Sovereign Risk and Out-of-Equilibrium Exchange Rate Dynamics

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Abstract

We show that sovereign risk premium contains important information about the short run exchange rate dynamics in emerging economies and that net foreign assets play the key role in the link between the two variables: on the one hand, the accumulation of foreign assets reduces the sovereign risk premium, since it provides a "crude form of collateral", appreciating the nominal exchange rate; on the other hand, the exchange rate appreciation worsens the trade balance, having a negative effect on the accumulation of net foreign assets. Our model is tested in two steps. First, we use annual data for the most liquid USD denominated external debt emerging markets and show how sovereign risk premium decreases with the level of net foreign assets. Second, we select from the original group the countries with a de facto independent floating exchange rate regime and show that out-of-sample forecasts using realized values for the sovereign risk premium successfully outperform a random walk.

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1 Introduction

The objective of this paper is to show that sovereign risk premium contains important information about the short run exchange rate dynamics in highly indebted emerging economies with independently floating regimes. Net foreign assets play the key role in the link between the two variables. On the one hand, the accumulation of foreign assets reduces the sovereign risk premium, since it provides a "crude form of collateral", appreciating the nominal exchange rate. On the other hand, a nominal exchange rate appreciation, in an economy where prices are sticky, worsens the trade balance, having a negative effect on the accumulation of net foreign assets.

Our paper is related to a larger literature of portfolio balance models with imperfect substitutability between domestic and foreign bonds. Branson and Henderson (1985) provide a survey of the older literature. More recent examples are Kumhof and Van Nieuwerburgh (2002), whose focus is on currency (instead of sovereign) risk premium, and Blanchard Giavazzi and Sa (2005), whose aim is to answer more practical issues related to the sustainability of the US current account deficit. Although the model described in Blanchard Giavazzi and Sa (2005) presents a very similar exchange rate dynamics, it differs significantly from our paper since valuation effects[1] are their main channel between exchange rates and net foreign assets, while in our paper this link is done by the sovereign risk.

There is also a large literature that analyzes the relationship between sovereign risks and macroeconomic variables. This literature can be divided in two main groups. The first group focuses on the determinants of the sovereign risk. Arora and Cerisola (2004)

[1]Also motivated by the large US current account deficit, other recent papers have studied the importance of valuation effects in the relationship between exchange rates and net foreign asset, although using different setups. Examples of such papers are Gourinchas and Rey (2005) and Ghironi, Lee and Rebucci (2006).

quantify the impact of changes in U.S. monetary policy on sovereign bond spreads in emerging market countries. Baek, Bandopadhyaya and Chan (2005) emphasize importance of the market's attitude towards risk. Cantor (2004) describes the effects of changes in bonds and market prices on sovereign ratings. Kletzer (1984) considers the asymmetric information between creditors and debtors. Lemmen and Goodhart (1999) find government default risk to depend positively on changes in the debt to GDP ratio and the variability of inflation and negatively on lagged inflation and changes in taxable capacity. The second group studies the impact of sovereign risk on macroeconomic variables. Aizenman and Marion (2004) and Ben-Bassat and Gottlieb (1992) model the effects of sovereign risk on the optimal level of international reserves. Kaminsky and Schmukler (2002) view the relationship between sovereign ratings, sovereign risk and stock returns. Reinhart (2002) suggests that sovereign credit ratings may predict the occurrence of defaults. Schnitzer (2002) relates sovereign risks to FDI.

In this paper, we present a theoretical model that rationalizes the existence of a strict relationship between sovereign risk premium and exchange rate dynamics in a small emerging economy. We develop a portfolio choice model in which investors from a large developed country may invest in bonds from small emerging economies that are imperfect substitutes and also subject to default risk. We take a country's ability/willingness to repay as given, and even though the net foreign assets have no effect on this probability, it affects the foreign investor's utility in the event of a default. The intuition follows Dooley et al (2006), in the sense that the accumulation of net foreign assets is viewed as a "crude form of collateral". According to the authors, "if the center (developed economy) cannot seize goods or assets after a default, it has to import the goods and services before the default and create a net liability. If the periphery (emerging economy) then defaults on its half of the implicit contract, the center can simply default on its gross liability and keep the collateral." Therefore, current account surpluses reduce the sovereign risk premium because, given the same probability of default, it provides collateral and reduces the foreign investors' loss in case default occurs. The solution yields a *saddle path* between the exchange rate and the sovereign risk premium: when the exchange rate is away from its long term equilibrium, there is a positive relationship between the two variables.

Since our model predicts that exchange rate and sovereign risks are closely related given the existence of a link between sovereign risks and net foreign assets, our empirical evidence is presented in two steps. In the first step, we use annual data for the 18 emerging economies with the most liquid USD denominated external debt markets (according to the JPMorgan EMBI+ Index criteria) between 1997 and 2005 to show how sovereign risk premium increases as the level of the public debt increases (where changes in the fiscal variable proxies for changes in the default probability) and, more importantly, how sovereign risk premium decreases as the net foreign assets increases. In the second step, we show that out-of-sample forecasts using only the realized values of a measure of sovereign risk consistently outperform the random walk along three metrics: the MSE ratio, the direction of change statistics and the consistency criteria. The data used in this second part is in a daily frequency, from January 2001 until August 2006, and includes the eight countries from our initial sample of 18 that have a *de facto* independently floating exchange rate regime (according to the IMF's criteria). Although our forecasts are based on the current realizations of the explanatory variable, we believe that the results obtained in this second part deserve attention since the behavior of the nominal exchange rate has been a challenge to explain since Meese and Rogoff (1983). While they showed that a random walk would outperform a wide range of macroeconomic models in terms of out-of-sample predictions, more than two decades later, Cheung, Chinn and Pascual (2005) reinforced this result by testing a wider set of macro-based exchange rate models.

The rest of this paper is organized as follows. Section 2 derives the main equations of the model. Section 3 solves the model. Section 4 presents the empirical evidence. Finally, section 5 concludes suggesting directions for future research.

2 Model Setup

2.1 Foreign Demand for Domestic Assets

Assume that the world is composed by one large developed economy and J small emerging economies (it is easier to think of the developed country as the US, but we could also think of it as the rest of the "developed" world). Since the emerging economies are significantly small relative to the developed country, we will assume that the flow of foreign assets in a small emerging economy j is fully determined by the large developed country demand.

The large developed country demand for the jth small emerging economy asset will be modeled as coming from a representative foreign investor specialized in investing in the J emerging markets. The foreign investor of generation t receives an endowment of W_t units of the large developed country currency (dollars) and decides how much to invest in the $J + 1$ assets available: the large developed country asset and the J small emerging economies assets. For each dollar invested in the large developed sovereign risk free bond in period t, the foreign investor receives in period $t + 1$ a gross return of $1 + r_t$. Emerging market bonds are subject to default risk with probability $\pi_{j,t}$. In case of no default, for each dollar invested in the jth emerging economy risky asset in period t, the foreign investor receives in period $t + 1$ a gross return of $\frac{R_{j,t}S_{j,t}}{S_{j,t+1}}$, with $R_{j,t}$

being the gross nominal interest rate country j and $S_{j,t}$ being the amount of country j's currency necessary to purchase one "dollar". In the case of default, the foreign investor loses a fraction $\Lambda_j \in [0,1)$ of the total amount to which he is entitled, that is, $1-\Lambda_j$ is the recovery ratio in the event of default. In this case, his gross return becomes $(1-\Lambda_j)\frac{R_{j,t}S_{j,t}}{S_{j,t+1}}$.

The foreign investor of generation t chooses $B_t = [B_{1,t}, B_{2,t}, \ldots, B_{J,t}]'$, where $B_{j,t}$ is the dollar amount invested in the jth small emerging economy asset, in order to maximize his expected utility written on his period $t+1$ wealth, W_{t+1}, subject to its budget constraint. We specialize the foreign investor utility function to have constant absolute risk aversion, $U(W) = -\exp(-\theta W)$.

In order to illustrate the foreign investor's budget constraint, we will work in the case where there are only two small emerging economies in the world. In the case where $J=2$, there are four possible outcomes for the foreign investor period $t+1$ wealth. Let $W_{t+1}^{D_0}$, $W_{t+1}^{D_1}$, $W_{t+1}^{D_2}$ and $W_{t+1}^{D_{1,2}}$ be, respectively, period $t+1$ budget constraints in the cases of no default in any country, default in country 1 only, default in country 2 only, and default in both countries:

$$W_{t+1}^{D_0} = (1+r_t)W_t + (r_{1,t} - r_t + s_{1,t} - s_{1,t+1})B_{1,t} + (r_{2,t} - r_t + s_{2,t} - s_{2,t+1})B_{2,t} \quad (1)$$

$$W_{t+1}^{D_1} = (1+r_t)W_t + (r_{1,t} - r_t + s_{1,t} - s_{1,t+1} - \lambda_1)B_{1,t} + \ldots$$
$$\ldots + (r_{2,t} - r_t + s_{2,t} - s_{2,t+1})B_{2,t} \quad (2)$$

$$W_{t+1}^{D_2} = (1+r_t)W_t + (r_{1,t} - r_t + s_{1,t} - s_{1,t+1})B_{1,t} + \ldots$$
$$\ldots + (r_{2,t} - r_t + s_{2,t} - s_{2,t+1} - \lambda_2)B_{2,t} \quad (3)$$

$$W_{t+1}^{D_{1,2}} = (1+r_t)W_t + (r_{1,t} - r_t + s_{1,t} - s_{1,t+1} - \lambda_1)B_{1,t} + \ldots$$
$$\ldots + (r_{2,t} - r_t + s_{2,t} - s_{2,t+1} - \lambda_2)B_{2,t} \quad (4)$$

where: $1+r_t$, $1+r_{j,t}$, $s_{j,t}$ and λ_j are log-linearized versions of R_t, $R_{j,t}$, $S_{j,t}$ and Λ_j.[2]

The foreign investor of generation t problem is to choose $B_{1,t}$ and $B_{2,t}$ in order to maximize:

$$\begin{aligned} E_t\left[U\left(W_{t+1}\right)\right] &= \left(1-\pi_1\right)\left(1-\pi_2\right)E_t\left[U\left(W_{t+1}^{D_0}\right)\right]+\pi_1\left(1-\pi_2\right)E_t\left[U\left(W_{t+1}^{D_1}\right)\right]+\ldots \\ &\quad \ldots+\left(1-\pi_1\right)\pi_2 E_t\left[U\left(W_{t+1}^{D_2}\right)\right]+\pi_1\pi_2 E_t\left[U\left(W_{t+1}^{D_{1,2}}\right)\right] \end{aligned} \tag{5}$$

subject to the budget constraints (1) to (4).

Proposition 1 *The optimal foreign demand for domestic assets in the emerging economy j is implicitly defined by:*

$$B_{j,t} = \left[\theta Var_t\left(s_{j,t+1}\right)\right]^{-1}\left(r_{j,t}-r_t+s_{j,t}-E_t\left[s_{j,t+1}\right]-\frac{\phi_{j,t}}{1+\phi_{j,t}}\lambda_j\right) \tag{6}$$

$$\text{with } \phi_{j,t} = \frac{\pi_{j,t}}{1-\pi_{j,t}}\frac{\left(1-\pi_{-j,t}\right)E_t\left[U\left(W_{t+1}^{D_j}\right)\right]+\pi_{-j,t}E_t\left[U\left(W_{t+1}^{D_{j,-j}}\right)\right]}{\left(1-\pi_{-j,t}\right)E_t\left[U\left(W_{t+1}^{D_0}\right)\right]+\pi_{-j,t}E_t\left[U\left(W_{t+1}^{D_{-j}}\right)\right]} \tag{7}$$

Proof. See Appendix A. ■

Equation (6) contains the usual ingredients: the optimal asset holdings of a risky asset increase with its expected excess return and decrease with its conditional variance and with the agents degree of risk aversion. However, it contains an extra term that tells us that the optimal holdings are also decreasing in the probability of default, the loss-ratio in case of default and also difference in the investor's expected utilities in the event of default and no-default.

Proposition 2 *The expected exchange rate depreciation in the small emerging economy*

[2] More precisely: $1+r_t = \log\left(R_t\right)$, $1+r_{j,t} = \log\left(R_{j,t}\right)$, $s_{j,t}-s_{j,t+1} = \log\left(\frac{S_{j,t}}{S_{j,t+1}}\right)$ and $\lambda_j = -\log\left(1-\Lambda_{j,t}\right)$.

j is:

$$E_t\left[s_{j,t+1}\right] - s_{j,t} = r_{j,t} - r_t - \rho_{j,t} - \xi_{j,t} \tag{8}$$

where $\rho_{j,t}$ is the currency risk premium and $\xi_{j,t}$ the sovereign risk premium defined as:

$$\rho_{j,t} = -\theta Var_t\left(s_{j,t+1}\right) NFA_{j,t} \tag{9}$$

$$\xi_{j,t} = \frac{\phi_{j,t}}{1+\phi_{j,t}}\lambda_j, \text{ with } \phi_{j,t} = \frac{\pi_{j,t}}{1-\pi_{j,t}} \exp\left(-\theta\lambda_j NFA_{j,t}\right) \tag{10}$$

Proof. See Appendix B. ■

Proposition 2 uses the market clearing condition $NFA_{j,t} = -B_{j,t}$: the small emerging economy j net foreign assets is given by the negative of the foreign holdings of domestic assets. Equation (8) is the interest rate parity condition with default risk. A higher sovereign risk premium has the same effect of an increase in the currency risk premium or in the developed economy interest rates: it makes the small emerging economy bond less attractive. As a consequence, an expected appreciation is needed to increase the expected return of the small emerging economy bond.

Corollary 1 *The sovereign risk premium in a small emerging economy j is a decreasing function of the net foreign assets; an increasing function of the default probability; and, if the country is net debtor ($NFA_{j,t} < 0$), an increasing function of the loss-ratio conditional on default.*

Proof. Follows directly from the partial derivatives of equation (10). See Appendix C for detailed expressions. ■

It is not surprising that the default probability or that the size of the loss-ratio conditional on default have a positive effect on the sovereign risk premium. Note that when one of the two variables is zero (default never occurs, $\pi_{j,t} = 0$, or there is no loss in the event of default $\lambda_j = 0$), the sovereign risk premium is also zero.

The sovereign risk premium is also a function of the net foreign assets because the latter affects the foreign investor's utility in the event of default. Given the same probability of default and the same loss-ratio conditional on default, a foreign investor will lose more the more it has invested in the emerging economy.

2.2 Balance of Payments Equilibrium

Since the interest payments to foreigners depend on whether the small emerging economy j has defaulted or not, the period t current account, $CA_{j,t}$, is:

$$
\begin{aligned}
CA_{j,t} &= (r_{j,t-1} + s_{j,t-1} - s_{j,t} - \lambda_j)\, NFA_{j,t-1} + TB_{j,t}, \text{ if country } j \text{ defaults;} \quad (11) \\
&= (r_{j,t-1} + s_{j,t-1} - s_{j,t})\, NFA_{j,t-1} + TB_{j,t}, \text{ otherwise.} \quad (12)
\end{aligned}
$$

with an expected value of:

$$
E_t\,[CA_{j,t}] = \{r_{j,t} + s_{j,t} - E_t\,[s_{j,t+1}] - \pi_{j,t}\lambda_j\}\, NFA_{j,t} + E_t\,[TB_{j,t+1}] \quad (13)
$$

Given that the focus of this paper is on the interaction between exchange rates and sovereign risk premium, we will assume a reduced form equation for the period t trade balance, $TB_{j,t}$:

$$
TB_{j,t} = \kappa_0 + \kappa_1\,(s_{j,t-1} - p_{j,t-1} + p_{t-1}) + \varepsilon_{j,t} \quad (14)
$$

Equation (14) defines the trade balance in a given period as a positive function of the previous period real exchange rate $s_{j,t-1}$ and other non-observable factors. First, it is not hard to show from a microfounded model that the trade balance and the real exchange rate are related[3]. Second, we include the past and not the current exchange rate since we will be focusing on the short horizons (monthly or daily) and the "J-curve" literature provides empirical evidence that the trade balance response to exchange rate shocks is delayed. Third, we know that there are other factors that are important for the trade balance, such as productivity shocks, but these factors are non-observable at the frequency we are interested.

Balance of payments equilibrium implies that:

$$E_t \left[\Delta NFA_{t+1} \right] = E_t \left[CA_{j,t} \right] \tag{15}$$

Rearranging terms and using equations (13) and (14) we arrive at:

$$\begin{aligned} E_t \left[NFA_{j,t+1} \right] - NFA_{j,t} &= \left\{ r_{j,t} + s_{j,t} - E_t \left[s_{j,t+1} \right] - \pi_{j,t} \lambda_j \right\} NFA_{j,t} + \ldots \\ &\quad \ldots + \kappa_0 + \kappa_1 \left(s_{j,t} - p_{j,t} + p_t \right) \end{aligned} \tag{16}$$

3 Solution

In the previous section, we derived two equations that described the expected evolution of the exchange rate and the net foreign assets in a small emerging economy. In this section, we will solve the model. To simplify the calculations, we will assume that the domestic and foreign interest rates and the default probability are constants.

If we linearize equations (8) and (16) and then substitute the linearized version of equation (8) into the linearized version of equation (16), we arrive at the following system

[3] See Wu (2005) for an example.

of equations:

$$
\begin{aligned}
E_t\left[s_{j,t+1}\right] - s_{j,t} &= \alpha_0 + \alpha_1 NFA_{j,t} & (17) \\
E_t\left[NFA_{j,t+1}\right] - NFA_{j,t} &= \beta_0 + \beta_1 NFA_{j,t} + \beta_2 s_{j,t} & (18)
\end{aligned}
$$

where $\alpha_1 > 0$ and $\beta_2 > 0$ (see Appendix D for details).

Before we proceed to the analytical solution, it is useful helpful to analyze the system's phase diagram in order to gain some intuition.

3.1 Graphical Solution

Given equation (17), the $E_t\left[\Delta s_{j,t+1}\right] = 0$ locus is given by:

$$E_t\left[\Delta s_{j,t+1}\right] = 0 \Rightarrow NFA_{j,t} = -\frac{\alpha_0}{\alpha_1} \tag{19}$$

Note that for countries that are net debtors, the net foreign assets are negative. If the NFA increase above the level implied by the $E_t\left[\Delta s_{j,t+1}\right] = 0$ locus, that is, if the net debt becomes smaller in magnitude, this means that the size of the foreign investor's loss in case of default is smaller, and therefore the sovereign and the currency risk premia will reduce. With a reduction in the risk premia, an expected depreciation is required to keep the developed economy's asset attractive. In summary, in the right side of the $E_t\left[\Delta s_{j,t+1}\right] = 0$ locus the exchange rate is expected to depreciate.

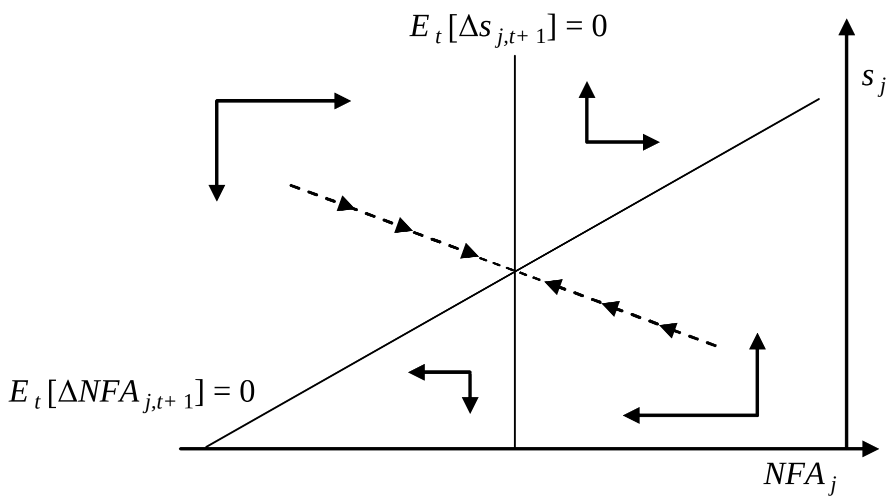
From equation (18), we find that the $E_t\left[\Delta NFA_{j,t+1}\right] = 0$ locus is:

$$E_t\left[\Delta NFA_{j,t+1}\right] = 0 \Rightarrow s_{j,t} = -\frac{\beta_0 + \beta_1 NFA_{j,t}}{\beta_2} \tag{20}$$

The $E_t\left[\Delta NFA_{j,t+1}\right] = 0$ locus can describe either a positive or negative relation between the exchange rate and the net foreign assets, depending on the magnitude of the emerging economy's nominal interest rate. However, it is important to notice that whenever the exchange rate is above the level required by the $E_t [\Delta NFA_{j,t+1}] = 0$ locus, the net foreign assets are expected to increase, due to the expected increase in the trade balance.

Figure 1 represents the dynamics of the system and shows that there is a unique *saddle path* that converges to the steady state:

Figure 1: Phase Diagram



3.2 Analytical Solution

The following proposition describes the equation for the system's unique *saddle path*, presented in figure 1.

Proposition 3 *If the following condition is satisfied:*

$$\alpha_1 \beta_2 < \frac{1}{2}\beta_1 + 1 \tag{21}$$

then the short run exchange rate dynamics is described by the unique saddle path:

$$s_{j,t} - \overline{s}_j = \gamma \left(NFA_{j,t} - \overline{NFA}_j \right), \text{ with } \gamma = -\frac{1}{2\beta_2} \left(\beta_1 - \sqrt{\beta_1^2 + 4\alpha_1\beta_2} \right) < 0 \qquad (22)$$

Proof. The system of stochastic difference equations given by equations (17) and (18) has two eigenvalues:

$$\omega_1 = 1 + \frac{1}{2} \left(\beta_1 + \sqrt{\beta_1^2 + 4\alpha_1\beta_2} \right) \qquad (23)$$

$$\omega_2 = 1 + \frac{1}{2} \left(\beta_1 - \sqrt{\beta_1^2 + 4\alpha_1\beta_2} \right) \qquad (24)$$

Since $\alpha_1 > 0$ and $\beta_2 > 0$, then $\sqrt{\beta_1^2 + 4\alpha_1\beta_2} > |\beta_1|$, which implies that $\delta < 0$, $\omega_1 > 1$ and $\omega_2 < 1$, regardless of the sign of β_1. Condition (21) guarantees that $\omega_2 > 0$, implying that it is a stable eigenvalue. The expression for γ is derived from the eigenvector associated with ω_2. ■

What is the intuition behind condition (21)? Imagine that there is an exogenous increase in the net foreign assets. This exogenous increase will reduce the sovereign risk premium, generating an expected depreciation of the exchange rate in order to realign the relative attractiveness between domestic and foreign assets. The magnitude of this effect is given by α_1. However, the expected depreciation generates a further expected increase in the net foreign assets, through its effect on the trade balance. The magnitude of this effect second effect is given by β_2. Equation (21) imposes a limit on the joint effects so that all feedback effects do not generate explosive expectations about the future paths of the net foreign assets and the exchange rate.

In order to take advantage of the fact that higher frequency data is available for sovereign risk than for net foreign assets[4], it is useful to rewrite the *saddle path* as a relationship between the exchange rate and the sovereign risk spread.

Corollary 2 *The saddle path can be written as a function of the sovereign risk premium:*

$$s_{j,t} - \overline{s}_j = \delta \left(\xi_{j,t} - \overline{\xi}_j \right), \text{ where } \delta = -\theta \overline{\phi}_j \left(\frac{\lambda_j}{1 + \overline{\phi}_j} \right)^2 \gamma > 0 \quad (25)$$

Proof. Substitute the linearized version of the sovereign risk premium derived in Appendix D (equation 49) in the *saddle path* described by equation (22). ■

It is interesting to notice that δ has a positive sign in the *saddle path.* Although according to the parity equation (8), an increase in the sovereign risk is associated with an expected appreciation (to keep the small emerging economy bond attractive), in the out-of-equilibrium dynamics, an increase in the sovereign risk is associated with a contemporaneous depreciation of the exchange rate: the contemporaneous exchange rate depreciates to a level above the steady state value precisely to generated the expected future appreciation. This feature is common to Dornbusch's (1976) overshooting model.

4 Empirical Analysis

In this paper, we developed a model that described a positive out-of-equilibrium relationship between the sovereign risk and the exchange rate, with the key link being the effect of the net foreign assets on the sovereign risk premium. In this section, we will present two sets of empirical analysis. The first set is aimed at investigating the existence of this link between net foreign assets and sovereign risk in emerging economies.

[4] Daily changes in sovereign spreads reflect reactions to all information that change investors' perception of the small emerging economy net foreign assets.

If this link exists, then the model predicts that measures of sovereign risk should contain useful information about the exchange rate dynamics. In the second part of the empirical analysis we will test this second hypothesis.

4.1 Sovereign Risk and Net Foreign Assets

Equation (10) describes a relationship between sovereign risk premium, default probability, net foreign assets and the loss-ratio conditional on default, that is summarized by Corollary 1. We could estimate a linearized version of this equation using country fixed effects to control for differences in the loss-ratio accross countries, but we the agents' perception of the probability of default is a non-observable variable. Therefore, we have to proxy it using an observable variable for which data is available for a wide range of countries through a reasonable time span. A natural candidate is the debt over GDP ratio. There are many studies that find empirical evidence of the effect of fiscal variables on a country's default probability. Eichengreen and Mody (2000) analyze the spread on about 1300 developing country bonds launched between the years 1991 and 1997, and find that the debt to GNP ratio is an important determinant of the spread of for Latin American economies. relate this variable to . function of fiscal variables, such as the central government debt level.

However, this evidence is not limited to emerging economies. Alesina, De Broeck, Prati and Tabellini (1992) look at 12 OECD countries and find a strong correlation between the size of public debt and the spread between public and private rates of return, suggesting that the markets perceive a default risk on the public debt of some OECD countries Bernoth, von Hagen and Schuknecht (2006) find similar results using bond yield differentials among EU government bonds issued between 1993 and 2005. Another example is Bayoumi, Goldstein and Woglom (1995), who find evidence that the yield differential of 39 US states also depends positively on their levels of debt.

Therefore, if we linearize equation (10) taking into account that $\pi_{j,t} = f(Debt_{j,t})$, and we arrive at the equation that will be estimated in this section:

$$\xi_{j,t} \simeq \eta_0 + \eta_1 Debt_{j,t} + \eta_2 NFA_{j,t} + \eta_3 \lambda_j \tag{26}$$

4.1.1 Data

The dataset for this first set of empirical evidence includes annual observations of the sovereign risk premium, the net foreign assets and the level of public debt for 18 emerging economies from 1997 until 2005 (nine years). The countries are: Argentina, Brazil, Bulgaria, Colombia, Ecuador, Egypt, Mexico, Morocco, Nigeria, Panama, Peru, Philippines, Poland, Russia, South Africa, Turkey, Ukraine, and Venezuela.

This set of countries consists of the 18 countries that are included in the JPMorgan EMBI+ index, our measure of sovereign risk. The EMBI+ tracks total returns for actively traded external debt instruments issued by sovereign entities in emerging markets. Only those instruments denominated in US dollars are considered for inclusion, therefore, one important characteristic of the EMBI+ is that it provides a measure of sovereign risk that is not contaminated by currency risk.

That fact that we only consider in our sample countries that are included in the EMBI+ Index guarantees that the market for that country's external debt instruments is liquid enough so that spread movements are able to quickly reflect investors' perceptions on the country's ability to repay. This is because the EMBI+ places strict liquidity requirement rules for inclusion: bonds must have a minimum bid/ask spread and be quoted by a specific number of interdealer brokers. These liquidity criteria along with minimum issue size requirements ensure the capability of these external debt instruments to be bought and sold at short notice.

The net foreign assets data was collected from the World Bank's *World Development Indicators* database, and is defined as the sum of foreign assets held by monetary authorities and deposit money banks, less their foreign liabilities. The data for the level of the central government public debt was obtained from Jaimovich and Panizza (2006). Motivated by the incomplete country and period coverage provided by the most commonly used datasets[5], these authors searched several publicly available sources of data on public debt and compiled a database that covers 89 countries for the 1991–2005 period and 7 other countries for the 1993–2005 period.

4.1.2 Estimation Output

Table 1 presents the estimation output of equation (26). The dependent variable is the EMBI+ spread (end-of-year percentage rate) and the main explanatory variables are the net foreign assets and the central government public debt, both as percentages of the GDP. The difference between each of the four columns in the table is with respect the inclusion of time effects or country effects. The first equation does not include any controls for time effects of country effects. We can see that with only the level of public debt and the net foreign assets, both as percentages of the GDP, we are able to explain 46% of the variation of the sovereign risk in our panel. Moreover, both coefficients are significant at the 1% significant level and have the expected sign. An increase of 10% in the level of the public debt increases the sovereign risk premium by 3.15%, since it increases the probability of default, and an increase of 10% in the net foreign assets

[5]Such as the IMF's *International Financial Statistics* or the World Bank's *World Development Indicators*.

reduces the sovereign risk by 4.52%, since net foreign assets works as a crude form of collateral.

Table 1: Basic Specification

Dependent Variable: EMBI+
Frequency: annual
Sample Period: 1997 to 2005
Country Sample: 18 emerging economies
Number of Observations: 140 (unbalanced panel)

Regressor	**(1)**	**(2)**	**(3)**	**(4)**
Debt/GDP	0.315***	0.312***	0.378***	0.380***
	(0.060)	(0.064)	(0.058)	(0.068)
Net Foreign Assets/GDP	-0.452***	-0.419***	-0.540***	-0.484***
	(0.092)	(0.095)	(0.129)	(0.136)
Time effects?	no	yes	no	yes
Country effects?	no	no	yes	yes
F-statistics and p-values Testing Exclusion of Group of Variables				
Time effects = 0		1.61		2.14
		(0.1289)		(0.0376)
Country effects = 0			10.84	9.56
			(<0.0001)	(<0.0001)
R^2	46.1%	51.0%	74.8%	77.9%

Dummies variables are not reported. White's robust standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics. The symbols *, ** and *** denote that the individual coefficient is significant at the 10%, 5% and 1% significance level respectively.

In the second column we include time dummies. Time dummies capture changes in omitted variables that vary through time but are common to all countries, such as changes in liquidity in the international financial markets or changes in the risk appetite (or risk aversion) of the international investors. Once we include these time dummies, the values of the original coefficients are only marginally changed, and a small increase in the R^2 is verified, from 46.1% to 51.0%. In the third equation, we include country fixed effects. These dummies capture differences across countries that are specific to each economy, but constant over time, such as differences in the loss-ration or higher risk premiums that are paid by countries that have already defaulted on their debt obligations. When fixed effects are included, alone or together with time effects (columns three and four, respectively) we observe a significant increase in the R^2, to 74.8% and 77.9%, respectively. The coefficients associated to public debt and net foreign assets experience marginal increases, remaining significant at the 1% significance level.

Table 2: Robustness Checks

Dependent Variable: EMBI+
Frequency: annual
Sample Period: 1997 to 2005
Country Sample: 18 emerging economies

Regressor	**(1)**	**(2)**	**(3)**	**(4)**
Debt/GDP	0.384***	0.611***	0.403***	0.293***
	(0.131)	(0.218)	(0.079)	(0.075)
Net Foreign Assets/GDP	-0.568**	-0.504**	-0.947***	-0.355**
	(0.281)	(0.200)	(0.217)	(0.165)
Robustness Checks				
Sample	From 1997 until 2001	From 2002 until 2005	only Latin America	excludes Latin America
Number of obs.	69	71	70	70
R^2	58.6%	89.9%	83.6%	63.9%

All regressions include country dummy variables, which are not reported. Dummies variables are not reported. White's robust standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics. The symbols *, ** and *** denote that the individual coefficient is significant at the 10%, 5% and 1% significance level respectively.

In order to show that our results are not being generated by any particular episode or any particular set of countries, Table 2 presents the estimation output of two sets of robustness checks. The first check is to divide our time span in two sub-periods. The first sub-period includes data up to 2001, referring to a more turbulent period in the international financial markets, with the Asian crisis in 1997, the Russian crisis in 1998, the Brazilian crisis in 1999 and the Argentinean crisis in 2001. The second sub-period refers to a relative more tranquil time, from 2002 until 2005. The estimation output of equation (26) using only data for each sub-period is presented in the first and second columns of Table 2, respectively. We can see that both the public debt and the net foreign assets are significant in both periods, with the correct expected signs. The ratio of public debt with respect to GDP seems to have a larger impact on the sovereign risk premium in the second sub-period, while the net foreign assets have a similar impact in both sub-periods. It is also interesting to note that the R^2 in the second sub-period is much larger than in the first (89.9% against 58.6%), indicating that equation seems to fit much better the more recent behavior of the sovereign risk.

The second set of robustness check divides the sample between Latin American economies (the largest group in our sample) and the non-Latin American economies. The results are shown on the third and fourth columns respectively. Once again, both the public debt and the net foreign assets are significant with the expected sign in both subgroups. However, we can see that there is evidence that for the Latin American economies the net foreign assets are significantly more relevant, given its larger coefficient, and also that equation (26) fits better, given the larger R^2 (83.6% and 63.9% respectively) compared to non-Latin American countries.

4.2 Exchange Rates and Sovereign Risk

Given the evidence obtained in the first part of this empirical analysis, that the net foreign assets do have a significant effect on the sovereign risk premium, then our model predicts that measures of sovereign risk should contain useful information about the exchange rate dynamics (equation 25):

$$s_{j,t} - \overline{s}_j = \delta \left(\xi_{j,t} - \overline{\xi}_j \right), \text{ where } \delta = -\theta \overline{\phi}_j \left(\frac{\lambda_j}{1 + \overline{\phi}_j} \right)^2 \gamma > 0 \tag{27}$$

In this second part of the empirical analysis, we follow the convention in the empirical exchange rate modeling introduced by Meese and Rogoff (1983) by evaluating the performance of out-of-sample predictions relying solely on sovereign spreads.

4.2.1 Data

Our data set comprises of daily observations from January 2001 until August 2006 on exchange rates and EMBI+ spreads – our measure of sovereign risk premium – for Brazil, Colombia, Mexico, Peru, Philippines, Poland, South Africa and Turkey. These are the eight emerging economies from the 18 included in the JPMorgan EMBI+ index that also have a de facto independently floating exchange rate regime according to the latest IMF classification[6]. The IMF classifies as an independently floating exchange rate regime one in which "the exchange rate is market-determined, with any official foreign exchange market intervention aimed at moderating the rate of change and preventing undue fluctuations in the exchange rate, rather than at establishing a level for it"[7]. The reason why we limit ourselves to this type of regime is straightforward: the exchange rate has to be free to float in order to incorporate changes in the sovereign risk premium[8].

Figure 2 presents all 18 countries included in the EMBI+ as well as their weights

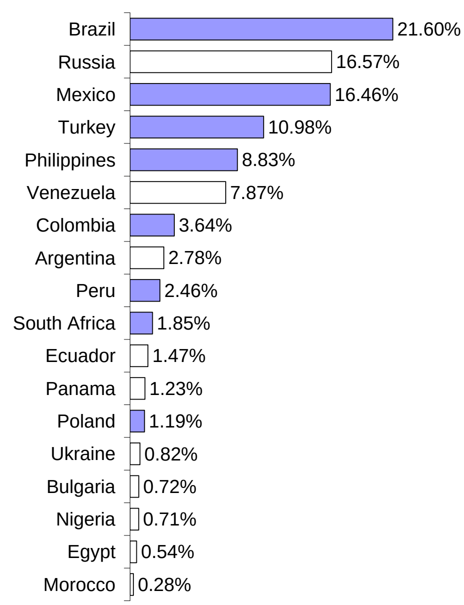
[6] December 31, 2005.

[7] There are eight possible classifications: exchange arrangements with no separate legal tender, currency board arrangements, conventional fixed peg arrangements, pegged exchange rates within horizontal bands, crawling pegs, exchange rates within crawling bands, and Managed floating with no predetermined path for the exchange rate.

[8] Curiously, all the eight selected countries operate under an inflation targeting monetary policy framework.

in the index – which are based on market capitalization – sorted in descendent order[9]. The countries in blue are the ones that are included in our sample. We can see from Table 1 that we are considering in our analysis four of the Top 5 and seven of the Top 10, totaling 67.1% – more than 2/3 – of the total market capitalization of the EMBI+. That is, we are considering the emerging economies with the largest and more liquid external debt markets and with free floating exchange rate regime.

Figure 2: EMBI+ Index Country Weights



Source:JPMorgan

Note: countries in blue are classified by the IMF as having de facto independently floating exchange rate regimes and therefore are included in our empirical analysis.

[9] As of August 2006.

4.2.2 Methodology

Our structural model is tested according to the convention in the empirical exchange rate modeling introduced by Meese and Rogoff (1983). First, we generate forecast series based on our model for each of the eight currencies in the following way:

i. we use the initial 252 trading days (approximately one year) and run the following regression for each of the eight currencies:

$$\Delta s_{j,t} = \delta_{j,0} + \delta_{j,1}\Delta\xi_{j,t} + \varepsilon_{j,t} \tag{28}$$

where $s_{j,t}$ is the log of the exchange rate and $\xi_{j,t}$ is the log of the EMBI+ spread in country j;

ii. using actual realizations of the EMBI+ spread, we generate out-of-sample forecasts for five different horizons: one, five, 10, 15, and 20 trading days[10];

iii. the sample is "rolled up" forward one period ahead – the first trading day of the initial sample is dropped and the observation subsequent to last trading day is added;

iv. the procedure is repeated until the five years and eight months in our sample are exhausted.

Then, we follow Cheung et all (2005) and evaluate the properties of the forecast series across three dimension: the mean squared error (MSE) ratio, the direction of change statistic and the consistency criterion.

The first criterion is the MSE ratio between our model and a driftless random walk. If the MSE ratio is smaller than one, then the out-of-sample forecasting performance of

[10] These are the same forecasting horizons used by Evans and Lyons (2006).

our model is better than that of the random walk. The second criterion, the direction of change statistic, computes the proportion of out-of-sample forecasts that correctly predicted the sign of the change in the actual series. A value above 0.5 indicates that our structural model has a better forecasting performance than a naïve model that predicts the exchange rate has an equal chance to go up or down. Standard errors and test statistics for the MSE ratio and the direction of change statistics are computed according to Diebold and Mariano (1995).

While the first two dimensions focus on the precision of the forecast, the third dimension emphasizes its time-series properties. According to Cheung and Chinn (1998), the forecast of a given spot exchange rate is labeled as consistent if (1) the two series have the same order of integration, (2) they are cointegrated, and (3) the cointegrating vector satisfies the unitary elasticity of the expectations condition. Intuitively, a forecast is consistent if it moves in tandem with the spot exchange rate in the long run.

4.2.3 Results

In Table 3 we present the MSE ratio between the forecast using sovereign risk premium only and the forecast based on a driftless random walk. We also report in parenthesis the p-value of the test of the null hypothesis that the ratio is not statistically different than one. MSE ratios and p-values are calculated for each of the eight emerging economy currency and each of the five forecast horizon, in a total of 40 MSE ratios and p-values pairs. We can see that six of the eight countries have MSE ratios smaller than one. For three of then – Brazil, Colombia and Mexico – the MSE ratios are significantly smaller than one at all five forecast horizons. The MSE ratio is smaller than one at the first three forecast horizons for Peru, at the 10% level, and for Turkey, at the 1% level for the 1 and 5 periods horizons and at the 5% level for the 10 periods horizon. For the Philippines, the MSE ratio is significantly smaller than one only at the 10 periods horizon. Poland and South Africa were the only two countries with MSE ratios greater than one. In South Africa, none of them is statistically different than one. In Poland, the MSE ratio is significantly larger than one at the 5% level for the 1 and 20 periods horizon and at the 10% level for the remaining forecast horizons.

Table 3: MSE Ratios

	Horizon *h* (trading days)				
	***h* = 1**	***h* = 5**	***h* = 10**	***h* = 15**	***h* = 20**
Brazil	0.673*** (0.000)	0.544*** (0.000)	0.537*** (0.000)	0.526*** (0.000)	0.525*** (0.001)
Colombia	0.922*** (0.007)	0.842*** (0.000)	0.838*** (0.002)	0.833*** (0.009)	0.840*** (0.025)
Mexico	0.910*** (0.002)	0.800*** 0.000	0.781*** (0.000)	0.793*** (0.002)	0.796*** (0.007)
Peru	0.944* (0.054)	0.941* (0.054)	0.936* (0.067)	0.939 (0.166)	0.947 (0.310)
Philippines	0.930 (0.738)	0.913 (0.145)	0.924* (0.073)	0.930 (0.145)	0.933 (0.204)
Poland	1.011** (0.024)	1.034* (0.064)	1.071* (0.057)	1.103* (0.053)	1.132** (0.049)
South Africa	1.011 (0.103)	1.025 (0.288)	1.054 (0.224)	1.073 (0.232)	1.086 (0.247)
Turkey	0.909*** (0.002)	0.920*** (0.002)	0.899** (0.041)	0.896 (0.115)	0.905 (0.183)

Note: Standard errors calculated from Diebold and Mariano (1995).

Table 4 presents the direction of change statistics. This statistics computes the proportion of times that our model correctly predicted the direction of the exchange rate change. It also presents in parenthesis the p-value of the test of the null hypothesis that the computed statistic is statistically different from 0.5. We can see that for six out of the eight countries in our sample, the direction of change statistics is not only greater than 0.5 but also statistically different at the 1% significance level. These countries are the same countries that reported MSE ratios smaller than one at all forecast horizons.

Table 4: Direction of Change Statistics

	Horizon *h* (trading days)				
	h **= 1**	***h*** **= 5**	***h*** **= 10**	***h*** **= 15**	***h*** **= 20**
Brazil	0.702***	0.751***	0.758***	0.764***	0.747***
	0.000	0.000	0.000	0.000	0.000
Colombia	0.557***	0.639***	0.651***	0.668***	0.660***
	0.000	0.000	0.000	0.000	0.000
Mexico	0.600***	0.645***	0.646***	0.664***	0.677***
	0.000	0.000	0.000	0.000	0.000
Peru	0.550***	0.601***	0.621***	0.639***	0.648***
	0.001	0.000	0.000	0.000	0.000
Philippines	0.505	0.592***	0.607***	0.615***	0.619***
	0.747	0.000	0.000	0.000	0.000
Poland	0.512	0.462***	0.439***	0.433***	0.411***
	0.429	0.009	0.000	0.000	0.000
South Africa	0.492	0.529*	0.533*	0.484	0.490
	0.654	0.090	0.061	0.347	0.576
Turkey	0.620***	0.654***	0.655***	0.661***	0.669***
	0.000	0.000	0.000	0.000	0.000

Note: Standard errors calculated from Diebold and Mariano (1995).

South Africa presented direction of change statistics not significantly different than 0.5 at the 1, 15 and 20 periods horizons, but significantly larger than 0.5 at the 10% significance level at the 5 and 10 periods horizons. For Poland, the direction of change statistics was significantly smaller than 0.5 at the 1% significance level at all horizons, with the exception being the 1 period horizon (not statistically different at the 10% level). In summary, the direction of change statistics reinforces the results obtained by the MSE ratios for seven of the eight countries: for six of them – Brazil, Colombia, Mexico, Peru, Philippines and Turkey – our model consistently outperforms the driftless random walk, and for one of them – Poland – consistently underperforms. For South Africa, results are mixed: while the MSE ratio tilts towards the random walk, the direction of change statistics tilts towards the structural model.

Table 5: Consistency Criterion

	Horizon *h* (trading days)				
	***h* = 1**	***h* = 5**	***h* = 10**	***h* = 15**	***h* = 20**
Brazil	0.153	0.223	0.154	0.030	0.075
	(0.696)	(0.637)	(0.694)	(0.864)	(0.784)
Colombia	41.75***	22.55***	17.95***	7.078***	6.244**
	(0.000)	(0.000)	(0.000)	(0.008)	(0.012)
Mexico	2.757*	1.934	1.427	0.588	0.623
	(0.097)	(0.164)	(0.232)	(0.443)	(0.430)
Peru	10.94***	5.831**	4.205**	1.507	1.254
	(0.001)	(0.016)	(0.040)	(0.220)	(0.263)
Philippines	22.41***	8.776***	6.071**	1.431	1.597
	(0.000)	(0.003)	(0.014)	(0.232)	(0.206)
Poland	9.368***	10.463***	3.211**	0.992	1.015
	(0.002)	(0.001)	(0.073)	(0.319)	(0.314)
South Africa	2.093	3.396*	3.004*	0.253	0.199
	(0.148)	(0.065)	(0.083)	(0.615)	(0.656)
Turkey	3.847*	1.763	2.191	1.829	1.382
	(0.050)	(0.184)	(0.139)	(0.176)	(0.240)

Note: P-values based on LR test for binding restrictions.

Finally, we evaluate the forecasts according to Cheung and Chinn (1998) consistency criteria. This evaluation was done in three steps. First, we tested the order of integration of all series – the actual exchange rate series and the five forecast series – for all countries. We found, using the Augmented Dickey-Fuller test, that all series have the same order of integration, I(1). Second, using the Johansen method, we were able to reject at the 5% level the null hypothesis that, for each country, the actual exchange rate series is not cointegrated with each of the five forecast series. In the third and final step, we calculate the cointegrating vector and then we test the null hypothesis that the vector is not different than (1, -1). In Table 3, we present the likelihood ratio statistic and the p-values of this test.

At the 5% significance level, only 35% of the cointegrating vectors do not satisfy the unitary elasticity requirement. At the 10% significance level, this percentage increases to 45%. This means more than one-half of the forecast series based on our structural model satisfies the consistency criteria. Interestingly, the longer the forecast horizon, the harder it is to reject the null hypothesis that the cointegrating vector is (1, -1). For example, at the 5% significance level, the null hypothesis is rejected in only one of the eight countries for the 15 and 20 periods horizons. The number of rejections increases to three as we move to the 10 periods horizon, then it increases to four at the 5 periods horizon, and then to five at the 1 period horizon.

Analyzing the results by country, Table 3 shows that only two out of the eight countries passes the consistency test at all five horizons at the 5% level: Brazil and Mexico. The other four countries that presented a better forecast performance based on the structural model relative to the random walk failed the consistency criterion at short horizons: Turkey at the 1 period horizon, Philippines at the 1 and 5 periods horizons, Peru at the 1, 5 and 10 horizons, and Colombia at all five horizons. Poland, for which both the MSE ratio and the direction of change statistics favored the random walk, presented two failures in consistency criteria: at the 1 and 5 periods horizon. Finally, the forecast for the exchange rate in South Africa satisfied the consistency criteria at all horizons.

4.2.4 Discussion

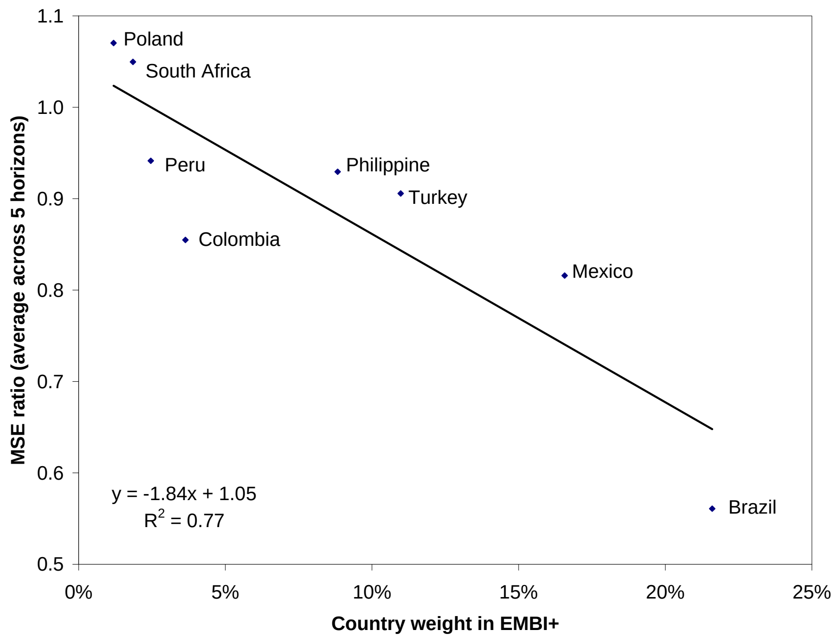
The empirical evidence presented in this section suggests that the sovereign risk premium contains relevant information about the exchange rates dynamics. We showed that out-of-sample forecasts à la Meese and Rogoff (1983) based on our structural model are consistently satisfactory regardless of the significance level used along three dimensions: the MSE ration, the direction of change statistics and the consistency criteria. Table 6 summarizes the results.

Table 6: Summary of Tests Results

		Significance Level		
		1% level	**5% level**	**10% level**
MSE Ratio	**< 1**	42.5%	45.0%	55.0%
	> 1	0.0%	5.0%	12.5%
	indifferent	57.5%	50.0%	32.5%
Direction of Change Statistic	**> 0.5**	72.5%	72.5%	77.5%
	< 0.5	10.0%	10.0%	10.0%
	indifferent	17.5%	17.5%	12.5%
Consistency Criterion	**passed**	77.5%	65.0%	55.0%
	failed	22.5%	35.0%	45.0%

At the 1% significance level, 42.5% of the 40 cases (eight emerging economies times five forecast horizons) have an MSE ratio significantly smaller than one, none have it greater than one, and 57.5% are not statistically different; the direction of change statistic was statistically greater than 0.5 for 72.5% of the cases, significantly smaller for 10% of the cases and indifferent for 17.5% of the cases; also, 77.5% of the cases passed the consistency criterion and only 22.5 failed. At the 5% significance level, 45% of cases had an MSE ration significantly smaller than one, 5% significantly smaller, and 50% indifferent; 72.5% of the direction of change statistics are statistically greater than 0.5, 10% statistically smaller, and 17.5 indifferent; and 65% of the cases passed the consistency criterion while 35% failed it. Finally, at the 10% significance level, the MSE ration is significantly greater than one for 55% of the cases, smaller for 12.5%, and indifferent for 32.5%; 77.5% of the cases have a direction of change statistic greater than 0.5, 10% significantly smaller, and 12.5 indifferent, and 55% of the cases satisfied the consistency criterion while 45% failed.

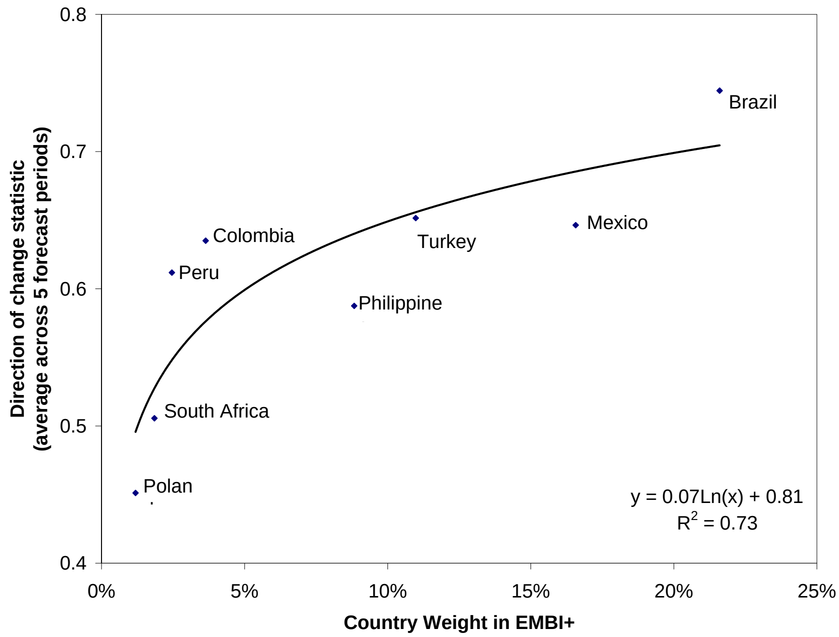
Figure 3: Country Weight in EMBI+ versus MSE Ratio



Source: JPMorgan and authors‘ calculations

The few cases in which our model seemed to have failed one of these criteria proposed, rather than being spread out across countries, were concentrated in Poland and South Africa. The results also suggest a very high correlation between the ranking in terms of the first two dimensions: the country with a low MSE ratio is most likely a country with a high direction of change statistic. Is there any country specific characteristic that may explain the pattern in our results?

Figure 4: Country Weight in EMBI+ versus Direction of Change Statistic



Source: JPMorgan and authors' calculations

Figures 3 and 4 have the country weight in the EMBI+ in the horizontal axis, and while the first figure has on the vertical axis the average MSE ratio across the five forecast horizons, the second figure has the average direction of change statistic. Both figures suggest that the larger is a country's market capitalization of its USD denominated external debt instruments; the better is the out-of-sample fit of our structural model: the largest is the market, the smaller is the average MSE ratio and the higher is the average direction of change statistic for that country exchange rate. Since market size is an important determinant of liquidity , these graphs reinforce the idea that the more liquid are the external debt bonds, the higher is the degree of information about exchange rates contained in the bonds spreads.

5 Conclusion

In this paper, we showed that sovereign risk premium contains important information about the exchange rate dynamics in a small emerging economy. The link between sovereign risk and exchange rates is made by the net foreign assets. On the one hand, using a portfolio choice model where investors from a large developed economy may invest in bonds from small emerging economies that are subject to default risk, we show how the sovereign risk premium is a function of the net foreign assets. On the other hand, the exchange rate is an important determinant of the net foreign assets through its effect on the trade balance. The solution yields a *saddle path* between the exchange rate and the sovereign risk premium: when the exchange rate is away from its long term equilibrium, there is a positive relationship between the two variables.

We test our model according to the convention in the empirical exchange rate modeling established by Meese and Rogoff (1983). Using data for the eight emerging economies with the most liquid USD denominated external-debt markets and with a de facto independent floating exchange rate regime, we show that out-of-sample forecasts using realized values for the sovereign risk premium have a satisfactory performance, when evaluated along three metrics: the MSE ratio, the direction of change statistic, and the consistency criterion. In particular, results were really good for Brazil, Colombia and Mexico, and promising to the least for Peru, Philippines and Turkey. The few cases in which our model seemed to have failed one of these criteria proposed were concentrated in Poland and South Africa. The results also suggest a very high correlation between the rankings in terms of the first two dimensions: the country with a low MSE ratio is most likely a country with a high direction of change statistic. Finally, we also presented evidence suggesting that the larger is a country's market capitalization of its USD denominated external debt instruments; the better is the out-of-sample fit of our structural model: the largest is the market, the smaller is the average MSE ratio and the higher is the average direction of change statistic for that country exchange rate. Since market size is an important determinant of liquidity , these graphs reinforce the idea that the more liquid are the external debt bonds, the higher is the degree of information about exchange rates contained in the bonds spreads.

There are several directions for future research. The first is to include the role of monetary policy as in the "new open economy macro" literature. The second is to distinguish between foreign assets held by the private sector and the international reserves. The third direction is to allow for contagion between emerging economies. In this paper, fundamental contagion was ruled out by assuming that emerging economies did not trade with each other and that exchange rates conditional on all information available in a given period, the next period exchange rates were uncorrelated. Another direction is to model the default probability as a function of the debt over GDP ration, allowing for fiscal dominance considerations, as in Blanchard (2004) and Favero and Giavazzi (2004): higher interest rates may increase the sovereign risk premium through the debt service and can potentially have perverse effect on inflation rates.

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A Proof of Proposition 1

The Normal-CARA set up allows us to write:

$$\begin{aligned} E_t\left[U\left(W\right)\right] &= -\exp\left(-\theta\left\{E_t\left[W\right]-\frac{\theta}{2}Var_t\left(W\right)\right\}\right) \\ \text{if } W_{t+1} &\sim N\left(E_t\left[W_{t+1}\right], Var_t\left(W_{t+1}\right)\right) \end{aligned} \tag{29}$$

Let $x_{j,t} = r_{j,t} - r_t + s_{j,t} - s_{j,t+1}$, the period t expected value and variance for each possible period $t+1$ wealth are:

$$E_t\left[W_{t+1}^{D_0}\right] = \left(1+r_t\right)W_t + E_t\left[x_{1,t}\right]B_{1,t} + E_t\left[x_{2,t}\right]B_{2,t} \tag{30}$$

$$E_t\left[W_{t+1}^{D_1}\right] = \left(1+r_t\right)W_t + \left(E_t\left[x_{1,t}\right]-\lambda_1\right)B_{1,t} + E_t\left[x_{2,t}\right]B_{2,t} \tag{31}$$

$$E_t\left[W_{t+1}^{D_2}\right] = \left(1+r_t\right)W_t + E_t\left[x_{1,t}\right]B_{1,t} + \left(E_t\left[x_{2,t}\right]-\lambda_2\right)B_{2,t} \tag{32}$$

$$E_t\left[W_{t+1}^{D_{1,2}}\right] = \left(1+r_t\right)W_t + \left(E_t\left[x_{1,t}\right]-\lambda_1\right)B_{1,t} + \left(E_t\left[x_{2,t}\right]-\lambda_2\right)B_{2,t} \tag{33}$$

$$\begin{aligned} Var_t\left(W_{t+1}^{m}\right) &= Var_t\left(s_{1,t+1}\right)B_{1,t}^2 + Var_t\left(s_{2,t+1}\right)B_{2,t}^2 \\ \text{for } m &= D_0,\ D_1,\ D_2 \text{ and } D_{1,2} \end{aligned} \tag{34}$$

where we assumed for simplicity that the foreign exchanges between the small emerging economies are independent.

The FOC of the foreign investor's problem with respect to $B_{j,t}$ is:

$$\begin{aligned} 0 = \; & \left(1-\pi_{j,t}\right)\left(1-\pi_{-j,t}\right)E_t\left[U\left(W_{t+1}^{D_0}\right)\right]\left(E_t\left[x_{j,t}\right]-\theta Var_t\left(s_{j,t+1}\right)B_{j,t}\right)+\ldots \\ & \ldots+\pi_{j,t}\left(1-\pi_{-j,t}\right)E_t\left[U\left(W_{t+1}^{D_j}\right)\right]\left(E_t\left[x_{j,t}\right]-\lambda_1-\theta Var_t\left(s_{j,t+1}\right)B_{j,t}\right)+\ldots \\ & \ldots+\left(1-\pi_{j,t}\right)\pi_{-j,t}E_t\left[U\left(W_{t+1}^{D_{-j}}\right)\right]\left(E_t\left[x_{j,t}\right]-\theta Var_t\left(s_{j,t+1}\right)B_{j,t}\right)+\ldots \\ & \ldots+\pi_{j,t}\pi_{-j,t}E_t\left[U\left(W_{t+1}^{D_{j,-j}}\right)\right]\left(E_t\left[x_{j,t}\right]-\lambda_1-\theta Var_t\left(s_{j,t+1}\right)B_{j,t}\right) \end{aligned} \tag{35}$$

Define:

$$\phi_{j,t} = \frac{\pi_{j,t}}{1-\pi_{j,t}} \frac{(1-\pi_{-j,t}) E_t \left[U\left(W_{t+1}^{D_j}\right)\right] + \pi_{-j,t} E_t \left[U\left(W_{t+1}^{D_{j,-j}}\right)\right]}{(1-\pi_{-j,t}) E_t \left[U\left(W_{t+1}^{D_0}\right)\right] + \pi_{-j,t} E_t \left[U\left(W_{t+1}^{D_{-j}}\right)\right]} \tag{36}$$

The FOC becomes

$$\begin{aligned} 0 &= E_t [x_{j,t}] - \theta Var_t (s_{j,t+1}) B_{j,t} + \phi_t (E_t [x_{j,t}] - \lambda_1 - \theta Var_t (s_{j,t+1}) B_{j,t}) \\ &= \left(1+\phi_{j,t}\right) (E_t [x_{j,t}] - \theta Var_t (s_{j,t+1}) B_{j,t}) - \phi_{j,t} \lambda_1 \\ &= E_t [x_{j,t}] - \theta Var_t (s_{j,t+1}) B_{j,t} - \frac{\phi_{j,t}}{1+\phi_{j,t}} \lambda_1 \end{aligned} \tag{37}$$

B Proof of Proposition 2

First, rewrite equation (6) as:

$$E_t [s_{j,t+1}] - s_{j,t} = r_{j,t} - r_t - \theta Var_t (s_{j,t+1}) B_{j,t} - \frac{\phi_{j,t}}{1+\phi_{j,t}} \lambda_j \tag{38}$$

Then, use the balance of payments equilibrium condition to substitute $B_{j,t}$ for $-NFA_{j,t}$.

Finally, simplify the expression for $\phi_{j,t}$:

$$\phi_{j,t} = \frac{\pi_{j,t}}{1-\pi_{j,t}} \frac{(1-\pi_{-j,t}) E_t \left[U\left(W_{t+1}^{D_j}\right)\right] + \pi_{-j,t} E_t \left[U\left(W_{t+1}^{D_{j,-j}}\right)\right]}{(1-\pi_{-j,t}) E_t \left[U\left(W_{t+1}^{D_0}\right)\right] + \pi_{-j,t} E_t \left[U\left(W_{t+1}^{D_{-j}}\right)\right]} \tag{39}$$

We can see that $\phi_{j,t}$ is the product of two ratios. The first ratio relates the probabilities of default and no-default. The second ration in the product is associated with the distance between the expected utilities in the event of default and no default. If we keep in mind that utilities associated with the CARA exponential function are expressed by negative numbers and that the closer the number is to zero, the higher is the utility, we will notice that the higher is the value of the second ratio, the greater is the utility loss in case of default.

Using equation (29), we can write the ratio of expect CARA utility functions as:

$$\frac{E\left[U\left(W_{t+1}^{p}\right)\right]}{E_t\left[U\left(W_{t+1}^{q}\right)\right]}=\frac{-\exp\left(-\theta\left\{E_t\left[W_{t+1}^{p}\right]-\frac{\theta}{2}Var_t\left(W_{t+1}^{p}\right)\right\}\right)}{-\exp\left(-\theta\left\{E_t\left[W_{t+1}^{q}\right]-\frac{\theta}{2}Var_t\left(W_{t+1}^{q}\right)\right\}\right)}$$

$$=\exp\left(-\theta\left\{E_t\left(\left[W_{t+1}^{p}\right]-E_t\left[W_{t+1}^{q}\right]\right)-\frac{\theta}{2}\left(Var_t\left(W_{t+1}^{p}\right)-Var_t\left(W_{t+1}^{q}\right)\right)\right\}\right) \quad (40)$$

We can use equations (30) to (34) and the balance of payments equilibrium condition to arrive at:

$$\frac{E\left[U\left(W_{t+1}^{D_j}\right)\right]}{E_t\left[U\left(W_{t+1}^{D_0}\right)\right]} = \exp\left(-\theta\lambda_j NFA_{j,t}\right) \quad (41)$$

$$\frac{E\left[U\left(W_{t+1}^{D_{-j}}\right)\right]}{E_t\left[U\left(W_{t+1}^{D_0}\right)\right]} = \exp\left(-\theta\lambda_{-j} NFA_{-j,t}\right) \quad (42)$$

$$\frac{E\left[U\left(W_{t+1}^{D_{j,-j}}\right)\right]}{E_t\left[U\left(W_{t+1}^{D_0}\right)\right]} = \exp\left(-\theta\lambda_j NFA_{j,t}-\theta\lambda_{-j} NFA_{-j,t}\right) \quad (43)$$

$$= \exp\left(-\theta\lambda_j NFA_{j,t}\right)\exp\left(-\theta\lambda_{-j} NFA_{-j,t}\right) \quad (44)$$

Finally, if we divide both the numerator and the denominator of equation (39) by $E_t\left[U\left(W_{t+1}^{D_0}\right)\right]$ and plug in the expressions (41) to (43) we get:

$$\phi_{j,t} = \frac{\pi_{j,t}}{1-\pi_{j,t}}\frac{\left(1-\pi_{-j,t}\right)\exp\left(-\theta\lambda_j NFA_{j,t}\right)+\pi_{-j,t}\exp\left(-\theta\lambda_j NFA_{j,t}\right)\exp\left(-\theta\lambda_{-j} NFA_{-j,t}\right)}{\left(1-\pi_{-j,t}\right)+\pi_{-j,t}\exp\left(-\theta\lambda_{-j} NFA_{-j,t}\right)}$$

$$= \frac{\pi_{j,t}}{1-\pi_{j,t}}\exp\left(-\theta\lambda_j NFA_{j,t}\right) \quad (45)$$

C Partial Derivatives of Corollary 1

The partial derivatives of the sovereign risk premium, $\xi_{j,t}$, with respect to the net foreign assets, $NFA_{j,t}$, the default probability, $\pi_{j,t}$, and the size of the loss in case of default, $\lambda_{j,t}$, are:

$$\begin{aligned}
\frac{\partial \xi_{j,t}}{\partial NFA_{j,t}} &= -\theta\phi_{j,t}\left(\frac{\lambda_j}{1+\phi_{j,t}}\right)^2 < 0 & (46)\\
\frac{\partial \xi_{j,t}}{\partial \pi_{j,t}} &= \lambda_j \frac{1}{\left(1+\phi_{j,t}\right)^2}\frac{1}{\left(1-\pi_{j,t}\right)^2}\exp\left(-\theta\lambda_j NFA_{j,t}\right) > 0 & (47)\\
\frac{\partial \xi_{j,t}}{\partial \lambda_j} &= \frac{\phi_{j,t} - \theta\lambda_j NFA_{j,t}\xi_{j,t}}{1+\phi_{j,t}} > 0, \text{ if } NFA_{j,t} < 0 & (48)
\end{aligned}$$

D Linearization of the system

Using the partial derivative (46), we can calculate the first-order Taylor expansion of the sovereign risk premium[11]:

$$\xi_{j,t} \simeq \overline{\xi}_j - \theta\overline{\phi}_j\left(\frac{\lambda_j}{1+\overline{\phi}_j}\right)^2\left(NFA_{j,t} - \overline{NFA}_j\right) \tag{49}$$

It is also useful to write the linearized version of the currency risk premium as:

$$\begin{aligned}
\rho_{j,t} &= \overline{\rho}_j - \theta\sigma_{s_j}^2\left(NFA_{j,t} - \overline{NFA}_j\right)\\
&= -\theta\sigma_{s_j}^2 NFA_{j,t} & (50)
\end{aligned}$$

where $\sigma_{s_j}^2$ is the steady state variance of the one-period ahead exchange rate. Plugging the linearized expressions for the sovereign and currency risk premium into equation (8)

[11] The first order Taylor expansion is more appropriate than the usual log-linearization since $NFA_{j,t}$ can be either positive or negative.

gives us:

$$E_t\left[s_{j,t+1}\right]-s_{j,t}=\alpha_0-\alpha_1 NFA_{j,t} \tag{51}$$

with:

$$\alpha_0 = r_j - r - \overline{\xi}_j - \theta\overline{\phi}_j\left(\frac{\lambda_j}{1+\overline{\phi}_j}\right)^2\overline{NFA}_j \tag{52}$$

$$\alpha_1 = \theta\sigma_{s_j}^2 + \theta\overline{\phi}_j\left(\frac{\lambda_j}{1+\overline{\phi}_j}\right)^2 > 0 \tag{53}$$

The linearized version of equation (16) is:

$$\begin{aligned} E_t\left[NFA_{j,t+1}\right]-NFA_{j,t} &= \left(r_j-\pi_j\lambda_j\right)NFA_{j,t}-\overline{NFA}_j\left(E_t\left[s_{j,t+1}\right]-s_{j,t}\right)+\kappa_1 s_{j,t}+\ldots \\ &\quad \ldots+\kappa_0+\kappa_1\left(-p_{j,t}+p_t\right)-\left(r_j-\pi_j\lambda_j\right)\overline{NFA}_j \end{aligned} \tag{54}$$

If we substitute $(E_t\left[s_{j,t+1}\right]-s_{j,t})$ in equation (54) using equation (51) we get:

$$E_t\left[NFA_{j,t+1}\right]-NFA_{j,t}=\beta_0+\beta_1 NFA_{j,t}+\beta_2 s_{j,t} \tag{55}$$

with:

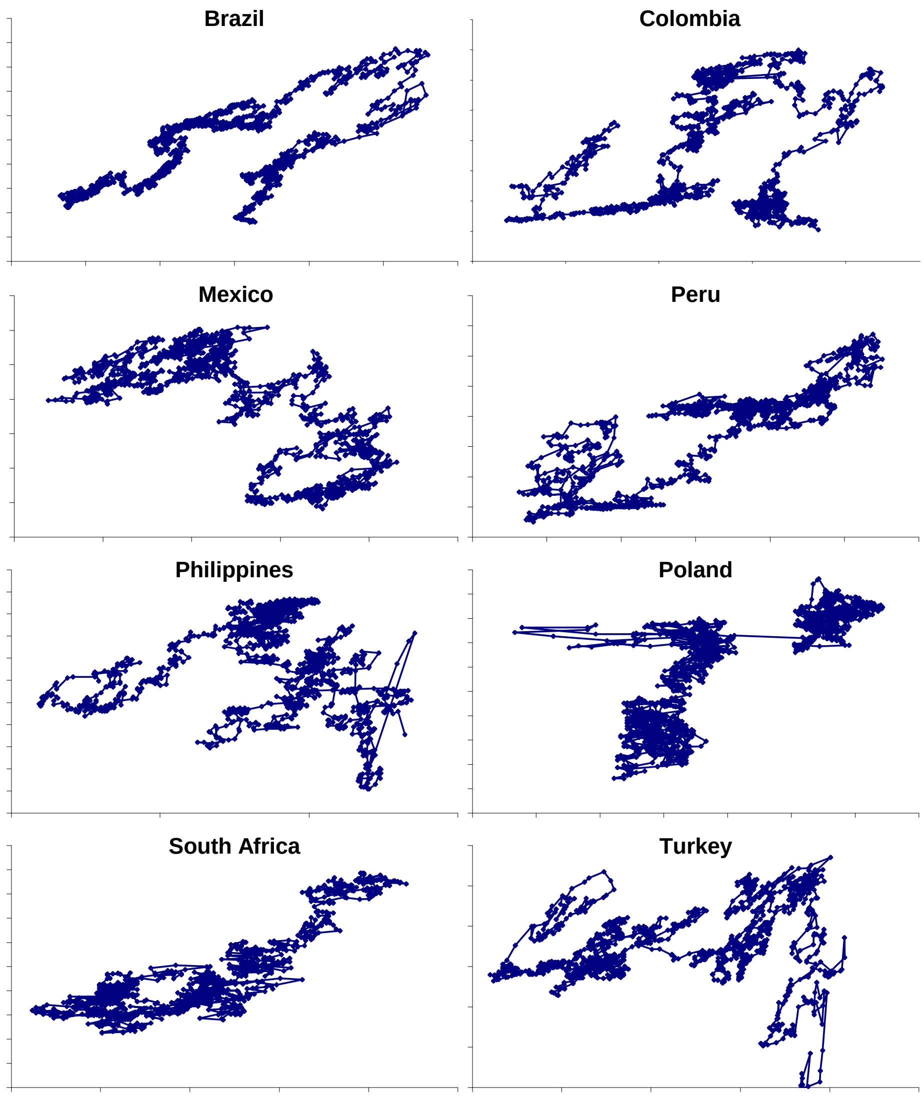
$$\beta_0 = \kappa_0+\kappa_1\left(-p_j+p\right)-\overline{NFA}_j\left(-r-\overline{\xi}_j-\theta\overline{\phi}_j\left(\frac{\lambda_j}{1+\overline{\phi}_j}\right)^2\overline{NFA}_j\right) \tag{56}$$

$$\beta_1 = r_j-\pi_j\lambda_j-\theta\sigma_{s_j}^2-\theta\overline{\phi}_j\left(\frac{\lambda_j}{1+\overline{\phi}_j}\right)^2 \lesseqgtr 0 \tag{57}$$

$$\beta_2 = \kappa_1 > 0 \tag{58}$$

E Exchange Rates versus Sovereign Risk Premium

Figure 5: EMBI+ Spreads (x-axis) and Exchange Rates (y-axis)



Source:JPMorgan

Note: variables in natural logs