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Emre Ozsoz
Fordham University, Department of Economics
Erick W. Rengifo
Fordham University, Department of Economics
Dominick Salvatore
Fordham University, Department of Economics

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Department of Economics
Fordham University
441 E Fordham Rd, Dealy Hall
Bronx, NY 10458
(718) 817-4048

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Emre Ozsoz* Erick W. Rengifo† Dominick Salvatore‡

Abstract
In dollarized financial systems, there exists a currency mismatch risk that could lead to financial crises. Central Banks in such economies have to adjust their foreign currency policies accordingly. This paper estimates the probability of Central Bankers' intervention in the foreign currency markets in dollarized economies as explained by the volatility measures of the local exchange rate. By employing data from five countries, we show that in controlled inflation environments, not only Central Banks' interventions but also the direction of the interventions can be predicted to a good degree while under high inflation our model fails to provide healthy results.

JEL Classification codes: F31, E58, G15
Keywords: Central Bank Intervention; Foreign Exchange Rates; Dollarization; Ordered Probit

* Fordham University New York, Department of Economics. 441 East Fordham Road, Dealy Hall, Bronx, NY 10458,USA. Phone: +1 (718) 817 4048, fax: +1 (718) 817 3518, e-mail: ozsoz@fordham.edu.
† Fordham University New York, Department of Economics. 441 East Fordham Road, Dealy Hall, E513, Bronx, NY10458, USA. Phone: +1 (718) 817 4061, fax: +1 (718) 817 3518, e-mail: rengifomina@fordham.edu
‡ Corresponding Author. Fordham University New York, Department of Economics. 441 East Fordham Road, Dealy Hall, E521, Bronx, NY 10458, USA. Phone: +1 (718) 817 3606, fax: +1 (718) 817 4690, e-mail: salvatore@fordham.edu

1. Introduction

Dollarization implies that a foreign currency is used as a unit of account, store of value or medium of exchange in addition to (de facto or unofficial dollarization) or in lieu of the domestic currency (de jure or official dollarization). According to De Nicolo, Honohan & Ize (2005) we can distinguish between currency substitution (foreign currency is used for transaction purposes), asset substitution (residents' holdings of financial assets or liabilities are in foreign currency) and, real dollarization (indexing of local prices and wages to the dollar).

The aspect of dollarization we examine in this paper is basically related to the financial dollarization (asset substitution) which we measure by the ratio of foreign currency deposits in the banking system to the overall deposits in the banking system M2 money base.

Our hypothesis is that the more dollarized is a given economy, in general, and the banking system, in particular, the more vulnerable the economy will be to exchange rate volatility after inflation has been effectively controlled[1]. In a heavily (financial) dollarized economy a banking crisis can have a larger impact on the economy, compared to a less (financial) dollarized one. Hence, government policies will be different according to the dollarization scenario that they are facing: highly dollarized economies would tend to protect the banking system ahead of facing exchange rate shocks by actively participating in the markets in order to avoid a potential social crises due to banks lack of liquidity, meanwhile less dollarized economies can concentrate their efforts towards reducing problems with their balance of trade.

We can distinguish mainly two types of risks that any banking system faces: Banks' currency mismatch risks and loan default risks. The former occurs when banks receive deposits in foreign currencies and lend in local currency. In this case, if devaluation happens (in general) debtors are affected less than banks that need extra local currency to cover their foreign currency liabilities. The latter type of risk happens when banks receive deposits and lend in foreign currencies. In this case if a devaluation (or sudden depreciation) occurs, this will

[1]Hereafter, in all our hypothesis we assume that inflation rates are controlled, in the sense that we assume low or moderate inflation rates.

have a direct impact on debtors' ability to repay their loans (i.e. they face -directly- the currency risk) and the bank suffers from default risk (induced by the currency risk of their clients)[2].

In this paper we try to determine if in a (financial) dollarized economy the governments have higher incentives to stabilize the exchange rate variation via unanticipated open markets operations. Moreover, we propose to use dollarization as a new investment signaling tool under the assumption that the inflation is under "control".

The data to test our hypothesis is limited to the exact date at which a given central bank intervenes in the exchange rate markets. Moreover, we have been able to find Central Banks' interventions information for only three heavily dollarized economies (Croatia, Turkey and Peru) and two slightly dollarized economies (Slovak Republic and Czech Republic[3]) Given this restriction with the availability of data in heavily dollarized economies, we are not able to run a general panel study to test our hypothesis. However, we are able to study the impact of real exchange rate volatility in central banks interventions. With the use of probit and ordered choice models we establish that in dollarized economies the real exchange rate volatility (measured by the standard deviation of the monthly log differences of the Real Effective Exchange Rate (REER) in a three month period), significantly explains Central Bank interventions[4]. The volatility of the exchange rate is calculated over 3, 6 and 12 months. Goodness-of-fit tests show that the models sufficiently support the data. Moreover, our model's forecasted probabilities of Central Bank interventions seem to be accurate in terms of the unbiasedness and efficiency of the forecasted probability with respect to realized interventions.

The remainder of the paper is organized as follows. Section 2 briefly explains the possible causes of dollarization and why de-dollarization actually did not happen as expected. In Section 3, we present the basic idea of the dollarization as an indicator for global investments. Section 4 presents the empirical implementation

[2] Note that what is common to both scenarios is that depositors are equally affected. If banks cannot recoup their investments in either case (unless they have a kind of FDIC insurance program), they simply are not going to be able to comply with their liabilities.
[3] We have spent a lot of time, effort and resources trying to get more data for more countries. Table 10 in the Appendix presents the data available and the problems we have encountered in the compilation. This paper presents evidence that support our hypothesis and points out to the need to have a clear and more frequent information from central banks in order to improve transparency that have a clear impact on capital flows via global investments.
[4] We use as additional instruments the average REER in the previous month, the 12 month moving average of the REER and, the percent deviation from the 12 month moving average REER.

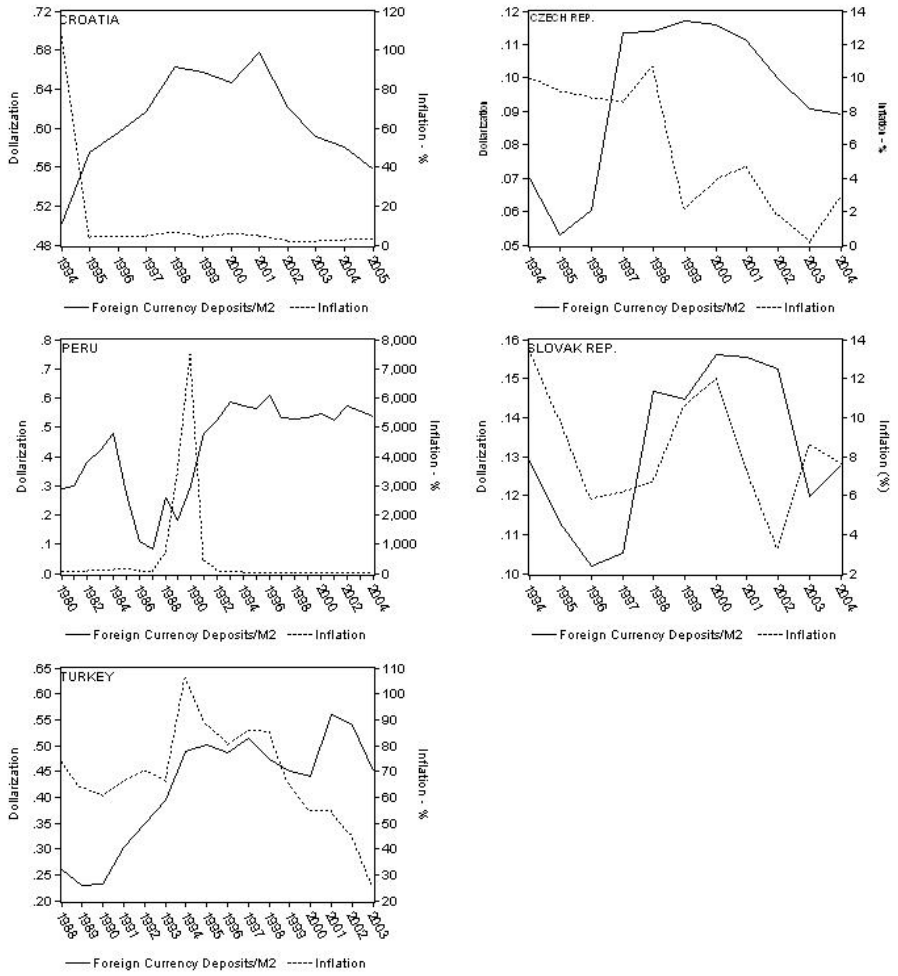
to test our hypothesis. Finally, Section 5 summarizes our findings and concludes. Further numerical results are included in the Appendix.

2. What causes dollarization?

Literature that studies the causes and experiences of dollarization focuses on Latin America, mainly Bolivia, Argentina, Mexico and Peru.

In these countries there were (and are) many good reasons why savers prefer to hold their assets in foreign currencies. During the 80's and early 90's the main cause of dollarization was attributable to the high inflation rates that these countries experienced. Under this circumstance, foreign currency (and mainly the US$) served as a shelter from inflation.

Figure 1: Inflation vs. Level of Foreign Currency Deposits in the Banking System for Selected Countries



The correlation of dollarization and inflation rates in Latin American countries has put inflation at the top of the list for explanations for the dollarization phenomenon[5]. Figure 1 shows this correlation in some of the world's highly dollarized economies. This fact created the basis for the well known "currency substitution" hypothesis. The theory developed thereafter explains the occurrence of high foreign currency holdings, especially in Latin America, as a result of high chronic inflation of these economies. As argued by Calvo & Vegh (1992), in countries with high inflation, foreign currency is used as a store of value or unit of account. According to these authors: "...of the three basic functions of money, this [store of value] is probably the one in which domestic money is the most vulnerable." As inflation rises, goods such as houses start to get quoted in foreign currency. Not too long after this, some transactions begin to be performed in foreign currency, mainly those involving large transfers of funds. Under these circumstances, foreign currency resumes the function of "medium of exchange". However, expected inflation cannot be the only reason why savers may choose to hold their savings in other currencies. After all, financial assets bear interest rates and as long as investors are compensated for the inflation premium, there should not be any reason why they should hold financial assets in other currencies. As argued by Calvo & Vegh (1997) inflation should not have an effect on portfolio choice as long as it is incorporated into the nominal interest rates. Yet in reality, it is the interest bearing financial assets such as the interest bearing savings deposits in the banks that have high dollarization ratios. If the real returns are the same in domestic and foreign currency denominated assets, there should not be any good reason for savers to hold their savings in foreign currency denominated assets[6].

Another challenge to the currency substitution view is the persistence of dollarization in Latin American economies in the 90s against a backdrop of declining inflation rates[7]. If inflation differentials are the main reason why savers choose foreign currencies in first place, why have we not seen "dedollarization" in Latin

[5] For a complete list of references, see the surveys by Calvo & Vegh (1997), Savastano (1996) and Salvatore (2003).
[6] The measure of dollarization used in this paper includes total value of foreign currency denominated savings accounts in a country's banking system. In most countries these dollar deposit accounts are allowed to earn a return in equal to, if not greater than those in the US.
[7] This persistence was attributed to the past experiences of high inflation among savers which foster high-inflation expectations even after stabilization has been achieved; see for example Savastano (1996).

America once inflation has been stabilized?[8] The empirical evidence we have at hand simply shows that this view is insufficient in explaining the entire story behind the "dollarization" phenomenon.

Recent literature has tried to explain the persistent dollarization of financial assets following price level stabilization. There is more than one credible explanation in the literature to the phenomenon. One recent alternative explanation is the minimum variance portfolio (MVP) hypothesis set forth by Levy-Yeyati (2006) and Ize & Levy-Yeyati (2003). The hypothesis focuses on the relative volatility of returns to financial assets. In this model, dollarization is driven by volatility of inflation and real exchange rate depreciation rather than the expected inflation and nominal depreciation. The domestic interest rate is determined according to an interest parity condition that is not related to the degree of financial dollarization in the country. Thus, for a given variance of inflation, an increase in the variance of the rate of depreciation reduces dollarization by limiting the hedging benefits of dollar assets. One important implication of this model is that it suggests that financial dollarization will persist as long as inflation volatility remains high in relation to exchange rate volatility even under low inflation.

Another view on the causes of dollarization examines the quality of the institutions as the catalyst for dollarization [Levy-Yeyati (2006)] also known as the institutional view[9]. When institutional quality is low, or government's credibility on fighting inflation is not good, the government may not be able to assure debt holders that it will not inflate away the debt as argued by Calvo & Guidotti (1990). In this case the government may choose to dollarize its debt obligations to be able to credibly commit to its low inflation program. This is a costly alternative but may be the only option left to the government to overcome the inflation bias.

3. Dollarization as an investment indicator

Dollarization has largely been studied to understand its causes and effects in the dollarized economies (Salvatore 2003). However, the potential of this indicator as an investment signal, to the best of our knowledge, has never been proposed. The information conveyed by this indicator can potentially be used as an investment

[8] Figure 1 shows the percentage change in foreign currency deposits vs. the inflation rate in some selected countries. The figure illustrates the non-occurrence of "de-dollarization" once inflation levels achieve low values.

[9] Although Levy-Yeyati (2006) is one of the first to use the term *institutional view* others before him such as Savastano (1996) and Calvo & Vegh (1992) have stressed the importance of institutions in countries' dollarization process. For example Rajan (2004) argues the institutions may influence the dollarization process through their effect on inflation.

instrument that can signal different governments' compromises trying to avoid dramatic exchange rate variations, an extremely important variable to consider for global investment strategies.

When investors decide where to invest their funds worldwide, they carefully evaluate the likelihood of devaluations, i.e. local currency devaluations with respect to the US$, since a devaluation can simply wipe out any possible earnings from financial markets. Thus, having an indicator that tells investors the likelihood of a Central Bank intervention in the exchange rate market given past information of some macroeconomic variables, would be crucial: based on this likelihood, investors can decide to hedge against pervasive exchange rate variability (e.g. devaluations of the local currencies) and establish their best trading strategies. This is obviously important because hedging implies extra costs that must be considered before deciding where and by how much to invest in a given country.

The basic idea relies on the fact that in these heavily dollarized economies, where loans are given in foreign currencies, devaluations of local currencies could imply that borrowers (who borrowed in the foreign currencies and earn in local currencies) are not able to repay the loans and, as the banks depend on the repayments of these loans, the likelihood of potential liquidity and solvency crises increase. These types of crises are undesirable for any government since they imply a major social problem from two sides: the borrowers who will be worse off if the legal mechanisms are well established (i.e. if the banks can ask for the collateral to cover the defaulted money) and the depositors, who will see their deposits in the banking system, disappear[10]. On other hand, if deposits are in foreign currencies and loans in local currencies an appreciation of the local currency would imply the impossibility for the banks to cover their liabilities denominated in a foreign currency. Again, a highly undesirable potential for social problems that governments would try to avoid. Thus, under a scenario of a heavily dollarized economy, governments (Central Banks) would have a high incentive to intervene in the foreign exchange markets to avoid unexpected high variations. In general, this can also mean that dollarization in the banking system could be seen as a signal of government open markets operations willingness that could be used as an investment tool to determine the likelihood of a Central Bank intervention.

[10] Again, these losses can be limited if the country has set up FDIC-type insurances. However, even under this system, general banking crisis can imply the impossibility of the insurance to cover all claims.

In this paper we propose that dollarization indeed can be used as an indicator to determine the likelihood of CB intervention when facing pervasive exchange rate movements, i.e. we argue that exchange rate movements in a heavily dollarized economy are smaller than in non dollarized economies, once the inflationary process has been controlled[11].

4. Empirical Results

4.1. Data And Model Specification

Our sample consists of five dollarized economies[12], Czech Republic, Croatia, Peru, Slovak Republic and Turkey[13], for which we obtain data on the amount of foreign exchange deposits in their banking systems through Central Bank Bulletins. The dollarization measure that we use is the average ratio of the foreign exchange deposits in the country's banking institutions to the country's M2 money supply for the given period. Our hypothesis deals with heavily dollarized economies but with low levels of inflation. In order to test the effect of inflation we separate our five countries in two groups: Czech Rep, Croatia, Peru and Slovak Rep. (that present similar levels of inflation) and, Turkey (a heavily dollarized economy but also with high inflation rates). Figure 2 presents the time series of the inflation of these five countries.

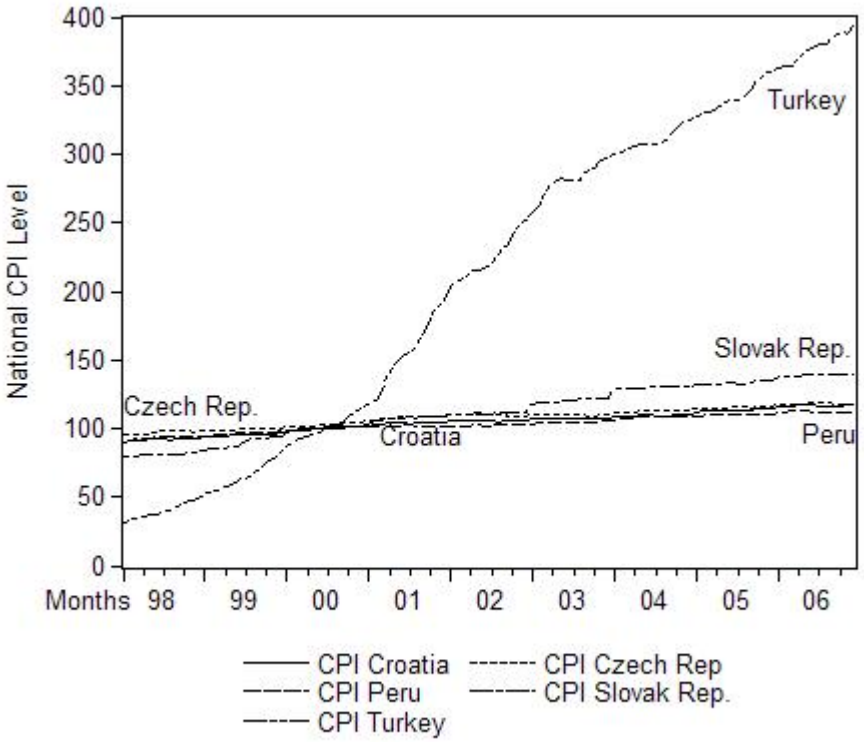
We constructed a monthly index for Central Bank intervention in the foreign exchange market by observing periods of intervention from each Central Bank's Annual Reports. The availability of this data is limited by the amount of information available from each country's Central Bank. The most comprehensive dataset for Central Bank interventions in our sample is for Slovak Republic (1998 to 2006). For each of the countries in our sample, we use each Central Bank's announced dates of intervention in the foreign exchange market. Table 9, in the Appendix, provides information per country on the monthly foreign exchange interventions of Central Banks.

In choosing explanatory variables for our model we follow previous literature, mainly the work of Ito and Yabu (2007). We use the volatility of the real effective exchange rate (REER), the average REER in the

[11] Note that when we talk about dollarization, in fact we refer to financial dollarization, which implies that banks have deposits in foreign currencies and that also they lend to local individuals in foreign currency.
[12] From these five countries, three of them -Croatia, Turkey and Peru- are heavily dollarized and, the others, Czech and Slovak Republics represent moderately dollarized economies.
[13] See table 8 in the appendix for the dollarization ratios in respective countries and the years data is available.

previous month, the 12 month moving average of the REER and, the percent deviation from the 12 month moving average REER. The volatility of the exchange rate is calculated over 3 and 6 months. We obtained this last explanatory variable by taking the standard deviation of 3 months of the log differences of the monthly REER (relative to the CPI) as reported in the IMF's IFS database.

Figure 2: Changes in the CPI Levels - Croatia, Czech Rep., Peru, Slovak Rep and Turkey



The main hypothesis of the paper is that in dollarized economies; Central Banks closely monitor the changes in the exchange rate as sudden (and permanent) movements could lead to currency mismatches which could lead to bank failures and systemic bank crises. It is in the interest of the Central Banks to intervene in the foreign exchange market when needed to avoid such outcomes. To check for the validity of this hypothesis, first we use a probit estimation in order to determine the probability of Central Bank's intervention in the foreign exchange market[14]. Second, also using the probit specification, we analyze if there is some asymmetry in the

[14] At this point we only estimate the probability of CB intervention because our estimation does not differentiate between the directions of the intervention. In this particular case our intervention index takes on the value of 1 if there is a Central Bank intervention during the period and 0 if not.

responses of the CBs interventions analyzing their response functions to purchases and sells of foreign currencies independently. Finally, in a third analysis, we analyze the probabilities of CBs interventions, given the vector of instruments, to buy or sell foreign currencies using an ordered probit model[15]. Given the characteristics of the data at hand, we only present a detailed analysis of the second and third procedures for Czech and Slovak Republic due to the lack of enough information from the other two countries. However, from these results we can argue of the importance of this indicator and the need for collecting information on CB's intervention.

In general our empirical estimation takes the following form:

$$inter_{it} = \alpha_i + \rho_i erv_{it} + \theta_i reer_{it-1} + \beta_i movav_{it} + \gamma_i dev_{it} + \acute{\varepsilon}_{it} \qquad (4.1)$$

where $inter_{it}$ represents the probability of Central Bank intervention in country i at time t, erv_{it} is volatility of the real effective exchange rate (REER), $reer_{it-1}$ is the value of the real effective exchange rate in the previous month, while $movav_{it}$ is the moving average of the REER for the past 12 month period, dev_{it} represents the percent deviation from the 12 month moving average of the REER for month t in country i. $\acute{\varepsilon}_{it}$ it is a mean zero, constant variance disturbance term, assumed to be normally distributed.

The probit model is defined as:

$$Pr(Y_i = 1 | x_{it}, \beta) = 1 - \Phi(-x_i'\beta) = \Phi(-x_i'\beta), \qquad (4.2)$$

where Φ is the standard normal cumulative distribution function. The basic idea is to relate this equation to the existence of an underlying latent variable y^* that is linearly related to x:

$$y_i^* = x_i'\beta + \upsilon_i, \qquad (4.3)$$

where υ is a normally distributed random term. The depended variable is determined by whether y_i^* exceeds a threshold value[16]:

$$y_i = \begin{cases} 1, \text{ if } y_i^* > 0 \\ 0, \text{ if } y_i^* \leq 0 \end{cases} \qquad (4.4)$$

[15] We code as -1, 0 or 1 if a sell, no or buy intervention occurred.
[16] For example, in this paper we will call $y = 1$ if there was a central bank intervention and, 0 if there was no intervention.

The ordered probit specification is similar to the probit one but allows for more than two possible values for the dependent variable y. In this case Equation 4.4 takes the following form[17]:

$$y_i = \begin{cases} 0, & \text{if } y_i^* \leq \upsilon_1 \\ 1, & \text{if } \upsilon_1 \leq y_i^* \leq \upsilon_2 \\ 2, & \text{if } \upsilon_2 \leq y_i^* \leq \upsilon_3 \\ \dots & \dots \\ K, & \text{if } \upsilon_K \leq y_i^* \end{cases} \qquad (4.5)$$

Next, we present the analysis of our sample of countries, separated as previously mentioned and, using the three different strategies to capture the desired relationships of our paper.

4.2. The Cases Of Croatia, Czech Republic And Slovak Republic

Croatia is an example of highly dollarized economy as Table 8 shows. It also has the lowest exchange rate flexibility in our sample despite that it follows a managed floating regime since 1993. During our observation period of 24 months, the Croatian Central Bank intervened in the foreign exchange markets for 13 times, averaging an intervention in less than every two months, while for Slovak Republic there is an average of one intervention per 13 months[18]. The Czech Republic switched to a floating exchange rate regime in 1997 while the CB retained its right to intervene in the case of excess volatility. Between 1997 and 2001, Czech National Bank intervened in the country's foreign currency markets in 47 months out of the 60 month period.

We present the results of the probit model where the CBs interventions take on the value of 1 if there was a Central Bank intervention during the period and 0 if not[19]. Table 1 shows the results of our estimations of this model. McFadden R square and Hosmer-Lemeshow Statistics are also presented.

[17] For the specific case that we introduce afterwards we use -1, 0 and 1 to represent sell interventions, no interventions and buy interventions respectively.
[18] During the 1998-2006 period, there were only 8 interventions in the foreign exchange markets by the Slovak Central Bank.
[19] We do not use the actual intervention amounts but a dummy variable instead. As Ito & Yabu (2007) argue "if an impact on the exchange rate is due more to the fact that there is an intervention than to how large it is, then authority's decision on whether or not to intervene is more important than how much to intervene".

Table 1: Probability of Central Bank Intervention – Croatia, Czech Rep, and Slovak Rep.

Dependent Variable:	CB Intervention†		
Country Time Variable	Croatia 2005-2006	Czech Rep. 1997-2001	Slovak Rep. 1998-2006
Percent Change in ERV	6.34*** (2.10)	0.44* (0.28)	0.10* (0.03)
REERt-1	0.19 (0.25)	0.01 (0.05)	0.12** (0.06)
REER Moving Av	-0.13 (0.33)	-0.17*** (0.06)	-0.13** (0.06)
McFadden R2	0.22	0.16	0.14
No of observations	24	49	97
LR Stat	7.40(0.06)	6.78(0.08)	13.39(0.003)
H-L Statistic	12.4 (0.13)	12.76(0.12)	13.44(0.09)

This table shows the results of probit estimations on the probability of Central Bank Intervention in the Foreign Currency Markets. The dependent variable is the dummy for Central Bank intervention observed at monthly intervals; takes on the value of 1 if there is a Central Bank intervention during the period and 0 otherwise. ERV are (the three or six month) volatility of the local currency exchange rate. REER is the Real Effective Exchange Rate, $REER_{t-1}$ is the REER in the previous period and REER Moving Av is the 12 month moving average of the REER. For Croatia we use the ERV corresponding to the 6 month volatility.
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

For Czech Republic, the 3-month volatility of REER is significant and has the expected sign, meaning that an increase in volatility of the REER rate increases the probability of CB's interventions. The other significant variable is the moving average of the REER of the last 12 months, meaning that the higher this average is the higher the probability of CB intervention. In the case of Croatia we observe that the only variable that has an explanatory power is the 3 or the 6 month volatility of the REER rate[20]. In the case of Slovak Republic, we observe that all our variables except deviation from the moving average of the REER are significant in explaining the probability of Central Bank interventions. The global fit of models as implied by the LR test, shows that the regressors satisfactorily explain the CB interventions. We checked for the goodness-of-fit of the model using the Hosmer-Lemeshow test. This Pearson χ^2-type test has as a null that the model provides sufficient fit to the data. The results presented in Table 1 also validate the previous statement at a 13%, 13% and 9% significance level for Czech Rep., Croatia and Slovak Republic respectively. In all cases, and as expected,

[20] We also checked the significance using the 3-month volatility. The individual parameter was significant but the global fit of the model was worse compared to the one predicted.

the percentage change in REER increases the probability of Central Bank interventions. However, the strength of the relationship is stronger for Croatia (a heavily dollarized economy[21]).

In none of the cases the percentage deviation from the REER moving average for the last 12 month was significant. Moreover, we analyzed the expectation-prediction table. The percentage gains of using our model versus a model that only includes the constant (meaning that the probability of a CB intervention equals the empirical probability) is equal to 63.64%, 0% and 17.65% for Croatia, Czech Rep and Slovak Republic respectively.(see Table 2). In the case of Czech Republic, the percentage gain is almost null due to the fact that this country's CB intervenes in the market most the time to purchase (84%). Moreover, in the sample the Czech National Bank intervened constantly in the market (purchasing foreign currency) until Nov 2000. Then they stopped for 4 months and started again in 2001. In the case of Slovak Republic this gain comes from the ability of our model to predict better the central and interventions and, in the case of Croatia, thanks to the ability of our model to predict no interventions[22].

[21] The marginal effect of a explanatory variable on the conditional probability is given by: $\frac{\partial E(y_i \mid x_i, \beta)}{\partial x_{i,j}} = f(-x_i'\beta)\beta_j$ where $f(x) = dF(x)=dx$ is the density of the corresponding F.

[22] Note that in this last case the interventions are quite well predicted.

Table 2. Prediction Tables for Interventions - Slovak Republic, Croatia & Czech Republic

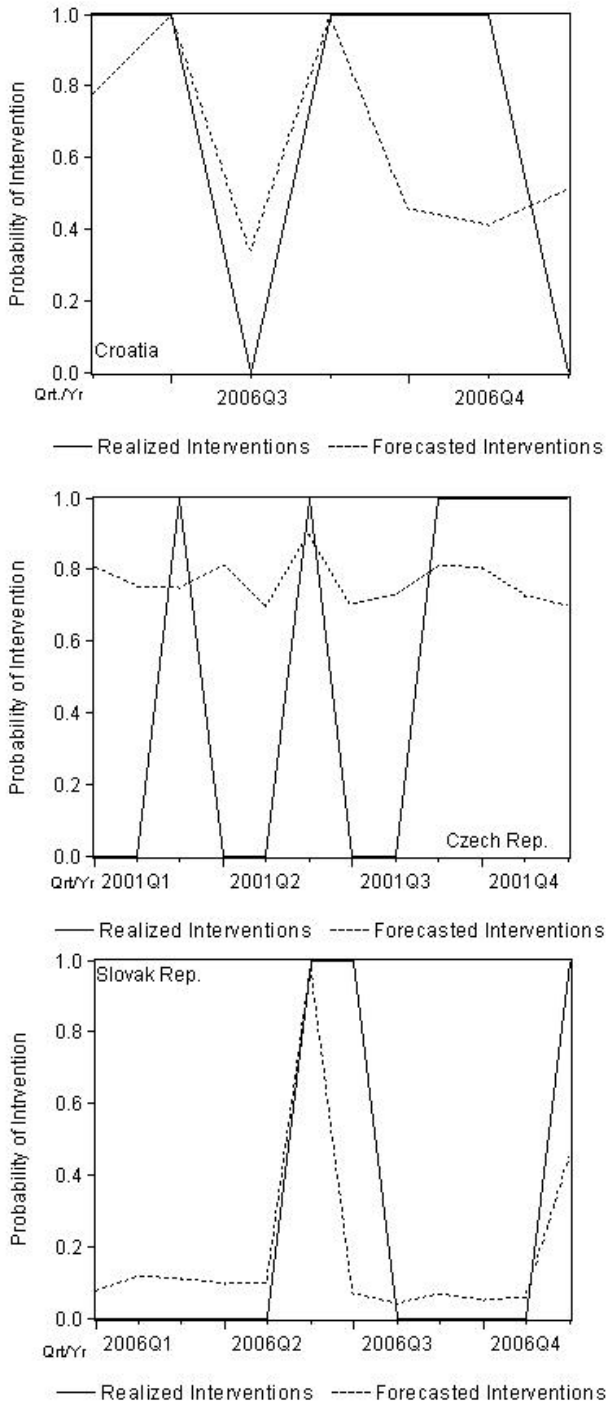
	Slovak Rep.				**Croatia**				**Czech Rep.**			
	Estimated Equation		Constant Probability		Estimated Equation		Constant Probability		Estimated Equation		Constant Probability	
	0	1	0	1	0	1	0	1	0	1	0	1
Total	80	17	80	17	11	13	11	13	8	41	8	41
Correct	79	3	80	0	7	9	0	13	0	40	0	41
%Correct	98.75%	17.65%	100%	0%	63.64%	69.23%	0%	100%	0%	97.56%	0%	100%
%Incorrect	1.25%	82.35%	0%	100%	33.36%	30.77%	100%	0%	100%	2.44%	100%	0%
Percent Gain	NA	17.65%			NA				0%	NA		

The cutoff point is 0.5.
This table shows the predictions of the probit estimations on the probability of Central Bank Intervention in the Foreign Currency Markets versus the Constant Probability Function. The value 1 represents intervention by the Central Bank and 0 the case of no intervention. The column "Est. Eq." lists the predictions by the probit function; the column "Constant Probability" lists the predicted values of the constant probability estimation. The improvement in estimations using the probit function is given in the "Percent Gain" line.

Next, we tested the predictability power of our approach. Figure 3 presents the forecasted probability for the year 2006[23] of a CB intervention with the dummy variable that represents the actual interventions. As expected the forecasts for Czech Republic are not good due to the facts explained above(mainly the fact that out of 49 interventions, only 8 were to sell, and that 4 of these were concentrated around Nov 2000 - March 2001. The bias proportion is equal to 0.23 and the variance proportion is equal to 0.63. The bias proportion of the forecast equals 0.004685 for Croatia and 0.043063 for Slovak Republic; the variance proportion is 0.323586 for Croatia and 0.285235 for Slovak Republic, meaning that our forecasted probability seems to be unbiased and with a reasonable variance. These last results, once more, imply that our model is able to capture the mean and the variance of the CB interventions quite well, in a dollarized economy with moderate inflation as the case of our sample of countries[24].

[23] For Croatia, our forecast is for the second half of 2006 due to the short length of our dataset.
[24] Considering the limitations of the Czech case.

Figure 3. Real Vs Forecasted CB Intervention in Croatia, Czech Rep, And Slovak Republic



NOTE: Forecasted versus realized CB interventions in both economies. Dependent variable is the dummy for Central Bank intervention observed at monthly intervals; takes the value 1 if there is a Central Bank intervention during the period and 0 otherwise.

Continuing with our research, in the next step we analyze possible asymmetries in the responses of CBs to buy or sell currencies for the case of Slovak Republic[25]. In order to analyze this, we develop two probit models one for purchases and one for sells. The results are presented in Table 3.

Table 3: Probability of Central Bank Intervention – Slovak Rep.

	Dec 1998 – Dec 2006	
Dependent Variable	**BUY**	**SELL**
Percent Change in ERV	-0.480*** (0.24)	0.18*** (0.06)
REERt-1	0.25*** (0.08)	-0.07 (0.09)
REER Moving Av	-0.26*** (0.08)	0.06 (0.07)
McFadden R2	0.25	0.29
No of observations	97	97
LR Stat	17.3(0.001)	13.00(0.005)
H-L Statistic	7.09(0.52)	5.15(0.74)

This Table shows the results of probit estimations on the probability of Central Bank Intervention in the foreign currency markets. The Dependent variables are dummy variables for probability of CB's buying transactions in forex Markets and probability of CB's Selling transactions in forex markets. Interventions are observed at monthly intervals; they take the value 1 if there is a Central Bank intervention(either a buy or a sell transaction) during the period and 0 otherwise. ERV is the three and six month volatility of the local currency exchange rate. REER is the Real Effective Exchange Rate, $REER_{t-1}$ is the REER in the previous period and REER Moving Av. is the moving average of the last 12-months REER.
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.
The p values are in parenthesis

We observe that the global fit of the model is good according to the LR statistic. All the variables are statistically significant and have the expected signs. We indeed observe that the Central Bank's responses to the percentage change of the 3-month REER volatility are asymmetric: an increase the percentage change of the 3-month REER decreases (increases) the probability intervention to buy (sell) foreign currency. Moreover, the magnitude of the effect of the percentage change of the 3-month REER is different for the buys than for the sells being larger for the buys.

Finally, we perform an ordered probit analysis for the case of Czech and Slovak Republic. With this model we try to determine the probabilities of the direction of central bank interventions, i.e. interventions to

[25] We cannot perform this analysis for Croatia since we just have 13 interventions, with only 1 sell intervention, that makes the modeling impossible. We have the same limitation in the case of Czech Republic, as explained before.

buy, sell foreign currencies or no intervention at all. We code as -1, 0 and 1 if there was a sell, no and buy intervention, respectively. Table 4 presents the results of this model.

As can be seen from the LR test the model fits the data reasonably well. The only variable that appears to be individually significant is the percentage change of the 3-month REER[26]. The table also presents the intervention bands. The no intervention band was estimated to be (12.48,-11.83) for Czech Rep and (-2.33, 1.12) for Slovak Republic. In our case the no intervention band is asymmetric toward the Czech and Slovak Koruna appreciation than the Czech and Slovak Koruna depreciation.

Table 4: Ordered Probit Estimations For Central Bank Interventions – Czech Rep. & Slovak Rep.

Dependent Variable :	**CB Intervention**	
	Czech Rep.	**Slovak Rep.**
Percent Change in ERV	0.51** (0.27)	-0.31** (0.13)
REERt-1	0.08 (0.13)	0.05 (0.11)
REER Moving Av	-0.20 (0.17)	-0.06 (0.12)
Thresholds		
μ_1*	-12.48* (7.12)	-2.33** (1.19)
μ_1*	11.83* (7.01)	1.12 (1.16)
Pseudo R^2	0.12	0.25
No of observations	49	97
LR Stat	10.16(0.03)	28.18(0.000011)
Akaike info criterion	1.69	0.98

This table shows the results of ordered probit estimations on the probability of Slovak and Czech Central Bank Intervention in the Foreign Currency Markets. The dependent variable is a dummy variable for probability of CB's buying and selling transactions in the foreign currency markets. Interventions are observed at monthly intervals; they take the value 1 if Central Bank intervenes in the foreign currency market by purchasing foreign currency and ¡1 if the CB sells foreign currency and 0 if the CB does not intervene at all during the period. ERV is the three month volatility of the local currency exchange rate. REER is the Real Effective Exchange Rate, $REER_{t-1}$ is the REER in the previous period and REER Moving Av. is the average of the REER for the last 12 months.
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.
The p values are in parenthesis

To understand the results in the table, remember that the sign of the parameter estimates ($\hat{\beta}_j$) in the model shows the direction of the change in the probability of falling in the end point rankings when x_{ij} changes.

[26] We performed redundant variable tests and the results showed that the model presented in Table 4 is the most desirable one. We also use information criteria and the results also support this finding.

Pr(intervention = -1) changes in the opposite direction of the sign of $\hat{\beta}_j$ and *Pr(intervention = 1)* changes in the same direction as $\hat{\beta}_j$. Thus, relating this explanation to an increase in the percentage change of the 3-month REER, it will increases the probability of a central bank intervention to sell and decreases the probability of a central bank intervention to buy.

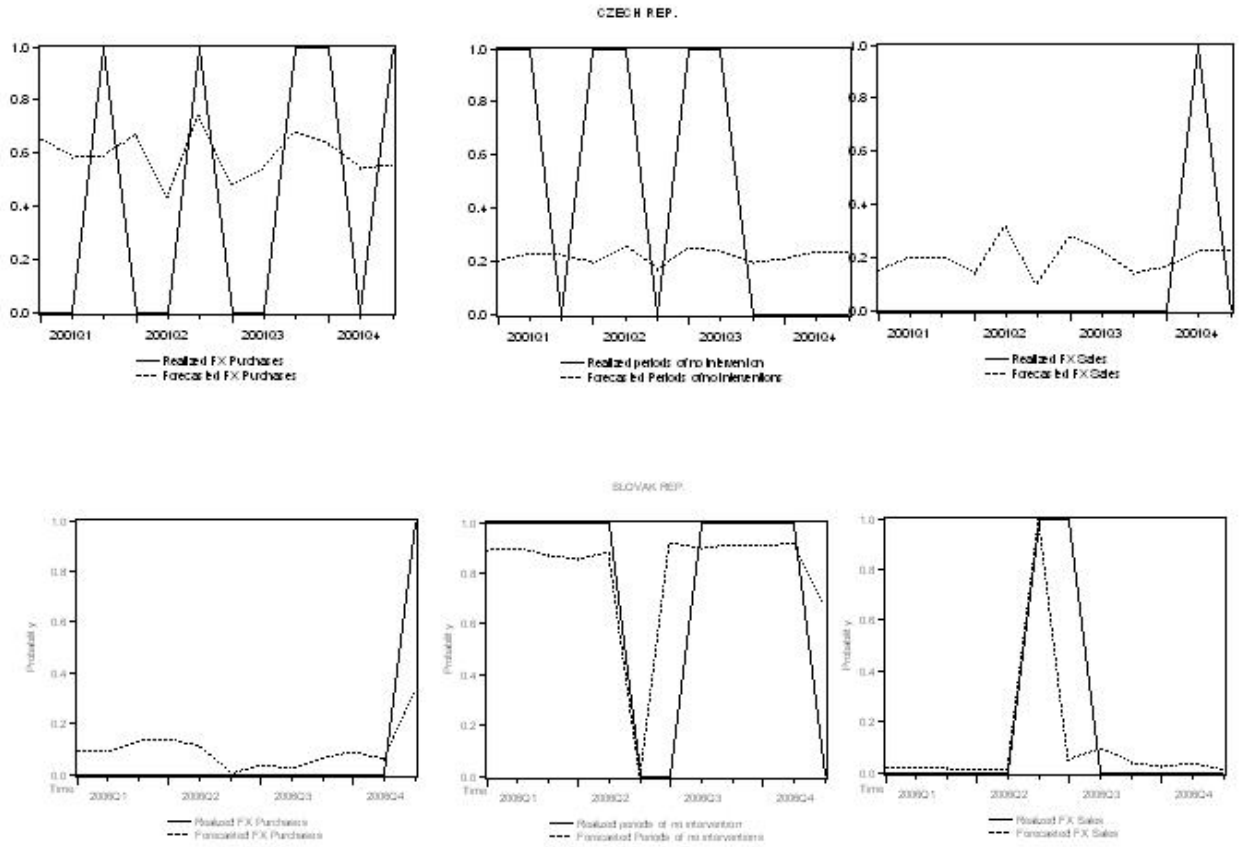
Table 5. Prediction Evaluation for Ordered Specification - Czech and Slovak Republics

Czech Rep.						
	Estimated Equation			**Constant Probability**		
Value	Sell (-1)	No Intervention (0)	Purchase (1)	Sell (-1)	No Intervention(0)	Purchase (1)
Total	7	8	34	7	8	34
Correct	2	0	32	0	0	34
% Correct	28.57%	0%	94.11%	0%	0%	100%
% Incorrect	71.42%	100%	5.88%	100%	100%	0%
Pct Gain*	28.57%	0%	0%			
Slovak Rep.						
Value	Sell (-1)	No Intervention (0)	Purchase (1)	Sell (-1)	No Intervention(0)	Purchase (1)
Total	6	80	11	6	80	11
Correct	2	80	1	0	80	0
% Correct	33.33%	100%	9.09%	0%	100%	0%
% Incorrect	66.67%	0%	90.9%	100%	0%	100%
Pct Gain*	33.33%	NA	9.09%			

This Table shows the predictions of the ordered probit estimations on the probability of Central Bank Intervention in the foreign currency markets versus the constant probability function. The value 1 represents an intervention by the Central Bank by purchasing foreign currency, -1 by selling foreign currency and 0 represents the case of no intervention. The column "Estimated Equation" lists the predictions by the ordered probit function; the column "Constant Probability" lists the predicted values of the constant probability estimation. The improvement in estimations using the ordered probit function are given in the "Percent Gain" line. Cutoff point is 0.5.
*Percent gain over Constant Probability of incorrect (default)prediction corrected by equation

As usual, we also present the prediction evaluation of this model compared to the naive prediction implied by the constant probability model. Results are presented in Table 5. From this table, we appreciate that the percentage gains in predictability power of our model vs. the constant probability model for the Czech Rep. equals 28.57%(0%) for sell(buy) and for the case of Slovak Rep. equals 33.33%(9.09%) for the predictions to sell(buy).

Figure 4. Ordered Probit Forecasts for Czech and Slovak Republics.



These figures illustrate the forecasts of Czech and Slovak National Banks' buying and selling transactions and the forecasted periods of no interventions versus the realized buying and selling transactions and the realized periods of no interventions. The dependent variables are the dummy variables for Central Bank interventions (by buying or selling foreign currency) and the case of no interventions observed at monthly intervals. In the ordered probit estimation, the value 1 represents an intervention by the Central Bank by purchasing foreign currency, 1 by selling foreign currency and 0 represents the case of no intervention.

Finally, we also present the forecasts of this model. Figure 4 present a graphical representation of the results. As can be seen the forecasts are quite well in predicting either sell, no and buy central bank interventions.

4.3. Peru

Peru was the only Latin American country with CB interventions that we can use. See Table 10 in the Appendix for additional info. In the case of Peru, we have analyzed the probability of Central Bank intervention in the foreign currency market only by using a probit model in which value of 0 indicates a "sale" of foreign

currency and 1 indicates a "purchase" of foreign currency. The reason why we have used a simple probit function as opposed to an ordered choice model is because Central Bank of Peru intervenes in the foreign currency market by purchasing and selling foreign currency every month, i.e. there is a single threshold. The direction of the transaction however is determined by the CB based on the current economic climate and the exchange rate. Results are similar to those cases presented before: all variables are significant at 5% level and the LR statistics shows that the model describes the endogenous variables reasonably well. However, the sign of the percentage change in ERV is not negative, meaning that an increase in the volatility decreases the probability of CB's intervention. However, in this case the percentage deviation from the 12-month moving average is significant, positive and larger in magnitude than the percentage change in Exchange Rate volatility, meaning that the resulting probability is dominated by the effect of the percent deviation from the 12-month moving average from the REER.

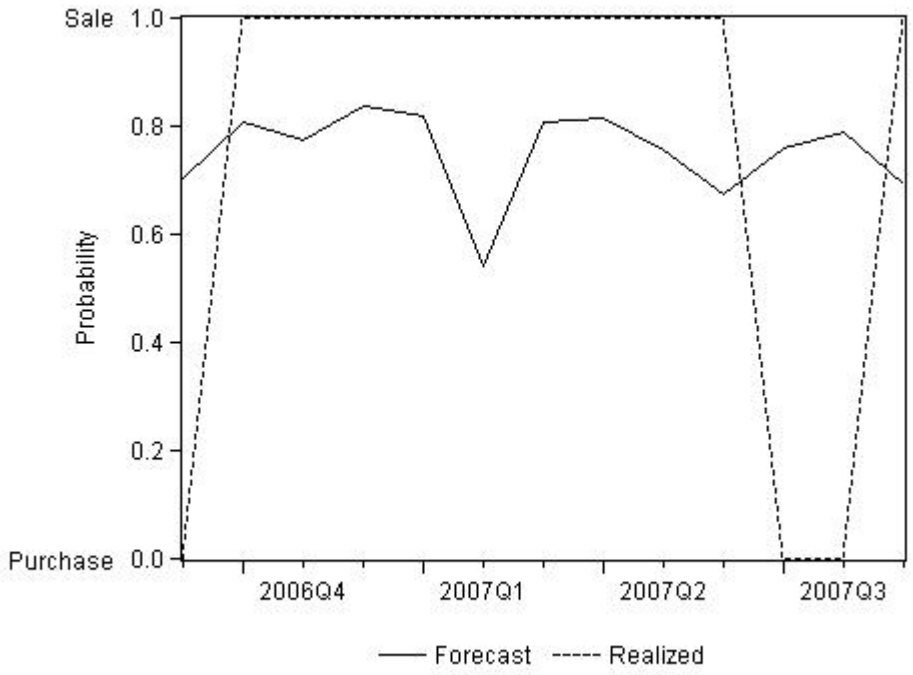
Table 6: Probability of Central Bank Intervention – Peru

Dependent Variable **Time Period**	**CB's Purchase and Sale of Foreign Currency** **1992 Jan – 2002 Sep**
Percent Change in ERV	-0.26*** (0.09)
$REER_{t-1}$	-7.14*** (2.09)
REER Moving Av	6.64*** (2.11)
Deviation(%) from REER Moving Av.(12 mo)	7.00*** (3.14)
McFadden R^2	0.10
No of observations	189
LR Stat	25.17(0.00004)
H-L Statistic§	10.84(0.21)

This Table shows the results of probit estimations on the probability of Peruvian Central Bank intervention in the foreign currency markets. Dependent variable is the dummy for Central Bank intervention observed at monthly intervals; takes the value 1 if the Central Bank buys foreign currency and 0 if it sells foreign currency during the period. *ERV* is the three month volatility of the exchange rate. REER is the Real Effective Exchange Rate; $REER_{t-1}$ is the REER in the previous period.
* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.
§ The p values are in parenthesis

Figure 5 presents the forecasted probability of CB intervention for the one year period between September 2006 and 2007. The bias proportion of the forecast equals 0.001918 and the variance proportion is 0.641296, meaning that our forecasted probability seems to be unbiased, although the efficiency of the model is not optimal. We can explain this due to the behavior of Peruvian interventions. During the sample, the Peruvian CB intervened most of the time having not interventions just in 2007(the forecasted year). However, in general the probability of intervention is well above 60% meaning a higher probability of intervention forecasted with the model and validated with the data.

Figure 5. Real vs. Forecasted CB Intervention in Peru



Forecasted versus realized CB interventions in Peru from Sept 2006 to Sep 2007. Dependent variable is the dummy for Central Bank intervention observed at monthly intervals; takes the value 1 if there is a purchase of foreign currency by the Central Bank during the period and 0 if a sale.

4.4. Turkey

In Turkey's case, our data set only covers the period starting at 2002, when the Turkish Government switched to a floating exchange rate regime to 2005, for which we have available data. The Turkish Central Bank's interventions are mostly discrete in nature and announced after the intervention has taken place. As

Egert (2006) observes, the objective of the CBRT has not always been to maintain exchange rate stability, but also to increase the country's international reserves within the framework of the country's IMF agreement. Remember from previous exposition, that Turkey is a heavily dollarized economy that also presents a high inflation rate. We are interested in presenting this case because the main hypothesis of the paper was minded to work for dollarized economies with controlled inflation. The following results support our previous hypothesis regarding the need of managed inflations to allow dollarization to be a good investment signal.

Table 7: Probability of Central Bank Intervention – Turkey

Dependent Variable Time Period	CB's Purchase and Sale of Foreign Currency 2002 – 2006
Percent Change in ERV	0.02 (0.12)
$REER_{t-1}$	-3.72* (2.23)
REER Moving Av	5.50** (2.82)
McFadden R^2	0.06
No of observations	60
LR Stat	4.41(0.21)
H-L Statistic§	4.06(0.85)
This Table shows the results of probit estimations on the probability of Turkish Central Bank intervention in the foreign currency markets. Dependent variable is the dummy for Central Bank intervention observed at monthly intervals; takes the value 1 if the Central Bank buys foreign currency and 0 if it sells foreign currency during the period. *ERV* is the three month volatility of the exchange rate. REER is the Real Effective Exchange Rate, $REER_{t-1}$ is the REER in the previous period. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent. § The p values are in parenthesis	

Again, to analyze this country we only perform a probit specification to understand the intervention or no-intervention of its central bank. Due to limited data available we are not able to perform further analysis as we have done in the case of Slovak Republic (asymmetry in the responses for example).

Table 7 present the results of the model. As expected, our estimations for Turkey show that the model variables do not explain the central bank's interventions. We tried many other possible explanations but none of

them seem to explain the interventions[27]. Thus, for Turkey, a highly dollarized and high-inflation economy the currency substitution hypothesis seems to be confirmed, our model fails to predict central bank interventions in the exchange rate market, while for highly dollarized but low-inflation economies (such as Croatia) the variance of inflation seems to be confirmed by this study.

5. Conclusion

Central Bankers in dollarized economies face a particular challenge: avoiding financial crises due to balance sheet mismatches in the face of sudden exchange rate movements. Recent literature has highlighted the possible causes and the consequences of such crises resulting from balance sheet mismatches. In this paper, we have looked at the predictability of Central Bankers' behavior in the country's foreign exchange markets as a result of an effort to avoid such mismatches. Our hypothesis in this paper is in a heavily dollarized economy with controlled moderate to low inflation; the Central Bankers will monitor closely the volatility of the local exchange rate and take actions to intervene in the foreign currency markets as a result of these volatility movements. Thus Central Banks' intervention in foreign currency markets can be predicted as a result. By utilizing available data from five dollarized economies, we have tested this model. Our results have shown that in low to moderate inflation economies with significant dollarization ratios, Central Bank interventions can be predicted to a great extent by exchange rate volatile measures. In addition, the direction of the Central Bank intervention can also be predicted with good accuracy as the cases of Czech and Slovak Republics have shown. Our model however cannot predict the timing or the direction of CB's intervention in the case of high inflation as the case of Turkey has demonstrated. This implies, price stability is an important aspect of a Central Bank's foreign currency intervention even in the case of highly dollarized economies that are subject to financial crises as a result of currency mismatches caused by sudden depreciations. In fact, our findings in the case of Turkey can shed light on the country's experience with financial crises not uncommon in the country's recent history.

[27] We also ran the estimation using other explanatory variables that include exports, imports and changes in the CPI level. Our results show that only the changes in the CPI levels determine the central bank's intervention. Results are available upon request.

Appendix

Table 8: Dollarization Data - (Foreign Currency Deposits/M2 Ratio)

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006
Croatia	66.2%	65.7%	64.6%	67.7%	62.0%	59.0%	58.0%	55.7%	48.0%
Czech Rep.	11.4%	11.7%	11.6%	11.1%	10.0%	9.1%	8.9%		
Peru	52.7%	53.3%	54.5%	52.5%	57.4%	55.4%	53.5%		
Slovak Rep.	14.6%	14.4%	15.6%	15.5%	15.2%	11.9%	12.7%		
Turkey	47.2%	45.0%	44.0%	56.0%	53.9%	45.0%	40.8%	33.0%	

Table 9: Dollarization Data - (Foreign Currency Deposits/M2 Ratio)

Country / Year	Croatia	Czech Rep	Peru	Slovak Rep	Turkey
1997		December	Every month		
1998		Every mo.	Every month	Aug, Sep	
1999		Every mo.	Every month	Feb, Mar & Dec	
2000		Every mo except Nov & Dec	Every month	Jan, Feb, Mar, Apr, May	
2001		Mar, June, Sep, Oct, Nov, Dec	Every month	Jan	
2002			Every month	June	July, Dec
2003			Every month	May	May, June, July, Sep
2004			Every month	July, Dec	Feb & May
2005	Jan, Mar, Apr, June, Oct, Dec		Every month	Jan	Jan, Mar, June, July, Oct, Nov
2006	Feb, May, June, July, Sep, Oct, Nov, Dec		Every month	June, July, Dec	Feb, June

Table 10: Data Availability for Central Bank Intervention in the Foreign Currency Markets

Country	CB intervention Data Available	Data Notes
Latin America		
Brazil	**NA**	No data on dollarization available on Central Bank's website.
Chile	**2001-2002**	Country adopted the floating regime in 1999. However, CB intervenes "during exceptional episodes of uncertainty and volatility" (*Monetary Policy Report - January* 2003). All interventions during the data period are for the sale of foreign currency to prevent "excessive depreciation of the currency". For more information see (Gregorio & R. 2004)
Colombia	**NA**	Country moved to floating exchange rate regime in September 1999. The Central Bank intervenes in the foreign currency market to accumulate reserves or to control exchange rate volatility. The CB follows predetermined rules when intervening in the market to control exchange rate volatility.(If the exchange rate is 4% or more below (above) its last 20 working-day moving average, volatility auctions are held to sell put (call) options.) Therefore probability function has not been estimated. For more info see section "Exchange Rate Policy" from Central Bank of Colombia's website (http://www.banrep.gov.co).
Costa Rica	**2008**	Country uses an exchange rate band for intervention so probability function is not estimated. Information verified with Acuna Jarquin Olga of the Costa Rican Central Bank.
Ecuador	**NA**	Country is fully dollarized
El Salvador	**NA**	Country is fully dollarized
Guatemala	**NA**	No data on dollarization available
Mexico	**May 2003 – May 2008**	The CB uses a floating regime. The objective of intervention is to "slow the pace of international reserves accumulation" since May 2003. That's why the CB persistently sells foreign currency in its operations.
Panama	**NA**	Country is fully dollarized
Paraguay	**NA**	No foreign currency intervention data available from the CB's website. The CB only provides open market operations data related to interbank operations.
Peru	**1992-2007**	CB's monthly interventions are available for the period.
Uruguay	**2005**	CB only has only one year of intervention data (2005) available in its annual report. We were able to obtain this data through communication with Centro de Comunicacin Institucional Banco Central del Uruguay.
Eastern Europe		
Bulgaria		The CB follows a peg to the Euro; therefore no CB interventions are estimated.
Croatia	**2005-2006**	Data obtained from Central Bank's annual reports.
Czech rep.	**1998-2002**	Data obtained from Central Bank's annual reports and communication through Tomas Holub of the Czech National Bank.
Hungary	**2002-2005**	There was only one intervention during the period by the CB. For more information see Egert (2006).
Poland	**NA**	The country's CB does not intervene in the foreign currency market (Gregorio & R. 2004).
Romania		We could not find data on the CB website. We have consulted Egert (2006) for data from who referred us to the CB website.
Slovak Rep.	**1998-2006**	Obtained from Central Bank's annual reports available on its website.
Turkey	**2002-2006**	Obtained from Central Bank's report on foreign currency market operations.

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