Comparative Economic Studies, 2010, 52, (104–129)

www.palgrave-journals.com/ces/

Currency Allocation of Public External Debt and Synchronization Indicators of Exchange Rate Volatility

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This paper uses synchronization indicators of domestic and foreign fundamentals to choose suitable currency allocation of public external debt. The selection of explanatory variables for exchange rate volatility is motivated using a New Keynesian Policy model that predicts that not only traditional optimum currency area (OCA) variables, but also variables considered by the literature on currency preferences, such as money velocity, should be relevant for explaining exchange rate volatility. I find that measures of inflation synchronization, money velocity synchronization and interest rate synchronization are useful indicators for deciding on the currency denomination of public external debt.
Comparative Economic Studies (2010) **52,** 104–129. doi:10.1057/ces.2009.22; published online 21 January 2010

Keywords: public debt management, currency allocation of external debt, emerging market economies

JEL Classifications: H63, F34, F41

INTRODUCTION

Governments are often forced to issue debt in a foreign currency if their funding needs cannot be met by issuing debt denominated in the domestic currency due to the underdevelopment of domestic bond markets or an attempt to avoid crowding out domestic firms from domestic currency borrowing (Turner, 2002), the 'original sin' (Eichengreen *et al.*, 2003), low monetary credibility (Jeanne, 2005), or an emphasis of the cost element in the cost/risk trade-off (Broner *et al.*, 2007). A suitable tool for managing foreign exchange (FX) exposures is the use of foreign currency derivatives. Although the use of derivatives among emerging market economies (EMEs) has increased in recent years, their utilization in debt management remains low due to laws limiting the instruments that can be used for debt management, a lack of examples, low staff capacity and also a lack of markets for many EMEs currencies (Caballero and Cowan, 2006; Claessens, 2006; and Bordo and Meissner, 2006).[1] As a result governments can be exposed to FX risk from currency mismatches in their balance sheets. Currency mismatches could arise if, after matching the cash flows from assets and liabilities denominated in similar currencies, there still remains an open position in some foreign currency.[2] I thus focus on management of the FX risk inherent in an unhedged government debt portfolio while acknowledging the fact that some countries have to borrow in foreign currencies.[3] Hence, I do not attempt to contribute to the literature on the 'original sin' or explain how currency mismatches come about, and I take these circumstances as given.

Based on the review of current approaches to FX risk management of government debt, provided in Bolder (2002) and Melecky (2007), solutions of typical economic problems dealing with optimal allocation of foreign currency debt across a spectrum of available currencies imply that the optimal currency structure of foreign debt is largely determined by relative magnitudes of variances of exchange rates with respect to the relevant foreign currencies, and covariances between domestic fundamentals and the exchange rates. In practice, however, not much guidance can be expected from the estimated covariances of nominal exchange rates with the domestic primary balance (Bohn, 1990a). This is due to the inability of fundamentals to forecast exchange rates (Engel and West, 2005) and the high degree of noise incorporated in exchange rates (De Grauwe and Grimaldi, 2005; and Melecky, 2007) which limits the information available from historical data. Also, the use of fixed exchange rates complicates the choice of currencies for denominating foreign debt, because it is not clear why debt managers should rely on the promise of the central bank to sustain a peg to certain currency,

[1] The limited use of derivatives also derives from the type and structure of the derivatives. Although, swapping one hard currency for another is possible, the feasibility of swapping a foreign hard currency into the domestic currency of a developing country can be costlier or not possible due to much larger transaction costs or limited external convertibility of the domestic currency.

[2] Usually the most important asset of a government is the present value of its future revenues. As the revenues are most often denominated in the domestic currency, borrowing in foreign currencies creates currency mismatches in government's balance sheet. In the case where the revenues are denominated in foreign currencies, for example, oil revenues or royalties, borrowing entirely in domestic currency would also create currency mismatches.

[3] The latter refers to an open, short position of a sovereign in any foreign currency.

especially in EMEs. The volatility of managed exchange rates has proven to be no smaller than the volatility of floating exchange rates over a medium- to long-term horizon (Reinhart and Rogoff, 2008).

In this paper I propose a macroeconomic approach to use as a complement to existing portfolio approaches (Bohn, 1990b; or Giavazzi and Missale, 2004) when choosing the currency structure of foreign debt. The underlying idea of this paper can be summarized as follows. Consider the bilateral exchange rate defined as the relative value of two currencies. Unfavorable shocks to the domestic economy will result *ceteris paribus* in depreciation of the domestic currency relative to the foreign currency. The same is true for the foreign currency that rises with favorable shocks and falls with unfavorable ones. Consider now three scenarios. (i) If the domestic and foreign economies are converging in the sense that the shocks hitting both economies are becoming more correlated, the relative value of the two currencies, the exchange rate, is becoming less volatile. (ii) If, however, the economies are not linked at all, shocks either in the domestic or foreign economy will be purely idiosyncratic and fully reflected in the exchange rate. (iii) If the shocks are in general negatively correlated, the relative value of the domestic and foreign currency will be significantly more volatile than in case (i) or (ii).

I propose to look across a spectrum of foreign currencies available for foreign debt denomination and pick those for which the domestic shocks and foreign shocks are positively correlated. Furthermore, it is not only the correlation of the shocks that matters, but also their transmission into the domestic and foreign fundamentals that determine domestic and foreign currency values. I thus propose to use a measure of synchronization in the movements of relevant domestic and foreign fundamentals when choosing currency(ies) for denomination of foreign debt. The proposed approach can be linked to the literature on optimum currency areas (OCAs) such as Bayoumi and Eichengreen (1998), the literature on modeling bilateral exchange rate volatility (Devereux and Lane, 2003), and the literature on currency preferences (Kingston and Melecky, 2007). In this paper the interplay between exchange rate volatility and exchange rate regimes is handled by using the exchange market pressure index (EMPI) following Eichengreen *et al*. (1996). Further, I attempt to frame the selection of explanatory variables for exchange rate volatility into a conventional New Keynesian Policy model that predicts that not only traditional OCA variables, but also variables considered by the literature on currency substitution and complementarity, such as money velocity, should be relevant for explaining exchange rate (EMPI) volatility.

The empirical analysis carried out in this paper focuses on middle-income countries (MICs) for three reasons. First, high-income countries

(HICs) have well-developed domestic markets or are able to issue debt in their own currencies offshore, that is, they do not suffer from 'original sin'. On the other hand, low-income countries (LICs) rely heavily on official assistance from multilateral and bilateral donors that is provided at concessional rates, and thus the choice of currency denomination for their debt is usually determined by the supply side.[4] Second, the size of shocks varies significantly for developed and EMEs (Caballero and Cowan, 2006). Third, the institutional frameworks of HICs, MICs and LICs can differ considerably and one may prefer to analyze a more homogenous group of countries that is constrained to borrow in foreign currency and for whom the required data are readily available.

Based on the empirical analysis in this paper, I find that countries trying to select a suitable currency for denominating their sovereign debt can use measures of inflation synchronization, money velocity synchronization and interest rate synchronization as indicators in order to minimize the expected variance of their FX debt charges due to exchange rate volatility. However, if a country increasingly uses interest rate differentials to intervene in the FX market, interest rate synchronization should be viewed as the main indicator when selecting the currency structure of foreign debt. If, on the other hand, the country is intervening in FX markets using its FX reserves to manage the exchange rate, the main indicator to be used is inflation synchronization.

The remainder of the paper is organized as follows. The next section presents theoretical motivation of the empirical framework used in the paper. The section after that describes the data and estimation methodology. In the penultimate section, the empirical analysis is performed using regressions, and the last section concludes.

THEORETICAL UNDERPINNING

By engaging in FX risk management, a government aims to minimize the impact of unexpected movements in exchange rates on the fiscal budget through debt-service charges. The debt managers thus use their policy instrument, the currency composition of foreign debt, to minimize the FX risk of the government financing strategy.[5] The benchmark portfolio for foreign

[4] For example, LICs borrowing from the World Bank get their funds denominated in SDRs. Similarly, bilateral donors from Japan or Germany would lend in Japanese yen or euros.

[5] Although the debt managers' objective is commonly expressed as minimizing borrowing cost subject to an acceptable level of risk, I emphasize the risk minimization perspective in the context of FX risk as its magnitude is potentially much greater than the difference in the borrowing cost across major currencies.

currency debt is then determined with respect to the risk preferences of the government.

The debt manager's objective pertaining to FX risk of the public debt portfolio is specified in this paper in a way that relates to tax smoothing. The objective function focuses on minimizing the fluctuations in government budget financing requirements to avoid disruptive changes in taxes, unexpected inflation or government borrowing under unfavorable circumstances, that is, at a very high cost. Therefore, the debt manager aims to[6]

$$\min_{\mathbf{ex}_t} \ var\left(F_t^{FX}\right) \tag{1}$$

where $\mathbf{ex}_t$ is a vector of chosen currency exposures, and F_t^{FX} represents the government financing requirements subjected to FX risk management. F_t^{FX} is the difference between the primary balance, PB_t, that is, the difference between government revenues and non-financial expenditure, and debt-service charges exposed to FX risk, C_t^{FX}:[7]

$$F_t^{FX} = PB_t - C_t^{FX} \tag{2}$$

Given the definition of C_t^{FX}, its movements will be determined by the changes in the exchange rates, Δs_t, to which the debt portfolio is exposed, assuming the debt manager issued a fixed-interest bond.[8] Using the formula for writing out the variance of a difference between two variables, we can express the objective function for FX risk management as[9]

$$\min_{\mathbf{ex}_t} \left[var(PB_t) + var(\Delta s_t) - 2cov(PB_t, \Delta s_t)\right] \tag{3}$$

A debt manager's goal is thus to choose a currency for denomination of foreign debt for which the exchange rate *vis-a-vis* the domestic currency is relatively stable and the covariance of the exchange rate and the primary balance is strongly positive, all subject to cost considerations. In other words, a debt manager cannot influence either the variability of the primary balance

[6] I use here an objective function that focuses on the flows, but the objective for this problem can be equivalently expressed while focusing on the stocks.

[7] I thus condition here on the foreign interest rate movements as these constitute a part of interest rate risk.

[8] For this to hold at all times the bond has to be perpetual.

[9] $var\ (X-Y) = var\ (X) + var\ (Y) - 2cov\ (X,\ Y)$.

or the exchange rates, but he can manage exposure to their unexpected variations. The debt manager selects the net exposure to a foreign currency by issuing net foreign debt in that particular currency. The overall exposure of the government changes as the domestic economy, the government balance sheet and the exchange rate absorb various shocks. The covariance terms then represent the aim of the debt manager to select such a foreign currency for denomination of FX debt that, at times when the primary balance worsens, the exchange rate pertinent to the selected foreign currency improves (the domestic currency appreciates relative to the selected foreign currency).[10]

It is important for a debt manager to try to understand each term of equation 3 to effectively manage the exposure to FX risk. In this paper I will mainly focus on the second term of equation 3, $var\ (\Delta s_t)$ for the following reason. In practice, it might be difficult to justify large fluctuations of debt-service charges due to exchange rate movements by resorting to counter-balancing movements in the net primary balance or in fiscal revenues. Although theoretically possible, political economy constraints may prevent such a policy response. Public debt managers in developing countries therefore often choose to initially minimize the variance of the service charges on their debt portfolio with respect to the long-term costs of their borrowing strategies. The volatility of debt-service charges due to excessive exchange rate risk are then captured by exchange rate volatility. Hence, this paper tries to provide some practical guidance in the first step of understanding the term $var\ (\Delta s_t)$ of equation 3.

Next, I will focus on identification of possible empirical indicators for selecting foreign currencies with relatively low volatility of exchange rates with respect to the domestic currency. I motivate and frame the selection of candidate explanatory variables for exchange rate volatility using the New Keynesian Policy model of Monacelli (2005) with an added money demand equation and the role for money based on the motivation consistent with the P-star model of Hall *et al.* (1991):

$$y_t = \rho_y E_t y_{t+1} + (1-\rho_y) y_{t-1} - \delta_R (i_t - E_t \pi_{t+1}) + \delta_{y^*} y_t^* + \delta_q q_t + \varepsilon_t^{IS} \qquad (4)$$

[10] Each economy is likely to be influenced by exchange rate variations to a different extent given its country-specific pass-through of exchange rates to the overall domestic price level and the degree of openness of the economy. Moreover, government revenues can be to a different degree dependent on income from tradables as opposed to non-tradables. This implies that the primary balance is affected by exchange rate variability to a different degree. The latter interdependencies between the primary balance and exchange rates are captured by the covariance term in equation 3.

$$\pi_t = \rho_\pi E_t \pi_{t+1} + (1-\rho_\pi)\pi_{t-1} + \lambda_y y_t + \lambda_m \varepsilon_t^{MD} + \lambda_q q_t + \varepsilon_t^{AS} \quad (5)$$

$$m_t - y_t = \gamma_i i_t - E_t \Delta s_{t+1} - \gamma_i i_t + \varepsilon_t^{MD} \quad (6)$$

$$i_t = \rho_i i_{t-1} + (1-\rho_i)(\phi_\pi \pi_t + \phi_y y_t) + \varepsilon_t^{MP} \quad (7)$$

$$q_t = (1-\alpha) tot_t \quad (8)$$

$$\Delta s_t = \Delta q_t + \pi_t - \pi_t^* + \varepsilon_t^{ER} \quad (9)$$

$$i_t^* = \rho_i^* i_{t-1}^* + (1-\rho_i^*)(\phi_\pi^* \pi_t^* + \phi_y^* y_t^*) + \varepsilon_t^{*MP} \quad (10)$$

$$m_t^* - y_t^* = \gamma_i^* i_t^* + \varepsilon_t^{*MD} \quad (11)$$

$$\pi_t^* = \rho_\pi^* E_t \pi_{t+1}^* + (1-\rho_\pi^*)\pi_{t-1}^* + \lambda_y^* y_t^* + \lambda_m^* \varepsilon_t^{*MD} + \varepsilon_t^{*AS} \quad (12)$$

$$y_t^* = \rho_y^* E_t y_{t+1}^* + (1-\rho_y^*) y_{t-1}^* - \delta_R^* (i_t^* - E_t \pi_{t+1}^*) + \varepsilon_t^{*IS} \quad (13)$$

where y_t is the output growth, π_t is inflation, m_t is the deviation of real money balances from their steady state value and i_t is the short-term, money market interest rate. Further, q_t is the real exchange rate, s_t is the nominal exchange rate expressed as the units of domestic currency per unit of foreign currency and tot_t are the terms of trade assumed to follow an AR(1) process. ε_t's represent structural shocks with attached superscripts identifying their type. * indicates the foreign economy equivalents of the respective variables and shocks. E_t stands for model consistent rational expectations conditional on information available to the agents at time t. The Greek letters with subscripts are coefficients.

Equation 4 is the familiar open-economy Investment Saving (IS) curve derived from an intertemporal optimization of consumption and investment, where the current output growth increases in response to higher expectations about future output growth, higher past output growth, the lower *ex ante* real interest rate, higher foreign demand (output gap) and relatively weaker domestic currency in real terms.

Equation 5 is the Phillips curve describing the dynamics of inflation for an open-economy where I have augmented the traditional form of the Phillips curve with the response of inflation to disequilibriums in money markets along the lines of the *P*-star model (Hall *et al.*, 1991; Tatom, 1992; Garcia-Herrero and Vasant Pradhan, 1998; Tsionas, 2001; Nachane and Lakshmi, 2002). Inflation is thus assumed to increase if there are high inflation expectations, increasing output growth, a positive deviation of money supply from money demand and weakening domestic currency in real terms.

Equation 6 describes equilibrium in the money market where real money demand increases in response to increasing output growth and the domestic interest rate, declining foreign interest rate and expected strengthening of the domestic currency. ε_t^{MD} then represents the deviation of the money supply from the existing demand for money.

Equation 7 is a simple Taylor rule that characterizes the response of the central bank to inflation and output growth. Namely, the central bank is assumed to increase its policy instrument, the interest rate, in response to positive inflation and increasing output growth to stabilize the economy.[11] In order to ensure stability, the central bank increases the nominal interest rate more than one to one with increasing inflation so that $\phi_\pi > 1$.

Equation 9 links the real exchange rate to the terms of trade through the degree of openness of the domestic economy captured by α. Equation 10 links the changes in the nominal exchange rate to the changes in the real exchange rate.

Consider a foreign economy that can be described using an identical model to the one described by equations 4–7 with the respective foreign variables being indicated by *, and assuming that the foreign economy is unaffected by the domestic economy.

The solution of the model for the nominal exchange rate could be expressed as a combination of lagged endogenous variables and shocks:

$$s_t = f(s_{t-1}, y_{t-1}, \pi_{t-1}, v_{t-1}, i_{t-1}, t_{t-1}, y^*_{t-1}, \pi^*_{t-1}, v^*_{t-1}, i^*_{t-1}, t^*_{t-1}, \varepsilon_t, \varepsilon^*_t) \quad (14)$$

where v_t is money velocity, that is, money demand per unit of local currency, defined as $v_t \equiv m_t - y_t$ and $f(\cdot)$ is a linear function. I use money velocity

[11] Although I use short-term output growth in this model instead of the output gap, which is traditionally included in this type of models, short-term output growth merely represents a different type of detrending of GDP and should thus be seen as analogous to the traditional output gap measure.

instead of real money balances themselves as the former is useful in identification of currency complements and currency substitutes (Kingston and Melecky, 2007; Brittain, 1981).[12] The solution in equation 14 can be equivalently expressed as:

$$\Delta s_t = f(y_t - y_t^*,\ \pi_t - \pi_t^*,\ v_t - v_t^*,\ i_t - i_t^*,\ t_t - t_t^*,\ \varepsilon_t - \varepsilon_t^*) \qquad (15)$$

Equation 15 implies that one should look at the ratios of the fundamental variables and structural shocks when predicting exchange rate movements. If this linear relationship holds also for the standard deviations of the variables, we can write:

$$stdev(\Delta s_t) = stdev(\mathbf{x}_t. - \mathbf{x}_t^*)'\eta + \zeta \qquad (16)$$

where $x_t \equiv [y_t,\ \pi_t,\ v_t,\ i_t,\ t_t]$. Equation 17 then implies that the variability of exchange rates is going to be relatively larger if the movements in the fundamentals of the domestic economy are highly asynchronous with the movements in fundamentals of the foreign economy. More precisely, the highly asynchronous movements in domestic and foreign variables would occur if the element-by-element correlations of the vector of domestic variables and the vector of foreign variables were significantly negative.

When trying to understand and model exchange rate variability, one faces potential complications. In practice, the exchange rate fluctuations could be managed by the national central banks, and this could be happening to exchange rates with respect to some currencies and not to others. To account for this potential problem, one can consider another variable as a substitute for *stdev* (Δs_t) that would capture the underlying variability of exchange rates. exchange market pressure index, $EMPI_t$, which I define as did Eichengreen *et al*. (1996):[13]

$$EMPI_t = \alpha\Delta s_t + \beta\Delta(i_t - i_t^*) - \gamma(\Delta rs_t - \Delta rs_t^*) \qquad (17)$$

where $(i-i^*)_t$ is the interest rate differential, rs_t stands for FX reserves, and α, β and γ are weights. The rationale for this index is as follows. If capital

[12] Currency complements are defined as currencies with positively correlated money velocities, while currency substitutes have negatively correlated money velocities. Hence, in the case of currency complements, money demand is synchronized whereas in the case of currency substitutes it is asynchronous.

[13] One could argue that capital controls should be brought into the equation as well to broaden the set of available tools for exchange rate management. I leave this for future research due to low data availability and refer the reader to Edwards and Rigobon (2005) for useful insights.

inflows reverse, the government can let the exchange rate depreciate. Alternatively, it can defend the currency by running down reserves or by increasing interest rates (Sachs *et al.*, 1996). In addition, the index captures some important links to asset and liability management. First, adjustments in the interest rate differential are expected to affect government revenues and thus the primary balance. For instance, an increasing domestic interest rate will result in decreasing inflation and output growth, and thus government revenues. Similarly, depletion of FX reserves will reduce government's ability to exploit natural hedges, the only hedges if it is constrained from using currency derivatives.[14] When determining the weights α, β and γ, I follow Eichengreen *et al.* (1996) and set them so that all components are equally important. Thus, α, β and γ are given by the inverse of the median standard deviation of each components across countries. I use the median to avoid the leverage effect of huge outliers present in my sample, such as Argentina. Since the willingness of monetary policy to trade variability in one EMPI component for another most likely varies according to the circumstances of individual economies (Hausmann *et al.*, 2001), I also use an unweighted average of the three components to construct an alternative measure of EMPI to check how robust the results are to different values of α, β and γ.[15] In the unweighted EMPI index α, β and γ are all set to one. By trying to understand the determinants of the EMPI variance across countries we try to understand why exposures to certain foreign currencies are relatively less risky for a given country.

For this, I run the following regression:

$$stdev(EMPI_t)_{j,i} = stdev(\mathbf{x}_{t}. - \mathbf{x}_t^*)'_{j,i}\theta + \xi_{j,i} \tag{18}$$

where $x_t \equiv [y_t, \pi_t, v_t, i_t, t_t]$ and v_t is money velocity, *stdev* $(\cdot)$ stands for standard deviation of a variable, θ is a vector of estimated coefficients, ξ_i is an error term, and the subscripts j and i denote the number of different foreign currencies and number of domestic currencies, respectively.

[14] Here the government is defined in a broader sense to include the central bank, the government's agent with separate objectives but working in coordination with the principal. Therefore, the broader ALM approach considers a consolidated balance sheet including the central government and the central bank.

[15] The authors point out the importance of the relative strength of the credit and balance sheet channels. While reductions in interest rate can have an expansionary effect through the credit channel, the depreciation induced by the interest rate reduction can be contractionary through the balance sheet channel. Therefore, as the importance of foreign exchange debt increases the monetary authority can choose less exchange rate flexibility.

A priori, the signs of all estimated coefficients, that is, the elements of θ, are expected to be significantly positive. This means that *a priori* we expect a higher correlation between corresponding domestic and foreign variables in $\mathbf{x}_t$ and $\mathbf{x}_t^*$, for example, y_t and y_t^*, to result in lower volatility of the corresponding exchange rate (Bayoumi and Eichengreen, 1998). On aggregate, this implies that two economies with more synchronized fundamentals should have a bilateral exchange rate that is less volatile than the bilateral exchange rate of two economies whose fundamentals are less synchronized.

DATA AND ESTIMATION METHODOLOGY

Data

As described by equation 18 the dependent variable in my estimations is the standard deviation of the EMPI index. The standard deviations of $EMPI_t$ and $X_t./X_t^*$, the ratios of the domestic and foreign fundamentals, are estimated over the period 1976–2006 using annual data to maximize the coverage of countries. This implies that $t=1, \ldots, 30$. The standard deviations are computed for a sample of 44 MICs, where I use as reference currencies the US dollar, the euro, the Japanese yen and the British pound.[16] This implies that I have available 176 observations, such that $i=1, \ldots, 176$.[17] In the actual regressions, I work with two measures of the EMPI. The first one, as discussed above, is constructed by setting α, β and γ to the inverse of the median standard deviation of the relevant components across countries. The second, alternative measure is constructed as an unweighted average of the EMPI components outlined in equation 17, that is, when setting $\alpha=\beta=\gamma=1$. I use the two different measures of exchange rate volatility to ensure that the results are reasonably robust to a simple change in government preferences across the commonly used tools in exchange rate management.

The exchange rate series of MICs' currencies *vis-a-vis* the US dollar were obtained from the IMF's International Financial Statistic, and I used the end-of-period values. The exchange rates for the EUR, JPY and GBP were calculated using cross-currency exchange rates where the synthetic USD/EUR exchange rate was taken from DataStream. The interest rate series used are the money market interest rates from the IMF's International Financial Statistic where the pre-1999 data for the euro area were obtained from the

[16] Table A1 presents the list of countries included in the regression analysis.

[17] I also worked with a larger sample including 75 high-income, middle-income and low-income countries, and the results were quite similar. The reason for this is the fact that the MICs dominated in this larger sample.

Table 1: Pairwise correlations of explanatory variables

	$\sigma(y_t/y_t^*)_i$	$\sigma(\pi_t/\pi_t^*)_i$	$\sigma(v_t/v_t^*)_i$	$\sigma(i_t/i_t^*)_i$	$\sigma(t_t/t_t^*)_i$
$\sigma(y_t/y_t^*)_i$	1.000				
$\sigma(\pi_t/\pi_t^*)_i$	0.406	1.000			
$\sigma(v_t/v_t^*)_i$	−0.213	0.033	1.000		
$\sigma(i_t/i_t^*)_i$	0.187	0.106	−0.087	1.000	
$\sigma(t_t/t_t^*)_i$	0.096	0.070	0.033	0.011	1.000

A star would indicate significance at the 5% level.

Fagan *et al*. (2001) data set. The data series of countries' official FX reserves and narrow money were obtained from the IMF's International Financial Statistic where the series for the euro area was taken from DataStream and the FX reserves series extended from 1997 back to 1976 using growth rates of German FX reserves.

The series for GDP growth rates and inflation were acquired from the World Development Indicators (WDI) database of the World Bank where GDP growth rates and inflation for the euro area were taken from the Fagan *et al*. (2001) data set and DataStream, respectively. The money velocity was constructed as the ratio of money over nominal GDP obtained from the WDI database of the World Bank where the euro area equivalents were taken from DataStream and the Fagan *et al*. (2001) data set, respectively. The terms of trade series were taken from the WDI database of the World Bank and the terms of trade series for the euro area was constructed as an average of the euro area 12 countries.[18] The measures of synchronization of movements in y_t, π_t, v_t, i_t and t_t are based on ratios of the national fundamentals with respect to those of the US, the euro area, Japan and the UK, so that they correspond to the constructed EMPI *vis-a-vis* the US dollar, the euro, the Japanese yen and the British pound.

Given that the vector of explanatory variables contains second moments of the constructed ratios, one can expect that possible collinearities will be subdued. Nevertheless, for the sake of completeness I report the pairwise correlations in Table 1, where $\sigma(\cdot)$ stands for standard deviation of a variable. The only sizable correlation appears between the synchronization measure of output and inflation, but even this is not significant at the 5% level.

[18] I also constructed an average using the four biggest countries Germany, France, Italy and Spain, but the series was very similar to that for the euro area 12 countries.

Estimation Methodology[19]

When estimating equation 18 for the sample of 44 MICs, using 176 observations with respect to the US, the euro area, Japan and the UK by OLS, the regression residuals indicate the presence of major outliers and these are those associated with Argentina. However, when observations on Argentina are given zero weights in the regression some other less obvious outliers emerge, for example, Brazil. We do not want the regression to be contaminated by the presence of huge outliers but, at the same time, we would like to retain some rigor in the procedure of detecting outliers and giving weights to individual observations in the regression. For this purpose I employ robust regression methodology.

Robust regression falls into a general class of the *M*-estimators (Wooldridge, 2007). The objective function of the estimator can be expressed as

$$\sum_{i=1}^{n} \rho(e_i) = \sum_{i=1}^{n} \rho(y_i - \mathbf{X}_i'\mathbf{b}) \tag{19}$$

where the function $\rho(\cdot)$ determines the contribution of each regression residual e_i to the objective function, for example, least-squares estimation sets $\rho(e_i) = e_i^2$.[20] Differentiating the objective function with respect to $\mathbf{b}$, defining $\psi = \rho'$ to be a derivative of ρ, and setting the partial derivatives to zero, produces a system of estimating equations for the coefficients of interest, $\mathbf{b}$:

$$\sum_{i=1}^{n} \psi(y_i - \mathbf{X}_i'\mathbf{b})\mathbf{X}_i' = 0. \tag{20}$$

Define the weight function $w(e) = \psi(e)/e$, and let $w_i = w(e_i)$. Then the estimating equations may be written as

$$\sum_{i=1}^{n} w_i(y_i - \mathbf{X}_i'\mathbf{b})\mathbf{X}_i' = 0. \tag{21}$$

[19] The structure of my data set allows the use of a panel data estimation approach provided that one can calculate the within-year variance of the exchange rates (EMPI index) employing monthly data, and uses within-year variance, which might be seen as a somewhat different concept of the dependent variable. Further, a low synchronization of two economies can manifest itself immediately or with a lag; in an environment of managed exchange rates this manifestation can be delayed substantially, but not avoided. For this reason I prefer to use cross-country regression rather than panel regression, although the two approaches complement each other.

[20] A reasonable $\rho(\cdot)$ should have certain properties Fox (2002).

The weights, however, depend upon the residuals, the residuals upon the estimated coefficients and the estimated coefficients depend upon the weights. An iterative solution, called iterative reweighted least squares, is therefore required (Fox, 2002). In this paper, I use the Huber and Tuckey biweight estimators where first iterations using the Huber estimator are performed and then followed up by Tuckey biweight iterations.[21] The weights for the Huber estimator decline when $|e| > k$, while the weights for the Tuckey biweight estimator decline as soon as e departs from 0, and are 0 for $|e| > k$. The tuning constant k for the Tuckey biweight estimator is set in the estimations performed in this paper to $k = 4.685\sigma$. I follow Fox (2002) and estimate σ as $\hat{\sigma} = \text{MAR}/0.6745$, where MAR is the median absolute residual from the OLS regression.

ESTIMATION RESULTS

The main regression

The estimation of equation 18 using the robust regression method outlined in the 'Estimation methodology'section produces the results reported in Table 2. The estimations are carried out using both the EMPI of Eichengreen *et al.* (1996) and EMPI for which $\alpha = \beta = \gamma = 1$. I also include the OLS estimation results for comparison and as an indication of how well equation 18 fits the data.

When looking at the first two columns under the robust regression heading, the estimation results suggest that the degree of synchronization in output growth is not significant in explaining the EMPI's standard deviation, despite the expected significantly positive impact.[22] The result does not support the findings of Devereux and Lane (2003) who find that increasing business cycle synchronization significantly increases exchange rate variance for both industrialized countries and developing countries when considering only exchange rates with major currencies. Further, Bayoumi and Eichengreen (1998) find that increasing synchronization of output growth significantly decreases the exchange rate volatility for a sample of industrialized countries. The two latter studies, however, do not include a measure of synchronization for inflation in the vector of explanatory variables as I do. At least in the short run, a part of the output growth can be inflationary thus creating possible colinearity between output growth and inflation that can be

[21] For the exact functional forms see Fox (2002).

[22] Recall at this point that higher synchronization of two economic variables implies lower standard deviation of the ratio of the two variables.

Table 2: Estimation results – EMPI volatility regressions

Dependent variable stdev $(EMPI_t)_i$	*Robust regression*		*OLS*	
	(weighted)	*(unweighted)*	*(weighted)*	*(unweighted)*
$\sigma(y_t/y_t^*)_i$	−36.54	156.8	−183.0	83.48
	(0.35)	(0.30)	(1.13)	(0.14)
$\sigma(\pi_t/\pi_t^*)_i$	−11.43	−37.22	−11.05	−23.46
	(4.86)***	(3.15)***	(1.74)*	(1.22)
$\sigma(v_t/v_t^*)_i$	42.47	−34.57	4.44	−167.1
	(1.68)*	(0.26)	(0.11)	(1.10)
$\sigma(i_t/i_t^*)_i$	4.37	12.92	4.31	12.82
	(174.2)***	(71.89)***	(12.91)***	(6.70)***
$\sigma(t_t/t_t^*)_i$	−21.34	−4.17	22.36	120.1
	(1.20)	(0.05)	(0.61)	(0.94)
constant	−940.6	−2812	316.7	−5421
	(0.83)	(0.49)	(0.22)	(1.10)
R squared	n.a.	n.a.	0.9631	0.9350
No. of obs.	174	174	176	176

* and *** stand for significance at the 10% and 1% level, respectively.

reflected in the respective measures of synchronization. See Table 1 for some support of this explanation. In addition, the effect of increasing foreign demand from GDP growth in the US, the euro area, Japan and the UK can be transmitted into the economies of MICs with a lag so that the co-movements of business cycles might be better captured with an appropriate lead/lag structure. However, this investigation is outside the scope of this paper.

Further, I find a significant effect of inflation synchronization on EMPI variability; however, the direction of this effect implies that higher inflation synchronization increases EMPI variability. This result is somewhat puzzling given the hypothesized significantly positive effect. This finding will be further investigated and explained using estimated regressions for the EMPI components later in the paper. For now, it is useful to keep in mind that it is not only the variances of the exchange rate, the interest rate differential and the FX reserves differential that determine the variability of the EMPI. It is also the covariances between the latter three terms that enter into this determination and these could be quite influential in periods of external or financial turmoil and in crises in particular.

The synchronization of money velocities is emphasized by the literature on currency preferences as a useful tool for detecting currency substitutes and currency complements (Brittain, 1981; Kingston and Melecky, 2007). Since the demand for currency complements is positively correlated, one would expect the exchange rates between currency complements to be less volatile.

In other words, higher money velocity synchronization should result in lower EMPI volatility. This hypothesis is supported by the estimation results from the regression of the weighted EMPI at the 10% significance level. However, the results from the regression of the unweighted EMPI turn out to be insignificant, making the overall result inconclusive.

On the other hand, the impact of interest rate synchronization on EMPI variability is estimated to be significantly positive as expected. Hence, higher synchronization in interest rate movements significantly reduces the variability of EMPI. This result holds strongly both for the weighted and unweighted EMPIs. Given that I have used short-term interest rates, the interpretation can be possibly extended to apply to synchronization in monetary policy setting. However, one could claim that this result arises purely due to the presence of the interest rate differential in the EMPI. Therefore, I have run two more regressions using an identical set of explanatory variables and weighted and unweighted EMPIs excluding the interest rate differential. The latter could be interpreted as allowing the monetary authority to intervene in the FX markets using only FX reserves. The results are reported in Table A2 and support the previous finding that the degree of interest rate synchronization is a good indicator of EMPI volatility. Nevertheless, one can see that in the last two columns under the OLS heading the *R*-squared of the two additional regressions dropped from about 0.95, in Table 2, to about 0.40, in Table A2, as a result of excluding the interest rate differential from the EMPI.

Finally, the effect of the terms of trade synchronization on the EMPI variability is estimated to be insignificant. This may support the hypothesis that the relative effect of capital flows and associated fundamentals such as interest rates on exchange rates is more important in the case of MICs than is the effect of real external shocks to the terms of trade, which are relatively more important for LICs.

Regarding the currency allocation of foreign debt, the results of this section suggest that a MIC should allocate relatively more of its FX debt into currencies whose interest rates are more synchronized with the MIC's interest rate and whose inflation is more negatively correlated with the CPI inflation in the MIC. In other words, in the currency allocation of FX debt, MICs should look towards currencies of countries that have a relatively more positively correlated setting of monetary policy and negatively correlated supply shocks.

Regressions of the EMPI components

This section intends to provide a more detailed insight into the results obtained from the main regression and to facilitate the interpretation of the results, especially that of the significant negative effect of inflation synchronization on EMPI variability. For this purpose, I decompose the variance of EMPI as follows:[23]

$$\begin{aligned} var(EMPI_t) &= var(\alpha\Delta s_t + \beta\Delta(i_t - i_t^*) - \gamma(\Delta rs_t - \Delta rs_t^*)) \\ &= var(\alpha\Delta s_t) + var(\beta\Delta(i_t - i_t^*)) + var(\gamma(\Delta rs_t - \Delta rs_t^*)) \\ &+ 2cov(\alpha\Delta s_t, \beta\Delta(i_t - i_t^*)) - 2cov(\alpha\Delta s_t, \gamma(\Delta rs_t - \Delta rs_t^*)) \\ &- 2cov(\beta\Delta(i_t - i_t^*), \gamma(\Delta rs_t - \Delta rs_t^*)) \end{aligned} \quad (22)$$

We are interested in the impact of the explanatory variables, that is, the vector $\mathbf{stdev}(\mathbf{x}_t - \mathbf{x}_t^*)_i$, where $\mathbf{x}_t \equiv [y_t, \pi_t, v_t, i_t, t_t]$ on the individual components of the EMPI variance described in equation 22. I have therefore run six more regressions for the case of the weighted EMPI and the results for the variance terms, that is, $var(\alpha\Delta s_t)$, $var(\beta\Delta(i_t - i_t^*))$, and $var(\gamma(\Delta rs_t - \Delta rs_t^*))$ are reported in Table 3, whereas the results for the covariance terms, that is, $cov(\alpha\Delta s_t, \beta\Delta(i_t - i_t^*))$, $cov(\alpha\Delta s_t, \gamma(\Delta rs_t - \Delta rs_t^*))$, and $cov(\beta\Delta(i_t - i_t^*), \gamma(\Delta rs_t - \Delta rs_t^*))$ are presented in Table 4.[24] I will discuss the regression results for the six EMPI components next, one by one, and then summarize the implication for the overall results at the end of this section.

Exchange rate variance

The first column of Table 3 shows the regression results for $var(\alpha s_t)$. It appears that output synchronization is not significant in explaining exchange rate volatility. This somewhat contradicts the findings of Devereux and Lane (2003, Table A2 and 3) that for a broad pool of developing countries increasing output synchronization significantly increases exchange rate volatility. Nevertheless, for other smaller pools of developing countries Devereux and Lane do find that output synchronization is rather insignificant in explaining exchange rate variability.[25] Also, the explanatory power of my

[23] I use here the formula for decomposition of the variance of a sum of three random variables, that is: $var(X+Y+Z) = var(X) + var(Y) + var(Z) + 2cov(X, Y) + 2cov(X, Z) + 2cov(Y, Z)$.

[24] I apply the decomposition to the weighted EMPI and report the estimation results for its components, since the estimation results for the unweighted EMPI's components are identical, and only the estimated coefficients are scaled accordingly.

[25] Devereux and Lane's results regarding the effect of output growth differentials on exchange rate volatility are contradictory for subsamples of industrialized and developing countries. Nevertheless, for developing countries and major currency exchange rates, the effect appears to be negative. In contrast, Bayomi and Eichengreen find a significantly positive effect of variability of the output growth differential on exchange rate volatility and EMPI. In this paper, I find no significant effect either on exchange rate volatility or the EMPI variance. Therefore, this indicator appears to be insufficiently reliable to be employed for the currency allocation of foreign debt for countries transitioning from the developing to the industrialized stage of development.

Table 3: Estimation results – Breakdown EMPI volatility regressions, part I

Dependent variable stdev $(EMPI_t)_i$ components	*Robust regression*			
	$\sigma(\Delta s_t{}^*)_i$	$\sigma(\Delta(i_t - i_t{}^*))_i$	$\sigma(\Delta(i_t - i_t{}^*))_i$	$\sigma(\Delta rs_t - \Delta rs_t{}^*)_i$
$\sigma(y_t/y_t{}^*)_i$	−0.009	−152.98	−5.913	−0.164
	(0.09)	(0.68)	(2.02)**	(2.31)**
$\sigma(\pi_t/\pi_t{}^*)_i$	0.002	−11.46	0.179	0.005
	(10.06)***	(2.23)**	(2.67)***	(2.87)***
$\sigma(v_t/v_t{}^*)_i$	0.072	65.59	−0.523	−0.012
	(2.85)***	(1.15)	(0.70)	(0.67)
$\sigma(i_t/i_t{}^*)_i$	0.001	5.05	n.a.	0.001
	(27.3)***	(86.0)***	n.a.	(0.15)
$\sigma(t_t/t_t{}^*)_i$	−0.020	−16.42	0.084	0.017
	(1.13)	(0.42)	(0.17)	(1.38)
constant	1.023	−874.19	68.95	1.852
	(0.92)	(0.35)	(2.13)**	(2.37)**
No. of obs.	176	174	176	173
OLS R squared	0.1422	0.9377	0.6410	0.3939

*,** and *** stand for significance at the 10%, 5% and 1% level, respectively.

regression and theirs appear to be very close and both rather low with R squared around 0.15, despite using a different set of explanatory variables.

Inflation synchronization, on the other hand, appears to be significant in explaining exchange rate variance. Namely, increasing inflation synchronization seems to significantly decrease exchange rate volatility. This result is consistent with our *a priori* hypothesis and contradicts the corresponding significantly negative estimate obtained from the EMPI regression.

Similarly, money velocity synchronization is estimated to significantly affect exchange rate volatility. The more synchronized are the movements in money velocities between two currencies the less volatile is their respective exchange rate. This result supports the hypothesis from the literature on currency substitution and complementarity, namely, that the exchange rate between currency complements should experience less volatility than the exchange rate between currency substitutes.

Interest rate synchronization is significant in explaining exchange rate volatility, and higher interest rate synchronization for a given two currencies is predicted to decrease the volatility of their respective exchange rate. Finally, synchronization of the terms of trade fluctuations seems to be insignificant in explaining exchange rate volatility of MIC's currencies with respect to the four major currencies. This finding again points in the direction of capital flows being much more influential than changes in the terms of trade when it comes to the determination of exchange rates and external balances of MICs.

Table 4: Estimation results – Breakdown EMPI volatility regressions, part II

Dependent variable stdev ($EMPI_t$)$_i$ components	*Robust regression*		
	$\sigma(s_t;\ i_t - i_t^*)_i$	$\sigma(s_t;\ rs_t - \Delta rs_t^*)_i$	$\sigma(i_t - i_t^*;\ rs_t - \Delta rs_t^*)_i$
$\sigma(y_t/y_t^*)_i$	312.2	−2.521	106.5
	(0.30)	(3.39)***	(1.82)*
$\sigma(\pi_t/\pi_t^*)_i$	−152.5	0.074	−4.787
	(6.43)***	(4.38)***	(3.60)***
$\sigma(v_t/v_t^*)_i$	326.2	−0.229	6.808
	(1.24)	(1.22)	(0.46)
$\sigma(i_t/i_t^*)_i$	57.3	0.001	0.372
	(169.5)***	(0.72)	(10.90)***
$\sigma(t_t/t_t^*)_i$	−238.2	0.215	−15.17
	(1.32)	(1.67)*	(1.50)
constant	−16.553	16.96	−461.3
	(1.45)	(2.07)**	(0.72)
No. of obs.	173	173	173
OLS *R* squared	0.9217	0.3945	0.3939

*,** and *** stand for significance at the 10%, 5% and 1% level, respectively.

I have also run the same regression as the one described in the first column of Table 3 with 25% of the cross-section observations with the lowest exchange rate volatility eliminated from the sample. The results were very similar to those reported in Table 3 regarding both the coefficient estimates and the explanatory power of the regression. Only the effect of inflation synchronization on exchange rate volatility increased about 10 times.

When only exchange rate volatility is considered, as opposed to EMPI, as the relevant dependent variable, the estimation results imply that a MIC should allocate its FX debt relatively more towards currencies with synchronized movements in inflation (supply shocks), in interest rates (monetary policy setting) and in money velocities (currency complements). This finding holds even if more rigid exchange rate regimes are taken out of the underlying regression of the exchange rate volatility on the considered synchronization indicators. These results are more in line with the hypothesized effects of the variables on exchange rate volatility than the results obtained from the EMPI regression. While both the synchronization of business cycles and the terms of trade remain insignificant, the effect of increased inflation synchronization causing higher exchange rate volatility, found in the EMPI regression no longer holds in the pure exchange rate volatility regression. The results suggest that increased inflation synchronization significantly decreases exchange rate volatility.

Variance of interest rate differentials
In order to investigate how the underlying regression explains the EMPI component proportional to the volatility of the interest rate differential, I estimate two regressions. The first one includes the interest rate synchronization to see what could be happening in the main EMPI regression, and the second one excluding the interest rate synchronization to see how well the remaining variables explain the variability of the interest rate differential and whether their coefficient estimates change, since in the first regression the effect of interest rate synchronization on the volatility of the interest rate differential is almost tautological.

As we can see in the second and third columns of Table 3, the estimated effect of output synchronization on interest differential volatility is negative and significant. One can probably explain this effect by the synchronization of the transmission mechanisms related to the credit channels in the domestic and foreign economies, that is, managing output volatility implies higher interest rate volatility. The effect of inflation synchronization on interest differential volatility appears to be negative in the regression including interest rate synchronization. This result supports the overall negative signing of inflation synchronization in the EMPI regression. However, when the interest rate synchronization is removed from the regression the coefficient on $\sigma(\pi_t/\pi_t^*)_i$ becomes significantly positive. Money velocity synchronization does not contribute significantly to variability in interest rate differentials. Similarly, the terms of trade appear to be insignificant in explaining the volatility of interest rate differentials.

The overall implication of these results are as follows. The presence of the interest rate differential on both sides of the EMPI regression: (i) renders the business cycle synchronization insignificant, possibly due to the origination of business cycle synchronization in monetary policy synchronization; (ii) changes the direction of the impact of inflation synchronization on EMPI volatility.[26]

Variance of the relative changes in FX reserves
The estimated results from the regression of the variability in the relative changes in FX reserves are reported in the last column of Table 3. Output synchronization is estimated to have a significantly negative effect on the variability of the reserves differential. On the other hand, inflation

[26] A possible explanation could be as follows. Since co-movements in demand-driven components of inflation synchronization could be more influential than co-movements in supply-driven components, the presence of the interest rate differential in the regression cancels out the demand-driven components.

synchronization appears to have a significant positive effect on this dependent variable. The remaining explanatory variables, money velocity synchronization, interest rate synchronization and terms of trade synchronization, do not seem to be significant in explaining the variance of the relative changes in FX reserves. The most important finding here is that the effect of the inflation differential's variability is significantly positive while interest rate synchronization is insignificant in the regression. Therefore, the negative coefficient on the standard deviation of the inflation differential cannot be attributed to the effect of this indicator on the variability in relative FX reserves. In addition, the findings of Devereux and Lane (2003) and Bayoumi and Eichengreen (1998) that increasing business cycle synchronization could be increasing exchange rate volatility, especially for industrialized countries, may be attributed to a relatively higher use of FX reserves in exchange rate interventions by these countries.

The covariance terms

Table 4 reports the estimation results from regressions of the covariance terms on the vector of explanatory variables. Considering all three regressions, one can see that the effect of output synchronization on the covariance terms is insignificant in the case of the covariance of exchange rates and interest rate differentials, $cov(\alpha\Delta s_t, \beta\Delta(i_t - i_t^*))$, and the covariance of interest rate differentials and relative movements in FX reserves, $cov(\beta\Delta(i_t - i_t^*), \gamma(\Delta rs_t - \Delta rs_t^*))$, and significantly negative in the case of the covariance of exchange rates and relative movements in FX reserves, $cov(\alpha\Delta s_t, \gamma(\Delta rs_t - \Delta rs_t^*))$. Therefore, the effect of business cycle synchronization would have been insignificant or insignificantly negative had it been only based on the influence of the variable on the covariance terms.

The impact of inflation synchronization on the covariance terms is significant in all three cases; however, the signs of these effects vary. For the covariance of exchange rates and interest rate differentials and the covariance of interest rate differentials and relative movements in FX reserves, the coefficients on the inflation synchronization are significantly negative, where the coefficient corresponding to the former regression is of substantially higher magnitude than the other coefficients for inflation synchronization in the remaining regressions for the EMPI components. On the other hand, in the regression for the covariance of exchange rates and relative movements in FX reserves, the effect of inflation synchronization is significantly positive. Hence, two out of three estimated effects of inflation differential variability on the covariance terms have negative signs and could thus largely explain the unexpected negative sign of the variable in the main EMPI regression.

The measure of money velocity synchronization appears to be consistently insignificant in explaining the covariance terms. The overall insignificance of the effect of money velocity synchronization on the covariance terms could help explain the insignificance of the variable in the EMPI regression and its significance in the exchange rate volatility regression (see Table 3, column one).

On the other hand, synchronization of interest rates is found to have a positive effect on all three covariance terms, the covariance of exchange rates and interest rate differentials, the covariance of exchange rates and relative movements in FX reserves, and the covariance of interest rate differentials and relative movements in FX reserves. However, only in the case of the first and third covariance terms are the coefficients significant. The significant coefficient attached to interest rate synchronization in the regression for the covariance of exchange rates and interest rate differentials is much higher in terms of its magnitude than the coefficients on interest rate synchronization in the remaining regressions for the EMPI components. The overall significantly positive effect of interest rate differential variability on EMPI variance is largely supported also by its effect on the covariance terms, the components of the EMPI variance.

Finally, the effect of the terms of trade synchronization is estimated to be significant only in the case of the covariance of exchange rates and relative movements in FX reserves. In the latter case, the effect of the terms of trade synchronization appears to be positive and significant at the 10% level. The effect of this variable on the covariance terms also contributes to explaining its overall insignificance in the EMPI regression.

Summary of the estimation results

It is useful at this point to summarize the detailed estimation results obtained from the regressions for the EMPI components and relate those to the estimation results from the main regression. From the main regression we have inferred that the effect of interest rate synchronization on EMPI variability is significantly positive. The significantly positive effect of the interest rate synchronization was confirmed in the regressions for the EMPI components. Most important, the significantly positive effect of the interest rate synchronization held also in the regression of the exchange rate volatility on the employed vector of explanatory variables. In addition, an interesting finding is that interest rate synchronization appears to be insignificant in all EMPI components regressions where relative movements in FX reserves are involved.

Further, I find a significant negative effect of inflation synchronization in the main regression that was viewed as puzzling. The regressions of the EMPI components are helpful in explaining this puzzling result. The estimated negative coefficient on inflation synchronization in the main regression is most likely attributable to the significant negative effect of inflation synchronization on the covariance between the exchange rates and interest rate differentials, on the covariance between the interest rate differentials and relative movements in FX reserves, and also on the variability of the interest rate differential. On the other hand, the effect of inflation synchronization on exchange rate variance itself is significantly positive and consistent with the underlying theory.

Finally, the synchronization of money velocities is highly significant in explaining exchange rate volatility. Increasing money velocity synchronization between two currencies, which identifies currency complements, significantly decreases the variability of the exchange rate.

Based on these results I draw the following preliminary conclusions. Countries trying to select a suitable currency in which to denominate their sovereign debt can use the measures of inflation synchronization, money velocity synchronization and interest rate synchronization as indicators in order to minimize the expected variance in their FX debt charges due to exchange rate volatility. However, if a country is increasingly using interest rate differentials to intervene in the FX markets, interest rate synchronization should be viewed as the main indicator when selecting the currency denomination of foreign debt. If, on the other hand, the country intervenes in FX markets using its FX reserves to manage an exchange rate the main indicator to be used is inflation synchronization.

CONCLUSION

Countries with major trade links and high capital inflows may face some policy dilemmas regarding their foreign currency debt allocation. While for some countries like the Czech Republic or other new EU member states the increasing share of the trade with EMU members would suggest a clear choice of currency, the euro, for other countries like Uruguay or Argentina the connection between trade links and the choice of a foreign currency are not as obvious. In addition to trade links, emerging economies receive substantial inflows of capital, the currency denomination and origins of which could suggest a different allocation of foreign currency debt to that suggested by trade flows. Exchange rate volatility, the main driver of fluctuations in foreign debt service, as argued in this paper, is determined by combination of trade and capital flows. The intensity of the latter two is assumed to be driven by asynchronous movements in the domestic and foreign economy.

In this paper, I have made an attempt to propose a macroeconomic framework for management of foreign currency debt that can be used in conjunction with, or as an alternative to, the existing financial approaches.

The proposed framework selects a currency for foreign debt denomination that will minimize the variability of debt charges on FX debt. For practical purposes the default variable that I was trying to explain was the EMPI. The latter controls for the possibility of exchange rate management using interest rate differential and FX reserves when one tries to model the shadow exchange rate between a pair of currencies equivalent to the free floating exchange rate. Such controlling is important since changes in the domestic interest rate affect domestic output and inflation and thus government revenues, and because fluctuations in FX reserves create uncertainty about available natural hedges for foreign debt. The vector of explanatory variables used in the empirical regressions was motivated by a New Keynesian policy model that predicts that not only traditional optimum currency area variables but also variables considered by the literature on currency preferences, such as money velocity, should be relevant for explaining exchange rate volatility.

I find that countries trying to select a suitable currency for denomination of their sovereign debt can use measures of inflation synchronization, money velocity synchronization and interest rate synchronization as suitable indicators in order to minimize the variance in their FX debt charges due to exchange rate volatility. However, if a country is increasingly using interest rate differentials to intervene in the FX markets, interest rate synchronization should be viewed as the main indicator when selecting the currency denomination of foreign debt. If, on the other hand, the country is intervening in FX markets using its FX reserves, the main indicator to be used is the inflation synchronization.

The future work on the macroeconomic approach to FX debt management should focus on incorporating the role of covariances between the government primary balance and exchange rates from the flow perspective. Alternatively, from the stock perspective, it can focus on incorporating the covariances between the net exposures in individual currencies and the relevant exchange rates into the present framework. Further, the set of indicators can be broadened to include other macroeconomic fundamentals such as the term structure of interest rates.

Acknowledgements

The opinions expressed in this work are those of the author and should not be attributed to the World Bank. The author thanks Joe Brada, Stijn Claessens, Santiago Herrera, Antonio Velandia, Phillip Anderson and Eriko Togo for their suggestions and comments on an earlier draft of this paper. Financial support from the Czech Science Foundation GA402/08/0067 and GA402/08/1015 is gratefully acknowledged.

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APPENDIX

See Table A1 and A2.

Table A1: Countries included in the regression analysis

Algeria	Czech Rep.	Jordan	Namibia	St.Vinc.& Grenad
Argentina	Dominica	Latvia	Panama	Swaziland
Armenia	Dominican Rep.	Lithuania	Paraguay	Thailand
Bolivia	El Salvador	Malaysia	Philippines	Tunisia
Brazil	Estonia	Maldives	Poland	Turkey
Bulgaria	Georgia	Mauritius	Russian Fed.	Ukraine
Chile	Grenada	Mexico	Slovak Rep.	Uruguay
Colombia	Guatemala	Moldova	South Africa	Venezuela, RB
Croatia	Indonesia	Morocco	Sri Lanka	

Table A2: Estimation results – EMPI (no IRD) volatility regressions

Dependent variable stdev $(EMPI_t^{IRD})_i$	*Robust regression*		*OLS*	
	(weighted)	*(unweighted)*	*(weighted)*	*(unweighted)*
$\sigma(y_t/y_t{}^*)_i$	−0.88	−21.2	14.94	677.9
	(2.50)**	(2.87)***	(0.96)	(0.99)
$\sigma(\pi_t/\pi_t{}^*)_i$	0.03	0.74	0.13	5.20
	(4.05)***	(4.45)***	(0.51)	(0.46)
$\sigma(v_t/v_t{}^*)_i$	−0.04	−1.13	−5.29	−232.6
	(0.47)	(0.61)	(1.08)	(1.07)
$\sigma(i_t/i_t{}^*)_i$	0.001	0.015	0.07	2.95
	(3.54)***	(3.39)***	(1.39)	(1.38)
$\sigma(t_t/t_t{}^*)_i$	0.05	1.41	1.97	86.04
	(0.84)	(1.10)	(0.83)	(0.82)
constant	9.23	218.2	−175.6	−7936
	(2.37)**	(2.69)***	(1.32)	(1.35)
R squared	n.a.	n.a.	0.3984	0.3960
No. of obs.	173	173	176	176

*,** and *** stand for significance at the 10%, 5% and 1% level, respectively.