INSTITUT NATIONAL DE LA STATISTIQUE ET DES ETUDES ECONOMIQUES
Série des Documents de Travail du CREST
(Centre de Recherche en Economie et Statistique)

n° 2008-11

Exchange Rate Volatility And Productivity Growth : The Role of Liability Dollarization*

K. BENHIMA[1]

* I am grateful to Agnès Bénassy-Quéré, Guy Laroque, Enrique Mendoza, seminar participants at CREST and EQUIPPE (Lille), the RIEF 2007 Conference and 2008 doctoral meeting, the 2007 ESEM meeting, the 2008 T2M conference and the 2008 SMYE meeting. All remaining errors are mine.

[1] CREST, Laboratoire de Macroéconomie, 15 Boulevard Gabriel Péri, 92245 MALAKOFF Cedex, France. Tel. 33 (0) 1 41 17 37 90, mail : benhima@ensae.fr and ECONOMIX, Université Paris X-Nanterre.

Abstract: The contribution of this study is to show how liability dollarization conditions the effect of exchange rate volatility on growth. To illustrate this point, the paper lays down a model in which credit constrained firms face liquidity shocks denominated in tradable goods while their revenues are both in tradable and nontradable goods. Under the assumptions that the production of nontradable goods is labor-intensive, that nominal wages are preset and that the elasticity of substitution between goods is lower than one, a fixed exchange rate is growth enhancing in countries whose debt is denominated in terms of foreign currency (complete dollarization) because it stabilizes firms' cash flows. However, in countries where a fraction of the debt is denominated in domestic currency (partial dollarization), the difference between the growth performance of fixed and flexible exchange rate regimes can disappear since the debt structure can help firms hedge their cash-flow risk under floating regimes. The theoretical results are backed by an empirical analysis on a panel of 77 countries spanning the years 1995-2004. It appears that the higher the degree of liability dollarization, the more negative the impact of exchange rate flexibility on growth.
Key Words: Exchange rate regimes, Growth, Liability dollarization, Balance-sheet effects, Credit constraints.

Résumé: La contribution de cette étude est de montrer comment la dollarisation de la dette conditionne l'effet de la volatilité du taux de change sur la croissance. Pour illustrer cette idée, le papier développe un modèle dans lequel des firmes contraintes financièrement font face à des chocs de liquidité en bien échangeable alors que leurs revenus sont en biens échangeables et non échangeables. Dans un cadre où la production de biens non-échangeables est intensive en travail, où les salaires nominaux sont prédéterminés et où l'élasticité de substitution entre biens est inférieure à un, le régime de change fixe est favorable à la croissance dans les pays où la dette est libellée en dollars (dollarisation totale), car il stabilise le cash flow des firmes. Cependant, dans les pays où une part de la dette est libellée en monnaie domestique (dollarisation partielle), la différence de performance en termes de croissance des régimes de change fixe et flexible peut disparaître puisque la dette en monnaie domestique permet aux firmes de stabiliser leur cash flow sous le régime de change flexible. Ce résultat théorique est soutenu par une analyse empirique sur un panel de 77 pays entre 1995 et 2004. Il apparaît que plus le degré de dollarisation de la dette est élevé, plus l'impact de la flexibilité du taux de change sur la croissance est négatif.
Mots-clés: Régimes de change, Croissance, Dollarisation de la dette, Effets de bilan, Contraintes de crédit.

JEL Class.: O16, O24, O41, O42.

1 Introduction

The choice of exchange rate regime and its impact on economic performance is among the most controversial issues in macroeconomic policy. The empirical works on the growth effect of exchange rate volatility conclude either on exchange rate neutrality, or on a different effect in industrial and developing countries. Baxter and Stockman (1989) were the first to bring this "instability puzzle" forward. The literature has since been inconclusive on the subject: Husain et al. (2005) find that exchange rate flexibility is growth-enhancing in industrial countries and neutral in developing economies, while Dubas et al. (2005), relying on an alternative exchange-rate classification, find that a fixed exchange rate has good growth performances in the latter while it is neutral in the former; similarly, De Grauwe and Schnabl (2005) show that exchange rate stability is associated with higher growth in South-Eastern and Central European countries.

Some recent studies suggest that the failure of the empirical literature at bringing a stable, clear-cut effect of exchange volatility to the fore may be due to nonlinear effects: Razin and Rubinstein (2006) allow the exchange rate regime to have both a direct effect on short-term growth, and an indirect one that is channelled through the crisis probability, while Aghion et al. (2006) introduce the interaction of the exchange rate regime with financial development. Using a sample of 83 countries spanning the years 1960-2000, they show that real exchange rate volatility can have a significant impact on the long-term rate of productivity growth, but the effect depends critically on the countries' level of financial development. For economies with relatively low levels of financial development, exchange rate volatility generally reduces growth, whereas for financially advanced countries, there is no significant effect. Their empirical result is consistent with the previous literature, in particular with the finding that exchange rate stability is more growth enhancing in developing than in industrial countries. Their theoretical model suggests that exchange rate flexibility exacerbates the volatility of firms' cash flows. As a consequence, exchange rate volatility makes the financing of innovations more difficult on average when financial development is low, that is when credit requirements are stricter, and results in lower growth. The main idea is that during slumps, the innovating capacity of firms is hampered while booms do not significantly foster the ability of firms to overcome the liquidity shock. The consequence of this asymmetry is that less volatility fosters growth.

In this paper, the effect of exchange rate volatility on growth is related to the level of liability dollarization, also referred to as "original sin", that is the inability of developing countries to borrow in their own currency. As a preliminary evidence on the link between exchange rate volatility and growth for different levels of liability dollarization, consider Figure 1. It represents the scatter plot of residuals of regressions of productivity growth and a measure of exchange rate volatility on control variables for low and high levels of dollarization[1]. Pooled regressions of productivity growth and exchange rate volatility are performed using five-year average data for 51 (upper graphs) or 75 (lower graphs) countries

[1] The control variables include initial productivity, financial depth, secondary schooling, government expenditure, inflation, trade openness. These variables are defined in section 4.

over 1995-2005. Low and high levels of dollarization are respectively those below and above the sample median. Two proxies are used to account for exchange rate flexibility: the standard deviations of the real effective exchange rate in the upper graphs and the Levy-Yeyati and Sturzenegger (2002) classification of exchange rate regimes in the lower graphs. The dollarization measure is the external "original sin" taken from Hausmann et al. (2001) and Hausmann and Panizza (2003). High dollarization countries exhibit a significant negative relationship between exchange rate flexibility and growth, while the slope is not significantly different from zero in low dollarization countries. The contribution of the paper is to provide a theoretical model that would predict this fact and to confirm the robustness of this preliminary evidence, using a panel of 77 countries over the period 1995-2004.

As in Aghion et al. (2006), a model of an open monetary economy with wage stickiness, where exchange rate fluctuations affect the growth performance of credit-constrained firms is developed: on the one hand, to be able to innovate, firms have to finance a transitory liquidity shock; on the other hand, exchange rate volatility affects cash flows volatility under wage stickiness and thus impairs firms' financing capacities on average. But this framework is not sufficient to account for liability dollarization and is supplemented with two important features: 1) the production is split into tradable and nontradable goods while the liquidity cost is in tradable goods to allow a mismatch; 2) the firms' cash flows are the profits net of debt repayments, whereas in Aghion et al. (2006), the cash flows are made of the firms' gross profits. Holding everything equal, the value of nontradable production in terms of tradables would fall after a nominal depreciation while the value of the tradable output would remain constant under the law of one price. Since the liquidity cost is denominated in tradable goods, this would reduce the firms' financing capacities. But if the firms' debt is partially denominated in domestic currency, this depreciation would also alleviate debt repayments and thus limit the fall in firms' cash flows. An a priori intuition is therefore that under complete debt dollarization, a fixed exchange rate regime is growth-enhancing as compared to a flexible exchange rate regime, but when the level of dollarization falls, the growth advantage of pegged regimes diminishes.

However, whether exchange rate flexibility destabilizes firms' production in terms of tradable goods under general equilibrium is not a trivial issue. According to Milton Friedman, a flexible exchange rate has a stabilizing effect on output when the source of shocks is external since a foreign shock that requires a real depreciation would imply a costless nominal depreciation while there would be a contractionary deflation under a fixed exchange rate. As a result, a flexible exchange rate has a stabilizing effect on output. However, the output *measured in foreign currency* depends on both the output in real terms and the real exchange rate. Therefore, firms' revenues in foreign currency can be better stabilized by a fixed exchange rate regime if its stabilizing effect on the real exchange rate compensates for its destabilizing effect on output. In the model presented here, with productivity shocks in the tradable sector, it is the case: because the nontradable sector is more labor-intensive than the tradable sector, the traditional contractionary deflation effect under a peg is present, but because the elasticity of substitution between the nontradable and tradable goods is lower than one (as is widely admitted in the literature), the net effect is mitigated under a peg.

To test the basic hypothesis that exchange rate flexibility has a more negative impact in dollarized countries, standard growth regressions are used (the baseline specification is taken from Levine et al. (2000)). Those standard growth regressions are augmented by a measure of exchange rate flexibility (as in Aghion et al. (2006)), a measure of external dollarization and the interaction term of exchange rate flexibility and dollarization. The results are based on a dynamic panel of 77 countries between 1995 and 2004 described above. Both OLS and GMM methodologies are adopted and robust two-step standard errors are also computed using the method of Windmeijer (2004). The GMM methodology helps tackle the issue of endogeneity but suffers from the problem of weak instruments. The set of instruments is therefore carefully selected using both overidentification and underidentification tests. Afterwards, robustness checks are run.

The introduction of original sin to understand the impact of exchange rate on growth is motivated by the recurrent use of liability dollarization in the literature to understand emerging markets. It has been pointed to as a source of vulnerability by several authors, among which Eichengreen and Hausmann (1999), Reinhart et al. (2003) and Calvo et al. (2004). Original sin is therefore a major candidate to explain the relative growth performances of exchange rate regimes in developing and industrial countries. A few papers, like Levy-Yeyati (2006), have examined the overall growth impact of original sin, but none yet have considered its effect on aggregate productivity when interacted with exchange rate volatility.

Another reason for enriching the approach of Aghion et al. (2006) is that an exchange rate depreciation has expansionary effects in their model: since firms produce only tradable goods and because of the law of one price, a depreciation is equivalent to inflation which leads to a decrease in the real wage. The negative effect of exchange rate volatility thus comes mainly from the appreciation episodes, which goes against the evidence, especially for developing countries. The introduction of a nontradable good sector which is more labor-intensive than the tradable good sector helps reverse this prediction, so that an exchange rate depreciation is contractionary.

Section 2 presents a stylized model of growth and monetary policy. Section 3 derives the empirical implications of the model concerning the link between growth and exchange rate volatility. Section 4 tests these empirical predictions.

2 A stylized monetary model

2.1 A small open economy with sticky wages and two sectors

Consider a small open economy with a continuum of firms, indexed by $i \in [0, 1]$, that are owned by a continuum of households indexed by $j \in [0, 1]$. Households supply labor and start period t with a stock of monetary balances. Firms produce both tradable goods T, which are identical to the outside world good, and nontradable goods N. There are two currencies: the domestic currency (peso) and the foreign currency (dollar).

Firms are price-taker and competitive so that the law of one price applies in the sector of tradables:

$$P_t^T = S_t P_t^{T*}$$

where P_t^T and P_t^{T*} are respectively the domestic (peso) and foreign (dollar) price of tradable goods and S_t is the nominal exchange rate. P_t^{T*} is assumed to be constant and normalized to one. Thus $P_t^T = S_t$: dollars and tradables are one and unique good.

The timing within period t is the following:

1. Wages are preset.
2. The entrepreneurs borrow D_t to be able to innovate in period $t+1$: that is upgrade A_t, the level of productivity.
3. An aggregate productivity shock occurs in the tradable sector, firms hire labor L_t and produce $A_t Y_t^T$ and $A_t Y_t^N$, respectively the production of tradable and nontradable goods.
4. Firms repay their debt D_t, and pay the wages $A_t W_t L_t$, with $A_t W_t$ the wage rate and L_t aggregate labor.
5. Firm i, $i \in [0,1]$ faces a liquidity shock $A_t \Phi_t^i$ in dollars. If the liquidity shock is financed, then the firm is able to innovate and recovers $A_t \Phi_t^i$. If it is not financed, then the firm cannot innovate and disappears at the end of the period.
6. Firms distribute profits to the household and consumption takes place.

We assume that there are no credit markets at step 5. This important assumption implies that the ability to innovate can be hampered because of a bad shock on cash flows. We also make the simplifying assumption that there is no intertemporal trading, so the analysis can be split into the within-period equilibrium and the evolution of productivity A_t, which depends on the equilibrium cash flow of period t. First, the process governing the evolution of productivity is presented to derive how growth depends on current cash flows and then a within-period analysis is run to determine how cash flows react to shocks under a flexible and fixed exchange rate regime.

2.2 The evolution of productivity

2.2.1 Innovation process

The innovation process is specified as follows: if the firm is able to overcome the liquidity shock of period t, then its $t+1$ productivity evolves according to:

$$A_{t+1} = \delta \rho_t A_t + (1-\rho_t) A_t$$

with $\delta > 1$ and ρ_t the proportion of innovating firms. The firm benefits from positive innovation externalities. Otherwise, the firm disappears and is replaced by a new firm that benefits from the new level of productivity. These assumptions are made to rule out heterogeneity among firms and to keep their number constant. The aggregate growth rate is therefore $g = (\delta - 1)\rho_t$.

2.2.2 Liquidity shocks and credit market imperfections

To be able to innovate, the firm has to pay a fixed cost $D_t = dA_t$ ($d > 0$) in dollars at the beginning of period t (before the revelation of the aggregate shock), and pay an idiosyncratic liquidity cost $A_t\Phi_t^i$ in dollars at the end of period t, after paying the wage bill and repaying its debt, where Φ_t^i is independently and identically distributed across firms, with cumulative distribution function F. A_t is used to scale the fixed cost and the liquidity shock to ensure a balanced growth path.

Firms start the period without funds, so they must borrow D_t. For tractability, firms' indebtedness is introduced under the form of a fixed cost. It is also assumed for simplicity that the credit constraints are not binding at this stage and that the cost of borrowing is lower than the expected value of innovation, which implies that firms always choose to pay the fixed cost. This cost can be viewed as spending on R&D, learning expenses or investment in a new technology.

At the end of the period t, firm i faces the liquidity cost shock $A_t\Phi_t^i$. If they do not finance this cost, the firms cannot innovate and disappear at the end of the period. If firms meet this cost, they will recover $A_t\Phi_t^i$ at the end of the current period and pay back their creditors before the beginning of the next one. For simplicity, it is also assumed that the liquidity cost can be financed with a zero interest rate. As a consequence, the innovation cost is neutral regarding the net profit of the current period. Therefore, it is always profitable for the firms to finance the liquidity shock. $A_t\Phi_t^i$ can be viewed as the cost induced by a delay, typically in an equipment delivery, or any shock that would ruin the business unless there is enough liquidity to overcome it.

It is assumed that there are no credit markets at this stage, so they are able to overcome the transitory liquidity shock if and only if their cash flow is sufficient to meet the cost:

$$\Pi_t \geq \Phi_t^i$$

where Π_t is the cash flow of the firm expressed in dollars and scaled by A_t.

Firms have the same cash flows Π_t and differ only regarding the liquidity shock Φ_t^i. Therefore, ρ_t, the proportion of firms which are not constrained (and thus of innovating firms), is the proportion of firms whose liquidity shock is lower than Π_t:

$$\rho_t = P(\Phi_t^i < \Pi_t) = F(\Pi_t) \tag{1}$$

The aggregate growth rate depends directly on the level of cash flows Π_t. The purpose of the next subsection is to determine the behavior of Π_t depending on the exchange rate regime.

2.3 Within-period analysis

The purpose of this subsection is to examine the impact of exchange rate policy, which is implemented through a monetary instrument, in terms of transmission of shocks to prices and quantities, and therefore to firms' cash flows. For this purpose, the structure of the within-period model is specified. The presence of nominal rigidities (preset wages) implies that monetary policy has real consequences, in particular in terms of cash flows volatility. Some other key assumptions contribute to shape the model's predictions. First, the nontradable sector is more labor-intensive than the tradable one. This is empirically relevant, but it has also an important implication, which is that an output contraction is consistent with a real depreciation. As a result, the peso-denominated debt has hedging properties regarding cash-flows volatility in terms of dollars. Second, the elasticity of substitution between tradables and nontradables is lower than one, which is widely admitted in the literature, but is also key in ranking the flexible and fixed exchange rate regimes in terms of cash-flow volatility.

Finally, the level of dollarization is exogenous. Indeed, the fact that liability dollarization is imposed on developing countries is widely admitted in the literature. Eichengreen and Hausmann (1999), among others, support this view:

The problem is not that firms simply lack the foresight to match the maturity structure of their assets and liabilities; it is that they find it impossible to do so. The incompleteness of financial markets is thus at the root of financial fragility.

This financial markets incompleteness can be due for example to the credibility of monetary policy. Liability dollarization can be a means of forcing the governement not to use exchange rate movements to depreciate the country's debt repayments.

2.3.1 Firms

Production and growth

Final goods are produced using labour and an intermediate imported good. Labour is differentiated across households, so that households have market power in wage setting. We can define the aggregate labor composite as:

$$L = \left[\int_0^1 (L^j)^{1-1/\delta} dj \right]^{\frac{1}{1-1/\delta}}$$

where L^j is employment of household j, and $\delta > 1$ is the elasticity of substitution between labor varieties.

Firms have identical technologies. A firm produces both tradable and nontradable goods. The tradable and nontradable productions of firm $i \in [0, 1]$ during period t are respectively denoted by $A_t Y_t^{Ti}$ and $A_t Y_t^{Ni}$ and:

$$Y_t^{Ti} = Y_t^T = e^{u_t} \tag{2}$$

$$Y_t^{Ni} = Y_t^N = \sqrt{L_t} \tag{3}$$

Y_t^{Ti} and Y_t^{Ni} are the firm's productions scaled by the level of productivity and u_t is the aggregate productivity shock in the tradable sector, with $Eu_t = 0$ and $V(u_t) = \sigma_u^2$. The labor demand is identical across firms because firms have the same technology. For simplicity, it is assumed that the production of nontradables requires labor while the production of tradables involves no input. This specification has been chosen to capture the fact that the nontradable sector is more labor-intensive than the tradable sector.

Firms choose employment to maximize the nontradable profit $P_t^N \sqrt{L_t} - \int_0^1 W_t^j L_t^j dj$ with respect to L_t^j, $j \in [0, 1]$, subject to the labor composite definition, where W_t^j is the wage set by household j in pesos, scaled by A_t, and P_t^N is the peso price of nontradable goods. We get the implicit labor demand function:

$$W_t^j = \frac{P_t^N}{2\sqrt{L_t}} \left(\frac{L_t^j}{L_t} \right)^{\frac{-1}{\rho}} \tag{4}$$

In a symmetric equilibrium, $W_t^j = W_t$ and $L_t^j = L_t$. We therefore get the optimal aggregate employment condition:

$$W_t L_t = \frac{P_t^N Y_t^N}{2} \tag{5}$$

Indebtment and dollarization

Firms borrow the fixed cost $D_t = dA_t$ in dollars to be able to innovate in period $t + 1$. It is assumed that debt is contracted in nominal terms and is denominated either in foreign currency (dollars) or in local currency (pesos). An exogenous fraction α is denominated in dollars while the rest is denominated in pesos. α is the degree of dollarization.

r^*, the interest rate on dollar bonds, is fixed internationally. It is assumed that foreigners are risk neutral and value dollars so that r, the interest rate on peso bonds, satisfies the following no-arbitrage condition:

$$(1 + r)E\frac{1}{P_t^T} = 1 + r^*$$

At the end of period t, the firm has therefore to repay in dollars:

$$\left(\alpha + \frac{1}{P_t^T E \frac{1}{P_t^T}} (1 - \alpha) \right) (1 + r^*) D_t$$

Cash flows

The liquidity shock occurs after the firm has paid the wage bill and repaid the debt, so the cash flow in terms of dollars and scaled by A_t is $\Pi_t = Y_t^T + \frac{P_t^N}{P_t^T} Y_t^N - \frac{W_t L_t}{P_t^T} - \left(\alpha + \frac{1}{P_t^T E\left(\frac{1}{P_t^T}\right)} (1 - \alpha) \right) (1 + r^*) d$. After replacing the wage bill using labor demand (5), one gets:

$$\Pi_t = \underbrace{Y_t^T + \frac{1}{2} \frac{P_t^N}{P_t^T} Y_t^N}_{\text{Gross profits}} - \underbrace{\left(\alpha + \frac{1}{P_t^T E\left(\frac{1}{P_t^T}\right)} (1 - \alpha) \right) (1 + r^*) d}_{\text{Debt repayments}} \tag{6}$$

The cash flows include gross profits, but to get the actual cash on hand, debt repayments must be substracted from them. Comparing the gross profit component and the debt component of cash flows will give the actual financing capacity of firms.

Because firms' revenues are partly in nontradable goods while the liquidity shock is denominated in tradables, firms face a *currency mismatch*. According to (6), firms' gross profits are sensitive to nominal exchange rate variations (changes in P_t^T). However, the peso-denominated fraction of firms' debt helps them hedge the variations in the nontradable value of their profits. For example, everything else being equal, a nominal depreciation implies a fall in the value of gross profits in terms of tradables. If $\alpha = 1$, debt repayments, in terms of tradables, are immune to exchange rate variations, whereas if $\alpha < 1$, a nominal depreciation leads to a decrease in debt repayments in terms of tradables, which alleviates the overall impact of the depreciation on the cash flows. However, in order to generalize this intuition, the model needs to be closed.

2.3.2 Households

The households maximize their utility: $\log(A_t C_t) + \log\left(\frac{A_t M_t}{P_t}\right) - v(L_t^j)$, $v' > 0$, $v'' > 0$, with respect to C_t, their consumption basket and M_t, their nominal money balances, both scaled by the level of productivity A_t:

$$C_t = \left[\gamma^{\frac{1}{\theta}} C_t^{T\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_t^{N\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{7}$$

subject to their -scaled- budget constraint:

$$P_t^T C_t^T + P_t^N C_t^N + M_t = \Pi_t + W_t^j L_t^j + T_t + M_{t-1} A_{t-1}/A_t \tag{8}$$

where C_t^T and C_t^N are respectively the consumptions of tradables and nontradables, and T_t are monetary transfers from the government, all scaled by A_t. $M_{t-1}A_{t-1}$ is the initial stock of monetary balances. The households use the dividends (firms' net profits), their wage, government transfers and their begining-of-period money balances from the previous generation to finance his consumption in tradables and nontradables and his current money balances. θ is the elasticity of substitution between tradable and nontradable goods. It is assumed that $\theta < 1$, which means that goods are weakly substitutable. This is a standard assumption concerning tradables and nontradables. $0 < \gamma < 1$ is the weight of tradables in the consumption basket.

The program yields the relative demand for tradables and nontradables:

$$\frac{P_t^N}{P_t^T} = \left(\frac{1-\gamma}{\gamma}\frac{C_t^T}{C_t^N}\right)^{\frac{1}{\theta}} \tag{9}$$

and the demand for money:

$$\frac{1}{P_t C_t} = \frac{1}{M_t} \tag{10}$$

The general price index associated to the household maximization program is the following:

$$P_t = \left(\gamma P_t^{T1-\theta} + (1-\gamma) P_t^{N1-\theta}\right)^{\frac{1}{1-\theta}} \tag{11}$$

2.3.3 Wage setting

To model wage stickiness, we assume that nominal wages are preset ex ante. Household j sets the wage W_t^j in order to maximize his expected utility subject to his budget constraint (8) and to the implicit labor demand (4). Since each household possesses a small fraction of the firms, he does not internalize the effect of his wage on the dividends. In a symmetric equilibrium, this yields:

$$W_t = \frac{\rho}{\rho - 1} \frac{E(L_t v'(L_t))}{E\left(\frac{L_t}{P_t C_t}\right)} \tag{12}$$

2.3.4 Monetary policy

The monetary policy targets either the stability of the general price index - flexible exchange rate:

$$P_t = \bar{P} \tag{13}$$

or the stability of the nominal exchange rate - fixed exchange rate:

$$P_t^T = \bar{P^T} \tag{14}$$

where $\bar{P}$ and $\bar{P^T}$ are exogenous. The government's instrument is a nominal transfer T_t, which is the amount of banknotes that are created by the government and distributed to the households. The outside world has a zero net demand for money balances. The government's budget constraint therefore yields:

$$M_t - M_{t-1} A_{t-1}/A_t = T_t \tag{15}$$

2.3.5 Equilibrium

Closing the model

The aggregate equilibrium budget constraint (balanced current account), scaled by A_t, is given by:

$$P_t^T Y_t^T + P_t^N Y_t^N - \left(\alpha P_t^T + (1-\alpha)\frac{1}{E\left(\frac{1}{P_t^T}\right)}\right)(1+r^*)d = P_t^T C_t^T + P_t^N C_t^N$$

Since nontradables cannot be traded internationally:

$$Y_t^N = C_t^N \tag{16}$$

which also yields:

$$Y_t^T - \left(\alpha + (1-\alpha)\frac{1}{P_t^T E\left(\frac{1}{P_t^T}\right)}\right)(1+r^*)d = C_t^T \tag{17}$$

This means that both current accounts, in tradables and nontradables, are balanced: the nontradable output is entirely consumed and the tradable consumption is what remains from the tradable production after repaying the debt. Nominal exchange rate movements have therefore an impact on tradable consumption: if $\alpha < 1$, a depreciation enables the household to consume more tradable goods by alleviating the burden of the peso debt.

Definition: For each period t, given A_{t-1} and A_t, a symmetric equilibrium is defined by a set of prices $\{P_t^N, P_t^T, P_t, W_t\}$ and allocations $\{Y_t^N, Y_t^T, C_t^N, C_t^T, C_t, L_t, M_t, T_t\}$ that solves the supply of non-tradable and tradable goods (2) and (3), the aggregate labor demand (5), the consumption basket (7) the relative demand for tradable and nontradable goods (9), the demand for money (10), the price index (11), the symmetric wage setting (12), one of the two monetary policies (13) or (14), the government budget constraint (15) and the equilibrium conditions on the tradable and nontradable markets (16) and (17).

If the equilibrium productions and prices are determined, the values of firms' cash flows Π_t can be inferred from (6).[2]

The non-stochastic steady state equilibrium

It can be shown that the non-stochastic solution (without aggregate shock in the tradable sector) for $\{Y_t^N, Y_t^T, C_t^N, C_t^T, C_t, L_t, P_t^N, P_t^T, P_t, W_t\}$ is unique and constant. This defines the steady-state equilibrium of the model. Let X denote the steady-state value for X_t.

This steady-state equilibrium is derived as follows. Take the labor demand (5) and the supply of nontradable goods (3) and derive the expression for Y^N:

$$Y^N = \frac{P^N}{2W} \tag{18}$$

We have also:

$$Y^T = 1 \tag{19}$$

Use then the relative demand for tradable and nontradable goods (9), where the consumptions for tradables and nontradables are replaced using the equilibrium equations in the tradable and nontradable markets (16) and (17) and where Y^N and Y^T are replaced using (18) and (19), to derive:

$$\left(\frac{P^N}{W}\right)^{1+\frac{1}{\theta}} = \frac{P^T}{W}\left(\frac{1-\gamma}{\gamma}2\left(1-(1+r^*)d\right)\right)^{\frac{1}{\theta}} \tag{20}$$

For (20) to be well-defined, we must assume that $1-(1+r^*)d > 0$.

P^N/W is implicitely defined by (20) as an increasing function of P^T/W.

The non-stochastic wage setting equation, derived from (12), gives:

$$W = \frac{\rho}{\rho-1}v'(L)PC \tag{21}$$

Using the labor demand (5), the supply of nontradables and tradables (18) and (2), the consumption basket (7), and the price index (11), (21) yields:

$$\frac{1}{[\gamma(P^T/W)^{1-\theta}/+(1-\gamma)(P^N/W)^{1-\theta}]^{\frac{1}{1-\theta}}} = \frac{\rho}{\rho-1}v'\left(\left[\frac{P^N}{2W}\right]^2\right)\left[\gamma^{\frac{1}{\theta}}(1-(1+r^*)d)^{\frac{\theta-1}{\theta}}+(1-\gamma)^{\frac{1}{\theta}}\left(\frac{P^N}{2W}\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{22}$$

[2] To obtain the value of the aggregate variables in absolute terms, multiply $\{Y_t^N, Y_t^T, C_t^N, C_t^T, C_t, W_t, M, T_t\}$ by A_t ($\{L_t, P_t^N, P_t^T, P_t\}$ are already in absolute terms).

(22) defines an implicit decreasing relation between P^N/W and P^T/W. Appendix 1 shows that (20) and (22) admit a unique solution for P^N/W and P^T/W which do not depend on the exchange rate regime.

Using one of the two monetary rules (13) or (14), along with the price index (11), one can derive W, P^T, P^N and P.

Once P^T, P^N and W are determined, we can infer Y^N using (18). Then, C^N can be determined using (16) and C^T using (17). Finally, C can be derived from (7). So there is a unique solution for $\left\{Y^N, Y^T, C^N, C^T, C, L, P^N, P^T, P, W\right\}$. Notice that since P^N/W does not depend on the exchange rate regime, neither does Y^N. As a consequence, with no uncertainty, the allocations and relative prices are the same under both regimes.

Π can then be derived from (6). Finally, the amount of nominal monetary balances required to satisfy the policy objective is derived from C, P and the demand for money (10). T must then satisfy the steady-state version of the government budget constraint (15) $gM/(1+g) = PT$, with $A_{t+1} = (1+g)A_t$ and g the steady-state growth rate.

The empirical predictions of the model are derived in the next section by log-linearizing the model around the non-stochastic steady state and by studying the transmission mechanisms under both regimes.

3 Model's empirical implications

In this section, we study the differential impact of aggregate shocks on the quantities and prices under both regimes by using a reduced-form log-linearized model and then derive some conclusions on exchange rate regimes on growth.

3.1 The log-linearized, reduced-form model

Let x_t denote the deviation from the non-stochastic steady state of X_t: $x_t = \frac{X_t - X}{X} \backsimeq \ln(X_t) - \ln(X)$.

We are interested in the behavior of π (time subscripts are dropped for simplicity). We thus log-linearize (6) and use the labor demand (5) to infer:

$$\pi = \underbrace{(1-\kappa)(\eta+1)y^T + \kappa(p^N - p^T + y^N)}_{\text{Gross profit effect}} + \underbrace{(1-\kappa)\eta(1-\alpha)p^T}_{\text{Debt valuation effect}}$$

where $\kappa = \frac{\frac{P^{N2}}{2P^T W}}{1-(1+r^*)d+\frac{P^{N2}}{2P^T W}}$ denote the steady-state share of nontradables in the cash flows. We have $0 < \kappa < 1$. The first and second terms of π represent respectively the tradable and nontradable gross profits valued in terms of tradables (or dollars). The last term represents the effect of the debt currency composition on the financing capacities of firms. For example, everything equal, a nominal exchange rate depreciation (appreciation), that is a rise in p^T (a fall) leads to a depreciation (appreciation) in the value of the nontradable gross profits, but it also alleviates (increases) the peso-denominated part of the debt when $\alpha < 1$. If $\alpha = 1$, debt repayments in terms of tradables are immune to nominal exchange rate variations and cannot hedge the variations in the tradable value of profits. However, one needs to consider how y^T, y^N, p^T and p^N vary jointly. To know how π reacts to the productivity shock u, it is then sufficient to know the behavior of production and prices, which we can derive from the following reduced-form model.

The log-linearization of the relative demand for tradables and nontradables (9) ($p^N - p^T = \frac{1}{\theta}(c^T - c^N)$) and the equilibrium conditions (16) ($c^N = y^N$) and (17) ($c^T = (\eta + 1)y^T + \eta(1-\alpha)p^T$) gives:

$$p^N - p^T = \frac{1}{\theta}[(\eta + 1)y^T + \eta(1-\alpha)p^T - y^N] \tag{23}$$

where $\eta = \frac{(1+r^*)d}{1-(1+r^*)d} > 0$ the steady-state ratio of debt repayments over tradable consumption. The relative price of nontradables in terms of tradables has to fall either if the production of nontradables rises or if the production of tradables falls. This also happens if $\alpha < 1$ and the nominal exchange rate appreciates (p^T falls), because this makes the peso-denominated debt increase which leaves less tradable goods to consume for the household.

Besides, the log-linearization of supply of nontradables (3) ($y^N = \frac{l}{2}$) and the labor demand (5) ($p^N + y^N = l$) yields:

$$y^N = p^N \tag{24}$$

Here we see that a deflation in p^N has a contractionary effect on y^N. This is because nominal wages are preset. As a consequence, a deflation in p^N depresses the production of nontradables through the rise of the real wage.

Moreover, by log-linearizing the supply for tradables (2), we obtain:

$$y^T = u \tag{25}$$

Finally, the two possible policy choices are the following:

- Flexible exchange rate:

$$p = 0$$

  Besides, according to (11) ($p = \gamma p^T + (1-\gamma)p^N$) the flexible rule reduces to:

$$p^T = \frac{-(1-\gamma)}{\gamma} p^N \tag{26}$$

- Fixed exchange rate:

$$p^T = 0 \tag{27}$$

With only (23), (24), (25) and one of the two monetary rules (26) or (27), π can be inferred.

3.2 Reactions of quantities and prices to shocks

The reduced form model composed of (23), (24), (25) and one of the two monetary rules (26) or (27) is solved to obtain the following Lemma:

Lemma 1

- Under a flexible exchange rate,

$$p^{Nflex} = \frac{\gamma(\eta+1)u}{\theta+\gamma+(1-\gamma)\eta(1-\alpha)}, \quad p^{Tflex} = \frac{(1-\gamma)(\eta+1)u}{\theta+\gamma+(1-\gamma)\eta(1-\alpha)}$$

$$p^{Nflex} - p^{Tflex} = \frac{(\eta+1)u}{\theta+\gamma+(1-\gamma)\eta(1-\alpha)}, \quad y^{Nflex} = \frac{\gamma(\eta+1)u}{\theta+\gamma+(1-\gamma)\eta(1-\alpha)}, \quad y^{Tflex} = u$$

- Under a fixed exchange rate,

$$p^{Nfix} = \frac{(\eta+1)u}{\theta+1}, \quad p^{Tfix} = 0, \quad p^{Nfix} - p^{Tfix} = \frac{(\eta+1)u}{\theta+1}, \quad y^{Nfix} = \frac{(\eta+1)u}{\theta+1}, \quad y^{Tfix} = u$$

Lemma 1 is used to establish the following proposition:

Proposition 1 (proof in Appendix 1):

After an identical negative productivity shock in the tradable sector:

- If $\alpha = 1$, the production of nontradables (y^N) falls more under a peg than under a float. However, the relative price of nontradables ($p^N - p^T$) (henceforth the real exchange rate) experiences a higher depreciation under a float.
- When α diminishes, the fall in the production of nontradables and in the real exchange rate is mitigated under a float.

The intuition is the following: a negative shock on the productivity of the tradable sector requires a real depreciation (a fall in $p^N - p^T$) which results in a contractionary deflation in the nontradable sector under both regimes, as illustrated in Figure 2. This negative effect is accentuated under the fixed exchange rate regime because the real depreciation occurs only through a deflation in p^N while under a flexible regime it is shared between a rise in p^T and a fall in p^N. However, precisely because of the further contraction in y^N, the real exchange rate depreciation is milder under a peg because it compensates for the fall in y^T. But when α falls, the consumption of tradable is stabilized under a float thanks to the hedging effect of the peso-denominated debt, which mitigates the required real depreciation and the consecutive adjustment in y^N, as Figure 2 shows.

As a result, the comparative impact of a negative shock on the nontradable production valued in terms of tradables seems ambiguous. But the following proposition can be established:

Proposition 2 (proof in Appendix 1):

After an identical negative productivity shock in the tradable sector:

- If $\alpha = 1$, the fall in the nontradable production valued in terms of tradables $(y^N + p^N - p^T)$ is higher under a float than under a peg.
- When α diminishes, this fall is mitigated under a float.

Since tradable and nontradable goods are weakly substitutable ($\theta < 1$), prices move more than quantities. As a result, when $\alpha = 1$, the additional fall in the relative price of nontradables under a float offsets the additional fall in nontradable output under a peg. The production of nontradables expressed in tradables therefore falls more under a float than under a peg. When α diminishes, the stabilizing effect of the peso debt on the consumption of tradables makes the response of nontradable production in terms of tradables smoother under a float, because it stabilizes both the production and the real exchange rate, according to Proposition 1. This is illustrated by the behavior of $y^N + p^N - p^T$ in Figure 2.

3.3 Comparing regimes

The non stochastic steady-state cash flows Π are the same under both regime. However, uncertainty affects the distribution of Π_t through two main channels: the level of the stochastic steady state $E\Pi_t$, which differs from the non-stochastic steady state because of the presence of risk premia, and the volatility around $E\Pi_t$. These two channels are affected by the nature of the regime. Finally, the proportion of innovating firms $E\rho_t = EF(\Pi_t)$ depends on the distribution of Π_t, so $E\rho_t$ depends on the exchange rate regime. To make the comparison between exchange rate regimes tractable, we focus on small productivity shocks u_t.

Lemma 2 (proof in Appendix 1):

If F sufficiently concave around $u = 0$ and $\sigma^2 = 0$, then when u and σ^2 close to 0, $EF(\Pi_t^{flex}) - EF(\Pi_t^{fix})$ is of the same sign as $V(\pi^{fix}) - V(\pi^{flex})$.

Assuming that F is sufficiently concave insures that the effect of σ on the volatility around the steady state has a higher impact on growth than its effect on the stochastic steady state itself. In this case, more volatility around Π implies that in a boom, where Π_t is high, only a few more firms are able to overcome the liquidity shocks, whereas in slumps, where Π_t is low, many more firms are prevented from innovating. It then follows that the regime that results in more volatile cash flows Π_t yields a lower innovating probability. If this is not the case, then there is the possibility that more volatility could stimulate innovation and productivity growth in expansions. The empirical section suggests that this latter effect is dominated. In what follows, it is then admitted that lower volatility yields higher growth.

3.4 The impact of exchange rate regimes on growth

Once we admit that lower cash-flow volatility yields higher growth through higher innovating probability, it is possible to infer what regime is preferred in terms of growth.

Proposition 3 (proof in Appendix 1):

- If $\alpha = 1$, a peg yields higher growth than a float.
- When α decreases, the growth differential between a peg and a float decreases.
- If $\frac{\kappa(1-\theta)}{\eta[1+\kappa+(1-\kappa)\theta]} < 1$, there exist values of $\alpha > 0$ such that a float yields higher growth than a peg.

The first point of Proposition 3 is derived directly from Proposition 2. The second and third points come from the fact that the peso-denominated debt has two stabilizing effects on firms' cash flows under a float: 1) a direct stabilizing effect through the hedging role of debt repayments in pesos, 2) an indirect stabilizing effect through the stabilization of the nontradable gross profits expressed in terms of tradables (Proposition 2). Thus, under a flexible exchange rate regime, the level of dollarization has a negative impact on growth because it annihilate the hedging properties of the peso-denominated debt.

If the level of dollarization is high, then a fixed exchange rate regime is always better for growth. Indeed, in that case, the potential gross profit effects dominate the potential debt valuation effects and therefore a peg stabilizes the cash flow better. But if the indebtment level η and the elasticity of substitution θ are high and if the share of nontradable production κ is low, then when the level of dollarization is low, debt valuation effects can be high enough compared to profit effects to make a float more growth-enhancing than a peg for low values of dollarization.

Figure 3 shows the behavior of the variance of firms' cash flows under fixed and flexible exchange rate regimes for some parameter values. The dashed lines are constructed under the assumption that $\eta = 0.1$ (low level of debt) and the solid lines are drawn under the assumption that $\eta = 0.7$ (high level of debt). Besides, the elasticity of substitution θ has been set at 0.6, which is a standard estimate of the elasticity of substitution between tradable and nontradable goods (Lorenzo et al., 2005), and the weight of tradable goods in the consumption basket γ as well as in cash flows $1-\kappa$ are set to 0.4 (**?**). It appears clearly that the volatility of cash flows under a float increases with the level of dollarization under both parameters' configuration. Under the first hypothesis, the volatility of cash flows with the flexible exchange rate regime is always higher than with the fixed regime, whereas under the second hypothesis, the volatility becomes lower with the flexible exchange rate regime for small values of α.

As a conclusion, the testable empirical implication of this model is that fixed exchange rates are growth-enhancing as compared to flexible exchange rates in countries with high liability dollarization and that the growth differential is decreasing as the level of dollarization falls. Whether there are values of dollarization for which flexible exchange rate regimes become more growth-enhancing than fixed exchange rate regimes depend on parameters values.

4 Empirical Analysis

In this section, the prediction that the level of dollarization conditions the impact of exchange rate regimes on growth is tested. The basic hypothesis is that exchange rate flexibility has a more negative impact in dollarized countries. Some authors have already studied the impact of dollarization on growth: Reinhart et al. (2003) compare average growth rates for low and high dollarization economies, with mixed results, and Levy-Yeyati (2006) evaluates the effect of dollarization, showing that growth is sensibly smaller in financially dollarized economies. The effect of dollarization has never been assessed for different levels of exchange rate flexibility.

To do so, standard growth regressions are used (the baseline specification is taken from Levine et al. (2000)). Those standard growth regressions are augmented by a measure of exchange rate flexibility (as in Aghion et al. (2006)), a measure of external dollarization and the interaction term of exchange rate flexibility and dollarization. First, the data and methodology are presented and then the results based on a dynamic panel of 77 countries between 1995 and 2004 are discussed.

4.1 Data and methodology

As is common in the growth empirical literature, we work on non-overlapping five-year averages. This transformation aims at filtering business cycles fluctuations and so allows us to focus on long-run effects only.

4.1.1 The dependent variable

The explained variable is the average growth rate of productivity on a five-year period. Productivity is defined as the ratio of real output per worker. Real GDP is in 1995 PPP-adjusted US dollars. The work force and GDP data come respectively from the World Bank (World Development Indicators database) and CEPII (CHELEM database).

4.1.2 The dollarization variable

The most important and most problematic variable is the liability dollarization measure. It is difficult to find a measure which is both accurate and encompassing, because the currency breakdown of domestic and external liabilities is often not available.

The data provided by Hausmann et al. (2001) and Hausmann and Panizza (2003) are used to construct a proxy for liability dollarization. They provide measures of "original sin", that is the inability of an economy to borrow internationally in its own currency. Their dataset covers 90 industrial and developing countries. They rely on -non public- BIS data of the currency breakdown of foreign banks' assets and liabilities vis-à-vis industrial and developing countries and construct three indicators of original sin.

Those measures are restricted *de facto* to external dollarization and have a small time coverage, but they encompass industrial countries and thus allow a substantial variability in the dollarization index. Their advantage is that they give a good picture of the currency composition of the world's banking sector's assets in the economy, especially for debt securities. The problem is that they ignore domestic dollarization and do not distinguish the public from the private sector. However, first, domestic dollarization is likely to be correlated with external dollarization and second, the dollarization of the public sector has probably a similar impact as that of the private sector, since it prevents the government from subsidizing firms and helping them invest in the bad states. The original sin measures are provided as averages for 1993-1998 and 1999-2001, which allows to use only two 5-year sequences, 1995-1999 and 2000-2004. The dollarization index used in this paper is computed as the average of the three indicators. Its range is $[0, 1]$.

Figure 4 presents the distribution of original sin in industrial and developing countries. It appears that it is concentrated on its maximum value in developing countries, while in industrial countries it is lower on average and shows more variability. Besides, it is noteworthy that the original sin index varies only in 20% of the countries between 1993-1998 and 1999-2001. Those characteristics of the dollarization variable, that is high persistence and concentration on high values in developing countries, have to be born in mind when choosing the methodology and running the robustness checks.

4.1.3 Exchange rate flexibility variables

Two alternative measures of exchange rate flexibility are considered. The first measure is the volatility of the index of real effective exchange rate provided by the World Bank. Volatility is measured as the standard deviation of annual changes in the logarithm of the index, calculated over five years.

The second measure is an index of exchange rate flexibility based on the Levy-Yeyati and Sturzenegger (2002) (henceforth LS) classification of exchange rate regimes. They define exchange rate regimes according to the behavior of three classification variables: changes in the nominal exchange rate, the volatility of these changes, and the volatility of international reserves. Since originally this index is a measure of rigidity, exchange rate regimes are reordered from the more rigid to the more flexible: $\{1, 2, 3, 4\}$ = {fix, crawling peg, dirty float, float}. This index is averaged over five years.

While the first is a measure of *de facto* exchange rate volatility, the second is more a measure of exchange rate management. According to the prediction of the model, they are positively correlated (see Appendix 3): a more flexible exchange rate regime results in a higher real exchange rate volatility.

4.1.4 Other variables

The set of control variables follows Levine et al. (2000) and Aghion et al. (2006): financial development measured as in Beck et al. (1999) by the amount of credit provided by banks and other financial institutions to the private sector (as a share of GDP), education measured as the average years of secondary schooling (Barro and Lee, 2000), inflation and the size of government measured by governement consumption as a percentage of GDP and trade openness measured by the share of exports and imports in GDP (World Bank). Finally, the usable dataset covers 77 countries and two periods: 1995-1999 and 2000-2004. When real exchange rate volatility is used, this sample reduces to 51 countries, among which 12 have only one observations, and when the LS flexibility index is used, it reduces to 75 countries, among which

17 have only one observation. Appendix 2 gives the exhaustive list of countries present in both samples and Appendix 3 provides some descriptive statistics.

4.1.5 Methodology

The benchmark specification follows Levine et al. (2000) and Aghion et al. (2006). But, instead of interacting exchange rate flexibility and financial development as Aghion et al. (2006) do, I interact exchange rate flexibility and dollarization. The estimated equation is the following:

$$\Delta y_t^i = y_t^i - y_{t-1}^i = (\alpha - 1) y_{t-1}^i + \gamma_1 Flex_t^i + \gamma_2 OSIN_t^i + \gamma_3 Flex_t^i * OSIN_t^i + \beta' Z_t^i + d_t + \epsilon_t^i \qquad (28)$$

where y_t^i is the logarithm of real output per worker in country i at the end of period t, $t = 1995 - 1999, 2000 - 2004$, $Flex_t^i$ is the exchange rate flexibility measure, $OSIN_t^i$ is the measure of original sin, Z_t^i is the set of control variables, d_t is a time effect and ϵ_t^i is the error term.

$\gamma_1 + \gamma_3 OSIN_t^i$ describes the overall effect of exchange rate flexibility on growth. γ_1 (the linear term) and $\gamma_1 + \gamma_3$ (which is provided as complementary information) can be interpreted respectively as the effect of exchange rate flexibility in low dollarization countries (original sin=0) and in high dollarization countries (original sin=1). The threshold original sin for which the sign of the overall impact of exchange rate flexibility changes is $\frac{-\gamma_1}{\gamma_3}$. The estimate for $\frac{-\gamma_1}{\gamma_3}$ is provided along with its significance test as complementary information in the regressions. Besides, a Wald test for the significance of exchange rate total effect is run.

The main hypothesis to test is whether exchange rate volatility has a more negative effect on growth when the level of dollarization increases. This would be validated by the data if γ_3 is found significantly negative. Otherwise, the model would be rejected. The second hypothesis is that the threshold original sin $\frac{-\gamma_1}{\gamma_3}$ is between 0 and 1. This would mean that the impact of exchange rate risk on growth switches from positive to negative within the actual range of the original sin measure. The validation of this hypothesis would shed some light on the exchange rate instability puzzle, which could then be explained by the presence of this kind of non-linearities.

First OLS are run with time effects to estimate this model. However, since it is a dynamic model, country effects are necessarily correlated with y_{t-1}^i. The GMM dynamic panel data estimator developed by Arellano and Bond (1991), Arellano and Bover (1995) is implemented. The persistence of the dollarization data justifies the use of the extended system-GMM estimator elaborated by Blundell and Bond (1998) and Blundell and Bond (2000). Robust two-step standard errors are also computed by following the method of Windmeijer (2004). Using this approach, the issue of the endogeneity of the lagged explained variable is addressed, with different assumptions about the status of the other explanatory variables: strict exogeneity, predetermination and endogeneity. Original sin can only be considered as predetermined because higher lags are not available. Robustness checks are then considered by adding other controls.

4.2 The role of financial dollarization

4.2.1 OLS

Table 1 shows the results of the OLS regression of productivity growth on the set of explanatory variables described earlier, using equation (28).

Consider the impact of exchange rate flexibility and original sin on growth. The literature has underscored several times the absence of *linear* long-run effects of exchange rate flexibility on productivity growth. Regressions (1) and (4) confirm this fact again: the impact of exchange rate flexibility on growth is not significant, whether it is measured by the standard deviation of the real exchange rate (column (1)) or by the LS measure of exchange rate flexibility (column (4)). When the sample is restrained to data points for which the original sin measure is available (columns (2) and (5)), this effect becomes significantly negative. This is because the size of the sample has diminished and it does not challenge common wisdom.

Importantly, as column (3) shows, liability dollarization makes the impact of real exchange rate volatility on growth more negative, as conjectured. This is illustrated by the fact that the coefficient of the interaction term of original sin and real exchange rate volatility is significantly negative (at the 5% level). Similarly, the results of column (6) suggest that a higher level of dollarization makes exchange rate flexibility significantly more costly in terms of growth (at the 1% level) when it is measured by the LS index.

As conjectured, the threshold level is between 0 and 1: respectively 0.44 when using real exchange rate volatility and 0.50 when using the LS flexibility index. As a consequence, on the one hand, the impact of exchange rate flexibility is significantly negative in both specifications when original sin is equal to 1. On the other hand, exchange rate flexibility has a positive impact on growth in low dollarization countries (the coefficient of the linear term is positive), but this impact is not significant when using real exchange rate volatility. In both specifications, the total effect of exchange rate flexibility is significant.

Column (7) gives a clue about how the impact of exchange rate volatility on growth is channeled. It includes the mean real exchange rate depreciation rate and its interaction with original sin. It shows that a real exchange rate depreciation has a negative impact on growth, and that this negative impact is magnified by the level of dollarization (the interaction term is negative and significant at the 10% level). This confirms the prediction of the model that a real depreciation hampers growth by disrupting firms' balance sheets when their level of dollarization is high. This also suggests that the negative effect of exchange rate volatility on growth comes mainly from the depreciation episodes. Note also that a real exchange rate depreciation is never growth enhancing (the threshold level is not significantly different from zero).

4.2.2 GMM

In order to avoid the shortcomings of OLS, the GMM methodology is implemented.

Table 2 reports the results of the GMM regressions. These results are drawn under the following assumption: all the explanatory variables except initial income are predetermined and they are uncorrelated with fixed effects. This assumption about the explanatory variables has been chosen after excluding more restrictive ones which suffered from weak instruments issues according to the Anderson and Cragg-Donald tests of underidentification. These tests assess whether the equation is identified and whether the instruments give sufficient information to identify the effect of the variable of interest. As shown in Table 2, these tests reject underidentification in all columns. Therefore, this set of instrument does not show weak instruments problems. According to the Hansen test, it can also be considered as globally valid, despite the use of a large number of instruments. Moreover, difference-in-Sargan tests can help evaluate the exogeneity of subsets of instruments. After running some of those tests, it appears that neither the predetermination of regressors nor the absence of correlation between the latter and fixed effects can be rejected at the 10% level. However, because of data scarcity, it is problematic to use second order lags of original sin. But, as highlighted by Aghion et al. (2006), the interaction term is less vulnerable to potential endogeneity issues than the corresponding linear terms.

The results of columns (1) and (2) of Table 2 are again in line with the main model's prediction, which is that the impact of exchange rate flexibility on growth is more negative when the level of dollarization is higher, according to the coefficients of the interaction terms. Both regressions provide the same - significant - threshold original sin (respectively 0.52 and 0.55). The second conjecture is again satisfied since it is in the right range. As a result, consider the two extreme cases: when original sin is maximal, exchange rate rigidity is significantly better for growth while exchange rate flexibility is preferred when original sin is minimal, but not necessarily in a significant fashion (the coefficient of the linear term of exchange rate flexibility is not significant when using real exchange rate volatility (column (1)). Column (3) confirms the negative impact of a real depreciation, especially in highly dollarized countries. The effect is even stronger in absolute value and in term of significance than with the OLS methodology.

To illustrate the magnitude of these effects, consider South Africa: between the end of the nineties and the beginning of the 2000s, its index of original sin moved from 0.78 to 0.58. Considering its real exchange rate volatility (0.16) and its LS index (4) during 200-2004, its growth gain is respectively 1.3 or 0.9 percentage point per year, depending on the specification. Similarly, an entirely dollarized emerging country (original sin index equal to 1) with a rather high exchange rate flexibility like Colombia during 2000-2004 (real exchange rate volatility equal to 0.10 and flexibility index equal to 4) would gain 1.8 percentage point of annual growth according to both models.

Up to this stage, the hypothesis of the existence of a nonlinear effect of exchange rate volatility on growth is not rejected by the data when using the OLS methodology and some reasonable GMM specifications. More specifically, exchange rate rigidity is found to be growth-enhancing in high dollarization countries. The fact that exchange rate flexibility promotes growth in low dollarization countries is also suggested by the data but is less robust. The remainder of the section explores further robustness issues. The next regressions will also be run using the GMM methodology and under the assumption of predetermined regressors and absence of correlation with fixed effects.

4.3 Robustness checks

Tables 3 reports the results of the same regressions as before, using the two-stage system-GMM and Windmeijer (2004) small sample robust standard errors, but with additional variables to control for potential simultaneity. Columns (1) and (5) incorporate the average of Kaufmann et al. (1999) Governance indicators, which is taken as a proxy for institutional quality. Columns (2) and (6) include the logarithm of net external debt over GDP and column (3) and (7) present the results with both additional controls.

One surprising outcome is that the coefficient of financial development is significantly negative in columns (2) and (3), that is when real exchange rate volatility is used as a measure of flexibility and net debt is introduced, which is not in line with Levine et al. (2000) and Aghion et al. (2006). This might be explained by the fact that the dataset used here is smaller and more subject to colinearity problems. Indeed, the correlation matrix provided in Appendix 3 shows a high negative correlation between financial development and original sin on the one hand and financial development and external debt on the other. To show whether this colinearity problem drives the main results, the financial development variable is removed in column (4).

As for the effect of original sin and the real exchange rate volatility, consider the first four columns: the inclusion of additional controls does not change the results. The additional controls themselves do not appear significant. The impact of the interaction term is negative, even when financial development is removed (column (4)). When the LS index of exchange rate flexibility is used (last three columns), the results are less robust, especially when both the institutional variable and net external debt are included: in column (7), the coefficient of the interaction term is not significant at the conventional levels, though it still has a negative sign. Nevertheless, it is worth noticing that its level of significance is 11%, which is close to the conventional ones. The Kaufmann governance index has a positive but often non significant impact, and net external debt has a negative, non-significant impact on growth, which may be explained by the growth costs of debt defaults.

In the theoretical model, the firms' vulnerability is caused mainly by the volatility of the price of nontradables in terms of tradables. However, the view that the volatility of the real exchange rate is mainly driven by the volatility of the price of nontradables is controversial. On the one hand, Engel (1999) shows that the variability of the relative price of tradable goods accounts for most of the real exchange rate volatility in the United States. On the other hand, Mendoza (2000) provides evidence that the variance decomposition of real exchange rate variations between variations in the relative price of tradable goods and variations in the price of nontradables in terms of tradables is unstable across countries and across periods, and depends on the exchange rate regime. Table 4 introduces terms of trade volatility and its interaction with original sin to control for the volatility of the relative price of tradable goods. The interaction of the exchange rate flexibility measure and original sin remains significantly negative at the 10% level when using the real exchange rate volatility (columns (1) to (3)). In column (1) and (2), the financial development variable appears with a negative sign, so it is excluded in column (3). Despite this, The interaction term is still significantly negative. When using the LS flexibility measure, and when only the linear terms-of-trade volatility term is introduced, the interaction term has a negative impact on growth, but not in a significant fashion (column (4)). However, when introducing the interaction of terms-of-trade volatility term with original sin, it becomes significant (column (5)).

Table 5 presents further robustness checks. The question tackled here is the role of currency crises. Currency crisis episodes are eliminated from the sample to check whether the negative growth effect of the interaction between original sin and exchange rate volatility is limited to episodes of financial turmoil. A currency crisis episode is defined by the two following conditions:

- There is a substantial depreciation: the nominal exchange rate change within one year is greater than 25% and exceeds by at least 10% the exchange rate change of the previous year, which is the definition of a currency crisis suggested by Frankel and Rose (1996).
- The depreciation follows a peg. The periods of pegged exchange rate are determined by referring to the classification of LS. Besides, the year of the depreciation must not be classified by LS as a peg.

The currency crisis episodes are defined so as to detect temporary and substantial disruptions of pegs that result in exchange rate volatility and thus could be misleadingly taken as the outcome of a flexible exchange rate regime. It is essential to remove them to confirm the benefit of fixed exchange rate regimes. Again, the control variables have the expected signs or, at worst, are not significant. As for the variables of interest, the results remain robust: when considering real exchange rate standard deviations, the interaction term is significant at the 10% level, and when considering the LS index of exchange rate flexibility, it is significant at the 5% level. This shows that the particularly negative impact of flexible exchange rate regimes in dollarized countries highlighted before is not due to financial turmoil episodes.

Table 6 tries to answer a legitimate question: are the results due to the fact that original sin is very high in developing countries and low in industrial economies in general? Then the results could reflect only the fact that exchange rate flexibility is bad for growth in emerging economies as other authors have already shown, without proving necessarily the role of dollarization. This objection is justified by the observation that original sin is very correlated with the fact of being a developing or industrial country (see Figure 4 and the correlation between initial productivity and original sin in Appendix 3). A dummy for industrial countries and its interaction with exchange rate flexibility measures are thus added. The results are robust: when using the standard deviation of the real exchange rate (columns (1) and (2)), the coefficient of the interaction term remains negative at the 10% level even when the interaction of the industrial country dummy and volatility is added. When using the LS index of exchange rate flexibility (columns (3) and (4)), the significance of the interaction term remains significant at the 5% or 10% level. The significance of the interaction term certainly declines with both measures, but remains at reasonable levels considering the sample size and the high correlation between the industrial country dummy and original sin.

As a conclusion, the nonlinear effect of exchange rate flexibility and original sin on growth is globally robust to the inclusion of institutional quality, indebtment measures, and terms-of-trade volatility: exchange rate volatility has a more negative impact on productivity growth in dollarized than in non-dollarized countries. Besides, this additional negative effect is not due to exchange rate crisis episodes. Finally, the correlation between the industrial country dummy and original sin is not enough to explain the significance of the interaction term: there is still enough volatility in the original sin index to identify a significant nonlinear effect. The threshold original sin is still significantly between 0 and 1.

Conclusion

As Aghion et al. (2006), this paper challenges the conventional view that there is no significant difference in the growth performances of fixed and flexible exchange rate regimes. This view has been misleadingly vehicled by the empirical literature because usually the specificity of emerging markets financial systems is not taken into account. But, whereas Aghion et al. (2006) highlight the role of financial development, this paper focuses on original sin, which is another prominent feature of the developing world. A theoretical model is developed, in which the higher the share of foreign currency in external debt, the more exchange rate volatility is detrimental to growth, which is in line with the empirical results of section 4: the interaction of exchange rate flexibility with original sin has a negative impact. It also appears that exchange rate flexibility is growth-reducing in highly dollarized countries and growth-enhancing in low dollarization countries (but this last effect is not always significant). Consistently, the threshold original sin above which exchange rate risk becomes detrimental to growth is estimated to be significantly between 0 and 1. This sheds some light on the instability of the effect of exchange rate volatility on growth in previous litterature.

It is also shown that these predictions are robust to the inclusion of institutional quality, net external debt and terms-of-trade volatility, and are not the mere reflect of the heterogeneity between developing and industrial countries. Besides, they are robust to the elimination of exchange rate crisis episodes. However, further robustness checks were prevented by the lack of data: the GMM methodology could not be used to tackle the possible contemporaneous endogeneity of original sin since only two five-year averages were available. It was not possible either to study the three-way interaction of exchange rate flexibility, liability dollarization and financial development, because of the lack of data. An extension of this work would therefore have to rely on broader datasets, either by extending the time coverage or by using firm-level information.

References

Aghion, P., P. Bacchetta, R. Rancière and K. Rogoff (2006), 'Exchange rate volatility and productivity growth: The role of financial development', NBER Working Paper No 12117.

Arellano, M. and O. Bover (1995), 'Another look at the instrumental-variable estimation of error components models', *Journal of Econometrics* **68**, 29–51.

Arellano, M. and S. Bond (1991), 'Some tests of specification for panel data: Monte carlo evidence and an application to employment equations', *Quarterly Journal of Economics* **120**(1), 173–222.

Barro, R. J. and J.-W. Lee (2000), 'International data on educational attainment: Updates and implications'.

Baxter, M. and A. Stockman (1989), 'Business cycles and the exchange rate regime', *Journal of Monetary Economics* **23**(3).

Beck, T., A. Demirguc-Kunt and R. Levine (1999), 'A new database on financial developement and structure', World Bank Policy Research Working Paper No 2146.

Blundell, R. and S. Bond (1998), 'Initial conditions and moment conditions in dynamic panel data models', *Journal of Econometrics* **87**, 115–143.

Blundell, R. and S. Bond (2000), 'Gmm estimation with persistent panel data: An application to production functions', *Econometric Reviews* **19**, 321–340.

Calvo, G., A. Izquierdo and L.-F. Mejia (2004), 'On the empirics of sudden stops: The relevance of balance-sheet effects'.

De Grauwe, P. and G. Schnabl (2005), 'Exchange rate stability, inflation and growth in (south) eastern and central europe', Mimeo.

Dubas, J.M., B.-J. Lee and N.C. Mark (2005), 'Effective exchange rate classifications and growth', NBER Working Paper No 11272.

Eichengreen, B. and R. Hausmann (1999), 'Exchange rates and financial fragility', NBER Working Paper No 7418.

Engel, C. (1999), 'Accounting for u.s. real exchange rate changes', *Journal of Political Economy* **107**(3), 507–38.

Frankel, J.A. and Andrew K. Rose (1996), 'Currency crashes in emerging markets: An empirical treatment', *Journal of International Economics* **41**, 351–66.

Hausmann, R. and H. Panizza (2003), 'On the determinants of original sin: an empirical investigation', *Journal of International Money and Finance* **22**(7).

Hausmann, R., H. Panizza and E. Stein (2001), ‘Why do countries float the way they float?’, *Journal of Development Economics* **2**(66).

Husain, A. M., A. Mody and K. Rogoff (2005), ‘Exchange rate regime durability and performance in developing versus advanced economies’, *Journal of Monetary Economics* **52**(1).

Kaufmann, D., A. Kraay and P. Zoido-Lobaton (1999), ‘Aggregating governance indicators’, World Bank Policy Research Working Paper No 2195.

Levine, R., Norman Loayza and T. Beck (2000), ‘Financial intermediation and growth: Causality and causes’, *Journal of Monetary Economics* **46**(1), 31–77.

Levy-Yeyati, E. (2006), ‘Financial dollarization: Evaluating the consequences’, *Economic Policy* (january), 61–118.

Levy-Yeyati, E. and F. Sturzenegger (2002), ‘Classifying exchange rate regimes: Deeds vs. words’, Mimeo, Universidad Torcuato Di Tella available at www.utdt.edu/ fsturzen.

Lorenzo, F., D. Aboal and R. Osimani (2005), ‘The elasticity of substitution in demand for non-tradable goods in uruguay’, Inter-American Development Bank Research Network Working paper No R-480.

Mendoza, E.G. (2000), ‘On the instability of variance decompositions of the real exchange rate across exchange- rate-regimes: Evidence from mexico and the united states’, NBER Working Paper No 7768.

Razin, A. and Y. Rubinstein (2006), ‘Evaluation of currency regimes: the unique role of sudden stops’, *Economic Policy* **46**, 119–152.

Reinhart, C.M., K.S. Rogoff and M. Savastano (2003), ‘Addicted to dollars’, NBER Working Paper No 10015.

Windmeijer, F. (2004), ‘A finite sample correction for the variance of linear two-step gmm estimator’, *Journal of Econometrics* **126**(1), 25–51.

Appendix

Appendix 1: Proofs

Existence and uniqueness of the steady-state equilibrium

P^N/W is implicitely defined by (20) as a function of P^T/W. Denote by $P_1^N(.)$ this function.

The LHS of (22) is decreasing in $\frac{P^N}{W}$ and $\frac{P^T}{W}$ while the RHS is increasing in $\frac{P^N}{W}$. (22) defines another implicit relation between P^N/W and P^T/W. Denote this implicit function of P^T/W as $P_2^N(.)$. P_2^N is strictly decreasing in P^T/W with $P_2^N(0) > 0$ and $(P_2^N)^{-1}(0) > 0$. Since $P_1^N(.)$ is continuous and strictly increasing, with $\lim P_1^N(P^T)_{P^T\to 0} = 0$ and $\lim P_1^N(P^T)_{P^T\to\infty} = \infty$, there exists only one positive intersection of P_1^N and P_2^N. This intersection defines P^N/W and P^T/W. P^N/W and P^T/W do not depend on the exchange rate regime.

Under a fixed exchange rate regime, P^T is fixed. We can then infer $W = P^T \frac{1}{P^T/W}$ and then $P^N = W \frac{P^N}{W}$. P is then derived from the price index (11).

Under a flexible exchange rate regime, P/W can be derived using the price index (11). Since P is fixed, we can derive $W = P \frac{1}{P/W}$, and from it $P^T = W \frac{P^T}{W}$ and $P^N = W \frac{P^N}{W}$.

Proof of Proposition 1

- From Lemma 1, if $u < 0$:

  $y^{Nflex} > y^{Nfix} \Leftrightarrow \gamma(\theta+1) < \theta + \gamma + (1-\gamma)\eta(1-\alpha) \Leftrightarrow (1-\gamma)[\theta + \eta(1-\alpha)] > 0$: always true.

  $p^{Nflex} - p^{Tflex} < p^{Nfix} - p^{Tfix} \Leftrightarrow \theta + 1 > \theta + \gamma + (1-\gamma)\eta(1-\alpha) \Leftrightarrow \alpha > 1 - \frac{1}{\eta}$, true for $\alpha = 1$.

- From Lemma 1, y^{Nflex} and $p^{Nflex} - p^{Tflex}$ are both decreasing in $(1-\alpha)$.

Proof of Proposition 2

- From Lemma 1, we derive:

$$y^{Nflex} + p^{Nflex} - p^{Tflex} = \frac{\kappa(1+\gamma)(\eta+1)u}{\theta + \gamma + (1-\gamma)\eta(1-\alpha)} < y^{Nfix} + p^{Nfix} - p^{Tfix} = \frac{2\kappa(\eta+1)u}{\theta+1}$$

  if $u < 0$:

$$\Leftrightarrow \frac{(\kappa(1+\gamma)(\eta+1)}{\theta + \gamma + (1-\gamma)\eta(1-\alpha)} > \frac{2\kappa(\eta+1)}{\theta+1}$$

$$\Leftrightarrow \kappa(1+\gamma)(\theta+1) > 2\kappa[\theta + \gamma + (1-\gamma)\eta(1-\alpha)]$$

  after rearranging:

$$\Leftrightarrow \alpha > 1 - \frac{\kappa(1-\theta)}{\eta}$$

  true for $\alpha = 1$ since $\theta < 1$

- $y^{Nflex} + p^{Nflex} - p^{Tflex}$ decreasing in $(1-\alpha)$.

Proof of Lemma 2

Consider $F(\Pi(u, \sigma^2))$ and take a second-order expansion around $u = 0$ and $\sigma^2 = 0$:

$$F(\Pi(u,\sigma^2)) = F(\Pi(0,0)) + \frac{\partial F(\Pi)}{\partial u}(0,0)u + \frac{\partial F(\Pi)}{\partial \sigma^2}(0,0)\sigma^2 + \frac{1}{2}\frac{\partial^2 F(\Pi)}{\partial u \partial \sigma^2}(0,0)u\sigma^2 + \frac{1}{2}\frac{\partial^2 F(\Pi)}{\partial u^2}(0,0)u^2 + \frac{1}{2}\frac{\partial^2 F(\Pi)}{(\partial \sigma^2)^2}(0,0)\sigma^4$$

Its expected value can be approximated by (terms of higher order than σ^2 are neglected):

$$EF\Pi(\sigma^2) = F(\Pi(0,0)) + \left[\frac{\partial F(\Pi)}{\partial \sigma^2}(0,0) + \frac{1}{2}\frac{\partial^2 F(\Pi)}{\partial u^2}(0,0)\right]\sigma^2$$

We have:

$$\frac{\partial F(\Pi)}{\partial \sigma^2}(0,0) = f(\Pi(0,0))\frac{\partial \Pi}{\partial \sigma^2}(0,0)$$

$$\frac{\partial^2 F(\Pi)}{\partial u^2}(0,0) = f(\Pi(0,0))\frac{\partial \Pi}{\partial u^2}(0,0) + f'(\Pi(0,0))\left(\frac{\partial \Pi}{\partial u}(0,0)\right)^2$$

So, if $|f'|$ sufficiently high, then:

$$EF\Pi(\sigma^2) = \frac{1}{2}f'(\Pi(0,0))\left(\frac{\partial \Pi}{\partial u}(0,0)\right)^2$$

When u small, $\Pi(u,0) = \Pi(\pi+1)$ with $\pi = \bar{\pi}u$, so $\frac{\partial \Pi}{\partial u}(0,0) = \Pi\bar{\pi}$

As a consequence, since $f'(\Pi^{flex}(0,0)) = f'(\Pi^{fix}(0,0)) = f'(\Pi(0,0))$:

$$EF(\Pi^{fix}) - EF(\Pi^{flex}) = \frac{1}{2}f'(\Pi(0,0))\Pi[(\bar{\pi}^{fix})^2 - (\bar{\pi}^{flex})^2]\sigma^2$$

We have $V(\pi) = \bar{\pi}^2\sigma^2$, so:

$$EF(\Pi^{fix}) - EF(\Pi^{flex}) = \frac{1}{2}f'(\Pi(0,0))\Pi[V(\pi^{fix}) - V(\pi^{flex})]$$

So, if $f' < 0$ (F concave), then $EF(\Pi^{fix}) - EF(\Pi^{flex})$ is of the same sign as $V(\pi^{flex}) - V(\pi^{fix})$.

Proof of Proposition 3

From Lemma 1, we derive:

$$\pi^{flex}(u) = \frac{[\theta+\gamma+\kappa(1-\theta)](\eta+1)}{\theta+\gamma+(1-\gamma)\eta(1-\alpha)}u$$

$$\pi^{fix}(u) = \frac{[\theta+1+\kappa(1-\theta)](\eta+1)}{\theta+1}u$$

Thus:

$$V(\pi^{flex}) = \frac{[\theta+\gamma+\kappa(1-\theta)]^2(\eta+1)^2}{[\theta+\gamma+(1-\gamma)\eta(1-\alpha)]^2}\sigma^2 = \left(\frac{\partial \pi^{flex}}{\partial u}\right)^2\sigma^2$$

$$V(\pi^{fix}) = \frac{[\theta+1+\kappa(1-\theta)]^2(\eta+1)^2}{(\theta+1)^2}\sigma^2 = \left(\frac{\partial \pi^{fix}}{\partial u}\right)^2\sigma^2$$

- $V(\pi^{flex}) > V(\pi^{fix}) \Leftrightarrow [\theta+\gamma+\kappa(1-\theta)](\theta+1) > [\theta+1+\kappa(1-\theta)][\theta+\gamma+(1-\gamma)\eta(1-\alpha)]$

  $\Leftrightarrow \alpha > 1 - \frac{\kappa(1-\theta)}{\eta[1+\kappa+(1-\kappa)\theta]}$: true for $\alpha = 1$ since $\theta < 1$.

- $\frac{\partial(V(\pi^{fix})-V(\pi^{flex}))}{\partial\alpha} = \frac{-\partial V(\pi^{flex})}{\partial\alpha}$

  $\frac{\partial V(\pi^{flex})}{\partial\alpha}$ is of the same sign as $\frac{\partial\pi^{flex}}{\partial u\partial\alpha}$, which is positive, so $\frac{\partial(V(\pi^{fix})-V(\pi^{flex}))}{\partial\alpha} < 0$.

- $V(\pi^{fix}) > V(\pi^{flex}) \Leftrightarrow \alpha > 1 - \frac{\kappa(1-\theta)}{\eta[1+\kappa+(1-\kappa)\theta]}$ and $1 - \frac{\kappa(1-\theta)}{\eta[1+\kappa+(1-\kappa)\theta]} > 0 \Leftrightarrow \frac{\kappa(1-\theta)}{\eta[1+\kappa+(1-\kappa)\theta]} < 1$

Appendix 2: Countries in sample

Asia

China
Hong Kong, China*
India*
Indonesia*
Korea, Rep.*
Malaysia
Pakistan
Philippines
Sri Lanka*
Thailand*

Transition countries

Bulgaria
Czech Republic
Cyprus (only 95-99)
Estonia*
Hungary (only 00-04)
Kazakhstan (only 00-04)*
Latvia*
Lithuania*
Moldova (only 95-99)
Poland
Romania (only 00-04)
Slovak Republic
Slovenia*
Turkey*
Ukraine 95-99
Ukraine 00-04**

Latin America

Argentina*
Bolivia (only 95-99)
Brazil*
Chile
Colombia
Costa Rica
Dominican Republic
Ecuador
El Salvador*
Guatemala*
Jamaica*
Mexico*
Nicaragua
Panama (only 95-99)*
Papua New Guinea (only 95-99)
Peru*
Trinidad and Tobago 95-99**
Trinidad and Tobago 00-04
Uruguay
Venezuela, RB (only 95-99)

Middle East and North Africa

Algeria (only 95-99)
Bahrain (only 95-99)
Egypt, Arab Rep. (only 00-04)*
Israel
Oman (only 95-99)*
Morocco**
Tunisia

Sub-Saharan Africa

Kenya (only 95-99)*
Mauritius*
South Africa
Zimbabwe (only 95-99)*

Industrial countries

Australia
Austria (only 00-04)
Belgium (only 00-04)
Canada
Denmark
Finland
France (only 00-04)
Germany
Greece
Ireland
Italy
Japan
Netherlands (only 00-04)
New Zealand
Norway
Portugal
Spain
Sweden
Switzerland
United Kingdom
United States

*: Not in the REER volatility sample.

**: Not in the LS flexibility index sample.

Appendix 3: Descriptive statistics

Summary statistics 1995-2004 (data in five-year averages)

Variable	Observations	Mean	Std. Dev.	Min	Max
Productivity growth	134	0,02	0,02	-0,05	0,10
Initial productivity	134	26413,24	18668,75	2172,53	70091,68
Financial development	134	0,53	0,39	0,03	1,63
Education	134	83,79	28,43	14,00	158,76
Trade openness	134	81,38	46,03	18,11	322,35
Inflation	134	0,08	0,11	-0,02	0,78
Government burden	134	15,87	5,17	5,52	29,21
Kaufman governance indicator	134	3,19	4,83	-7,06	11,69
Net external debt	134	0,24	0,42	-2,15	1,88
Real effective exchange rate volatility	90	0,06	0,04	0,01	0,19
LS Index of exchange rate flexibility	129	2,40	1,18	1,00	4,00
Original sin	134	0,86	0,22	0,20	1,00

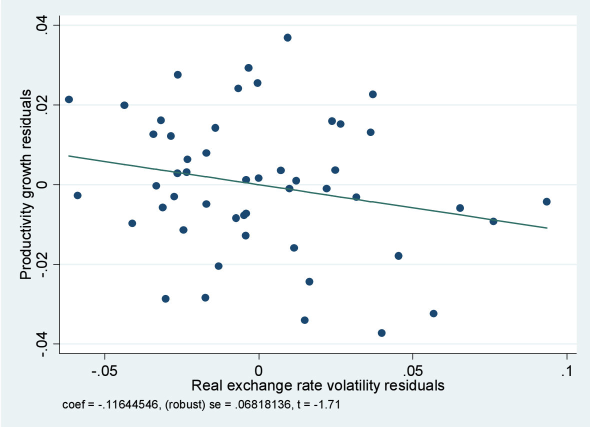
Sample correlations 1995-2004 (data in five-year averages)

	Productivity growth	Initial productivity	Financial development	Education	Trade openness	Inflation
Productivity growth	1,00					
Initial productivity	0,13	1,00				
Financial development	0,19	0,61	1,00			
Education	0,22	0,74	0,51	1,00		
Trade openness	0,11	-0,05	0,00	0,01	1,00	
Inflation	-0,44	-0,44	-0,48	-0,34	-0,01	1,00
Government burden	-0,09	0,50	0,20	0,62	0,06	-0,20
Kaufman governance indicator	0,29	0,84	0,63	0,80	0,02	-0,48
Net external debt	-0,24	-0,39	-0,36	-0,22	-0,24	0,18
Real effective exchange rate volatility	-0,51	-0,37	-0,31	-0,25	-0,07	0,59
LS Index of exchange rate flexibility	-0,22	-0,18	-0,21	-0,06	-0,30	0,10
Original sin	-0,02	-0,68	-0,65	-0,50	0,24	0,35

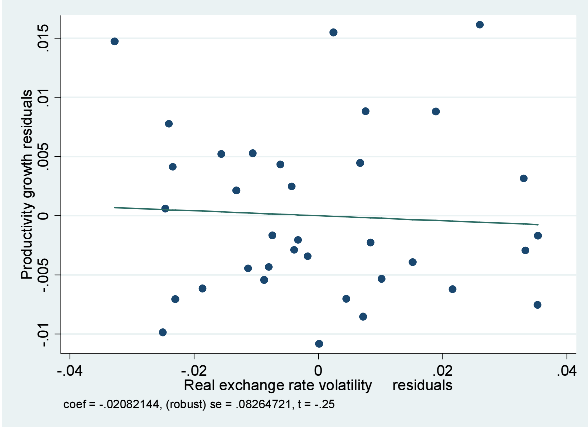
	Government Burden	Kaufman governance indicator	Net external debt	Real effective exchange rate volatility	LS Index of exchange rate flexibility	Original sin
Government burden	1,00					
Kaufman governance indicator	0,44	1,00				
Net external debt	0,01	-0,31	1,00			
Real effective exchange rate volatility	-0,16	-0,42	0,11	1,00		
LS Index of exchange rate flexibility	-0,07	-0,16	0,09	0,26	1,00	
Original sin	-0,23	-0,59	0,31	0,17	0,00	1,00

Figure 1: Real exchange rate volatility, exchange rate flexibility and productivity growth

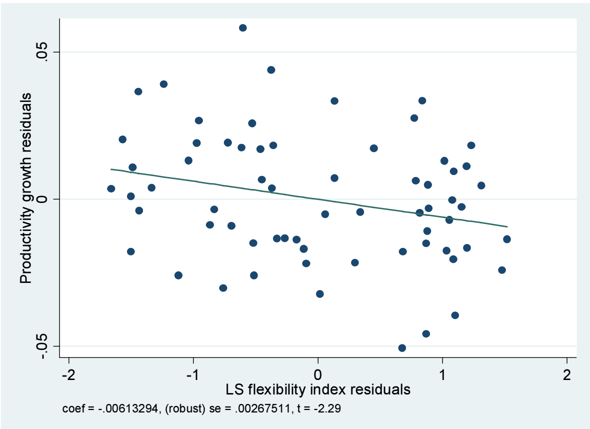
High levels of dollarization (above median)*



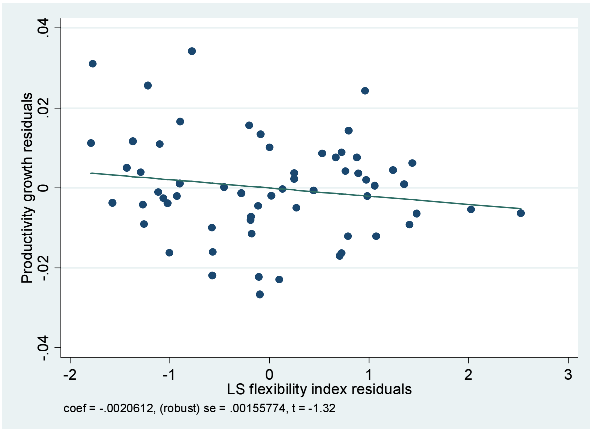
Low levels of dollarization (below median)*



High levels of dollarization (above median)*

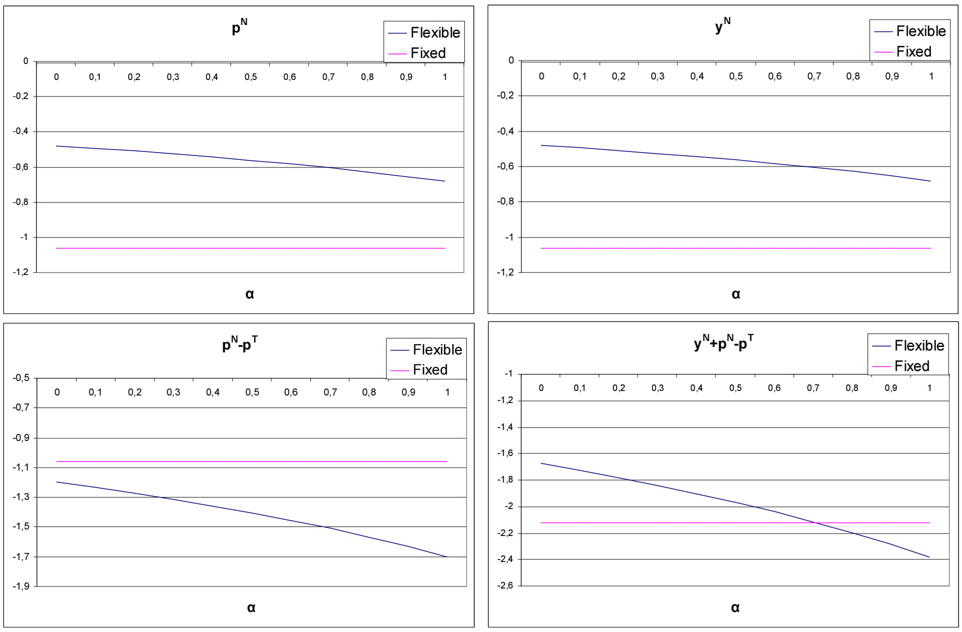


Low levels of dollarization (below median)*



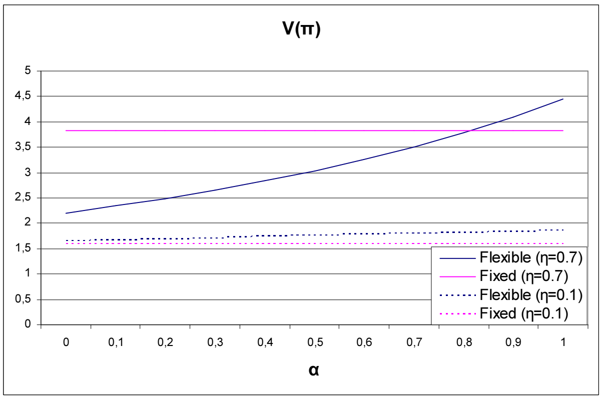
*: Pooled regressions of productivity growth, real exchange rate volatility (standard deviation of real exchange rate changes) and exchange rate flexibility (LS classification of exchange rate management) are performed using five-year average data for 51 (upper graphs) to 75 (lower graphs) countries over 1995-2005. The control variables include initial productivity, financial depth, secondary schooling, government expenditure, inflation, trade openness. For each group, the regressions are performed and then the residuals of productivity growth are regressed on the residuals of real exchange rate volatility or exchange rate flexibility.

Figure 2: The effect of a negative shock in the tradable sector ($u = -1$)



Assumptions: $\theta = 0.6$, $\gamma = 0.4$, $\kappa = 0.6$, $\eta = 0.7$.

Figure 3: The variance of firms' cash flows



Assumptions: $\theta = 0.6$, $\gamma = 0.4$, $\kappa = 0.6$.

Figure 4: Distribution of original sin in industrial and developing countries

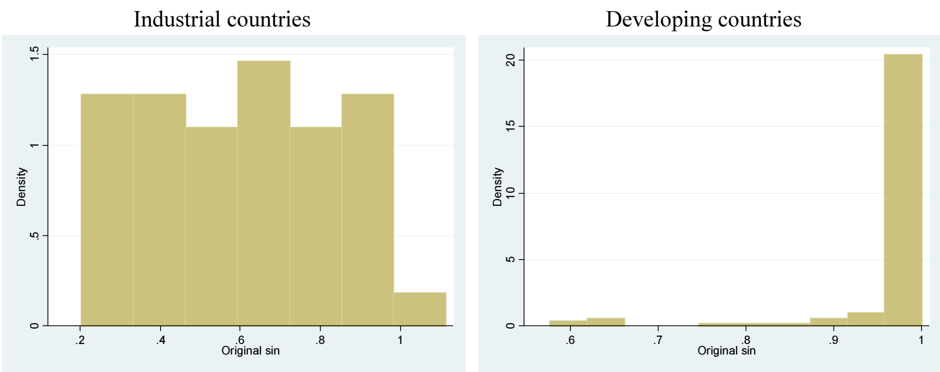


Table 1: Growth effects of the flexibility of Exchange Rate Regime - OLS with robust standard errors and time effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Initial output per worker	-0.013**	-0.010	-0.006	-0.004	-0.011**	-0.008	-0.005
	(2.17)	(1.37)	(0.81)	(1.11)	(2.04)	(1.40)	(0.74)
Financial development	0.002	-0.001	-0.001	0.001	-0.002	-0.001	0.001
	(0.35)	(0.34)	(0.31)	(0.28)	(0.44)	(0.23)	(0.28)
Original sin			0.034**			0.043**	0.018*
			(2.15)			(2.41)	(1.83)
Real effective exchange rate volatility	-0.077	-0.211***	0.203				
	(1.53)	(3.17)	(1.15)				
REER volatility*Original sin			**-0.461****				
			(2.02)				
LS index of exchange rate flexibility				-0.002	-0.005***	0.007**	
				(1.37)	(2.73)	(2.22)	
LS Flexibility*Original sin						**-0.014*****	
						(2.84)	
REER Depreciation							-0.006
							(0.03)
REER Depreciation*Original sin							**-0.444***
							(1.72)
Control variables							
Education	0.021**	0.032***	0.030***	0.009	0.031***	0.027***	0.018*
	(2.40)	(3.26)	(3.10)	(1.54)	(3.66)	(3.36)	(1.72)
Trade openness	0.006	0.003	0.003	0.005*	0.004	0.005	0.002
	(1.40)	(0.72)	(0.62)	(1.66)	(1.12)	(1.16)	(0.56)
Inflation	-0.033	-0.049*	-0.039	-0.016**	-0.071***	-0.067***	-0.126***
	(1.63)	(1.91)	(1.59)	(1.98)	(3.02)	(2.89)	(4.63)
Government burden	-0.001	-0.023***	-0.024***	-0.003	-0.009	-0.008	-0.017***
	(0.23)	(3.67)	(3.75)	(0.59)	(1.40)	(1.31)	(2.78)
Intercept	0.052	0.049	-0.011	0.020	0.017	-0.040	0.022
	(1.17)	(0.89)	(0.17)	(0.60)	(0.37)	(0.90)	(0.46)
Wald test (F-statistic):							
H_0: Exchange rate flex./dep. total effect = 0			5.67***			4.56**	4.48***
Threshold Original sin			0.44			0.50	-0.01
H_0: Threshold = 0 (F-statistic)			5.70**			28.38***	0.00
H_0: Threshold = 1 (F-statistic)			61.00***			250.68***	4.42**
Observations	177	90	90	261	129	129	89
R-squared	0.249	0.420	0.437	0.131	0.282	0.308	0.500

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2: Growth effects of the flexibility of Exchange Rate Regime - 2-step system-GMM estimation with Windmeijer (2004) small sample robust correction and time effects

	(1)	(2)	(3)
Initial output per worker	0.002	0.003	-0.013
	(0.24)	(0.35)	(1.32)
Financial development	-0.004	-0.004	0.002
	(0.81)	(0.57)	(0.63)
Original sin	0.037**	0.041*	0.008
	(2.08)	(1.93)	(0.53)
Real effective exchange rate volatility	0.223		0.008
	(1.18)		(0.53)
REER volatility*Original sin	**-0.429***		
	(1.90)		
LS index of exchange rate flexibility		0.006*	
		(1.87)	
LS Flexibility*Original sin		**-0.011****	
		(2.19)	
REER Depreciation			0.103
			(0.64)
REER Depreciation*Original sin			**-0.546****
			(2.64)
Control variables			
Education	0.023**	0.018	0.026**
	(2.17)	(1.22)	(2.16)
Trade openness	0.003	0.008	0.005
	(0.66)	(1.38)	(1.11)
Inflation	-0.049	-0.066**	-0.128***
	(1.55)	(2.18)	(5.41)
Government burden	-0.021***	-0.012*	-0.018***
	(2.96)	(1.68)	(2.87)
Intercept	-0.081	-0.119*	0.060
	(1.10)	(1.84)	(0.83)
Wald test (F-statistic):			
H_0: Exchange rate flex./dep. total effect = 0	6.21***	2.45*	8.60***
Threshold Original sin	0.52	0.55	0.19
H_0: Threshold = 0 (F-statistic)	7.92***	21.47***	0.63
H_0: Threshold = 1 (F-statistic)	67.80***	164.50***	11.59***
Hansen overidentification test			
H_0 Valid instruments (Prob > chi2)	0.520	0.327	0.315
Anderson underidentification test			
H_0 Underidentification (Prob > chi2)	0.0000	0.0000	0.0000
Cragg-Donald underidentification test			
H_0 Underidentification (Prob > chi2)	0.0000	0.0000	0.0000

Table 3: Growth effects of the volatility of Exchange Rate Regime with additional controls - 2-step system-GMM estimation with Windmeijer (2004) small sample robust correction and time effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Initial output per worker	-0.007	0.005	-0.004	-0.006	-0.020	0.002	-0.016
	(0.54)	(0.59)	(0.75)	(0.73)	(1.18)	(0.21)	(1.53)
Financial development	-0.004	-0.008**	-0.009***		-0.005	-0.006	-0.006
	(0.79)	(2.46)	(3.18)		(0.66)	(1.07)	(1.29)
Original sin	0.031	0.032**	0.024*	0.020	0.037*	0.031	0.026
	(1.50)	(2.14)	(1.78)	(1.58)	(1.68)	(1.60)	(1.48)
Real effective exchange rate volatility	0.195	0.344**	0.329**	0.187			
	(0.93)	(2.31)	(2.21)	(1.63)			
REER volatility*Original sin	**-0.433***	**-0.592*****	**-0.566****	**-0.361****			
	(1.71)	**(3.06)**	**(2.62)**	**(2.46)**			
LS index of exchange rate flexibility					0.005	0.007**	0.005*
					(1.45)	(2.53)	(1.78)
LS flexibility*Original sin					**-0.010****	**-0.011****	**-0.008**
					(2.28)	**(2.38)**	**(1.61)**
Control variables							
Education	0.023**	0.021*	0.019***	0.018**	0.028**	0.021	0.029***
	(2.28)	(1.83)	(2.74)	(2.51)	(2.53)	(1.63)	(3.65)
Trade openness	0.004	0.009*	0.008*	0.008**	0.004	0.012**	0.010*
	(0.81)	(1.96)	(1.88)	(2.02)	(0.84)	(2.15)	(1.92)
Inflation	-0.040	-0.042*	-0.043	-0.027	-0.064***	-0.068***	-0.058***
	(1.33)	(1.70)	(1.43)	(1.39)	(2.81)	(3.13)	(2.78)
Government burden	-0.019**	-0.023***	-0.019**	-0.019***	-0.011	-0.012*	-0.011
	(2.26)	(2.71)	(2.53)	(3.17)	(1.49)	(1.74)	(1.59)
Additional control variables							
Governance index	0.001		0.001	0.001	0.003		0.002
	(0.92)		(1.31)	(0.60)	(1.21)		(1.47)
Net external debt		-0.002	-0.004	-0.005		-0.002	-0.005*
		(0.56)	(1.13)	(1.35)		(0.72)	(1.68)
Intercept	-0.002	-0.115*	-0.029	0.007	0.071	-0.136**	0.008
	(0.02)	(1.70)	(0.59)	(0.10)	(0.42)	(2.54)	(0.08)
Hansen test (Prob > chi2)	0.373	0.810	0.908	0.541	0.173	0.571	0.344
Observations	90	77	77	84	129	113	113
Number of group(cty)	51	44	44	46	75	66	66

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Growth effects of the volatility of Exchange Rate Regime, controlling for terms of trade volatility - 2-step system-GMM estimation with Windmeijer (2004) small sample robust correction and time effects

	(1)	(2)	(3)	(4)	(5)
Initial output per worker	0.003	0.004	-0.000	-0.017	-0.018
	(0.55)	(0.73)	(0.03)	(1.35)	(1.41)
Financial development	-0.009**	-0.010***		-0.007*	-0.006
	(2.65)	(2.96)		(1.75)	(1.33)
Original sin	0.035**	0.028	0.034***	0.004	0.006
	(2.12)	(1.50)	(2.89)	(0.15)	(0.28)
Real effective exchange rate volatility	0.284	0.258	0.249		
	(1.43)	(1.24)	(1.59)		
REER volatility*Original sin	**-0.573***	**-0.514***	**-0.543****		
	(1.99)	**(1.79)**	**(2.56)**		
LS index of exchange rate flexibility				0.004	0.004
				(0.99)	(1.18)
LS flexibility*Original sin				**-0.008**	**-0.008***
				(1.30)	**(1.74)**
Terms of trade volatility	0.004	0.000	-0.001	-0.004	-0.003
	(1.22)	(0.03)	(0.08)	(0.52)	(0.18)
Terms of trade volatility*Original sin		0.004	0.005		0.000
		(0.30)	(0.46)		(0.01)
Control variables					
Education	0.024**	0.023*	0.024**	0.018	0.018
	(2.43)	(1.86)	(2.04)	(1.43)	(1.38)
Trade openness	0.005	0.005	0.006	0.007	0.007
	(0.84)	(0.74)	(1.53)	(0.99)	(0.99)
Inflation	-0.048	-0.044	-0.028	-0.064**	-0.066**
	(1.54)	(1.42)	(0.74)	(2.37)	(2.17)
Government burden	-0.023***	-0.028***	-0.026***	-0.011	-0.012
	(3.40)	(3.30)	(4.37)	(1.37)	(1.64)
Constant	-0.067	-0.049	-0.053	-0.140*	-0.150*
	(0.79)	(0.50)	(1.02)	(1.83)	(1.85)
Hansen test (Prob > chi2)	0.600	0.670	0.553	0.546	0.558
Observations	68	68	74	87	87
Number of group(cty)	43	43	44	60	60

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Growth effects of the flexibility of Exchange Rate Regime, excluding currency crisis episodes - 2-step system-GMM estimation with Windmeijer (2004) small sample robust correction and time effects

	(1)	(2)
Initial output per worker	-0.001	-0.006
	(0.06)	(0.70)
Financial development	-0.006	-0.008
	(0.71)	(1.49)
Original sin	0.020	0.024
	(1.27)	(1.47)
Real effective exchange rate volatility	0.162	
	(0.97)	
REER volatility*Original sin	**-0.339***	
	(1.74)	
LS index of exchange rate flexibility		0.006**
		(2.21)
LS flexibility*Original sin		**-0.010****
		(2.17)
Control variables		
Education	0.022*	0.032***
	(1.86)	(2.90)
Trade openness	0.006	0.010**
	(1.39)	(2.15)
Inflation	-0.061**	-0.072**
	(2.30)	(2.54)
Government burden	-0.018**	-0.011*
	(2.25)	(1.78)
Constant	-0.055	-0.092
	(0.49)	(1.52)
Hansen test (Prob > chi2)	0.467	0.437
Observations	84	124
Number of group(cty)	49	73

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Growth effects of the flexibility of Exchange Rate Regime, industrial versus developing countries - 2-step system-GMM estimation with Windmeijer (2004) small sample robust correction and time effects

	(1)	(2)	(4)	(5)
Initial output per worker	0.000	-0.003	0.006	0.007
	(0.04)	(0.23)	(0.52)	(0.58)
Financial development	-0.004	-0.005	-0.005	-0.004
	(0.91)	(0.97)	(0.64)	(0.56)
Original sin	0.036**	0.056	0.036*	0.042
	(2.17)	(1.53)	(1.74)	(1.36)
Real effective exchange rate volatility	0.225	0.597		
	(1.21)	(1.39)		
REER volatility*Original sin	**-0.435***	**-0.801***		
	(1.89)	**(1.71)**		
LS index of exchange rate flexibility			0.006	0.009
			(1.66)	(1.09)
LS flexibility*Original sin			**-0.011****	**-0.014***
			(2.02)	**(1.76)**
Industrial country	0.002	0.028	-0.008	-0.003
	(0.20)	(1.36)	(0.59)	(0.13)
Exchange rate volatility*Industrial country		-0.314		
		(1.12)		
Exchange rate flexibility*Industrial country				-0.002
				(0.47)
Control variables				
Education	0.024**	0.023*	0.018	0.018
	(2.43)	(1.86)	(1.43)	(1.38)
Trade openness	0.005	0.005	0.007	0.007
	(0.84)	(0.74)	(0.99)	(0.99)
Inflation	-0.048	-0.044	-0.064**	-0.066**
	(1.54)	(1.42)	(2.37)	(2.17)
Government burden	-0.023***	-0.028***	-0.011	-0.012
	(3.40)	(3.30)	(1.37)	(1.64)
Constant	-0.067	-0.049	-0.140*	-0.150*
	(0.79)	(0.50)	(1.83)	(1.85)
Hansen test (Prob > chi2)	0.550	0.608	0.284	0.212
Observations	90	90	129	129
Number of group(cty)	51	51	75	75

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%