Financial fragility in emerging markets: firm balance sheets and the sectoral structure

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This version: July 2007
First draft: January 2005

Abstract

Capital account liberalization in emerging economies is often followed by a shift of resources from the tradable to the non-tradable sector and sometimes leads to a balance-of-payments crisis. 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 crisis which can produce multiple equilibria within a single time period, including a crisis equilibrium with a depreciated real exchange rate and defaults in the non-tradable sector. The within-period crisis equilibrium exists when the non-tradable sector is large enough compared to the tradable sector and its balance sheets are sufficiently leveraged. 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. Financial fragility persists after the transitory phase when the world interest rate is low and the domestic economy sufficiently opened to external finance.

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

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

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I would like to thank Robert Boyer, André Cartapanis, Pierre-Olivier Gourinchas, Pierre Jacquet, Ricardo Hausmann, Philippe Martin, Maurice Obstfeld, Jean-Paul Pollin, and Aaron Tornell for their useful comments and advice, as well as participants of the 10th LACEA meeting, the LIVth Congrès de l'AFSE and seminars in PSE and UC Berkeley. Of course, all the remaining errors are my own.

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 has been followed in a number of cases by a shift of resources from the tradable to the non-tradable sector. In the first few years after the liberalization of the capital account, the non-tradable sector grew on average faster than the tradable sector by about 2 percentage points above normal times. During the same period many emerging economies experienced financial and balance-of-payments crises. Among the different factors of fragility that were identified by the empirical literature, sectoral factors also seemed to have played a role. 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. Has capital account liberalization led 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 an emerging economy where balance-of-payments crises can happen within single time periods. The model shows that an increase in financial openness 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.

In the model, when financial openness increases, larger capital inflows finance a higher level of investment, boost the demand for non-tradable goods, and provoke a real appreciation which hurts the tradable sector. In the medium run, this induces a reallocation of resources towards the non-tradable sector. Table 1 shows that this result is supported by the data. The growth rate of the non-tradable to tradable ratio (measured in constant price value added) is regressed on time dummies indicating the number of years the capital account has been liberalized. The estimation covers 17 liberalization episodes in 12 emerging countries between 1973 and 1999. It uses fixed effects (a *within* estimator) and controls for the occurrence of twin crises.[1] The non-tradable to tradable ratio is found to grow faster than average by 1 to 2.5 percentage points in the first few years of a liberalization episode.[2] The coefficients of the first two time dummies are statistically

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

[2] All the liberalization episodes last at least three years. Three of the seventeen last less than five years. The coefficients of the fourth and fifth dummies in column (2) are therefore likely to capture a composition effect in addition to the average country dynamics.

significant and their magnitude is about the same as that of the twin crisis dummy. Financial opening boosts the non-tradable sector with respect to the tradable sector about as much as twin crises do the reverse.

Table 1: Evolution of the sectoral structure after a capital-account liberalization

	Within estimator	
	(1)	(2)
First year of liberalization	0.017* (0.009)	0.019** (0.009)
Second year of liberalization	0.023** (0.009)	0.025*** (0.009)
Third year of liberalization	0.010 (0.009)	0.012 (0.009)
Fourth year of liberalization		0.013 (0.009)
Fifth year of liberalization		0.015 (0.01)
One/two years after twin crisis	-.017** (0.007)	-.016** (0.007)
Obervations	324	324
Countries	12	12
Years	27	27

Dependent variable: $\Delta \log N/T_{it}$. Within estimator. Standard deviations in parentheses. * denotes 10% statistical significance, ** 5%, *** 1%.

The model shows how such a shift of the sectoral structure towards non-tradable goods, along with the higher leverage induced by cheaper foreign finance, can favor balance-of-payments crises. Intuitively, any shock resulting in a lower demand for non-tradable goods—like a sudden stop—has to be accommodated by a real depreciation in the short run. When the demand for non-tradable goods stemming from the tradable sector is small compared to the size of the non-tradable sector, the economy needs a more depreciated real exchange rate to adjust. And indeed, some empirical studies have pointed to the role played by sectoral factors in emerging market crises. Tornell & Westermann (2002) show that the relative size of the non-tradable sector usually increases before twin crises in middle-income countries. Calvo, Izquierdo & Mejía (2004) find that the probability of a sudden stop is higher in economies where the absorption of tradable goods is small compared to the pre-crisis current-account deficit, a proxy for the size of a possible sudden stop.

The paper also sheds some light on the timing of the effects of capital account liberalization. The increase in the relative size of the non-tradable sector is essentially a short to medium run phenomenon. Once the initial real appreciation subsides, the tradable sector partly catches up with the non-tradable sector. In addition, larger foreign debt repayments absorb a rising part of profits and lower consumption demand of non-tradable goods (in relative terms). In general, this overshooting of the sectoral structure makes financial fragility more likely to be a concern in the medium run than in the longer run. This result is consistent with the empirical evidence reported by Kaminsky & Schmukler (2003). They argue that the large amplitude of boom-bust cycles in the stock market following financial liberalization is a transitory phenomenon and disappears in the long run. In the model however, when the world interest rate is low enough and the economy opens sufficiently, financial fragility can persist even after the sectoral reallocation has taken place. This could help to explain why in some particular instances, like Argentina in 2001, a crisis can take place a whole decade after the capital account was liberalized.

Formally, the model builds on Schneider & Tornell's (2004) dynamic model of a booming non-tradable sector with self-fulfilling balance-of-payments crises. While using the same formal structure, this paper differs substantially in some important ways. These differences will be discussed below. The economy modeled is a small open economy with an overlapping generation structure, peopled by entrepreneurs producing either tradable or non-tradable goods. The model assumes that domestic savings are low so that the interest rate in autarky is larger than the world rate of interest, capturing the idea that emerging economies should be net recipients of capital flows when they open their capital account. Financial opening is modeled as a decrease in a transaction cost on international financial flows and results in a lower domestic interest rate. Crises are modeled by the possible existence of multiple equilibria within a single time period, in the spirit of Krugman (1999). They are the result of two financial frictions: a borrowing constraint and the absence of a market for bonds denominated in non-tradable goods. They reproduced several of the stylized facts identified by the empirical literature on emerging market crises: a depreciated real exchange rate, a sharp drop in investment, widespread defaults, and sectoral asymmetries (Kaminsky & Reinhart 1999, Tornell & Westermann 2002, Calvo, Izquierdo & Talvi 2006, Calvo et al. 2004).

This paper belongs to both the literature studying the sectoral evolution of open economies and the literature on emerging market crises. As regards the former, 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). More recently, Hausmann & Rigobon (2002) show how a high concentration of capital in the non-tradable sector increases the volatility of the real exchange rate. This in return induces a shift of resources from the tradable to the non-tradable sector, eventually leading to a complete specialization in non-tradable goods. Caballero & Lorenzoni (2007) study the optimal policy response to episodes of persistent appreciations during which resources move away from the export sector to the non-tradable sector.

The paper is also related to models of balance-of-payments crises based on financial frictions, currency mismatches, and balance-sheet effects in the corporate sector, particularly models with multiple equilibria. Krugman (1999) constructs a simple baseline model of a real economy with multiple equilibria. A similar mechanism underlies Aghion, Bacchetta & Banerjee's (2004*b*) model but leads to endogenous cycles instead of multiple equilibria. Aghion, Bacchetta & Banerjee (2004*a*) get multiple equilibria in a monetary model with nominal rigidities. Jeanne & Zettelmeyer (2002) propose a simple and unified framework that encompasses several static balance-sheet approaches based on either currency mismatches or maturity mismatches and bank runs. The financial frictions that originate the multiplicity of equilibria have also been incorporated into quantitative real business cycle models where they amplify otherwise small shocks (Mendoza 2002).

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. By inserting a static crisis mechanism into a dynamic framework, the present paper follows the methodology used by Schneider & Tornell (2004). These authors 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. The boom is fueled by the expectation of a future increase in the demand for non-tradable goods, induced for example by a reform. The model focuses on the non-tradable sector alone and, since it studies a transitory phenomenon, has a finite number of periods. By contrast, this paper studies how an increase in financial openness impacts the allocation of resources between the tradable and non-tradable sectors. The two sectors are therefore modeled explicitly and in a symmetric way. The model has an infinite number of periods and studies the effect of financial openness both during the transitory phase of sectoral change and in the new steady state.[3]

The paper is organized as follows. The model is presented in section 2. Section 3 solves the within-period equilibrium and shows that multiple equilibria may arise, making self-fulfilling crises possible. Section 4 studies the equilibrium dynamics of the model. Section 5 examines whether equilibrium paths exhibit financial fragility and under what condition. Section 6 concludes.

2 The model

Consider a small open economy with an overlapping generation structure. Time is discrete. There are two kinds of agents: domestic entrepreneurs and deep-pocket foreign lenders. All agents live two periods. They are risk-neutral and value consumption in their second period of life only. There are two 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.

These two goods can be aggregated to form a domestic (non-tradable) consumption good C with relative price p_t^μ,

$$C = \left(\frac{T}{1-\mu}\right)^{1-\mu}\left(\frac{N}{\mu}\right)^{\mu} \tag{1}$$

where $\mu \in (0,1)$, and a domestic (non-tradable) capital good K with relative price p_t^η,

$$K = \left(\frac{T}{1-\eta}\right)^{1-\eta}\left(\frac{N}{\eta}\right)^{\eta} \tag{2}$$

where $\eta \in (0,1)$.

[3]There is another, more technical, difference. Schneider & Tornell (2004) use linear production functions where production is limited by a binding borrowing constraint. During the boom, both the production and the debt of the non-tradable sector grow. In this paper, production functions are concave and borrowing constraints need not bind in equilibrium. This allows to distinguish the effect of a larger non-tradable sector (with respect to the tradable sector) from that of a more leveraged non-tradable sector.

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.

A firm in sector s produces in period t a quantity $Y_t^s = g^{(1-\delta)t}(K_t^s)^\delta$ of goods using capital K_t^s with decreasing returns, where $\delta \in (0,1)$ and $g-1$ is an exogenous growth rate coming from technological progress. Capital has to be installed one period in advance and completely depreciates. Investment expenditures of sector s in period t are denoted $I_t^s \equiv p_t^\eta K_{t+1}^s$. The production function can be restated as

$$Y_t^s = g^{(1-\delta)t}\left[\frac{I_{t-1}^s}{p_{t-1}^\eta}\right]^\delta \qquad s = T, N. \tag{3}$$

Entrepreneurs

Each firm is run by successive generations of risk-neutral entrepreneurs. Entrepreneurs value consumption of the consumption good C in their second period of life only. In period t a young entrepreneur in sector s starts running the firm with internal funds W_t^s and makes investment and borrowing decisions (given financial constraints described below) to maximize the expected next period profit $\mathrm{E}_t\,\Pi_{t+1}^s$. In period $t+1$, the old entrepreneur gets a fixed fraction $1-\gamma$ of the firm's profits as dividends for her own consumption, with $\gamma \in (0,1)$. The internal funds in period $t+1$ are the sum of the remaining fraction γ of profits and a possible subsidy from the Government.

Foreign lenders

Foreign lenders are risk-neutral and value consumption of the tradable good in their second period of life. They are endowed with eg^t tradable goods in their first period of life and have access to a storage technology with return r^* (thus, the world riskless interest rate is r^*-1). It is assumed they have deep pockets, *i.e.* e is large enough to always satisfy the demand for loans by domestic entrepreneurs.

Financial contracts

Agents can trade one-period bonds denominated in tradable goods. A bond issued in period t is a promise to pay one unit of tradable good in the next period. Denote B_t^s the number of bonds issued by the entrepreneurs of sector s in period $t-1$. When the proceeds from the sales of a firm fall short of the promised repayment, the entrepreneur defaults on her loan and gets zero profit. Thus, profits are given by:

$$\Pi_t^T = \max(0, Y_t^T - B_t^T)\,, \tag{4}$$

$$\Pi_t^N = \max(0, p_t Y_t^N - B_t^N)\,. \tag{5}$$

The financial market is subject to several imperfections.

To begin with, there is an iceberg cost $\tau \geq 1$ to international financial transactions. When a foreign lender lends τ units of tradable good to a domestic agent, the domestic agent only gets 1 unit, and *vice versa*. This iceberg cost makes it possible to model different level of financial openness in a simple way. The case $\tau = 1$ corresponds to an economy entirely opened to international finance.

Then, there are no bonds denominated in non-tradable goods. Consequently, there is a currency mismatch in the balance sheets of the non-tradable sector and entrepreneurs producing non-tradable goods cannot insure against real exchange rate risk (except by choosing not to issue any debt). 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*.[4]

The third imperfection is that debt contracts involving entrepreneurs are subject to a borrowing constraint. An entrepreneur with internal funds W_t^s can at most borrow $(\lambda - 1)W_t^s$, with $\lambda \geq 1$. I shall refer to coefficient λ as the *financial multiplier*. Appendix A.2 proposes a possible microfoundation for this borrowing constraint based on the imperfect enforcement of debt contracts, whereby the financial multiplier λ can be interpreted as the level

[4]See Eichengreen & Hausmann (1999). Eichengreen, Hausmann & Panizza (2005) investigate the empirical relevance of this concept. According to Hausmann & Panizza (2003), Original Sin might be the result of transaction costs in international finance which set a finite number of currencies in the world's portfolio. The cost to detain the marginal currency should compensate the benefit derived from risk diversification. As large countries offer more diversification than small ones, they argue that one should expect the currencies of large countries to be dominant in international portfolios and provide empirical evidence to support this view.

Alternatively, several authors have proposed arguments to explain why domestic firms *choose* to take a risky position by issuing debt denominated in foreign currency: moral hazard induced by expected bail-outs (Schneider & Tornell 2004), borrowing constraints in the domestic financial system (Caballero & Krishnamurthy 2000), commitment problems (Jeanne 2000) or the lack of credibility of the domestic monetary policy (Jeanne 2003).

of domestic financial development. The case $\lambda = 1$ corresponds to a fully financially repressed economy while the case $\lambda = \infty$ corresponds to a perfect domestic financial system.

Finally, there is a bankruptcy cost. When a firm defaults, the entire value of production is lost as a bankruptcy cost so that lenders do not get anything back.[5]

Defaults

Because of the currency mismatch in the balance sheets of the non-tradable sector, firms in this sector default on their loans if the real exchange rate is sufficiently depreciated. This happens when $p_t < \frac{B_t^N}{Y_t^N}$. Widespread defaults in sector N together with a depreciated real exchange rate is what defines a balance-of-payments crisis in this model. Let $\zeta_t \in \{0, 1\}$ be a dichotomic variable indicating a crisis in period t:

$$\zeta_t = 1 \text{ if } p_t < \frac{B_t^N}{Y_t^N}\,, \quad 0 \text{ otherwise.} \tag{6}$$

During crisis times, the Government intervenes to refund firms producing non-tradable goods, thus preventing the non-tradable sector from completely disappearing. Each firm in sector N receives a subsidy $z_t g^t$. This subsidy is financed by a lump-sum tax of the same amount on the internal funds of firms in sector T. Thus,

$$W_t^T = \gamma \Pi_t^T - \zeta_t z_t g^t\,, \tag{7}$$

$$W_t^N = \gamma \Pi_t^N + \zeta_t z_t g^t\,. \tag{8}$$

Technical assumptions

The parameters of the model are assumed to satisfy the following restrictions.

Assumption 1.

$$\frac{\delta g}{\gamma} > \tau r^*$$

The left-hand side of this inequality is the steady state marginal rate of return of investment when the economy is closed to capital flows (see section 4.2). The condition states that this autarky rate of return is strictly

[5]This assumption yields a simple expression for the rate of return on risky bonds. See equation (9) below.

higher than the (iceberg cost adjusted) world rate of return. Therefore, the open economy should receive net capital inflows in normal (*i.e.* non-crisis) times, a situation which describes well emerging markets in the nineteen-nineties.

Assumption 2.

$$(1-\gamma)\mu + \gamma\eta\lambda > 1$$

This condition requires a large enough financial multiplier, *i.e.* a sufficiently developed domestic financial system. It makes possible the existence of multiple within-period equilibria.

3 The within-period equilibrium

Financial market

Given the existence of an iceberg cost and the fact that foreign lenders have deep pockets, the price of a riskless bond issued by a domestic agent is $1/r^d$ with $r^d = \tau r^*$.[6]

The possibility of multiple equilibria creates uncertainty in the real exchange rate. Therefore, while bonds issued by the tradable sector are riskless, bonds issued by the non-tradable sector are risky and must be priced accordingly. Denote $\mathrm{P}_t[\zeta_{t+1} = 0]$ the conditional probability as of time t that firms in sector N can repay their loans at $t+1$. From the risk-neutrality of foreign lenders, the price of a bond issued in period t by a firm of sector N is $1/r_t^N$ with

$$r_t^N = \frac{\tau r^*}{\mathrm{P}_t[\zeta_{t+1} = 0]} \,. \tag{9}$$

Investment decisions

Denote $\mathrm{E}_t[p_{t+1}|\zeta_{t+1}=0]$ the expected relative price p_{t+1} conditional on the information set available at time t (which includes ζ_t) and the fact that there is no default in period $t+1$. An entrepreneur in sector N chooses I_t^N and B_{t+1}^N to maximize next period expected profits

$$\mathrm{E}_t\,\Pi_t^N = \mathrm{P}_t[\zeta_{t+1} = 0]\left(\mathrm{E}_t[p_{t+1}|\zeta_{t+1}=0]Y_{t+1}^N - B_{t+1}^N\right)$$

[6] A domestic agent lending abroad would get a rate of return equal to r^*/τ.

subject to the production function (3) and

$$I_t^N = \frac{B_{t+1}^N}{r_t^N} + W_t^N \,, \tag{10}$$

$$\frac{B_{t+1}^N}{r_t^N} \leq (\lambda - 1) W_t^N \,. \tag{11}$$

Equation (10) is the budget constraint and equation (11) is the borrowing constraint.

Consider first the case when the incumbent entrepreneur has not defaulted ($\zeta_t = 0$). The solution to the optimization program depends on whether the borrowing constraint binds or not. It is given by:

$$I_t^N = \min\left(g^{t+1} \left[\frac{\delta\, \mathrm{E}_t[p_{t+1}|\zeta_{t+1}=0]}{p_t^{\eta\delta} r_t^N} \right]^{\frac{1}{1-\delta}}, \lambda\gamma\big(p_t Y_t^N - B_t^N\big) \right).$$

Then, B_{t+1}^N follows from (10).

Consider now the case when the incumbent entrepreneur has defaulted. The young entrepreneur starts with internal funds given by $W_t^N = z_t g^t$. I suppose that z_t is low enough so that the borrowing constraint binds and $I_t^N = \lambda z_t g^t$. On the whole, investment expenditures in sector N are given by:

$$I_t^N = \begin{cases} \min\left(g^{t+1} \left[\frac{\delta\, \mathrm{E}_t[p_{t+1}|\zeta_{t+1}=0]}{p_t^{\eta\delta} r_t^N} \right]^{\frac{1}{1-\delta}}, \lambda\gamma\big(p_t Y_t^N - B_t^N\big) \right) & \text{if } p_t \geq \frac{B_t^N}{Y_t^N} \,, \\ \lambda z_t g^t & \text{if } p_t < \frac{B_t^N}{Y_t^N} \,. \end{cases} \tag{12}$$

Note that the borrowing constraint does not bind when the relative price p_t is large enough. Because of the currency mismatch, profits—and therefore internal funds—increase when the real exchange rate appreciates, which loosens the borrowing constraint. This balance-sheet effect is a crucial ingredient of the crisis mechanism.

Similarly, in the tradable sector, the optimal investment and borrowing decisions require

$$I_t^T = \min\left(g^{t+1} \left[\frac{\delta}{p_t^{\eta\delta} r_t^d} \right]^{\frac{1}{1-\delta}}, \lambda W_t^T \right) \,, \tag{13}$$

$$B_{t+1}^T = r^d (I_t^T - W_t^T) \,. \tag{14}$$

Market for goods

The demand for non-tradable goods stems both from consumption by old entrepreneurs and investment by young ones. With the choice of a Cobb-Douglas aggregator for consumption and investment goods—see equations (1) and (2)—the market clearing condition for non-tradable goods is:

$$p_t Y_t^N = \mu(1-\gamma)\big(\Pi_t^T + \Pi_t^N\big) + \eta\big(I_t^T + I_t^N\big)\,. \tag{15}$$

Definition of the within-period equilibrium

The within-period equilibrium can now be formally defined.

Definition 1 (Within-period equilibrium)**.** *For given values of the predetermined variables* Y_t^T*,* Y_t^N*,* B_t^T*,* B_t^N *and given expectations* $\mathrm{P}_t[\zeta_{t+1}=0]$ *and* $\mathrm{E}_t[p_{t+1}|\zeta_{t+1}=0]$*, a within-period equilibrium is a price vector* (p_t, r_t^N)*, an allocation vector* (I_t^T, I_t^N)*, and a crisis indicator* ζ_t *satisfying the crisis definition (6), the optimal investment decisions (12) and (13), and the market clearing conditions (9) and (15).*

The equilibrium can be graphically represented in the plane (p_t, I_t^N) (see figure 1). The investment function of sector N, given by equation (12), together with the expression of the risky rate of return r_t^N (9), provides a first relationship between the real exchange rate p_t and sector N investment expenditures I_t^N. This relationship is represented by the II schedule in figure 1.

A second relationship comes from the market clearing condition (15) together with the investment function of sector T (13). This second relationship is represented by the NN schedule in figure 1. Along this schedule, p_t increases with I_t^N because the supply of non-tradable goods Y_t^N is predetermined. Higher investment expenditures I_t^N increase the demand for non-tradable goods. With a predetermined supply this increase has to be met by a real appreciation.

Multiple within-period equilibria

As it can be seen in figure 1, it is possible that the II and NN schedules intersect three times, thus yielding multiple equilibria. The equilibrium located in the middle segment of the II schedule is unstable (in the sense of any virtual out-of-equilibrium dynamics corresponding to the walrasian auctioneer's *tatonnement*) and we are left with two stable equilibria: (a) a tranquil time equilibrium ($\zeta_t = 0$), labeled H, with high investment expenditures and

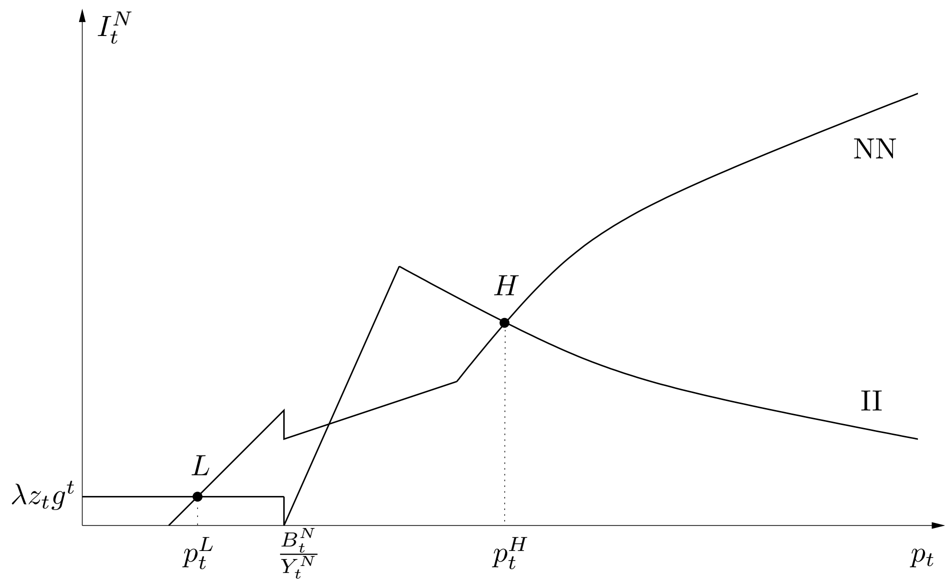

Figure 1: Within-period multiple equilibria.

an appreciated real exchange rate, where N firms have high internal funds and are not constrained, (b) a crisis equilibrium ($\zeta_t = 1$), labeled L, with low investment expenditures and a depreciated real exchange rate, where N firms default on their loans.

The following proposition derives conditions for the multiplicity of equilibria and the existence of a crisis equilibrium L.

Proposition 1. *A necessary condition for the existence of two within-period equilibria H and L with $\zeta_t^H = 0$ and $\zeta_t^L = 1$ is*

$$(1-\gamma)\mu + \gamma\eta\lambda > 1\,.$$

A sufficient condition for the existence of the crisis equilibrium L is

$$\frac{B_t^N}{\Pi_t^T} > (1-\gamma)\mu + \gamma\eta\lambda\,. \tag{16}$$

Proof. See appendix A.3. □

The necessary condition for the multiplicity of equilibria is satisfied by assumption 2. Graphically, it means that the slope of the II schedule is steeper than the slope of the NN schedule on the interval where sector N is constrained but does not default.[7] Note that this condition requires a large enough financial multiplier λ, *i.e.* a weak enough borrowing constraint. If coefficient λ is interpreted as the level of financial development, it means that the domestic financial system has to be sufficiently developed. The kind of crisis described here would not happen in an economy subject to financial repression.[8]

To get the intuition behind this result, it is useful to look at the special case when entrepreneurs do not get dividends ($\gamma = 1$). The condition then simply becomes $\eta\lambda > 1$. The parameter η determines how the demand for N goods, and consequently the real exchange rate, react to changes in investment expenditures. The financial multiplier λ determines how the maximum level of investment expenditures in sector N reacts to changes in internal funds driven by changes in the real exchange rate. A real appreciation feeds into higher investment expenditures through λ and higher investment expenditures feed into a real appreciation through η. Multiple equilibria can only appear when both effects are strong enough, *i.e.* when η and λ are large enough. As an example, consider the case $\eta = 1$ (capital consists only of N goods). The condition $\eta\lambda > 1$ would then always be satisfied. If on the contrary $\eta = 0$ (capital consists only of T goods), a change in investment has no effect on the real exchange rate and the condition is never satisfied.

Consider now the sufficient condition for the existence of the crisis equilibrium L.[9] According to this condition, the crisis equilibrium exists when the debt repayment of sector N is large enough compared to the profits of sector T. The ratio $\frac{B_t^N}{\Pi_t^T}$ can be decomposed in the product of two factors: $\frac{B_t^N}{\Pi_t^T} = \frac{B_t^N}{\Pi_t^{N,H}} \frac{W_t^{N,H}}{W_t^{T,H}}$. The first factor $B_t^N/\Pi_t^{N,H}$ relates debt service to tranquil time profits and reflects the financial structure of sector N balance sheets. As debt is denominated in tradable goods, it also measures the extent of the currency mismatch. The second factor $W_t^{N,H}/W_t^{T,H}$ describes the relative size of both sectors (measured by their tranquil time internal funds) and is an indicator of the sectoral structure of the whole economy. The sectoral structure is what determines the level of the real exchange rate needed to adjust a shock on the demand for non-tradable goods. Then, depending on the extent of the currency mismatch of sector N, a depreciated real exchange

[7] This condition states that the intermediate equilibrium is unstable.

[8] This is a usual result in the literature on balance sheets and financial crises. See for example Aghion et al. (2004*b*) and Schneider & Tornell (2004).

[9] Graphically, it means that the NN schedule intersects the horizontal line $I_t^N = \lambda z_t g^t$ on the left of $\frac{B_t^N}{Y_t^N}$.

rate can lead to defaults and a crisis, or not.

Thus, highly leveraged firms in sector N and a sectoral structure largely oriented toward the production of non-tradable goods are conditions that favor the possibility of crises. These two factors are predetermined in the within-period equilibrium but they endogenously evolve over time. To determine whether a crisis equilibrium can indeed exist along an equilibrium path, the model dynamics has to be studied. This is what the next section does.

4 The model dynamics

4.1 Equilibrium paths

An equilibrium path is a sequence of within-period equilibria with rational expectations. In addition, since there can be multiple within-period equilibria, agents in the model need a selection rule to coordinate across the two possible outcomes. Suppose there is an exogenous sunspot variable S_t that takes the value 0 with probability ω and the value 1 with probability $1-\omega$. Consider the following selection rule:

$$\zeta_t = F_t S_t \tag{17}$$

$$\text{with } F_t \equiv \begin{cases} 1 & \text{if } \zeta_{t-1}=0 \text{ and} \\ & \frac{r^d}{\omega}\left[g^t\left[\frac{\delta\,\mathrm{E}_{t-1}[p_t|\zeta_t=0]}{p_{t-1}^{\eta\delta}\frac{r^d}{\omega}}\right]^{\frac{1}{1-\delta}} - W_{t-1}^N\right] > \left[(1-\gamma)\mu+\gamma\eta\lambda\right]\Pi_t^T, \\ 0 & \text{otherwise.}\end{cases} \tag{18}$$

With this selection rule, a crisis takes place in period t if (a) the sufficient condition for the existence of the crisis equilibrium (16) is satisfied in a way that is consistent with rational expectations, (b) no crisis took place in the previous period, and (c) the sunspot takes the value 1. Note that agents can compute F_{t+1} at time t. Therefore, this rule allows them to form expectations regarding the future probability of no crisis: $\mathrm{P}_t[\zeta_{t+1}=0] = 1-(1-\omega)F_{t+1}$.

An equilibrium path can be defined in the following way.

Definition 2 (Equilibrium path). *For given initial conditions $Y_{t_0}^T$, $Y_{t_0}^N$, $B_{t_0}^T$, $B_{t_0}^N$, and F_{t_0}, an equilibrium path is a sequence of prices $\{(p_t, r_t^N)\}_{t\geq t_0}$, allocations $\{(I_t^T, I_t^N)\}_{t\geq t_0}$, crisis indicators $\{\zeta_t\}_{t\geq t_0}$, productions and debts $\{Y_t^T, Y_t^N, B_t^T, B_t^N\}_{t>t_0}$ such that*

- *the vectors* (p_t, r_t^N), (I_t^T, I_t^N), *and* ζ_t *form a within-period equilibrium for all* $t \geq t_0$,
- *productions evolve according to* (3) *(for* $t > t_0$*) and debts according to* (10) *and* (14) *(for* $t \geq t_0$*),*
- *and the crisis indicator follows the selection rule* (17) *for* $t \geq t_0$.

Note that the selection rule requires the tranquil time equilibrium H to exist in every period.

Such an equilibrium path is said to be financially fragile in period t when $F_t = 1$. Then, a crisis occurs in period t with probability $1 - \omega$. For the sake of simplicity, the remaining of the paper studies the limit $\omega \to 1$. In this limit the sunspot variable S_t always takes the value 0 and crises never happen. So, $\mathrm{P}_t[\zeta_{t+1}=0] = 1$ and $r_t^N = \tau r^* = r^d$.

By extension, this equilibrium path with $\omega = 1$ is again said to be financially fragile when $F_t = 1$, even though the selection rule now prevents agents to actually coordinate on the crisis within-period equilibrium. By continuity, results concerning financial fragility when $\omega = 1$ are also valid when $\omega < 1$ provided that the probability of crisis $1 - \omega$ is low enough.[10] The advantage of studying this limiting case is that the dynamics converges to a steady state, which is not necessarily true when $\omega < 1$.[11]

In the following, lower-case letters are used to denote variables normalized by the productivity trend g^t.[12] Also, the following reduced parameter is introduced:

$$\psi = \frac{g}{r^* \tau} = \frac{g}{r^d} \tag{19}$$

This parameter increases with financial openness (*i.e.* decreases with τ), technological progress (g), and the supply of international liquidity (*i.e.* decreases with r^*). When $g - 1$ and $r^d - 1$ are small, we have $\psi \approx 1 + g - r^d$. Therefore, $\psi - 1$ is approximately equal to the difference between the growth rate and the domestic interest rate.

The remaining of this section studies the steady state and the transitory dynamics after a permanent increase in financial openness. It focuses on

[10] An alternative interpretation of financial fragility in the case $\omega = 1$ is that the economy can be subject to non anticipated crises, *i.e.* crises triggered by an unexpected expectational shock.

[11] If $F = 1$ in the steady state of the equilibrium path corresponding to $\omega = 1$, equilibrium paths with ω close enough but strictly inferior to 1 never converge to a steady state: instead, convergence is repeatedly interrupted by crises each time $F_t = 1$ and $S_t = 1$.

[12] *E.g.*: $y_t^T = Y_t^T / g^t$, $w_t^T = W_t^T / g^t$, etc.

the effect of financial openness on the sectoral structure. Financial fragility along equilibrium dynamics will be addressed in section 5.

4.2 The steady state

The equilibrium steady state is an equilibrium path along which all quantities grow as g^t and the price p_t is constant. It is described by the following proposition.

Proposition 2. *There is a unique $\psi_{max} > \frac{\gamma}{\delta}$ and a unique function $f(\cdot) > 0$ such that when $\frac{\gamma}{\delta} < \psi < \min\big(\frac{\gamma}{\delta}[\delta + \lambda(1-\delta)], \psi_{max}\big)$, there is an equilibrium steady state characterized by $\frac{i^N}{i^T} = \frac{w^N}{w^T} = f(\psi)$ and*

$$p = \left[\frac{i^N}{i^T}\right]^{1-\delta}, \tag{20}$$

$$i^N = g^{-\frac{\delta}{1-\delta}} (\delta\psi)^{\frac{1}{1-\delta}} \left[\frac{i^N}{i^T}\right]^{1-\eta\delta}, \tag{21}$$

$$b^s = \frac{1}{\psi}\frac{\psi - \frac{\gamma}{\delta}}{\psi - \gamma} i^s \qquad s = T, N, \tag{22}$$

$$w^s = \frac{\frac{\gamma}{\delta} - \gamma}{\psi - \gamma} i^s \qquad s = T, N. \tag{23}$$

The function $f(\cdot)$ diverges to $+\infty$ when $\psi \to \psi_{max}$. When $\frac{\gamma}{1-\gamma}\frac{1-\delta}{\delta} < \frac{\mu}{\eta}$, $f(\cdot)$ is U-shaped on $(\frac{\gamma}{\delta}, \psi_{max})$, first decreasing to a minimum, then increasing. Alternatively, when $\frac{\gamma}{1-\gamma}\frac{1-\delta}{\delta} \geq \frac{\mu}{\eta}$, $f(\cdot)$ is strictly increasing on $(\frac{\gamma}{\delta}, \psi_{max})$.

Proof. See appendix A.4. □

As this proposition makes clear, the steady state is completely determined by the sectoral allocation of capital $\frac{i^N}{i^T}$ (which is equal to the ratio $\frac{w^N}{w^T}$).

For the steady state to exist, ψ has to be bounded from above. The condition $\psi < \psi_{\max}$ ensures that $\frac{i^N}{i^T}$ is finite and the condition $\psi < \frac{\gamma}{\delta}[\delta + \lambda(1-\delta)]$ makes sure that a non-crisis within-period equilibrium H always exists. More specifically, this last condition states that $i^N < \lambda w^N$ in (23). Because the ratio of investment to internal funds is the same in both sectors, the borrowing constraint does not bind in the tradable sector either. The lower bound on ψ corresponds to assumption 1. Equation (22) shows that there would be no external debt with $\psi = \frac{\gamma}{\delta}$ which therefore corresponds to autarky.

In general, the relative size of sector N is a U-shaped function of parameter ψ (except when γ is large enough with respect to δ, in which case it is simply increasing). This is because the long run effect of an increase in financial openness (or, equivalently, of a lower world interest rate) on the sectoral structure is ambiguous. On the one hand, it makes domestic entrepreneurs invest more and increases their demand for non-tradable goods. This alone would induce a shift of resources from the tradable sector to the non-tradable sector.[13] On the other hand, entrepreneurs finance this higher investment with foreign debt which they have to pay back. Higher debt repayments decrease profits relative to investment expenditures (in equation (23) w^s/i^s decreases with ψ) and lead to a lower consumption demand for non-tradable goods in relative terms. This second effect tends to decrease the relative size of sector N. As debt repayment differs from newly issued debt by a factor $r^d/g = 1/\psi$, the first effect should dominate when ψ is large enough, which is what the proposition shows.[14]

The transitory dynamics

Let us now turn to the transitory dynamics that follows an increase in financial openness. Suppose the economy is initially in a steady state (at $t = 0$). At $t = 1$, the transaction cost τ unexpectedly and permanently decreases and domestic entrepreneurs have suddenly access to cheaper foreign loans.[15] Figure 2 shows an example of the subsequent dynamics, with $g = 1.03$, $\mu = \eta = 0.6$, $\delta = 0.95$ (small decreasing returns), $\gamma = 0.89$ (which corresponds to an autarky interest rate larger than the growth rate by 7 percentage points), and $\lambda = 2$. The simulated shock is a 1% decrease in r^d, which is initially set at 1.07. With these values, the initial equilibrium steady state is on the upward-sloping part of the curve $(i^N/i^T)(\psi)$ so that the long-run effect of the shock is to increase p and i^N/i^T. However, the transitory dynamics during the first few periods after the shock does not crucially depend on this.[16]

[13] Higher investment also means a higher demand for tradable goods, but contrary to non-tradable goods, tradable goods can be imported. This mechanism is very similar to the so-called *Dutch disease*.

[14] How large should ψ be so that the first effect dominates depends on the relative importance of consumption vs investment demand for non-tradable goods, that is, on the ratio μ/η. Appendix A.4 shows that i^N/i^T increases with ψ when $\psi \geq \gamma + \sqrt{\frac{\mu}{\eta}(\frac{1}{\delta} - 1)\gamma(1-\gamma)}$.

[15] Alternatively, the negative shock on the domestic rate of return $r^d = \tau r^*$ can obtain from a negative shock on the foreign rate of return r^*.

[16] The simulation is performed using Dynare. See Juillard (1996) for details on the algorithm used. The total number of periods is set to 200. Only the first 10 periods are

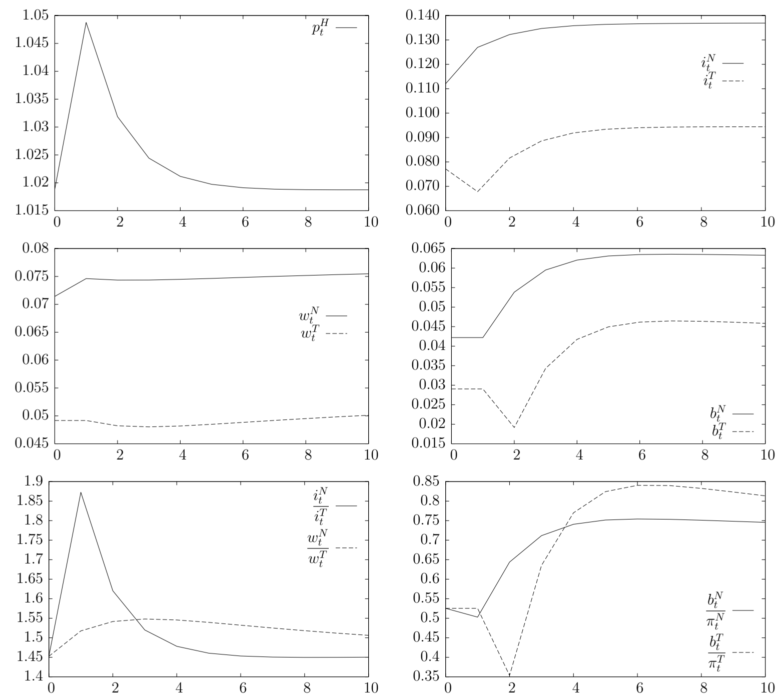

Figure 2: Equilibrium path following a permanent decrease in r^d. Parameters: $g = 1.03$, $\mu = \eta = 0.6$, $\delta = 0.95$, $\gamma = 0.89$, and $\lambda = 2$. At $t = 0$, $r^d = 1.07$. For $t \geq 1$, $r^d = 1.06$. Only the first 10 periods are displayed.

The dynamics is essentially driven by the following equation:

$$i_t^N = \delta\psi p_{t+1} y_{t+1}^N = \delta\psi\left[\tfrac{\mu(1-\gamma)}{\gamma}(w_{t+1}^T + w_{t+1}^N) + \eta(i_{t+1}^T + i_{t+1}^N)\right] \quad (24)$$

Suppose for a moment that i_t^T,w_t^T, and w_t^N were constant. Then, i_t^N could be solved forward and would instantaneously jump to a higher value as ψ unexpectedly increases at $t = 1$, thereby raising the demand for non-tradable goods. With a predetermined supply the adjustment in the first period can only come from a real appreciation and the relative price would also jump to a higher value when the shock happens. Then, production y_t^N would slowly increase in the next periods, which would decrease the relative price p_t while maintaining $p_t y_t^N$ constant.

Consider now the way investment by the tradable sector alters this simple dynamics. The real appreciation provoked by the shock makes the capital good more expensive. While a higher price of capital is offset in sector N by the expectation of high future proceeds, this is not the case in sector T. So, investment expenditures of sector T decrease when the shock hits and recover as the real exchange rate gradually depreciates.[17] Therefore, demand for non-tradable goods—the right-hand side of equation (24)—has to be increasing with time, which is why i_t^N does not adjust in one period. With an expanding non-tradable sector and a tradable sector that initially contracts, the ratio i_t^N/i_t^T overshoots. The ratio w_t^N/w_t^T (which is not equal to i_t^N/i_t^T outside the steady state) also overshoots but its evolution is much smoother since it is more dependent on lagged variables. Debt dynamics closely follows investment dynamics.

The effect of capital inflows on the sectoral structure

The results of this section show the effect that capital inflows have on the sectoral structure. An increase in financial openness lowers the domestic interest rate and is followed by an inflow of new foreign debt. These capital inflows finance higher investment expenditures and raise the demand for the domestically produced non-tradable good. Their immediate effect (the short

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displayed in figure 2. The initial and final steady states are locally determinate (*i.e.* the Jacobian matrix has as many eigenvalues outside the unit circle as there are forward looking variables in the dynamics). To be sure that the simulated dynamics is an equilibrium path I check that within-period equilibrium H exists in each period, *i.e.* that $i_t^N < \lambda w_t^N$ for each t.

[17] In some cases, the subsequent increase of sector T investment expenditures can be slowed down by a binding borrowing constraint. By definition of the equilibrium path this cannot happen in sector N.

run) is to bid up the relative price of the non-tradable good. While the real appreciation initially penalizes sector T, it benefits sector N: in the medium run, the relative size of the non-tradable sector (measured by the ratio of internal funds) increases.

In the longer run, however, higher debt repayments of firms slow down profits and consumption demand for non-tradable goods, which has an opposite effect on the sectoral structure. When the domestic interest rate is large compared to the growth rate, the effect of higher debt repayments dominates and the relative size of sector N decreases in the long run. On the contrary, when the difference between the domestic interest rate and the growth rate is lower, the effect of new debt dominates and the new steady state sectoral structure has a larger share of non-tradable goods.

5 Financial fragility

This section addresses the issue of financial fragility and the possibility of balance-of-payments crises along an equilibrium path. An equilibrium path is financially fragile in period t when the indicator F_t defined in equation (18) is equal to 1. In the limit $\omega \to 1$, this is the case when inequality (16) is satisfied. More precisely, the equilibrium path is financially fragile when b_t^N/π_t^T—the product of the leverage in the non-tradable sector, b_t^N/π_t^N, and the relative size of sector N, w_t^N/w_t^T—exceeds some threshold.

The previous section studied the evolution of the sectoral structure w_t^N/w_t^T both in steady states and along transitory dynamics. From equations (22) and (23), the steady state financial structure b^N/π^N is equal to $\frac{\delta}{1-\delta}\left(1-\frac{\gamma/\delta}{\psi}\right)$. It is strictly increasing with ψ. In the long run more financially opened economies (or economies where the world rate of return is lower) are more leveraged. In the transitory dynamics plotted in Figure 2, the ratio b_t^N/π_t^N starts increasing in the period that followed the shock on ψ.[18] Therefore, we expect b_t^N/π_t^T to increase in the medium run after an increase in financial openness.

Suppose the economy is initially in a steady state that is not financially fragile.[19] At $t = 1$, financial openness increases. Does the economy becomes financially fragile along the subsequent transitory dynamics? and if so, how long does it stay fragile? Figure 3 shows the evolution of the ratio b_t^N/π_t^T after a 1% negative shock on the domestic rate of return r^d for three different

[18]In the period of the shock, it decreases because b_t^N is predetermined and profits increase with the real appreciation.

[19]Since debt is 0 in autarky, this is the case if ψ is close enough to its autarky value $\frac{\gamma}{\delta}$.

initial rates of return. The ratio overshoots in the medium run, an evolution driven by the overshooting of w_t^N/w_t^T (see figure 2). As a result, an economy can be financially fragile during the transition phase following the financial opening but not in the long run, as shown in figure 3b.[20] In figure 3a, where the economy is initially closer to financial autarky,[21] the increase in b_t^N/π_t^T is not enough to make it fragile. In the third case, reported in figure 3c, the economy is more financially open to start with. It becomes financially fragile in the third period and stays so in the longer run.

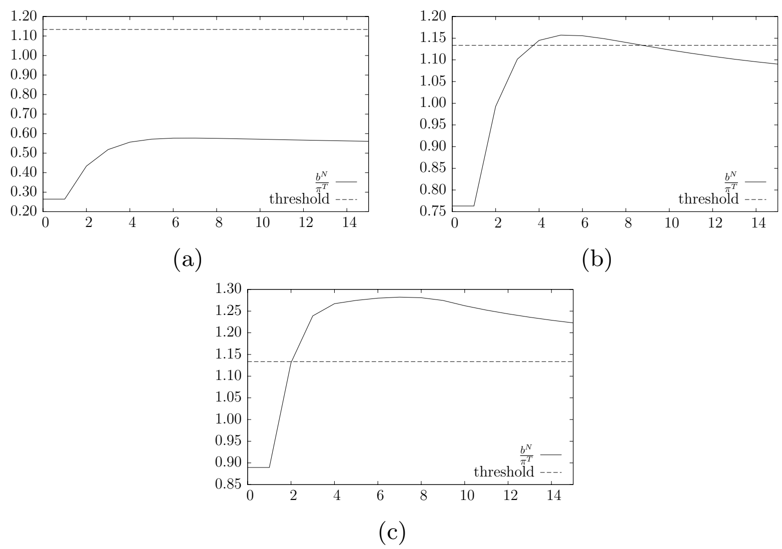

Figure 3: Financial fragility in the dynamic equilibrium path following a permanent decrease in r^d. Parameters: $g = 1.03$, $\mu = \eta = 0.6$, $\delta = 0.95$, $\gamma = 0.89$, and $\lambda = 2$. At $t = 0$ the initial interest rate is (a) $r^d = 1.09$, (a) $r^d = 1.07$, and (a) $r^d = 1.065$. The shock is a 1% decrease in r^d happening at $t = 1$. Only the first 15 periods are displayed.

The following proposition shows under what condition an equilibrium path displays financial fragility after the transitory phase.

Proposition 3. *There is a unique* ψ_{frag} *in* $\left(\frac{\gamma}{\delta}, \min\left(\frac{\gamma}{\delta}[\delta + \lambda(1-\delta)], \psi_{max}\right)\right)$ *such that a steady state equilibrium path is financially fragile if and only if* $\psi > \psi_{frag}$.

[20] This result is consistent with the empirical evidence reported by Kaminsky & Schmukler (2003) on boom-bust cycles following financial liberalization.

[21] With the parameter values used in figure 3, financial autarky corresponds to $r^d = 1.10$.

Proof. See appendix A.5. □

This proposition relies on the fact that b^N/π^T is strictly increasing with ψ. In the long run, an increase in financial openness (or a decrease in the world interest rate) unambiguously moves this ratio closer to the financial fragility threshold. While this is obvious when the economy is located on the upward-sloping part of the sectoral structure w^N/w^T (for high values of ψ—see proposition 2), it is also true when it is on its downward-sloping part (for low values of ψ).

A direct corollary from this proposition is that any equilibrium path associated to $\psi > \psi_{\text{frag}}$ eventually becomes financially fragile.[22] Thus, self-fulfilling balance-of-payments crises occur along equilibrium paths when (a) there is a large supply of international liquidity (the rate of return r^* is low), (b) the economy is very opened to international capital flows (the iceberg cost to international transactions τ is small), and (c) the growth rate is high (because of large productivity gains).

Note that depending on the parameter values, ψ_{frag} can be both lower or greater than 1. When it is greater than 1, a steady state can only be financially fragile with $r^d < g$, *i.e.* when the economy is dynamically inefficient. This is possible in the framework of an overlapping generation model.[23] However, a dynamically inefficient economy has other kinds of equilibrium paths where agents trade assets with no intrinsic value (bubbles).[24] Would such "bubbly" equilibrium paths also be financially fragile? Studying how domestically traded bubbles affect equilibrium paths, the sectoral structure, and financially fragility, would be outside the scope of this paper. Consider briefly, however, what happens if foreign lenders trade bubbles. Assume $g > r^*$ and suppose that old foreign lenders sell a bubble to young ones. For the bubble not to explode or asymptotically disappear, it has to grow exactly at the rate g. The bubble's rate of return is equal to g and strictly dominates the storage technology. The world rate of return is then equal to g and $\psi = \frac{1}{\tau} < 1$. Therefore, if $\psi_{\text{frag}} > 1$, an equilibrium path can never be financially fragile in the long run when foreign lenders trade bubbles.

Under what condition is ψ_{frag} lower than 1? When $\psi = 1$, b^N/π^T is

[22] This result extends to the case $\omega < 1$. It is possible to show that there is a similar threshold $\psi^{\omega}_{\text{frag}} < \min\left(\frac{1}{\omega}\frac{\gamma}{\delta}[\delta + \lambda(1-\delta)], \psi^{\omega}_{\max}\right)$ for all $\omega \in (0, 1]$, where $\psi^{\omega}_{\max}$ denotes the extension of $\psi_{\max}$ to the case $\omega < 1$.

[23] In the case of the present model, it also requires that $\min\left(\frac{\gamma}{\delta}[\delta + \lambda(1-\delta)], \psi_{\max}\right)$ is strictly greater than 1.

[24] See Samuelson (1958) for the case of an endowment economy and Tirole (1985) for the case of a production economy.

equal to

$$\left(\frac{b^N}{\pi^T}\right)_{\psi=1} = \frac{\delta}{1-\delta}\left(1-\frac{\gamma}{\delta}\right)\frac{(1-\delta)\mu+\delta\eta}{1-\left[(1-\delta)\mu+\delta\eta\right]}$$

It goes to $+\infty$ when either δ gets close to 1 or μ and η get close to 1. Therefore, the financial fragility threshold ψ_{frag} is strictly lower than one when decreasing returns to scale are sufficiently low or when the capital and consumption goods have a large enough share of non-tradable goods. When this is the case, financial fragility in equilibrium steady states does not require dynamic inefficiency.

6 Final remarks

This paper has built a two-sector overlapping generation 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 higher relative size of the non-tradable sector. This is in line with the observed behavior of the sectoral structure following a capital account liberalization. At the same time, access to cheaper foreign loans leads firms to increase their leverage. The evolution of these two factors tends to make crises more likely after an increase in financial openness. In the longer run, higher debt repayments mitigates the shift of resources toward the non-tradable sector, which tend to make crises less likely than during the transition phase. The model showed that crises occur in the longer run when the world interest rate is low enough and the domestic economy sufficiently opened to financial flows.

In the model, crises are triggered by self-fulfilling purely expectational shocks. However, the model could also account for crises triggered by exogenous shocks on fundamentals. When there are multiple within-period equilibria and a shock on fundamentals makes the normal time equilibrium H disappear, the economy jumps on the remaining crisis equilibrium L. With multiple equilibria small shocks on fundamentals can therefore have very large effects. There are several candidates for such a shock, for example a decrease in the terms of trade or a sudden stop.[25] Empirically, Calvo et al.

[25] A decrease in the terms of trade can be modeled as a decrease in the productivity of the tradable sector: the NN schedule moves to the left in figure 1. A sudden stop can be modeled as an increase in the world interest rate, which would move the right-hand side of the II schedule down.

(2004) argue that the sudden stop which followed the Russian crisis of 1998 led to episodes of real depreciation in emerging countries and several studies have found that crises were driven by sudden rises in the world interest rate (Frankel & Rose 1996, Milesi-Ferretti & Razin 1998). Then, depending on the underlying domestic factors of financial fragility, two economies can react very differently to the same external shock. In the case of a sudden stop for example, a financially fragile economy can jump on the crisis equilibrium, while other economies remain in the high 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 Argentine 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 mismatches in firm balance sheets is a lesson that is now widely agreed on,[26] 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.)[27] and suggests that there might be some complementarity between financial integration and industrial policy.

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[26] See for example Allen, Rosenberg, Keller, Setser & Roubini (2002).

[27] See van Wijnbergen (1984), Hausmann & Rigobon (2002), Caballero & Lorenzoni (2007).

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A Appendix

A.1 Data appendix

The data covers 12 emerging economies during the period 1973–1999: 7 Latin American countries (Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela) and 5 Asian countries (Indonesia, Korea, Malaysia, Philippines, Thailand).

The relative size of the non-tradable sector is constructed with data on sectoral value added in constant local currency units from the World Development Indicators. As the Colombian data from this source displays a strong discontinuity in 1994 (the price index was changed in this year), it was replaced by data from the Colombian Central Bank. The tradable sector is defined as agriculture and manufacturing. The non-tradable sector is defined as services and non-manufacturing industry.

The capital account is defined as liberalized when the *de jure* monthly index of Kaminsky & Schmukler (2003) indicates a "partially liberalized" or "fully liberalized" capital account. The starting date of a liberalization episode is chosen so that the capital account has been liberalized for at least six months. An episode ends if the capital account stops being liberalized for at least a year and a half.

Dates of banking crises are taken from Caprio & Klingebiel (2003). Dates of currency crises are constructed using monthly data from the International Financial Statistics. An exchange market pressure index is defined as the average of the rate of real depreciation (with respect to the US dollar) and the rate of foreign reserve depletion weighted by the inverse of their sample variances. A currency crisis occurs in a given month when this index exceeds the sample mean by two standard deviations. Finally, a twin crisis occurs when a currency crisis takes place in a one-year window around a banking crisis. Twin crises have to be separated by at least three years.

A.2 A microfoundation for the borrowing constraint

Following Schneider & Tornell (2004) and Aghion, Banerjee & Piketty (1999), it is possible to deduce the borrowing constraint from individual decisions in the context of moral hazard and imperfect monitoring.

Suppose, as in Schneider & Tornell (2004), that the entrepreneur of sector s has the possibility at the beginning of period $t+1$, if there is no crisis in period $t+1$, to run away with the production without repaying her debt B^s_{t+1}. This requires some special effort and costs her a disutility $d\,I^s_t$ proportional to the size of the investment project. If she chooses to run away, the lender can try to find her and force her to repay her debt. He can choose the probability of success m, which can be thought of as the intensity of monitoring. As in Aghion et al. (1999), monitoring also requires some effort and costs him a disutility $C(m)\frac{B^s_{t+1}}{r^s_t}$ proportional to the size of the loan, with $C(m) = -c\log(1-m)$.[28] Therefore, if the entrepreneur has disappeared in the beginning of period $t+1$, the lender chooses the intensity of monitoring m_{t+1} to maximize $m_{t+1}B^s_{t+1} - C(m_{t+1})\frac{B^s_{t+1}}{r^s_t}$, which yields $m_{t+1} = 1 - \frac{c}{r^s_t}$, provided that B^s_{t+1} does not exceed the value of production.

The entrepreneur has incentives to repay her debt if the disutility from

[28]This functional form gives a financial multiplier independent of the interest rate. This is a knife-edge case whose only purpose is analytical tractability.

running away is higher than the expected debt repayment:

$$dI_t^s + \left(1 - \frac{c}{r_t^s}\right) B_{t+1}^s \geq B_{t+1}^s \, .$$

This condition can be reduced to

$$\frac{B_{t+1}^s}{r_t^s} \leq (\lambda - 1) W_t^s \qquad (*)$$

where $\lambda - 1 = \frac{1}{\frac{c}{d} - 1}$.

There are two kinds of debt contracts: secured loans which satisfy condition $(*)$, possibly by limiting the size of the loan $\frac{B_{t+1}^s}{r_t^s}$, and unsecured loans which do not satisfy $(*)$. Consider an unsecured loan. Since foreign lenders are risk neutral, an unsecured loan in the non-tradable sector must satisfy the following break-even constraint (when B_{t+1}^N is lower than the value of production):

$$\mathrm{P}_t[\zeta_{t+1} = 0][m_{t+1} r_t^N - C(m_{t+1})] = \tau r^* \, .$$

With m_{t+1} being a function of c and r_t^N, this equation implicitly defines a unique risky rate of return $r_t^N > c$ as a function of c. Likewise, in the tradable sector, unsecured debt contracts have a rate of return r^T greater than c. Assume now that c is greater than d (this ensures that $\lambda > 1$) and is so large that the debt repayment, in the state of nature where the lender succeeds in forcing the entrepreneur to repay, always exceeds the value of production. Then, the entrepreneur never fully repays the lender even when the latter succeeds in finding her and because of the bankruptcy cost the lender never receives anything out of an unsecured loan.[29] Therefore, all loans have to be secured in equilibrium. This gives rise to the borrowing constraint $(*)$.

A.3 Proof of proposition 1

An equilibrium real exchange rate is a zero of the function

$$f(p_t) = p_t Y_t^N - \mu(1-\gamma)[\Pi_t^T + \Pi_t^N(p_t)] - \eta[I_t^T(p_t) + I_t^N(p_t)].$$

[29] The bankruptcy cost is not necessary. Without bankruptcy costs, a high enough value of c entails that the lender takes all the expected value of production. The net expected value of investment would then be negative for the entrepreneur, who would never invest.

Suppose assumption 2 is *not satisfied*. Then, when $p_t \geq \frac{B_t^N}{Y_t^N}$, we have

$$\begin{aligned} f'(p_t) &= Y_t^N[1-\mu(1-\gamma)] - \eta\left[\frac{\partial I_t^T}{\partial p_t} + \frac{\partial I_t^N}{\partial p_t}\right] \\ &\geq Y_t^N\left[1-\mu(1-\gamma) - \eta\gamma\lambda\right] \\ &\geq 0 \end{aligned}$$

where we use the fact that I_t^T is either strictly decreasing with p_t or constant, so that $\frac{\partial I_t^T}{\partial p_t} \leq 0$, and that $\frac{\partial I_t^N}{\partial p_t}$ is either strictly negative (when the borrowing constraint does not bind) or equal to $\lambda\gamma Y_t^N$ (when it does). The function f is continuous and increasing on the interval $[\frac{B_t^N}{Y_t^N}, +\infty)$. Besides, it tends to $+\infty$ when p_t tends to $+\infty$. Therefore, it has a zero on this interval if and only if $f\left(\frac{B_t^N}{Y_t^N}\right) \leq 0$.

On the interval $[0, \frac{B_t^N}{Y_t^N})$, f is also an increasing function. This implies:

$$\forall p_t \in [0, \tfrac{B_t^N}{Y_t^N}), \quad f(p_t) < \lim_{p_t \overset{<}{\longrightarrow} \frac{B_t^N}{Y_t^N}} f(p_t)\,.$$

This limit is equal to $f\left(\frac{B_t^N}{Y_t^N}\right)$ when the constraint binds in sector T at $p_t = \frac{B_t^N}{Y_t^N}$ and to $f\left(\frac{B_t^N}{Y_t^N}\right) - \eta\lambda z_t g^t$ when it doesn't. In both cases it is lower than (or equal to) $f\left(\frac{B_t^N}{Y_t^N}\right)$. Therefore if there exists an equilibrium with $p_t \geq \frac{B_t^N}{Y_t^N}$, $f(p_t) < f(\frac{B_t^N}{Y_t^N}) \leq 0$ for all p_t in $[0, \frac{B_t^N}{Y_t^N})$ so that there cannot be another equilibrium with $p_t < \frac{B_t^N}{Y_t^N}$ at the same time. With a similar argument, if there exists an equilibrium with $p_t < \frac{B_t^N}{Y_t^N}$, there cannot be another equilibrium with $p_t \geq \frac{B_t^N}{Y_t^N}$ at the same time.

To show the second part of the proposition, note that $f(0) < 0$. For $p_t < \frac{B_t^N}{Y_t^N}$,

$$\begin{aligned} f(p_t) &= p_t Y_t^N - \mu(1-\gamma)\Pi_t^T - \eta[I_t^T(p_t) + \lambda z_t g^t] \\ &\geq p_t Y_t^N - \mu(1-\gamma)\Pi_t^T - \eta\lambda\gamma\Pi_t^T\,. \end{aligned}$$

If condition (16) is satisfied, $f(p_t)$ has a zero on $(0, \frac{B_t^N}{Y_t^N})$.

A.4 Proof of proposition 2

Equations (20)–(23) are easily obtained under the assumption that i^s, w^s, b^s, and p are constant. Besides, from the market clearing condition (15), we get

$$\frac{i^N}{i^T} = f(\psi) = \frac{\mu(\frac{1}{\delta}-1)\frac{1-\gamma}{\psi-\gamma}+\eta}{\frac{1}{\delta\psi}-\Big[\mu(\frac{1}{\delta}-1)\frac{1-\gamma}{\psi-\gamma}+\eta\Big]}\,.$$

The denominator has the sign of $-P(\psi)$ where

$$P(X) = \delta\eta X^2 + \big[(1-\delta)\mu(1-\gamma)-\delta\eta\gamma-1\big]X+\gamma\,.$$

We have $P(\frac{\gamma}{\delta})<0$. Therefore, this polynomial has two positive roots $\psi_{\min}$ and $\psi_{\max}$ with $0<\psi_{\min}<\gamma/\delta<\psi_{\max}$. When $\psi>\psi_{\max}$, $f(\psi)$ has a negative denominator and i^N/i^T does not converge to a finite value.

The derivative $f'(\psi)$ has the sign of $\eta(\psi-\gamma)^2-(\frac{1}{\delta}-1)\mu\gamma(1-\gamma)$. So, $f(\psi)$ is minimum when $\psi=\gamma+\sqrt{\frac{\mu}{\eta}(\frac{1}{\delta}-1)\gamma(1-\gamma)}$.

If $\frac{\gamma}{1-\gamma}\frac{1-\delta}{\delta}<\frac{\mu}{\eta}$, we have

$$\frac{\gamma}{\delta}<\gamma+\sqrt{\frac{\mu}{\eta}(\frac{1}{\delta}-1)\gamma(1-\gamma)}<\gamma+(1-\gamma)\frac{\mu}{\eta}\,.$$

Since $P\big(\gamma+(1-\gamma)\frac{\mu}{\eta}\big)<0$, we have $\gamma+\sqrt{\frac{\mu}{\eta}(\frac{1}{\delta}-1)\gamma(1-\gamma)}<\psi_{\max}$. Otherwise, $\gamma+\sqrt{\frac{\mu}{\eta}(\frac{1}{\delta}-1)\gamma(1-\gamma)}\leq\frac{\gamma}{\delta}$ and $f(\cdot)$ is strictly increasing on $(\frac{\gamma}{\delta},\psi_{\max})$.

Finally, the definition of the equilibrium path requires that a within-period equilibrium of type H exists in each period. This is the case in the steady state if $i^N\leq\lambda w^N$. From (23), ψ has to be smaller than $\frac{\gamma}{\delta}[\delta+\lambda(1-\delta)]$.

A.5 Proof of proposition 3

A steady state is financially fragile when $\frac{b^N}{\pi^T}>(1-\gamma)\mu+\gamma\eta\lambda$.

Let us first prove that the steady state ratio $\frac{b^N}{\pi^T}$ is strictly increasing with ψ. Denote $\frac{b^N}{\pi^T}=h(\psi)=\frac{\delta}{1-\delta}\big(1-\frac{\gamma/\delta}{\psi}\big)f(\psi)$. The derivative of $h(\cdot)$ has the sign of $Q(\psi-\gamma)$ with:

$$Q(X)=\eta(1-\eta\gamma)X^2-2\eta\gamma(1-\gamma)\mu(\tfrac{1}{\delta}-1)X+\gamma(1-\gamma)\mu(\tfrac{1}{\delta}-1)^2[1-\mu(1-\gamma)]$$

The discriminant of this polynomial is

$$4\eta\mu\gamma(1-\gamma)(\tfrac{1}{\delta}-1)^2\Big[(1-\gamma)\mu+\gamma\eta-1\Big]<0$$

Therefore, $Q(\psi-\gamma)$ is always strictly positive and $h(\cdot)$ is a strictly increasing function.

We have $h\big(\frac{\gamma}{\delta}\big)=0$. When $\psi\to\psi_{\max}$, $f(\psi)$ diverges to $+\infty$ and so does $h(\psi)$. This proves the proposition when $\psi_{\max}\leq\frac{\gamma}{\delta}[\delta+\lambda(1-\delta)]$. When $\psi_{\max}>\frac{\gamma}{\delta}[\delta+\lambda(1-\delta)]$, the proposition follows from $h\left(\frac{\gamma}{\delta}[\delta+\lambda(1-\delta)]\right)>(1-\gamma)\mu+\gamma\eta\lambda$. We have

$$h\left(\tfrac{\gamma}{\delta}[\delta+\lambda(1-\delta)]\right)=\frac{\delta(\lambda-1)}{\delta+\lambda(1-\delta)}\;\frac{(1-\gamma)\mu+\gamma\eta\lambda}{\frac{\lambda}{\delta+\lambda(1-\delta)}-(1-\gamma)\mu-\gamma\eta\lambda}$$

The desired inequality is satisfied if

$$\frac{(1-\gamma)\mu+\gamma\eta\lambda-1}{\frac{\lambda}{\delta+\lambda(1-\delta)}-(1-\gamma)\mu-\gamma\eta\lambda}>0$$

The denominator is strictly positive when $\frac{\gamma}{\delta}[\delta+\lambda(1-\delta)]$ is strictly lower than $\psi_{\max}$. The numerator is strictly positive by assumption 2.