics.[33] As Figure 6 shows, they do not account for its magnitude either.

A *negative* sector-T productivity shock would directly result in a higher N-to-T ratio (Figure 8f). It would also lead to a current account deficit as the economy would need to import the tradable goods it no longer produces (Figure 8e).[34] However, it would imply a decrease in GDP, which is hard to reconcile with the data. As Figure 6 makes clear, the data for Thailand only allows for small negative sector-T productivity shocks, not enough to explain the dynamics of the current account and the N-to-T ratio.[35]

Overall, these results suggest that increased financial integration resulting in a lower cost of external finance is likely to have played an important role in the sectoral reallocation of resources.

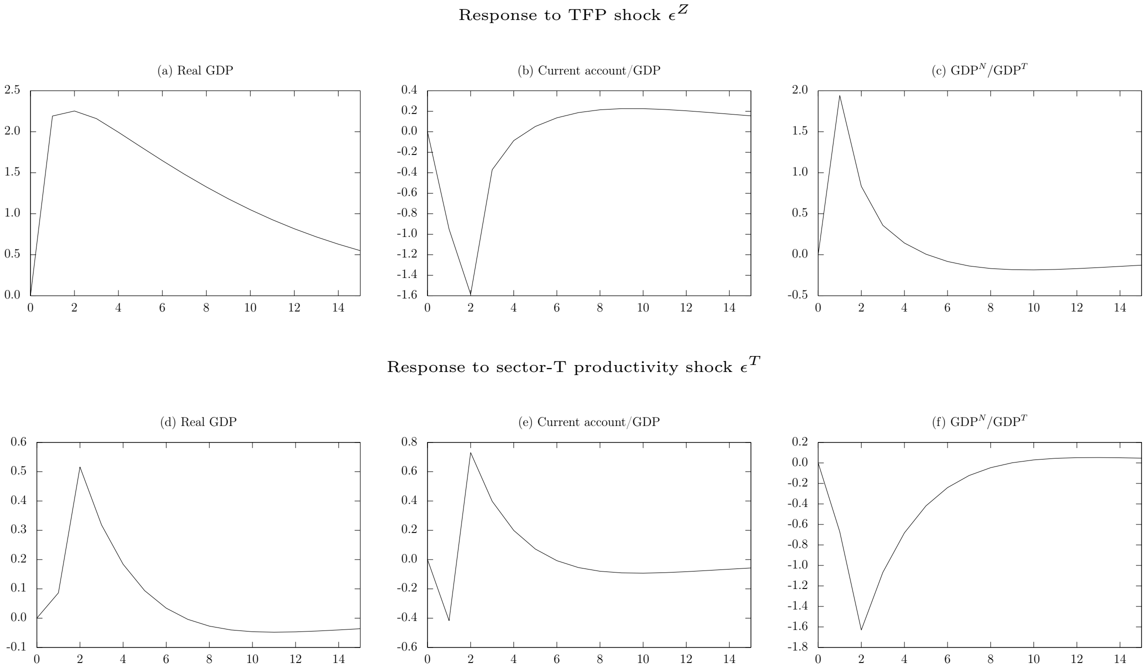


Figure 8: Responses to positive one standard deviation technology shocks for Thailand, in log points for real GDP and GDP^N/GDP^T, and percentage points for current account/GDP. The shock takes place in period 1.

[33]This would be even more true if the domestic iceberg cost τ were lower so that households would find it optimal to save part of the temporarily higher income.

[34]Due to the time-to-build assumption, the initial response to a negative sector-T productivity shock is a current account surplus as entrepreneurs cut their purchases of inputs one period before production actually decreases.

[35]Negative sector-T productivity shocks are also found to play a role in Finland, as can be seen from Figure C.3 in the Appendix. This is consistent with the collapse of trade with the USSR, which is likely to have partly contributed to the Finnish crisis, as argued by Gorodnichenko, Mendoza & Tesar (2012).

Financial fragility and crises

What does this imply for financial fragility and crises? I focus on the case of Thailand to show how the sectoral reallocation triggered by capital inflows might have increased financial fragility.

Financial fragility As in the simple model, financial fragility occurs when the ratio $r_{t-1}(p^Z_{t-1}z^N_t - m^N_{t-1})/m^T_t$ exceeds a threshold that depends on the financial multiplier λ (see Appendix B.3).

I assume the economy is initially, in 1988H2, in a steady state corresponding to the iceberg cost τ^*_0. Then, I feed the model with the shocks $\{\epsilon^\tau_t\}$ backed out from the data on the time period 1989–1997 as described in the previous exercise. These shocks imply a gradual decrease in the iceberg cost τ^*_t and in the rate of return of bonds r_t. Figure 9 shows the resulting evolution of the financial fragility ratio $r_{t-1}(p^Z_{t-1}z^N_t - m^N_{t-1})/m^T_t$ (solid blue line). The black thin lines represent the threshold above which the economy is financially fragile, for different values of the financial multiplier λ. A stronger borrowing constraint (a lower λ) makes financial fragility more likely.

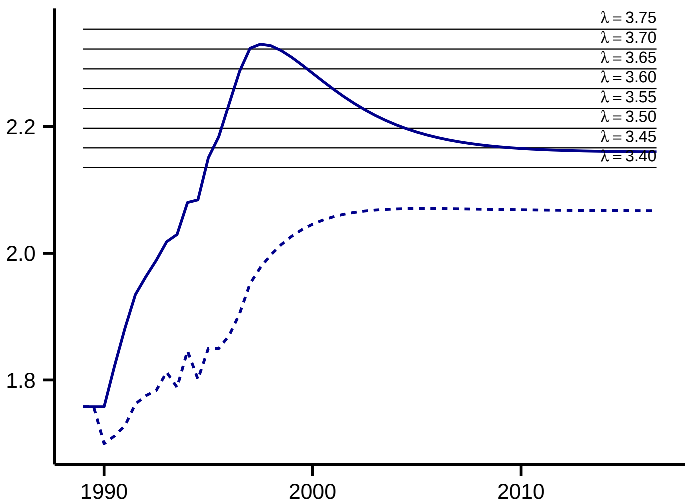


Figure 9: Evolution of financial fragility when the economy is hit by estimated shocks to the iceberg cost τ^*. Solid blue line: financial fragility ratio $r_{t-1}(p^Z_{t-1}z^N_t - m^N_{t-1})/m^T_t$. Dashed blue line: $r_{t-1}(p^Z_{t-1}z^N_t - m^N_{t-1})/m^N_t \times (m^N/m^T)_{\text{constant}}$ where m^N/m^T is kept constant at its initial value. Thin lines: thresholds corresponding to different values of λ.

As the figure shows, the financial fragility ratio displays significant overshooting in the medium term. For a given value of the financial multiplier, the economy is more likely to experience financial crises in the medium term than in the long term. Financial fragility requires at least $\lambda \lesssim 3.71$ during the transition. With $\lambda \lesssim 3.43$, the economy displays financial fragility even in the final steady state. The ratio is particularly large at the time of the actual crisis, 1997.

By how much does the sectoral reallocation contribute to financial fragility? The dashed blue line shows the evolution of the same ratio holding m^N/m^T constant at its initial value. While this modified ratio increases significantly over time, reflecting a higher leverage in sector N as shown by Equation (11'), it does not display any overshooting. The sectoral reallocation is key to getting stronger financial fragility in the medium term. This confirms the result obtained in the simple model.

Crises The aim of the model is to reproduce the pre-crisis dynamics more than the crisis itself. However, it is instructive to look at the evolution of the main variables predicted by the model should a crisis take place. Using the same simulation as before, I assume that a crisis takes place in 1997H1. Table 4 reports the simulated changes in several key variables in the period of the crisis and compares them with the observed peak-to-trough changes in the data. The equilibrium corresponding to a crisis depends on the parameter of the borrowing constraint λ. I report results for $\lambda \in [3.40, 3.70]$, that is, for λ low enough to get financial fragility in 1997H1 (see Figure 9). At the lower value of $\lambda = 3.40$, the economy stays financially fragile in the new steady state.

Table 4: Observed and simulated peak-to-trough evolution of key variables during the crisis in Thailand.

	p^F	I	L	GDP	NX	DD
Observed data						
	-36	-60	-4	-13	+17	-59
Model						
$\lambda = 3.70$	-39	-50	-4	-1	+35	-65
$\lambda = 3.60$	-40	-52	-5	-2	+36	-67
$\lambda = 3.50$	-41	-54	-5	-2	+37	-68
$\lambda = 3.40$	-43	-55	-6	-2	+37	-70

I: real investment. NX: net export reversal as a share of initial GDP. DD: domestic demand reversal as a share of initial GDP. All reported figures are % change, except the net export and domestic demand reversals which are absolute changes in percentage points. In the data, p^F refers to the bilateral CPI-based real exchange rate with the US dollar. To construct measures of NX and DD in tradable goods, I multiply current prices in domestic currency by the nominal exchange rate with the US dollar and deflate by the US CPI. Peak-to-trough changes are computed on halfyearly data, except employment which uses yearly data.

Overall, the simulated magnitudes are close to the data, which is remarkable given the simplicity of this multiple equilibria framework. In particular, the model does a good job at producing the right order of magnitude for the real depreciation, around 40%. With a binding borrowing constraint for financial intermediaries, investment in the model drops sharply during the crisis, by around 50–55%, compared to 60% in the data. The magnitude of this simulated decrease in investment depends on the strength of the borrowing constraint (λ) and the size of internal funds of intermediaries, driven by the share ϵ of financial services.

The model predicts a 5% drop in employment, very close to the decrease observed in the data. The mechanism behind the fall in employment is the following. With binding constraints, the demand for inputs drops during the crisis, inducing a lower wage bill in sector Z. For a given supply of labor, the wage w decreases. The price of the final good, p^F, also decreases during a crisis, but to a lesser extent since it partly consists of tradable goods. As a result, the real wage w/p^F decreases, which induces households to reduce their labor supply. GHH preferences are crucial to get this result (see below).

Given the decrease in employment, the model predicts a 2% drop in GDP. While this is already substantial for an endogenous decrease driven by a self-fulfilling crisis, it falls short of the 13% collapse observed in the data. The difference comes from the decrease in measured total factor productivity (TFP) which the model was not designed to produce. A plausible explanation for the decline in measured TFP in the data is the banking crisis that took place in 1997 and that very likely disrupted production processes. The counterpart to the banking crisis in the model is the fact that financial intermediaries massively default on their debt. The model assumes that those defaults have no effect on production, arguably an unrealistic assumption.[36]

The model does not do a good job at matching the reversal in net exports. It produces a reversal that amounts to about 35% of the initial GDP, compared to 17% in the data. The difference can be explained by the fact that GDP declines less than in the data as discussed above. For a given change in domestic demand, this implies a larger net export reversal. One way to correct for this is to consider the reversal in domestic demand measured in tradable goods instead of the net export reversal.[37] The model reproduces the former better (see the last column of Table 4).

On the whole, these results show how a model with multiple equilibria can successfully reproduce a crisis of a very large magnitude.

Wealth effect in labor supply As explained above, GHH preferences, which imply no wealth effect in labor supply, are important to get employment dynamics right during a crisis. As is well known, with a wealth effect in labor supply, households would react to the lack of resources during a sudden stop by working more, leading to an economic expansion (Chari, Kehoe & McGrattan 2005). Consider for example the case of separable intratemporal utility: $u(c, L) = \frac{c^{1-\sigma}}{1-\sigma} - \frac{\chi}{1+\chi} L^{\frac{1+\chi}{\chi}}$. Then, the real exchange rate, investment, and the trade balance would react similarly to what is reported in Table 4, but employment would increase by around 30% during a crisis, implying a 10% expansion of real GDP. Without additional ingredients, a wealth effect in labor supply is not consistent with the observed behavior of employment and output during a twin crisis.

Fixed exchange rate regime What would a crisis look like in a fixed exchange rate economy where nominal rigidities impede the real depreciation? Following the discussion on page 25, I simulate the same crisis using a model with monopolistic competition and pre-set prices in sector N. By construction, there is no real depreciation. The reversals of net exports and domestic demand have the same order of magnitude as in Table 4. By contrast, employment decreases by around 25% and real GDP by 20–25%, that is, substantially more than in an economy able to depreciate the real exchange rate. Indeed, absent the decrease in prices of non-tradables, real

[36]In the context of sovereign debt, Arellano (2008) argues that output costs of defaults are important to account for empirically observed default probabilities.

[37]The net export reversal is equal to $\Delta\text{NX}/\text{GDP} = \Delta(\text{GDP} - \text{DD})/\text{GDP} = \Delta\text{GDP}/\text{GDP} - \Delta\text{DD}/\text{GDP}$, where GDP and DD are measured in tradable goods.

wages experience a substantial decline, discouraging work. Real GDP declines because of both lower employment and lower capacity utilization. Because the price of capital goods (which depends on the price of non-tradables) stays high and investment expenditures are limited by the borrowing constraint, real investment declines more (by 68%). These predictions are remarkably close to what a crisis country in a monetary union such as Greece has experienced. As of 2013, the peak-to-trough change was -20% for employment, -24% for GDP, and -64% for fixed capital formation.

5 Final remarks

This paper has built a two-sector model of financial fragility in a small open economy. The model was used to study the effect of an increase in financial openness on the sectoral structure of the economy and the financial structure of its non-tradable sector. In the short to medium run, larger capital inflows lead to a larger relative size of the non-tradable sector. This is in line with the documented behavior of the sectoral structure during episodes of large capital inflows. At the same time, access to cheaper foreign loans leads firms to increase their leverage. The paper shows how the evolution of these two factors tends to make crises more likely. This confirms the documented empirical evidence that large N-to-T ratios and large credit-to-GDP ratios are good predictors of twin crises.

A quantitative version of the model was brought to the data and suggests that decreases in the cost of foreign finance might have largely contributed to sectoral dynamics in several episodes of large capital inflows, including the recent crises in the euro area periphery.

On the methodological front, the paper also suggests that a model with multiple equilibria can be a useful tool to quantitatively match the behavior of macroeconomic variables during a large financial crisis such as Thailand in 1997.

In the model, crises are triggered by self-fulfilling purely expectational shocks but they could also be triggered by exogenous shocks on fundamentals which make the normal-time market clearing price disappear, *e.g.* a sudden stop that tightens borrowing constraints.[38] This could explain why small shocks on fundamentals can have very large effects. It could also explain why two economies can react very differently to the same external shock: a financially fragile economy can jump to the crisis equilibrium, while other economies remain in the normal-time equilibrium, simply experiencing a slight real depreciation and a low decrease of investment. This is fully consistent with the way Argentina and Chile reacted to the 1998 sudden stop, as reported by Calvo & Talvi (2005): the Argentinean economy collapsed while Chile went through a mild recession.

As regards policy issues, financial fragility depends on two factors: (a) how large foreign currency liabilities are compared to domestic currency assets in firm balance sheets and (b) how large the non-tradable sector is compared to the tradable sector. While paying attention to

[38] Calvo et al. (2004) argue that the sudden stop which followed the Russian crisis of 1998 led to episodes of large real depreciation in emerging countries.

mismatches in firm balance sheets is a lesson that is now widely agreed on,[39] this paper suggests that monitoring the evolution of the sectoral structure is also important. If policy makers are trying to prevent balance-of-payments crises, some intervention might be justified to mitigate the sectoral effects of capital inflows. A first way to do it would be to implement macroeconomic policies aimed at decreasing (or not increasing) the size of the financial transfer from abroad (for example by increasing domestic savings or limiting the extent of financial integration). Alternatively, policy makers could resort to sectoral interventions directly aimed at protecting the tradable sector from the effect of the real appreciation. This provides another justification for protecting or promoting the tradable sector to the ones already identified by the literature (increasing returns to scale, sunk costs to enter export markets, financial frictions, etc.)[40] and suggests that there might be some complementarity between financial integration and industrial policy.

[39] See for example Allen, Rosenberg, Keller, Setser & Roubini (2002).
[40] See van Wijnbergen (1984), Hausmann & Rigobon (2002), Caballero & Lorenzoni (2007).

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A Proofs

A.1 Proof of proposition 1

From the first order conditions (10a) and (10b), we get $\theta p(z^N)^\theta = rp^\mu z^N$ and $\theta(z^T)^\theta = rp^\mu z^T$. Plugging this into the market-clearing condition (10c) yields $z^N = \frac{\theta\mu}{r}(z^N + z^T)$. The relative size of both sectors is then given by

$$\frac{z^N}{z^T} = \frac{\frac{\theta\mu}{r}}{1 - \frac{\theta\mu}{r}}.$$

For $r > \theta\mu$, the right-hand size of this expression is strictly positive and the relative size is well defined in the steady state. The relative size of sector N is strictly decreasing in r.

The steady state value of p, z^T, and z^N can be derived from the relative size z^N/z^T. From the first order conditions (10a) and (10b), we have $p = (z^N/z^T)^{1-\theta}$. Knowing p, (10b) gives the value of z^T. The value of z^N follows.

Then, from equations (8) and (9) internal funds in the steady state are given by $m^s = (\frac{1}{\theta} - 1)\frac{\gamma r}{1-\gamma r}p^\mu z^s$, $s = N, T$. They are strictly positive provided that $r < 1/\gamma$. Note that $m^N/m^T = z^N/z^T$. Debt is equal to $p^\mu z^s - m^s = \frac{1-\frac{\gamma r}{\theta}}{1-\gamma r}p^\mu z^s$. Given the restriction $r < 1/\gamma$, debt is strictly positive for $r < \theta/\gamma$. The borrowing constraint (1) does not bind when $p^\mu z^s < \lambda m^s$, *i.e.* when $r > \frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}$.

To sum it up, the steady state exists and features strictly positive debts and non-binding borrowing constraints when $\max(\frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}, \theta\mu) < r < \frac{\theta}{\gamma}$. To further restrict the gross interest rate r to be greater than 1, one has to assume that $\theta > \gamma$.

The debt repayment-to-internal funds ratio, an indicator of leverage, is given by

$$\frac{r(p^\mu z^s - m^s)}{m^s} = \frac{1 - \frac{\gamma r}{\theta}}{\gamma\left(\frac{1}{\theta} - 1\right)}$$

and is strictly decreasing in r.

A.2 Proof of proposition 2

Under the assumption of perfect foresight and slack borrowing constraints, the dynamics of the model can be reduced to a simple two-dimensional system. First, since the constraints do not bind, balance-sheet variables m_t^N and m_t^T do not matter. Second, from (10b), inputs purchased by the tradable sector z_t^T are completely determined by the current level of the real exchange rate and the real interest rate. Therefore, the no-crisis transitory dynamics can be fully described by the evolution of z_t^N and p_t. These two variables form a perfect-foresight two-dimensional system (z_t^N, p_t) that satisfies:

$$p_{t+1} = \frac{1}{\theta} r_t p_t^{\mu} (z_{t+1}^N)^{1-\theta} \,, \tag{22a}$$

$$z_{t+1}^N = \frac{1}{\mu} p_t^{1-\mu} (z_t^N)^{\theta} - \left[\frac{\theta}{p_t^{\mu} r_t}\right]^{\frac{1}{1-\theta}} . \tag{22b}$$

Equation (22a) simply restates (10a). Equation (22b) follows from (10c) and (10b).

Denote $\hat{x}_t \equiv \log(x_t/\bar{x})$ the log-difference between the variable x_t and its value $\bar{x}$ in a particular steady state corresponding to $r = \bar{r}$. From Appendix A.1, we know that $z^N/(z^N + z^T) = \theta\mu/r$ in the steady state. Using this expression, we can log-linearize equations (22) to get

$$\hat{p}_{t+1} = \hat{r}_t + \mu \hat{p}_t + (1-\theta)\hat{z}_{t+1}^N \,, \tag{23a}$$

$$\hat{z}_{t+1}^N = \left[\tfrac{\bar{r}}{\theta\mu}[1-\theta(1-\mu)] - \mu\right] \frac{\hat{p}_t}{1-\theta} + \tfrac{\bar{r}}{\mu}\hat{z}_t^N + \left(\tfrac{\bar{r}}{\theta\mu} - 1\right)\frac{\hat{r}_t}{1-\theta} \,. \tag{23b}$$

Injecting (23b) into (23a) to eliminate z_{t+1}^N yields the usual Blanchard-Kahn form:

$$\hat{p}_{t+1} = \tfrac{\bar{r}}{\theta\mu}[1-\theta(1-\mu)]\hat{p}_t + \tfrac{\bar{r}}{\mu}(1-\theta)\hat{z}_t^N + \tfrac{\bar{r}}{\theta\mu}\hat{r}_t \,,$$

$$\hat{z}_{t+1}^N = \left[\tfrac{\bar{r}}{\theta\mu}[1-\theta(1-\mu)] - \mu\right] \frac{\hat{p}_t}{1-\theta} + \tfrac{\bar{r}}{\mu}\hat{z}_t^N + \left(\tfrac{\bar{r}}{\theta\mu} - 1\right)\frac{\hat{r}_t}{1-\theta} \,,$$

where $\hat{z}^N$ is predetermined while $\hat{p}$ is a jump variable.

The slope of the loci along which $\hat{p}_t = \hat{p}_{t+1}$ and $\hat{z}_t^N = \hat{z}_{t+1}^N$ are given by:

$$\frac{d\hat{p}}{d\hat{z}^N}_{|\hat{p}_{t+1}=\hat{p}_t} = \frac{-\frac{\bar{r}}{\mu}(1-\theta)}{\frac{\bar{r}}{\theta\mu}[1-\theta(1-\mu)] - 1}$$

$$\frac{d\hat{p}}{d\hat{z}^N}_{|\hat{z}_{t+1}=\hat{z}_t} = \frac{-\left(\frac{\bar{r}}{\mu} - 1\right)(1-\theta)}{\frac{\bar{r}}{\theta\mu}[1-\theta(1-\mu)] - \mu}$$

When $\bar{r} > 1$, both slopes are strictly negative and the slope of the $\hat{p}_t = \hat{p}_{t+1}$ locus is steeper. This gives the phase diagram represented in Figure 3a.

To show that the steady state is a saddle-point, we can compute the eigenvalues of the system. The characteristic polynomial is

$$P(X) = X^2 - \tfrac{\bar{r}}{\theta\mu}(1+\theta\mu)X + \bar{r} \,.$$

We have $P(0) = \bar{r} > 0$ and $P(1) = 1 - \frac{\bar{r}}{\theta\mu} < 0$ when $\bar{r} > 1$. Thus, the two eigenvalues X_1 and X_2 satisfy $0 < X_1 < 1 < X_2$. With one and only one eigenvalue inside the unit circle, the dynamics is saddle-path stable. With one jump variable ($\hat{p}$) and one pre-determined variable ($\hat{z}^N$), there is a unique path converging to the steady state.

It is easy to show that a decrease in $\hat{r}$ moves the new steady state to the north-east, as illustrated in Figure 3b. The resulting dynamics proves the first and second points of the proposition.

The dynamics of z^N/z^T follows from equations (10a) and (10b):

$$\frac{z^N_{t+1}}{z^T_{t+1}} = p_{t+1}^{\frac{1}{1-\theta}}\,. \tag{25}$$

Starting in period $t = 2$, the ratio z^N/z^T follows the same dynamics as the relative price p_t, which proves the third point.

Finally, we can log-linearize the evolution of internal funds (8) and (9) to get

$$\begin{aligned}
\hat{m}^N_t &= \gamma\bar{r}(\hat{m}^N_{t-1} + \hat{r}_{t-1}) + (1-\gamma\bar{r})\left[\tfrac{1}{1-\theta}\hat{p}_t - \tfrac{\theta}{1-\theta}(\mu\hat{p}_{t-1} + \hat{r}_{t-1})\right],\\
\hat{m}^T_t &= \gamma\bar{r}(\hat{m}^T_{t-1} + \hat{r}_{t-1}) + (1-\gamma\bar{r})\left(\tfrac{-\theta}{1-\theta}\right)(\mu\hat{p}_{t-1} + \hat{r}_{t-1})\,.
\end{aligned}$$

In the log-linear approximation, the ratio m^N/m^T evolves according to

$$\hat{m}^N_t - \hat{m}^T_t = \gamma\bar{r}(\hat{m}^N_{t-1} - \hat{m}^T_{t-1}) + (1-\gamma\bar{r})\frac{\hat{p}_t}{1-\theta}$$

and is an exponential smoothing of the relative price p_t. Given the dynamics followed by p, and unless the smoothing factor $\gamma\bar{r}$ is very close to either 0 or 1, the ratio m^N_t/m^T_t has a hump-shaped response to the unexpected and permanent decrease in the domestic interest rate.

A.3 Proof of proposition 3

Consider a given time period t. The variables z^N_t, $\mathcal{W}^T_t \equiv [(z^T_t)^\theta - r_{t-1}(p^\mu_{t-1}z^T_t - m^T_{t-1})]$, $b^N_t \equiv r^N_{t-1}(p^\mu_{t-1}z^N_t - m^N_{t-1})$, and p_{t+1} are taken as given. A market-clearing real exchange rate p_t is a zero of the function

$$f(p_t) = p_t(z^N_t)^\theta - \mu p^\mu_t[z^T_{t+1}(p_t) + z^N_{t+1}(p_t, p_{t+1})],$$

where $z^N_{t+1}(\cdot)$ and $z^T_{t+1}(\cdot)$ solve the entrepreneurs' optimization program. Let $p^* \equiv b^N_t/(z^N_t)^\theta$ be the threshold below which sector N defaults.

I first show that condition (11) implies the existence of a crisis-time market-clearing price $p^{\text{crisis}}_t < p^*$. The function f is continuous and strictly increasing on the interval $[0, p^*)$, with $f(0) < 0$. The derivative of f on $[0, p^*)$ is indeed given by

$$\begin{aligned}
f'(p_t) &= (z^N_t)^\theta - \mu\frac{\partial}{\partial p_t}p^\mu_t[z^T_{t+1}(p_t) + z^N_{t+1}(p_t, p_{t+1})]\\
&\geq (z^N_t)^\theta > 0\,,
\end{aligned}$$

because $p^\mu_t(z^T_{t+1} + z^N_{t+1})$ is either strictly decreasing with p_t or constant on $[0, p^*)$ depending on whether the borrowing constraints bind. Besides, for $p_t = 0$, the borrowing constraints are binding and $f(0) = -\mu\lambda(m^T_t + m^N_t) < 0$. Therefore, f has a unique zero on $(0, p^*)$ if $f(\tilde{p}_t) \geq 0$ for some $\tilde{p} \in (0, p^*)$.

Consider $\tilde{p} = \mu\gamma\lambda\mathcal{W}^T_t/(z^N_t)^\theta$. If condition (11) is satisfied, then $\mu\gamma\lambda\mathcal{W}^T_t < b^N_t$ so that

$\tilde{p} < p^*$. For $0 < p_t < p^*$, the borrowing constraints imply that $f(p_t) \geq p_t(z_t^N)^\theta - \mu\lambda(m_t^N + m_t^T)$. When $p_t < p^*$, entrepreneurs in sector N default. Their only internal funds are the subsidy S_t^N received from the Government. This subsidy is financed by sector T entrepreneurs out of their internal funds. Therefore, $m_t^N + m_t^T = \gamma \mathcal{W}_t^T$ when $p_t < p^*$. Then, $f(\tilde{p}) \geq 0$ and f has a unique zero on $(0, \tilde{p}]$. This zero is the crisis-time market-clearing price p_t^{crisis}.

To show that $\mu\gamma\lambda > 1$ is a necessary condition for the existence of multiple market-clearing prices corresponding to normal- and crisis-times, I assume that $\mu\gamma\lambda \leq 1$ and show that f cannot have at the same time a zero on the interval $[0, p^*)$ and a zero on the interval $[p^*, +\infty)$. This follows from the fact that (i) f is strictly increasing on the interval $[0, p^*)$, (ii) f is increasing on the interval $[p^*, +\infty)$ when $\mu\gamma\lambda \leq 1$, and (iii) $\lim_{p_t \xrightarrow{>} p^*} f(p_t) \geq \lim_{p_t \xrightarrow{<} p^*} f(p_t)$. (i) was established above. I now prove (ii) and (iii).
(ii) When $p_t \geq p^*$,

$$
\begin{aligned}
f'(p_t) &= (z_t^N)^\theta - \mu \frac{\partial}{\partial p_t} p_t^\mu [z_{t+1}^T(p_t) + z_{t+1}^N(p_t, p_{t+1})] \\
&\geq (1 - \mu\gamma\lambda)(z_t^N)^\theta \geq 0\,.
\end{aligned}
$$

Here, I have used the fact that $p_t^\mu z_{t+1}^T$ is either strictly decreasing with p_t or constant (depending on whether the borrowing constraint binds), that $\partial p_t^\mu z_{t+1}^N / \partial p_t$ is either strictly negative (when the borrowing constraint does not bind) or equal to $\lambda\gamma(z_t^N)^\theta$ (when it does), and that $\mu\gamma\lambda \leq 1$.
(iii) If the borrowing constraint binds in sector T when $p_t \xrightarrow{<} p^*$, then

$$
\lim_{p_t \xrightarrow{>} p^*} f(p_t) = b_t^N - \mu(p^*)^\mu z_{t+1}^T(p^*) \geq b_t^N - \mu\gamma\lambda\mathcal{W}^{\mathcal{T}} = \lim_{p_t \xrightarrow{<} p^*} f(p_t)\,.
$$

If it does not,

$$
\lim_{p_t \xrightarrow{>} p^*} f(p_t) = b_t^N - \mu(p^*)^\mu z_{t+1}^T(p^*) \geq b_t^N - \mu(p^*)^\mu z_{t+1}^T(p^*) - \mu\lambda S_t^N = \lim_{p_t \xrightarrow{<} p^*} f(p_t)\,.
$$

Intuitively, the inequality $\mu\gamma\lambda > 1$ states that a within-period equilibrium where sector N faces a binding borrowing constraint but does not default would be unstable (in the sense of any virtual out-of-equilibrium dynamics corresponding to the walrasian auctioneer's *tatonnement*), leaving two stable within-period equilibria: one where the borrowing constraint does not bind and one where sector N defaults.

A.4 Proof of proposition 4

A steady state is financially fragile when $\frac{r(p^\mu z^N - m^N)}{m^T} > \mu\lambda$. Denote $g(r)$ the left-hand side of this inequality. It is continuous on $(\theta\mu, +\infty)$ and strictly decreasing. Indeed, using the steady state values computed in the proof of proposition 1, it reduces to

$$
g(r) = \frac{\theta\mu}{\gamma(\frac{1}{\theta} - 1)} \frac{1 - \frac{\gamma r}{\theta}}{r - \theta\mu}\,.
$$

We have $g\big(\frac{\theta}{\gamma}\big) = 0 < \lambda\mu$. To prove the existence and uniqueness of r_{frag}, it is enough to show that $g(r) > \lambda\mu$ when $r \xrightarrow{>} \max(\frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}, \theta\mu)$.

When $r \xrightarrow{>} \theta\mu$, $g(r)$ diverges to $+\infty$. This takes care of the case $\theta\mu \geq \frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}$. When $\theta\mu < \frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}$, we have to show that $g\big(\frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}\big) > \mu\lambda$. With basic algebra, it is easy to see that

$$\begin{aligned} g\big(\tfrac{\theta}{\gamma}\tfrac{1}{\theta+\lambda(1-\theta)}\big) &= \frac{\theta\mu(\lambda-1)}{1-\mu\gamma[\theta+\lambda(1-\theta)]} \\ &> \lambda\mu \quad \text{iif} \quad \mu\gamma\lambda - 1 > 0\,. \end{aligned}$$

The last inequality is the necessary condition for financial fragility (12) which is satisfied by assumption. The threshold r_{frag} is then the unique root of $g(r) = \lambda\mu$ in $\big(\max(\frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)}, \theta\mu), \frac{\theta}{\gamma}\big)$.

When $\theta > \frac{\lambda}{\lambda-1+1/\gamma}$, then $\frac{\theta}{\gamma}\frac{1}{\theta+\lambda(1-\theta)} > 1 > \theta\mu$ and $r_{\text{frag}} > 1$.

B Extensions

B.1 A model with mobile entrepreneurs

Consider the model in its simple version with perfect foresight and non-binding borrowing constraints and assume that entrepreneurs can freely choose their sector in each period. Let $\varphi_{t+1} \in [0, 2]$ the number of entrepreneurs starting production in sector N in period t. Assume that the economy is in a steady state corresponding to $r = r_0$ at $t = 0$ and that the gross interest rate unexpectedly and permanently changes to r_∞ at $t = 1$.

Free mobility implies that expected next period profits are the same in both sectors: $p_{t+1}(z^N_{t+1})^\theta - r_t p_t^\mu z^N_{t+1} = (z^T_{t+1})^\theta - r_t p_t^\mu z^T_{t+1}$. Together with the first-order conditions (10a) and (10b), this implies that entrepreneurs purchase the same amount of inputs in both sectors and that the expected relative price of non-tradable goods is equal to 1:

$$z^N_{t+1} = z^T_{t+1} = z_{t+1} = \left[\frac{\theta}{r_t p_t^\mu}\right]^{\frac{1}{1-\theta}}\,, \qquad \mathrm{E}_t[p_{t+1}] = 1\,.$$

The market-clearing condition becomes

$$p_t\varphi_t(z_t)^\theta = 2\mu p_t^\mu z_{t+1}\,.$$

Therefore, for $t \geq 2$, $p_t = 1$, $z^{1-\theta}_{t+1} = \frac{\theta}{r_\infty}$, and $\varphi_{t+1} = \frac{2\theta\mu}{r_\infty}$. The real exchange rate, the amount of inputs purchased, and the choice of sector reach their steady state value in period 2, *i.e.* one period after the shock hits. Note that the relative size of both sectors in the steady state, measured by the amount of inputs used, is the same as in the model with specialized entrepreneurs (see appendix A.1):

$$\frac{\varphi z^N}{(2-\varphi)z^T} = \frac{\frac{\theta\mu}{r_\infty}}{1-\frac{\theta\mu}{r_\infty}}\,.$$

However, like φ, it reaches its steady state value in the period following the shock.

Before the shock hits, p_0, z_1, and φ_1 take the steady state value corresponding to r_0. In the period of the shock, p_1, z_2, and φ_2 solve the market-clearing conditions in periods 1 and 2 and the first-order condition for z. Defining $\eta = \frac{\mu}{\mu+(1-\theta)(1-\mu)}$, we get $p_1 = (\frac{r_0}{r_\infty})^{\frac{1}{\mu+(1-\theta)(1-\mu)}}$, $z_2^{1-\theta} = (\frac{\theta}{r_0})^{\eta}(\frac{\theta}{r_\infty})^{1-\eta}$, and $\varphi_2 = \frac{2\mu\theta}{r_\infty}(\frac{r_0}{r_\infty})^{\frac{\eta\theta}{1-\theta}}$. When the shock is a decrease in the rate of return ($r_\infty < r_0$), the relative price p_1 increases above its steady state value in the period of the shock. This slows down the increase in the scale of production, which takes two periods to reach its new steady state value. The relative size of sector N, φ_2, also overshoots to allow for a sufficient production of non-tradable goods in period 2 despite the small scale of production.

To sum it up, the model with free mobility of entrepreneurs also generates some overshooting of the real exchange rate and the sectoral structure when financial openness increases, but this overshooting only lasts for a single period.

B.2 A model with a fixed exchange rate regime and nominal rigidities

Denote p^T (p^N) the nominal price in the tradable (non-tradable) sector. By the law of one price, we have $p^T = e$ where e is the nominal exchange rate.[41] The relative price of non-tradables is then $p = p^N/e$. Suppose the exchange rate is fixed at $e = 1$. Then, the relative price of non-tradables is determined by their nominal price: $p = p^N$.

Consider a variant of the simple framework of Section 3 with monopolistic competition and pre-set prices in the non-tradable sector. Entrepreneurs in sector N produce differentiated goods indexed by i. Production of variety i is $y_{it}^N = u_{it}(z_{it}^N)^\theta$, where u_{it} is capacity utilization. Entrepreneurs are subject to a utility cost $f(u)$ per unit of full capacity income (in tradable goods), with $f(u) = 0$ for $u \leq 1$ and $f'(u) > 1$ for $u > 1$. This ensures that operating above full capacity is never optimal.

Individual varieties are aggregated by a competitive sector with $y_t^N = \left[\int (y_{it}^N)^{\frac{\xi-1}{\xi}} di\right]^{\frac{\xi}{\xi-1}}$. This generates a demand for variety i equal to

$$y_{it}^N = y_t^N (p_{it}^N / p_t^N)^{-\xi}, \tag{26}$$

where p_{it}^N is the nominal price of variety i and p_t^N is the nominal price of the aggregate. Market-clearing condition (3) of the benchmark model has to be replaced by $y_t^N = x_t^N$.

Assume the following sequence of decisions. As in the benchmark model, entrepreneurs choose $z_{i,t+1}^N$ in period t. At the beginning of period $t+1$, after shocks on exogenous variables (i.e. on the iceberg cost τ_{t+1}^*) are known but before they know whether a self-fulfilling crisis occurs, they set their price $p_{i,t+1}^N$. After they learn whether a crisis occurs or not, they set capacity utilization $u_{i,t+1}$.

In normal times, borrowing constraints are lax and the optimal decision consists in maxi-

[41] The price of foreign tradables has been normalized to 1.

mizing next period expected wealth given by

$$\mathrm{E}_t\Big[(1+\zeta)\big[u_{i,t+1}-f(u_{i,t+1})\big]p^N_{i,t+1}(z^N_{i,t+1})^\theta - r_t\big(p^Z_t z^N_{i,t+1}-m^N_t\big)-T_{t+1}\Big]$$

subject to (26). Here, ζ is a subsidy that will be set to remove the distortion created by monopolistic competition. It is financed by lump sum taxes T with $T_t = \int \zeta u_{it} p^N_{it}(z^N_{it})^\theta di$. Ex ante, it is optimal to set $u_{i,t+1}=1$. Then, we get the usual markup pricing over marginal cost, which implies

$$z^N_{i,t+1} = \Big[(1+\zeta)\frac{\xi-1}{\xi}\frac{\theta}{p^\mu_t r_t}\,\mathrm{E}_t[p_{i,t+1}]\Big]^{\frac{1}{1-\theta}}. \tag{27}$$

By symmetry, all prices and all quantities are equal: $p^N_{it}=p^N_t=p_t$, $z^N_{it}=z^N_t$, $u_{it}=u_t=1$. For $\zeta = 1/(\xi-1)$, the optimal investment decision (27) is identical to equation (10a) of the benchmark model. The analysis of the no-crisis equilibrium path is then identical to Section 3, with $p_t = p^N_t$.

In crisis time, the relative price $p_t = p^N_t = p^N_{it}$ has been pre-set to its normal time value and cannot adjust. The market-clearing condition (3) is replaced by

$$y^N_t = u_t(z^N_t)^\theta = x^N_t \tag{28}$$

where u_t adjusts to the lower demand for non-tradable intermediary inputs. Entrepreneurs in sector N default if $u_t p_t (z^N_t)^\theta < r_{t-1}(p^Z_{t-1}z^N_t - m^N_{t-1})$. Nominal demand for non-tradable inputs is limited by the borrowing constraint: $p_t x^N_t = \mu p^Z_t y^Z_t \le \mu\lambda(m^N_t + m^T_t)$. Since entrepreneurs in sector N default, their internal funds are equal to the Government bailout: $m^N_t = S^N_t$ and internal funds in the tradable sector are given by $m^T_t = (z^T_t)^\theta - r_{t-1}(p^\mu_{t-1}z^T_t - m^T_{t-1}) - S^N_t$. Then, it easy to see that Inequality (11) is still a sufficient condition for the existence of a crisis equilibrium.

B.3 The quantitative model

Optimization problems The optimization problems for sector N entrepreneurs and financial intermediaries are solved in Section 4.1 and yield the first-order conditions (17) and (18). Similarly, optimization by entrepreneurs from sector T imply the following first-order condition:

$$\mathrm{E}_t\, M^{t+1}_t \tfrac{\Lambda_{t+1}}{p^F_{t+1}}\big[\theta e^{a^T_t}(z^T_{t+1})^{\theta-1} - r_t p^Z_t\big] = 0\,. \tag{29}$$

The first-order condition of the household with respect to labor is given by

$$h'(L_t) = \frac{w_t}{p^F_t}\,. \tag{30}$$

Profit maximization by firms producing good Z yields:

$$\rho_t^Z K_t = \alpha(1-\eta)p_t^Z y_t^Z\,, \tag{31}$$
$$w_t L_t = (1-\alpha-\epsilon)(1-\eta)p_t^Z y_t^Z\,, \tag{32}$$
$$w_t^F = \epsilon(1-\eta)p_t^Z y_t^Z\,, \tag{33}$$
$$p_t^F J_t = \eta p_t^Z y_t^Z\,. \tag{34}$$

Capital producers maximize their profits $q_t(K_{t+1}-K_t)-p_t^F(K_{t+1}-K_t)-p_t^F\Phi(K_{t+1},K_t)-\rho_t^K K_t$. Denote $\phi(K_{t+1}/K_t) = \Phi(K_{t+1},K_t)/K_t$. The first-order conditions together with the Euler theorem give

$$q_t = p_t^F[1+\phi'(K_{t+1}/K_t)]\,, \tag{35}$$
$$\rho_t^K = p_t^F[(K_{t+1}/K_t-1)\phi'(K_{t+1}/K_t)-\phi(K_{t+1}/K_t)]\,. \tag{36}$$

Finally, as in the simple model, profit maximization and the zero-profit condition in the sector producing final goods give:

$$p_t x_t^N = \mu p_t^F y_t^F \tag{37}$$
$$p_t^F = (p_t)^\mu\,. \tag{38}$$

No-crisis equilibrium path The no-crisis equilibrium is fully defined by the first-order conditions (17)–(18) and (29)–(38), the market clearing conditions (2), (3), (15), the binding borrowing constraint $B_t = 0$, the evolution of internal funds

$$m_t^N = \gamma\big[p_t(z_t^N)^\theta - r_{t-1}(p_{t-1}^Z z_t^N - m_{t-1}^N)\big]\,, \tag{39}$$
$$m_t^T = \gamma\big[e^{a_{t-1}^T}(z_t^T)^\theta - r_{t-1}(p_{t-1}^Z z_t^T - m_{t-1}^T)\big]\,, \tag{40}$$
$$m_t^F = \gamma\big[(q_t+\rho_t^Z+\rho_t^K-\delta p_t^F)K_t - r_{t-1}(q_{t-1}K_t - m_{t-1}^F)\big] + w_t^F\,, \tag{41}$$

and the budget constraint of the household

$$p_t^F c_t = w_t L_t + \frac{1-\gamma}{\gamma}(m_t^N + m_t^T + m_t^F - w_t^F) \tag{42}$$

where I have taken into account the binding borrowing constraint (14) and substituted the expressions for the dividends paid by entrepreneurs and financial intermediaries.

Crises During a crisis, entrepreneurs from sector N and financial intermediaries default, and borrowing constraints are binding so that $p_t^Z y_t^Z = \lambda(m_t^N + m_t^T) = \lambda\gamma\mathcal{W}_t^T$, $p_t^F c_t = w_t L_t + (1-\gamma)\mathcal{W}_t^T = [(1-\alpha-\epsilon)(1-\eta)\lambda\gamma + (1-\gamma)]\mathcal{W}_t^T$ and $m_t^F = w_t^F = \epsilon(1-\eta)\lambda\gamma\mathcal{W}_t^T$. The market-clearing condition for non-tradables is then:

$$
\begin{aligned}
p_t(z_t^N)^\theta &= \mu p_t^F y_t^F \\
&= \mu \mathcal{W}_t^T \big[(1-\gamma) + \lambda\gamma[(1-\alpha-\epsilon)(1-\eta) + \eta + \lambda\epsilon(1-\eta)]\big] - \mu\rho_t^K K_t
\end{aligned} \tag{43}
$$

where I have used the fact that capital producers make zero profits in equilibrium and that (13) holds with equality. A candidate crisis equilibrium is given by $(p_t, q_t, \rho_t^K, K_{t+1})$ satisfying (35), (36), (43), and the binding constraint (13). To be a crisis equilibrium, the two following default conditions must hold:

$$
\begin{aligned}
r_{t-1}(q_{t-1}K_t - m_{t-1}^F) &> (q_t + \rho_t^K - \delta p_t^\mu)K_t + \alpha(1-\eta)\lambda\gamma\mathcal{W}_t^T\,, \\
r_{t-1}(p_{t-1}^Z z_t^N - m_{t-1}^N) &> p_t(z_t^N)^\theta\,.
\end{aligned}
$$

By analogy to condition (11), a sufficient condition for the latter inequality is

$$
\frac{r_{t-1}(p_{t-1}^Z z_t^N - m_{t-1}^N)}{m_t^T} > \mu\Big[\frac{(1-\gamma)}{\gamma} + \lambda[(1-\alpha-\epsilon)(1-\eta) + \eta + \lambda\epsilon(1-\eta)]\Big]
$$

where m_t^T is the no-crisis level of internal funds.

C Data and empirical analysis

C.1 Data

The data covers 24 emerging and 16 advanced economies during the period 1970–2010:

Emerging economies Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Czech Republic, Estonia, Hungary, Indonesia, India, Korea, Lithuania, Latvia, Mexico, Malaysia, Peru, Philippines, Poland, Singapore, Slovak Republic, Slovenia, Thailand, Venezuela,

Advanced economies Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, United Kingdom, USA.

I use sectoral data from the Groningen Growth and Development Center 10-sector database for Latin American and Asian countries, and from EU KLEMS for advanced and other European economies. The relative size of the non-tradable sector is constructed with data on sectoral value added at constant price. The tradable sector is defined as the sum of (i) Manufacturing, (ii) Agriculture, Forestry, and Fishing, and (iii) Mining and quarrying. The non-tradable sector is defined as the sum of (i) Public Utilities, (ii) Construction, (iii) Wholesale and Retail Trade, (iv) Hotels and Restaurants, (v) Transport, Storage, and Communication, and (vi) Finance, Insurance, and Real Estate.[42] The relative price of non-tradable goods is constructed as the ratio of sectoral GDP deflators.

[42] Community, Social, Personal Services, and Government Services, where measurement is often imprecise, are excluded from the non-tradable sector.

Current account data comes from IMF World Economic Outlook (starting in 1980) and International Financial Statistics for years before 1980. Dates of banking crises are taken from Valencia & Laeven (2012). Sudden stops are constructed using current account data following Ferretti & Razin (2000). The list of twin crises in the sample is given by Table C.1. Exchange rate regimes are defined using the de facto classification of Ilzetzki, Reinhart & Rogoff (2010). I classify peg, crawling peg and dirty floating (regimes 1 to 4 in their coarse classification) as a peg, and freely floating and freely falling (regimes 5 and 6) as a floating exchange rate.

Table C.1: List of identified twin crises

Country	Crisis dates
Argentina	1989, 2001
Colombia	1999
Finland	1992
Greece	2010
Hungary	1991
Indonesia	1998
Ireland	2009
Korea	1998
Latvia	2009
Malaysia	1998
Mexico	1982, 1995
Peru	1984
Philippines	1984, 2002
Slovak Republik	1999
Slovenia	2009
Spain	2009
Sweden	1993
Thailand	1997

The data used in the logit model of crises comes from various sources. GDP growth, CPI inflation, credit/GDP, FDI/GDP and reserves/GDP are taken from the World Development Indicators, and complemented by data from the IMF World Economic Outlook where needed. Government fiscal balance/GDP, export growth, terms-of-trade and the LIBOR come from the IMF World Economic Outlook. Government debt/GDP is taken from the IMF public debt database (Abbas, Belhocine, ElGanainy & Horton 2010). Data on external debt and net foreign assets come from the External Wealth of Nations dataset (Lane & Milesi-Ferretti 2007). Nominal interest rates comes from the IMF International Financial Statistics (line 60c, 60b, or 60, depending on data availability) complemented with national sources in some cases. Finally, real effective exchange rates were compiled using data from IMF International Financial Statistics, complemented with BIS or OECD data when not available, except for Argentina and Thailand where the data respectively comes from J.P. Morgan and the Bank of Thailand.

C.2 Identification of episodes of large capital inflows

Denote $\overline{CA}_t$ the 3-year average of the current account to GDP ratio, centered in year t. Using 3-year averages allows to abstract from short-term fluctuations in net capital flows. An episode starts in year T as soon as the 3-year difference $\overline{CA}_T - \overline{CA}_{T-3}$ falls below some country-specific threshold $-\sigma$. I choose σ to be the semi-standard deviation of negative 3-year differences. Formally,

$$\sigma = \left[\frac{1}{N-1} \sum_{\overline{CA}_t - \overline{CA}_{t-3} < 0} \left(\overline{CA}_t - \overline{CA}_{t-3} \right)^2 \right]^{\frac{1}{2}}$$

where the sum is carried over the observations for which $\overline{CA}_t - \overline{CA}_{t-3} < 0$ and N is the number of these observations. I use a semi-standard deviation instead of the usual standard deviation to make sure that the threshold is not biased by possible current account reversals (resulting in large positive values of the 3-year difference) that usually take place during balance-of-payments crises. An episode stops at $T+K$ when $\overline{CA}_{T+K} - \overline{CA}_{T-3} > -\sigma$. I discard episodes lasting less than 3 years and episodes where $\overline{CA}_t$ stay above -2%. This last requirement avoids counting as an episode mere decreases in current account surpluses.

The identified episodes are represented graphically by the shaded areas in Figures C.1 and C.2, with the current account represented by a dashed line.

C.3 Event study

To conduct the event study, the following equation is estimated on an unbalanced panel of 40 countries from 1974 to 2007:

$$\log N/T_{it} = \sum_{s=1}^{N} \alpha_s \, \mathrm{episode}(s)_{it} + \alpha_{>N} \, \mathrm{episode}(> N)_{it} + \beta_i + \gamma_i t + \delta \, \mathrm{twin}_{it} + \varepsilon_{it}$$

where (i,t) denotes a country-year pair, $\mathrm{episode}(s)_{it}$ is equal to 1 in year s of an episode of large capital inflows in country i, and 0 otherwise, $\mathrm{episode}(> N)_{it}$ is equal to 1 in years $N+1$ and more of an episode in country i, and twin_{it} is a dummy equal to 1 during the two years that follow a twin crisis. The error term is supposed to display country-specific heteroskedasticity and autocorrelation: $\varepsilon_{it} = \rho_i \varepsilon_{it-1} + u_{it}$, where $u_{it} \sim N(0, \sigma_i)$. The equation is estimated by Generalized Least Squares. The estimated coefficients α_s, $\alpha_{>N}$ are plotted on Figures 1a and 2 along with the 95% confidence interval. The number of time dummies is chosen, starting at $N = 3$, by increasing N until the last dummy α_N is not statistically significant any more at the 5% level, with a maximum of 9 years. By definition, all the episodes last at least three years. About 40% (70%) of the episodes last less then six (nine) years. The coefficients of the later dummies in Figures 1a and 2 are therefore likely to capture a composition effect in addition to the average country dynamics.

C.4 Logit model of twin crises

The estimated discrete-choice model of twin crises follows the literature on early-warning signals.[43] I estimate a logit model for the probability of a twin crisis occurring in a window of 1, 2

[43]See, among many others, Bussiere & Fratzscher (2006), Calvo et al. (2004), Frankel & Rose (1996), and Gourinchas & Obstfeld (2012)

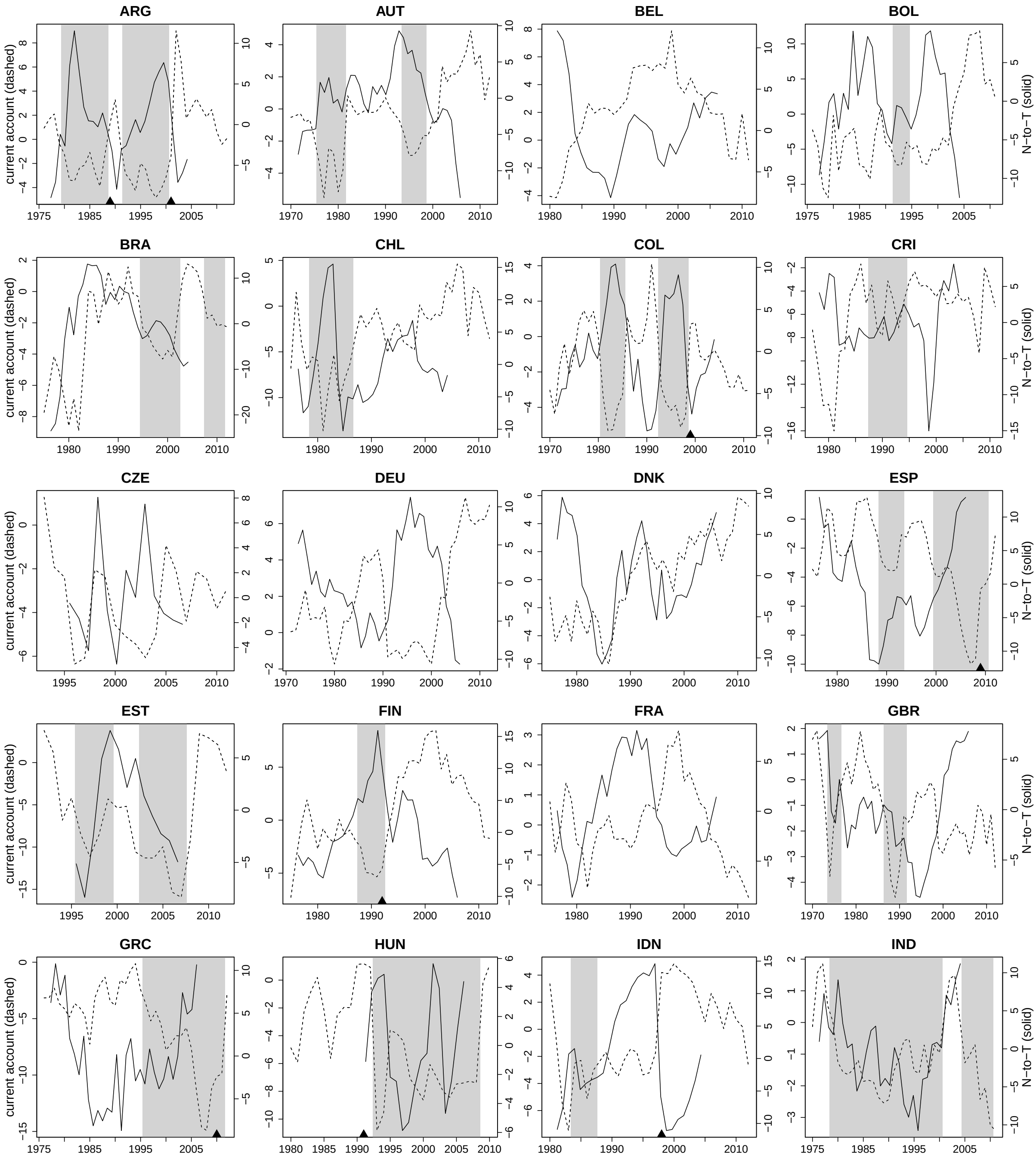

Figure C.1: Episodes of large capital inflows (1). Solid line: logarithm of the N-to-T ratio (in log points, deviation from a linear trend). Dashed line: current account/GDP (in percentage points). Shaded area: episodes of large capital inflows. Black triangles: twin crises.

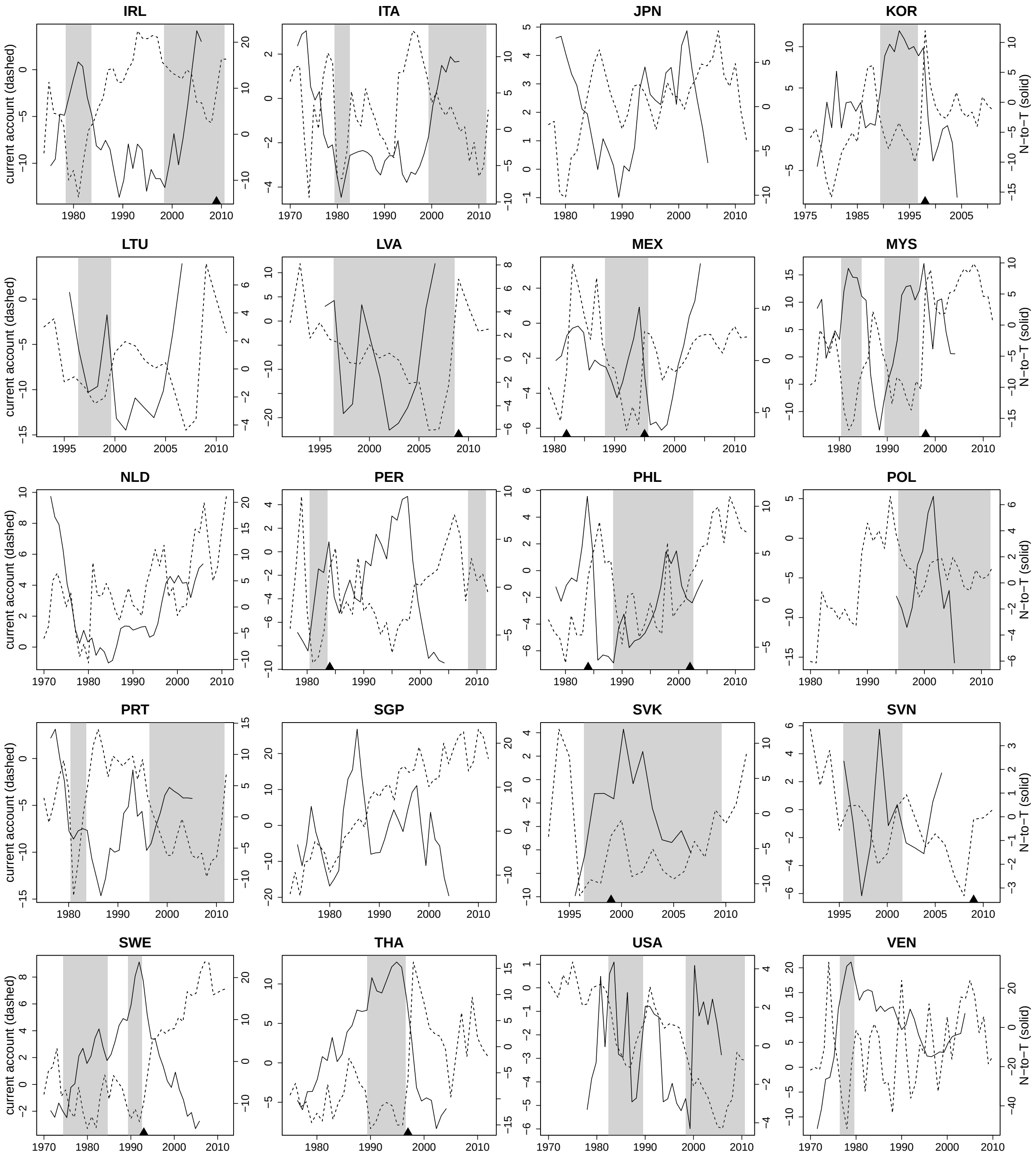

Figure C.2: Episodes of large capital inflows (2). Solid line: logarithm of the N-to-T ratio (in log points, deviation from a linear trend). Dashed line: current account/GDP (in percentage points). Shaded area: episodes of large capital inflows. Black triangles: twin crises.

or 3 years. Define an indicator of twin crisis $y_{it}^k = 1$ if there is a twin crisis in country i between years $t+1$ and $t+k$, with $k = 1, 2, 3$. The estimated model is

$$\log \frac{\mathrm{P}[y_{it}^k = 1 | X_{it}]}{1 - \mathrm{P}[y_t^k = 1 | X_{it}]} = \alpha + \beta X_{it} + \varepsilon_{it}$$

As in Gourinchas & Obstfeld (2012), observations of years $\tau_i, \ldots, \tau_i + 3$, where τ_i is a crisis year in country i, are dropped from the sample to address the post-bias sample discussed by Bussiere & Fratzscher (2006). The sample consists of an unbalanced panel of 40 countries from 1975 to 2007, and includes 18 twin crises. Most regressions estimate the model on pooled data, but Table C.2 uses a fixed-effect conditional logit model.

Table C.2: Conditional logit model of the probability of a twin crisis

	1 year		2 years		3 years	
	(1)	(2)	(3)	(4)	(5)	(6)
N-to-T ratio		21.8^{*}		30.7^{***}		30.9^{***}
		(12.2)		(10.5)		(9.0)
Relative price N/T		7.5		8.3^{**}		7.8^{**}
		(5.0)		(4.2)		(3.6)
Current account	−6.1	1.2	-24.6^{*}	−18.8	-35.0^{***}	-36.5^{**}
	(18.1)	(18.7)	(12.8)	(15.6)	(10.7)	(14.4)
Credit/GDP	13.8^{***}	14.6^{**}	14.0^{***}	14.2^{***}	15.9^{***}	13.2^{***}
	(4.6)	(6.9)	(3.3)	(4.8)	(3.1)	(4.0)
GDP growth	-24.9^{**}	−22.2	-18.6^{**}	−15.6	−2.4	0.6
	(11.4)	(13.6)	(9.3)	(11.7)	(8.3)	(10.3)
REER	−3.4	-8.1^{*}	−2.7	-7.9^{**}	−3.2	-8.1^{***}
	(2.8)	(4.3)	(2.2)	(3.4)	(2.0)	(3.0)
Reserves/GDP	−8.1	−3.4	−2.7	0.0	−2.3	−1.7
	(10.5)	(12.3)	(6.2)	(8.9)	(5.0)	(6.9)
N	40	40	40	40	40	40
$N \times T$	894	894	894	894	894	894

Conditional logit (fixed effects) model. Dependent variable: probability that a twin crisis takes place in a 1, 2, or 3 year window. The N-to-T ratio, the relative price of non-tradables, and the real effective exchange rate (REER) are in logarithm. All three variables and credit/GDP are deviations from a linear trend. Standard errors are reported in parenthesis.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C.3: Robustness checks (1)

	1 year		2 years		3 years	
	(1)	(2)	(3)	(4)	(5)	(6)
N-to-T ratio	16.2*	16.3**	24.8***	17.4***	29.0***	18.4***
	(8.7)	(6.7)	(7.0)	(4.8)	(6.1)	(4.0)
Relative price N/T	2.6	5.2	3.9	5.2*	4.7	5.3**
	(4.0)	(3.8)	(3.2)	(2.8)	(3.1)	(2.4)
Current account	−6.3	−5.4	−17.6**	−13.8**	−22.0***	−16.1***
	(13.8)	(10.1)	(8.2)	(6.0)	(7.1)	(4.8)
Credit/GDP	9.0**	8.2***	7.8***	8.3***	6.2***	8.6***
	(3.9)	(2.8)	(2.7)	(2.1)	(2.2)	(1.8)
GDP growth	−36.5***	−29.2***	−36.0***	−17.8**	−21.0*	−3.4
	(13.3)	(9.5)	(12.5)	(7.2)	(11.3)	(6.4)
REER	−1.4	−2.5	1.0	−0.4	1.7	0.6
	(2.8)	(2.5)	(2.4)	(1.8)	(2.0)	(1.6)
Reserves/GDP	−7.9	−6.1	−2.7	−6.0*	−5.7	−6.7**
	(7.5)	(4.7)	(4.5)	(3.4)	(4.2)	(2.9)
Emerging country	4.3***	3.7***	4.2***	3.1***	3.6***	2.6***
	(1.5)	(1.1)	(1.2)	(0.8)	(0.9)	(0.6)
Gov't debt	−3.2		−2.7		−0.9	
	(2.5)		(1.9)		(1.2)	
Fiscal balance	−7.0		17.0		30.5***	
	(17.5)		(12.7)		(10.6)	
Inflation		0.0		0.0		0.0
		(0.3)		(0.2)		(0.2)
Real interest rate		0.0		0.1		1.1*
		(2.9)		(1.9)		(0.6)
N	40	40	40	40	40	40
$N \times T$	651	832	651	832	651	832

Logit model on pooled data. Dependent variable: probability that a twin crisis takes place in a 1, 2, or 3 year window. The N-to-T ratio, the relative price of non-tradables, and the real effective exchange rate (REER) are in logarithm. All three variables and credit/GDP are deviations from a linear trend. Government debt and fiscal balance are relative to GDP. The real interest rate is the logarithm of the ex-post gross real rate of interest. Standard errors are reported in parenthesis.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C.4: Robustness checks (2)

	1 year			2 years			3 years		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
N-to-T ratio	14.2^{**}	13.1^{**}	12.5^{**}	15.4^{***}	14.5^{***}	14.0^{***}	16.7^{***}	15.4^{***}	15.7^{***}
	(5.9)	(5.8)	(5.8)	(4.2)	(4.1)	(4.1)	(3.5)	(3.3)	(3.4)
Relative price N/T	2.6	4.8	2.6	3.4	3.9	3.3	3.5	4.3^{*}	4.0^{*}
	(3.5)	(4.2)	(3.5)	(2.6)	(2.7)	(2.6)	(2.3)	(2.3)	(2.3)
Current account	−5.3	−9.8	−2.6	-13.1^{**}	-16.8^{**}	-10.3^{**}	-14.1^{***}	-19.7^{***}	-12.6^{***}
	(8.7)	(10.2)	(8.3)	(5.7)	(6.6)	(5.2)	(4.7)	(5.7)	(4.3)
Credit/GDP	6.2^{**}	7.9^{***}	6.5^{***}	6.7^{***}	7.9^{***}	6.9^{***}	6.6^{***}	7.6^{***}	6.8^{***}
	(2.5)	(2.6)	(2.5)	(1.8)	(1.9)	(1.8)	(1.5)	(1.6)	(1.5)
GDP growth	-18.5^{**}	-18.6^{**}	-15.6^{*}	−11.3	−10.5	−8.1	0.6	2.3	4.2
	(9.1)	(9.0)	(8.6)	(7.4)	(6.8)	(6.7)	(6.5)	(6.0)	(6.0)
REER	−1.6	−3.4	−2.3	−0.5	−2.0	−1.2	0.4	−1.2	−0.4
	(2.0)	(2.1)	(1.9)	(1.5)	(1.5)	(1.4)	(1.3)	(1.3)	(1.2)
Reserves/GDP	−8.1	-11.9^{*}	−8.1	-8.0^{**}	-9.8^{**}	-7.6^{**}	-7.9^{**}	-7.4^{**}	-8.0^{***}
	(5.4)	(6.7)	(5.5)	(3.9)	(4.4)	(3.8)	(3.2)	(3.3)	(3.1)
Emerging country	2.9^{***}	2.5^{**}	2.9^{***}	2.5^{***}	2.4^{***}	2.4^{***}	2.0^{***}	2.1^{***}	1.9^{***}
	(1.0)	(1.1)	(1.0)	(0.7)	(0.7)	(0.7)	(0.6)	(0.6)	(0.5)
Export growth	4.4			2.2			1.9		
	(4.6)			(3.3)			(2.8)		
Terms-of-trade growth	4.0			5.0			2.3		
	(4.2)			(3.2)			(2.5)		
Change in LIBOR	−6.0			−11.1			2.2		
	(19.4)			(14.4)			(12.1)		
FDI/GDP		−10.1			0.5			−6.8	
		(17.5)			(5.2)			(6.4)	
External debt/exports		−0.3			−0.1			0.0	
		(0.2)			(0.1)			(0.1)	
NFA/GDP		1.0			1.3			1.6^{*}	
		(1.8)			(1.1)			(1.0)	
FX peg			0.3			0.1			−0.2
			(0.8)			(0.5)			(0.4)
N	40	40	40	40	40	40	40	40	40
$N \times T$	822	875	894	822	875	894	822	875	894

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Logit model on pooled data. Dependent variable: probability that a twin crisis takes place in a 1, 2, or 3 year window. The N-to-T ratio, the relative price of non-tradables, and the real effective exchange rate (REER) are in logarithm. All three variables and credit/GDP are deviations from a linear trend. Standard errors are reported in parenthesis.

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

C.5 Bayesian estimation

The shock decomposition is conducted using standard bayesian methods. There are three observables: real GDP (GDP_t^O), the current account-to-GDP ratio (CA_t^O), and the N-to-T ratio ($\mathrm{N/T}_t^O$). As in the empirical section, the relative size of the non-tradable sector is defined as the ratio of sectoral value added at constant prices. The N-to-T ratio is the linearly detrended logarithm of this relative size. Real GDP is also in logarithm and linearly detrended.

The relationship between these observables and the variables of the model is given by the following measurement equations:

$$\begin{aligned}
\mathrm{GDP}_t^O &= \log(\mathrm{rGDP}_t^N + \mathrm{rGDP}_t^T) - \log(\mathrm{rGDP}_{\mathrm{init}}^N + \mathrm{rGDP}_{\mathrm{init}}^T) + u_t^{\mathrm{GDP}} \\
\mathrm{CA}_t^O &= \mathrm{CA}_t/(\mathrm{GDP}_t^N + \mathrm{GDP}_t^T) + u_t^{\mathrm{CA}} \\
\mathrm{N/T}_t^O &= \log(\mathrm{rGDP}_t^N/\mathrm{rGDP}_t^T) - \log(\mathrm{rGDP}_{\mathrm{init}}^N/\mathrm{rGDP}_{\mathrm{init}}^T) + u_t^{\mathrm{N/T}}
\end{aligned}$$

where CA_t is the current account in the model defined as minus the increase in the total debt of both types of entrepreneurs and financial intermediaries. The subscript "init" denotes the value of a model's variable in the steady state corresponding to τ_0^*. The measurement errors u_t^{GDP}, u_t^{CA}, and $u_t^{\mathrm{N/T}}$ are assumed to be iid and normally distributed.

The sample of observables starts one year before the episode of large capital inflows and stops one year after its end. Denote $t = 0$ the start of the sample. Then, the episode itself starts at $t = 2$. I assume that the iceberg cost τ_t^* is equal to 0 before the beginning of the episode. To do this, the set of observables is complemented by observations $\tau_t^* = \tau_0^*$ for $t \in [-40, 1]$. The observations corresponding to $t \in [-40, -1]$ are used to initialize the Kalman filter, but the estimation itself only uses observations corresponding to $t \geq 0$.

Table C.5: Priors

Parameter	Distribution	Mean	Std. Dev.
ρ^Z	Beta	0.7	0.1
ρ^T	Beta	0.7	0.1
$100\sigma^\tau$	Gamma	0.7	0.3
$100\sigma^Z$	Gamma	0.7	0.3
$100\sigma^T$	Gamma	0.7	0.3
$(D/E)_0$	Gamma	1	0.7

The parameters to be estimated are the standard deviations of shocks and measurement errors, the two autocorrelation coefficients of productivity shocks, and the initial debt-to-equity ratio. Priors are given in Table C.5. Priors for the standard deviations of measurement errors are the same as for the standard deviations of shocks. I use the Metropolis-Hastings algorithm to calculate the posterior distribution, as in Smets & Wouters (2007), An & Schorfheide (2007), Rabanal (2009), and many others. Two Markov chains of 100000 draws are used (after neglecting the first 25000 draws of each chain) to explore the posterior distribution. The model is then evaluated at the posterior mean. Estimations are done with Dynare (Adjemian, Bas-

Table C.6: Posterior mean of parameters (standard deviation in parenthesis).

Parameter	Finland	Malaysia	Thailand	Argentina	Colombia	Greece	Spain
ρ^Z	0.76 (0.05)	0.84 (0.05)	0.85 (0.04)	0.74 (0.05)	0.77 (0.07)	0.91 (0.03)	0.69 (0.11)
ρ^T	0.74 (0.07)	0.87 (0.04)	0.74 (0.09)	0.81 (0.05)	0.73 (0.09)	0.90 (0.03)	0.72 (0.08)
$100\sigma^\tau$	0.2 (0.0)	0.2 (0.1)	0.2 (0.0)	0.1 (0.0)	0.2 (0.0)	0.3 (0.0)	0.2 (0.0)
$100\sigma^Z$	1.8 (0.3)	0.9 (0.2)	1.3 (0.2)	1.6 (0.2)	1.3 (0.2)	0.7 (0.2)	0.4 (0.1)
$100\sigma^T$	0.7 (0.2)	1.2 (0.2)	0.7 (0.2)	0.7 (0.2)	0.9 (0.4)	1.0 (0.2)	1.0 (0.3)
$(D/E)_0$	0.78 (0.39)	0.96 (0.47)	1.13 (0.53)	0.89 (0.47)	0.78 (0.39)	0.70 (0.17)	0.82 (0.36)
γ	0.80	0.78	0.77	0.79	0.80	0.80	0.79

tani, Juillard, Karamé, Mihoubi, Perendia, Pfeifer, Ratto & Villemot 2011) and reported in Table C.6.

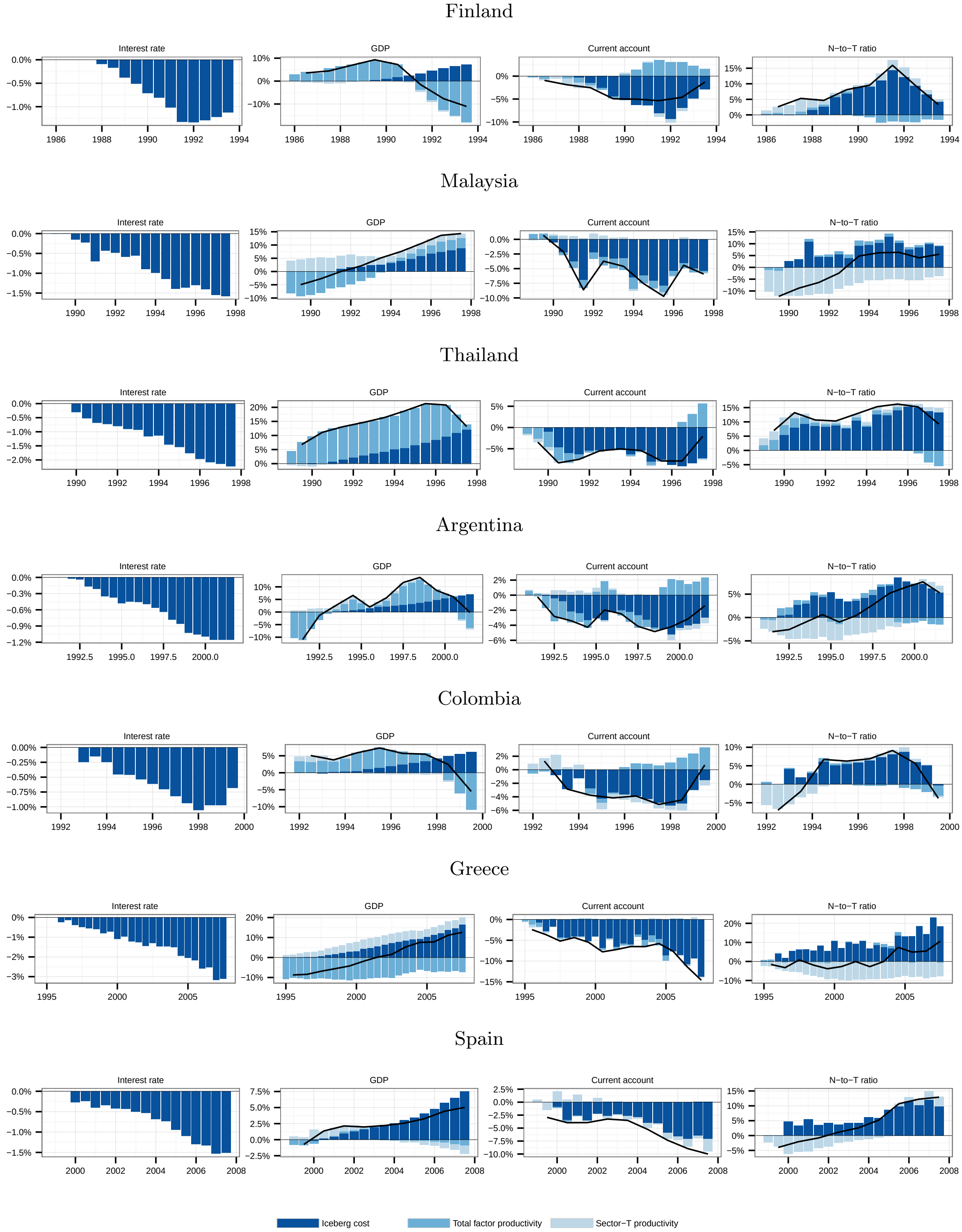

Figure C.3: Shock decomposition in episodes of large capital inflows. Black solid line: observed variable. Blue bars: contribution to observed variable from shocks.

Documents de Travail

490. F. Pegoraro, A. F. Siegel and L. Tiozzo 'Pezzoli, "Specification Analysis of International Treasury Yield Curve Factors," June 2014

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