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External constraint and financial crises with balance sheet effects

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Abstract: This paper investigates the dynamic implications of Krugman's (1999) model of financial crises with balance-sheet effects, which has a considerable impact on the literature of international financial crisis. Considering explicitly the wealth-accumulation constraint and the external equilibrium condition, I describe an emerging-market financial crisis as a jump from an unstable dynamic trajectory to a stable one, instead of a jump from a "good" to a "bad" equilibrium with zero investment and zero foreign debt. By discriminating the financial crises according to the severity of the negative impacts of some internal and external factors, this paper also adds some insights into the anti-crisis policy.

Keywords: Currency crisis, balance sheet effect, external solvency constraint, financial crisis.

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1. Introduction

In the aftermath of 1997 Asian financial crisis, there was much controversy among economists about its origin and nature. A decade later, economists know much more about financial and currency crises even though the lessons from these crises are not fully learned.

Currency crisis models developed before the 1997 Asian turmoil are relevant in explaining other particular crisis in the 1990s. The first-generation models focused on budgetary deficits and the effect of its continuing monetary financing (e.g., Krugman (1979), Flood and Garber (1984)). The second-generation models (e.g., Obstfeld (1994), Sachs, et al. (1996)) highlighted the trade-off between employment and exchange rate stability and explained the crisis as a jump between multiple equilibria. In most crisis countries of Asia, neither of these stories has much relevance. In terms of conventional fiscal indicators such as budgetary deficits, the governments of the distressed economies were in quite good shape at the beginning of 1997. While growth had slowed and some signs of excess capacity appeared in 1996, none of them faced a clear trade-off between employment and exchange rate stability.

The third-generation models were then developed to answer the particular questions raised during the Asian crisis. A largely shared idea in these models is that the crisis should be seen as a result of a shock that is amplified by what Bernanke, et al. (1999) have called a financial accelerator mechanism.¹ Since firms' assets and liabilities are denominated in domestic and foreign currency respectively, real depreciation can have a large effect on output if it affects the credit access of some agents by worsening their balance sheets. Then, this output effect may in turn affect the exchange rate, further amplifying the shock and causing it to persist. A

¹ Another important strand of literature has argued that the core of the problem lies in the banking system (Corsetti, et al. (1999), Chang and Velasco (2001)).

large theoretical literature of financial crisis that focuses on the story of balance-sheet effects and leverage constraint has been developed into different directions.²

Krugman (1999) has noticed that the transfer problem, debated by Keynes and Ohlin in the 1920s, was central to what has happened to Asia. In effect, many authors were mainly concerned with the behavior of investors in one-good models and did not pay much attention to the movement in the terms of trade and the reversal in the current account. In practice, this reversal has been achieved partly through massive real depreciation, and partly through severe recession that produces a compression of imports. Krugman (1999) advances therefore the transfer problem as another way of explaining the Asian crisis: foreign currency debt and leveraged financing make the domestic economy fragile and prone to crisis. He has shown the existence of three equilibria with the crisis brought on by a pure shift in expectations, leading to a possible jump from an equilibrium with high investment to one with zero investment, suggesting persistent negative effects of real currency depreciation on output.

Empirically, Upadhyaya and Upadhyay (1999) have found that currency devaluation in Asian countries generally fails to make any effect on output over any length of time. Kim and Ying (2007) have even observed strongly expansionary effects of devaluation in several countries except for the crisis period. However, after currency devaluation, the level of GDP can remain permanently below its initial trend, suggesting that the shocks underlying a currency crisis are persistent (Hong and Tornell (2005)). Taking a long-term view, Bordo, et al. (2010) have found empirical evidence of significant permanent output losses due to financial crises driven by exposure to foreign currency debt.

² For example, Mendoza (2002) has shown that a mismatch between the denomination of debt and income exacerbates financial crises. Aghion, et al. (2001, 2004a, b) have provided optimal monetary policy prescriptions when a crisis occurs in models integrating the credit side with the monetary side. Schneider and Tornell (2004) have developed a model based on sectoral asymmetries in corporate finance with currency mismatch and borrowing constraints arising endogenously, leading to self-fulfilling crises. For a survey, see Allen, et al. (2002).

The advances in the literature of international financial crisis, induced by the 1997 Asian crisis, have also great pertinence for understanding the repercussions of subprime crisis on Iceland and Central and Eastern European countries (Krugman (2010)). In effect, many of these countries have large amount of debt denominated in foreign currencies (e.g, Sirtaine and Skamnelos (2007), Von Hagen and Siedschlag (2008), Buitert and Sibert (2009), and Danielsson (2009)) and they are vulnerable to a real devaluation or depreciation, exactly as in the 1997 Asian crisis. It is surprising that the great lessons of the Asian crisis are not learned.³

In this context, it is particularly interesting to revisit Krugman's (1999) model, distinguished by its profound insights and its capability of dealing with a large number of issues on currency and foreign debt crisis. It is among the early models to draw the attention of economists on issues of debt composition and particularly currency denomination, and has had a large impact on the twin crisis literature. It can still give good insights into the recent twin crisis affecting Iceland and some Central and Eastern European countries.

We remark that, ignoring the wealth-accumulation constraint and external equilibrium condition, Krugman (1999) has reached the following intriguing result: a crisis is a jump from a good equilibrium with high investment and high foreign-currency debt to a bad equilibrium with zero investment and zero foreign debt. This prediction is not verified by the empirical evidence and is hard to understand from a theoretical point of view. Therefore, the central objective of this paper is to reexamine the relevance of this theoretical result by providing a dynamic analysis of Krugman's model. For this purpose, I introduce the wealth-accumulation constraint and the external equilibrium condition while making some additional assumptions to ensure the tractability of the model. This extension allows us to examine from another point of view the mechanism of financial crisis driven by the exposure to foreign currency debt.

³ A debate emerged in the late 1990s regarding the causes of the prevalence of foreign currency denominated foreign debt in emerging markets. Some saw it as a consequence of moral hazard. Hausmann (1999) and Eichengreen and Hausmann (2000) advanced the "original sin hypothesis". Eichengreen, et al. (2005) have argued that it was not a mere consequence of bad policies or institutions.

The reminder of the paper is structured as follows. The next section presents the model. The section after describes the steady state equilibrium. Section 4 examines the model's dynamic properties and the mechanism of financial crisis. Section 5 discusses some factors inducing financial fragility or crisis. Section 6 analyzes the policy implications. The last section concludes.

2. The model

The extended version of the small open-economy model of Krugman (1999) is as follows:

$$y_t = G(K_t, L_t) = K_t^\alpha L_t^{1-\alpha}, \quad 0 < \alpha < 1, \quad (1)$$

$$y_t = (1 - \mu)I_t + (1 - \mu)C_t + p_t X_t = (1 - \mu)I_t + (1 - \alpha)(1 - \mu)y_t + p_t X_t, \quad (2)$$

$$p_t = \frac{y_t[1 - (1 - \alpha)(1 - \mu)] - (1 - \mu)I_t}{X_t}, \quad (3)$$

$$I_t \leq (1 + \lambda)W_t, \quad (4)$$

$$1 + r_t = p_t^{-\mu} G_k(K_t, L_t), \quad \text{with } K_t = I_{t-1} p_{t-1}^{-\mu}, \quad (5)$$

$$\frac{(1 + r_t)p_t}{p_{t+1}} \geq 1 + r_t^*, \quad (6)$$

$$I_t \geq 0, \quad (7)$$

$$W_t = \alpha y_t - (1 + r_{t-1})D_{t-1} - p_t(1 + r_{t-1}^*)F_{t-1}, \quad (8)$$

$$D_t + p_t F_t = I_t - W_t, \quad (9)$$

$$\begin{aligned} B_{ee} &= p_t X - \mu I_t - \mu C_t - r_{t-1} D_{t-1} - r_{t-1}^* p_t F_{t-1} + (D_t - D_{t-1}) + p_t (F_t - F_{t-1}) \\ &= p_t X - \mu I_t - (1 - \alpha)\mu y_t - r_{t-1} D_{t-1} - r_{t-1}^* p_t F_{t-1} + (D_t - D_{t-1}) + p_t (F_t - F_{t-1}). \end{aligned} \quad (10)$$

where y_t denotes the output, K_t the stock of physical capital, L_t the labor, I_t the investment, C_t the consumption, p_t the real exchange rate (or the relative price of foreign goods), X_t the domestic exports, W_t the net wealth of domestic entrepreneurs, D_t and F_t the domestic and foreign currency denominated debt respectively, and r_t and r_t^* the domestic

and foreign real interest rate respectively. Among these variables, y_t , I_t , C_t , W_t and D_t are measured in terms of domestic goods, K_t in terms of investment goods which is built using domestic and foreign goods, X_t and F_t in terms of foreign goods.

Equation (1) presents the Cobb-Douglas production function of the small open economy that produces a single good each period using capital and labor. The capital is assumed to last only one period so that this period's capital, once measured in domestic goods, is equal to the last period's investment. We assume that the flexibility on the labor market will ensure full employment and the labor supply is normalized to unity so that $L_t = 1, \forall t$.

Equation (2) describes the market clearing condition for domestic goods. The domestic demand functions are based on the assumption that domestic residents are divided into two distinct classes. Workers, who receive a share $1 - \alpha$ of domestic income, lack access to the capital market and spend all their income within each period. Entrepreneurs create and own domestic capital by saving and investing all their income until the exhaustion of domestic investment opportunities and then they are assumed to consume the surplus of their revenue over investment.⁴ In the periods where entrepreneurs do not consume, domestic consumption and investment are equal to workers' income and entrepreneurs' income respectively. The domestic and foreign goods are imperfect substitutes with unitary elasticity of substitution. Thus, a share $1 - \mu$ of both consumption and investment is spent on domestic goods, and μ on imports. The value of domestic exports in terms of foreign goods is assumed to be fixed with $X_t = X$, i.e. the foreign elasticity of substitution is also unitary.

Equation (3) is obtained using (2). It expresses the domestic real exchange rate as a function increasing in domestic output and investment but decreasing in exports.

⁴ We introduce this assumption to close the small open-economy model to avoid that these entrepreneurs accumulate an infinite amount of wealth. This assumption might not be plausible for describing some emerging economies having sufficiently accumulated capital. As illustrated by recent international developments of South Korean firms, ambitious entrepreneurs might be tempted to invest on international financial assets and/or industrial projects. See Schmitt-Grohé and Uribe (2003) for other ways of closing the model.

Inequality (4) specifies that the ability of domestic entrepreneurs to invest is limited by their wealth in the way of Bernanke *et al.* (1999). Lenders impose a limit on leverage, justified by motives such as the risk of bankruptcy and asymmetric information. Hence, entrepreneurs can borrow at most $(1 + \lambda)$ times their wealth.

Equation (5) shows that the return of domestic bonds is equal to the marginal productivity of capital. Because a share μ of investment falls on foreign goods, the price index for last period's investment goods relative to that of domestic output is $p_{t-1}^{-\mu}$. One unit of domestic good saved in t allows buying $p_t^{-\mu}$ units of capital before the production takes place and therefore the return on domestic bonds should (by arbitrage) be equal to $p_t^{-\mu} G_k(K_t, L_t) = \alpha I_{t-1}^{\alpha-1} p_{t-1}^{-(\alpha-1)\mu} p_t^{-\mu}$.

According to (6), entrepreneurs will not borrow beyond the point at which the real return on domestic investment, determined by (5), equals that on foreign bonds. It is similar to uncovered interest rates parity (UIRP), which compares the rate of return of foreign bonds r_t^* and the return (converted into foreign goods at p_{t+1}) that can be achieved with domestic investment equivalent to a unity of foreign goods (converted into domestic goods at p_t).

Equation (7) imposes that investment cannot be negative.

Equation (8) defines the net wealth of entrepreneurs as the difference between a share α of domestic revenue attributed to the owners of domestic capital and the actual value of the debt that they owe, at an aggregate level, to international lenders. The income accruing to capital (αy_t) also represents the value of domestic capital which lasts only one period.

Equation (9) describes the evolution of foreign debt used by domestic entrepreneurs to finance an investment greater than their wealth. It represents their balance-sheet constraint.

Equation (10) represents the external equilibrium condition or balance of payments. Under a flexible exchange rate regime (i.e., $B_{ee} = 0$), it can be obtained by combining (2), (8) and

(9). It implies that a temporary current account deficit can be financed by the inflow of capital. In the long term, a trade balance surplus must be generated to ensure the interest payments on foreign debt.

Equations (9) and (10) represent the logic extension of Krugman's model. They are important to our understanding of the dynamic features of a crisis-prone economy.

Assume that entrepreneurs are risk neutral and maximize their firms' profits in period t . If $\alpha I_{t-1}^{\alpha-1} p_{t-1}^{-(\alpha-1)\mu} p_t^{-\mu} \geq 1 + r_t$, i.e. the marginal rate of return of capital is higher than the cost of financing investment, entrepreneurs will borrow from abroad the maximal amount allowed by the leverage constraint (4) which is therefore binding. Otherwise, (4) will not be binding.

At the equilibrium on the international financial market, the absence of arbitrage opportunity between domestic and foreign currency denominated bonds implies that (6) is verified with equality:

$$p_{t+1}(1 + r_t^*) = (1 + r_t)p_t. \quad (11)$$

The ratio of foreign currency (or goods) denominated debt relative to domestic currency denominated debt is assumed for simplicity to be constant and equal to ν :⁵

$$\frac{F_t}{D_t} = \frac{F_{t-1}}{D_{t-1}} = \nu. \quad (12)$$

The ratio ν can be arbitrarily modified to examine the effect of its variation on economic equilibrium. In the following, D_t is simply named "foreign debt" even though the "total foreign debt" is a multiple of it, i.e. $D_t + p_t F_t = (1 + \nu p_t) D_t$.

Foreign banks would pay attention to the wealth left to entrepreneurs after the payment of principal and interests. Using (1) with $K_t = I_{t-1} p_{t-1}^{-\mu}$, (8) and (11)-(12), we obtain:

⁵ This assumption partially reflects the original sin hypothesis advanced by Eichengreen and Hausmann (1999) who define it as a situation in which the domestic currency cannot be used to borrow abroad or to borrow long term even domestically, and modified by Eichengreen, et al. (2005) who discard the domestic element of original sin and redefine original sin as a situation in which most countries cannot borrow abroad in their own currency.

$$W_t = \alpha I_{t-1} p_{t-1}^{-\mu} - \left(\frac{p_t}{p_{t-1}} + p_t v \right) (1 + r_{t-1}^*) D_{t-1}. \quad (13)$$

If $W_t \leq 0$, no bank will lend to these entrepreneurs and therefore they will bankrupt and invest zero. For a given wealth W_0 , (13) is rewritten as:

$$D_{t-1} = \frac{\alpha I_{t-1} p_{t-1}^{1-\mu} - p_{t-1} W_0}{(1 + p_{t-1} v) p_t (1 + r_{t-1}^*)}. \quad (14)$$

An iso-wealth curve represents the combinations of foreign debt and investment that ensure a constant wealth. A given combination of investment and foreign debt (I_0, D_0) can correspond to different wealth levels, according to parameters. A counterclockwise rotation of the curve Iso-wealth around C to Iso-wealth *bis* (W'_0) implies a fall in wealth, i.e. $W'_0 < W_0$.⁶

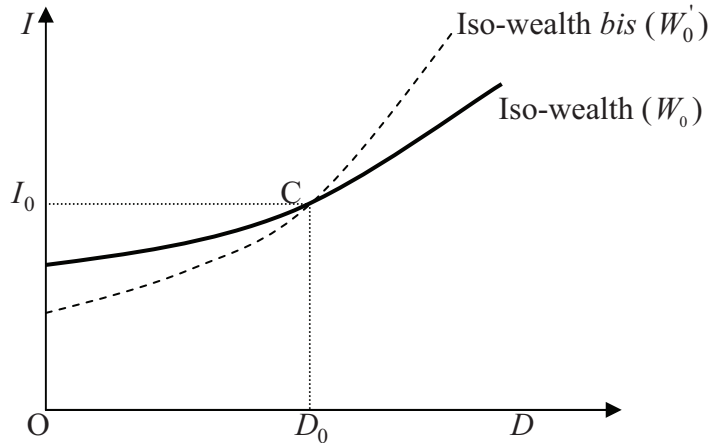


Fig. 1: Iso-wealth curve.

The model has nine endogenous variables and is solved in two steps. The first step of the resolution consists to solve the difference equations for p_t , I_t and D_t . In the second step, we can solve for y_t , C_t , K_t , r_t , W_t and F_t . Substituting y_t given by (1) into (3) yields:

⁶ According to (14), this is the case when there is: i) an increase in r_t^* that reduces entrepreneurs' wealth; ii) a decrease in X , since this implies according to (3) a real depreciation, decreasing the current value of domestic product but increasing the value of foreign debt measured in domestic currency; iii) an increase in μ that, by increasing the demand for foreign goods, implies a real depreciation and hence has a similar effect as a decrease in X . However, an increase in α has ambiguous effects on the wealth. It induces an increase in the revenue attributed to capitalists as well as a real depreciation (due to higher productivity of existing capital and hence higher output, and higher part of revenue that is exported) with the above-mentioned effects. Finally, a variation of λ has no effect on the iso-wealth curve.

$$p_t = \frac{I_{t-1}^\alpha p_{t-1}^{-\alpha\mu} [1 - (1-\alpha)(1-\mu)] - (1-\mu)I_t}{X}. \quad (15)$$

Under the assumption that the risk-neutral entrepreneurs, when their wealth is low enough, use the leverage financing so that (4) is binding, i.e. $I_t = (1+\lambda)W_t$. Combining the latter condition with (1), (8) and (11)-(12) to eliminate F_t , W_t and r_t yields

$$I_t = \alpha(1+\lambda)I_{t-1}^\alpha p_{t-1}^{-\alpha\mu} - \frac{1+\nu p_{t-1}}{p_{t-1}}(1+\lambda)(1+r_{t-1}^*)p_t D_{t-1}. \quad (16)$$

The dynamics of D_t , representing the country's external debt, is described equivalently by (8)-(9) or (10) with $B_{ee} = 0$. Using (1), (8)-(9) and (11)-(12) to eliminate F_t , W_t and r_t gives:

$$D_t(1+p_t\nu) = I_t - \alpha I_{t-1}^\alpha p_{t-1}^{-\alpha\mu} + \frac{1+\nu p_{t-1}}{p_{t-1}} p_t (1+r_{t-1}^*) D_{t-1}. \quad (17)$$

Difference equations (15)-(17) describe the dynamic behavior of real exchange rate, investment and foreign debt. They are non-linear and cannot be solved explicitly. However, the static and dynamic properties of the system can be studied with the help of a phase diagram.

3. Steady state equilibrium

The steady state equilibrium, where variables are denoted by an upper bar, is attained when the dynamic effects of shocks are fully realized. Since optimal investment verifies

$\alpha I_{t-1}^{\alpha-1} p_{t-1}^{-(\alpha-1)\mu} p_t^{-\mu} \geq 1+r_t$, the steady state investment must satisfy:

$$\bar{I} \leq \hat{I} = \arg\{\alpha \bar{I}^{\alpha-1} \bar{p}^{-\alpha\mu} = 1 + \bar{r}^*\}. \quad (18)$$

Given \bar{r}^* , the highest steady state investment, \hat{I} , equalizes the marginal productivity of capital and the opportunity cost of investing.

The steady state counterparts of (15)-(17) are given as follows:

$$\bar{p} = \frac{\bar{I}^\alpha \bar{p}^{-\alpha\mu} [1 - (1-\alpha)(1-\mu)] - (1-\mu)\bar{I}}{X}, \quad (19)$$

$$\bar{I} = (1 + \lambda)\alpha\bar{I}^\alpha\bar{p}^{-\alpha\mu} - (1 + \lambda)(1 + v\bar{p})(1 + \bar{r}^*)\bar{D}, \quad (20)$$

$$\alpha\bar{I}^\alpha\bar{p}^{-\alpha\mu} - \bar{I} = (1 + v\bar{p})\bar{r}^*\bar{D}. \quad (21)$$

The steady state equilibrium of the reduced dynamic system is defined by the vector $(\bar{I}, \bar{p}, \bar{D})$. Given \bar{I} , (19) determines $\bar{p} = \psi(\bar{I})$. Equation (20) corresponds to the combination of investment and foreign debt along the quickest wealth-accumulation path limited by condition (18). Given the real exchange rate, it would determine a “financeable” level of investment that would occur if (4) was binding and the maximal credit (or debt capacity) that could be granted to domestic firms. Equation (21) is the solvency constraint of entrepreneurs, which implies that the surplus of wealth over investment is equal to interest payments on foreign debt. Since the foreign debt is uniquely contracted by entrepreneurs, their solvency constraint is also the economy’s external solvency constraint. Thus, (21) is equivalent to the steady state counterpart of (10) meaning that, in the long-run, the trade surplus must be equal to interest payments on foreign debt.

Substituting $\bar{p} = \psi(\bar{I})$ into (20)-(21) and rearranging the terms lead to

$$\bar{D}\Big|_{inv} = \frac{\alpha(1 + \lambda)\bar{I}^\alpha[\psi(\bar{I})]^{-\alpha\mu} - \bar{I}}{(1 + \lambda)[1 + v\psi(\bar{I})](1 + \bar{r}^*)}, \quad (22)$$

$$\bar{D}\Big|_{ee} = \frac{\alpha\bar{I}^\alpha[\psi(\bar{I})]^{-\alpha\mu} - \bar{I}}{[1 + v\psi(\bar{I})]\bar{r}^*}. \quad (23)$$

where $\bar{D}\Big|_{inv}$ and $\bar{D}\Big|_{ee}$ denote, for all levels of investment, the highest steady state debt compatible with the leverage constraint and the external solvency constraint respectively. Equations (22)-(23) constitute a sub-system incorporating the effects of the real exchange rate on wealth, i.e. balance sheets, and can be solved to obtain \bar{I} and \bar{D} taking account of (18).

The curves $\bar{D}\Big|_{inv}$ and $\bar{D}\Big|_{ee}$ could be represented as in Fig. 2 where \tilde{I}_{id} represents the intersection point of these two curves, and \tilde{I} and \bar{I}_d respectively the higher intersection point

of $\bar{D}|_{inv}$ and $\bar{D}|_{ee}$ with the axe I (see Appendix A). At high levels of I , the leverage constraint (4) will not bind. Instead, investment is determined using (5) and (11) and is consequently limited to \hat{I} with $\hat{I} < \tilde{I}_{id}$. Using (18) and $\hat{I} < \tilde{I}_{id}$, the set of feasible combinations of debt and investment is constituted of AB (i.e., $I = \hat{I}$) and OB (i.e., the dark part on the curve $\bar{D}|_{inv}$). For $\bar{I} < \hat{I}$, risk-neutral entrepreneurs will fully use their debt capacity allowed by (4) corresponding to the most rapid wealth growth. When \hat{I} is attained, entrepreneurs will reduce the leverage to a level smaller than $(1 + \lambda)$.

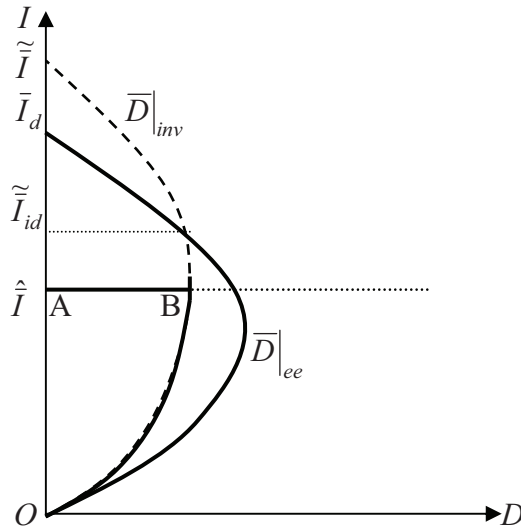


Fig. 2: Steady state equilibria.

The relative position of $\bar{D}|_{inv}$ and $\bar{D}|_{ee}$ depends on the value of X , r^* , μ , ν and α . Whereas λ is a determinant of $\bar{D}|_{inv}$, it does not affect $\bar{D}|_{ee}$. These two curves rotate counterclockwise around O if: i) X decreases, implying a depreciation of the real exchange rate. This will increase the value of foreign currency debt when measured in domestic currency; ii) r^* rises, increasing financial burden of foreign debt; iii) μ increases, leading to a similar effect as a decrease in X . An increase in ν also induces a counterclockwise rotation of these curves around O . Since it is equivalent to an increase of total foreign debt, to keep foreign debt at a constant level compatible with the leverage and external solvency constraints, domestic

currency debt must be reduced. An increase in λ expands proportionally the debt capacity of entrepreneurs, leading to clockwise rotation of $\overline{D}|_{inv}$, but has no effect on the external solvency constraint. Finally, an increase in α has ambiguous effects on these curves.

The foreign debt is assumed to be non negative, i.e. $\overline{D} + \overline{p}\overline{F} \geq 0, \forall \overline{I}$, translating the assumption that, after having exhausted domestic investment opportunities, entrepreneurs will consume the surplus of their revenue over investment. Therefore, there are only two steady state equilibria, i.e. the point A where foreign debt is zero and investment equals \hat{I} , and the point O where they are both zero because entrepreneurs have no collateral. Since $\hat{I} < \tilde{I}_{id}$, the intersection point of $\overline{D}|_{inv}$ and $\overline{D}|_{ee}$ is not a steady state equilibrium.

4. Dynamics and mechanism of financial crisis

Since the difference equations (15)-(17) are non linear, it is not possible to deduce algebraically the sign of $\Delta I_t = I_t - I_{t-1}$ and $\Delta D_t = D_t - D_{t-1}$ in the different areas of the space (D, I) for the purpose of drawing a phase diagram.⁷ We use the economic analysis to deduce the sign of ΔI_t and ΔD_t in order to draw the phase diagram represented in Fig. 3.

At the right (left) of $\overline{D}|_{ee}$, because the external debt is too high (low) in the sense that the trade surplus is not sufficient to pay interests on the existing foreign debt and the latter keeps increasing due to the current account deficit, ΔD_t has positive sign and is represented by arrows pointing to the right (left respectively). Under the line AB and at the left of $\overline{D}|_{inv}$, the

⁷ Using (16), we have $\Delta I_t = I_t - I_{t-1} = -I_{t-1} + \alpha(1 + \lambda)I_{t-1}^\alpha p_{t-1}^{-\alpha\mu} - \frac{1+p_{t-1}}{p_{t-1}}(1 + \lambda)(1 + r_{t-1}^*)p_t D_{t-1}$. This is not a complete derivation since according to (15) since p_t is a function of I_t and I_{t-1} . For $p_t = p_{t-1} = \overline{p}$ and $I_t = I_{t-1} = \overline{I}$ and without taking account of the constraint $\alpha I_{t-1}^{\alpha-1} p_{t-1}^{-(\alpha-1)\mu} p_t^{-\mu} \geq 1 + r_t$, when D_{t-1} is higher than \overline{D} , we have $\Delta I_t < 0$ and *vice versa*. In the space delimited by $\overline{D}|_{inv}$ and the axe I, and above the line AB, the lack of profitability leads rational entrepreneurs to reduce investment. Using (17) to obtain $\Delta D_t = D_t - D_{t-1} = \frac{1}{(1+p_t\nu)}I_t - \frac{\alpha}{(1+p_t\nu)}I_{t-1}^\alpha p_{t-1}^{-\alpha\mu} + \frac{1+p_{t-1}}{(1+p_t\nu)p_{t-1}}p_t(1 + r_{t-1}^*)D_{t-1} - D_{t-1}$. For $p_t = p_{t-1} = \overline{p}$ and $I_t = I_{t-1} = \overline{I}$, we have $\Delta D_t > 0$ and *vice versa*.

foreign debt is smaller than the debt capacity of entrepreneurs. Thus, the latter can invest more and more to increase their wealth, implying that ΔI_t has a positive sign and is represented by up arrows in area 1. Above the line AB, investment is too high in the sense that its marginal rate of return is smaller than that offered by the international financial market and it must be reduced. Under the line AB and at the right of $\bar{D}|_{inv}$, the foreign debt is too high to satisfy the leverage constraint and the wealth will be insufficient to sustain the past level of investment. Thus, investment must be reduced, implying down arrows for areas 2-7.

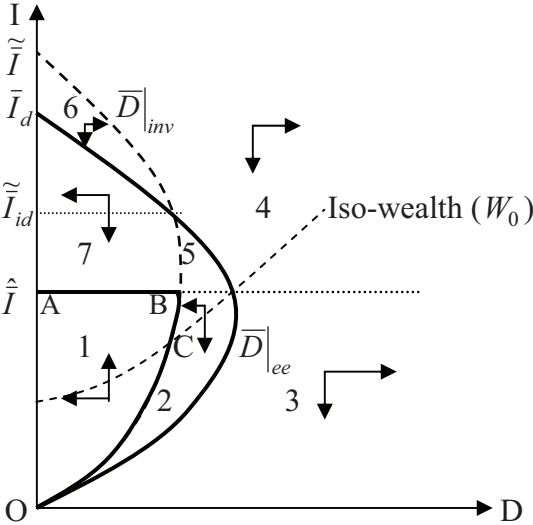


Fig. 3: Phase diagram and multiple equilibria.

The equilibrium A is stable since any trajectory originated in its near neighborhood converges to it. The equilibrium O is unstable because a small wealth is sufficient to start a wealth accumulation process with more and more investment and foreign debt, finally leading the economy to the equilibrium A. A more detailed discussion, distinguishing seven areas in Fig. 3, makes clearer the underlying dynamics of investment and foreign debt.

In area 1 (area ABO), bounded at the above by the line AB and at the right by $\bar{D}|_{inv}$, the foreign debt is smaller than the debt capacity determined by the leverage constraint (4) and is compatible with the external solvency constraint. Risk-averse entrepreneurs choose a path in the interior of area 1. Given the high rate of return on investment, the wealth accumulation is

delayed by not fully using the debt capacity. However, risk neutral entrepreneurs tend to use totally the debt capacity to enrich themselves as quickly as possible, i.e. along the curve OB. They will reduce their debt and invest more by using their own wealth once \hat{I} is attained. The path OB could lead to financial crisis in the event of adverse shocks or when lenders turn pessimistic about the perspectives of the domestic economy.

In area 2, delimited by the line prolonging AB, the curve $\overline{D}|_{ee}$ and the curve OB, the foreign debt is higher than the debt capacity but is compatible with the external solvency constraint. In this area, entrepreneurs are constrained to reduce investment in order to reduce the foreign debt. The realized temporary equilibrium after adjustment of the international lending can be more or less favorable, depending on the confidence of international lenders placed on these entrepreneurs and on the perspectives of the domestic economy. Given a wealth W_0 , instead of reducing their lending to a level corresponding to a point like C on the curve OB, the herd behavior could lead international lenders to reduce lending to zero. In this case, I_t will jump to W_0 . Such an adjustment could happen only when the debt is short run.

In area 3, at the right of the curve $\overline{D}|_{ee}$ and under the line prolonging AB, the foreign debt exceeds the limit imposed by leverage and external solvency constraints. Entrepreneurs cannot pay back the debt without reducing investment. Before the foreign debt becomes too large, lenders could recover all or most of their lending. If they wait, the situation could deteriorate so that they make a loss while most entrepreneurs bankrupt.

In area 4, above the line prolonging AB and bordered at the left by the curve $\overline{D}|_{inv}$ for $I > \tilde{I}_{id}$ and the curve $\overline{D}|_{ee}$ for $I \in]\hat{I}, \tilde{I}_{id}[$, the investment is higher than \hat{I} , and the foreign debt exceeds the level compatible with both leverage and external solvency constraints.

Entrepreneurs must reduce the investment to \hat{I} . Meanwhile, international lenders could react negatively to the over-investment except when the foreign debt is low and the wealth high.

In area 5, between curves $\bar{D}|_{inv}$ and $\bar{D}|_{ee}$ with $I \in]\hat{I}, \tilde{I}_{id}[$, investment is higher than \hat{I} . Even if the external solvency constraint is respected, the foreign debt exceeds the level compatible with the leverage constraint. The entrepreneurs, constrained by lenders, must reduce investment to \hat{I} . Due to modest debt levels and high wealth, the risk of crisis is small.

In area 6, between curves $\bar{D}|_{inv}$ and $\bar{D}|_{ee}$ with $I > \tilde{I}_{id}$, investment is higher than \hat{I} and the foreign debt, which is smaller than the debt capacity determined by the leverage constraint, exceeds the level compatible with the external solvency constraint. Entrepreneurs must reduce investment to \hat{I} and the foreign debt correspondingly. Otherwise, the foreign debt will increase due to unpaid interests and well-informed international lenders would consider that the increasing current account deficit is not sustainable in the long term.

In area 7, above the line AB, bordered by the curves $\bar{D}|_{ee}$, $\forall I \in]\tilde{I}_{id}, \bar{I}_d[$ and $\bar{D}|_{inv}$, $\forall I \in]\hat{I}, \tilde{I}_{id}[$, investment is higher than \hat{I} . The foreign debt is compatible with both constraints. Entrepreneurs reduce investment and foreign debt until the point A is attained. In this area, reducing both investment and foreign debt is optimal and feasible. An outburst of financial crisis is improbable since wealth is high with regard to the debt.

As in Krugman (1999), the foreign debt capacity of entrepreneurs depends on their wealth, which in its turn depends on the amount of such debt because the volume of capital inflows affects the terms of trade and hence the valuation of foreign-currency denominated debt. Therefore, a decline in capital inflows can adversely affect the balance sheets of domestic entrepreneurs, reducing their ability to borrow and hence further reducing capital inflows.⁸ In

⁸ It is largely documented that the Asian countries affected by 1997 financial crisis had a balance of payments characterized by large current account deficits compensated by net inflows of foreign capital.

the interior of areas 1 and 7, the probability of such a crisis is zero and there will be nothing that resembles an Asian-style financial crisis. However, on the curve OB and at the left of this curve (areas 2-5), the risk of financial crisis depends positively on the level of debt and negatively on the level of wealth. In the area 6, there is not any financial risk in the short run.

A prosperous economy pursuing a quick wealth-accumulation path like OB can be suddenly hit by a capital outflow due to spill-over effects (Masson, 1999), i.e. crisis in one country may affect other emerging markets by contagion due to linkages operating through trade, economic activities or competitiveness. A typical example is a currency devaluation of a rival country in crisis, which reduces domestic exports. In such an event, an economy initially on the path OB could be found at the right of $\bar{D}|_{inv}$ or in the worst case at the right of $\bar{D}|_{ee}$ as these curves rotate counter-clockwise following a fall in exports. This could make the initial temporary equilibrium with high investment and high foreign debt unsustainable judging by the leverage constraint and/or the external equilibrium condition. If the leverage constraint is violated while the external solvency constraint is respected, the panic of lenders and the resulting financial crisis might not be too severe since the reduction of liquidity in the domestic economy will not bankrupt most entrepreneurs. In effect, a reduction in exports will negatively impact the entrepreneurs' wealth (the iso-wealth curve rotates counter-clockwise) since it implies a real depreciation and hence an increase in the value of foreign-currency debt measured in domestic currency. If both constraints are violated, the panic of lenders and the resulting financial crisis would be much severe. To analyze the severity of a crisis, one must appropriately consider factors such as initial wealth, leverage multiplier, amplitude of the fall in exports and other structural parameters of the economy. For emerging market economies that initially offer a high rate of return of capital, the crisis could result from earlier choices of entrepreneurs who underestimate the effects of adverse shocks on the financial stability and their repercussion on the rate of return of the capital.

Any temporary equilibrium along the curve OB is submitted to the risk that a loss of lenders' confidence could be validated by a financial collapse if these lenders radically change their attitude and behavior towards domestic entrepreneurs. In normal times, domestic entrepreneurs could finance their investment by fully using the debt capacity determined by the leverage constraint. But in bad times (e.g., a financial crisis hits other emerging market economies), as the debt is short-run, panicking international lenders could arbitrarily reduce the leverage multiplier to a level that guarantees the repayment of principal and interests, translating an increase in their risk aversion or a loss of their confidence on future perspectives of the domestic or/and world economy. This induces the curve $\bar{D}|_{inv}$ to rotate counter-clockwise while the curves $\bar{D}|_{ee}$ and iso-wealth remain unaffected. A reduction in the leverage multiplier might not be sufficient to lead a financial crisis to occur except when the pessimistic expectations of lenders are realized. If wealth is not affected, investment and foreign debt will adjust orderly towards lower levels.

Under a flexible exchange rate regime, a severe and instantaneous reduction of investment and foreign debt can take place when some shocks modify hugely and adversely the current and future real exchange rates. Lenders would examine attentively to what extent any important shock of this kind will reduce entrepreneurs' wealth and hence increase the risk of economic and financial collapse leading to a low level of investment and wealth. This scenario is more probable when investment and foreign debt are both jumping variables. If investment is only partially amortized in every period and the foreign debt is long term, the immediate collapse will be less severe. However, the financial crisis, while less violent than the one with sudden withdrawal of foreign lending, could be long-lasting if appropriate policy measures are not taken by national authorities and/or international financial institutions.

Even though the basic part of this model is the same as in Krugman, the discussion here is somewhat different. In fact, Krugman worked with three equilibria that are made possible by

using a static analysis. A financial crisis then corresponds to a jump from the equilibrium with high investment to the one with zero investment since all entrepreneurs are bankrupt, given that the intermediate equilibrium is unstable. Examining the dynamic model, we have shown that there are only two steady state equilibria. A financial crisis is then a dynamic phenomenon of an emerging market economy that uses extensively foreign currency denominated debt to finance its development. It is a jump, susceptible to occur when some factors make international lenders panicking, from one dynamically unstable trajectory of wealth-accumulation with high foreign debt and high investment to another trajectory with less investment and lower foreign debt. When a severe financial crisis occurs, not all entrepreneurs are systematically bankrupt. The economic and financial collapse does not imply that the previous investments were unsound. The problem is instead one of financial fragility in a dynamic context.

5. Other factors at the origin of financial fragility and crisis

We have previously analyzed the mechanism of financial crisis using the example of a crisis by contagion. The financial fragility in this model has nothing to do with the mismatch between short-term debt and long-term investments, nor does it appear to depend on foreign exchange reserves. In the following, we reexamine, in the dynamic setting, factors such as high leverage, low marginal propensity to import and large foreign-currency debt relative to exports that Krugman (1999) consider as potential causes of financial collapse. The effects induced by monetary policy shocks in industrial countries are also discussed.

High leverage increases the speed of wealth accumulation by domestic entrepreneurs but also accelerates the wealth destruction when the economy is hit by adverse shocks. It makes the economy more vulnerable to a negative change in lender's attitudes towards domestic entrepreneurs. An increase in leverage, i.e. a higher λ , will induce the curve $\bar{D}|_{inv}$ to rotate

clockwise without modifying the position of $\bar{D}|_{ee}$. Whatever is the value of λ , $\bar{D}|_{inv}$ is always at the left of $\bar{D}|_{ee}$, $\forall I < \hat{I}$. The new quickest wealth-accumulation path OB' will be nearer to the external solvency constraint (see Fig. 4). This increases the fragility of the economy by increasing the probability that the economy violates not only the leverage constraint but also the external solvency constraint in the event of negative shocks inducing these constraints to rotate counterclockwise (not drawn in Fig. 4).

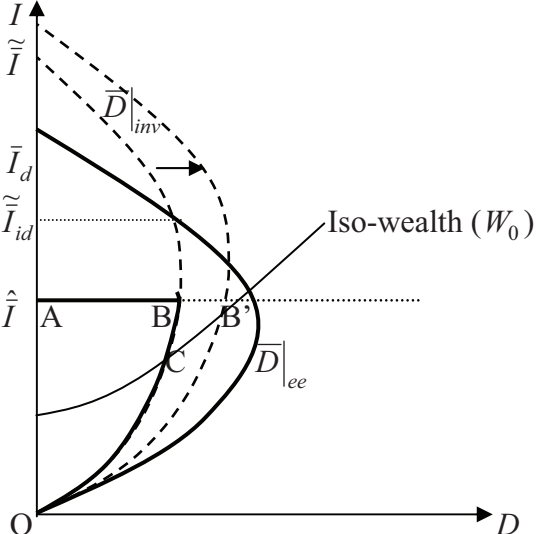


Fig. 4: High leverage and steady state equilibrium.

A lower marginal propensity to import will induce a higher domestic production and hence a higher revenue (or wealth) for domestic entrepreneurs, leading the latter to increase the foreign debt. Graphically (figure not drawn here), a decrease in the marginal propensity to import will induce the curves $\bar{D}|_{inv}$ and $\bar{D}|_{ee}$ to rotate clockwise with the later being more sensible. A higher foreign debt will increase the sensitivity of the economy to shocks negatively affecting the terms of trade. Hence, it will increase the fragility of the economy and reduce the latter's capability of buffering against adverse shocks.

The ratio of foreign-currency debt relative to exports is a complex indicator which is not clearly discussed by Krugman. A large ratio of foreign-currency debt relative to exports can be due to multiple factors. Using (12) and (22), the ratio can be written as:

$$\frac{pF}{X} = \frac{pvD}{X} = \frac{v\psi(\bar{I})\{\alpha(1+\lambda)\bar{I}^\alpha[\psi(\bar{I})]^{-\alpha\mu} - \bar{I}\}}{(1+\lambda)[1+v\psi(\bar{I})](1+\bar{r}^*)X}. \quad (24)$$

An increase in v , μ and λ , and an decrease in \bar{r}^* and X could lead domestic firms to increase the foreign currency debt, implying an increase in the ratio $\frac{pF}{X}$, while an increase in α has an ambiguous effect. A larger ratio $\frac{pF}{X}$ will make these firms more vulnerable to a financial crisis because, in the event of such a crisis, the outflows of capital must be financed by the surplus of the trade balance. The ratio $\frac{pF}{X}$ also depends on investment and hence the stage of economic development. It is to notice that some parameters or exogenous variables, such as λ , \bar{r}^* and X , can vary adversely and brutally, leading to a financial crisis.

Generally, the above-mentioned factors leading to the financial fragility could also induce a financial crisis if they come to change adversely. They matter because they make the circular loop from past investment to real exchange rate to balance sheets to current investment more powerful. But they didn't explain why Asian financial crisis occurred. All afflicted Asian economies were peculiarly vulnerable to a financial crisis due to a high leverage and unusually high levels of foreign currency debt. These borrowings have placed them before an increased risk of financial collapse if the real exchange rate depreciates.

The monsoonal effects could be one possible explanation of the 1997 Asian crisis. The monsoonal effects emanate from the global environment (in particular, from policies in industrial countries), and sweep over all emerging countries to a greater or lesser extent (Masson (1999)). Thus, a monetary contraction in the world leading country could considerably raise the financial costs of investment for an indefinite horizon and hence put some emerging market economies under great financial pressures. One important factor, which is present before the Asian financial crisis, is the high 3-month Libor interest rate (Kwack, 2000). In effect, previous to the crisis, the Fed has adopted a restrictive stance for its

monetary policy, inducing the interest rate to rise on international financial markets. According to (18) and (22)-(23), an increase in r^* shifts the line AB downward and induces the curves $\bar{D}|_{inv}$ and $\bar{D}|_{ee}$ and hence the curve OB to rotate counter-clockwise. An increase in the foreign interest rate reduces the foreign funds that domestic entrepreneurs can borrow because it diminishes their wealth and hence their debt capacity. If wealth is high enough at the initial temporary equilibrium, the resulting adjustment can place the economy on the new wealth-accumulation path. If wealth is low, the foreign debt can instantly jump to a low level if it is short term and hence induces a violent financial crisis. Increasing the part of long term debt reduces the severity of the crisis but can make the latter long-lasting.

6. Policy analysis

The dynamic setting can be easily used to reexamine three policy issues considered by Krugman (1999), i.e. preventive measures against financial crisis, policy during the financial crisis and rebuilding the economy after the financial crisis. It is to notice that the present framework, formulated in non-monetary terms, is more adapted for analyzing the situation of emerging market economies exposed to foreign currency debt under floating exchange rate regime.⁹ However, an exchange rate peg can be mimicked by a real exchange rate peg. Henceforward, we do not explicitly consider the exchange rate peg in the following.

Regarding the preventive measures against financial crisis, Krugman has argued that the imposition of Chilean-type restrictions on short-term borrowing denominated in foreign currencies, which reduces the short-term foreign-currency exposure, could not allow emerging market countries to significantly reduce the risks of being forced into a crisis by a loss of confidence. In addition, as long as a country has free convertibility of capital, short-term foreign loans are only one of many different possible sources of capital flight. Our dynamic analysis allows a more nuanced analysis since we can consider the case where only a

⁹ This is to some extent the case in most Central and Eastern European countries and Iceland.

small part of foreign loans is short term, foreign debt will not be a totally free jumping variable and will not fall to zero whenever there is a financial crisis.

Consider again the example of a contagious financial crisis in a competing country, which decreases the expected exports of the domestic country in the future. As analyzed in section 4, such an event reduces the sustainable level of foreign loans by reducing the entrepreneurs' net wealth, leading all three curves $\bar{D}|_{inv}$, $\bar{D}|_{inv}$ and iso-wealth to rotate counterclockwise. Therefore, a temporary equilibrium on the quickest wealth-accumulation path before the financial crisis is not anymore sustainable. Denote by $\bar{D}'|_{inv}$ the new location to which rotates counterclockwise the curve $\bar{D}|_{inv}$. A high level of long-term foreign debt implies that the financial crisis could be less violent but long-lasting. The refusal of the holders of short-term foreign debt to roll it over could generate an exchange rate depreciation that deteriorates the balance sheets and bankrupts some entrepreneurs until the foreign debt is sufficiently low (i.e. at left of the curve $\bar{D}'|_{inv}$). Nonetheless, a higher rate of return of capital allows entrepreneurs having survived the crisis to regain the confidence of international lenders.

The nuances that we introduce in the analysis of the impact of the financial crisis does not put into question Krugman's proposition about the appropriate prophylactic policy, i.e., to avoid any transmission of international crisis to the domestic economy, it is necessary to discourage firms from taking on foreign-currency-denominated debt of any maturity. In effect, the real-exchange-rate impact of adverse shocks has negative effects on domestic investment financed with such debt but let unaffected an economy without it. These effects are magnified through balance-sheet effects to cause economic distress if such debt is high.

The dynamic setting can be used to analyze the policies adopted during the Asian financial crisis. In the period before 1997, Asian countries have grown rapidly and liberalized their capital account as urged by the IMF while operating a nominal exchange rate peg. The

peg of Asian monies to the US dollar is an important characteristic of these countries. To avoid the risks of financial trauma due to the foreign currency debt was a major reason why the IMF advised its Asian client countries to follow the much-criticized “IMF strategy” which consists to defend their currencies with high interest rates rather than simply letting them devalue.¹⁰ We can get some insight at the nature and consequences of the IMF strategy by imagining that the effect of that strategy is to hold the real exchange rate p constant even when the willingness of international lenders to finance investment declines.¹¹ Stabilizing the nominal and real exchange rates, while closing one channel for a potential financial collapse, opens another: according to equation (8), increasing strongly domestic interest rate hence the interest rate paid to international lenders implies that the sustainable level of foreign debt is drastically reduced, especially when leverage is high.

The phase diagram (Fig. 3) can be modified to examine such type of policy in the case where the domestic economy is submitted to a contagious crisis.¹² Even though the contagion by the crisis in neighbor countries leads international lenders to think that the foreign debt is too high for the leverage constraint to be respected, the above measure is justified if the level of investment before the crisis is less than \hat{I} and if the foreign debt is always compatible with the external solvency constraint. The anticipated depreciation of domestic currency (and hence that of the real exchange rate) indicates a possible temporary equilibrium with smaller wealth and lower investment following a counterclockwise rotation of the curves iso-wealth and $\bar{D}|_{inv}$. Hence, maintaining the temporary equilibrium at the point C can consume much

¹⁰ One mistake of the Thailand’s government is to raise local interest rate since the interest rate parity theorem tells us that those speculators who have already sold short baht in the forward market will be enriched, not hurt. Moreover, it can hurt entrepreneurs and hence precipitate a financial crisis (Miller (1998)).

¹¹ A controversy measure used by Malaysia during the 1997 crisis, imposing a strict curfew on capital flight and which is not discussed in order to limit the length of the paper, could also rule out the possibility of a downward financial spiral by maintaining the real exchange rate constant. In Fig. 3, it consists to maintain the economy at the point C by keeping unchanged the real exchange rate and by not letting the foreign lenders reducing their lending. It is justified by the fact that standstill agreements on foreign-currency debt are not sufficient to avoid the crisis. It is efficient only if the adverse shocks are temporary and over-investment not observed.

¹² For detailed analysis about how the curves shift, see section 4.

financial resources given that some foreign lenders will reduce their lending. To maintain the level of investment corresponding to the point C, the IMF's financial aid must be enough to compensate the credit lost by firms so as to allow investment to continue. If the IMF funds are used to defend the nominal exchange rate peg, the aid must be large enough to substitute all private foreign lending capital which could quit the country at the official nominal exchange rate. Such a measure could be successful if shocks are temporary.

Considering the bad equilibrium with zero investment, Krugman (1999) suggested that the main problem with the post-crisis rebuilding of the economy was that the entrepreneurs who drove investment and growth before the crisis are now effectively bankrupt and unable to raise capital. Our nuanced results about the severity of financial crisis following a foreign exchange crisis suggest that the post-crisis rebuilding of the economy could be looked with more optimism in the sense that, generally, the economy hit by a financial crisis can return to a rapid growth without waiting for foreign aid and a new set of entrepreneurs.

In the dynamic setting, the situation depends on the initial levels of wealth and foreign currency debt of every individual entrepreneur. If the aggregate wealth of entrepreneurs after the devaluation of the domestic currency is high and only slightly affected by the twin crises, many entrepreneurs can survive. They are able to reimburse their foreign debt and continue to develop in a context with less competition and higher profitability since the investment level is lower. Then, this will create a new wave of development soon after the twin crises. In this case, the efforts focused on bank restructuring and recapitalization are sufficient.

However, these efforts will not be sufficient in the case where the aggregate wealth after the devaluation is near zero or negative and most entrepreneurs have bankrupted. Even if a big wave of development can be initiated by non-bankrupted entrepreneurs once the dust of the crises is settled, the deep economic recession is too costly in the short run. Solutions proposed by Krugman, such as rescuing bankrupt entrepreneurs through some kind of "private

sector Brady Plan”, and/or growing a new set of entrepreneurs and/or welcoming foreign direct investment, are needed to reduce the negative economic and social consequences of the twin crises and to accelerate the economic recovery.

7. Conclusion

This paper analyzes the dynamic implication of the Krugman’s (1999) model by extending it to explicitly take account of wealth accumulation and external equilibrium constraints. Our dynamic analysis complements his discussion of factors susceptible to induce financial fragility and crisis while suggesting some nuanced crisis scenarios and policy implications.

This study has shown the existence of two equilibria. The equilibrium characterized by zero investment and zero foreign debt is unstable since a small amount of capital could put the economy on a wealth-accumulation path leading to the other equilibrium with positive investment and zero debt. In this dynamic process, an economy largely exposed to foreign-currency denominated debt can be hit by a financial crisis analyzed as a jump from one wealth-accumulation path to another one with lower investment and lower foreign debt. The violence of such a crisis will depend on the part of short-run debt in the total foreign debt. In contrast, Krugman obtained three equilibria through a static analysis. Thus, a financial crisis is considered as a jump from the equilibrium with high investment and high debt to the stable one where all entrepreneurs are bankrupt and do not invest.

Furthermore, the dynamic analysis allows discriminating the severity of financial crises and their economic consequences according to the pre-crisis wealth. It allows gaining more intuition about the adjustments induced by different anti-crisis policy measures. In particular, our analysis suggests that even during a severe financial crisis, not all entrepreneurs are bankrupt. Since these having survived the crisis could jump-start a wealth-accumulation process, policy measures other than bank restructuring and recapitalization are not always needed to rebuild the economy except when the consequences of such a crisis are very severe.

APPENDIX A: THE RELATIVE POSITION DE $\bar{D}|_{inv}$ AND $\bar{D}|_{ee}$

According to (22), $\bar{D}|_{inv}$ is positive for $\bar{I} \in]0, \tilde{I}[$ and it equals zero for $\bar{I} = 0$ and $\bar{I} = \tilde{I}$, with:

$$\tilde{I} = \arg\{\alpha(1+\lambda)\tilde{I}^{\alpha-1}[\psi(\tilde{I})]^{-\alpha\mu} = 1\}. \quad (\text{A.1})$$

According to (23), we have $\bar{D}|_{ee} > 0$ for $\bar{I} \in]0, \bar{I}_d[$ with $\bar{I}_d = \arg\{\alpha\bar{I}^\alpha[\psi(\bar{I})]^{-\alpha\mu} = 1\}$ and

$\bar{D}|_{ee} = 0$ for $\bar{I} = 0$ and $\bar{I} = \bar{I}_d$.

The relative position of $\bar{D}|_{inv}$ and $\bar{D}|_{ee}$ is examined through their difference, i.e.,

$$\bar{D}|_{inv} - \bar{D}|_{ee} = \frac{-\alpha(1+\lambda)\bar{I}^\alpha[\psi(\bar{I})]^{-\alpha\mu} + [1+\lambda(1+\bar{r}^*)]\bar{I}}{(1+\lambda)[1+\nu\psi(\bar{I})](1+\bar{r}^*)\bar{r}^*}. \quad (\text{A.2})$$

As the denominator at the right hand of (A.2) is positive, it is straightforward to show that

$\bar{D}|_{inv} - \bar{D}|_{ee} = 0$ has two solutions. The first solution is zero and the second one denoted by

\tilde{I}_{id} is positive and is defined by $\tilde{I}_{id} = \arg\left\{\bar{I}^{\alpha-1}[\psi(\bar{I})]^{-\alpha\mu} = \frac{[1+\lambda(1+\bar{r}^*)]}{\alpha(1+\lambda)}\right\}$, i.e.,¹³

$$\tilde{I}_{id} = \left[\frac{\alpha(1+\lambda)}{\lambda\bar{r}^* + (1+\lambda)} \right]^{\frac{1}{1-\alpha(1-\mu)}} \left\{ \frac{\alpha(1+\lambda)X}{\lambda\bar{r}^*[1-(1-\alpha)(1-\mu)] + (1+\lambda)\mu} \right\}^{\frac{\alpha\mu}{1-\alpha(1-\mu)}} > 0. \quad (\text{A.3})$$

Thus, we have $\bar{D}|_{inv} - \bar{D}|_{ee} \begin{cases} \geq 0, & \text{if } \bar{I} \geq \tilde{I}_{id} \\ < 0, & \text{if } \bar{I} < \tilde{I}_{id} \end{cases}$. For $\bar{I} < \tilde{I}_{id}$ ($\bar{I} \geq \tilde{I}_{id}$), the level of foreign debt

compatible with external equilibrium is higher (respectively equal to or lower) than the debt

capacity determined by the leverage constraint. Rewrite \hat{I} given by (18) as

$\hat{I} = \arg\{\bar{I}^{\alpha-1}[\psi(\bar{I})]^{-\alpha\mu} = \frac{1+\bar{r}^*}{\alpha}\}$ and compare it with $\tilde{I}_{id} = \arg\left\{\bar{I}^{\alpha-1}[\psi(\bar{I})]^{-\alpha\mu} = \frac{[1+\lambda(1+\bar{r}^*)]}{\alpha(1+\lambda)}\right\}$.

¹³ This corresponds to the second solution for \bar{I} using (19)-(21) and without taking account of (18). To solve it, we first use (20)-(21) to eliminate \bar{D} and to express $\bar{I}^\alpha \bar{p}^{-\alpha\mu}$ in terms of \bar{I} and substitute then the latter in (19) to express \bar{p} in terms of \bar{I} . Finally, using $\bar{I}^\alpha \bar{p}^{-\alpha\mu}$ and \bar{p} expressed in \bar{I} and (20) (or (21)) to solve for \bar{D} , \bar{I} and \bar{p} .

Since $\frac{1+\bar{r}^*}{\alpha} > \frac{[1+\lambda(1+\bar{r}^*)]}{\alpha(1+\lambda)}$, and $\bar{I}^{\alpha-1}[\psi(\bar{I})]^{-\alpha\mu}$ has a derivative which tends to $+\infty$ if $\bar{I} \rightarrow 0$ and

is increasing in \bar{I} when \bar{I} is small, it is easy to show that $\hat{I} < \tilde{I}_{id}$. ■

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