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Exchange rate pass-through, monetary policy and real shocks: an empirical evaluation*

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Abstract

We look at a panel of Latin American countries from 1970 and 2016 to enquire how exchange rate pass-through has changed over time, and whether this owes to monetary or real shocks hitting the economy. We estimate conventional pass-through measures, both short and long run; then we obtain rolling estimates of those measures, and relate them to monetary and real variables using fixed effect models. We find that: in keeping with previous studies, pass-through coefficients have fallen sharply in recent decades in Latin America; money growth tends to be strongly associated to short-run exchange rate pass through, with a small influence of real shocks such as terms-of-trade changes; money growth is also associated to long-run pass-through, while terms of trade shocks are more statistically significant. Results are consistent with the hypothesis that ERPT changes with the kind of shock and the monetary policy response to it.

JEL classification codes: F31, E31, E52, C23
Keywords: Exchange rate pass through, monetary policy, panel data models

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1 Introduction

Exchange rate pass through (ERPT) is treated in many policy discussions as something of a fundamental parameter in the economy, given by the import content of prices or other structural factors. This framing assumes that there is an exogenous shock (nominal depreciation), to which local prices adjust. It can be argued, however, that: a) nominal depreciations are not necessarily a shock, but part of the response of the economy to an external or internal shock; b) depending on what type of shock the economy is subject to, and what is the policy response to it, ERPT may be higher or lower.

This leads to discussing a number of elements, with ERPT emerging as consequence of them: type of shocks (monetary, real); policy responses (monetary convalidation or not); features of the economy (openness, cyclical phases, real exchange rate misalignment, monetary and exchange rates regimes, level of inflation) and of policy (credibility). Additionally, the analysis should take into account the weight given to first-round and second-round effects. While the former refer to adjustment in relative prices between tradable and non-tradable goods that impact on import prices, the latter denote the potential magnifications of ERPT generated by labor/product markets rigidities, or poorly anchored inflation expectations, and it is evidenced in the general price level of the economy.

In this paper, we examine a panel of Latin American countries over several decades, and estimate models that link monetary policy stance and ERPT, as well as country specific and time-specific controls. We are interested in contrasting real and monetary factors (terms-of-trade vs monetary policy easing, for instance), and how they are associated to different degrees of ERPT over time. Our hypothesis is that ERPT is linked to the monetary and foreign exchange regime in place, and as monetary policy generates shocks (through increased money growth, for instance) or convalidates them (by easing in the face of deteriorating terms-of-trade, for example) ERPT coefficients change. The rest of the paper is organized as follows. Section 2 motivates our research and puts it in the context of the applied ERPT literature. Section 3 presents our econometric approach: it describes the basic measure of ERPT we employ, and looks at how it changed across countries and time periods in our sample; and provides our first econometric results that link monetary and real factors with ERPT. Section 4 concludes and details further work.

2 Exchange rate pass through, monetary and real factors

There is a sharp contrast between conventional views on ERPT, which take it more or less as given, and a more fundamental, general equilibrium conception of it, that incorporates shocks and policy responses, and gives a more active role to monetary policy in its determination. Our hypothesis is that a low ERPT coefficient is facilitated by monetary regimes more focused on delivering price stability, with lower money growth and inflation variability (a view that is in line with Taylor, 2000).

There are diverse ways to explore ERPT determinants, both micro and macroeconomic (see Aron et al., 2014, for a very useful review of developing countries' literature). Our work touches on the latter, while the former is currently better explored based on microeconometric methods, something carried out by several of the projects in this BIS CCA network. Not surprisingly, most macroeconomic studies of ERPT include or focus on developing economies, as instability and changes of macroeconomic regimes can make these factors far more dominant than market structure, product denomination, and other microeconomic issues.

A first set of macroeconometric works basically estimates reduced form equations (price change as functions of exchange rates movements and other control variables), obtains pass-through coefficients and look at how these change under different circumstances or country groupings. Thus, Calvo and Reinhart (2000) employ vector autoregressive models (VAR) to compare ERPT coefficients of emerging and developed countries. Choudhri and Hakura (2006) test Taylor (2000) hypothesis that low inflation is conducive to lower ERPT by estimating ERPT coefficients (using exchange rate changes, inflation of trading partners and an autoregressive component) and then estimate an equation where they are explained. Comparable approaches are followed by Ca'Zorzi et al. (2007) and Albagli et al. (2015), using VAR models and focusing on differences between emerging and developed countries. Ghosh (2013) takes a panel of Latin American countries. In turn, Caselli and Roitman (2016) estimate non-linearities and asymmetries in the ERPT coefficients of several emerging economies and find evidence of non-linearities in episodes of exchange rate depreciation.

A second literature strands imposes structure from economic theory, either through the use of structural VARs (Shambauth, 2008) or by constructing DSGE models (see Bouakez and Rebei, 2008, for Canada; and Shioji, Vu and Takeuchi, 2009, for Japan). Palleja (2018) applies the model of García-Cicco et al. (2014) in order to gauge pass-through conditional to the type of shock undergone by the economy, comparing the cases of Chile and Mexico. He finds that rather than structural discrepancies between those economies, it is the type of shock, and the policy response to it that accounts for ERPT coefficients. Our approach is quite similar to it in spirit (see also BCRA, 2016 and 2017), but employing a different methodology.

Our own econometric work follows that of Ghosh (2013) and comprises two basic steps: first, we estimate exchange rate pass through measures for a number of South American countries, and analyze how they change over time; second, we relate those measures to different macroeconomic variables, so as to determine to what extent they can be associated to varying ERPT coefficients over time. We go beyond the framework of Ghosh (2013) in that: a) we do not only look at monetary factors in the determination of pass-through, but also consider real variables, such as terms of trade; b) we consider if different exchange rate and monetary regimes may lead to different ERPT coefficients; c) we employ a longer sample, that includes the period following the global financial crisis. Point a) is appropriate in light of our hypothesis that exchange rate depreciation in response to real shocks should weigh differently from that in response to monetary ones. Point b) is relevant as there may be aspects of monetary and exchange rate policy regimes that are not directly captured by the evolution of money growth, interest rates or inflation. Finally, the global financial crisis provides an excellent opportunity of showcasing ERPT dynamics in response to a systemic shock, the reaction to which is a subject of natural analytical interest.

It could be argued that a structural approach is a more natural way to deal with the kind of hypothesis we are interested in: while we recognize this, we point out that there is a modelling tradeoff between structure and identification. As models gain structure, they also typically become more costly in terms of parameter identification –more assumptions are needed to achieve identication, or certain parameters are calibrated instead of estimated. In the same breath, uni-equational models are more adept at dealing with structural change than multi-equational ones (see Aron et al, 2014, for a comprehensive comparison of both approaches when it comes to ERPT). Finally, any economic question of interest is better addressed from a multiplicity of perspectives; in our case, as there are already structural and DSGE model focused on Latin America, reduced form models like the one we propose are complementary to them. Before taking on the econometric models proper, we look at the basic, descriptive statistics and correlations in our sample that motivate our hypothesis.

2.1 Inflation, exchange rates and money growth: basic correlations

We take a sample of South American countries from 1970 to 2016, in order to capture different monetary regimes implemented during that period. The sample is comprised by: Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Mexico, Paraguay, Peru, Uruguay and Venezuela. Our observations are quarterly; for the whole sample, the correlation between inflation and exchange rate depreciation (both measured in year-over-year changes) is 83,5% (table 1). But this changes markedly across different periods, with a very pronounced fall during the 2000s, where correlation is around a fifth of its value for the complete period. Country-level data also follow, to certain extent, this general fall in prices-exchange rates correlations (see annex).

Table 1

Correlation coefficients between changes in exchange rate and CPI inflation Latin America – selected countries					
1970-2016	**1970-1979**	**1980-1989**	**1990-1999**	**2000-2009**	**2010-2016**
0.8350	0.6798	0.8195	0.9185	0.0997	0.1792

The general hypothesis is that as Latin American monetary regimes evolved from some kind of fiscal dominance towards focus on price stability, monetary shocks have become a much less important source of ERPT; and real shocks have not been accompanied by monetary policy "convalidation", thus having the exchange rate function effectively as "shock absorber". Rather than conceiving pass-through as (more or less) primitive coefficient, it can be thought of as result of both a certain shock, and the reaction of the economy (including that of policy) to it.

We can take two polar cases to illustrate the hypothesis of regime-dependent ERPT. Take a standard open economy model with fleirxible prices, in which monetary neutrality holds. Thefirst case is thatof a purely monetary shock: an increase in money supply,ceteris paribus, will entail a nominal depreciation of the local currencyagainst the foreign one. With perfectly flexible prices, such a shock must be completely reflected in domestic prices, andtherefore involve perfect exchange rate pass-through. As local prices are perfectly flexible, no change in relative prices is involved, and therefore there are no reasons for quantities to change; the general price level changes one-to-one with the exchange rate .

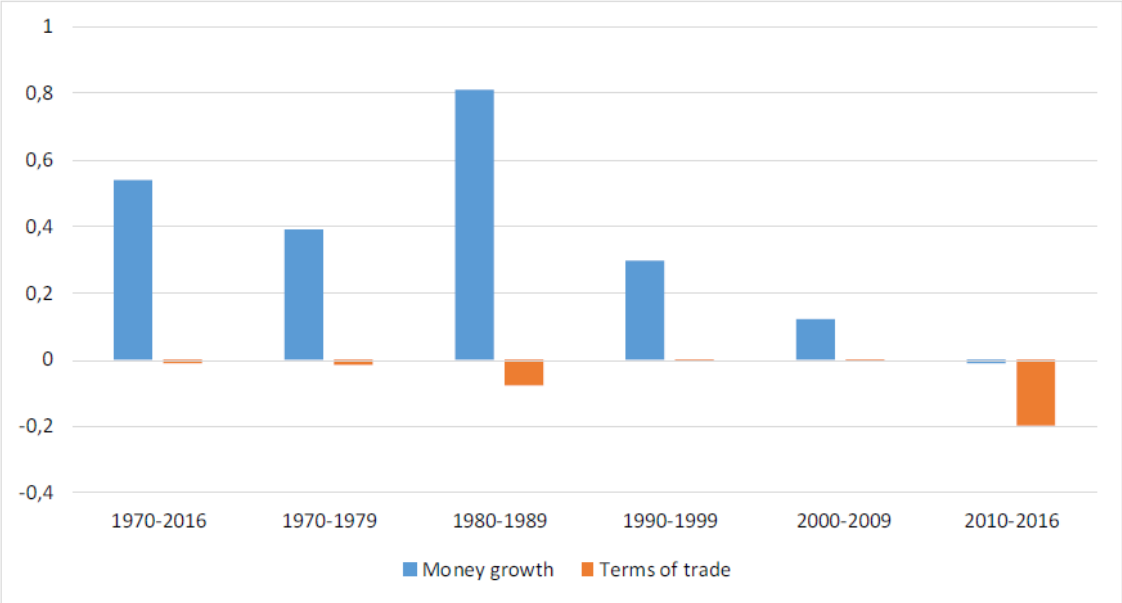
The second case is a purely real shock to the same economy, such as change in the terms of trade. If the money supply is unaltered, and with flexible prices, the shock will be completely reflected in relative prices (and so, with changes in quantities). There will therefore be no impact on thegeneral domestic price level. In this case, ERPT is zero. To be sure, these are merely extreme examples, but they aimto clarify the notion that pass-through changes with the shock and policy response to it.

With an intermediate, sticky-price case, we could find some degree of pass-through in both cases, but it will be higher aslong as changes in money supply are involved. The latter could take place either as shock (if,say, there is monetary financing of the fiscal deficit in the first case) or as policy response (if, for instance, the monetary authority wishes to moderate the impact of an adverse terms-of-trade-shockin the second case).

There is some preliminary evidence which is suggestive of the hypothesis of ERPT being associated to the monetary regime. Chart 1 depicts the correlation between nominal exchange rate depreciation and: a) money growth; b) terms of trade; for our sample of Latin American countries. During the 1970s and 1980s, the correlation between depreciation and money growth

increases, but then decreases dramatically in the 1990s and 2000s; at the same time, the correlation between depreciation and terms of trade is generally negative, and decreases markedly toward the end of the sample. Indeed, in the 2010s, the correlation with T-O-T is negative and, in absolute value, several times larger that with money growth. A possible interpretation of these changes has to do with the region suffering adverse real shocks which are monetized, and thus depreciation is passed on to prices in the 1970s and 80s. In contrast, in recent years terms of trade shocks are processed by more stable monetary policy frameworks, and so the exchange rate may act as shock absorber, as evidenced by the negative correlation of terms of trade and exchange rate depreciation; while hardly any is found correlation between money growth and exchange rate variation.

Figure 1. Correlation coefficients of nominal exchange rate depreciation and: M1 growth, terms-of-trade.
Selected Latin American countries



3 Econometric analysis

3.1 Initial pass-through estimates

In the first step of the econometric work, we estimate the following model (Ghosh, 2013; Campa and Goldberg, 2005), that relates inflation with: nominal exchange rate depreciation, domestic growth (as a proxy for local demand pressures), foreign prices (as a proxy for foreign market costs)), and lagged local inflation (see Annex 1 for data definitions and sources). We estimate the model for each country k over the 1970-2015 period, based on quarterly data, and also estimate it for a panel of selected countries. These include: Argentina, Brazil ,Bolivia, Chile, Colombia, Ecuador, Mexico, Paraguay, Peru, Uruguay and Venezuela.

$$\Delta Log\_prices_{k,t} = \beta_0 + \sum_{j=0}^{4} \beta_{1j} \Delta Log\_exchange\_rate_{k,t-j} + \sum_{j=0}^{4} \beta_{2j} \Delta Log\_GDP_{k,t-j} + \sum_{j=0}^{4} \beta_{3j} \Delta Log\_foreign\_prices_{k,t-j} + \sum_{j=1}^{4} \beta_{4j} \Delta Log\_prices_{k,t-j} + \varepsilon_{kt}$$

(1)

With the estimated coefficients, we define both a short run and a long run exchange rate coefficient (in what follows, SR and LR ERPT). The SR ERPt is simply the β_{1t} coefficient in equation (1); while the LR ERPT is defined as

$$LR\_ERPT = \frac{\sum_{j=0}^{4} \beta_{1j}}{1 - \sum_{j=1}^{4} \beta_{4j}}$$

This definition accounts not only for the total impact of the nominal exchange rate on inflation after four quarters, but also for the fact that inflation is lagged up to four periods. Table 2 shows preliminary results, using different estimation methods (fixed effects, random effects, feasible generalized least squares and seemingly unrelated regressions). While fixed and random effects models would typically be chosen for panel data, macroeconomic panel data such as those we are analysing can be considered "long" in terms of time dimension with respect to the number of individuals; this makes the use of models that relate individual regressions, such as the seemingly unrelated one, more appropriate (see Burdisso and Sangiácomo, 2015, for an applied discussion). Nonetheless, all methods show comparable estimates in size.

Table 2

Short and Long Run estimated ERPT coefficients - Selected Latin American countries

	1970-2016		1970-1979		1980-1989		1990-1999		2000-2009		2010-2016	
	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run
FE	0,47	0,96	0,01	0,61	0,65	1,37	0,59	1,08	0,05	0,14	0,04	0,10
RE	0,48	0,95	n.d.	n.d.	0,60	1,27	0,54	1,03	0,06	0,21	0,04	0,20
XTGLS	0,47	0,96	0,00	0,60	0,63	1,26	0,57	1,03	0,06	0,27	0,04	0,21
SUR	0,47	0,96	0,00	0,00	0,63	1,26	0,57	1,03	0,06	0,24	0,04	0,21

Our ERPT estimates are consistent with previous findings in the literature: they show a marked reduction of both short run and long run ERPT in the region, especially during the 2000s. For the whole sample and over 35 years, a 10% exchange rate depreciation in one quarter is associated to almost 5% inflation during the same period. But the pass through to domestic prices is 93% complete over one year (the "long run" coefficient). In the last five years of the sample, estimated elasticities fall to 5% (short run) and around 20% (long run). That is to say that a 10% depreciation is associated only to 0,4% inflation over one quarter, and to approximately 2% over a year. This, among other possibilities, is consistent with our hypothesis

of pass through being related to monetary policy stance, or at least to an environment of lower inflation.

Country estimates show comparable dynamics. Argentina, Brazil, Chile, Colombia, Perú and Uruguay show estimated short run pass-through coefficients that peak between the 1980s and 1990s (table 3). The following section is devoted to linking ERPT estimates to their possible determinants.

Table 3

ERPT – Short-run elasticities - selected Latin American countries

	1970-2016	1970-1979	1980-1989	1990-1999	2000-2009	2010-2016	2000-2016
Argentina	0,59	-0,10	0,81	0,34	0,11	0,26	0,15
Bolivia	0.25	n.a.	0.23	0.76	-0.77	0.07	0.16
Brazil	0.55	n.a.	0.52	0.64	0.00	0.00	0.01
Chile	0.08	n.a.	0.22	0.06	0.00	0.06	0.06
Colombia	0.04	n.a.	0.84	-0.10	0.05	0.03	0.03
Ecuador	0.00	n.a.	-0.18	-0.20	0.00	n.a.	0.00
Mexico	0.01	-0.00	0.20	-0.03	-0.02	-0.05	-0.01
Paraguay	-0.08	0.00	0.02	-0.16	-0.10	0.10	-0.05
Peru	0.03	0.16	0.49	0.03	-0.10	0.03	0.02
Uruguay	0.15	0.16	0.23	0.16	0.19	0.07	0.16
Venezuela	0.25	n.a.	0.23	0.16	0.19	0.07	0.16

3.2 Exchange rate pass-through and its possible determinants

In order to proceed with our analysis, we estimate ERPT coefficients for each country in the sample at different points in time, so that we can relate them to their possible determinants. We then estimate rolling regressions for each country, under two alternatives: a) fixing the "width" of the window, and changing the starting point of the regression each quarter (thus obtaining a "local" estimate of ERPT); b) fixing the starting point of the regression and increasing sample size each quarter. The latter is usually viewed as part of parameter stability diagnostics. At this point of the project, we implement a). This is certainly one of several possible approaches: Ghosh (2013), for instance, generates a recursive representation of ERPT and estimates coefficients using the Kalman filter.

With the estimated rolling coefficients, we have a panel of eleven countries with quarterly observations since 1970. We then go on to select a number of variables that can be related to different type of shocks: monetary and real, so that we can ascertain to what extent changes in ERPT coefficients are associated to changes in the monetary policy stance or real factors such as terms-of-trade shocks.

At this stage, we look at whether monetary factors, such as money growth and interest rate, inflation and exchange rate volatility can help explain ERPT variability across countries over time (equation 3). We run fixed effect models for the following equation:

$$\begin{aligned} ERPT_{kt} &= \beta_0 + \beta_1 \Delta Log\_money_{k,t-1} + \beta_2 Log\_interest\_rate_{k,t-1} + \beta_3 \Delta Log\_prices_{k,t-1} \\ &\quad + \beta_4 Exchange\_rate\_vol_{k,t-1} + \beta_5 openness_{k,t-1} + \beta_6 TOT_{k,t-1} + \varepsilon_{kt} \end{aligned}$$

(5)

in which the dependent variable is the short run ERPT coefficient estimated as in equation (1) for each country in the sample over a rolling window of 24 quarters. And independent variables are: inflation (annualized quarterly growth); money (M1) growth (annualized quarterly growth): deposit interest rate volatility (quarterly average); nominal exchange rate volatility; trade openness (export plus imports in terms of GDP); and terms of trade. Independent variables are computed for each country over rolling 12-month averages (see annex 2 for their main descriptive statistics. Models are estimated for the1970-2015 period, with fixed effects by country and time effects (a linear trend). Variance-covariance matrices are robust to autocorrelation and heterokedasticity (Huber-White correction). As the sample includes several episodes of extreme instability (such as hyperinflations), outlying values of the dependent variable (ERPT elasticities exceeding 500%) were excluded.

Money growth is positively and significantly associated to short-run ERPT coefficients in different models (table 4, a and b): including only that variable (model 1); with exchange rate volatility (model 6); with exchange rate volatility and openness (model 7); including the deposit interest rate (model 10); with the inflation rate (model 11); and in the most complete specification, (model 12). In the latter specification, other significant variables include: nominal exchange rate volatility, which adds to pass-through; trade openness, which shows a negative and significant coefficient across al models; and the terms of trade, an initial way to gauge possible impacts of real shocks on pass through, with a positive (but very small) association to ERPT. The positive estimated coefficient on money growth is consistent with the hypothesis of monetary factors weighing on pass-through, and to a certain extent the same applies to exchange rate variability: in so far as nominal exchange rate volatility can be attributed to monetary shocks, this could also be considered another channel through which such shocks add to ERPT. In turn, the negative sign on trade openness can be connected to the negative impact on inflation that openness shows in other studies.

In the most complete specification, an increase of 10% money growth is linked to an increase of 3% in ERPT coefficients for the whole sample (model 12). We also ran the same models using quarterly growth of variables without annualizing; the results were the same in terms of statistical significance, but in this case, estimated coefficients imply that a 10% change in quarterly money growth translates into an 8,5% change in short term ERPT.

Table 4 (a)

CPI exchange Rate pass-through and macroeconomic variables – Short run						
Dependent variable [1]: short-run ERPT coefficients (t)						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Independent variables[2]:						
M1 growth (t-1)	0.0960					0.1077
	(8.3323)					(7.7821)
	[0.0000]					[0.0001]
Deposit rate		-0.0160				
		(-0.2318)				
		[0.8218]				
Inflation rate (t-1)			0.0343			
			(1.2952)			
			[0.2275]			
Exchange rate volatility (t-1)				0.2418		-0.1807
				(0.8713)		(-2.4295)
				[0.4062]		[0.0455]
Trade openness					-0.0333	
					(-2.4801)	
					[0.0381]	
Term of trade						
Constant	-0.1691	0.9113	0.7013	0.7273	0.0460	-0.1609
	(-1.2764)	(1.9842)	(1.4257)	(1.7494)	(0.1323)	(-1.1824)
	[0.2376]	[0.0785]	[0.1877]	[0.1142]	[0.8980]	[0.2710]
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.1143	0.0674	0.0653	0.0552	0.0929	0.1144
Sample size	662	751	780	781	569	662

Term in parenthesis denote t-student.
Term in brackets denote p-value.
Note: (1) rolling regression with a window of 24 quarters.
(2) moving averages with a window of 12 quarters.
Econometric methodology: linear panel model for panel data with fixed effects with vce(robust) option for errors.

Table 4 (b)

CPI exchange rate pass-through and macroeconomic variables – Short-run						
Dependent variable[1]: short-run ERPT coefficients (t)						
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Independent variables[2]:						
M1 growth (t-1)	0.2770			0.0793	0.2063	0.3154
	(3.1120)			(4.5033)	(3.6428)	(2.7061)
	[0.0170]			[0.0020]	[0.0066]	[0.0353]
Deposit rate			-0.0844	0.0422		-0.0743
			(-1.0186)	(1.9874)		(-1.5459)
			[0.3382]	[0.0821]		[0.1731]
Inflation rate (t-1)		0.1395	0.1231		-0.1045	-0.1769
		(0.7624)	(0.6889)		(-2.1709)	(-1.2056)
		[0.4677]	[0.5104]		[0.0617]	[0.2733]
Exchange rate volatility (t-1)	1.2875	1.0515	1.1664			1.5492
	(2.9419)	(1.6067)	(1.8083)			(3.4207)
	[0.0217]	[0.1468]	[0.1082]			[0.0141]
Trade openness	-0.0147	-0.0335	-0.0332			-0.0181
	(-2.6586)	(-2.5080)	(-2.5188)			(-2.0315)
	[0.0325]	[0.0365]	[0.0359]			[0.0885]
Term of trade						0.0000
						(2.1940)
						[0.0707]
Constant	-0.5770	-0.0467	-0.0867	-0.1124	-0.1767	-0.7452
	(-3.5542)	(-0.1438)	(-0.2869)	(-0.6693)	(-1.3774)	(-2.6244)
	[0.0093]	[0.8892]	[0.7815]	[0.5222]	[0.2057]	[0.0394]
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.1221	0.0938	0.0952	0.1263	0.1233	0.1246
Sample size	496	569	569	651	662	404

Term in parenthesis denote t-student.
Term in brackets denote p-value.
Note: (1) rolling regression with a window of 24 quarters.
(2) moving averages with a window of 12 quarters.
Econometric methodology: linear panel model for panel data with fixed effects with vce(robust) option for errors.

In the case of long run exchange rate coefficient models (table 5), money, interest rates, inflation, and exchange rate volatility are individually significant in univariate regressions; while openness is not significant (table 2, models 1-5). Money growth retains statistical significance in other specifications, those that also include exchange rate volatility (model 6), trade openness (model 7) and the deposit rate (model 10) ; the other variables are statistically significant only in some of the multivariate models. In the most complete specification (model 12),nominal exchange rate volatility is positively and significantly linked to long run ERPT, while the terms of trade are

significant (but small in coefficient size); inflation shows a positive coefficient at 10,4% significance . These results also support the weigh of monetary factors on long-run ERPT, though to a less conclusive extent; and they continue to give some support to the idea that real shocks can also contribute to determining pass-through in the long run.

All in all, our econometric models are a first approximation to enquire about the role of monetary factors behind ERPT in Latin America. They suggest that money growth is more associated to exchange rate pass through in the short term, while both monetary and real shocks have some impact in long term pass-through determination (terms of trade in short-term pass through are statistically significant only at a 7% level). Impact of monetary factors in the short term appear to be somewhat more robust across specifications.

Table 5 (a)

CPI exchange rate pass-through and macroeconomic variables – Long-run						
Dependent variable [1]: short-run ERPT coefficients (t)						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Independent variables[2]:						
M1 growth (t-1)	0.7088 (10.9260) [0.0000]					0.4838 (3.6484) [0.0065]
Deposit rate		1.1566 (3.7087) [0.0049]				
Inflation rate (t-1)			0.6828 (11.7163) [0.0000]			
Exchange rate volatility (t-1)				7.4755 (4.2091) [0.0023]		3.6018 (1.2813) [0.2360]
Trade openness					-0.0978 (-1.3612) [0.2105]	
Term of trade						
Constant	-2.6111 (-2.9759) [0.0177]	-2.1938 (-1.3158) [0.2208]	-2.2911 (-2.6864) [0.0249]	-1.6363 (-1.7036) [0.1227]	-6.1629 (-1.5196) [0.1671]	-2.7677 (-2.5343) [0.0350]
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.0040	0.0048	0.0055	0.0033	0.0046	0.0031
Sample size	662	751	780	781	569	662

Term in parenthesis denote t-student.
Term in brackets denote p-value.
Note: (1) rolling regression with a window of 24 quarters.
(2) moving averages with a window of 12 quarters.
Econometric methodology: linear panel model for panel data with fixed effects with vce(robust) option for errors.

Table 5 (b)

CPI exchange rate pass-through and macroeconomic variables– Long-run						
Dependent variable [1]: short-run ERPT coefficients (t)						
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Independent variables[2]:						
M1 growth (t-1)	2.1151			0.4340	-0.3906	-0.2278
	(2.7749)			(5.2675)	(-0.5211)	-0.1523
	[0.0275]			[0.0008]	[0.6164]	0.8840
Deposit rate			0.2333	0.8424		-0.2262
			(0.6607)	(3.1683)		(-0.3697)
			[0.5274]	[0.0132]		[0.7243]
Inflation rate (t-1)		5.5799	5.6253		1.0424	6.4499
		(2.2756)	(2.3094)		(1.4292)	(1.9178)
		[0.0524]	[0.0497]		[0.1908]	[0.1036]
Exchange rate volatility (t-1)	36.9388	31.3735	31.0559			45.9985
	(1.3409)	(1.1199)	(1.0926)			(2.4502)
	[0.2218]	[0.2952]	[0.3065]			[0.0498]
Trade openness	-0.2485	-0.1066	-0.1075			-0.0113
	(-2.0318)	(-1.7165)	(-1.7662)			(-0.1125)
	[0.0817]	[0.1244]	[0.1153]			[0.9141]
Term of trade						0.0004
						(5.3616)
						[0.0017]
Constant	-8.2609	-9.3886	-9.2780	-3.7667	-2.5356	-12.4754
	(-1.6457)	(-2.4140)	(-2.3208)	(-1.9414)	(-3.1198)	(-2.9174)
	[0.1438]	[0.0422]	[0.0489]	[0.0882]	[0.0142]	[0.0267]
Country effect	Yes	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.0100	0.0148	0.0131	0.0047	0.0037	0.0209
Sample size	496	569	569	651	662	404

Term in parenthesis denote t-student.
Term in brackets denote p-value.
Note: (1) rolling regression with a window of 24 quarters.
(2) moving averages with a window of 12 quarters.
Econometric methodology: linear panel model for panel data with fixed effects with vce(robust) option for errors.

3.2.1 The role of monetary and exchange rate regimes

So far, our regressions include observable variables that vary across countries and across time, as well as unobservable variables that vary across countries (country fixed effects) and over time (time fixed effects). It may be argued, however, that there are unobservable variables that change both across countries and over time. Thus, certain elements that make up the monetary and exchange rate regime may not be sufficiently captured in the observable variables we have chosen. To contemplate this possibility, we estimated our models including also: a) a *de facto* exchange rate regime classification, under two possible criteria (Ilzetzki, Reinhart and Rogoff, 2017; Levy-Yeyati and Sturzenegger, 2016); b) a dummy variable for countries and periods in which inflation targeting was implemented (considering adoption dates as provided by Mishkin and Schmidt-Hebbel, 2002, Hammond, 2011, and information from central banks that adopted inflation targeting in later dates). The exchange rate regime classifications are defined as categorical variables, with the lowest value for a *de facto* peg and the highest one for the most flexible arrangement. It makes sense to include two different classifications as they focus on different aspects: Reinhart and Rogoff's (IRR) tends to be a measure of nominal volatility, while Levy-Yeyati and Sturzenegger's (LYS) includes foreign exchange policy (through the change in international reserves).

We look at both short-run and long-run ERPT coefficients. Model 13 is estimated with the IRR regime classification (table 6a); we find no association between short-run coefficients and neither the *de facto* exchange rate regime nor the implementation of inflation targeting. However, the estimated coefficient for the exchange rate classification is positive and significant in the case of long-run ERPT: this suggests that as *de facto* flexibility increases, so does long-run pass-through. We also find a positive coefficient (but significant only at the 10% threshold) for the inflation targeting dummy in the case of long-run ERPT. This result appears somewhat puzzling, as following the rest of our findings we would expect that IT implementation goes together with lower incidence of monetary shocks.

Model 14 is estimated with the LYS foreign exchange classification (table 6b); we continue to find no significant coefficients for neither the exchange rate regime nor the inflation targeting dummy in the case of short-run ERPT. But we find a positive and significant coefficient (at 8% significance) for the *de facto* exchange rate regime in the long-run ERPT model estimation; in this case, we continue to find no significance for the IT dummy.

Thus, we try to gauge the impact of the monetary and foreign exchange regime, over and above the observable variables already included, the exchange rate arrangement appears to yield some association, and only in the case of long-run pass through (this could be due to the frequency of exchange rate classifications employed, which is annual). In turn, whether the country implements inflation targeting or not does not seem to show a clear association with pass-through (it does in only in one specification); this could perhaps be due to most IT observations being concentrated in the last part of the sample –as it is, we think sample design does not seem particularly apt at helping disintangle the possible impact of IT in pass-through and more work would be needed on this specific point.

Table 6 (a)

CPI exchange rate pass-through and macroecomic variables – Model 13

Dependent variable [1]	short-run ERPT coefficients (t)	long-run ERPT coefficients (t)
Independent variable[2]		
M1 growth (t-1)	0.3155	-0.3530
	(2.8088)	(-0.3423)
	[0.0308]	[0.7438]
Deposit rate	-0.0746	-0.2030
	(-1.5966)	(-0.3108)
	[0.1615]	[0.7665]
Inflation rate (t-1)	-0.1793	7.0046
	(-1.2474)	(3.1322)
	[0.2587]	[0.0203]
Exchange rate volatility (t-1)	13.0270	29.9484
	(2.7861)	(1.6788)
	[0.0317]	[0.1442]
Trade openness	-0.0181	-0.0217
	(-1.9798)	(0.2113)
	[0.0951]	[0.8397]
Term of trade	0.0000	0.0004
	(2.7249)	(1.1000)
	[0.0344]	[0.000]
Forex regime	0.0392	2.4403
(Reinhart-Rogoff)	(1.2081)	(6.4437)
	[0.2725]	[0.0007]
IT dummy	0.0410	4.2177
	(0.2763)	(2.0778)
	[0.7916]	[0.0830]
Constant	-0.8269	-17.845
	(-3.000)	(-8.7448)
	[0.0197]	[0.0001]
Country fixed effect	Yes	Yes
Time effect	Yes	Yes
Adjusted R^2	0.1255	0.0327
Sample size	405	405

Term in parenthesis denote t-student.
Term in brackets denote p-value.
Note: (1) rolling regression with a window of 24 quarters
(2) rolling regression with a window of 24 quarters.
Econometric methodology: linear panel model for panel data with fixed effects with vce(robust) options for errors.

Table 6 (b)

CPI exchange rate pass-through and macroecomic variables – Model 14		
Dependent variable [(1)]	short-run ERPT coefficients (t)	long-run ERPT coefficients (t)
Independent variable[(2)]		
M1 growth (t-1)	0.3551	-2.0432
	(2.1321)	(-0.9033)
	[0.0770]	[0.4012]
Deposit rate	-0.0864	-0.1965
	(-1.5099)	(-0.4200)
	[0.1818]	[0.6891]
Inflation rate (t-1)	-0.2204	9.5607
	(-1.7411)	(2.3401)
	[0.1323]	[0.0578]
Exchange rate volatility (t-1)	1.5505	37.3124
	(4.5772)	(2.5653)
	[0.0038]	[0.0426]
Trade openness	--0.0195	-0.0351
	(-2.1990)	(0.3350)
	[0.0702]	[0.7490]
Term of trade	0.0000	0.0001
	(1.1753)	(1.1500)
	[0.1371]	[0.2948]
Forex regime	0.0125	1.1128
(Levy Y-Sturzenegger)	(0.3867)	(2.0432)
	[0.7123]	[0.0871]
IT dummy	0.0296	5.5543
	(0.2025)	(1.7722)
	[0.8468]	[0.1267]
Constant	-0.8269	-17.669
	(-3.000)	(-3.4585)
	[0.0197]	[0.0135]
Country fixed effect	Yes	Yes
Time effect	Yes	Yes
Adjusted R^2	0.1147	0.0220
Sample size	358	358

Term in parenthesis denote t-student.
Term in brackets denote p-value.
Note: (1) rolling regression with a window of 24 quarters
(2) rolling regression with a window of 24 quarters.
Econometric methodology: linear panel model for panel data with fixed effects with vce(robust) options for errors.

3.2.2 Dynamic structure and the "long" panel

In addition to variables that capture unobservable aspects of the monetary and foreign exchange regime in place in each country at each point of time, the dynamic structure of specifications can be enriched. This is relevant as several factors may be at play that imply exchange rate appreciation and depreciation phases that extender over several quarters, such as domestic and global financial cycles (Borio and Lowe, 2002), with the consequent impact on prices.To this end, we added a second lag to our specification: in the most complete specification, money growth continues to be posively associated to short run ERPT to money growth (in the second lag), and so do exchange rate volatility after two quarters and the terms of trade (table 7). In turn, the interest rate is now negatively and significantly associated to short run ERPT. These results

remain when we control for monetary regimes (IT dummy) and de facto exchange rate regime in both definitions employed here (second and third columns in table 7).

Table 7

CPI exchange rate pass-through and macroeconomic variables			
Dependent variable [1]	short-run ERPT coefficients (t)		
	Model 12c	Model 13c	Model 14c
Independent variable[2]			
M1 growth (t-1)	-0.1194	-0.1334	-0.2767
	(-1.0610)	(-1.0556)	(-0.9379)
	[0.3295]	[0.3318]	[0.3845]
(t-2)	0.4662	0.4756	0.6410
	-31.707	-28.016	-30.913
	[0.0193]	[0.0311]	[0.0214]
Deposit rate (t-1)	-0.2641	-0.2515	-0.0914
	(-6.5336)	(-6.1681)	(-1.6448)
	[0.0006]	[0.0008]	[0.1511]
(t-2)	0.1916	0.1766	
	-39.975	-36.388	
	[0.0071]	[0.0109]	
Inflation rate (t-1)	-0.5266	-0.5143	-0.4629
	(-0.6620)	(-0.6502)	(-0.6751)
	[0.5325]	[0.5396]	[0.5248]
(t-2)	0.3504	0.3415	0.2711
	(0.4526)	(0.4370)	(0.4080)
	[0.6668]	[0.6774]	[0.6974]
Exchange rate volatility (t-1)	52.869	42.246	56.470
	-41.557	-29.782	-45.718
	[0.0060]	[0.0247]	[0.0038]
(t-2)	-32.256	-23.212	-36.366
	(-2.5432)	(-1.7710)	(-2.5217)
	[0.0439]	[0.1269]	[0.0452]
Trade openness	-0.0039	-0.0097	-0.0029
	(-0.0582)	(-0.1454)	(-0.0362)
	[0.9555]	[0.8892]	[0.9723]
(t-1)	-0.0138	-0.0082	-0.0166
	(-0.2080)	(-0.1233)	(-0.2075)
	[0.8421]	[0.9059]	[0.8425]
Terms of trade	-0.0000	-0.0000	-0.0000
	(-0.8067)	(-0.8104)	(-1.5453)
	[0.4506]	[0.4486]	[0.1732]
(t-1)	0.0000	0.0000	0.0000
	-38.681	-47.170	-38.405
	[0.0083]	[0.0033]	[0.0086]

Table 7 (continued)

Forex regime			
(Levy Y-Sturzenegger)			0.0326
			(0.8787)
			[0.4134]
Forex regime		0.0312	
(Ilzetzki, Reinhart, Rogoff)		-10.951	
		[0.3155]	
IT dummy		0.0479	0.0541
		(0.3471)	(0.3963)
		[0.7404]	[0.7056]
Constant	-0.8290	-0.9007	-0.9855
	(-2.8122)	(-3.1861)	(-2.6420)
	[0.0307]	[0.0189]	[0.0384]
Country fixed effect	Yes	Yes	Yes
Time effect	Yes	Yes	Yes
Adjusted R^2	0.1279	0.1259	0.1202
Sample size	400	400	354

Term in parenthesis denote t-student.

Term in brackets denote p-value.

Note: (1) rolling regression with a window of 24 quarters

Note: (2) rolling regression with a window of 12 quarters

Econometric methodology: linear panel model for panel data with fixed effects with vce(robust) option for errors.

An additional robustness check refers to the dimensions of our panel and our choice of econometric model. Typically, fixed effects models are employed with panels in which the number of individuals exceed the number of time periods; but we have a longitudinal or "macro" panel, in which the time dimension is higher than the cross-sectional one. This suggests the use of methods that can explicitly account for cross-sectional dependence among individual observations (Burdisso and Sangiacomo, 2016); in our estimation, correlation in the time dimension only is considered. With this aim, we estimated equation (5) by pooled ordinary least squares with a errors that assume correlations across countries: for short-run ERPT coefficients, the model retains the signs and statistical significance of money growth, exchange rate volatility and openness (table 8, in all three specifications: with and without controlling for IT and de facto foreign exchange regimes). In these cases, the interest rains carries a negative and significant sign, while terms of trade lose statistical signifciant. *De facto* exchange rate regimes are not statistically significant, while the IT dummy is once again positive and significant, once we allow for cross-sectional dependence in our sample.

Table 8

CPI exchange rate pass-through and macroeconomic variables			
Pooled OLS assuming cross-correlation over countries			
Dependent variable [1]	short-run ERPT coefficients (t)		
	Model 11b	Model 12 b	Model 13 b
Independent variable[2]			
M1 growth (t-1)	0.195	0.227	0.258
	(0.032)	(0.034)	(0.047)
	[0.000]	[0.000]	[0.000]
Deposit rate	-0.091	-0.092	-0.100
	(0.027)	(0.028)	(0.031)
	[0.001]	[0.001]	[0.001]
Inflation rate (t-1)	-0.033	0.010	-0.017
	(0.050)	(0.056)	(0.066)
	[0.507]	[0.863]	[0.794]
Exchange rate volatility (t-1)	1.455	1.132	1.297
	(0.361)	(0.396)	(0.382)
	[0.000]	[0.004]	[0.001]
Trade openness	0.001	-0.003	-0.003
	(-0.001)	(0.001)	(0.001)
	[0.489]	[0.001]	[0.000]
Terms of trade	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
	[0.601]	[0.467]	[0.514]
Forex regime (Levy Y-Sturzenegger)			0.002
			(0.018)
Forex Regime (Ilzetzki, Reinhart, Rogoff)		0.023	[0.916]
		(0.022)	
		[0.307]	
IT dummy		0.078	0.107
		(0.040)	(0.038)
		[0.048]	[0.005]
Constant	-0.804	-0.875	-0.869
	(0.079)	(0.095)	(0.108)
	[0.000]	[0.000]	[0.000]
Country fixed effect	No	No	No
Time effect	Yes	Yes	Yes

Term in parenthesis denote t-student.

Term in brackets denote p-value.

Note: (1) rolling regression with a window of 24 quarters

Note: (2) rolling regression with a window of 12 quarters

Econometric methodology: Pooled OLS with errors assuming correlation over country

All the results just reviewed are better regarded as indicating statistical association between short and long-run ERPT coefficients and macroeconomic variables: both in the first and second stage, it could be argued that prices can also affect the exchange rate (first stage), or that ERPT weighs on inflation, for instance (second stage). While this is (very) partially solved by using lagged values of the regressors, controlling for potential endogeneity through appropriate instruments may be considered for further work. Meanwhile, what we have is statistical associations which are consistent with our hypothesis of the role of monetary policy in determining ERPT.

4 Concluding remarks

Typically, exchange rate pass through is measured as either: the cumulative effect of exchange rate changes in inflation in impulse-response functions in VARs or in dynamic regressions; the ratio of inflation to devaluation over a period of time after an event; or the effect of the exchange rate on CPI through the import content of consumption. While these are all valid measures, focusing on them misses the basic fact the exchange rate is an endogenous variable. And not all depreciations or devaluations are alike: the shock that triggers them -whether it is nominal or real- matters, and so does the policy response to it -including the monetary policy framework. In this paper, we look at a panel of eleven Latin American countries from 1970 to 2016, and work in a two-step way in order to enquire how pass-through has changed over time, and whether this owes more to monetary or real shocks hitting the economy. In the first step, we estimate conventional ERPT measures, both short and long term; in the second one, we obtain rolling estimates of those measures, and relate them both monetary and real variables using fixed effect models. We find that:

- in keeping with previous studies, ERPT coefficients have fallen sharply in recent decades in Latin America;
- money growth tends to be strongly associated to short-run exchange rate pass through, with a small influence of real shocks such as terms-of-trade changes;
- money growth is also associated to pass-through in the long run, while terms of trade shocks are also statistically significant;
- the *de facto* exchange rate regime matters, suggesting that higher foreign exchange volatility is associated to higher long-run ERPT coefficients, while there does not seem to be a clear association with inflation targeting in our sample.

Our findings are robust to changing lags of independent variables and to alternative treatment of cross-correlation across countries.

Results are consistent with the hypothesis that ERPT changes with the kind of shock and the monetary policy response to it. As Latin American countries have moved regimes more focused on monetary stability, pass-through has decreased. That money growth tends to systematically carry a more important weight on ERPT dynamics than terms-of-trade shocks is consistent with the view that the monetary policy framework matters for pass-through.

We acknowledge this is only a very first step toward a more comprehensive analysis, and that our approach is complementary to more structural ones, such as those resorting to DSGE models (Palleja, 2018). Regarding data, we need to fill in the gaps in standard databases available such as IFS and ECLAC. Regarding the econometric methodology, we will explore several alternatives in further work: improve model especification for individual country ERPT estimates (first stage); using models that better capture the fact that our database is longer in time than in number of countries (second stage); use other country-level specifications in order to determine the weight of monetary versus real factors; gather information about depreciation events more associated with monetary shocks, others more linked to real shocks, and measure ERPT around them in order to better identify the impact of either shock; along the same lines, use interaction terms to identify when a real shock was "convalidated" through monetary policy, and when it was not; in general, develop a broader framework to assess the impact of monetary vis-a-vis real shocks, including the effect of monetary (eg. inflation targeting) and exchange rate arrangements.

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Annex 1. Description of variables and data sources

Variable	Description	Source
GDP	Real Gross Domestic Product for each country	Economic Commission for Latin America
Exchange rate	Nominal Exchange Rate of US dólar with domestic currency for each country	International Financial statistics
M1	Money Supply in domestic currency for each country	Economic Commission for Latin America
Foreign prices	USA Import price index	International Financial statistics
Prices	Consumer Price Index for each country	International Financial statistics
Deposit rate	Quarterly deposit rate for time deposit for each country	International Financial statistics
Terms of trade	Exports price divided by imports price	International Financial statistics
Trade openness	Exports plus imports as percentage of GDP for each country	International Financial statistics

Annex 2. Descriptive statistics - first stage variables

Period 1970-2016

stats	ΔLog_prices	$\Delta Log\_exchange\_rate$	ΔLog_GDP	$\Delta Log\_foreign\_prices$
mean	0,04	0,02	0,01	0,00
sd	0,76	0,86	0,21	0,13
N	2086	2066	1169	2255

Period 1970-1979

stats	ΔLog_prices	$\Delta Log\_exchange\_rate$	ΔLog_GDP	$\Delta Log\_foreign\_prices$
mean	-0,17	-0,14	0,01	-0,01
sd	1,88	1,83	0,08	0,27
N	318	438	50	479

Period 1980-1989

stats	ΔLog_prices	$\Delta Log\_exchange\_rate$	ΔLog_GDP	$\Delta Log\_foreign\_prices$
mean	0,15	0,14	0,01	0,01
sd	0,23	0,28	0,04	0,02
N	476	440	95	480

Period 1990-1999

stats	ΔLog_prices	$\Delta Log\_exchange\_rate$	ΔLog_GDP	$\Delta Log\_foreign\_prices$
mean	0,09	0,06	0,01	0,00
sd	0,20	0,22	0,06	0,02
N	480	440	285	480

Period 2000-2009

stats	ΔLog_prices	$\Delta Log\_exchange\_rate$	ΔLog_GDP	$\Delta Log\_foreign\_prices$
mean	0,02	0,01	0,02	0,01
sd	0,03	0,07	0,33	0,04
N	480	440	439	480

Period 2010-2016

stats	ΔLog_prices	$\Delta Log\_exchange\_rate$	ΔLog_GDP	$\Delta Log\_foreign\_prices$
mean	0,02	0,02	0,01	0,00
sd	0,04	0,06	0,06	0,02
N	332	308	300	336

Annex 3. Descriptive statistics - second stage variables

Period 1970-2016

stats	$ERPT\_SR$	$ERPT\_LR$	ΔLog_money	$\Delta Log\_interest\_rate$	ΔLog_prices	$Exchange\_rate\_vol$	$openness$	TOT
mean	0,16	0,19	0,28	0,61	0,34	0,10	37,39	113,27
sd	3,55	7,40	0,37	1,14	0,56	0,15	122,10	49,01
N	787	1840	828	1255	1550	1720	775	798

Period 1970-1979

stats	$ERPT\_SR$	$ERPT\_LR$	ΔLog_money	$\Delta Log\_interest\_rate$	ΔLog_prices	$Exchange\_rate\_vol$	$openness$	TOT
mean	0,05	0,01	0,79	0,98	0,33	0,09	n.a.	161,26
sd	0,22	0,08	0,29	1,58	0,31	0,12	n.a.	57,61
N	12	400	27	14	162	280	n.a.	52

Period 1980-1989

stats	$ERPT\_SR$	$ERPT\_LR$	ΔLog_money	$\Delta Log\_interest\_rate$	ΔLog_prices	$Exchange\_rate\_vol$	$openness$	TOT
mean	0,83	0,10	1,10	1,88	0,61	0,17	15,59	159,28
sd	0,63	0,56	0,40	1,70	0,58	0,17	8,12	57,02
N	52	400	44	213	348	400	56	108

Period 1990-1999

stats	$ERPT\_SR$	$ERPT\_LR$	ΔLog_money	$\Delta Log\_interest\_rate$	ΔLog_prices	$Exchange\_rate\_vol$	$openness$	TOT
mean	0,39	0,10	0,36	0,59	0,54	0,13	72,86	107,30
sd	1,92	12,85	0,51	1,03	0,81	0,21	251,84	53,13
N	128	400	190	388	400	0,00	175	184

Period 2000-2009

stats	$ERPT\_SR$	$ERPT\_LR$	ΔLog_money	$\Delta Log\_interest\_rate$	ΔLog_prices	$Exchange\_rate\_vol$	$openness$	TOT
mean	0,34	0,44	0,17	0,18	0,07	0,05	26,13	91,09
sd	4,66	8,60	0,11	0,40	0,05	0,03	18,27	23,83
N	356	400	351	400	400	400	328	288

Period 2010-2016

stats	$ERPT\_SR$	$ERPT\_LR$	ΔLog_money	$\Delta Log\_interest\_rate$	ΔLog_prices	$Exchange\_rate\_vol$	$openness$	TOT
mean	-0,38	0,37	0,16	0,22	0,09	0,03	31,42	107,81
sd	2,56	4,68	0,12	0,44	0,09	0,05	21,06	23,41
N	239	240	216	240	240	240	216	166

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