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Resumen

Si al pecado original, la imposibilidad que enfrentan los países emergentes para endeudarse en su propia moneda con el exterior, se le suman imperfecciones financieras, se imponen castigos macroeconómicos de dos clases: se aumentan y alargan los efectos de shocks adversos y se resta efectividad a la política monetaria en su capacidad de absorber estos shocks. Pero esta condena macroeconómica no es inevitable: en algunos casos, un cambio apropiado en la cantidad de dinero o en el tipo de cambio puede estabilizar parcialmente la producción, la inversión y el consumo.

Abstract

Original sin, coupled with other financial imperfections, causes macroeconomic penance of two kinds: adverse shocks have larger and more persistent effects and monetary policy becomes less effective as a shock absorber. But macroeconomic damnation is not inevitable: in some cases, suitable changes in money and exchange rates can still partially stabilize output, investment and consumption.

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1. Introduction

Original sin, defined as a country's inability to borrow abroad in its own currency, is arguably the biggest obstacle that emerging markets face today as they endeavor to become more integrated into the world economy. Original sin is increasingly blamed for a host of macroeconomic ills: volatility of capital flows, vulnerable fiscal balances and instability of investment and output.[1] The basic story is simple enough. Having to borrow in dollars or other major currencies leaves local residents open to exchange rate risk. When, for whatever reason, the real exchange rate depreciates, domestic balance sheets suffer. Locals with lower net worth find it harder to borrow abroad, and investment consequently goes down, perhaps pulling output down with it. If the shock is big enough, default and bankruptcy can take place. Understanding how vulnerable domestic corporations and banks are, foreign lenders are jittery, running for the exits at the first sign of trouble. This closes the circle, making both capital movements and exchange rates volatile, and exacerbating domestic exposure to currency risk.

The story is plausible, but it raises as many questions as it answers. First, what exactly is the link between exchange rates, balance sheets, and the capacity to borrow and invest? In the textbook IS-LM-BP model with well functioning financial markets and perfect international capital mobility, only expectations of future returns, properly arbitraged, guide capital flows and investment; corporate balance sheets and current output levels are irrelevant. This suggests that other financial imperfections must be added to original sin to cause macroeconomic damnation.

Second, how do these assorted financial imperfections interact with exogenous shocks? Does the response depend on the exchange rate regime in place, and how? A plausible conjecture is that the imperfections magnify the effects of shocks, but that the precise magnification mechanism depends quite crucially on the accompanying exchange rate movements.

A third issue has to do with the effects of exchange rates on aggregate demand and output. Even if balance sheet effects are contractionary, standard expenditure switching effects, which obviously have an expansionary effect, are still present. Which one prevails and when?

[1] The term *original sin* was coined by Hausmann and Eichengreen (1999). Calvo (1999) and Hausmann et al (2000) were among the first to warn about the dangers of dollarization of liabilities. See also Krugman (1999) and Calvo and Reinhart (2002).

This paper investigates these issues.[2] For that purpose we develop a simple general equilibrium open-economy model in which real exchange rates play a central role in the adjustment process, wages and prices are sticky in terms of domestic currency, liabilities are dollarized, and the country risk premium is endogenously determined by the net worth of domestic entrepreneurs, in the manner postulated by Bernanke and Gertler (1989). Hence, all the basic building blocks are there for unexpected real exchange rate movements to be financially dangerous under original sin. In spite of the model's apparent complexity, we obtain an analytic solution for all variables of interest, which can be depicted in terms of three familiar schedules: the IS and the LM, which correspond to equilibrium conditions in the goods and money market, and the BP, along which the international loan market is in equilibrium. This characterization helps to identify exactly how the combination of balance sheet effects and liability dollarization may lead to departures from the standard framework. We show, for instance, that the effect of financial imperfections is to change the slope of the BP, leaving the IS and BP unchanged. This affects comparative statics and the dynamic reaction of the economy to foreign shocks, and can give rise to results that do not appear in the standard model.

We distinguish between a situation of high indebtedness and the resulting *financial vulnerability*, so that a real depreciation raises the country risk premium, and one of *financial robustness*, in which the opposite happens. Vulnerability is likely to occur when capital market imperfections are large (in a sense to be made precise below), when total initial debt is large, and when the dollar share of that debt is also large.

The paper makes three main points. First, devaluation may be expansionary or contractionary, depending on initial conditions. It is always expansionary in financially robust economies, as it is in standard models without balance sheet effects. But if the economy is financially vulnerable, several subcases arise. Depending on the extend of vulnerability, devaluation may still expand both output and investment, it may expand output but cause investment to contract, or it may be contractionary for both output and investment.

Second, the precise effect of shocks depends jointly on the exchange rate regime

[2] An additional issue, which we do not study in detail here, is the uniqueness of equilibrium. The story in which exchange rate movements cause an economic contraction, which in turn causes capital outflows and exchange rate movements, has a strong flavor of self-fulfilling expectations. When are crises prompted by the shift to a "bad" equilibrium possible?For an analysis, see Velasco (2001), Céspedes, Chang and Velasco (2001) and Krugman (1999).

in place *and* the extent of financial vulnerability. Under financial robustness, flexible exchange rates cushion the effects of adverse shocks, and they are the preferred policy. Under financial vulnerability, exchange rate movements can be stabilizing or destabilizing, as we saw above. The domestic effects of shocks then depend on initial conditions and parameter values, and on the extent policy allows the exchange rate to move. Under extreme financial vulnerability, limiting exchange rate movements may help limit the reaction of domestic output to shocks.

Third, for any exchange rate regime, the effects of external shocks –such as a fall in export volumes or an increase in the world real interest rate– are magnified by the presence of financial imperfections. The magnification effect is especially sharp under financial vulnerability, high original sin and flexible exchange rates. Real depreciation and a fall in aggregate demand can exert negative feedback on each other: an initial depreciation reduces net worth sharply when dollar debts are large, pushing the risk premium up and reducing investment. This in turn may cause the relative price of domestic goods to fall (the real exchange rate depreciates even further), causing another round of investment cuts. Toward the end of the paper we explore the implications of this analysis for the design of exchange rate policy.

2. The Model

There are two periods, $t = 0, 1$. Labor and capital are supplied by distinct agents called workers and entrepreneurs. Workers work and consume an aggregate of the domestic and foreign good. Entrepreneurs own capital, and also own the firms. In order to finance investment in excess of their own net worth, entrepreneurs borrow from the world capital market. For concreteness, we focus on the effect of temporary shocks only at the start of period 0.

2.1. Domestic Production

Production of each variety of domestic goods is carried out by a continuum of firms acting as monopolistic competitors. These firms have access to a Cobb-Douglas technology given by

$$Y_{jt} = AK_{jt}^{\alpha}L_{jt}^{1-\alpha},\ 0 < \alpha < 1 \tag{2.1}$$

where Y_{jt} denotes output of variety j in period t, K_{jt} denotes capital input and L_{jt} denotes labor input. Assume that workers' labor services are heterogeneous.

The input L_{jt} is a CES aggregate of the services of the different workers in the economy:

$$L_{jt} = \left[\int_0^1 L_{ijt}{}^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}} \tag{2.2}$$

where workers are indexed by i in the unit interval, L_{ijt} denotes the services purchased from worker i by firm j, and $\sigma > 1$ is the elasticity of substitution among different labor types. The minimum cost of a unit of L_t is given by

$$W_t = \left[\int_0^1 W_{it}{}^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} \tag{2.3}$$

which can be taken to be the aggregate nominal wage. The j^{th} firm's maximizes expected profits in every period. Profits are given by

$$\Pi_{jt} = P_{jt} Y_{jt} - \int_0^1 W_{ijt} L_{ijt} \; di - R_t K_{jt} \tag{2.4}$$

where R_t is the return to capital, and profits are expressed in terms of the domestic currency (henceforth called *peso*), subject to the production function in 2.1 and the demand for its good

$$Y_{jt}^d = \left[\frac{P_{jt}}{P_t} \right]^{-\theta} Y_t^d \tag{2.5}$$

where Y_t^d must be understood to include demand from domestic consumers and investors and foreign consumers. Cost minimization yields the demand for worker i's labor:

$$L_{ijt} = \left(\frac{W_{it}}{W_t} \right)^{-\sigma} L_{jt} \tag{2.6}$$

where

$$L_{jt} = \frac{\int_0^1 W_{ijt} L_{ijt} \; di}{W_t} \tag{2.7}$$

Cost minimization also requires

$$\frac{R_t K_t}{W_t L_t} = \frac{\alpha}{1-\alpha} \tag{2.8}$$

Finally, firms set prices for its differentiated product as a constant markup over marginal cost. In the symmetric monopolistic competitive equilibrium, prices are set such that

$$ {}_{t-1}\left\{\frac{W_t L_t}{P_t Y_t}\right\} = (1-\alpha)\left(\frac{\theta-1}{\theta}\right) \tag{2.9} $$

where, for any variable X_t, the notation ${}_{t-1}X_t$ denote its expectation conditional on information available at $t-1$.

2.2. Workers

There is a continuum of workers, whose total "number" is normalized to one. The representative worker has preferences over consumption, labor supply, and real money balances in each period t given by

$$ \log C_t - \left(\frac{\sigma-1}{\sigma}\right)\frac{1}{\upsilon}L_t^{\upsilon} + \frac{1}{1-\varepsilon}\left(\frac{M_t}{Q_t}\right)^{1-\varepsilon} \tag{2.10} $$

where $\upsilon > 1$ and $\varepsilon > 0$. The consumption quantity C_t is an aggregate of home and imported goods:

$$ C_t = \kappa\left(C_t^H\right)^{\gamma}\left(C_t^F\right)^{1-\gamma} \tag{2.11} $$

where C_t^H denotes purchases of a basket of the different varieties of goods produced domestically, C_t^F purchases of the imported good, and $\kappa = [\gamma^{\gamma}(1-\gamma)^{1-\gamma}]^{-1}$ is a constant.

Assume that domestically produced goods are aggregated through the C.E.S. function

$$ C_t^H = \left[\int_0^1 C_{jt}^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}}, \ \theta > 1, \tag{2.12} $$

Assume also that the imported good has a fixed price, normalized to one, in terms of a foreign currency, which we shall refer to as the *dollar*. Imports are freely traded and the law of one price holds, so that the *peso* price of imports is equal to the *nominal exchange rate* of S_t pesos per dollar.

The only asset that workers can hold is money. Then, in every period t, the i^{th} worker's choices are constrained by

$$ Q_t C_{it} = P_t C_{it}^H + S_t C_{it}^F = W_{it} L_{it} + T_t - M_{it} + M_{it-1}, \tag{2.13} $$

where P_t is the *peso* price of one unit of the basket of domestically produced goods, given by

$$P_t = \left[\int_0^1 {P_{jt}}^{1-\theta} dj\right]^{\frac{1}{1-\theta}}, \tag{2.14}$$

and Q_t is the minimum cost of one unit of aggregate consumption, or CPI index:

$$Q_t = P_t^{\gamma} S_t^{1-\gamma} \tag{2.15}$$

Fiscal policy is as simple as can be: inflation tax revenues are rebated to workers through lump sum transfers:

$$M_t - M_{t-1} = T_t \tag{2.16}$$

where $M_t = \int_0^1 M_{it}\, di$. This assumption ensures that, in the symmetric equilibrium, workers consume their nominal income:

$$Q_t C_t = W_t L_t \tag{2.17}$$

Purchasing consumption at minimum cost requires

$$\left(\frac{1-\gamma}{\gamma}\right)\frac{C_t^H}{C_t^F} = \frac{S_t}{P_t} \equiv E_t \tag{2.18}$$

where absence of the subscript i indicates that we have imposed symmetry in equilibrium. Notice that E_t is the price of foreign goods in terms of domestic goods, or the *real exchange rate.*

Each worker optimally supplies labor to equate his marginal disutility of labor to its marginal return. Our assumptions on preferences then ensure that

$$_{t-1}L_t^{\upsilon} = 1 \tag{2.19}$$

in equilibrium.

Next adopt the convention that no subscript indicates an initial period variable, while a subscript 1 indicates a final period variable. Money demands in periods 0 and 1 are then given by

$$\left(\frac{M}{Q}\right)^{-\varepsilon} + \beta\frac{1}{C_1}\frac{Q}{Q_1} = \frac{1}{C} \tag{2.20}$$

$$\left(\frac{M_1}{Q_1}\right)^{-\varepsilon} = \frac{1}{C_1} \tag{2.21}$$

2.3. Entrepreneurs

Entrepreneurs borrow from abroad in order to finance investment. Assume that entrepreneurs start with some inhered debt repayments, due at the end of the period 0. Some fraction of debt repayments is denominated in pesos and the rest is denominated in dollars. After debt repayments, these entrepreneurs borrow from the world capital market in order to finance investment in excess of their own *net worth*. Since we do not consider shocks in the second period, we can assume without loss of generality that all new debt contracts (running from period 0 to 1) are denominated in dollars. Because of imperfections in financial markets, entrepreneurs are required to pay a risk premium over the risk free interest rate.[3]

Capital for next period is produced by combining home goods and imports. For simplicity, assume that capital is produced in the same fashion as consumption in 2.11. Therefore, the cost of producing one unit of capital available in period 1 is Q. The entrepreneurs' budget constraint in period 0 is therefore

$$PN + SD_1 = QI \tag{2.22}$$

where N stands for net worth, D_1 denotes the amount borrowed abroad in period 0 (to be repaid in period 1) and $I = K_1$ is investment in period 1 capital.

Net worth plays a crucial role because the interest cost of borrowing abroad is not simply the world safe rate ρ. Entrepreneurs borrow abroad paying a premium η above this risk-free interest rate. Assume that the risk premium is increasing in the ratio of the value of investment to net worth (or what is the same, in the ratio of debt to net worth), with the following functional form:

$$1 + \eta = \left(\frac{QI}{PN}\right)^{\mu} = \left(1 + \frac{ED_1}{N}\right)^{\mu} \tag{2.23}$$

For a derivation of this relationship from an underlying contract environment with imperfect information and costly monitoring, see Céspedes, Chang and Velasco (2000).

Capital depreciates completely in production. In equilibrium, the expected dollar yield on capital must equal the cost of foreign borrowing

[3] As in Bernanke and Gertler (1989).

$$\frac{R_1}{Q} = (1+\rho)(1+\eta)\left(\frac{S_1}{S}\right) \tag{2.24}$$

Given that entrepreneurs own local firms, rental on capital is not the only income they receive. They also get the profits resulting from the monopoly power of firms. Entrepreneurs' net worth therefore is

$$PN = RK + \Pi - SD^* - D = PY - WL - SD^* - D \tag{2.25}$$

where Π is firm profits in pesos, D^* dollar debt repayment and D peso-denominated debt repayment.

2.4. Equilibrium

Market clearing for the home goods require that domestic output be equal to demand. In period 0, the market for home goods clears when

$$Y = \gamma\left(\frac{Q}{P}\right)(I+C) + E^{\chi}X \tag{2.26}$$

Notice $E^{\chi}X$ stands for the home good demand by the rest of the world, where $\chi > 0$.

Given that period 1 is the final period, there is no investment then. Assuming that entrepreneurs consume only foreign goods, the market clearing condition for the second period is

$$P_1Y_1 = \gamma Q_1 C_1 + E_1^{\chi} P_1 X_1 \tag{2.27}$$

This last equation can be simplified further, since workers consume all their income each period:

$$Y_1 = \tau E_1^{\chi} X_1 \tag{2.28}$$

where $\tau = \left[1 - \gamma(1-\alpha)\left(1-\theta^{-1}\right)\right]^{-1} > 1$.

2.5. Linearization

The appendix establishes conditions under which there is a unique equilibrium when shocks are identically zero. The crucial condition is that financial imperfections, as captured by the parameter μ, cannot be too big. We will assume hereon that those conditions are satisfied.

The next step consists in obtaining log-linear approximations of the model around the no shock equilibrium. We start by deriving the equilibrium relations in period 1. The first relation is the log-linear version of equation 2.17:

$$q_1 + c_1 = w_1 + l_1. \tag{2.29}$$

(Lowercase letters denote log deviations from the no shock equilibrium.) Equation 2.9 shows that wage income in period 1 is a fraction of the total revenue. Therefore,

$$p_1 + y_1 = w_1 + l_1 \tag{2.30}$$

Combining these two equations we obtain

$$c_1 = y_1 - (q_1 - p_1) = y_1 - (1 - \gamma)\, e_1 \tag{2.31}$$

Assuming no export shocks in period 1, the log-linear version of the market clearing condition for period 1 is

$$y_1 = \chi e_1. \tag{2.32}$$

Putting these last two equations together we obtain

$$c_1 = (\gamma + \chi - 1)\, e_1.$$

Since under no shocks labor supply is fixed at one (recall the first order condition for labor supply), we have

$$y_1 = \alpha i.$$

Combining this with 2.32 we have

$$\left(\frac{\alpha}{\chi}\right) i = e_1. \tag{2.33}$$

Pulling together these results we arrive at

$$c_1 = (\gamma + \chi - 1) \left(\frac{\alpha}{\chi}\right) i \tag{2.34}$$

We can now solve the model in the initial period. The log-linear version of the resource constraint in period 0 is

$$\tau y+(1-\tau)(q+c)=\lambda(q+i)+(1-\lambda)(\chi e+x) \tag{2.35}$$

where $\lambda=\frac{\gamma\bar{Q}\bar{I}}{\gamma\bar{Q}\bar{I}+\bar{E}^{\chi}\bar{X}}<1$ and where, due to the assumption that prices are set one period in advance, $p=0$.[4]

Given that capital is a pre-determined variable in period 0, deviations of output from its no-shock equilibrium will be matched by changes in labor only:

$$y=(1-\alpha)l \tag{2.36}$$

Log-linearizing equation 2.17 we have $q+c=l$, since the nominal wage is pre-set. Combining these two equations we arrive at

$$q+c=\frac{y}{1-\alpha} \tag{2.37}$$

Replacing this last relation and $q=(1-\gamma)e$ into 2.35 and reordering we obtain the IS curve:

$$y=\tau\left[1-\gamma\left(1-\theta^{-1}\right)\right]^{-1}\{\lambda i+[\chi+\lambda(1-\gamma-\chi)]e+(1-\lambda)x\}. \tag{2.38}$$

For a given e, the IS schedule slopes up in (i,y) space, and its position in that space depends on the export shock x. A real devaluation (an increase in e) must increase y, given i, and the benefits of devaluation on current output naturally increase with χ.

In order to derive the effects of monetary policy we log-linearize money demand in each period, given by equations 2.20 and 2.21. The resulting relations are:

$$\varepsilon\left(m_1-q_1\right)=c_1 \tag{2.39}$$

$$\varepsilon\omega(m-q)+(1-\omega)\left(c_1+q_1-q\right)=c \tag{2.40}$$

where $\omega=1-\beta\frac{\bar{Q}\bar{C}}{\bar{Q}_1\bar{C}_1}$. Note that ω is between 0 and 1 as long as the growth of nominal consumption is not too negative, which we assume from now on. The parameter ε^{-1} can be interpreted as the elasticity of money demand with respect to consumption expenditures. Using 2.34 and 2.37 to substitute out the consumptions and rearranging we have the LM schedule:

[4] Note a bar over a variable denotes its no shock equilibrium level.

$$m=\frac{y}{\varepsilon\omega\left(1-\alpha\right)}-\left(\varepsilon^{-1}-1\right)\left(1-\gamma\right)e-\left(\omega^{-1}-1\right)\varepsilon^{-1}\left(\gamma+\chi-1\right)\left(\frac{\alpha}{\chi}\right)i \quad (2.41)$$

The final block of equations to be solved is the one associated with the entrepreneurs. The log-linear version of the arbitrage relation (equation 2.24) is

$$\left(r_1-p_1\right)-q=\rho+\eta+e_1-s, \quad (2.42)$$

while the log-linear version of 2.8 and 2.30 yield $r_1-p_1=-\left(1-\alpha\right)i$. Using this, the identity $q=\left(1-\gamma\right)e$ and 2.33 we have

$$\left(1-\alpha+\frac{\alpha}{\chi}\right)i=-\left(\rho+\eta\right)+\gamma e \quad (2.43)$$

The log-linear version of the equation for the risk premium (2.23) is

$$\eta=\mu\left[\left(1-\gamma\right)e+i-n\right], \quad (2.44)$$

which is obtained using the fact that $q=\left(1-\gamma\right)e$. The log-linear version of net worth equation (2.25) is

$$n=\theta^{-1}\left[1-\left(1-\alpha\right)\left(1-\theta^{-1}\right)\right]^{-1}\left(1+\psi\right)y-\phi\psi e \quad (2.45)$$

where $\psi=\frac{\overline{D}^T}{\overline{N}}>0$, $\overline{D}^T=\overline{D}+\overline{SD}^*$ is the total initial debt in units of the home good, and $\phi=\frac{\overline{SD}^*}{\overline{PD}^T}$ is the share of dollar-denominated debt in total (initial) debt. Note that when ψ is large, total initial debt is also large relative to net worth. If initial dollar denominated debt is zero, then real devaluations have no effect on net worth.

Combining the last set of equations we obtain the BP curve:

$$\begin{aligned} i \; &= \; \left[1-\alpha+\alpha\chi^{-1}+\mu\right]^{-1}\times \quad (2.46) \\ &\left\{-\rho+\theta^{-1}\left[1-\left(1-\alpha\right)\left(1-\theta^{-1}\right)\right]^{-1}\mu\left(1+\psi\right)y+\left[\gamma-\mu\left(1-\gamma+\phi\psi\right)\right]e\right\} \end{aligned}$$

Quite naturally, investment is decreasing in the world rate of interest. The other two terms are more novel. Investment increases with output only if capital markets are imperfect ($\mu>0$), since higher output increases net worth and reduces the risk premium. Hence the BP curve slopes up in (i, y) space for a given real exchange rate, and the intercept depends on the shock to the world interest rate. If $\mu = 0$, the BP is horizontal.

Investment may be increasing or decreasing in the real exchange rate. Standard arbitrage forces described above push for an increasing relationship: a higher e makes borrowing abroad cheaper. But the balance sheet effect pushes in the opposite direction: a higher e means a higher value of debt payments, and hence lower net worth and higher risk premia. It helps giving the possible cases a name. If in BP equation 2.46 the coefficient on e is positive, we have a *financially vulnerable economy*. If the coefficient is negative, we have a *financially robust economy*. Notice that financial vulnerability is more likely when:

- The risk premium is very sensitive to the investment expenditure-net worth ratio (large μ).
- The inherited ratio of total debt to net worth is high (large ψ).
- The share of dollar debt in total debt is high (large ϕ).
- The share of domestically produced goods in the investment and consumption aggregate is low (small γ).

Notice that if initial dollar debt is zero (so that $\phi = 0$), devaluation can only reduce investment via its effect on input costs: a real devaluation increases the cost of generating one unit of capital (in units of the home good), and therefore increases the risk premium for any given level of net worth. But if capital is produced only using home goods ($\gamma = 1$) or if capital markets are perfect ($\mu = 0$) this effect disappears.

2.6. Equilibrium under alternative exchange rate regimes

If the exchange rate floats (assuming predetermined output prices), expressions 2.38, 2.41 and 2.46 are 3 equations in 3 unknowns: output y, investment i and the real exchange rate e, for a given money supply and exogenous shocks. Alternatively, if the exchange rate is fixed, e becomes policy-determined in the short-run, and 2.38 and 2.46 pin down equilibrium investment and output. In turn, 2.41 yields the level of the money supply necessary for that particular equilibrium to obtain.[5].

[5] Recall these are percentage deviations from the no-shock steady state, holding prices and wages constant. Without nominal stickiness, output is exogenous (pinned down by the inherited

3. Shocks, policies and their effects

In the two sub-sections that follow we assume a fixed (but adjustable) exchange rate, so that we can solve the model diagrammatically in (i, y) space. We use that solution to perform comparative statics and analyze the effects of unexpected external shocks and of an unexpected devaluation on equilibrium output and investment. Later we consider the effects of shocks under flexible exchange rates.

3.1. External shocks under fixed exchange rates

Consider first the effects of a fall in current exports, depicted in figure 1. The shock shifts the IS up and to the left, so that for each level of investment there is now a smaller corresponding output level. The new intersection is at point A, with lower investment and output than in the steady state. The output fall is as in the standard model with perfect capital markets and no balance sheet effects, but the fall in investment is not. In that model, a fall in exports today does not affect the profitability of capital tomorrow, and hence it leaves investment unchanged. That is what happens in our model in the special case $\mu = 0$, so that the BP curve is horizontal. Notice that with stronger balance sheet effects (larger μ, ϕ and ψ) the BP becomes steeper, magnifying the adverse effects on both investment and output.

Consider now the effects of a one-period increase in the world rate of interest. In figure 2 the shock shifts the BP down and to the right, so that investment is lower for each output level. The result is lower investment and output, as in point A. This is qualitatively as it would be in the standard model with perfect capital markets and a horizontal BP curve, but quantitatively there is a difference: for the same downward shift, the steeper the BP the larger the reduction in investment and output. The capital market imperfections and resulting balance sheet effects magnify the real effects of adverse interest rate shocks.[6]

Next we put some numbers on these comparative statics exercises. This calibration should not be interpreted as a "real business cycle" exercise. Our purpose is only to illustrate and add some quantitative dimension to the previous analysis. We set the structural parameters of the economy to generate three different cases. One case has no financial frictions, so the presence or absence of original

capital stock and by equilibrim labor supply $l = 0$), the IS and BP pin down the equilibrium real exchange rate for a given output level, and the LM only determines the price level.

[6] The same is true of export shocks.

sin is irrelevant. The other two do feature financial frictions and differ only in the share of debt that is denominated in dollars: with full dollarization we have a situation of *mortal sin*, while with a small share of the debt in domestic currency we have merely *venial sin*. Table 1 displays the assumptions regarding the main parameters of the model.

Table 2 presents the reaction of output and investment to a 1 percent increase in the world interest rate when the exchange rate (nominal and real) is held unchanged. (Recall that since the exchange rate does not move on impact, the degree of original sin is irrelevant in this case.) Financial frictions amplify the shocks dramatically. The fall in output and investment are roughly four times higher under frictions-plus-sin.

3.2. Policy shocks under fixed (but adjustable) exchange rates

What are the effects of monetary and exchange rate shocks in this model? First we answer the question analytically and then we simulate some examples.

Start with a financially robust economy. A depreciation of the real exchange rate shifts the IS down and the BP up. This situation appears in figure 3. Both output and investment unambiguously go up. This is just as in the standard model: real depreciation is expansionary, and it can be used to offset the real effects of adverse shocks.[7]

Turn next to the financially vulnerable economy. Figure 4 illustrates the three possible situations. The IS still shifts down, but now the BP shifts down as well. The economy may settle in a point like A with higher output and investment (this is an economy that is vulnerable but not too much so); a point like B where there is a trade-off between investment and output; and a case like C where both output and investment decline. The last one is the case of unambiguously contractionary devaluation, and trying to use exchange rate and monetary policy for counter-cyclical purposes can only make matters worse.

The intuition of why devaluation can be contractionary is simple: with imperfect capital markets, balance sheets matter; if there are enough inherited dollar liabilities, the real depreciation worsens the balance sheet and increases the risk premium; in turn, this pulls down investment and aggregate demand; if the stan-

[7] Notice that the presence of financial imperfections has ambiguous effects on the size of the expansion. On the one hand, having $\mu > 0$ and δ_e large reduces the size of the vertical shift in the BP; on the other hand, a large μ increases the slope of the BP, which magnifies the equilibrium impact of any depreciation.

dard demand-switching effects of devaluation are not sufficiently strong, the overall impact can be contractionary.

Again, notice that none of this could happen with perfect capital markets. In that case the BP is horizontal and shifts up after a real devaluation. The only possible outcome is an increase in both investment and output.

Next we simulate some examples, using the same underlying parameters as in the earlier simulations but stressing the role of different degrees of original sin. Table 3 shows the effects on output and investment of an unexpected 1 percent devaluation.

Without financial frictions, the devaluation expands both output and investment, as in conventional Mundell-Fleming model. When the economy does display financial frictions, the outcome depends on the extent of original sin. With venial original sin, the devaluation expands output by 0.3 percent but reduces investment by nearly 0.8 percent: the presence of financial vulnerability makes the BP shift down, moving the equilibrium to a point like B in Figure 4. With mortal sin, output is unchanged while investment falls more: almost 1.1 percent.. This underscores the role of original sin in determining the real effects of exchange rate policy.

3.3. External shocks under flexible exchange rates

Turn next to the case of flexible exchange rates, which we define as a regime in which the money supply is constant and the nominal (and real) exchange rate adjusts endogenously. Now the equilibrium involves, as pointed out above, the solution to 3 equations in 3 unknowns, so a simple diagrammatic presentation is not feasible. Instead, we go directly to a simulation. Since the LM schedule now comes into play, we have to assume a value for the elasticity of money demand (ε^{-1}), which we set equal to 2.

Table 4 presents the effects of a 1 percent increase in the world interest rate under the constant money rule. A first striking result is that this rule implies little endogenous movement in the exchange rate in the robust economy (extreme case with no financial frictions at all), but much larger movements in the vulnerable economy –especially so if original sin is mortal. Effects on output and investment differ accordingly.

In the economy without frictions, flexibility in the exchange rate has a stabilizing role. Comparing this outcome with that of the same shock under fixed rates (recall Table 2), we see that the small depreciation under floating reduces the fall in output from 0.5 percent to almost zero, and dampens the investment contraction slightly.

Things are more complicated if the economy does have frictions and original sin is mortal, leading to extreme vulnerability. The endogenous depreciation is large (19 percent), causing to a mild recession (output falls by 0.4 percent) and a collapse of investment (it falls by 24 percent). If sin is merely venial, the depreciation is milder, output is practically constant, and the drop in investment is held down to 7.9 percent. Compared with the response to the same shock under a fixed exchange rate, we see that now the output fall is smaller, regardless of the degree of sin. But the cost of the depreciation is a much larger fall in investment, with the difference in the case of mortal sin being very substantial. This suggest it is investment that is particularly sensitive to the share of dollar debt in total indebtedness.

With original sin, the real depreciation and the fall in investment exert negative feedback on each other, a factor which helps explain the magnitude of the equilibrium movements in both variables. An initial depreciation reduces net worth sharply when dollar debts are large, pushing the risk premium up and reducing investment. If, on the other hand, the real depreciation does not increase exports much (because the price elasticity of exports is low, as assumed in the vulnerable economy), then total demand for domestically produced goods falls. This in turn causes the relative price of domestic goods to fall (the real exchange rate depreciates even further), causing another round of investment cuts and so on, until the system finally settles on a much lower investment rate and a sharply depreciated exchange rate.

3.4. Implications for the exchange rate regime

The extent to which this cycle plays itself out, of course, depends on the reaction of monetary policy. In the example above money is constant in response to the shock. But if policy makers fear these contractionary effects of depreciation, then they might try to limit it by manipulating monetary policy, thus giving rise to *fear of floating*. The model presented here has stark *positive* implications for the choice of exchange rate regimes. If output and investment stabilization are paramount objectives, one should observe countries with mortal original sin (Argentina? Uruguay?) trying to limit exchange rate movements, so that their observed reaction to shocks would resemble that of Table 2. Countries with only venial original sin (Chile, Brazil) would welcome the endogenous movements in the real exchange rate, in which case their observed reaction to shocks would resemble that of Table 4, last column on the right. Venial sin allows these latter countries to enjoy stabilizing effects of exchange rates (at least as far as current output is concerned) that are not available to irredeemable sinners.

This all leaves open the question of *normative* rules to guide optimal monetary and exchange rate policy. Optimality involves a lot more than output and investment stabilization. And there may be intertemporal trade-offs that the informal discussion above ignores. In Céspedes, Chang and Velasco (2000) we have identified conditions for floating to be welfare-maximizing in a model much like the one in this paper. There we show that floating can be optimal even with mortal original sin as long as domestic and foreign goods are sufficiently substitutable in consumption and investment. Computing optimal policies for other, more complex model economies, remains a task to be done.

4. Conclusions

Must original sin bring macroeconomic damnation? No, but it just might. Perhaps the most striking implication of the model presented in this paper is that –with financial imperfections– macroeconomic outcomes depend crucially on the extent of original sin.

But while all sinful economies are equal in this respect, some are more equal than others. We have seen that other factors –the size of total debt regardless of currency denomination, the sensitivity of the risk premium to debt levels, the degree of openness of the economy, the price elasticity of demand for exports– all matter in determining how the economy will react to shocks, including unexpected movements in the real exchange rate. There may be cases in which sinful economies can use the exchange rate to offset shocks, as in the textbooks.

The model presented here simplifies perhaps a bit too much. Other links between financial imperfections and the real exchange rate may also prove crucial. Here local capitalists borrow to invest, so financial imperfections affect the demand for investment and indirectly the real exchange rate. This leaves room for monetary policy to affect aggregate demand and potentially play a stabilizing role. Alternatively, local producers could borrow abroad to pay for productive inputs. In that case, shocks that affected the risk premium (for instance by lowering net worth) would cut domestic supply of goods directly, making it harder for aggregate demand policies to play a useful role. This is an important issue to explore in future work.[8]

[8] We re thankful to Mick Devereux for making this point.

A. Appendix: No shock equilibrium

Suppose that all shocks are identically zero, and let overbars denote no shock equilibrium values. Then, from 2.19

$$\bar{L} = \bar{L}_1 = 1$$

(as before, subscripts indicate future period values). Hence, domestic production is

$$\bar{Y} = A\bar{K}^{\alpha}, \bar{Y}_1 = A\bar{K}_1^{\alpha} \tag{A.1}$$

and 2.28 is

$$\bar{Y}_1 = \tau \bar{E}_1^{\chi} \bar{X}_1. \tag{A.2}$$

Next, note that if there are no shocks,

$$\bar{Q}\bar{C} = (1-\alpha)(\frac{\theta-1}{\theta})\bar{P}\bar{Y} \tag{A.3}$$

so the goods market equilibrium condition for the domestic good becomes

$$\left[1-\gamma(1-\alpha)(1-\theta^{-1})\right]\bar{Y} = \gamma\bar{E}^{1-\gamma}\bar{K}_1 + \bar{E}^{\chi}\bar{X} \tag{A.4}$$

Since $\bar{Y}$ is given by AK^{α}, the preceding equation is a relation between the no shock values of $\bar{E}$ and $\bar{K}_1$. It is a schedule that slopes down in $(\bar{K}_1, \bar{E})$ space.

For a second schedule, write the interest parity condition 2.24 as

$$\frac{\bar{R}_1\bar{K}_1/\bar{P}_1}{\bar{Q}\bar{K}_1/\bar{P}_0} = (1+\bar{\rho})\left[\frac{\bar{Q}\bar{K}_1}{\bar{P}\bar{N}}\right]^{\mu}\frac{\bar{E}_1}{\bar{E}} \tag{A.5}$$

Note now that $\bar{R}_1\bar{K}_1 = \alpha(1-\theta^{-1})\bar{P}_1\bar{Y}_1$, and use A.1 , A.2, and 2.25 to get

$$\left[\alpha(1-\theta^{-1})(\tau\bar{X}_1)^{1/\chi}\right](A\bar{K}_1^{\alpha})^{1-1/\chi} = \frac{(1+\bar{\rho})\bar{E}^{(1-\gamma)(1+\mu)-1}\bar{K}_1^{1+\mu}}{\left\{\left[1-(1-\alpha)(1-\theta^{-1})\right]\bar{Y} - \bar{E}D^* - D/\bar{P}\right\}^{\mu}}$$

This is the no shock BP. Note that since $\bar{Y}$, D^* and $D/\bar{P}$ are given, the preceding equation is also a relation between $\bar{E}$ and $\bar{K}_1$.

This is a complicated expression. However, note that if μ is zero, this curve must start from the origin and slope up in $(\bar{K}_1, \bar{E})$ space. Hence, if it intersects the no shock IS, the intersection must be unique. By continuity, there is a unique no shock equilibrium if μ is not too large.

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Figure 1 : fall in exports

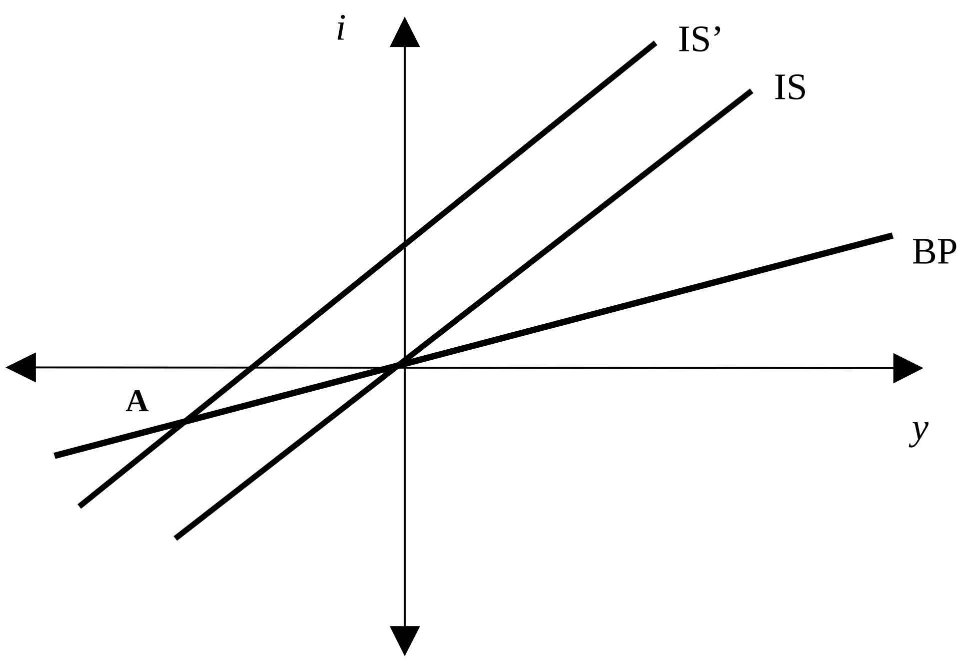

Figure 2: increase in the world interest rate

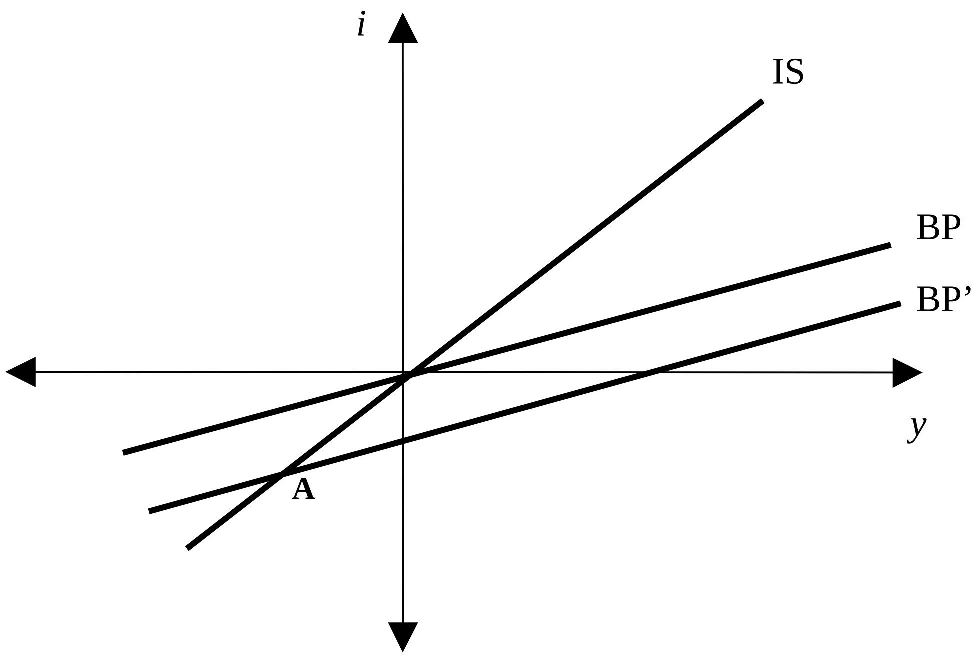

Figure 3: devaluation in financially robust economy

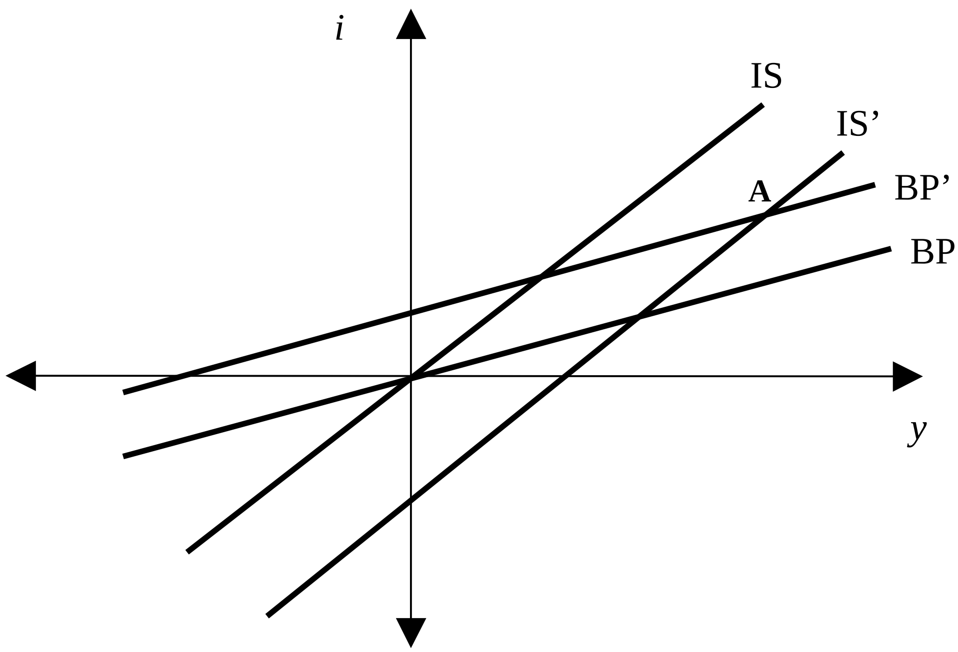

Figure 4: devaluation in financially vulnerable economy

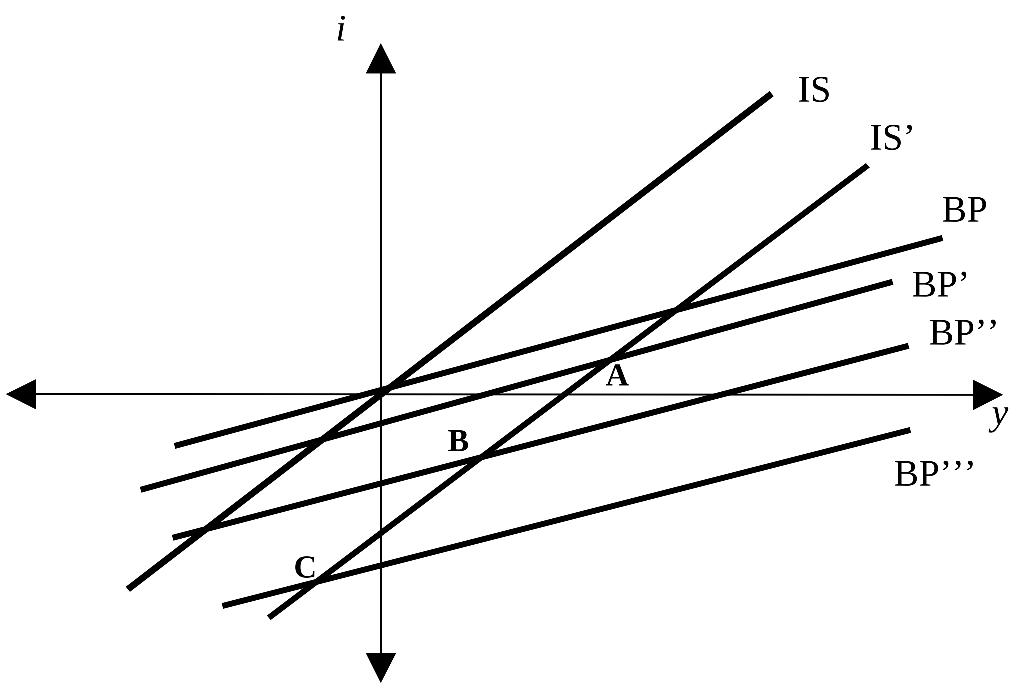

Table 1: Parameter Values

	No Financial Frictions	Financial Frictions	
	Original Sin Irrelevant	Mortal Original Sin	Venial Original Sin
α	0.30	0.30	0.30
χ	0.50	0.50	0.50
β	0.99	0.99	0.99
θ	2.00	2.00	2.00
γ	0.45	0.45	0.45
μ	0.00	0.20	0.20
ε	0.35	0.35	0.35
λ	0.42	0.42	0.42
ψ		10.00	10.00
φ		1.00	0.95

Table 2: Fixed Exchange Rates

Response to a 1% increase in world interest rate

	No Financial Frictions	Financial Frictions
Output	-0.50%	-2.00%
Investment	-0.76%	-3.05%

Table 3:

Response to a 1% unexpected devaluation

	No Financial Frictions	Financial Frictions	
		Mortal Sin	Venial Sin
Output	1.02%	0.00%	0.30%
Investment	0.35%	-1.09%	-0.77%

Table 4: Constant Money Rule

Response to a 1% increase in the world interest rate

	No Financial Frictions	Financial Frictions	
		Mortal Sin	Venial Sin
Exchange Rate	0.48%	19.00%	6.31%
Output	-0.01%	-0.40%	-0.13%
Investment	-0.60%	-24.00%	-7.89%

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