Facultad de Ciencias Económicas y Empresariales
Universidad de Navarra

# Working Paper nº 10/04

## Exchange Rate and Inflation Dynamics in Dollarized Economies

Luis Carranza
José Enrique Galdón Sánchez
Javier Gómez Biscarri

Facultad de Ciencias Económicas y Empresariales
Universidad de Navarra

Exchange Rate and Inflation Dynamics in Dollarized Economies
Luis Carranza, José Enrique Galdón Sánchez and Javier Gómez Biscarri
Working Paper No.10/04
May 2008
JEL No. F31, F33

**ABSTRACT**

We use a panel of a hundred-plus countries with differing degrees of dollarization to perform an empirical analysis of the effects of exchange rate depreciations in economies with high liability dollarization. The results qualify the common view that countries with higher dollarization exhibit higher inflation pass-through. We show that large depreciations tend to generate a negative impact on the pass-through coefficient, this impact being more intense the higher the level of dollarization of the economy. We interpret this as evidence that, in highly dollarized economies, the classic inflationary effects of a real depreciation -higher internal demand and imported inflation- can be offset or diminished by both the larger financial costs and the balance-sheet effect, especially if the depreciation is "large". Additionally, the exchange rate regime is shown to matter: countries with fixed exchange rates suffer more noticeable balance-sheet effects of large depreciations

Luis Carranza
Department of Economics
Universidad de Navarra
31080 Pamplona, Navarra

José Enrique Galdón Sánchez
Department of Economics
Universidad Pública de Navarra - Campus Arrosadia
31006 Pamplona, Navarra
jose.galdon@unavarra.es

Javier Gómez Biscarri
IESE Business School
08034 Barcelona
jgbiscarri@iese.edu

# Exchange Rate and Inflation Dynamics in Dollarized Economies*


Luis Carranza
Universidad San Martín de Porres

Jose E. Galdon-Sanchez† — Universidad Publica de Navarra

Javier Gomez-Biscarri — IESE Business School


May 29, 2008


*We thank Joshua Aizenman, Jose M. Campa, Sebastian Edwards, Graciela Kaminsky, Ed Leamer, Adrian Pagan, Carmen Reinhart, seminar participants at the University of Maastricht, the 2005 Meeting of the European Economic Association (Amsterdam), the 2005 Meeting of LACEA (Paris) and the 2nd International Conference on Advances in Economic Research (Pamplona), the editor Gordon Hanson, and, especially, two anonymous referees for helpful comments and suggestions. We also thank Jose Suarez-Lledo and Mike Lynch for valuable research assistance. Jose E. Galdon-Sanchez and Javier Gomez-Biscarri acknowledge financial support from the Spanish Ministerio de Educacion y Ciencia for projects SEJ2005-03470/ECON and SEJ2005-06302/ECON, respectively. Jose E. Galdon-Sanchez acknowledges financial support by FEDER, European Union. Javier Gomez-Biscarri thanks the Plan Especial de Investigacion de la Universidad de Navarra and IESE Business School for financial assistance. The usual disclaimers apply.



†Corresponding author: jose.galdon@unavarra.es. Departamento de Economia. Universidad Publica de Navarra. 31006 - Pamplona, Navarra (SPAIN). Other authors: lcarranzau@terra.com.pe; jgbiscarri@iese.edu

**Abstract**

We use a panel of a hundred-plus countries with differing degrees of dollarization to perform an empirical analysis of the effects of exchange rate depreciations in economies with high liability dollarization. The results qualify the common view that countries with higher dollarization exhibit higher inflation pass-through. We show that large depreciations tend to generate a negative impact on the pass-through coefficient, this impact being more intense the higher the level of dollarization of the economy. We interpret this as evidence that, in highly dollarized economies, the classic inflationary effects of a real depreciation -higher internal demand and imported inflation- can be offset or diminished by both the larger financial costs and the balance-sheet effect, especially if the depreciation is "large". Additionally, the exchange rate regime is shown to matter: countries with fixed exchange rates suffer more noticeable balance-sheet effects of large depreciations.



**JEL:** F31, F33

**Keywords:** Inflation pass-through, dollarization, balance-sheet effect, developing economies

# 1 Introduction

In recent years there has been an impressive development of the literature on the macroeconomic implications of real exchange rate depreciations. In the aftermath of the Asian and Latin American crises of the 1990s, researchers began to challenge the common consensus that a real depreciation has a positive impact on aggregate demand and is expansionary, which is the traditional implication of models in the spirit of Mundell-Fleming.

The countries affected by the aforementioned crises experienced large depreciations that were at the same time accompanied by severe disruptions in the real sector of their economies. Behind all these contractionary episodes, there was usually a story of a currency mismatch generated by a high level of indebtedness in foreign currency. This was a consequence of the impossibility of these countries to issue debt in their own currencies, a phenomenon known in the literature as the "original sin" (see Eichengreen and Hausman, 2003). As a result, the standard Mundell-Fleming model was extended along the lines of Krugman (1999) which incorporated, on top of the usual competitiveness effect of real depreciations, the negative impact on firms' net worth of the drastic reduction of the exchange rate. This additional effect of real exchange rate depreciations, known as the *balance-sheet effect*, produces a reduction of domestic investment that attenuates and may even compensate for the competitiveness effect on output.[1]

Since then, this balance-sheet effect has been widely studied both theoretically (see Aghion et al., 2001; Cespedes et al., 2003, 2004; Choi and Cook, 2004; Batini et al., 2007; Magud, 2007, among others), and empirically (see Harvey and Roper, 1999; Calvo and Reinhart, 2002; Forbes, 2002; Carranza et al., 2003; Aguiar, 2005, among others). Most of these analyses

[1] The contractionary effects of a real exchange rate depreciation had been already analyzed in a different context by Edwards (1986).

have stressed the negative impact on firms' net worth induced by a real depreciation, and the subsequent contractionary impact on output. However, there has been little attempt to analyze the consequences of balance-sheet effects on macroeconomic variables other than output. In particular, the inflation pass-through literature has generally overlooked this balance-sheet effect and it remains the standard view that inflation pass-through is higher in highly dollarized economies than in non-dollarized ones (see Reinhart et al., 2003; see also Choudhri et al., 2005, for some evidence to the contrary).

The objective of our paper is to analyze more in depth the pass-through from exchange rate changes into inflation by taking into account the balance-sheet effect likely present in highly dollarized economies (HDEs).[2] The existence of this balance-sheet effect suggests a lower inflation pass-through of a exchange rate depreciation. We argue that this negative balance-sheet effect is more intense the higher the level of dollarization of the economy. Moreover, large depreciations may be associated with even more negative balance-sheet effects, and therefore with even lower inflation, since the reduction in firms' net worth could be so acute that investment by firms might collapse. We support our arguments with a model in the spirit of Cespedes et al. (2004) that incorporates both the degree of dollarization and the effect of large depreciations.[3]

In order to test the implications of our discussion, we collect data on exchange rates and prices for a large set of countries with varying degrees of dollarization. The pass-through into inflation of nominal depreciations is then examined in a panel, where a distinction is made between small and large nominal depreciations by allowing for a threshold-type behavior of inflation rates that depends on the size of the depreciation.

[2] We define HDEs as those economies where a high proportion of firms' assets or liabilities are denominated in a foreign currency.

[3] A discussion of the model is included in Appendix I.

The results suggest that the extent of the pass-through is significantly affected by the degree of dollarization of the economy. More dollarized economies present higher pass-through coefficients, but when the nominal depreciation is large this relationship changes: large depreciations tend to reduce the extent of the pass-through and this effect is more intense the more dollarized the economy is. The result is therefore consistent with the possible contractionary effects of depreciations in HDEs –via balance-sheets and financial costs–. Additionally, we show that the exchange rate regime matters: countries with fixed exchange rate regimes present a more intense balance-sheet effect, whereas the evidence for intermediate regimes is much weaker and countries with flexible regimes do not seem to experience the balance-sheet effect at all. Finally, we show evidence which suggests that a contraction in investment may indeed be the mechanism that generates the reduction in inflation pass-through.

The paper contributes to the literature in four main dimensions. First, it provides an indirect test of balance-sheet effects, which have so far been quite elusive to empirical analysis. Second, it gives a step towards a better understanding of the costs of (high) partial dollarization. Third, it adds to the discussion on the preference for flexible vs. fixed exchange rate regimes. Finally, it stresses and analyzes the importance of nonlinearities at the macro level. Specifically, it shows evidence of the differing effect of large depreciations via a balance-sheet-induced collapse of firms' investment.

Our paper also relates with the large existing literature on exchange rate pass-through. However, it is important to point out several differences with that literature. First, our approach is more macro in nature. This is the reason why we look at CPI prices rather than looking at sectorial or import prices as in the Devereux and Engel (2002) framework. We also use a very wide panel of countries -a more micro approach would significantly reduce the number of countries that could be used. Moreover, our set of control variables is slightly different from the one used in single country studies (see for example, Goldberg and Knetter, 1997; Campa and Goldberg, 2005; and others) but the controls we use are consistent with the data availability and the macro scope of the analysis. Second, our results focus explicitly on "dollarization" and "the large depreciation" effect. The former has been treated empirically in Reinhart et al. (2003), who mentioned superficially the relationship between dollarization and pass-through, and the works of Ca'Zorzi et al. (2007), Bigio and Salas (2006), Leiderman et al. (2006) or Goujon (2006) among others. Evidence of the "large depreciation" effect on pass-through is scarcer (see Pollard and Coughlin, 2003, for the US or Khundrakpam, 2007, for India) and no paper that we are aware of combines the empirical analysis of liability dollarization and the pass-through of large depreciations. Third, our results are especially relevant to developing countries. These countries tend to have high degrees of dollarization and suffer large exchange rate swings, but the evidence on the pass-through literature is much more scarce for them (see Rowland, 2003; Goujon, 2006; Ito and Sato, 2007; Ca'Zorzi et al., 2007; Ghosh and Rajan, 2007a and 2007b). Finally, we use a simple yet intuitive model (see Appendix I) to justify the interpretation of the estimated coefficients. Our model is in line with the contributions of Cespedes et al. (2003, 2004).[4]

The paper is organized as follows. In section 2 we describe the main mechanisms that we believe are relevant for the exchange rate pass-through in HDEs and we set the framework for the empirical analysis. Section 3 contains an empirical analysis of exchange rate pass-through and inflation

[4]More complicated models of pass-through can be found in Devereux et al. (2004), Devereux and Yetman (2003), Devereux and Engel (2002). We do not think that using a more complex model would add much to the main point of our paper and it would increase unnecessarily the complexity of the estimation.

dynamics for a broad panel of countries that emphasizes the impact of both the degree of liability dollarization and large depreciations. Some concluding comments are provided in section 4. Two appendices contain the more technical material.

# 2 Pass-through in HDEs

Before we proceed to the empirical analysis, we review the main channels through which a rise in the real exchange rate -a real depreciation- can affect a HDE. The discussion in this section is formalized in Appendix I, where we develop a simple model based on Cespedes et al. (2003, 2004), that can account for the issues mentioned hereafter and that provides a justification for the equations estimated in Section 3.

In HDEs a rise in the real exchange rate can generate, other than the traditional expansionary competitiveness effect that affects the real side of the economy, two contractionary effects: the increase in the financial cost of imported capital and the destabilization of the balance-sheet of firms with a currency mismatch between assets and liabilities. The first cost is a direct effect of the depreciation -imported capital goods become more expensive-while the second is due to the fact that the net worth of those agents with debts denominated in foreign currency is instantly deteriorated. This deterioration in the balance-sheets may be transferred -via some financial restriction, for example- to the firm's investment decisions, which in turn implies that a real depreciation can end up negatively affecting aggregate internal demand and having recessionary effects.

The final impact of a real depreciation on the internal demand will depend on the relative strength of the balance-sheet effect versus the competitiveness effect. This impact may also depend on the size of the real depreciation.

In the case of small depreciations, the risk for the indebted firm rises only slightly, increasing financial costs and negatively affecting investment. However, in the event of a "large depreciation" the balance-sheet effect can be especially intense. This means that the net worth deterioration can be so acute that firms not only confront high interest rates but also, in some cases, lose the access to credit. This forces them to liquidate capital or go bankrupt. The situation can worsen if a severe deterioration in the net worth of banks takes place, since this compounds the credit restriction problem.[5]

The balance-sheet effect becomes relevant mainly for firms that produce non-tradable goods, since for those firms the currency mismatch between assets and liabilities is more damaging. If we consider firms that produce tradable goods, the final balance-sheet effect may be attenuated. There are two basic reasons for this. The first is that both the assets of tradable firms (the flow of revenues) and the foreign debt can be thought of being denominated in foreign currency. In this case a real depreciation may be irrelevant or, in case the firm also has debt denominated in local currency, may be positive given that the depreciation reduces the relative value of domestic debt. The second reason is that tradable firms are subject to the positive competitiveness effect to which nontradable firms are not.

This possible attenuation of the balance-sheet effect does not change, however, our main argument that investment will react more negatively to the real exchange rate when the depreciation is large. In this case, non-tradable firms may be squeezed out of the financial market and collapse. Consequently, aggregate investment is more intensely affected. This result suggests a nonlinear investment function that has a lower slope (maybe even negative) with respect to the real exchange rate for "large depreciations".

We attempt to test this effect in the empirical part of the paper. When

[5] We do not include possible balance-sheet effects in the banking system in our analysis.

confronting large variations in the real exchange rate, the nonlinearity in the investment response will be reflected in a nonlinear pass-through from exchange rates to domestic prices. Thus, when the variations in the exchange rate are small, we should observe the traditional results of positive and large pass-through (we elaborate more on this later). However, when a nominal depreciation pushes the real exchange rate over some threshold value, the drastic drop in aggregate investment may counter the competitiveness-induced rise in domestic prices. As a result, the extent of pass-through would be lower or, even, negative. The intensity of this effect must be related to the degree of dollarization in the economy.

The model in Appendix I formalizes the above arguments. The model explains pass-through in HDEs taking into account the competitiveness and balance-sheet effects of a real exchange rate depreciation. It includes a nonlinear investment function of the form:

$$i_t = (\lambda + \chi\rho)\,(e_t - p_t)\,; \chi = \mathbf{1}\left[(e_t - p_t) > \varphi\right] \tag{1}$$

where $i_t$ is aggregate investment, $e_t$ is the nominal exchange rate, $p_t$ is the domestic price level and $\varphi$ is the threshold that determines a "large depreciation".[6] The indicator function $\chi = \mathbf{1}\left[(e_t - p_t) > \varphi\right]$ takes value one if the real depreciation is larger than the threshold $\varphi$ and zero otherwise. The parameter $\lambda$ measures the regular balance-sheet effect and the parameter $\rho$ measures the additional (negative) effect of a large depreciation (see Appendix I).

As Appendix I shows, under some simplifying assumptions a resulting equilibrium evolution for domestic inflation $\pi_t$ corresponds to:

$$\pi_t = (\phi_1 + \chi\phi_2)\,\Delta e_t + \phi_3 \Delta Z_t + \phi_4 \pi_{t-1};\;\; \chi = \mathbf{1}\left[\Delta e_t > \varphi\right] \tag{2}$$

[6] All variables are in logarithms. A formal justification for this nonlinear investment equation can be found in Carranza et al. (2008).

where $\Delta e_t$ is the nominal depreciation and $\Delta Z_t$ is the change in exogenous variables other than the nominal exchange rate. In this equation, $\phi_1$ and $(\phi_1 + \phi_2)$ measure the exchange rate pass-through in the goods market of a "small" and "large" nominal depreciation, respectively. We attempt to examine these coefficients in our empirical analysis and, more specifically, see if they may be related to the level of dollarization of the economy.

# 3 Empirical Analysis

Equation (2) and the discussion contained in Appendix I suggest some testable empirical implications of pass-through in the context of HDEs. First, in HDEs a nominal depreciation may generate a contractionary balance-sheet effect –a reduction in firms' investment– that goes counter the typical expansionary competitiveness effect. Thus, the exchange rate-inflation pass-through in a HDE may be attenuated or, given extreme values of the structural parameters, even become negative. Second, the extent of this balance-sheet effect depends on the degree of dollarization of the economy. Third, the balance-sheet effect –and the attenuation of pass-through– will be especially intense in the presence of a large depreciation. Finally, and in line with previous literature, the degree of openness of the economy will be related to higher pass-through, both because of a higher competitiveness effect and a lower balance-sheet effect in the relatively larger tradable sector.

We test now these implications regarding pass-through, dollarization and other relevant macroeconomic variables in a cross-country panel setting.

## 3.1 Data

Our interest in the empirical analysis lies in testing that the level of dollarization matters for the pass-through coefficients. More specifically, we attempt to test that, due to financial costs and balance-sheet effects, in more dollarized economies the extent of the pass-through of a nominal depreciation may be smaller than in less dollarized countries, or even negative, and that this is even more so in the presence of large depreciations.

Since our analysis is inherently cross-country, it should cover the widest possible set of countries. These countries should be heterogeneous in their level of dollarization. For this purpose, we built a comprehensive database that contains prices and exchange rate data for one hundred and twenty four countries. These data come from the IFS database. This database covers a total of 169 countries but some had to be excluded due to problems of data availability and specific features of their economies (see Table 1 for a list of countries and the reasons for exclusion). In particular, we eliminated fully dollarized countries and countries with a fixed exchange rate during the complete sample period. For consistency of the time series procedure, we also eliminated countries with missing data in intermediate periods.

[TABLE 1 HERE]

Since the model in Appendix I explicitly solves for the evolution of a domestic composite price index, we use a quarterly 12-month CPI inflation rate as a measure of inflation. Exchange rate depreciation rates have been calculated quarterly using the nominal exchange rate expressed in units of local currency per dollar.[7]

The sample runs from 1996:Q1 to 2004:Q4. The choice of the initial period rested mainly on the availability of data for several emerging economies.[8]

[7]The dollar is the currency that most countries borrow in, so this exchange rate is the logical choice. This argument also justifies excluding from the dataset both fully dollarized countries and countries with a fixed exchange rate with the dollar.

[8]For emerging markets, the early 1990s was a period of rather large fluctuations in foreign exchange. Thus, despite the higher volatility of the data from those years, one

This leaves us with a panel of 124 countries and a maximum of 36 time periods. Countries with some missing observations at the beginning or at the end of the sample were included, and consequently our panel is unbalanced. Table 1 also shows the amount of usable observations available per country.

In order to account for the influence of the degree of dollarization, we have used the measure of dollarization developed by Reinhart et al. (2003). This is an index constructed as a weighted average of three indicators: percentage of bank deposits and domestic debt denominated in foreign currency, and percentage of external debt denominated in foreign currency. Even though this measure is time invariant, we use it for several reasons. First, it is the most comprehensive classification of degrees of dollarization that we are aware of, since it covers almost the whole population of countries. Second, the weighted averages already include some time-varying information. Finally, except in countries that go through drastic changes -Ecuador, for instance- time-varying measures of dollarization tend to be quite constant over time -this fact was also noted by Reinhart et al. (2003).[9]

We use four sets of additional control variables. The first three come from the WDI database of the World Bank. First we include the degree of openness of the economy (the ratio of exports plus imports to GDP), a likely determinant of pass-through intensity. Second, since in periods of lower overall activity inflation rates are lower, we control for the economic cycle

would expect to have more power to uncover relevant results using those data. Our analysis of a more tranquil period –at least with regards to inflation– is still able to uncover quite clearly the evidence of a balance-sheet effect in pass-through in HDEs. This is, we believe, much in favor of our analysis. We are especially indebted to Carmen Reinhart for bringing up this point.

[9]As an alternative, we tried to use the time-varying ratios of liability dollarization in Moody's Statistical Handbook. However, these ratios are only available for 28 of our 124 countries, which largely reduced the size and representativeness of our panel. Results using this measure are not presented, but are available upon request. The general results appear unchanged, but significance of the relationships is affected by the scarcity of countries.

by including real GDP growth. In a final robustness analysis, we include a measure of investment growth (real Gross Fixed Capital Formation growth, GFCF). Annual series of these three control variables were available for most countries in our sample. The fact that these controls are only available at the annual level does not invalidate the estimation. For example, openness ratios are quite constant over time, so the lower frequency of variation is not likely to affect the results significantly. Homogeneous measures of quarterly real GDP or GFCF growth are quite difficult, if not impossible, to find for a wide set of countries, and the use of yearly growth allows us to keep a large number of countries in the panel.[10]

In order to account for possible differences in average inflation of more open and fast-growing countries, openness and either GDP growth or GFCF growth are included as separate regressors. Moreover, in order to control for different pass-through intensity in open countries and along the cycle, they are also interacted with the depreciation rate.

The fourth set of control variables accounts for the exchange rate regimes that the countries are subject to. Theoretical analyses have shown that the exchange rate regime affects the intensity of balance-sheet effects. In particular, balance-sheet effects are found to lead to greater falls in output and investment under fixed exchange rates than under flexible rates (see Cespedes et al., 2004, or Magud, 2007). We should then expect the negative impact on pass-through coefficients to be more noticeable in countries with fixed exchange rate regimes. We therefore include two dummies, which control for fixed and intermediate (dirty floats or crawling pegs) regimes. These

[10] A previous version of the paper used quarterly data of these two control variables for a reduced number of countries (45 for the openness ratios and 49 for real growth). The results were comparable, but the reduced number of observations affected the significance of the estimated coefficients. More importantly, the reduced database could be subject to sample selection bias. The current analysis is much more comprehensive and robust.

data come from Levy-Yeyati and Sturzenegger (2003). In the final panel, we include the two dummies along with their interactions with the depreciation rate, and with the dollarization and the large depreciation variables.

## 3.2 Methodology

We estimate inflation pass-through regressions of the form:

$$\begin{aligned} \pi_{it} &= \delta_{0i} + \delta_1 \pi_{it-1} + \delta_2 \Delta e_{it-1} + \delta_3 d_i \Delta e_{it-1} + \delta_4 \mathbf{1}\left(\Delta e_{it-1} > \varphi\right) + ... \\ & ... + \delta_5 d_i \mathbf{1}\left(\Delta e_{it-1} > \varphi\right) \Delta e_{it-1} + \boldsymbol{\delta}' X_{it} + u_{it} \end{aligned} \quad (3)$$

where $\pi_{it}$ is domestic price inflation of country $i$ at time $t$, $\Delta e_{it-1}$ is the lagged nominal depreciation rate of the exchange rate expressed in units of local currency per dollar, $d_i$ is the measure of dollarization, $\mathbf{1}\left(\Delta e_{it-1} > \varphi\right)$ is an indicator function that takes value one if the nominal depreciation rate exceeds some level $\varphi$ and zero otherwise, and $X_{it}$ includes the control variables.

This specification implies that when the nominal depreciation is small ($\Delta e_{it-1} \leq \varphi$), the behavior of the inflation rate is:

$$\pi_{it} = \delta_{0i} + \delta_1 \pi_{it-1} + \delta_2 \Delta e_{it-1} + \delta_3 d_i \Delta e_{it-1} + \boldsymbol{\delta}' X_{it} + u_{it} \quad (4)$$

and when the nominal depreciation is larger than $\varphi$ the behavior is:

$$\pi_{it} = \left(\delta_{0_i} + \delta_4\right) + \delta_1 \pi_{it-1} + \delta_2 \Delta e_{it-1} + \left(\delta_3 + \delta_5\right) d_i \Delta e_{it-1} + \boldsymbol{\delta}' X_{it} + u_{it} \quad (5)$$

Given the controls included in the equations, the final pass-through coefficient is:

$$\begin{aligned} \frac{\partial \pi_{i,t}}{\partial \Delta e_{t-1}} &= \delta_2 + \delta_3 d_i + \delta_5 d_i 1(\Delta e_{t-1} > \varphi) + ... \\ & ... + \delta_7 open_{it} + \delta_9 GDP_{it} + ... \\ & + \delta_{11} Int_{it} + \delta_{12} Int_{it} d_i 1(\Delta e_{t-1} > \varphi) + \delta_{14} Fix_{it} + \delta_{15} Fix_{it} d_i 1(\Delta e_{t-1} > \varphi) \end{aligned} \quad (6)$$

where $open_{i,t}$, $GDP_{i,t}$, $Int_{it}$ and $Fix_{it}$ are the controls for openness, real GDP growth, intermediate and fixed exchange rate regimes, respectively.[11] Our main interest lies on the parameters $\delta_3$ and $\delta_5$. If there is an impact of the degree of dollarization on pass-through, these two coefficients (which are related to the coefficients $\lambda$ and $\rho$ in equation (1), respectively) should be significantly different from zero. Moreover, we expect $\delta_5$ to be negative.[12]

In order to estimate the panel, we follow two different approaches. As a first benchmark, we estimate the parameters conditional on $\varphi = 0, 0.15$. In the first case, the parameter $\delta_5$ would measure the differential impact of depreciations versus appreciations. In the second case, $\delta_5$ will be capturing the differential pass-through of depreciations larger than fifteen per cent.[13] To estimate these benchmark panels, we use the 2SLS procedure in Arellano (2003) for dynamic panels with lagged dependent variables and exogenous variables in a large $T$ setting (see Appendix II). We take three lags of the depreciation rate as instruments, along with the dollarization and control variables. Time dummies were included in some of the analyses, but they never contributed significantly to the explanatory power of the regressions.

Secondly, we estimate $\varphi$ endogenously, using a conditional least squares approach. We follow the threshold literature (see, Chan and Tsay, 1998, or Tsay, 2002) and estimate the above model for a full grid of values of $\varphi$. As estimate of $\varphi$ we take the value that minimizes the sum of squared residuals. Standard errors for $\varphi$ are calculated using 200 replications of a bootstrap on

[11] Note that not all controls are included in all the estimated panels, so the expression for the pass-through coefficient differs depending on the set of controls.

[12] A separate term in the equation for the dollarization level could be included to account for a higher level of inflation in dollarized countries. However, given that our main measure of dollarization is time invariant, that impact is captured by the individual effects.

[13] Results for a full grid of conditioning values of $\varphi$ are available from the authors. These results tell the same story, though. We include those for $\varphi = 0.15$ in Table 2 for comparison purposes.

the cross-sectional units. The grid for $\varphi$ is constrained to $\varphi \in [0, 0.3]$ since we are interested specifically in large depreciations but very few countries have experienced a quarterly depreciation rate larger than 30 per cent.

### 3.3 Results

Table 2 shows the results for the two versions of equation (3) with $\varphi$ constrained to 0 and 0.15, whereas Table 3 shows the results of the endogenous estimation of $\varphi$. We omit the individual effects $\widehat{\delta}_{0i}$ from the tables. The first columns in both tables show several pass-through equations where the dollarization or large depreciation variables have been omitted. We do not comment on the results of these baseline equations, that are in line with the literature, but offer them for the sake of completeness and for comparison purposes.

The results in Table 2 are quite consistent with previous findings in the literature. First, inflation rates are highly persistent ($\delta_1 = 0.86$). Second, direct pass-through coefficients ($\delta_2$) are in general small and not significant, probably due to the heterogeneity across countries in the various pass-through determinants and to the inclusion of the terms with control variables.[14] Third, countries with a higher degree of dollarization present higher pass-through coefficients (significant and positive coefficient $\delta_3$). The estimated values of $\delta_3$ suggest that the level of dollarization increases the exchange rate pass-through by two to three per cent per unit of the dollarization index in Reinhart et al. (2003) –that ranges from 0 to 25. Thus, highly dollarized countries could have pass-through coefficients of around 40% to 50%, a result which is consistent with the findings in Reinhart et al. (2003).

[14] Given the form of pass-through in equation (6), it is no surprise that $\delta_2$ becomes insignificant when controls are included since the extent of pass-through is captured by the dollarization, openness, GDP growth and exchange rate regime variables through the coefficients $\delta_3$, $\delta_5$, $\delta_7$, $\delta_9$, $\delta_{11}$, $\delta_{12}$, $\delta_{14}$ and $\delta_{15}$.

This last result deserves additional comments. We have stressed throughout the paper that the negative balance-sheet effect must be larger depending on the degree of dollarization, a statement which seems to be at odds with the result just mentioned. In light of the discussion in Appendix I, several factors can explain this result: dollarized countries may be more open (see Weymouth, 2006, or Frankel and Cavallo, 2006), have a larger elasticity of demand for their tradables or have larger inflationary effects of output growth.[15] In other words, $\delta_3$ is parallel to $\phi_1$ in Appendix I, a parameter that contains the three different impacts mentioned plus the "regular" balance-sheet effect that depends on $\lambda$. We obtain a positive estimate of $\delta_3$. This means that the pass-through is higher the higher the degree of dollarization, but it does not imply that $\lambda$ is a positive function of dollarization, since the reasons outlined above can compensate for the lower value of $\lambda$.

The estimate of the "large depreciation" effect $\delta_5$ would be capturing the unconditionally negative impact measured by $\rho$, which is indeed more negative the larger the degree of dollarization. The results in Tables 2 and 3 quite strongly support this hypothesis. Table 2 shows that the coefficient $\delta_5$ is significant and negative. In other words, large depreciations –or, simply, depreciations as in the case of $\varphi = 0$– have a negative impact on pass-through that is more intense the higher the level of dollarization of the country. Thus, HDEs present high pass-through coefficients –commented above– but this pass-through is less intense for large depreciations. The estimated value of $\delta_5$ suggests that when the depreciation is large, pass-through in HDEs is reduced by 1 to 2 per cent per unit of the index in Reinhart et al. (2003). Note that in none of the cases the magnitude of $\delta_5$ is big enough to compensate for $\delta_3$.

[15] Additionally, Devereux and Yetman (2003) show that two other factors, which are also higher in dollarized economies, increase the degree of pass-through: the level of inflation and exchange rate volatility. Even though the country fixed effects may capture the effect of these two factors, the estimate of $\delta_3$ probably also accounts for part of it.

However, the coefficient is robust, quite stable and always negative, across panels and control variables.[16]

The inclusion of control variables does not affect the results of the pass-through coefficients much, but it provides interesting additional evidence. Openness is positively related to the intensity of pass-through, as the consistently positive and significant value of $\delta_7$ –interaction of openness with the depreciation rate– shows. The magnitude of this coefficient is between 0.10 and 0.14: an increase in the openness ratio of ten per cent increases pass-through by one per cent. The inclusion of real GDP growth has an interesting effect: it increases the effect of openness ($\delta_7$ increases from 0.1 to 0.14) and the coefficient on the interaction of real growth with the depreciation, $\delta_9$, becomes significantly negative, suggesting that fast-growing countries show smaller inflation pass-through. We comment on the exchange-rate regime controls at the end of the section.

[TABLE 2 HERE]

Table 3 shows the results of the endogenous estimation of $\varphi$. These are not essentially different from those of Table 2 ($\varphi = 0.15$), since the estimated threshold is around thirteen per cent in all the estimated panels. Additionally, the estimated values of $\varphi$ across bootstrap resamples are concentrated around the mean value, so the estimate of the threshold appears to be quite robust. All the $\delta$ coefficients are comparable to those in Table 2, $\varphi = 0.15$ case. The results point again at higher pass-through coefficients in dollarized economies, but also at a negative impact of the level of dollarization in the

[16] Our discussion suggests the possibility of negative pass-through and some evidence for this has been found in Bolivia in 2001 (Leiderman et al., 2006) and, maybe, in Peru in the 1990s (Bigio and Salas, 2006), both HDEs. However, given the estimated values of $\delta_3$ and $\delta_5$, it is clear that a negative pass-through should be the exception: the "large depreciation" effect implies an attenuation of the pass-through but it is not enough to make it negative.

pass-through coefficient in the face of large depreciation rates. The standard errors included in Table 3 for the $\delta$ coefficients are regular 2SLS conditional on the value of $\varphi$ that minimizes the objective function. The bootstrap estimates of the $\delta$ coefficients were skewed to the left, and so the regular t-ratios are biased towards zero. In Figure 1 we show kernel estimates of the distributions of $\widehat{\delta}_5$. It can be seen that most of the resamples –see the last line in Table 3– yielded negative values of the parameter. Thus, the negative $\widehat{\delta}_5$, our main coefficient of interest, is robust even to sampling of the countries in the analysis. The panels with control variables behave similarly to those for constrained $\varphi$, so we do not dwell in more detail.

Regarding the exchange rate regime controls, the results are quite satisfactory and in line with the theoretical literature on balance-sheet effects. The last columns of Table 2 and Table 3 show that when the exchange rate regime is controlled for, the estimate of $\delta_5$ loses significance and it becomes basically zero. However, the negative pass-through effect is picked up by the intermediate and fixed exchange rate-regime variables. More specifically, the intermediate regime presents a mild negative impact on pass-through for large depreciations (-0.008) whereas the fixed regime presents a large and highly significant coefficient (-0.015). The fact that the baseline estimate $\delta_5$ is not significant implies that, for fully flexible regimes, the "large depreciation" balance-sheet effect on pass-through does not seem to be present. This result is in line with the implications of models such as those in Cespedes et al. (2004) and Magud (2007), among others, and points at flexible exchange rates as better shock absorbers than fixed exchange rates.

[TABLE 3 HERE]

[FIGURE 1 HERE]

Finally, we carry out one last exercise aimed at exploring whether it is indeed a contraction in investment the mechanism that is behind the estimated balance-sheet effect, as the model in Appendix I and our discussion suggest. A simple way of examining this hypothesis is to substitute the control for GDP growth by a control for investment growth (GFCF growth). If the reaction of investment to large depreciations is behind the balance-sheet effect, then controlling for investment growth should make the coefficient that measures the effect of large depreciations insignificant or, at least, of smaller magnitude. Figure 2 shows a graphical summary of the results of the balance-sheet effect estimates for large depreciations ($\delta_5$ in the baseline case or the combination of $\delta_5$ and the exchange-rate regime coefficients $\delta_{12}$ and $\delta_{15}$ in the equations that control for the exchange rate regime) conditional on $\varphi$. In the figure we plot the point estimates of the large depreciation effect for each possible value of $\varphi$ used in our estimation procedure. It is clear that, even for the three separate exchange rate regimes, the inclusion of investment growth reduces the magnitude of the estimate of $\delta_5$. The result holds when compared to the regular equations with GDP growth as control or to the "no cyclical control" case. Therefore, once we account for the investment behavior, the lower pass-through induced by large depreciations is much reduced. This result suggests that contractions in investment are, at least, partly responsible for the lower pass-through found in HDEs when large depreciations occur (and, by extension, for the lower economic activity found in the literature).

The figure also includes the results for the case where GDP growth is used as control: given that investment is part of output and it is therefore an output contraction what generates the balance-sheet effect, the inclusion of output should also lead to a reduction of the estimated balance-sheet parameters. However, since there are expansionary effects in output coming from a depreciation (the competitiveness effect) including a broad measure of output growth may not necessarily have as clear-cut an effect as when investment growth is included as control. This is indeed what we find. In particular, in the three panels of Figure 2 that account for the exchange rate regime, we can observe that using output as a control also reduces the magnitude of the estimate of the $\delta_5$ parameter, although by less than when we include investment as a control. This result is consistent across the three exchange rate regimes and, we believe, it supports our argument that the substantial negative balance-sheet effect of a large depreciation impacts mainly investment.[17]

[FIGURE 2 HERE]

We believe the evidence presented is quite supportive of our conclusion that dollarization plays a role in the response of inflation to nominal depreciations, but that this role is nonlinear: in the face of large depreciations, balance-sheet effects attenuate or compensate the traditional inflationary effects on domestic inflation. The results also support the intuition of the simple model by which the mechanism that generates the balance-sheet effect is the negative impact of a large depreciation on firms' investment.

# 4 Conclusion

In this paper we have taken a closer look at the traditional analysis of exchange rate-inflation pass-trough. Little work has been done so far on the differences induced by the degree of dollarization in pass-through coefficients. The accepted view (see Reinhart et al., 2003) is that pass-through is signif-

[17] The result is not as clear in panel A of Figure 2 where the effect of the exchange rate regime is not controlled for. The interplay between GDP growth and the exchange rate regime (see Cespedes et al., 2004) may be behind this result.

icantly higher in HDEs. We go a step further and qualify these results by stressing the importance of what we call a "large depreciation" effect.

A simple model with a financial friction suggests the possibility of an attenuation –and, in extreme cases, a change in the sign– of pass-through coefficients when balance-sheet effects are important. In particular, when exchange rate depreciations are large, a nonlinearity may appear that intensifies the negative balance-sheet effect. This suggests a threshold-type behavior of inflation rates with respect to nominal depreciations.

The results of our extensive empirical analysis are consistent with the accepted view that pass-through coefficients are larger in HDEs. However, the results also robustly support the intuition (backed by the model in Appendix I) that large depreciations have a negative impact on pass-through coefficients and that this negative impact is higher the higher the degree of dollarization of the economy. When the exchange rate regime is controlled for, the results suggest that these negative balance-sheet effects are mostly a fixed-exchange rate regime story, whereas countries with intermediate or flexible rates seem to be less subject to these effects. Finally, we show indirect evidence which confirms that investment behavior may be behind this balance-sheet effect, as we postulated.

Our main interest was to give a first look at the existence of a mechanism that has so far been neglected in the literature. Balance-sheet considerations in dollarized countries lead to effects of exchange rate changes that go against the traditional implications of Mundell-Fleming based models. Evidence for output has been more thoroughly analyzed but an analysis of the inflationary implications was still lacking and we believe that our exercise helps to close the gap in that direction. In particular, the "large depreciation" effect had not been yet analyzed in the context of high dollarization.

Our analysis focused on the behavior of inflation rates. However, taking the implications further, our results also show that the traditional trade-off between inflation and employment is contingent on the level of dollarization and exchange rate regime of the economy. The model and empirical evidence suggest that the extent of this trade-off changes with the degree of dollarization of the economy –through a balance-sheet effect– and is likely to differ depending on the size of the movements in the exchange rate. This has important implications for policymakers: monetary authorities, for example, should take this feature into account when designing and implementing exchange-rate based stabilization policies.

# References


[1] Aghion, P., P. Bacchetta and A. Banerjee, 2001. Currency Crises and Monetary Policy in an Economy with Credit Constraints. *European Economic Review* 45, 1121-1150.

[2] Aguiar, M.A., 2005. Investment, Devaluation, and Foreign Currency Exposure: The Case of Mexico. *Journal of Development Economics* 78, 95-113.

[3] Arellano, M., 2003. *Panel Data Econometrics*. Oxford: Oxford University Press.

[4] Batini, N., Levine, P. and J. Pearlman, 2007. Optimal Exchange Rate Stabilization in a Dollarized Economy with Inflation Targets. Mimeo, London Metropolitan University.

[5] Becker, G., M. Grossman and K. Murphy, 1995. An Empirical Analysis of Cigarette Addiction. *American Economic Review* 84, 396-418.

[6] Bigio, S. and J. Salas, 2006. Non-linear Effects of Monetary Policy and Real Exchange Rate Shocks in Partially Dollarized Economies: An Empirical Study for Peru. *Working Paper of the Banco Central de Reserva del Peru* 2006-008.

[7] Calvo, G. A. and C. Reinhart, 2002. Fear of Floating. *Quarterly Journal of Economics* 117, 379-408.

[8] Campa, J.M. and L. Goldberg, 2005. Exchange Rate Pass-Through into Import Prices. *Review of Economics and Statistics* 87 (4), 679-690.

[9] Carranza, L., J.M. Cayo and J.E. Galdon-Sanchez, 2003. Exchange Rate Volatility and Economic Performance in Peru: A Firm Level Analysis. *Emerging Markets Review* 4, 472-496.

[10] Carranza, L., J.E. Galdon-Sanchez and J. Gomez Biscarri, 2004. Exchange Rate and Inflation Dynamics in Dollarized Economies. Working Paper 10/04, Universidad de Navarra.

[11] Carranza, L., J.E. Galdon-Sanchez and J. Gomez Biscarri, 2008. The relationship between investment and large exchange rate depreciations in dollarized economies. Working Paper 01/08, Universidad de Navarra.

[12] Ca'Zorzi, M., Hahn, E. and M. Sanchez, 2007. Exchange Rate Pass-Through in Emerging Markets. *ECB Working Paper* 739.

[13] Cespedes, L., R. Chang and A. Velasco, 2004. Balance-sheet and Exchange Rate Policy. *American Economic Review* 94 (4), 1183-93.

[14] Cespedes, L., R. Chang and A. Velasco, 2003. IS-LM-BP in the Pampas. *IMF Staff Papers*, Special Issue 2003, 50 (0), 143-56.

[15] Chan, K.S. and R.S. Tsay, 1998. Limiting Properties of the Least Squares Estimator of a Continuous Threshold Autoregressive Model. *Biometrika* 85, 413-426.

[16] Choi, W.G. and Cook, D., 2004. Liability Dollarization and the Bank Balance Sheet Channel. *Journal of International Economics* 64, 247-275.

[17] Choudhri, E. U., H. Faruqee and D.S. Hakura, 2005. Explaining the Exchange Rate Pass-Through in Different Prices. *Journal of International Economics* 65, 349-374.

[18] Devereux, M.B. and C. Engel, 2002. Exchange Rate Pass-Through, Exchange Rate Volatility and Exchange Rate Disconnect. *Journal of Monetary Economics* 49, 913-940.

[19] Devereux, M.B., Engel, C. and P.E. Storgaard, 2004. Endogenous Exchange Rate Pass-Through when Nominal Prices are set in advance. *Journal of International Economics* 63, 263-291.

[20] Devereux, M.B. and J. Yetman, 2003. Price-Setting and Exchange Rate Pass-Through: Theory and Evidence. In *Price Adjustment and Monetary Policy*, 347-371. Ottawa: Bank of Canada.

[21] Diaz-Gimenez, J., E.C. Prescott, T. Fitzgerald and F. Alvarez (1992). Banking in computable general equilibrium economics. *Journal of Economic Dynamics and Control* 16, 533-559.

[22] Edwards, S., 1986. Are devaluations contractionary? *Review of Economics and Statistics* 68, 501-508.

[23] Eichengreen, B. and R. Hausman, 2003. *Debt Denomination and Financial Instability in Emerging Market Economics.* B. Eichengreen and R. Hausmann (eds). Chicago, Illinois: University of Chicago Press.

[24] Forbes, K., 2002. How Do Large Depreciations Affect Firm Performance? *IMF Staff Papers* 49, 214-238.

[25] Frankel, J. and E. Cavallo, 2004. Does Openness to Trade Make Countries Less Vulnerable to Sudden Stops? Using Gravity to Establish Causality. Kennedy School of Government, Harvard University

[26] Ghosh, A. and R. Rajan, 2007a. A Selective Survey of Exchange Rate Pass-Through in Asia: What does the Literature Tell Us. *Colorado College Workng Paper* 2007-01.

[27] Ghosh, A. and R. Rajan, 2007b. Macroeconomic Determinants of Exchange Rate Pass-Through in India. *Colorado College Workng Paper* 2007-02.

[28] Goldberg, P.K. and M.M. Knetter, 1997. Goods Prices and Exchange Rates: What have we learned? *Journal of Economic Literature* 35 (3), 1243-1272.

[29] Goujon, M., 2006. Fighting Inflation in a Dollarized Economy: The Case of Vietnam. *Journal of Comparative Economics* 34, 564-581.

[30] Harvey, C. and A. Roper, 1999. The Asian Bet. In A. Harwood, R.E. Litan and M. Pomerleano (eds.) *The Crisis in Emerging Financial Markets*, 29-115. Washington, DC: Brookings Institution Press.

[31] Ito, T. and K. Sato, 2007. Exchange Rate Pass-Through and Domestic Inflation: A Comparison between East Asia and Latin American Countries. *RIETI Discussion Paper Series* 07-E-040.

[32] Khundrakpam, J.K., 2007. Economic Reforms and Exchange Rate Pass-Through to Domestic Prices in India. *BIS Working Paper* 225.

[33] Kiyotaki, N. and J.H. Moore, 1997, Credit Cycles. *Journal of Political Economy* 105, 211-248.

[34] Krugman, P., 1999. Balance-sheet, the Transfer Problem, and Financial Crisis. In P. Isard, A. Razin and A.K Rose (eds.) *International Finance and Financial Crises: Essays in Honour of Robert P. Flood, Jr*, 31-44. Norwell, Massachusetts: Kluwer Academic Publishers.

[35] Leiderman, L., Maino, R. and E. Parrado, 2006. Inflation Targeting in Dollarized Economies. *IMF Working Paper* 06/157.

[36] Levy-Yeyati, E. and F. Sturzenegger, 2003. A de Facto Classification of Exchange Rate Regimes: A Methodological Note. Data Appendix for the paper: To Float or to Fix: Evidence on the Impact of Exchange Rate Regimes on Growth. *American Economic Review* 93(4), (available at http://www.aeaweb.org/aer/contents/).

[37] Magud, N., 2007. Currency Mismatch, Openness and Exchange Rate Regime Choice. University of Oregon Economics Department Working Papers, 2004-14.

[38] Pollard, P.S. and C.C. Coughlin, 2003. Size Matters: Asymmetric Exchange Rate Pass-Through at the Industry Level. *Federal Reserve Bank of St. Louis Working Paper* 2003-029C.

[39] Reinhart, C.M., K.S. Rogoff and M.A. Savastano, 2003. Addicted to Dollars. *NBER Working Paper* 10015.

[40] Rowland, P., 2003. Exchange Rate Pass-Through to Domestic Prices: The Case of Colombia. *Borradores de Economia of the Banco de la Republica de Colombia* 254.

[41] Tsay, R.S., 2002. *Analysis of Financial Time Series.* New York: John Wiley and Sons.

[42] Weymouth, S., 2007. Political Institutions, Policy Instability, and Financial Dollarization. Working Paper UC San Diego.

# Appendix I: A justification of the reduced-form equations

Following Cespedes et al. (2003), our macro analysis is based on a set of reduced form relationships. We abstract, however, from the assets market and assume that the exchange rate changes are exogenous to the goods market. For simplicity, we present only the (linearized) relationships that are relevant to our argument. We assume our economy to be small and with a high degree of liability dollarization, so that a large proportion of firms' debts are denominated in foreign currency.

The first equation is the definition of a domestic consumer price index (CPI) which depends on the price of tradeable and nontradable goods:

$$p_t = \delta p_t^{nt} + (1 - \delta) e_t \tag{A.1}$$

where $p_t$ is the logarithm of the CPI at time $t$, $p_t^{nt}$ is the logarithm of the price level of nontradable goods, $e_t$ is the logarithm of the nominal exchange rate and $0 \leq \delta \leq 1$ is the proportion of nontradable goods in the consumption bundle. We normalize international prices to one.

The prices of nontradable goods respond to demand pressures and to an inertial term:

$$p_t^{nt} = \beta y_t + \sigma p_{t-1} \tag{A.2}$$

where $y_t$ is the logarithm of the output gap, $\beta$ measures the impact of excess aggregate demand on nontradable prices, and $\sigma$ measures inertial factors of the economy (e.g. through salary pressures). For simplicity we consider the natural level of income to be zero.

Aggregate demand is given by the following equation:

$$y_t = \kappa i_t + \gamma Z_t + \alpha (e_t - p_t) \tag{A.3}$$

where $i_t$ is the logarithm of the investment level and $Z_t$ contains other exogenous variables affecting the income level. The parameters $\kappa$ and $\gamma$ measure the impact of investment and those other variables on aggregate demand, respectively. The parameter $\alpha$ represents the *competitiveness* impact of the real exchange rate (a larger real exchange rate -a real depreciation- implies a larger foreign net demand).

We postulate now that investment may respond negatively to increases in the real exchange rate due to the high dollarization of firms' debts (negative balance-sheet effect). The rationale for this relationship is that a higher real exchange rate reduces firms' net worth if there is a mismatch between the currency composition of liabilities and the firms' flow of income. This reduction in net worth increases the cost of capital for the firm and generates a negative impact on the firm's level of investment. Furthermore, when firms are financially vulnerable it may be the case that, if a large real depreciation occurs, the net worth deterioration of firms is so severe that they will be squeezed out of the credit market. In this extreme case, nonlinearities appear in the investment function since firms react more strongly when the depreciation is beyond some threshold value.

A simple partial equilibrium model that explains the appearance of this relationship between investment and the exchange rate can be found in Carranza et al. (2008). A version of the investment function that includes this nonlinearity could be the following:

$$i_t = (\lambda + \chi\rho)(e_t - p_t); \chi = \mathbf{1}[(e_t - p_t) > \varphi] \quad \text{(A.4)}$$

The parameter $\lambda$ (which could be either positive or negative) measures the slope of the investment function with respect to the real exchange rate in the "regular values" range, i.e. when the real exchange rate is below some threshold $\varphi$. The magnitude of $\lambda$ depends on both financial costs of investment and the balance-sheet effect of a real depreciation for both tradable and nontradable firms (see Carranza et al., 2008). The parameter $\rho$ measures the "large depreciation" effect, and it captures the change in the slope of the investment function when the real exchange rate is beyond some threshold $\varphi$. As Carranza et al. (2008) show, this slope $(\lambda + \rho)$ must be lower than $\lambda$, so that $\rho < 0$. The function $\mathbf{1}[(e_t - p_t) > \varphi]$ is an indicator function, which takes value one if the real exchange rate is beyond the threshold $\varphi$. The size of the two effects measured by $\lambda$ and $\rho$ will depend on the extent of the mismatch between the currency composition of liabilities and the firms' expected flows of income. Therefore, at the aggregate level, these effects will be more intense the higher the degree of dollarization of the economy (see Carranza et al., 2008). In other words, both $\lambda$ and $\rho$ are negative functions of the degree of dollarization.

Combining now equations (A.1) to (A.4) and solving for the price level -note that we assume exogenous changes in the exchange rate and sticky prices, so that a nominal depreciation induces a real depreciation-, we obtain:

$$p_t = (\phi_1 + \chi\phi_2)\, e_t + \phi_3 Z_t + \phi_4 p_{t-1};\ \chi = \mathbf{1}\left[\Delta e_t > \varphi\right] \tag{A.5}$$

where, if we call $\omega = \frac{1}{1+\delta\beta(\alpha-\kappa(\lambda+\chi\rho))}$, then $\phi_1 = \omega\,(1-\delta+\delta\beta\alpha+\delta\beta\kappa\lambda)$, $\phi_2 = \omega\,(\delta\beta\kappa\rho)$, $\phi_3 = \omega\,(\delta\beta\gamma)$ and $\phi_4 = \omega\,(\delta\sigma)$. The coefficients $\phi_1$ and $\phi_2$ measure the exchange rate pass-through in the goods market of a nominal depreciation. Notice that this pass-through contains four different terms:

1. The term $(1-\delta)$ measures "imported inflation", the impact of a depreciation on the price of imported tradable goods.

2. The term $\delta\beta\alpha$ measures the "export-push" inflationary effect of an increase in foreign demand.

3. The term $\delta\beta\kappa\lambda$ measures the regular "balance-sheet effect", which may be positive or negative (see Carranza et al., 2008).

4. The term $\delta\beta\kappa\rho$ measures the "large depreciation effect", which is a nonlinearity in the balance-sheet effect: if the depreciation is beyond a threshold $\varphi$, the impact on prices will be lower (negative $\rho$) because of the collapse of nontradable firms' investment.

Differencing this equation leads to a reduced-form expression that corresponds to the equation estimated in the paper:

$$\pi_t = (\phi_1 + \chi\phi_2)\,\Delta e_t + \phi_3 \Delta Z_t + \phi_4 \pi_{t-1};\ \chi = 1\left[\Delta e_t > \varphi\right] \tag{A.6}$$

where $\pi_t$ is the CPI inflation rate and $\Delta e_t$ is the change in the nominal exchange rate.

# Appendix II: 2SLS estimation of panels conditional on $\varphi$

Given the reduced form equation we want to estimate:

$$\begin{aligned}\pi_{it} &= \delta_0 + \delta_1 \pi_{it-1} + \delta_2 \Delta e_{it-1} + \delta_3 d_{it} \Delta e_{it-1} + ... \\ &\quad ... + \delta_4 \mathbf{1}(\Delta e_{it-1} > \varphi) + +\delta_5 d_{it} \mathbf{1}(\Delta e_{it-1} > \varphi) \Delta e_{it-1} + \boldsymbol{\delta}' X_{it} + u_{it}\end{aligned} \quad (A.7)$$

and once a value for $\varphi$ has been fixed, the model becomes a simple linear dynamic panel. Let the stacked form of the model be:

$$y = W\delta + C\eta + u \quad (A.8)$$

where $y$ is the $\sum_i T_i \times 1$ vector of stacked inflation rates, $\eta$ is an $N \times 1$ vector of individual effects and $C$ is a $\sum_i T_i \times N$ matrix of individual dummies. The matrix $W$ is the $\sum_i T_i \times K_W$ matrix of explanatory variables, which includes the lagged inflation rate, the pass-through terms and possible control variables. We assume $u_{it}$ to be *iid* across $t$ and $i$.

Let $Z$ be a $\sum_i T_i \times K_Z$ matrix of instruments, where $K_Z \geq K_W$. Then the 2SLS estimator of $(\delta, \eta)$, using $Z$ and the individual dummies $C$ as instruments, is given by:

$$\begin{aligned}\begin{pmatrix} \widehat{\delta} \\ \widehat{\eta} \end{pmatrix} &= \left[W^{*\prime} Z^* \left(Z^{*\prime} Z^*\right)^{-1} Z^{*\prime} W^*\right]^{-1} W^{*\prime} Z^* \left(Z^{*\prime} Z^*\right)^{-1} Z^{*\prime} y \\ &= \left[\widehat{W^*}' \widehat{W^*}\right]^{-1} \widehat{W^*}' y\end{aligned} \quad (A.9)$$

where $W^* = (W, C)$, $Z^* = (Z, C)$ and $\widehat{W^*} = \left(\widehat{W}, C\right)$ are the fitted values of $W^*$ in a regression on $Z^*$. As Arellano (2003) mentions, when $T$ is large this procedure, using lags of the exogenous variables as instruments for the lagged dependent variable, is consistent even if the instruments are only predetermined. Becker et al. (1994), for example, use this same approach for a panel shorter than ours ($T = 31$).

## Table 1: List of countries and data available

| | In 124 | # of obs.* | DOL2** | Reason to exclude |
|---|---|---|---|---|
| **Albania** | Yes | 30 | | |
| **Algeria** | Yes | 30 | | |
| **Angola** | Yes | 31 | | |
| **Argentina** | Yes | 31 | Yes | |
| **Armenia** | Yes | 31 | | |
| **Aruba** | No | | | Fixed Exchange Rate |
| **Australia** | Yes | 31 | | |
| **Austria** | Yes | 31 | | |
| **Azerbaijan** | No | | | No CPI Data |
| **Bahamas** | No | | | Fully dollarized |
| **Bahrain** | No | | | Fixed Exchange Rate |
| **Bangladesh** | Yes | 27 | | |
| **Barbados** | No | | | Fixed Exchange Rate |
| **Belarus** | No | | | No CPI Data |
| **Belgium** | Yes | 31 | | |
| **Belize** | No | | | Fixed Exchange Rate |
| **Benin** | Yes | 29 | | |
| **Bolivia** | Yes | 31 | Yes | |
| **Bosnia** | No | | | No CPI Data |
| **Botswana** | Yes | 31 | | |
| **Brazil** | Yes | 31 | Yes | |
| **Bulgaria** | Yes | 31 | Yes | |
| **Burkina Faso** | Yes | 31 | | |
| **Burundi** | Yes | 31 | | |
| **Cambodia** | Yes | 31 | | |
| **Cameroon** | Yes | 23 | | |
| **Canada** | Yes | 31 | | |
| **Cape Verde** | Yes | 24 | | |
| **Central African Rep.** | Yes | 30 | | |
| **Chad** | Yes | 29 | | |
| **Chile** | Yes | 31 | Yes | |
| **China; Macao** | No | | | Fixed Exchange Rate |
| **China; Mainland** | No | | | No CPI Data |
| **China;Hong Kong** | No | | | Fixed Exchange Rate |
| **Colombia** | Yes | 31 | Yes | |
| **Congo, Dem. Rep.** | Yes | 23 | | |
| **Congo Rep. Of** | No | | | Incomplete CPI Data |
| **Costa Rica** | Yes | 31 | Yes | |
| **Cote D'ivoire** | Yes | 29 | | |
| **Croatia** | Yes | 31 | Yes | |
| **Cyprus** | Yes | 31 | | |
| **Czech Rep.** | Yes | 31 | | |
| **Denmark** | Yes | 31 | | |
| **Dominica** | No | | | Fixed Exchange Rate |
| **Dominican Republic** | Yes | 30 | Yes | |
| **Ecuador** | Yes | 31 | Yes | |
| **Egypt** | Yes | 31 | Yes | |
| **El Salvador** | No | | | Fixed Exchange Rate |
| **Estonia** | Yes | 31 | | |
| **Ethiopia** | Yes | 27 | | |
| **Fiji** | Yes | 29 | Yes | |
| **Finland** | Yes | 31 | | |
| **France** | Yes | 31 | | |
| **Gabon** | No | | | Incomplete CPI Data |
| **Gambia** | No | | | Incomplete CPI Data |
| **Georgia** | Yes | 23 | | |
| **Germany** | Yes | 31 | | |
| **Ghana** | Yes | 30 | | |
| **Greece** | Yes | 31 | | |
| **Grenada** | No | | | Fixed Exchange Rate |
| **Guatemala** | Yes | 31 | Yes | |
| **Guinea** | No | | | No CPI Data |
| **Guinea-Bissau** | Yes | 29 | | |
| **Guyana** | Yes | 23 | | |
| **Haiti** | Yes | 30 | | |
| **Honduras** | Yes | 31 | Yes | |
| **Hungary** | Yes | 31 | | |
| **Iceland** | Yes | 31 | | |
| **India** | Yes | 30 | Yes | |
| **Indonesia** | Yes | 31 | Yes | |
| **Iran, I.R. of** | Yes | 30 | | |
| **Ireland** | Yes | 31 | | |
| **Israel** | Yes | 31 | | |
| **Italy** | Yes | 31 | | |
| **Jamaica** | Yes | 31 | Yes | |
| **Japan** | Yes | 31 | | |
| **Jordan** | No | | | Fixed Exchange Rate |
| **Kazakhstan** | Yes | 31 | Yes | |
| **Kenya** | Yes | 31 | | |
| **Korea** | Yes | 31 | | |
| **Kuwait** | No | | | Fixed Exchange Rate |
| **Kyrgyz Rep.** | Yes | 31 | | |
| **Lao, P.'s Dem. Rep.** | Yes | 30 | | |
| **Latvia** | Yes | 31 | | |
| **Lebanon** | No | | | Fixed Exchange Rate |
| **Lesotho** | No | | | Incomplete CPI Data |
| **Lithuania** | Yes | 31 | | |
| **Luxembourg** | Yes | 31 | | |
| **Macedonia, FYR** | Yes | 30 | | |
| **Madagascar** | Yes | 31 | | |
| **Malawi** | Yes | 30 | | |
| **Malaysia** | Yes | 31 | Yes | |
| **Maldives** | No | | | Fixed Exchange Rate |
| **Mali** | Yes | 30 | | |
| **Malta** | Yes | 30 | | |
| **Mauritania** | Yes | 27 | | |
| **Mauritius** | Yes | 31 | Yes | |
| **Mexico** | Yes | 31 | Yes | |
| **Moldova** | Yes | 28 | Yes | |
| **Mongolia** | Yes | 29 | | |
| **Morocco** | Yes | 28 | Yes | |
| **Mozambique** | Yes | 29 | | |
| **Myanmar** | Yes | 28 | | |
| **Namibia** | No | | | No dollarization value |
| **Nepal** | Yes | 30 | | |
| **Netherlands** | Yes | 31 | | |
| **Netherlands Antilles** | No | | | Fixed Exchange Rate |
| **New Zealand** | Yes | 31 | | |
| **Nicaragua** | Yes | 30 | Yes | |
| **Niger** | Yes | 28 | | |
| **Nigeria** | Yes | 30 | | |
| **Norway** | Yes | 31 | | |
| **Oman** | No | | | Fixed Exchange Rate |
| **Pakistan** | Yes | 31 | Yes | |
| **Panama** | No | | | Fully dollarized |
| **Papua New Guinea** | Yes | 30 | Yes | |
| **Paraguay** | Yes | 30 | Yes | |
| **Peru** | Yes | 31 | Yes | |
| **Philippines** | Yes | 31 | Yes | |
| **Poland** | Yes | 31 | | |
| **Portugal** | Yes | 31 | | |
| **Romania** | Yes | 31 | | |
| **Russia** | Yes | 31 | Yes | |
| **Rwanda** | No | | | |
| **Samoa** | Yes | 27 | | |
| **Sao Tome** | No | | | No CPI Data |
| **Saudi Arabia** | No | | | Fixed Exchange Rate |
| **Senegal** | Yes | 28 | | |
| **Seychelles** | Yes | 30 | | |
| **Sierra Leone** | Yes | 30 | | |
| **Singapore** | Yes | 31 | | |
| **Slovak Republic** | Yes | 31 | | |
| **Slovenia** | Yes | 31 | | |
| **Solomon Islands** | Yes | 28 | | |
| **South Africa** | Yes | 31 | Yes | |
| **Spain** | Yes | 31 | | |
| **Sri Lanka** | Yes | 31 | | |
| **St. Lucia** | No | | | Fixed Exchange Rate |
| **St. Vincent & Gre.** | No | | | Fixed Exchange Rate |
| **St.Kitts and Nevis** | No | | | Fixed Exchange Rate |
| **Sudan** | No | | | |
| **Suriname** | No | | | |
| **Swaziland** | Yes | 30 | | |
| **Sweden** | Yes | 31 | | |
| **Switzerland** | Yes | 31 | | |
| **Syria** | No | | | Fixed Exchange Rate |
| **Taiwan** | No | | | No CPI Data |
| **Tajikistan** | No | | | No CPI Data |
| **Tanzania** | Yes | 31 | | |
| **Thailand** | Yes | 31 | Yes | |
| **Togo** | Yes | 28 | | |
| **Tonga** | Yes | 30 | | |
| **Trinidad and Tobago** | Yes | 28 | Yes | |
| **Tunisia** | Yes | 31 | Yes | |
| **Turkey** | Yes | 31 | Yes | |
| **Turkmenistan** | No | | | No CPI Data |
| **Uganda** | Yes | 31 | | |
| **Ukraine** | No | | | No CPI Data |
| **United Arab Emirates** | No | | | No CPI Data |
| **United Kingdom** | Yes | 31 | | |
| **United States** | No | | | Reference currency |
| **Uruguay** | Yes | 31 | Yes | |
| **Uzbekistan** | No | | | No CPI Data |
| **Vanuatu** | Yes | 28 | | |
| **Venezuela, Rep. Bol.** | Yes | 31 | Yes | |
| **Vietnam** | Yes | 31 | Yes | |
| **Yemen** | No | | | No CPI Data |
| **Zambia** | Yes | 23 | | |
| **Zimbabwe** | No | | | Incomplete CPI Data |

* This column already accounts for the observations lost due to inclusion of lags in the dynamic equation

** Availability of the alternative dollarization variable

Table 2: 2SLS-dynamic panel estimates of pass-through equations; φ=constrain

Dependent variable: Interannual CPI-inflation rate; t-stats in second row;

Measure of dollarization in Reinhart et al. (2005)

| | | | | | | φ=0 | | | | | φ=0.15 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ |
| $\delta_1$ | $\pi_{t-1}$ | 0.881 | 0.905 | 0.870 | 0.893 | 0.878 | 0.875 | 0.876 | 0.874 | 0.892 | 0.865 | 0.863 | 0.864 | 0.861 | 0.887 |
| | | 95.3 | 85.5 | 89.4 | 80.7 | 90.7 | 88.1 | 89.9 | 86.8 | 77.1 | 94.0 | 91.3 | 93.2 | 90.0 | 79.3 |
| $\delta_2$ | **Xr depr.** | 0.068 | 0.168 | -0.003 | 0.104 | 0.048 | -0.012 | 0.048 | -0.019 | 0.086 | -0.004 | -0.081 | 0.002 | -0.093 | -0.007 |
| | | 2.71 | 4.97 | -0.10 | 3.04 | 2.34 | -0.44 | 2.31 | -0.69 | 1.59 | -0.19 | -2.89 | 0.09 | -3.32 | -0.15 |
| $\delta_3$ | **Xr depr.*dol** | | | 0.013 | 0.013 | 0.031 | 0.030 | 0.031 | 0.030 | 0.016 | 0.029 | 0.029 | 0.029 | 0.029 | 0.018 |
| | | | | 6.82 | 7.00 | 6.20 | 5.78 | 6.23 | 5.67 | 3.05 | 9.91 | 9.53 | 9.88 | 9.45 | 5.63 |
| $\delta_4$ | **1(Xr depr>φ)** | | | | | 0.000 | 0.001 | 0.001 | 0.001 | 0.000 | 0.049 | 0.052 | 0.050 | 0.056 | 0.035 |
| | | | | | | 0.21 | 0.29 | 0.27 | 0.48 | 0.09 | 6.66 | 6.66 | 6.73 | 7.07 | 4.25 |
| $\delta_5$ | **Xr depr*dol*1(Xrdepr>φ)** | | | | | -0.016 | -0.016 | -0.017 | -0.017 | -0.001 | -0.016 | -0.017 | -0.017 | -0.020 | 0.003 |
| | | | | | | -3.16 | -3.05 | -3.23 | -3.16 | -0.13 | -5.99 | -6.19 | -6.20 | -6.85 | 0.43 |
| $\delta_6$ | **Openness ratio** | -0.002 | -0.002 | -0.001 | -0.001 | | -0.002 | | -0.001 | -0.001 | | -0.002 | | -0.002 | -0.001 |
| | | -0.84 | -0.82 | -0.64 | -0.45 | | -0.70 | | -0.59 | -0.44 | | -0.84 | | -0.77 | -0.62 |
| $\delta_7$ | **Openness ratio*Xr depr.** | 0.157 | 0.102 | 0.097 | 0.034 | | 0.086 | | 0.101 | 0.036 | | 0.107 | | 0.139 | 0.066 |
| | | 6.04 | 3.56 | 3.65 | 1.19 | | 3.38 | | 3.80 | 1.27 | | 4.24 | | 5.18 | 2.27 |
| $\delta_8$ | **rGDP growth** | -0.028 | -0.013 | -0.034 | -0.018 | | | -0.040 | -0.041 | -0.020 | | | -0.021 | -0.023 | -0.014 |
| | | -1.14 | -0.56 | -1.45 | -0.80 | | | -1.78 | -1.73 | -0.86 | | | -0.97 | -0.99 | -0.60 |
| $\delta_9$ | **rGDP growth*Xr depr.** | -0.866 | -0.729 | -0.213 | -0.152 | | | -0.013 | -0.252 | -0.165 | | | -0.284 | -0.645 | -0.227 |
| | | -4.57 | -3.94 | -1.03 | -0.76 | | | -0.07 | -1.20 | -0.82 | | | -1.47 | -3.05 | -1.10 |
| $\delta_{10}$ | **Intermediate** | | 0.0059 | | 0.0051 | | | | | 0.0052 | | | | | 0.0039 |
| | | | 2.30 | | 2.06 | | | | | 2.04 | | | | | 1.58 |
| $\delta_{11}$ | **Intermediate*Xr depr.** | | -0.057 | | -0.061 | | | | | -0.039 | | | | | -0.017 |
| | | | -1.75 | | -1.93 | | | | | -0.74 | | | | | -0.39 |
| $\delta_{12}$ | **Intermediate*dol*Xrdepr*1(Xrdepr>φ)** | | | | | | | | | -0.002 | | | | | -0.009 |
| | | | | | | | | | | -0.41 | | | | | -1.43 |
| $\delta_{13}$ | **Fixed** | | 0.2174 | | -3E-04 | | | | | -4E-04 | | | | | -6E-04 |
| | | | 0.00 | | -0.12 | | | | | -0.18 | | | | | -0.30 |
| $\delta_{14}$ | **Fixed*Xr depr.** | | -0.104 | | -0.065 | | | | | -0.068 | | | | | 0.0053 |
| | | | -2.61 | | -1.66 | | | | | -1.19 | | | | | 0.11 |
| $\delta_{15}$ | **Fixed*dol*Xrdepr*1(Xrdepr>φ)** | | | | | | | | | 0.0011 | | | | | -0.016 |
| | | | | | | | | | | 0.17 | | | | | -2.42 |
| | $s_y$ | 0.176 | 0.155 | 0.176 | 0.155 | 0.171 | 0.176 | 0.170 | 0.176 | 0.155 | 0.171 | 0.176 | 0.170 | 0.176 | 0.155 |
| | $s_e$ | 0.052 | 0.048 | 0.052 | 0.046 | 0.050 | 0.052 | 0.050 | 0.052 | 0.046 | 0.050 | 0.051 | 0.050 | 0.051 | 0.046 |
| | N | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 |
| | sum($T_i$) | 3427 | 3079 | 3427 | 3079 | 3718 | 3427 | 3710 | 3427 | 3079 | 3718 | 3427 | 3710 | 3427 | 3079 |

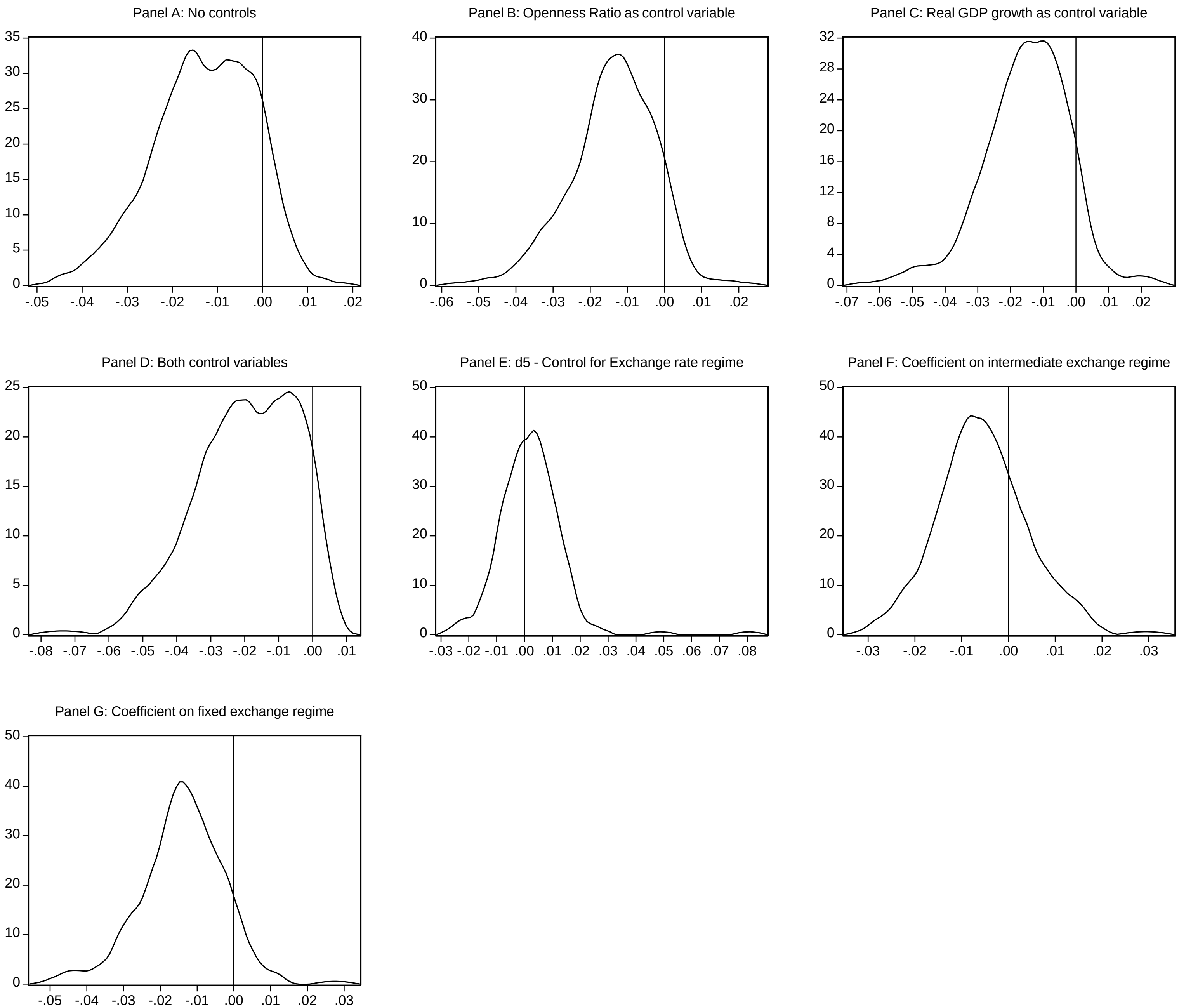
## Table 3: Conditional 2SLS-dynamic panel estimates

Dependent variable: Interannual CPI-inflation rate; t-stats in second row - bootstrap t-stats for φ;

Measure of dollarization in Reinhart et al. (2005)

| | | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ | $\delta_{2SLS}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $\delta_1$ | $\pi_{t-1}$ | 0.881 | 0.905 | 0.870 | 0.893 | 0.863 | 0.861 | 0.862 | 0.860 | 0.884 |
| | | 95.3 | 85.5 | 89.4 | 80.7 | 92.8 | 90.2 | 92.1 | 89.0 | 79.5 |
| $\delta_2$ | **Xr depr.** | 0.068 | 0.168 | -0.003 | 0.104 | -0.012 | -0.087 | -0.006 | -0.098 | -0.004 |
| | | 2.71 | 4.97 | -0.10 | 3.04 | -0.59 | -3.15 | -0.33 | -3.53 | -0.08 |
| $\delta_3$ | **Xr depr.*dol** | | | 0.013 | 0.013 | 0.026 | 0.026 | 0.026 | 0.026 | 0.014 |
| | | | | 6.82 | 7.00 | 8.35 | 8.01 | 8.34 | 7.97 | 4.38 |
| $\delta_4$ | **1(Xr depr>φ)** | | | | | 0.053 | 0.055 | 0.054 | 0.058 | 0.036 |
| | | | | | | 8.39 | 8.33 | 8.44 | 8.69 | 5.11 |
| $\delta_5$ | **Xr depr*dol*1(Xrdepr>φ)** | | | | | -0.012 | -0.014 | -0.013 | -0.016 | 0.005 |
| | | | | | | -4.30 | -4.49 | -4.51 | -5.11 | 0.93 |
| $\delta_6$ | **Openness ratio** | -0.002 | -0.002 | -0.001 | -0.001 | | -0.002 | | -0.002 | -0.002 |
| | | -0.84 | -0.82 | -0.64 | -0.45 | | -0.95 | | -0.89 | -0.75 |
| $\delta_7$ | **Openness ratio*Xr depr.** | 0.157 | 0.102 | 0.097 | 0.034 | | 0.104 | | 0.133 | 0.062 |
| | | 6.04 | 3.56 | 3.65 | 1.19 | | 4.15 | | 5.01 | 2.15 |
| $\delta_8$ | **rGDP growth** | -0.028 | -0.013 | -0.034 | -0.018 | | | -0.017 | -0.018 | -0.009 |
| | | -1.14 | -0.56 | -1.45 | -0.80 | | | -0.77 | -0.79 | -0.42 |
| $\delta_9$ | **rGDP growth*Xr depr.** | -0.866 | -0.729 | -0.213 | -0.152 | | | -0.268 | -0.610 | -0.212 |
| | | -4.57 | -3.94 | -1.03 | -0.76 | | | -1.39 | -2.90 | -1.04 |
| $\delta_{10}$ | **Intermediate** | | 0.0059 | | 0.0051 | | | | | 0.0039 |
| | | | 2.30 | | 2.06 | | | | | 1.57 |
| $\delta_{11}$ | **Intermediate*Xr depr.** | | -0.057 | | -0.061 | | | | | -0.023 |
| | | | -1.75 | | -1.93 | | | | | -0.50 |
| $\delta_{12}$ | **Intermediate*dol*Xrdepr*1(Xrdepr>φ)** | | | | | | | | | -0.008 |
| | | | | | | | | | | -1.31 |
| $\delta_{13}$ | **Fixed** | | 0.2174 | | -3E-04 | | | | | -6E-04 |
| | | | 0.00 | | -0.12 | | | | | -0.29 |
| $\delta_{14}$ | **Fixed*Xr depr.** | | -0.104 | | -0.065 | | | | | 0.0069 |
| | | | -2.61 | | -1.66 | | | | | 0.14 |
| $\delta_{15}$ | **Fixed*dol*Xrdepr*1(Xrdepr>φ)** | | | | | | | | | -0.015 |
| | | | | | | | | | | -2.26 |
| | φ | -- | -- | -- | -- | 0.126 | 0.126 | 0.126 | 0.126 | 0.126 |
| | | -- | -- | -- | -- | 4.03 | 3.45 | 3.04 | 2.56 | 2.71 |
| | $s_y$ | 0.176 | 0.155 | 0.176 | 0.155 | 0.171 | 0.176 | 0.170 | 0.176 | 0.155 |
| | $s_e$ | 0.052 | 0.048 | 0.052 | 0.046 | 0.049 | 0.051 | 0.049 | 0.051 | 0.0457 |
| | N | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 |
| | sum($T_i$) | 3427 | 3079 | 3427 | 3079 | 3718 | 3427 | 3710 | 3427 | 3079 |
| | **% of negative δ5 in bootstrap** | -- | -- | -- | -- | 89% | 92% | 93% | 95% | 42% |

Figure 1: Kernel-density estimates of distribution of bootstrap estimates of the interaction parameter
(Epanechnikov Kernel; Silverman's bandwidth)



# Figure 2:
# Estimated values of large depreciation pass-through as a function of φ; baseline case and exchange rate regime controls