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CHOOSING THE CURRENCY STRUCTURE OF FOREIGN-CURRENCY DEBT: A REVIEW OF POLICY APPROACHES*

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Abstract

Starting from the constraints and incentives that cause countries to issue debt in foreign currency, this paper provides an overview of policy approaches for choosing the optimal currency structure of sovereign foreign-currency debt. The objective of sovereign debt managers generally includes both risk and cost minimization, while constraints to foreign-currency debt allocation originate in the parameters of the domestic macroeconomy, the shocks it faces, and the initial conditions. Overall, the main parameters that drive the solutions for optimal currency allocation of foreign-currency debt are the covariances of macrovariables with exchange rates and the variances of different exchange rates. Both the covariances and the exchange rate volatility can be deceptive when a fixed exchange rate regime is maintained, however. To adequately capture the expected covariances in the context of managed exchange rate regimes, we suggest that sovereign debt managers work with *equilibrium* instead of *actual* exchange rates. For the same reason and because the estimates of relative exchange rate variances should be forward looking, we suggest using synchronization indicators in the policy analysis to better capture the underlying drivers of exchange rate volatility across currencies.

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JEL Classification: H63, F37, G11.

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1 Introduction

Sovereign borrowers often have large funding needs owing to their efforts to stabilize income over time and across circumstances, increase income faster than when relying only on their own resources, support monetary policy, and develop domestic capital markets. When funding needs cannot be met by issuing debt denominated in the domestic currency, governments sometimes issue debt in a foreign currency and, as a result, become exposed to foreign exchange risk through possible currency mismatches on their balance sheets. Such currency mismatches could arise when, after matching the cash flows from assets[1] and liabilities denominated in similar currencies, there remains an open position in any foreign currency.

Foreign exchange risk, typically considered one of the major risks for emerging market economies' sovereign debt portfolios, is significantly higher for emerging economies than for industrialized economies because emerging economies are more exposed to external shocks, such as those concerning the terms of trade and the cost of financing, in addition to financial contagion and natural disasters (see Caballero and Cowan, 2006, and Claessens, 2005). The importance of finding suitable currency benchmarks for sovereign debt portfolios has been stressed in work of Caballero and Cowan (2006), Claessens (2006), and Bordo and Meissner (2006), who pointed out that although foreign exchange risk in emerging market economies is high, the use of derivatives for hedging is limited and other types of hedging, such as accumulation of foreign exchange reserves and foreign trade diversification, are costly. Although the use of derivatives by emerging market economies has increased in recent years, they remain underutilized in public debt management due to laws restricting their usage, a lack of leading examples, lack of staff experience with such instruments, and limited market appetite for many emerging market currencies.[2]

[1]Typically, the largest 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—e.g. oil revenues or royalties—borrowing entirely in domestic currency would also create currency mismatches.

[2]The limited use of derivatives also derives from the type and structure of the derivatives. While swaps of one currency for another are readily available, the feasibility of swapping a foreign currency into the domestic currency

When discussing the reasons sovereigns borrow in foreign currencies, one needs to distinguish foreign-currency borrowing due to opportunistic cost minimization from that due to rationing. A sovereign borrower that is rationed in its domestic market may issue either domestic-currency-denominated or foreign-currency-denominated debt in international markets if it is or is not, respectively, subjected to the "original sin" problem.[3] A sovereign borrower that is rationed in its domestic markets could also issue foreign-currency debt for opportunistic reasons in either domestic or international markets. The freedom of a sovereign to choose the share of domestic-currency debt in its debt portfolio is far from granted, however, when rationing in domestic-currency markets binds and the sovereign is subject to the original sin problem. When a sovereign borrower is not able to issue debt in its domestic currency domestically or internationally, it faces the choice of which foreign-currency denomination(s) would be most suitable for its debt portfolio so as to reflect its preference regarding the cost/risk tradeoff.

As for the rationing constraints, the inability of developing countries' governments to issue desired amounts of debt denominated in domestic currency can be attributed to the unwillingness of foreign investors to hold sovereign debt denominated in currencies of small, developing countries. In this regard, the literature on original sin—see, e.g. Eichengreen et al. (2003), Hausmann and Panizza (2003) and Chamon and Hausmann (2005)—highlights the role of path dependence and international factors in foreign exchange borrowing while downplaying the importance of institutional and macroeconomic factors. This implies that there is not much leeway left for many emerging market economies in need of financing, as policy makers cannot alter the initial conditions and improvements in policies and institutions do not seem to affect their ability to issue domestic-currency debt offshore. In contrast to the evidence from the

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of a developing country can be limited due to significant costs or constrained external convertibility of the domestic currency. Further, the structure of swaps can be seen as less convenient for budgeting purposes than, e.g. options, as the swap is settled in the future and the premium for options is paid up front.

[3] The "original sin" problem broadly refers to the constraint that small developing economies are not able to issue domestic-currency debt in international markets. We discuss this constraint in more detail later in the text.

original sin literature, which finds, most importantly, that country size[4] explains the currency structure of sovereign debt, Claessens et al. (forthcoming) find that institutional and macroeconomic factors are related to the currency composition of government bond markets when controlling for country size.[5] Moreover, sovereigns may not issue as much domestic-currency debt as possible, and rather opt for foreign-currency debt to avoid crowding out domestic firms from domestic-currency borrowing. This decision can stem from the recognition that in the case the private sector has limited capacity to manage foreign exchange risk, elimination of such risk from a government's balance sheet can shift it to the private sector's balance sheets and possibly increase the value of government's contingent liabilities.[6]

The obvious solution to the problem of eliminating the foreign exchange risk from sovereign balance sheets is development of the domestic government bond market. This entails gradual elimination of the rationing constraints due to factors such as lack of benchmark issues, institutional investors, a liquid secondary market, and better mobilization of domestic savings. Institutional factors are crucial in this respect. Burger and Warnock (2004), Santos and Tsatsaronis (2003), and Turner (2002), among others, stress the role of creditor-friendly policies and laws, sound debt management, and public governance for domestic government bond market development. Since institutional factors show high persistence, it is not likely that sovereigns could eliminate foreign exchange risk inherent in their balance sheets in a rapid

[4] E.g. Eichengreen et al. measure the country size as the principal component of the log of total GDP, log of total trade and log of total domestic credit.

[5] Claessens et al. also find that economies with deeper domestic financial markets issue less foreign currency debt, and that increasing demand from foreign investors for foreign currency debt and less flexible exchange rate regimes are associated with more foreign currency issuance.

[6] Another possible constraint could arise for low-income countries when borrowing from international financial institutions. For instance, countries eligible for financing by the World Bank's International Bank for Reconstruction and Development may choose the currency in which they want to borrow whereas low-income countries eligible for the World Bank's International Development Association (IDA) financing must borrow in special drawing rights (SDRs). Nevertheless, even in the case of IDA countries, the World Bank is not the sole lender and the countries borrow in a range of currencies from other sources, such as bilateral donors. If there are enough borrowing opportunities with similar terms, an IDA country can effectively choose the currency denomination of its public debt.

manner.[7] Moreover, the potential size of the domestic market might still not suffice for accommodating the demand for funds from the government and other entities in the domestic economy. Practical experience with alleviation of the domestic market's constraints in selected countries is summarized in World Bank (2007).[8]

Aside from the rationing constraints, sovereigns sometimes issue foreign-currency debt simply because it appears less expensive, at times, than issuing domestic-currency debt.[9] Habib and Joy (2008) identify four factors behind the incentives for sovereigns to issue foreign-currency. The first factor has to do with the sovereign's desire to match its foreign-currency revenues with foreign-currency debt service obligations in order to balance the foreign exchange risk exposure. The sovereign can use the debt issuance to create a "natural hedge" against its primary currency risk or use currency derivatives to create a synthetic hedge or a *synthetic debt* with desired currency denomination.[10] The second factor concerns the

[7]There are also transitional issues for many economies, relating to macroeconomic policies, that impact exchange rates and overall monetary conditions.

[8] In addition, sovereigns can be constrained in issuing desired amounts of debt in domestic currency due to partial dollarization of the domestic economy. Dollarization is usually ascribed to decreasing monetary credibility, an argument put forth by Jeanne (2005), among others. Low monetary credibility is then often an outcome of insufficiently independent monetary policy and interference of fiscal policy with the way monetary policy is conducted. Lack of independent monetary policy implies higher inflation expectations and inflation volatility due to the possibility of the government trying to inflate the debt away (see Togo, 2006; Burnside, 2003; Blinder, 1983; and Sargent and Wallace, 1981). Monetary policy has long been considered an important determinant of debt composition in the literature on Organisation for Economic Co-operation and Development (OECD) countries—see e.g. Bohn (1990a) on debt currency composition and monetary policy or Falcetti and Missale (2002) on debt currency composition and central bank independence.

[9] Broner et al. (2007) offer an explanation of the emphasis on cost considerations in borrowing programs of emerging market economies. Such an opportunistic approach is not uncommon, even among the OECD countries. See e.g., Wolswijk and de Haan (2005), who indicate that Austria, Finland, and Sweden have more than 10 percent of their sovereign debt denominated in foreign currencies.

[10] The sovereign can issue domestic-currency debt and use currency swaps to create synthetic foreign currency debt by transforming a stream of cash outflows in domestic currency into foreign currency. Analogously, currency swaps may be used to create synthetic domestic-currency debt by transforming foreign-currency debt into a domestic-currency liability. In principle, swaps and foreign-currency debt could thus be used as substitutes.

sovereign's borrowing strategy, which could include the aim to diversify the investor base for large-size bond issues; to take advantage of lower credit constraints in more-liquid foreign debt markets; and to collect some liquidity premium on the debt issuance. The third factor is the potential scope for reduction in borrowing costs through debt issuance in whichever currency offers the lowest effective borrowing cost at the time. A lower effective borrowing cost can involve lower covered costs (incorporating the cost of covering against exchange rate risk) or simply lower nominal costs (lower nominal interest rates). It is important, however, that debt managers duly assess the risk aspects of any issuance driven by cost-opportunistic considerations in order to ensure that they make an informed choice in respect to the government's cost-risk and other preferences.

In this paper, we consider a medium-term perspective in thinking about the foreign-currency structure of sovereign debt portfolios, as debt managers should in order to manage effectively foreign exchange risk in their debt portfolios and minimize the use of add-on hedging products while taking into account cost considerations. We acknowledge that a sovereign may borrow in foreign currencies for the reasons discussed above and, as a result, incur an open foreign exchange position on its balance sheet. With this in mind, we review current policy approaches that public debt managers could use when trying to determine the optimal currency structure for their foreign-currency debt, and discuss issues inherent in these approaches. Hence, we do not attempt to contribute to the literature on the original sin or explain how currency mismatches come about, as we take these circumstances as given.

Section two reviews recent analytical and numerical policy approaches that can be employed in choosing the optimal currency structure of foreign-currency sovereign debt. Section three discusses and points to issues related to the concepts and assumptions underlying these approaches. Section four provides conclusions and offers directions for future work.

2 Overview of Policy Approaches

Current approaches in use by sovereigns for dealing with currency allocation of foreign-currency debt include, but are not limited to, (i) the minimum variance portfolio, (ii) matching the

currency structure of foreign exchange reserves, foreign trade, or capital flows, and (iii) relying on the promise of the national central bank to maintain a peg against a chosen currency. Employing the minimum variance portfolio approach for the currency choice is limited in its success in that it aims at optimal diversification and does not consider the link to government revenues and the time-varying ability of government to service its debt. Matching of currency structure of sovereign debt to foreign reserves, foreign trade, or capital flows goes beyond efficient diversification and embraces the idea of an asset and liability management (ALM) approach. Nevertheless, it is hard to understand the interplay of foreign trade and capital flows, so that in practice the guidance is limited. Furthermore, mimicking the structure of foreign reserves has limitations due to the fact that most countries do not maintain de facto free-floating exchange rate regime; rather, they intervene in foreign exchange markets, thus altering the free-float level and composition of foreign exchange reserves.

In this section, we review a selected group of recently-adopted analytical and computational approaches to support policy decisions and deliberations on the currency allocation of foreign-currency sovereign debt. The section is divided into two subsections: one covering analytical approaches, which essentially developed out of academic research, and the other covering computational approaches that derive from finance practitioners' work on public debt management.

2.1 Analytical Approaches

The basic framework of analytical approaches to the currency allocation of foreign-currency sovereign debt comprises an objective function (i.e. the debt management policy objective) and the constraints policy makers face when trying to maximize the utility (objective) function, including the modeling of the macroeconomy.

Bohn (1990) argues that the case for foreign-currency debt is based on the interaction of hedging and incentives—more specifically, that foreign-currency debt could have desired hedging properties while not creating the incentive problem.[11] In the context of multiple

[11] The incentive problem relating to domestic nominal debt is related to the possibility that a government may choose to inflate the debt away.

possible currency denominations of the foreign-currency debt, the best currency is the one that provides the best hedge for the government by matching the fluctuations in its revenues and debt service charges. Essentially, Bohn adopts a risk-minimizing motivation. The same risk-minimizing objective is adopted by Licandro and Masoller (2000), who use the tax-smoothing argument to derive their objective function for public debt management, which minimizes the expected variation in the tax rate. Bohn, however, uses a more comprehensive objective function deriving from welfare maximization of a social planner focused on the utility of a representative household.

Missale (2002) more explicitly distinguishes the risk-minimizing and cost-minimizing approaches that underpin sovereign debt managers' appropriate choice of an objective function. His risk-minimizing approach derives from the attempt to minimize the shocks to the budget and hinges, as in Licandro and Masoller (2000), on the tax-smoothing objective. Missale recommends that, in the absence of imperfections and informational and credibility problems (incentive problems), debt managers only minimize budgetary risk arising from macroeconomic shocks affecting interest rates, tax revenues, and public spending. According to Bohn (1990), the presence of an increasing credibility (incentive) problem then justifies issuance of a larger share of foreign-currency debt in total debt. Nevertheless, the opportunistic or cost-minimizing objective could also drive debt managers' objectives. If imperfections exist, a policy that does not reduce interest rate costs is optimal only if the expected returns on government debt reflect the risk-return characteristics resulting from macroeconomic uncertainty (i.e. that the risk-return characteristics are properly reflected in a risk premia).

Missale (2002) thus proposes to minimize the expected present value loss of an objective function incorporating the level and square of inflation, public debt, and government spending. However, Bacchiocchi and Missale (2005) employ a somewhat simpler specification of a loss function that incorporates both the cost-minimizing and risk-minimizing objectives. This is done through a linear-quadratic function of debt growth rates, where minimizing debt growth itself derives from the attempt to capture the possible opportunistic or cost-minimizing objectives, and where minimizing the expected square of the debt growth rate captures the risk-minimizing objective of reducing the disturbances to the budget from varying debt servicing

costs. Finally, in their application to Brazil, Giavazzi and Missale (2004) propose an objective function for emerging market economies attempting to undergo a transitory period of targeted debt reduction, including the probability that this attempt could fail. One should note that even if the constraints are identical in each instance, using differing objective functions will result in differing solutions to the problem of foreign-currency debt allocation.

While the optimization constraints and modeling of the macroeconomy could be discussed in great detail, only the key differences are discussed here. These include the modeling of the main macroeconomic variables, most notably inflation, and the treatment of exchange rate uncertainty. It is interesting to note that Bohn (1990) uses the identity deriving from the quantity theory of money for inflation determination along with the cash-in-advance constraint. All other studies reviewed above use a cyclical, as opposed to long-run, relationship to model inflation, most notably the Phillips curve in its different closed/open economy variations. As also noted by Bohn (1990), the latter could have implications for the implied covariances of major macroeconomic variables, such as output and inflation, and affect the ultimate results for debt allocation. While these implications mainly relate to the allocation of domestic- versus foreign-currency debt, they also matter in the allocation of foreign-currency debt across different currencies. Furthermore, Bohn assumes in his framework that purchasing parity holds and that there is no exchange rate uncertainty. Thus, his results hinge solely on the synchronization and different degrees of dominance of domestic and international shocks. However, in the analyses of Giavazzi and Missale (2004) and Licandro and Masoller (2000), exchange rate uncertainty, along with exchange rate determination, plays a crucial role in the solutions for currency allocation of sovereign debt.

While the majority of the reviewed approaches to debt currency allocation emphasize the role of the exchange rate risk (uncertainty) and synchronization of domestic fundamentals and exchange rates as the key concepts in determining the optimal portfolio weights in their solutions, Bohn (1990) relies on long-term theory focusing on foreign and domestic shocks variation and their synchronization, leaving out the exchange rate altogether. Bohn finds that if inflation is positively correlated across countries, nominal domestic- and foreign-currency debts, become substitutes, as opposed to complements, in the liability portfolio of governments.

Extending this logic to multi-currency case, the foreign currency with the highest correlation of its inflation with the domestic inflation would be the best substitute for the domestic-currency nominal debt. In addition, Giavazzi and Missale (2004) find that covariances between the returns (costs) of different debt instruments are vital in determining currency weights in the sovereign debt portfolio, where positive covariance of the returns characterizes the related debt instruments as substitutes. Extending this result to the multi-currency case, covariances among all exchange rates of candidate currencies should be also considered in an optimal currency structure of foreign-currency debt.

Though analytical frameworks are convenient for their tractability and neat solutions, crucial parameters involving variance and covariance of main macroeconomic variables need to be calibrated to reflect the specifics of a given economy. In this respect, these approaches become somewhat problematic, as different authors employ different metrics, such as using unconditional versus conditional moments of variables. The identification of conditional moments from the data is particularly challenging, as it amounts to identification of structural shocks and their cross-correlation, which is often assumed to be zero for identification purposes in the empirical work.[12] Therefore, from a policy perspective, the analytical approaches are likely more useful for forming strategic guidelines for debt management rather than for determining strategic benchmarks for optimal debt portfolio allocation.[13]

2.2 Numerical Approaches

There are other approaches that deal with minimization of a government loss function while taking into account the structure of the government balance sheet and possible shocks the government may face. While these numerical approaches do not provide an explicit analytical solution that would guide one conceptually in the choice of the currency structure for foreign-currency debt, they do provide one with "exact" numbers as an output from the numerical optimization encompassing simulations from macroeconometric or financial models. The indicators each numerical method produces constitute key inputs into the government's

[12] See, for instance, the vast literature working with structural autoregressive models (SVARs).
[13] See Melecky (2009) for a cross-country analysis of public debt management strategies.

candidate objective function, as their values could be minimized or maximized in accord with government preferences. Work involving the following broadly specified indicators is reviewed: (i) cost at risk (CaR) or value at risk (VaR), (ii) default probability based on a specified government's debt-to-GDP default ratio, and (iii) default probability based on a distress barrier. Although the indicators ultimately look at similar risk measures, we prefer to draw a slight distinction among the three groups with regard to the structures of the numerical approaches.

The first group includes analysis conducted, for instance, by the Bank of Canada (Bolder, 2002, 2003); Danmarks Nationalbank (2006); Hahm and Kim (2004) in reference to Korea; the U.K. Debt Management Office (2006) and Pick (2005) in reference to the United Kingdom; Bergstom and Holmlund (2000) in reference to Sweden; and the Peruvian Ministry of Economy and Finance (2005). The main indicator of interest within this group is the CaR measure, which expresses risk as a percentile distance, typically between the 50th and 95th percentile of the simulated cost allocation.[14] The larger the percentile distance, the higher the risk within the government liability portfolio. Cost is typically measured as a ratio to GDP and can be expressed either in nominal or real terms. Typically, CaR is simulated by a model that includes the paths of underlying economic/financial variables such as interest rates, output growth, inflation, and exchange rates, along with a financial accounting framework for computation of the cost measure for each generated scenario. Since the financial accounting framework is deterministic and fixed for each model,[15] the crucial part in this case is the model simulating the paths of the underlying economic variables.

The work of the Bank of Canada and Danmarks Nationalbank focuses on simulation of the term structure of interest rates, as the interest rate risk is a major focus there. In their model for Korea, Hahn and Kim (2004) combine the concept of the efficient frontier with estimates of CaR penalties to derive the optimal benchmark portfolio for government debt. In the model for Peru, the process used to generate discrete-time observations of financial

[14]For a detailed explanation of this method, see Danmarks Nationalbank (2000).

[15]The fixed structure can, however, differ across models depending on the selected level of aggregation of the borrowing instruments (categories).

variables is derived from a multivariate, continuous-time model. On the other hand, the model for Sweden is a discrete-time model based on univariate autoregressive processes with regime switches characterizing the data generating processes (DGPs) of the economic variables. Finally, Pick (2005) uses a reduced form of an implicit structural model in combination with regime switches to generate the likely paths of economic variables in the United Kingdom.

The second group of numerical approaches considered here includes Garcia and Rigobon (2004) and Xu and Ghezzi (2004). In general, their approach also uses simulated paths of economic variables and the debt structure to compute corresponding government debt-to-GDP ratios. The numerous possible paths of the variables give rise to a distribution of the debt-to-GDP ratios at each point in time. The probability mass in the tail of these distributions cut off by a specified debt-to-GDP default threshold is then used as a measure of the probability that a government's finances will be unsustainable at a given point in time. The two approaches differ mainly in the aspect of using discrete- and continuous-time model specifications, respectively. Garcia and Rigobon (2004) use an unrestricted vector autoregressive model to simulate the economic variables, whereas Xu and Ghezzi (2004) use a system of Brownian motions as the basis for their simulation.

Finally, the third group of numerical approaches, Gapen et al. (2005) and Gray et al. (2005), works with an explicit measure of sovereign credit risk derived from a contingent claim analysis. Gray et al. use option pricing formulas to capture possible non-linearities in the relationships of interest. They start from determining a distress barrier analogous to the default threshold, as in the second group, which is to some extent endogenized in this framework. The distress barrier is determined based on the seniority of consolidated government's liabilities. More specifically, Gapen et al. assume that the distress barrier is equal to the book value of the short-term foreign-currency debt plus interest and one-half of the long-term foreign-currency debt.[16] The value of domestic-currency liabilities is then modeled as an implicit call option on sovereign assets. In a nutshell, the distance to distress and the measure of sovereign credit risk

[16]Although this approach fundamentally treats the distress barrier as fixed or deterministic (fixed for a certain period) from a practical point of view, it can be also random and have a distribution.

is derived from the probability mass in the tail of the distribution for the value of assets at a given point in time. The tail containing the probability of default is cut off by the distress barrier.

One can use the approaches in established in these three groups to set up an optimization that estimates the optimal weights on each currency considered for denomination of foreign debt. Proceeding along these lines, one can take the calibrated model structures of the frameworks in the three groups as a set of constraints and minimize the value of a relevant indicator, say probability to default, while varying (optimizing over) the weights of individual currencies in the foreign-currency debt portfolio. Such numerical approaches can provide greater insight compared to more analytical or judgmental approaches, particularly due to their higher granularity and assumed non-linearities. Although not as apparent as in the case of the analytical approaches, the results of the numerical frameworks hinge upon how the model structures that generate the economic variables are calibrated. The most crucial parameters in this respect will be again the covariances of variables or basic shocks generating those variables and their volatility. If the parameters are estimated, the assumption about conditional means of the modeled variables may considerably influence estimates of the shocks' covariances. Nevertheless, the numerical models have potentially greater use in identification of strategic debt portfolio benchmarks than the analytical approaches due to their more refined nature. However, one has to be especially careful when using non-linear models for policy decisions, as mistakes in calibration of such models have potentially much greater impact on the outcomes.

It is crucial that the development of numerical models to support the decision-making process of debt managers follows a top-down route—i.e., responding to the questions raised at the managerial levels rather than introducing unnecessary complexity and detail from the start. In addition, given the limited capacity of debt management offices in developing countries, we do not see the numerical procedures as the mainstream approach. Instead, we suggest that forecasts of the expected paths for economic fundamentals such as output growth, interest rates, inflation, and exchange rates (including their associated confidence intervals) be taken from the national central banks, which have usually much higher capacity in this respect and put considerable effort into forecasting of such variables. This can enable sovereign debt managers to construct baseline scenarios and perform a sensible scenario analysis. The use of

macroeconomic predictions from the national central banks is also advisable in order to ensure consistency of macroeconomic policies and the assumptions on which they are based.

3 Issues with Current Policy Approaches

Typical economic problems dealing with optimal foreign-currency allocation within sovereign debt portfolios imply that such allocation is to a large extent determined by magnitudes of covariances between domestic fundamentals and the considered exchange rates, and by variances of the considered exchange rates (see Section 2). In this section, we aim to further discuss (i) the economic concept underlying the variances and covariances in the aforementioned economic problems, (ii) their empirical measures, and (iii) their role in risk analysis of sovereign debt portfolios.

3.1 Covariances of Exchange Rates and Domestic Fundamentals

Following the outlined structure we first discuss point (i), the economic concept underlying the role of the covariances in problems dealing with the optimal currency denomination of foreign debt. The covariances appear in the solution results because both the variables characterizing servicing costs of the debt and performance of the domestic economy (random variables) and the economic structure relating all the economic variables in question are uncertain. The main purpose of the covariances is thus to capture the structural links among the economic variables of interest. Essentially, one would like to capture a structure that is coherent in terms of available theory and stable over time. Nevertheless, especially in developing and emerging market economies, structural links between economic variables are evolving, sometimes substantially as countries adjust their production, new economic policies are implemented, and the transition process to market economies takes hold. Moreover, the covariances employed for characterization of the structural links among economic variables should reflect the perspective and decision horizon of a sovereign debt manager, which usually covers a period of at least three to five years. The estimated covariances are thus intended to be sustained and forward looking, although higher-frequency and historical data are often used to estimate them.

This leads us to (ii), the discussion of empirical measures used to capture the

covariances. There are essentially two ways to proceed in this respect: one can work with either the economic variables themselves (i.e. unconditional covariances) or the underlying structural shocks driving those variables (i.e. conditional covariances). Both approaches have pros and cons. When working with the variables themselves, one has to be careful about how the individual time-series components impact the big picture one would like to obtain. Each variable includes a trend component (both deterministic and stochastic) and a cyclical (short-term) component.[17] While the trend components will commonly dominate the cyclical components in estimations involving longer time series, the cyclical components may deliver a very different and sometimes more important story for the debt managers about the economic structure. The trend components mostly arise due to the transition and catching-up processes the developing countries are experiencing and its dominance is often valid not only from a statistical but also an economic point of view.

Employing the economic variables themselves for estimation of covariances has the disadvantage of assuming that the conditional mean of the variables is constant and not putting any economic structure on the estimation. The latter refers to the fact that, ideally, one would want to capture the underlying forces (structural shocks) that drive each variable and leave out the systematic component. The main challenge associated with this approach is the structural identification of the underlying shocks. Neither Licandro and Masoller (2000) nor Giavazzi and Missale (2004) apply structural identification of the underlying shocks, and thus fail to capture the covariances of interest in their estimations. Licandro and Masoller use one-step-ahead forecast errors from a VAR model to characterize the underlying shocks, while Giavazzi and Missale use a reduced form[18] of an implicit structural model to do the same. In both cases, the authors identify a structural shock as the estimated (forecast) error attached to a given variable,

[17]We ignore seasonality in our discussion, as this component is usually eliminated from the data before it is employed in analysis.

[18]One can object to this classification and claim that Giavazzi and Missale use a structural model. What is considered a structural model here is a system of equations in which the contemporaneous covariance matrix of endogenous variables is not simply an identity matrix, as in the case of Giavazzi and Missale, where the structure would derive purely from lag selection. The classification used here is thus more in line with the SVAR and New Keynesian models.

e.g. a demand shock as the residual from the output equation of their VAR. In fact, in both cases, the identified shocks appear to be a combination of the structural shocks, so that the estimated covariances among the shocks do not provide the information the authors sought. It is essential to employ methods that allow structural identification of the underlying shocks in this respect, such as structural VAR models or micro-founded models featuring rational expectations. However, in those models, the structural shocks are often assumed to be uncorrelated for identification purposes, so that any estimated empirical covariances should be zero to avoid contradictions with the *a priori* estimation assumptions.

Moreover, from an empirical point of view, estimating the covariances between exchange rates and domestic fundamentals will most likely provide very little information that would help debt managers decide on the optimal allocation of foreign-currency debt. This is due to the fact that the covariances are usually very low or not statistically different from zero—see, e.g. Bohn (1990b; Table 4, columns 2-3). This might be due to the failure of the fundamentals to predict exchange rates (Meese and Rogoff, 1983). On the other hand, Engel and West (2005) argue that although exchange rates cannot be predicted by economic fundamentals, exchange rates have some power in predicting the fundamentals. The latter would suffice to produce at least some correlation between an exchange rate and the fundamentals that would guide debt managers in their decisions. What we see as the main problem from the policy perspective is the use of relatively high-frequency data and the *actual* exchange rate for estimation of the covariances among the model variables of the theoretical framework—here, the exchange rates and the economic fundamentals. This is due to the fact that the exchange rate observations show a substantial amount of noise[19] that blurs the information one strives to retrieve from the covariances. To illustrate this point, consider the following example. Assume that the DGP for the exchange rate, s_t, is

$$s_t = \tilde{s}_t + \varepsilon_{s,t}, \tag{1}$$

where $\tilde{s}_t$ is the fundamental (equilibrium) value of the exchange rate given by

[19] In the short run, the trading in the exchange rate markets is not based on currencies' fundamentals and is driven largely by trends in the trade set by chartists. Fundamentalists come to trade only if there is a sizable adjustment needed to bring the exchange rate to its fundamental value (De Grauwe and Grimaldi, 2005).

$$\tilde{s}_t = \pi_t - \pi_t^* , \tag{2}$$

where π_t and π_t^* are domestic and the foreign inflation, respectively, following simple AR(1) processes, i.e.

$$\begin{aligned} \pi_t &= \rho^* \pi_{t-1} + \varepsilon_{AS,t} \\ \pi_t^* &= \rho \pi_{t-1}^* + \varepsilon_{AS,t}^* \end{aligned} . \tag{3}$$

Finally, assume that the domestic output growth is generated as

$$y_t = \rho_y y_{t-1} + \varepsilon_{AS,t} + \varepsilon_{IS,t} , \tag{4}$$

i.e. by a combination of the supply and demand shocks. We set $\mathrm{var}\left(\varepsilon_{AS,t}\right) = \mathrm{var}\left(\varepsilon_{IS,t}\right) = 1$ and $\mathrm{var}\left(\varepsilon_{AS,t}^*\right) = 0.5$, $\mathrm{var}\left(\varepsilon_{s,t}\right) = 10$ using the common knowledge that flexible exchange rates are usually more volatile than other economic fundamentals; further $\rho = \rho^* = 0.8$ and $\rho_y = 0.6$. We generate 10,000 observations of the variables and compute the correlation of both the domestic output growth, y_t, and inflation, π_t, with the *actual* and *equilibrium* exchange rates, s_t and $\tilde{s}_t$.

Table 1: Simulated Exchange Rate Covariances

	s_t	$\tilde{s}_t$
y_t	0.0090	0.1208
π_t	0.0666	0.5003

The results illustrate our point that the large amount of noise in the actual exchange rate observations precludes the investigator retrieving the desired information on structural links between the variables. Given this and the fact that the decision horizon of sovereign debt managers is medium to long term, one should employ some measure of an equilibrium exchange rate when trying to estimate the covariances between an exchange rate and domestic fundamentals to be used in the theoretical model. There are various concepts of the equilibrium

exchange rate.[20] One of the most popular and suitable for emerging markets economies is the behavioral equilibrium exchange rate (BEER) discussed by Clark and MacDonald (1998). This concept is relatively simple and allows more empirically-driven selection of the equilibrium exchange rate determinants.

Concerning point (iii), the risk analysis, in addition to the concept of equilibrium exchange rate, one should work with future scenarios that allow information on likely developments in the structure of foreign trade, intended utilization of comparative advantages, strategic diversification of exports and imports, possible financial-market integration and its impact on the currency structure of capital flows, and economic integration (such as accession to a trade or currency union) to be incorporated. Further, working with equilibrium exchange rates allows debt managers to carry out comprehensive risk analysis even when the local currency is pegged against a certain foreign currency.

Consider the Russian 1998 debt crises, before which the government of Russia was happy to expose its balance sheet to potential movements in the RUB/USD rate, since at that time the ruble was pegged against the dollar. That behavior, however, ignored the fact that a severe misalignment of the RUB/USD exchange rate had developed. Russia's 1998 debt crises was triggered by a currency crisis that took hold as the needed adjustment of the pegged rate towards the shadow market rate was exercised by the markets. More generally, if debt managers use the pegged rate in their analysis, they focus entirely on risk minimization and ignore the covariance between the financing cost of foreign debt and domestic fundamentals of government primary balance altogether, as the covariance of domestic variables with a hard peg is essentially zero. The covariances can be deceiving under a currency peg, since the rate is sustained more by central bank's interventions than market forces and fundamentals. Debt managers are thus interested in *relative* expected covariances of domestic fundamentals with exchange rates against candidate currencies for foreign-currency debt denomination. Employing equilibrium exchange rates[21] to perform a relative comparison of the covariances across

[20]For an overview of NATREX, FEER, DEER, BEER, and other models, see MacDonald (2000) or Driver and Westaway (2005).

[21]The use of equilibrium exchange rate is probably not the ultimate solution due to the lack of a general agreement

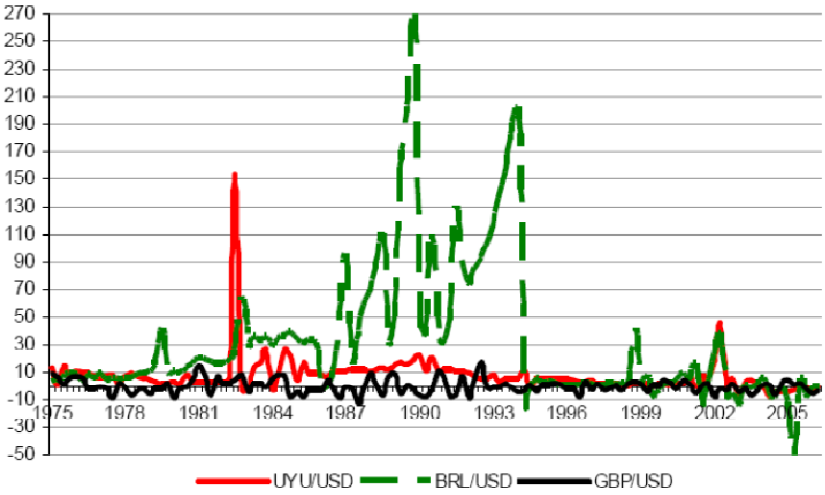
candidate currencies has the clear advantage of exercising equal treatment.

3.2 Exchange Rate Variance

Another important parameter for decisions on currency allocation of foreign-currency debt is the degree of uncertainty concerning future movements in exchange rates. This uncertainty is often approximated by estimated volatility (standard deviation) using historical data. Unlike the covariances, which are intended to capture the economic structure and help in thinking about future trends in economic development (i.e. the central tendency of variables), exchange rate volatility is intended to capture the magnitude of likely deviations of exchange rates from their future central tendencies. Similar to the calibrated covariances, exchange rate variance is intended to be forward looking. Since the historical data of developing countries often includes both relatively tranquil periods and periods of currency crises, there appear to be large spikes in the data mostly in the direction of large depreciation. In addition to isolated spikes in the exchange rates of developing countries, the series often also show clustering of volatility (see Figure (1)). This clustering of volatility stems from the fact that one crisis is often followed by another, or that a crisis triggers major restructuring or resetting of macroeconomic policies that themselves induce swings in the economic performance of a given country.

Figure 1: Historical Changes in Selected Exchange Rated

on a suitable model for equilibrium exchange rates. It is rather a step forward in the direction of a more structural approach to foreign exchange risk management, one that is being currently developed in a companion paper.



To determine the currency allocation benchmark for a foreign-currency debt portfolio, one requires an overall measure of the riskiness of each currency—i.e. the overall measure of relevant exchange rate volatility. The estimation of volatility can be revised on a yearly basis, as can the currency benchmark for foreign-currency debt. However, one must make a choice regarding which period is to be covered in the estimation. The estimation period can then cover crises periods, different exchange rate regimes and macroeconomic policies. Estimations based on historical data can therefore be deceptive, and one must make judgments about how risky each foreign currency is likely to be in the future. We illustrate how the choice of the estimation period matters by computing standard deviations for the three exchange rate series plotted in Figure (1) for different periods. The results are shown in Table (2), where uyu/usd, brl/usd, and gbp/usd denote exchange rates of the Uruguayan peso, Brazilian real, and British pound against the U.S. dollar.

Table 2: Changes in Foreign Exchange Risk Estimates with Differing Time Span

	Standard Deviation of		
As of	d(uyu/usd)	d(brl/usd)	d(gbp/usd)
1975	14.9205	49.4310	5.1868
1985	7.6615	57.9931	4.9470
1995	7.6051	13.1201	3.3610

Lower cases denote logs and *d* denotes the first difference operator

Furthermore, if a currency peg is exercised with respect to a certain currency and not others, the extremely low volatility in the case of the pegged exchange rate can be misleading, since the central parity can be severely misaligned with respect to the equilibrium exchange rate that would restore a country's external balance. Such misalignment creates potential for large depreciation, which constitutes risk that debt managers are not taking into account when working with the *actual* as opposed to the *equilibrium* exchange rate. For the purposes of adequate risk consideration, we argue that one is better off working with some measure of equilibrium exchange rates, as this ensures more conservative and comprehensive treatment of the foreign exchange risk and does not bias the relative magnitudes under different exchange rate regimes either across currencies or over time.

Concerning risk analysis, standard practice among sovereign debt managers is to stress-test scenarios involving possible future trends in domestic fundamentals and the exchange rates by generating disturbances from assumed Normal distributions of the relevant variables, where the parameters of the distributions have been estimated on historical data. We do not think that this approach to stress testing of a debt portfolio or an entire balance sheet generates the insights one would like to acquire from such an exercise. Instead, we suggest following the argument started in the previous section on covariances that variances used to establish a currency benchmark for foreign-currency debt be computed using some equilibrium measure of exchange rates. This addresses two possible misperceptions in estimations of exchange rate risk (expected volatility).

First, a misperception could arise in regard to the choice of foreign debt denomination under fixed exchange rate regimes. If debt managers rely on the promise of the national central bank to sustain the announced peg at all times, they ignore the risk of mismanagement of the pegged exchange rate regime and the possible emergence of exchange rate misalignments and, consequently, speculative attacks. However, if an equilibrium exchange rate is employed, debt managers get a better picture about the underlying forces behind medium-term exchange rate movements and their volatility relative to other foreign currencies.

Second, if currency crises emerge and the exchange rate peg is abandoned, one would

not want to include the excessive volatility during the current period in expectations of future volatility, nor would one want to assume that the currency crisis would occur under more flexible exchange rate regimes. Again, the equilibrium exchange rate can serve as a useful filter so that the expected volatility (risk) is measured consistently across candidate currencies. It is thus not the observed volatility per se that the debt managers need to take into account; rather, it is the *relative* expected volatility across exchange rates with respect to candidate currencies for foreign-currency debt denomination.

In estimations of the conditional expected volatility for individual exchange rates, one essentially allows for time variation in these variance estimations based on the information set available at the time when the expectation is formed. This process is analogous to estimation of the conditional mean of variables, as applied e.g. by Missale and Giavazzi (2004), for the main macro variables. Nevertheless, even the analytical approaches fall short of considering conditional expectation of the exchange rate variance and other macroeconomic variables, as they are often postulated in the analytical solutions (see, e.g. Missale and Giavazzi, 2004, and Bacchiocchi and Missale, 2005).

One can address this shortcoming either through better statistical description of the time-varying variance using models of time-varying volatility or mixtures of distributions. A simple approach could be to let the variance depend on its past value or some function for its past value using (generalized) autoregressive conditional heteroscedasticity models (see Bollerslev, 1986), mixtures of distributions (McLachlan and Basford, 1988), or models of stochastic volatility (Hull and White, 1987). The latter approach is especially appealing from the point of view of economic analysis since it enables one to adopt a more structural approach when estimating the conditional expected variance.

Such estimation could be easily reconciled with the literature modeling the exchange rate variance (Bayoumi and Eichengreen, 1998; Devereux and Lane, 2003). While in general the pure gravity models do not help much in estimating the relative expected volatility across individual exchange rates, the models of Bayoumi and Eichengreen (1998) and Devereux and Lane (2003) also include synchronization indicators such as the degree of synchronization in GDP growth or inflation. Melecky (2010) follows this avenue and estimates the significance of a

whole range of synchronization indicators in determining exchange rate volatility, finding that measures of inflation synchronization, money velocity synchronization, and interest rate synchronization are useful indicators for determination of expected exchange rate volatility.[22] Using the synchronization indicators of exchange rate volatility enables sovereign debt managers to bring some economic structure and a forward-looking focus in the process of choosing the optimal currency allocation of foreign-currency debt.

4 Conclusion

This paper overviewed approaches policy makers could employ to determine the most suitable currency structure for their foreign-currency debt in light of the constraints and incentives that make sovereigns issue debt in foreign currency. These include, most notably, rationing of the sovereigns in their domestic markets, opportunistic debt issuance aimed at decreasing the cost of debt, and exploiting the hedging attributes of foreign-currency debt. The opportunistic issuance of foreign-currency debt could be driven by the prevailing cost-minimizing objective over the risk-minimizing one. The combination of risk- and cost-minimizing goals could be expressed in a formal objective function of the debt managers. The objective function is optimized with respect to the constraints originating in the structure and functioning of the domestic macroeconomy and the initial conditions, including the current structure of the government liability portfolio, in order to derive a strategic benchmark portfolio as the intermediate target for the debt management policy (here, a parallel to inflation targeting could be drawn). The objective functions of the reviewed policy approaches differ according to their risk- or cost-minimizing focus. Even by itself this introduces arbitrariness in the optimized currency structure of the strategic benchmarks. In addition, different approaches model the macroeconomic constraints and initial conditions using a different degree of aggregation and complexity, including non-linearities. Nevertheless, the crucial parameters driving the solution for the strategic benchmarks for foreign-currency debt are the covariances of macrovariables,

[22] Melecky (2010) employs annual data for 44 middle-income countries (MICs) over the period 1976–2006 and considers the exchange rates of the MICs currencies against the U.S. dollar, the euro, and the Japanese yen.

most importantly those of the macrovariables with the exchange rates, and the variances of the exchange rates.

In order to properly capture the expected covariances between exchange rates and other variables, we suggest that sovereign debt managers work with *equilibrium* exchange rates instead of the *actual* ones when employing the reviewed policy approaches in practice. This suggestion is based on the fact that actual exchange rates carry a lot of noise which precludes the debt manager relying on inference based on historical data. Further, both the covariances between domestic fundamentals and exchange rates, and the exchange rate variances, can be deceptive when a fixed exchange rate regime is maintained. This is because the shadow (equilibrium) exchange rate, which would balance the external accounts of the country, is not revealed and captured in the analysis of the covariances, and because the risk of possible large depreciation of the domestic currency due to exchange rate misalignments is not explicitly considered. Moreover, the fact that the estimates of exchange rate variances should be forward looking and conditional on a time-varying information set necessitates a different approach than that employed in the reviewed policy approaches. In this respect, we suggest using the synchronization indicators of movements in corresponding foreign and domestic fundamentals in policy analysis to better capture the underlying drivers of exchange rate volatility across various foreign currencies.

Future work could focus on development of simple and robust policy frameworks that developing countries can use to find suitable strategic benchmarks (or guidelines) for the currency structure of their foreign-currency debt. In this respect, the promising avenue could be the use of synchronization indicators aimed at capturing the degree of convergence of the real and monetary sectors of the domestic and foreign economies, in particular the forces behind foreign trade, capital flows, and remittances. The synchronization indicators could be used not only to understand exchange rate volatility, but also to understand the covariances of exchange rates with other macroeconomic variables, thus more effectively exploiting available natural hedges.

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