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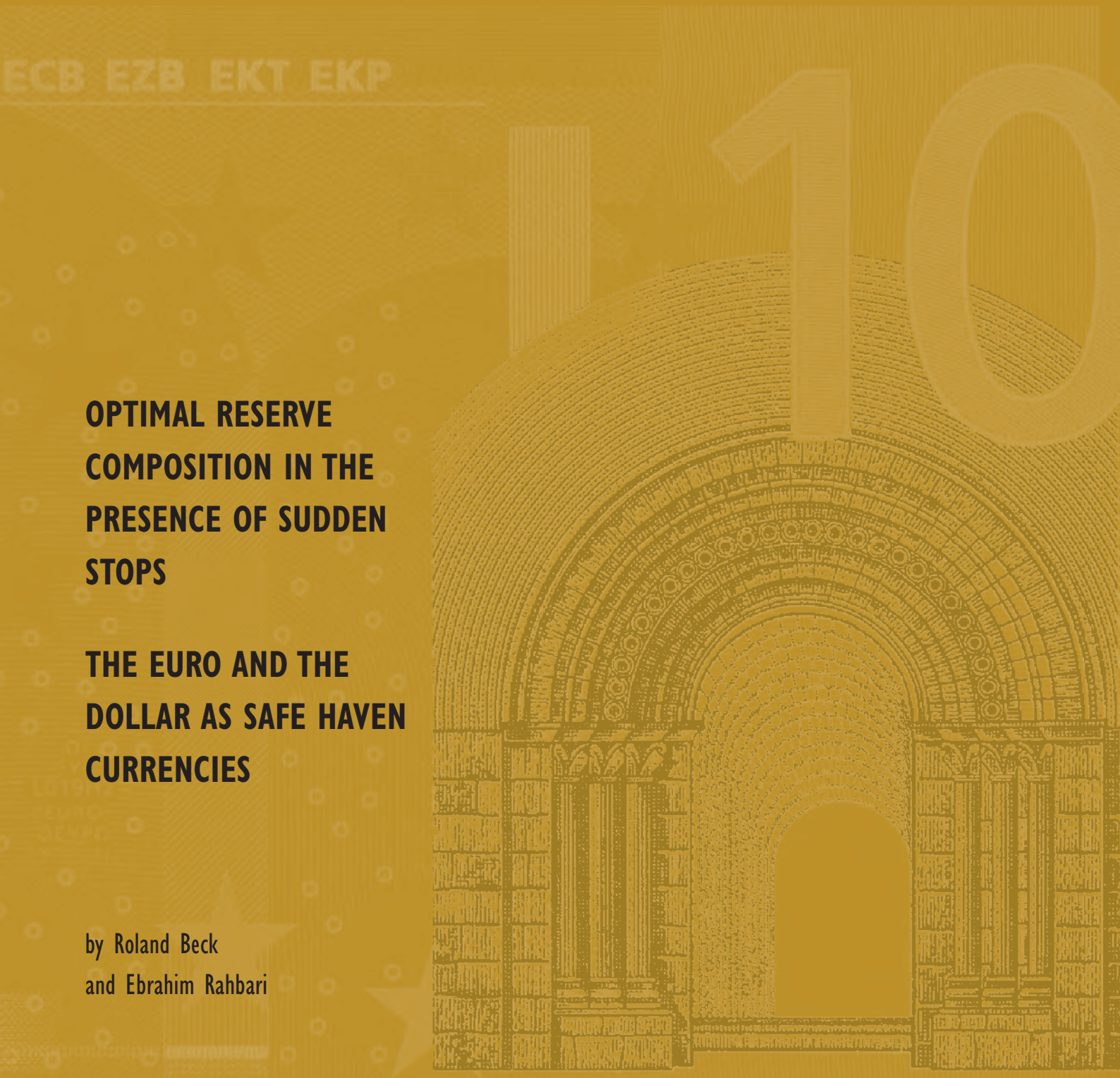

OPTIMAL RESERVE COMPOSITION IN THE PRESENCE OF SUDDEN STOPS

THE EURO AND THE DOLLAR AS SAFE HAVEN CURRENCIES

by Roland Beck

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In 2008 all ECB publications feature a motif taken from the €10 banknote.

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2 European Central Bank, Kaiserstrasse 29, D-60311 Frankfurt am Main, Germany; e-mail: roland.beck@ecb.europa.eu

3 London Business School, Economics Department, Regent's Park, London, NW1 4SA, United Kingdom; e-mail: erahbari.phd2004@london.edu

Address
Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address
Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone
+49 69 1344 0

Website
http://www.ecb.europa.eu

Fax
+49 69 1344 6000

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CONTENTS

Abstract

We analytically derive optimal central bank portfolios in a minimum variance framework with two assets and "transaction demands" caused by sudden stops in capital inflows. In this model, the transaction demands become less important relative to traditional portfolio objectives as debt to reserve ratios decrease. We empirically estimate optimal dollar and euro shares for 24 emerging market countries and find that optimal reserve portfolios are dominated by anchor currencies and, at current debt to reserve ratios, introducing transactions demand has a relatively modest effect. We also find that euro and dollar bonds act as "safe haven currencies" during sudden stops. Dollars are better hedges for global sudden stops and for regional sudden stops in Asia and Latin America, while the euro is a better hedge for sudden stops in Emerging Europe. We reproduce qualitatively the recent decline in the share of the dollar in emerging market reserves and find that the denomination of foreign currency debt has very little importance for optimal reserve portfolios.

JEL Classification Numbers: F31, F32, F33, G11
Keywords: Foreign exchange reserves, currency composition, sudden stops

Non-Technical Summary

Emerging market central banks have accumulated in recent years sizable levels of foreign exchange reserves and have, until now, invested these foreign assets mainly in US government securities. In view of the high level of these reserves and the fact that the euro may have become a "credible competitor" to the dollar as reserve currency, a debate has emerged whether a diversification into euro-denominated assets was to be expected.

According to the available data on the currency composition of foreign exchange reserve held by emerging market central banks, the share of the euro has gradually increased since the launch of the European Monetary Union. However, this trend appears to have levelled off in recent years. We offer an explanation of these stylised facts which is based on a new framework for optimal reserve portfolios in emerging markets.

In the theoretical literature on central bank reserve portfolios, it is typically assumed that central banks behave like normal investors trying to achieve the highest return for any given level of desired risk which is commonly believed to be small for central banks. However, the empirical literature has documented that "transactions motives" stemming from the need to intervene, finance imports or external debt appear to be important determinants of the currency composition of official reserves.

In this paper, we attempt to combine both transaction needs and wealth diversification motives in a single theoretical framework. Here, the central banks can invest in dollar or euro-denominated bonds and minimises the portfolio variance in real local currency terms. Transaction needs arise because countries are subject to sudden reversals in capital flows ("sudden stops") and the central bank uses its reserves to repay the short term foreign denominated debt that is not rolled over in these events. In this framework, optimal portfolio weights depend, in addition to standard minimum variance variables, on the extent to which these assets can be used to hedge against sudden stops.

In our empirical application, we compute optimal portfolios for a number of emerging market economies and regional aggregates. Our results first confirm previous findings which suggest that a standard minimum variance portfolio in local currency (abstracting from transactions demand considerations) is dominated by the "anchor currency" if the country operates de facto an exchange rate peg or tightly managed float. Therefore, countries in Asia and Latin America tend to have high optimal dollar shares whereas the euro dominates the reserve portfolios of countries in Emerging Europe. Countries with more flexible exchange rates tend to have more diversified portfolios.

We then compute optimal central bank portfolios using three different definitions of transactions demand taking into account global, regional and country-specific sudden stops. Using our global measure of sudden stops, we find that optimal dollar shares tend to be higher when we include transactions demand. When we use our regional measure of transactions demand, we obtain a regionally varying pattern, with the optimal dollar share rising in Asia and Latin America, while countries in Emerging Europe would hold more euro denominated assets. We tentatively interpret these findings as reflecting the status of the dollar and the euro as "safe haven currencies" which tend to appreciate during sudden stops in

which investors redirect capital to mature markets. While the dollar appears to retain his traditional role as the currency of choice in such circumstances, the euro appears to have assumed a similar role in Emerging Europe.

Our results are also consistent with the observed trends in aggregate data on the currency composition of reserves in emerging market economies. According to our model, the decline of the share of the dollar could reflect the notion that transaction motives have become less important as a consequence of rising reserve levels. Likewise, the subsequent stability of currency shares may be seen in the light of our model as a reflection of optimal reserve portfolios converging to standard minimum variance portfolios.

1 Introduction

Emerging market central banks have recently accumulated very large amounts of foreign exchange reserves. Since 1999 foreign exchange reserves held by developing countries have more than quadrupled and now amount to more than four trillion dollars (around 75% of global foreign exchange reserves, see chart 1 in Appendix 7.1). Until now, a large share of these foreign exchange reserves of emerging market central banks has been invested in US government securities. However, recently a debate has emerged whether more diversification was to be expected, in particular in the light of high absolute reserve levels for many countries. This debate is all the more topical, as emerging market central banks have financed an increasing part of the US current account deficit and may have contributed in recent years to low US interest rates (Warnock and Warnock (2006)). In addition, some have argued that the euro has become a "credible competitor" (Chinn and Frankel (2005) for the dollar as reserve currency. In fact, euro-denominated bond markets have become very liquid and caught up with the dollar-denominated markets in terms of size.[1]

But despite the strong policy interest thorough analysis of official reserve choices has been hampered by poor data availability on the empirical side and the lack of a convincing model for central bank behaviour on the theoretical side. Only around one half of emerging market reserves are included in the International Monetary Fund's (IMF's) "Currency Composition of Official Foreign Exchange Reserves" (COFER) database. In addition, many countries have transferred official foreign exchange reserves from their central bank to sovereign wealth funds (see e.g. ECB (2007a)). For those countries which report the currency composition of their "traditional" reserves to the Fund, the IMF publishes figures for the emerging market aggregate which suggests that the share of the dollar in emerging market reserves has decreased from 71% in 1999 to 61% as of June 2007. During the same time, the share of the euro has increased from 18% to 29%. However, the bulk of these developments have

[1] Bid-ask spreads of euro-denominated government bonds declined from about 0.08% in 2003 to 0.05% in 2006 (ECB (2007b, p. 61)). For a comparison of the microstructure of euro debt markets with those of the US and the UK, see Dunne et al (2006). According to the BIS, the share of the euro in global bond markets has gradually increased since 1999 from around 24% to around 30%. During the same time period, the share of the dollar has decreased from around 47% to 42%.

taken place until end-2004. Since then, aggregate currency shares have remained relatively stable (see chart 2).

We offer an explanation of these stylised facts which is based on a new framework for optimal reserve portfolios in emerging markets. Central bank behaviour is thought to be motivated by "transaction needs" and "wealth diversification" (Roger (1993), ECB (2004)). The wealth diversification motive for central banks is supposed to be working in the same way, as for normal investors, motivating them to pursue the maximum return for a given amount of risk, with the only potential difference being a smaller appetite for risk for central banks as opposed to normal investors. Transaction needs are somewhat unique to central banks and encompass temporary import financing, foreign exchange interventions or the balancing of capital outflows. While the need for reserves for import financing purposes is rather small even for most emerging market countries, the financial crises in Asia and Latin America have reaffirmed the importance of the other transaction motives for holding foreign exchange reserves. But while empirical studies using confidential data provided by the IMF (Heller and Knight (1978), Dooley et al (1988) and Eichengreen and Mathieson (2000)) or the publicly available aggregates (Chinn and Frankel (2005)) have generally found transaction motives to be important for central bank currency choices, quantitative theoretical work has largely ignored these and focussed solely on portfolio considerations (see e.g. Ben Bassat (1980)).

In this paper, we attempt to combine both transaction needs and wealth diversification in a single framework and compute optimal portfolios for a number of emerging market economies and regional aggregates. Here, the central banks can invest in dollar or euro-denominated bonds and minimise the portfolio variance in real local currency terms. In our framework, transaction needs arise because countries are subject to sudden reversals in capital flows ("sudden stops") and the central bank uses its reserves to repay the short term foreign denominated debt that is not rolled over in these events (see Calvo et al (2004), Jeanne and Ranciere (2007), Rothenberg and Warnock (2006) for evidence on sudden stops). We focus on emerging market economies, as these economies have accumulated a large amount of reserves in recent years and are more likely to be subject to high volatility in capital inflows.

In our framework, optimal asset shares depend, in addition to their variances and the covariances of the assets with each other on the extent to which these assets can be used to hedge against sudden stops. This sudden stops risk consists of both exchange rate risk – as the liabilities are denominated in foreign currency – and risk associated with the occurrence of a sudden stop. While the former provides a rationale for matching the currency composition of debt with the composition of liabilities, the latter may or may not imply such a pattern depending on the covariances of currency returns with the sudden stops. We use our simple model to arrive at an analytical solution for optimal currency shares and show that a rise (decline) in reserves (short-tern debt) leads to a decline of the importance of the transactions demand.

In our empirical application, we first document that a standard minimum variance portfolio in local currency (abstracting from transactions demand considerations) is dominated

by the "anchor currency" if the country operates de facto an exchange rate peg or tightly managed float, as already indicated by Papaioannou, Portes and Siourounis (2006) and others. Therefore, countries in Asia and Latin America tend to have high optimal dollar shares whereas the euro dominates the reserve portfolios of countries in Emerging Europe. Countries with more flexible exchange rates tend to have more diversified portfolios.

We then compute optimal central bank portfolios using three different definitions of transactions demand taking into account global, regional and country-specific sudden stops. We find that introducing transactions demand in general has a modest effect on optimal portfolios, with optimal dollar shares changing by a few percentage points. Using our global measure of sudden stops, we find that optimal dollar shares tend to be higher when we include transactions demand. When we use our regional measure of transactions demand, we obtain a regionally varying pattern, with the optimal dollar share rising in Asia and Latin America, while countries in Emerging Europe would hold more euro denominated assets. We tentatively interpret these findings as reflecting the status of the dollar and the euro as "safe haven currencies" which tend to appreciate during sudden stops in which investors redirect capital to mature markets. While the dollar appears to retain his traditional role as the currency of choice in such circumstances, the euro appears to have assumed a similar role in Emerging Europe.

Our results are also consistent with the observed trends in aggregate data on the currency composition of reserves in emerging market economies. According to our model, the decline of the share of the dollar could reflect the notion that transaction motives have become less important as a consequence of rising reserve levels. Our results also suggest, however, that the optimal dollar share is often still very high when transactions considerations are neglected, suggesting that we should not expect a further rise in reserve levels to lead to strong diversification away from the dollar. If anything, we find that the optimal euro share is somewhat higher in the available data than our model would suggest.

A further significant decline of dollar-denominated assets in the reserve portfolios of emerging economies is only likely if currency arrangements in these countries were to change, i.e. with countries moving towards more flexible exchange rate arrangements or increasing the weight attributed to the euro in the case of pegged or tightly managed exchange rate regimes. In fact, this has happened for example in the case of Russia which introduced a dollar-euro currency basket in February 2005 and subsequently raised the share of the euro in its foreign exchange reserves to 45%. Likewise, smaller reserve holders which recently become new EU members or EU candidates appear to have increased the share of the euro in their reserve portfolios, following a stronger exchange rate orientation towards the single European currency. More recently a debate on the appropriateness of the dollar pegs in the Gulf Co-operation Countries has emerged. However, a change to a currency basket which includes the euro has so far only occurred to a small extent in the case of Kuwait. Beyond these cases, a more prominent role for the euro as currency anchor with a possible diversification into euro-denominated reserves has been either politically motivated or very gradual, suggesting substantial inertia both in exchange rate arrangements and reserve management decisions. In our framework, the inertia in exchange rate arrangements will

also imply very gradual changes in reserve portfolios.

2 Related Literature

The academic literature on the currency composition of official foreign exchange reserves can be traced back at least to Heller and Knight (1978) and can broadly be classified into two general categories: an empirical literature trying to relate the reserve portfolio of central banks to observable country or reserve currency characteristics, and a literature that uses portfolio theory to derive the optimal currency composition of reserves.[2]

Empirical work on the determinants of the currency composition of reserves has been hampered by a lack of publicly available data on the reserve portfolio of individual countries. The International Monetary Fund (IMF) collects data from a number of individual countries, but only publishes aggregate figures in its Currency Composition of Official Foreign Exchange Reserves (COFER) database. In addition to the data made available through the COFER database, the IMF grants researchers access to the confidential data set once every decade or so. Using for the first time a confidential data set on the currency composition of reserves of 76 countries, Heller and Knight (1978) find that a country's exchange rate regime and its trade patterns are significantly related with the currency composition of its reserves. These findings led Heller and Knight to conclude that transaction needs play a major role in determining the currency composition of reserves. Dooley et al (1988) use an updated version of this dataset and find further evidence that exchange rate regimes and trade flows are empirical determinants of the currency composition of reserves and interpret these findings as suggesting that countries alter the currency composition of their net foreign asset position through the composition of assets and liabilities other than reserve assets. Using even more recent confidential country level data, Eichengreen and Mathieson (2000) document for the period 1979-1996 that exchange rate pegs, trade flows and financial flows (i.e. the currency composition of external debt) determine the currency composition of reserves in a sample of 84 emerging and transition countries.

Chinn and Frankel (2005), using the aggregate data for the currency composition of reserves published in the COFER database, regress the currency shares of the main reserve currencies on various characteristics of the corresponding reserve currencies and find evidence that the size of the home country, the inflation rate (or the lagged depreciation trend) of the reserve currency, exchange rate volatility and the size of the home financial market centre are significant determinants of the currency shares in central bank reserve portfolios.

While the empirical literature in general finds evidence for a strong role of transaction motives as a determinant of reserve composition, the existing theoretical literature has for the most part ignored transaction motives and derived the currency composition of optimal reserves as the solution to an international version of a Markowitz type portfolio problem. The discussion then mainly revolved around the right method of applying optimal portfolio

[2]Prior to Heller and Knight (1978) the literature focused on the broader choice between gold, foreign exchange reserves and IMF assets since little information on the currency composition was available.

theory in an international context (i.e. the choice of deflator to calculate real from nominal returns, derivation of exchange rate return expectations, etc), rather than explicitly taking into account that central banks pursue objectives different from a normal investor. The resulting optimal portfolio was then compared to actual portfolios and a small difference between the two interpreted as support for the hypothesis that central banks pursue portfolio objectives. Thus, Ben-Bassat (1980) suggests applying mean-variance optimization in terms of a basket of import currencies. When comparing optimal to actual reserve portfolios using data for 1976 and 1980, he finds some evidence for portfolio objectives as a determinant of the currency composition of reserves of the emerging markets but not for industrialised countries.

Dellas and Yoo (1991) use data on the currency denomination of imports and the reserve composition for South Korea to test both a mean variance optimisation model and an import based version of the consumption capital asset pricing model (CCAPM). They show that actual central bank portfolio was quite close to the efficient frontier computed and that the restrictions implied by the CCAPM could not be rejected, but admit that the power of these tests are low.

In rare attempts to take account of the transaction motives of central banks, Dooley (1983) and Dooley, Lizondo and Mathieson (1988) use a very simple model to show that in the presence of both foreign currency assets and liabilities as well as transaction costs, the composition of gross assets would depend on the structure of transaction costs, and the composition of net assets on expected returns and covariances, in the case of a mean variance optimising central bank. Papaioannou, Portes and Siourounis (2006) investigate the mean variance optimal portfolio at the world level using a variety of methods to estimate covariance matrices and return expectations and different reference currencies. They also experiment with imposing different ad hoc constraints that reflect transaction considerations. The authors find that the reference currency is quantitatively very important and that the computed optimal euro at the world level share is lower than the actual aggregate share published in the COFER database.

On the empirical side, recent papers like Wong (2007) and Lim (2007) examine the impact of past exchange rate changes on aggregate currency shares of foreign exchange reserves and document that currency diversification in response to exchange rate changes have thus far tended to be rather stabilizing for foreign exchange markets, i.e. central banks have tended to pursue "portfolio rebalancing" à la Perold and Sharpe (1995) in which they buy (sell) falling (rising) currencies rather than market trend strategies in which one would buy (sell) rising (falling) currencies. Lim (2007) concludes that these findings are consistent with relatively stable currency shares in the COFER database. He also suggests that these findings may support the view that optimal reserve portfolios have hardly changed over time. Alternatively, Lim (p. 18) suggests that his findings may also support the view that optimal reserve portfolios have changed over time, but reserve managers have on average implemented the change very gradually.

Lately, there has also been renewed interest in explicitly modelling optimal levels of foreign exchange reserves, in part in response to the financial crises of the 1990s and, more

recently, the rapid accumulation of reserves in many developing countries since 2002.[3] In the academic literature, this massive reserve build-up has been explained by "insurance" and "mercantilist" motives. The insurance motive suggests that "hoarding international reserves can be viewed as a precautionary adjustment, reflecting the desire for self-insurance against exposure to future sudden stops" (Aizenman and Lee (2007, p. 192). The mercantilist motive, on the other hand, views the recent accumulation of foreign reserves as a response to concerns about export competitiveness – in particular in the case of China. Aizenman and Lee (2007) document empirically that the insurance motive dominates in the hoarding of international reserves by developing countries. Rodrik (2006) stresses that similar objectives in terms of improving external liquidity positions could have been achieved at lower costs by reducing more forcefully short-term debt. Jeanne and Ranciere (2006) and Jeanne (2007) assume that central banks use reserves to smooth a fall in domestic absorption in the case of sudden capital account reversals and find that optimal reserve levels in their framework are quite close to actual levels in many developing countries, even after the recent rise.

We add to the literature by explicitly introducing transaction motives into the optimal portfolio problem of the central bank, similar to recent efforts in the literature on optimal reserve levels. In our framework, the central bank uses reserves to smooth adjustment in the case of sudden capital account reversals and takes these reversals into account when choosing the optimal reserve portfolio. Since we are interested in the global implications of introducing transactions demand objectives, we also deviate from most of the literature by first obtaining optimal portfolios at the country level and combine the country results to arrive at regional and global aggregates.

3 The Model

3.1 Minimum Variance Analysis for Central Banks

We consider the problem of a benign central bank that chooses between investing in dollar- and euro-denominated bonds and takes into account transaction needs for foreign exchange. These needs can arise because the central bank would like to intervene in the foreign exchange market in order to support the domestic currency, because the central bank would like to cushion the impact of a sudden reversal of capital flows on domestic output or in order to temporarily finance an amount of imports. In the empirical application we focus on sudden capital account reversals. In the related literature these events are often referred to as "sudden stops" (Calvo (1998)) and we will sometimes use this term below. We assume that the economy is subject to an exogenous risk of sudden stops which have the effect that any maturing foreign held short term debt is not rolled over and therefore has to be repaid. The restriction to two assets is made for tractability and because we leave many aspects that differentiate the dollar and the euro from other possible reserve currencies unspecified

[3] For an overview of the reserve accumulation phenomenon, see e.g. ECB (2006).

in our model (liquidity, capital market size, etc).[4]

In our analysis, we assume the investor is minimizing the variance of end of period wealth in domestic real terms taking the level of reserves, the level of foreign debt and the level of the transaction need as given.[5] In addition, we impose a short selling constraint. We believe that the right model would be dynamic, let the central bank choose the level of reserves and foreign debt endogenously and simultaneously with the choice of currency composition, include a richer menu of assets and liabilities and a more general form of preferences. Nevertheless we believe that our approach is meritful for various reasons. Firstly, we would like to study the question of currency composition separately from the question of optimal reserve levels, as the former question has received relatively less attention than the latter. Nevertheless, we do allow the (exogenous) level of reserves to have an impact on the optimal currency composition. Secondly, in the real world the choice of the level and composition of debt in the economy and the choice of the level of foreign exchange reserves of central banks are usually independent of the choice of currency composition of foreign exchange reserves. Thirdly, central banks are very conservative investors and have until recently invested the bulk of their assets in short-term sovereign debt securities. Fourthly, the finance literature has documented that the impact of estimation error on optimal portfolio weights is particularly severe for expected returns but less so for estimation of the variances and co-variances. In response, Chopra and Ziemba (1993) have suggested to simply set all expected returns in an asset allocation problem equal to each other and focus on minimising the portfolio variance which is the approach we take. Finally, these assumptions allow us to arrive at analytical expressions for the drivers of the optimal portfolio decision and these drivers would also feature in a more comprehensive framework.

Formally, the central bank solves the following problem:

$$\begin{aligned} &\min_{\alpha} Var\left[W\right] \\ &s.t. \\ &W = \alpha A R_{US} + \left(1-\alpha\right) A R_{E} - S_{US} b B - S_{E}\left(1-b\right) B \\ &0 \leq \alpha \leq 1, \end{aligned} \tag{1}$$

where W is the real end of period level of wealth, A, α, B, b are the level of foreign exchange reserves, the share of dollar-denominated assets in reserves, the level of foreign debt and the share of dollar-denominated debt at the beginning of the period. R_{US} is the real return on dollar bonds, while $R_E$is the real return on euro bonds and the two are defined

[4] As argued in the introduction, euro and dollar-denominated assets have become reasonably similar in these respects.

[5] In Appendix 7.1 we consider also the case of mean-variance optimisation.

as:

$$R_{US} = \frac{1+i_{US}}{1+\pi}(1+e_{US})$$
$$R_E = \frac{1+i_E}{1+\pi}(1+e_E), \tag{2}$$

where i_{us} (i_e) is the nominal dollar (euro) interest rate, e_{us} (e_e) is the appreciation of the dollar (euro) against the reference currency, and π is a measure of the change in purchasing power (i.e. domestic inflation). S_{US} (S_E) are defined as:

$$S_{US} = \frac{1+e_{US}}{1+\pi}S$$
$$S_E = \frac{1+e_E}{1+\pi}S, \tag{3}$$

where S is a random variable whose realization lies between zero and one and indicates the "extent" of the sudden stop. The transactions demand in our model thus arises because in the case of a sudden stop a certain amount of foreign denominated short-term debt is not rolled over and thus has to be repaid. We assume that the central bank uses its reserves in these cases (see Jeanne and Ranciere (2006) for some evidence that during sudden capital account reversals central banks cushion the impact on domestic absorption). Below we will construct several different variables corresponding to S and we therefore postpone a more detailed discussion until then.

Under our assumptions (and for the moment disregarding the short selling constraint), we can arrive at an analytical solution for the optimal dollar share in the central bank portfolio:

$$\begin{aligned}\alpha = \quad & \frac{A\left(var\left[R_E\right] - cov\left[R_{US}, R_E\right]\right)}{A\left(var\left[R_{US}\right] + var\left[R_E\right] - 2cov\left[R_{US}, R_E\right]\right)} \\ & + \frac{bB\left(cov\left[R_{US}, S_{US}\right] - cov\left[R_E, S_{US}\right]\right)}{A\left(var\left[R_{US}\right] + var\left[R_E\right] - 2cov\left[R_{US}, R_E\right]\right)} \\ & + \frac{(1-b)B\left(cov\left[R_{US}, S_E\right] - cov\left[R_E, S_E\right]\right)}{A\left(var\left[R_{US}\right] + var\left[R_E\right] - 2cov\left[R_{US}, R_E\right]\right)}\end{aligned} \tag{4}$$

The corresponding euro share is:

$$\begin{aligned}1-\alpha = \quad & \frac{A\left(var\left[R_{US}\right] - cov\left[R_{US}, R_E\right]\right)}{A\left(var\left[R_{US}\right] + var\left[R_E\right] - 2cov\left[R_{US}, R_E\right]\right)} \\ & - \frac{bB\left(cov\left[R_{US}, S_{US}\right] - cov\left[R_E, S_{US}\right]\right)}{A\left(var\left[R_{US}\right] + var\left[R_E\right] - 2cov\left[R_{US}, R_E\right]\right)} \\ & - \frac{(1-b)B\left(cov\left[R_{US}, S_E\right] - cov\left[R_E, S_E\right]\right)}{A\left(var\left[R_{US}\right] + var\left[R_E\right] - 2cov\left[R_{US}, R_E\right]\right)}\end{aligned} \tag{5}$$

These equations have an intuitive interpretation with the first term reflecting conventional minimum variance considerations, and the final two terms reflecting the transactions motive we introduced. In the first term the euro variance enters positively, while the covariance between euro and dollar assets enters negatively. The latter reflects the strength of diversification benefits between investing in euro and dollars and has the effect of making dollar and euro shares more unequal, if the correlation between dollar and euro returns is positive, while it pushes the shares towards equality, if the correlation is negative. While this term is completely standard, it is worthwhile pointing out that in the context of optimal reserve management two important issues discussed in the literature can be directly linked to this term. The first is the importance of the exchange rate arrangement, and in particular of an exchange rate peg or tightly managed float. A peg or tightly managed float to a particular "anchor" currency implies a low volatility of returns of that currency and will tend to increase the optimal share of that currency in our framework. In general, however, there will also be a benefit to diversification, i.e. investing in more than one asset or currency. But the size of these benefits will depend crucially on the correlation between the different currencies.

The second and third term reflect transaction demand concerns. The second term is pre-multiplied by the amount of dollar debt, , and quantifies the extent to which dollar assets are a relatively better hedge than euro assets against a sudden stop in dollar-denominated debt. The optimal dollar share in reserves increases if the covariance between dollar returns and transaction needs arising from dollar debt is higher than the covariance of euro returns with these transaction needs. The third term reflects an analogous consideration with respect to euro-denominated debt and is pre-multiplied with the amount of euro debt, . Note that there are two factors that determine the effect of the currency composition of debt on the optimal composition of reserves. Firstly, the second term is weighted by b, the share of dollar debt, while the third term is weighed by $(1-b)$. This will only have a substantial effect, however, if the second factor, i.e. the relative covariances with dollar and euro sudden stops are very different between the two currencies. In addition, note that it is not necessarily true that the second term is positive (or the third term negative), i.e. it is not necessarily true that dollar assets are a better hedge for dollar sudden stops than euro assets. We revisit this point below.

It is worth noting that the above expression collapses to a standard minimum variance portfolio for two assets if the level of debt, B, is equal to zero. Note also that the second and third term are multiplied by the ratio of debt to reserves, B/A, which captures that the importance of the transactions demand relative to conventional portfolio objectives increases with increases in the debt to reserve ratio. In this regard, our framework generates a simple link between reserve accumulation (or a decline of short-term debt) and the optimal currency composition of reserves.

While we regard the simplicity of our approach to be a virtue, it necessarily implies that we cannot address a number of issues that have been raised in the academic or policy debate on developments in the international financial system. Firstly, note that the transactions demand is taken to be an exogenous event. Therefore reserves have no role in preventing the

possibility of a crisis, and neither does reserve composition. What is more, the exogeneity of sudden stops precludes analysis of moral hazard considerations associated with excessive lending or overborrowing in foreign currency. Since the currency composition of reserves is not a state variable in our framework, we do not include transaction costs, and take returns to be exogenous, we also cannot use our model to analyse the merits or possible effects of diversification of large reserve holders which could have an impact on currency returns through price pressure (e.g. in the case of China).

3.2 The Effect of Changes in Reserve Levels, Debt Levels and the Currency Composition of Foreign Debt

We can partially differentiate the analytical expression for the optimal dollar share with respect to the level of reserves A, the level of debt B, the debt/reserves ratio B/A and the fraction of debt denominated in dollars b to make some predictions about the effect of changes in reserve or debt levels and the currency composition of foreign-denominated debt on central bank reserve portfolio decisions.

3.2.1 Changes in Reserve Levels

Since the level of reserves only appears in the denominator of the second and third term of the optimal dollar share equation, we can see that as the level of reserves tends towards infinity, the second and third term go to zero and the optimal dollar share converges to the optimal share in a standard minimum variance portfolio. Until that point, we have:

$$\begin{aligned}\frac{\partial \alpha}{\partial A} &= -\frac{B}{A^2}\frac{1}{\left(var\left[R_{US}\right]+var\left[R_E\right]-2cov\left[R_{US},R_E\right]\right)}\times \\ &\left(b\left(cov\left[R_{US},S_{US}\right]-cov\left[R_E,S_{US}\right]\right)+(1-b)\left(cov\left[R_{US},S_E\right]-cov\left[R_E,S_E\right]\right)\right)\end{aligned} \tag{6}$$

The effect of an increase in the level of reserves on the optimal dollar share thus depends crucially on whether the dollar is a better hedge for sudden stops than the euro. If the dollar is a better hedge, then the above expression is negative and the optimal dollar share falls with an increase in the level of reserves.

3.2.2 Changes in Debt Levels

$$\begin{aligned}\frac{\partial \alpha}{\partial B} &= \frac{1}{A}\frac{1}{\left(var\left[R_{US}\right]+var\left[R_E\right]-2cov\left[R_{US},R_E\right]\right)}\times \\ &\left(b\left(cov\left[R_{US},S_{US}\right]-cov\left[R_E,S_{US}\right]\right)+(1-b)\left(cov\left[R_{US},S_E\right]-cov\left[R_E,S_E\right]\right)\right)\end{aligned} \tag{7}$$

An increase in the level of debt changes the optimal currency composition of reserves in the opposite direction of an increase in reserve levels. If dollars are a better hedge for

sudden stops, then an increase in the level of debt will increase the size of the optimal dollar share.

We can also differentiate the optimal share with respect to the ratio of debt to reserves, B/A:

$$\frac{\partial \alpha}{\partial (B/A)} = \frac{1}{(var[R_{US}] + var[R_E] - 2cov[R_{US}, R_E])} \times (b(cov[R_{US}, S_{US}] - cov[R_E, S_{US}]) + (1-b)(cov[R_{US}, S_E] - cov[R_E, S_E])) \quad (8)$$

Again, we can see that an increase in the debt/reserve ratio will only reduce the dollar share if the dollar is a better hedge for the sudden stops.

3.2.3 Change in the Currency Denomination of Debt

Eichengreen and Mathieson (2000), among others, have empirically documented that the currency composition of debt is a significant determinant of the currency composition of foreign exchange reserves. In our framework, the effect of an increase in the fraction of debt denominated in dollars is given by:

$$\frac{\partial \alpha}{\partial b} = \frac{B}{A}\frac{1}{(var[R_{US}] + var[R_E] - 2cov[R_{US}, R_E])} \times ((cov[R_{US}, S_{US}] - cov[R_E, S_{US}]) - (cov[R_{US}, S_E] - cov[R_E, S_E])) \quad (9)$$

This expression implies that an increase in the dollar share in debt will increase the optimal dollar share in reserves if the dollar is a relatively better hedge for dollar debt sudden stops than for euro debt sudden stops. Note that this is not trivially true. This is because the risk the central bank would like to hedge against is, loosely speaking, composed of exchange risk caused by the foreign denomination of the debt, as well as the possibility of a sudden stop which would in principle be there even if debt was denominated in domestic currency, but held by domestic agents. While the former is strongly linked to debt denomination and implies that risk can be minimized by holding assets in the currency of the liability, the sudden stop risk would best be insured by investing in assets that have a high payoff during capital account crises. In the absence of such contingent assets (so far, there are no "macro markets" for insuring against sudden stops), the co-movement of dollar and euro returns with occurrences of sudden stops will determine their relative hedging demands. A priori, there is no strong theoretical presumption that any one currency is more strongly linked with sudden stops. What is more, it is, a priori, unclear whether the exchange rate risk or the sudden stop risk is quantitatively more important. Finally, since both terms are multiplied by the debt to reserves ratio, B/A, it is worth noting that the impact of debt denomination is limited by the strength of the transaction motive for reserves: If the transactions motives quantitatively not important, then debt denomination cannot be, either.

4 Empirical Implementation

4.1 Reference Currency and Choice of Deflator

The previous literature (see, e.g. Papaiouannou et al (2006)) has noted the importance of the reference currency in international portfolio models. What is usually meant by reference currency is the currency of account. It is then often assumed that an investment in the reference currency is risk-free. This is only strictly true if one abstracts from inflation and interest rate risk which is sometimes justified by an assumption of perfect foresight for the former and buy-and-hold investing for the latter. In these models the existence of a risk-free asset would make the portfolio problem trivial when the objective is to minimize the portfolio variance. In our model this is not the case, as we include inflation and interest rate risk as well as another source of risk, the sudden stops. However, the reference currency is still quantitatively very important, as the variability of the returns of assets we consider is greatly reduced once we strip them of exchange rate risk. It is worth noting that the introduction of the transactions demand will in general reduce the importance of the reference currency, as we add another source of risk. This does not mean that the optimal share of the reference currency is necessarily smaller once we introduce transactions demand, but rather that in cases where the optimal share is higher it is because the currency returns commove positively with sudden stops, not because of its reference currency status.

Overall, there is no single theoretically convincing choice of reference currency. Previous papers have mostly either assumed that returns are measured in local currency (Dellas and Yoo (1991)) or in dollars. Papaiouannou et al (2006) also present results using euros and the SDR as the currency of account. When the local currency is used as the unit of account, it is justified on the grounds that the central bank maximizes domestic consumption which would in general be measured using real local currency units. Using the dollar as the reference currency is sometimes motivated by the fact that central banks in reality often use the dollar as their unit of account, both for internal and external accounting purposes. We agree with the former view, and will report results using the domestic currency as the reference currency.

It is worth noting that there is a second use of the term "reference currency" in the context of official reserve decisions, namely the currency whose exchange rate with the local currency is managed, e.g. in the case of pegged exchange rates or tightly managed floats. We suggest using the term "anchor currency" for this purpose, as for example in ECB (2007a). As noted above, exchange rate pegs or tightly managed floats will lead to high optimal shares in the anchor currency, exactly because the exchange rate risk associated with these investments is very small and exchange rate risk is a large part of the total risk for the assets we consider.

A second, related choice is the choice of deflator to convert nominal into real returns. Again, there is no consensus in the existing literature. Different alternatives that have been considered are to use a domestic consumption or production price index, to use an import price index, or to abstract from inflation altogether. The choice of one over the other would

ideally reflect strong priors on the eventual use of the currency. If the eventual aim is to purchase imports using foreign exchange reserves, then an import price index would appear to be most appropriate, while the use of a domestic consumption price index is preferred if reserves are used to finance domestic consumption. In practice, data is only available for many countries for consumer price indices, so we rely on these in our computations and, where available, provide some robustness checks with regard to using import price indices.

4.2 Transactions Demand

In order to arrive at optimal portfolio shares, we need to construct an empirical counterpart to our transaction demands. This presents several challenges. Firstly, we need to specify the use of reserves we have in mind in order to measure it. In the existing literature several motives for holding reserves have been noted, ranging from financing imports, smoothing adjustment during capital account reversals or repaying short term debt of the private or the public sector ((see e.g. Roger (1993), Aizenman and Marion (2004) or Jeanne (2007)). While we believe that all of them are potentially important, we focus here on abrupt changes in capital flows. Since we need to estimate the covariance with this measure of transactions demand, we need to construct a whole series for our sudden stop variables. Since, in general, sudden stops are relatively rare events, we face two difficulties: Many countries have not experienced a sudden stop during our sample and any estimation results that are based on the sample will therefore not attribute any importance to this transactions demand. More generally, sudden stops are relatively rare events which makes estimation problematic. Furthermore, we do not have bilateral capital flow data, thus it is not possible for us to distinguish between a sudden stop in dollar capital flows and a sudden stop in euro capital flows. In light of these difficulties, we make the following choices: Firstly, we do not distinguish between dollar and euro sudden stops and define a sudden stop in capital inflows using the methodology described in Rothenberg and Warnock (2006).[6] This method follows Calvo et al (2004) in generating monthly data on capital account reversals based on capital account data, but corrects for capital outflows of local investors. With annual data, the number of observations is relatively small and due to the often short lived nature of crises the number of crises observations is greatly reduced. We construct three different measures for sudden stops based on this method. Firstly, we construct a series relying solely on country specific observations for country i. For our second sudden stop measure, we divide our sample into four regions (Emerging Europe, Latin America, Middle East & Africa, Asia) and calculate as the sum of sudden stops in the region divided by the number of countries in the region. Thirdly, we calculate a global sudden stop measure S as the sum of all sudden stops divided by the number of countries in the sample. All measures are monthly and lie between zero and one (see table 7 for a graphical illustration of all sudden stop dates at country, regional and global level). The second and the third measure are

[6]Note that despite no distinction between dollar and euro sudden stops, the effect of sudden stops will still be different for dollar and euro debt, respectively, because of changes in exchange rates.

based on some understanding that patterns in other countries do carry some information that the central bank takes into account when estimating its future transaction demands.

The second substantial choice pertains to the size of the intervention in the event of a sudden stop. We assume that in the event of a sudden stop, the whole stock of foreign short-term debt that is maturing at the end of the period is not rolled over and that the central bank uses its reserves to make this repayment. Since we do not have data on the maturity composition of short term debt (defined as debt with maturity of less than a year), we simply assume that average maturity is six months, and that one sixth of the outstanding amount of short term debt is maturing at the end of each month. Similarly, geographical ownership data is not available for foreign currency, so we assume that most of the foreign currency debt is held by investors abroad.[7]

4.3 Estimation of Moments

It has been noted before (see e.g. Jorion (1992) or De Santis et al (2003)) that in portfolio models similar to ours, the estimation results for variances and covariances will depend quite strongly on the sample period and the estimation method used. Since we do not see our contribution in adding to this literature and are somewhat constrained in term of data availability, we simply pick the simplest estimation method and estimate the population moments by their sample analogues.[8]

4.4 Data

We compute optimal reserve portfolios for 24 emerging market economies which are Argentina, Brazil, Chile, China, Colombia, Czech Republic, Hungary, India, Indonesia, Jordan, Korea (South), Kuwait, Mexico, Pakistan, Peru, Philippines, Poland, Russia, Saudi Arabia, Slovakia, South Africa, Thailand, Turkey and Venezuela.

Our sample runs for most countries from January 1993 to December 2005, the longest possible sample we can construct for the variables used.[9] For the monthly euro and dollar real return series, we deflate 3-month LIBOR and EURIBOR rates with domestic consumer price indices. Since the currency composition for short-term debt is not available, we use the

[7]For example, according to the ECB (2007a), the stock of outstanding of euro-denominated debt securities which has been issued by non-residents amounted at end-2005 to USD 1,933 bn. Comparing this amount to euro area iip data (which differs somewhat in terms of valuation methodology) suggests that almost half of this amount was held by euro area residents. Lane and Shambaugh (2007) state that "from the Bank of Japan data, it is clear that Japanese investors purchase (virtually) all of the yen-denominated debt issued by other countries.

[8]More sophisticated techniques for the estimation of the variance-covariance matrix (e.g. GARCH estimation or realised volatility methods) require the availability of higher frequency data which is not an option in our set-up with macroeconomic variables which are only available at monthly frequency.

[9]In the case of Saudi Arabia, data is only available since January 2002. In the case of Jordan, data are only available since January 1998. In the case of Kuwait, data start in January 1995.

currency composition for all foreign debt as a proxy for it. In four cases (Czech Republic, Kuwait, Saudi Arabia and South Korea) the composition of external debt was not available. In these cases we used figures for similar countries as a proxy. Prior to 1999, the euro is proxied by a "synthetic" euro computed by Eurostat and based on the ECU. Likewise, for pre-1999 euro interest rates, we use a synthetic Eurostat series for the EURIBOR rate which is a GDP-weighted average of legacy currency interest rates. Sudden stops are taken from Rothenberg and Warnock (2006)'s monthly series of true sudden stops. We supplement their country sample with 4 major reserve accumulators for which we have no sudden stop data (China, Kuwait, Russia and Saudi Arabia). In these cases, we cannot compute the optimal dollar share with country-specific sudden stops and proxy the respective regional sudden stops and S using the country sample for which such data is available.

All data except the sudden stops have been retrieved using the Haver Analytics database. The original data sources are the World Bank's debt tables (for short-term debt and the currency composition of external debt), the IMF's International Financial Statistics (for the level of foreign exchange reserves and local exchange rates against the dollar), Eurostat (for the euro-dollar exchange rate and the EURIBOR rate), the Financial Times (for LIBOR rates) and national sources (for domestic consumer price and import price indices).

5 Results

5.1 Benchmark Case: Minimum Variance Portfolio without Transactions Demand

We present our results in terms of the optimal dollar share α - in our two-asset model, the respective optimal euro share is always given by $1 - \alpha$. In Table 1, we report in column 1 traditional minimum variance portfolios (i.e. the case B=0) as a benchmark. As described above, these computations are based on the longest possible time span (January 1993 – December 2005 except for Saudi Arabia and Russia). The stock data for the level of reserves, short-term debt and the denomination of external debt are as of end-2005.

The results exhibit a strong regional pattern which is mainly a reflection of (de facto) exchange rate regimes in the respective regions. Whereas countries in Asia and Latin America have a high optimal dollar share, countries in Emerging Europe tend to have a high optimal euro share.[10] In the Middle East and Africa, Middle Eastern countries have high optimal dollar shares whereas the respective figures for South Africa and Turkey are somewhat lower. Generally, countries operating de facto a relatively flexible exchange rate regime (e.g. South Africa, Poland) have more diversified optimal portfolios than countries with explicit or implicit exchange rate targets. The reason that the exchange rate regime has such a strong

[10] Note that the fact that Hungary has a larger optimal dollar share that the Czech Republic is likely to be a reflection of Hungary's currency basket which included prior to 2000 a sizable proportion of dollars. In fact, the share of the dollar was changed from 50% in 1993 to 30% during 1994-1999. Only since 2000 Hungary's reference basket contains only the euro.

effect on optimal reserve portfolios is that it has a strong effect on the exchange rate risk that the assets have and this exchange rate risk accounts for a large portion of the total risk of the assets we consider. In fact, countries which operate a de facto fixed exchange rate regime or manage their currency against the dollar or the euro have the opportunity to invest their foreign exchange reserves in an asset with very low variance. As the correlation between dollar and euro returns is usually quite high, the diversification benefits are limited and portfolios are dominated by the low variance currency asset. It is worth pointing out here that most emerging market economies have explicit or implicit exchange rate targets so that these findings would apply to the majority of emerging market central banks.[11] In a number of countries, the short sale constraint is hit, again reflecting the strong effect of the exchange rate regime and limited diversification benefits. In Mexico and Venezuela, the optimal portfolio consists of only dollar assets, while in the Czech Republic the optimal portfolio only contains euro denominated assets.

It should be stressed in this context that the results for the optimal dollar share can be very sensitive to the choice of sample period. In addition to the instability of covariance matrix estimation noted before in the literature, there are two aspects that aggravate this problem in our context. Firstly, many emerging market economies exhibit few, but very large depreciations (which often coincide with capital account crises) and these crises periods have a strong effect on measured variances and covariances. Secondly, during our sample period some countries underwent a change in their exchange rate regime (see Appendix 7.3 for a graphical illustration of real dollar and euro returns for all countries in the sample). Russia is a case in point. It had an implicit dollar peg until 2004, but changed to an operational currency basket which included the euro in February 2005.[12] Since we identify variances and covariances with their sample analogues and do not allow for structural breaks, the optimal dollar share using data for the whole sample period is very high (in fact it is 100%). Since Russian authorities have announced that this change in exchange rate policy has been accompanied by a rising share of the euro in foreign exchange reserves, we believe that the Central Bank of Russia could have implicitly decreased the weight of past observations which still refer to the old exchange rate regime. Therefore, we recomputed the optimal dollar share using only data from January 2004 to February 2005 and arrive at a lower dollar share. This number is reported in the table.

Our results are broadly in line with previous findings in the literature and actual reserve levels. As noted above, the "anchor" currency tends to be dominant in reserve portfolios, similar to the roles played by the "reference currency" (meaning currency of account) in Papaionnaou et al (2006). Our results are also in line with recent papers on home bias which document that home bias is more pronounced for bonds than for equities (see Fidora,

[11] According to the latest list on "De Facto Exchange Rate Arrangements and Anchors of Monetary Policy" compiled by the IMF as of July 2006, only 25 out of 146 countries with own legal tender are classified as "independently floating".

[12] The share of the euro in this currency basket which is used by the Central Bank of Russia for the management of daily volatility has been gradually increased from 10% to 20% (March 2005), 35% (August 2005), 40% (December 2005) and 45% (February 2007).

Fratzscher and Thimann (2007). This is because exchange rate risk accounts for a major portion of total risk for bonds, while it accounts for a smaller portion of the total risk of (the much riskier) equities. In quantitative terms, our country-specific findings for the minimum variance benchmark portfolio are broadly comparable to those in Papaioannou et al. (2006) for the BRIC countries (Brazil, Russia, India and China). Using a different methodology and data from January 1995 until December 2004, the authors find optimal dollar allocations (re-scaled to the 2-asset case) for Russia (75%), India (92%), China (93%), and Brazil (88%).[13]

A comparison of our model results with actual reserve portfolios at the country level is difficult since country data on the currency composition of foreign exchange reserves is only available in for a few of the countries in our sample. Rescaling the available actual currency shares to our 2-asset case, we find that our model results are generally quite close to the actual central bank portfolios (table 1, column 1 and 5). In the case of Russia, the optimal dollar share is close to the actual dollar share in 2005 (which is roughly known from public statements by central bank officials). Optimal dollar shares are somewhat higher than actual shares in Peru, Columbia and Chile. In the case of Slovakia, the optimal dollar share is lower than the actual dollar share.

Aggregating the countries in our sample, weighted by reserve levels, we find that the optimal dollar share lies at around 84% (table 1, column 1, bottom). One useful benchmark to compare this aggregate figure with is the IMF's COFER data which reports a dollar share of 61% for developing countries at the end of 2005 which would correspond to 68% in a portfolio that includes only dollar and euro-denominated assets (table 1, column 5, bottom). However, it is worth noting that, while our sample includes China, the COFER data does not, and, given China's large level of reserves and high optimal dollar share, including China increases the optimal dollar share quite significantly. Recomputing the emerging market total of our sample without China, we arrive at an optimal dollar share of around 74% (table 1, column 1, bottom).[14]

Given the strong regional character of optimal portfolios, we also compute various regional aggregates. We thus arrive at an optimal dollar share of 47% in Emerging Europe, 91% in Latin America, 81% in the Middle East & Africa and 91% in Asia, including China (table 1, column 1). While no regional breakdown of the IMF data is regularly available, Lim (2006) presents figures for certain sub-groups that can be compared to our regional

[13] Papaioannou et al (2006) compute optimal portfolio as solutions to a mean variance optimisation problem with transaction costs in terms of dollars and abstracting from inflation and interest rate risk. They estimate the variance covariance matrix using multivariate GARCH methods that allow for changing correlations. The authors also impose an ad hoc constraint which requires that the central bank holds reserves in the currencies of the country's main trading partners at levels equal to 50% of the respective trade share.

[14] According to the IMF (2005, p. 110), reporting compliance on the currency composition of reserves is particularly low in Asia. Given the (publicly known) size of China's foreign exchange reserves, it is highly plausible that China's reserves are not part of the IMF's "allocated reserves" on which aggregate currency shares are based.

aggregates. The author reports that the rescaled optimal dollar share for "all European countries surrounding the euro area and all countries worldwide that largely peg their currencies to the euro" (EU neighbouring regions) stood at 35% which is somewhat lower than our estimate (excluding Russia which is likely to have been classified by Lim as belonging to the dollar area) of 47%. The optimal dollar share for "Asia, the Western Hemisphere and all countries that largely peg their currencies to the US dollar" (dollar area) is equal to 81% which compares to a weighted average optimal dollar share from our model of 84% for Asia and Latin America. As regards countries in the Middle East and Africa, we believe that the dollar peggers in our sample have also been included by Lim in the dollar area. Therefore, we have also included these countries into our aggregate for the dollar area.

We thus see that a simple model of variance minimisation in local currency can rationalise the strongly regional pattern of reserve composition displayed in the disaggregated COFER data presented by Lim, mainly as a result of the prevailing exchange rate arrangements. In the following section, we analyse the effect of explicitly introducing transactions demands for foreign exchange.

5.2 Optimal Portfolios with Transactions Demand

As described above, we consider three different definitions for the transactions demand, based on country-specific, regional and global sudden stops.

5.2.1 Hedging against Country-specific Sudden Stops

First, we consider only country-specific sudden stops to predict future transactions needs and present the results in table 1, column 2. As stated above, we cannot compute optimal dollar shares for Russia, Kuwait, Saudi Arabia and China since no country-specific sudden stop dates are available for these countries. Note that in countries that did not suffer a sudden stop during our sample period, the optimal share is unchanged from the benchmark portfolio presented in the previous subsection (Czech Republic, Hungary, Poland, Chile, Jordan, South Africa, and India). For countries that have suffered a sudden stop during our sample period, the optimal dollar share often increases with the introduction of the transactions demand. This is the case for Brazil, Colombia, Peru, Indonesia, Pakistan, the Philippines and Thailand, while the euro share increases in Slovakia, Argentina, and Turkey. In some countries (Mexico, Venezuela) the short-sale constraint is hit with and without transactions demand. In Mexico, the optimal dollar share would be lower with hedging against country-specific sudden stops whereas in Venezuela it would be higher. Note also that in countries that have suffered a sudden stop during our sample period, the size of the change in the optimal reserve portfolio caused by the introduction of the transactions varies quite widely between the different countries, but is in general quite small. The smallest change is observed in the case of Pakistan (92.6% dollar share with transactions demand, 92.4 without), while the biggest change is observed in Indonesia (47.6% vs 30.8%). The reason that the effect of the transactions demands are quite small is that, in general,

sudden stops are rare events, and reserve levels are quite high, in particular compared to current levels of short-term foreign debt.

5.2.2 Hedging against Regional Sudden Stops

It is widely believed that crises in emerging market economies have effects on other emerging market economies that go beyond their direct trade links. This phenomenon is usually called "contagion" (for a recent survey of the contagion literature related to emerging market economies, see Forbes (2007)). While there is no consensus on the underlying mechanism leading to contagion, we regard it as highly plausible that central banks will use information from other emerging market economies with similar characteristics to forecast the possibility of swift capital account reversals. We therefore calculate optimal shares using our regional measure of sudden stop and present the results in column 3 of table 1. With very few exceptions, the effect of introducing a transactions demand on the optimal dollar share now follows a regional pattern. Whereas in Emerging European countries, the euro is a better hedge against regional sudden stops and introducing sudden stops now reduces the optimal dollar share, the respective optimal dollar shares in Latin American and Asian countries are higher than in our benchmark case. Within the Middle East and Africa, countries in the Middle East tend to have higher optimal dollar shares (with the exception of Saudi Arabia) whereas in Turkey and South Africa, the optimal dollar share is lower than in our benchmark portfolio. The magnitude of changes in optimal reserve portfolios compared to our minimum variance benchmark is again relatively modest, ranging from 0.4% in the case of Russia to 12.8% for Indonesia. It should be noted though that our results for Emerging Europe are based on only one sudden stop observation (i.e. that in Slovakia) and should therefore be treated with caution.

5.2.3 Hedging against Global Sudden Stops

In column 4 of table 1, we present optimal portfolios that are calculated using the global measure of sudden stops described above. We can see that in this case the optimal dollar share increases in virtually all cases.[15] We therefore see that introducing transactions demands based on sudden stops has different effects on optimal portfolios depending on the definition of sudden stops. For global sudden stop measures, the optimal dollar share increases, reflecting high dollar returns during periods of crises. For regional sudden stop measures, the effects depend on the region, with the optimal dollar share increasing in Latin America and Asia, and the euro share increasing in Emerging Europe. For country-specific sudden stops, the optimal dollar share increased in most countries.

Our interpretation of these results is based on the idea that during periods of heightened uncertainty or crises in emerging markets, capital is redirected to mature economies and financial markets bidding up the prices of assets in those countries, and therefore also their currencies. In Latin America and Asia the role of the "safe haven currency" is played by the

[15] Only in the case of Saudi Arabia is the euro share slightly higher reflecting the different sample period.

US dollar, while investment into Emerging Europe and some parts of the Middle East and Africa is dominated by euro area investors, making euro-denominated assets the destination of choice during crisis periods. In fact, according to the BIS' consolidated banking statistics, as of end-2005 more than 70% of foreign bank claims on countries in EU neighbouring regions were held by euro area banks.

5.2.4 A Rise in Reserves or Decline in Short-term Debt

Irrespective of how we measure sudden stops, table 1 suggests that, quantitatively, the impact of introducing transactions demands is relatively small for most countries. As demonstrated in section 3 a rise in reserves leads in our model to a decline of the transactions motive. Likewise, a decline in short-term debt leads to smaller hedging terms in our equation for the optimal dollar share. Since foreign exchange reserves have increased considerably over the past few years (recall Chart 1) and levels of foreign debt have decreased, one might interpret the small impact of transactions demand as reflecting very high reserve levels (or low levels of short-term debt) as of end-2005. It is worth noting in this context that in our sample all countries had reserves to short-term debt ratios of more than 100%, sometimes many times more, thereby comfortably exceeding the Greenspan-Guidotti rule. To quantitatively investigate the impact of changing reserve levels, we therefore recalculate optimal portfolios with all parameters kept equal to their values in table 1, but with reserve levels which are 50% lower than at the end of 2005. The results are summarised in table 2. As expected, the effect of introducing transactions demands is now larger, and, given that, on balance, the dollar is a better hedge for sudden stops for most measures of sudden stops, the aggregate optimal dollar share also increases. For individual countries, the impact can be quite large (in the extreme in the order of magnitude of 20 to 30 percentage points). At the regional level, the largest impact lies in the order of five to seven percentage points. These results are therefore also consistent with the evidence that dollar shares in actual central bank reserves have decreased somewhat during the period of strong reserve accumulation, though in our case the difference in the aggregate dollar share is very small. Note that the results would be very similar if we increased short term debt instead.

In table 3, we present results based on reserve levels which are twice as high as at the end of 2005. As can be seen, the effect of the transactions demand is now very small in most cases and the optimal shares become very close to the minimum variance benchmark. Note that, as in our minimum variance benchmark the optimal dollar share remains very high, no widespread diversification out of dollar-denominated assets should be expected as reserve levels increase to even higher levels.

5.2.5 A Change in the Denomination of External Debt

Finally, we reconsider the impact of the denomination of external debt on optimal portfolios. As explained in section 3, the impact of debt denomination depends on the extent to which the relative hedging properties of dollar and euro vary between dollar and euro sudden stops. In practice, it turns out that this difference is quite small, i.e. the dollar and the euro have

similar hedging properties for dollar sudden stops as for euro sudden stops. To a certain extent this reflects our modelling assumptions. In our framework, the central bank repays short term debt only in the event of a sudden stop. This has the effect that exchange rate risk is quite limited relative to the risk associated with the occurrence of a sudden stop. Put differently, in our framework, the central bank is concerned with holding an asset that has a high payoff when the sudden stop occurs, but does not care as much about the exchange rate risk of its liabilities. Of course, the preceding section indicated that the effect of introducing transactions demands is quite small in many cases which implies that in those cases, debt denomination cannot have strong quantitative effects, even if the hedging properties for euro and dollar sudden stops were very different. In order to demonstrate this in quantitative terms, we consider two extreme scenarios in tables 4 and 5. In table 4, we present optimal portfolios assuming that all external debt is euro-denominated (b=0) and in table 5, we present assuming that all external debt is dollar-denominated (b=1). Comparing tables 4 and 5, it can be seen that the difference between optimal portfolios is very limited even in the extreme examples we consider in this table.

5.2.6 Robustness to Alternative Deflators

Since countries may also care about real purchasing power in import terms, we also compute optimal currency shares using import price indices for deflating nominal returns (table 6). As such data is only available for a few countries in our sample (Czech, Republic, Hungary, Poland, Brazil, Mexico, Peru, Jordan, Turkey and South Korea) and in some cases only for shorter samples (Czech Republic, Hungary, Poland, Jordan), we can only draw limited conclusions from this exercise. In theory, we would expect import price indices to reflect the location of trading partners, the currency of invoicing, as well as other determinants of pricing decisions. Thus, countries that trade a lot with euro area economies and invoice in euros would be expected to have a lower variance of euro returns and thus a higher optimal euro share. In practice, we find that, with some exceptions, optimal portfolios have the same order of magnitude as in the case of CPI-deflated returns (table 1). In the case of Turkey, the considerably higher optimal dollar shares obtained when deflating with the import price deflator are mainly a result of a higher relative variance of real dollar returns. This can be rationalised with a high trade share with euro area economies.[16] In addition, we observe notable differences to the CPI-case for Hungary (lower optimal dollar share than in the CPI-case) and Brazil (higher optimal dollar share than in the CPI case). In the case of Hungary, this difference mostly reflects a difference in the sample period, as the import price sample starts only in May 2003. In fact, we obtain very similar optimal portfolios using the CPI for the same period.[17] In the case of Brazil, the differences appear to stem

[16] In June 2007, imports from euro area economies accounted for 30.0% of total Turkish imports, while imports from the US accounted for 5.0%.

[17] As stated above Hungary's reference currency basket contains only the euro since 2000. Using a sample starting in May 2003, we thus obtain much lower optimal dollar shares (which are in fact zero) both using the CPI and the IPI as the deflator on account of the low relative euro variance reflecting the changed de

from varying behaviour of consumer and import prices during the period of hyperinflation in 1993. When we remove the hyperinflation period from the sample, we get similar optimal dollar shares for the CPI and the import price case.

The inclusion of transactions demand tends to again increase optimal dollar shares when we consider hedging against global sudden stops. Also, the regional pattern in the case of hedging against regional sudden stops is robust to this change of deflators. When considering hedging against country-specific sudden stops, we find similar results to the CPI-case as well, i.e. unchanged optimal currency shares in countries with no sudden stop during the sample period (Czech Republic, Hungary, Poland), a higher optimal dollar share in Brazil, Peru, Jordan (ignoring the short-sale constraint) and a higher optimal euro share in Mexico (ignoring the short-sale constraint), Turkey and South Korea.

6 Conclusions

We derive optimal central bank portfolios in cases where the country is subject to sudden reversals in capital flows and the central bank uses its reserves to smooth decreases in absorption in the case of a reversal. We show that in our two asset minimum variance approach with transaction demand, the optimal shares can be decomposed analytically into asset demand derived from traditional portfolio objectives and hedging demands related to sudden stops. We further show that the hedging demands become less important relative to traditional portfolio objectives as debt to reserve ratios decrease. Whether the introduction of transactions demand increases or decreases the optimal dollar share depends on whether the dollar is a better hedge for sudden stops than the euro. In our empirical section, we find that dollars are a better hedge for global sudden stops, and for country specific sudden stops in many cases, but that there is a regional pattern if we consider regional sudden stops. In that case, the dollar appears to be a better hedge for sudden stops in Latin America and Asia, while the euro is a better hedge for sudden stops in Emerging Europe, which we interpret to reflect safe haven properties stemming from the geographical origin of investment flows in these regions. We also find that as reserve levels increase the global share of the dollar falls, as countries become less concerned with the risk of sudden stops, but our model predicts smaller changes in portfolios then seen in the data.

In any case, optimal dollar shares remain quite high in many cases, both with and without transactions demand, in particular in Asia, Latin America and those countries of the Middle East with a traditionally high dollar orientation. This finding to a large extent reflects current exchange rate arrangements in many emerging market economies (as well as our assumption of variance minimisation as the central bank objective). In many emerging market economies, exchange rates vis-à-vis the dollar are closely managed which implies a low volatility of dollar returns. Since the correlation of euro and dollar returns is often quite high, diversification benefits are limited and the low variance of dollar assets dominates the

facto exchange rate regime.

portfolio choice. Our framework therefore suggests that strong diversification out of dollar-denominated assets is unlikely as long as many emerging market economies continue to manage their exchange rate mainly against the dollar. However, we have recently seen some cases in which central banks have increased the weight of the euro in the exchange rate basket they are managing. In those cases which were mainly to be found among the EU Neighbouring countries, our model suggests that the share of the euro in the reserves should also rise. This is in line with the swift diversification into euro-denominated assets by the Central Bank of Russia, following the introduction of a dollar-euro currency basket.

We also find that the effect of the denomination of foreign currency debt on central bank portfolios is quite low, both because debt-to-reserve ratios are low, and because the exchange rate risk associated with sudden stops accounts for a small portion of its total risk.

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7 Appendix

7.1 Mean Variance Optimisation

Formally, the central bank solves the following problem:

$$\begin{aligned} &\max_{\alpha} E[W] - \frac{\gamma}{2} Var[W] \\ &s.t. \\ &W = \alpha A R_{US} + (1-\alpha) A R_E - S_{US} bB - S_E (1-b) B \\ &0 \leq \alpha \leq 1. \end{aligned} \tag{10}$$

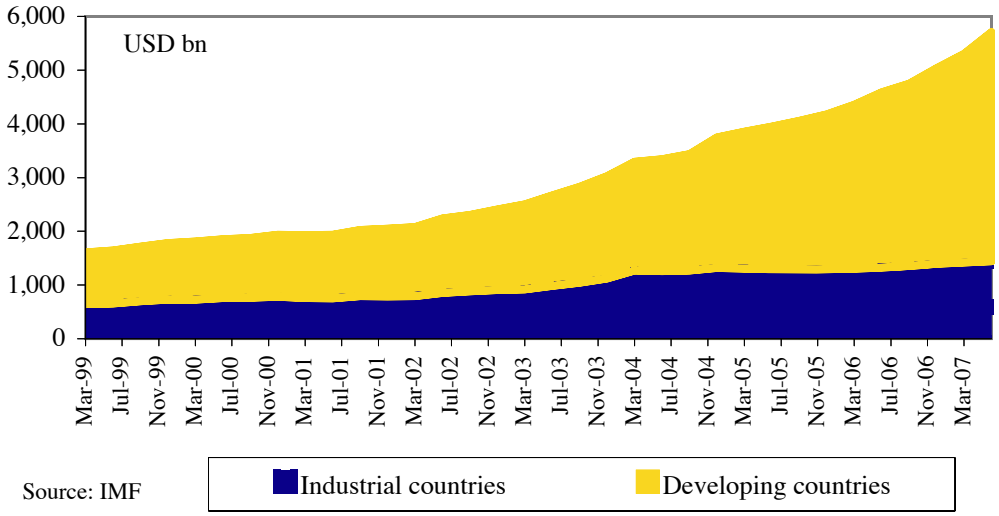
where γ is a coefficient reflecting the risk aversion of the central bank. The optimal dollar share is then given by:

$$\begin{aligned} \alpha \quad = \quad & \frac{E[R_{US}] - E[R_E]}{\gamma A \left(var[R_{US}] + var[R_E] - 2cov[R_{US}, R_E]\right)} \\ & + \frac{A \left(var[R_E] - cov[R_{US}, R_E]\right)}{A \left(var[R_{US}] + var[R_E] - 2cov[R_{US}, R_E]\right)} \\ & + \frac{bB \left(cov[R_{US}, S_{US}] - cov[R_E, S_{US}]\right)}{A \left(var[R_{US}] + var[R_E] - 2cov[R_{US}, R_E]\right)} \\ & + \frac{(1-b) B \left(cov[R_{US}, S_E] - cov[R_E, S_E]\right)}{A \left(var[R_{US}] + var[R_E] - 2cov[R_{US}, R_E]\right)} \end{aligned} \tag{11}$$

Compared to the version presented in the main part of the paper, there are two differences. Firstly, there exists now an additional term that reflects differences in expected returns between the two assets. The higher the expected return of dollar assets relative to euro assets, the higher is the optimal dollar share. The second difference is the presence of the risk aversion parameter, γ. The higher the value of γ, the smaller is the difference between the minimum variance and the mean variance optimization results, ceteris paribus. Also note that, for the case of no difference in expected returns, the first term drops out and we are back to the minimum variance case. In general, expected return differentials are small and do not materially affect our results, even for low values of the risk aversion parameter.

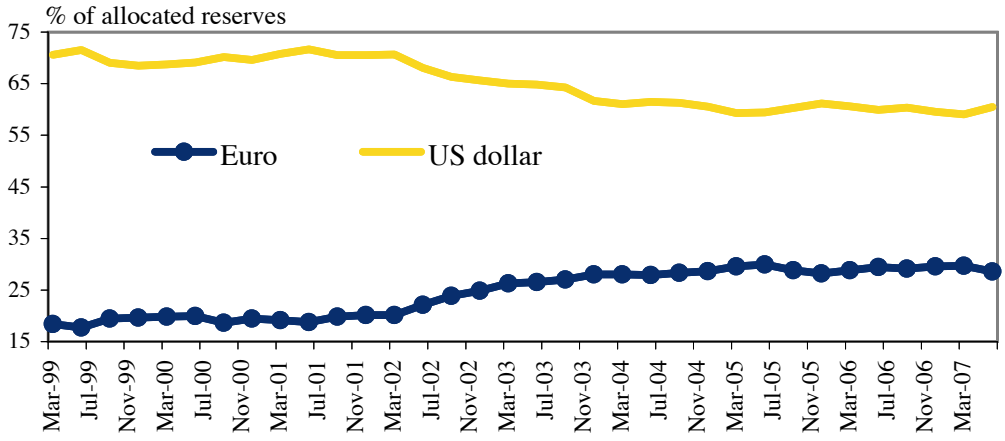
Appendix 7.2: Charts and Tables

Chart 1: Global Foreign Exchange Reserves



Source: IMF

Chart 2: Currency composition of Foreign Exchange Reserves



Source: IMF/COFER database

Note: Currency shares are reported in current exchange rates and exclude countries with unknown currency composition.

Table 1: Optimal dollar share for the 2-asset minimum variance portfolio, end 2005

	Without transaction motive	With transaction motive			Memo:
	-	Country-specific S	Regional S	Global S	Actual dollar share**
Country	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Czech Republic	0.0%	0.0%	0.0%	0.0%	na
Hungary	20.1%	20.1%	17.0%	23.3%	na
Poland	42.3%	42.3%	40.2%	44.4%	na
Russia*	62.9%	na	63.3%	63.0%	65%
Slovakia	3.0%	0.0%	0.0%	8.0%	22%
Emerging Europe	**47.3%**	**na**	**46.9%**	**48.1%**	
Argentina	96.0%	84.0%	100.0%	99.5%	na
Brazil	71.3%	82.5%	75.2%	73.5%	na
Chile	89.6%	89.6%	93.7%	91.8%	72%
Colombia	95.6%	100.0%	99.6%	97.6%	87%
Mexico	100.0%	100.0%	100.0%	100.0%	na
Peru	94.8%	99.4%	97.0%	95.9%	81%
Venezuela	100.0%	100.0%	100.0%	100.0%	na
Latin America	**91.1%**	**93.2%**	**93.2%**	**92.4%**	
Jordan	94.9%	94.9%	95.5%	95.7%	na
Kuwait	89.4%	na	91.0%	94.3%	na
Saudi Arabia	99.1%	na	97.2%	97.2%	na
South Africa	60.6%	60.6%	58.9%	63.3%	na
Turkey	76.8%	71.5%	74.0%	80.8%	na
Middle East & Afr.	**80.9%**	**na**	**79.0%**	**83.3%**	
China	97.0%	na	99.1%	97.9%	na
India	97.5%	97.5%	98.3%	97.8%	na
Indonesia	30.8%	47.6%	43.6%	35.7%	na
Korea, South	80.4%	79.6%	83.9%	81.8%	na
Pakistan	92.4%	92.6%	93.8%	93.0%	na
Philippines	89.5%	100.0%	94.4%	91.5%	na
Thailand	58.7%	66.9%	63.2%	60.5%	na
Asia Total	**90.9%**	**na**	**93.5%**	**92.0%**	
Asia ex China	**79.9%**	**na**	**83.4%**	**81.3%**	
All EMEs	**83.9%**	**na**	**85.7%**	**85.0%**	
All EME's ex China	**73.7%**	**na**	**75.3%**	**75.0%**	**68%*** **
EU Neighbouring Regions†	**52.3%**	**na**	**51.5%**	**53.7%**	
EU Neighbouring Regions ex Russia	**41.4%**	**na**	**39.3%**	**44.1%**	**35%*** **
Dollar area‡	**84.2%**	**na**	**87.0%**	**85.5%**	**81.2%*** **

Sources: Authors'calculations for optimal dollar shares. National central banks, IMF and Lim (2006) for actual dollar shares.

Notes: Short-sale constraints are taken into account for optimal dollar shares as reported in this table. Real returns are computed with the CPI as deflator. Sudden stops for individual countries from Rothenberg and Warnock (2006). Regional and global sudden stops are computed as sum over the respective countries divided by the number of countries. Regional aggregates are weigted by reserve levels as of end-2005. * Results for Russia based on Jan.2004 to Dec. 2005 due to change in currency basket. The actual dollar share in Russia's reserves is an estimate which is based on public statements made during 2005, stating that the share of the euro is about one third. ** Re-scaled to 2-asset case. *** Broadly corresponding aggregates from the IMF's COFER database and Lim (2006) as described in section 5.1. † All countries in Emerging Europe plus South Africa and Turkey. ‡ All countries in Latin America and Asia (excluding China) plus Jordan, Kuwait and Saudi Arabia.

Table 2: Optimal dollar share for the 2-asset minimum variance portfolio, end 2005, half reserve levels

	Without transaction motive	With transaction motive		
	-	Country-specific S	Regional S	Global S
Country	**(1)**	**(2)**	**(3)**	**(4)**
Czech Republic	0.0%	0.0%	0.0%	2.7%
Hungary	20.1%	20.1%	13.9%	26.5%
Poland	42.3%	42.3%	38.1%	46.4%
Russia*	62.9%	na	63.7%	63.0%
Slovakia	3.0%	0.0%	0.0%	13.1%
Emerging Europe	**47.3%**	**na**	**46.6%**	**49.2%**
Argentina	96.0%	72.1%	100.0%	100.0%
Brazil	71.3%	93.7%	79.0%	75.7%
Chile	89.6%	89.6%	97.8%	94.0%
Colombia	95.6%	100.0%	100.0%	99.5%
Mexico	100.0%	100.0%	100.0%	100.0%
Peru	94.8%	100.0%	99.3%	97.1%
Venezuela	100.0%	100.0%	100.0%	100.0%
Latin America	**91.1%**	**94.7%**	**94.6%**	**93.3%**
Jordan	94.8%	94.9%	96.0%	96.5%
Kuwait	89.4%	na	92.6%	99.2%
Saudi Arabia	99.1%	na	95.2%	95.3%
South Africa	60.6%	60.6%	57.2%	66.1%
Turkey	76.8%	66.2%	71.2%	84.8%
Middle East & Afr.	**80.9%**		**77.1%**	**85.7%**
China	97.0%	na	100.0%	98.8%
India	97.5%	97.5%	99.1%	98.2%
Indonesia	30.8%	64.4%	56.3%	40.6%
Korea, South	80.4%	78.9%	87.3%	83.2%
Pakistan	92.4%	92.9%	95.2%	93.5%
Philippines	89.5%	100.0%	99.3%	93.5%
Thailand	58.7%	75.0%	67.6%	62.3%
Asia	**90.9%**	**na**	**95.3%**	**93.1%**
Asia ex China	**79.9%**	**na**	**86.9%**	**82.7%**
All EME's	**83.9%**	**na**	**87.0%**	**86.1%**
All EME's ex China	**73.7%**	**na**	**76.8%**	**76.3%**

Source: Authors'calculations.

Notes: Short-sale constraints are taken into account for optimal dollar shares as reported in this table. Real returns are computed with the CPI as deflator. Sudden stops for individual countries from Rothenberg and Warnock (2006). Regional and global sudden stops are computed as sum over the respective countries divided by the number of countries. Regional aggregates are weigted by reserve levels as of end-2005. * Results for Russia based on Jan.2004 to Dec. 2005 due to change in currency basket.

Table 3: Optimal dollar share for the 2-asset minimum variance portfolio, end 2005, double reserve levels

	Without transaction motive	With transaction motive		
	-	Country-specific S	Regional S	Global S
Country	**(1)**	**(2)**	**(3)**	**(4)**
Czech Republic	0.0%	0.0%	0.0%	0.0%
Hungary	20.1%	20.1%	18.5%	21.7%
Poland	42.3%	42.3%	41.3%	43.3%
Russia*	62.9%	na	63.1%	62.9%
Slovakia	3.0%	0.0%	0.5%	5.5%
Emerging Europe	**47.3%**	**na**	**47.0%**	**47.7%**
Argentina	96.0%	90.0%	99.6%	97.8%
Brazil	71.3%	76.9%	73.2%	72.4%
Chile	89.6%	89.6%	91.6%	90.7%
Colombia	95.6%	100.0%	97.6%	96.6%
Mexico	100.0%	100.0%	100.0%	100.0%
Peru	94.8%	97.1%	95.9%	95.4%
Venezuela	100.0%	100.0%	100.0%	100.0%
Latin America	**91.1%**	**92.3%**	**92.3%**	**91.7%**
Jordan	94.9%	94.9%	95.2%	95.3%
Kuwait	89.3%	na	90.2%	91.8%
Saudi Arabia	99.1%	na	98.2%	98.2%
South Africa	60.6%	60.6%	59.8%	62.0%
Turkey	76.8%	74.1%	75.4%	78.8%
Middle East & Afr.	**80.9%**	**na**	**80.0%**	**82.1%**
China	97.0%	na	98.1%	97.4%
India	97.5%	97.5%	97.9%	97.7%
Indonesia	30.8%	39.2%	37.2%	33.3%
Korea, South	80.4%	80.0%	82.1%	81.1%
Pakistan	92.4%	92.5%	93.1%	92.7%
Philippines	89.5%	97.0%	91.9%	90.5%
Thailand	58.7%	62.8%	60.9%	59.6%
Asia Total	**90.9%**	**na**	**92.2%**	**91.5%**
Asia ex China	**79.9%**	**na**	**81.6%**	**80.6%**
All EME's	**83.9%**	**na**	**84.8%**	**84.5%**
All EME's ex China	**73.7%**	**na**	**74.5%**	**74.3%**

Source: Authors'calculations.

Notes: Short-sale constraints are taken into account for optimal dollar shares as reported in this table. Real returns are computed with the CPI as deflator. Sudden stops for individual countries from Rothenberg and Warnock (2006). Regional and global sudden stops are computed as sum over the respective countries divided by the number of countries. Regional aggregates are weigted by reserve levels as of end-2005. * Results for Russia based on Jan.2004 to Dec. 2005 due to change in currency basket.

Table 4: Optimal dollar share for the 2-asset minimum variance portfolio, end 2005. Only euro debt.

	Without transaction motive	With transaction motive		
	-	Country-specific S	Regional S	Global S
Country	**(1)**	**(2)**	**(3)**	**(4)**
Czech Republic	0.0%	0.0%	0.0%	0.0%
Hungary	20.1%	20.1%	16.9%	23.1%
Poland	42.3%	42.3%	40.2%	44.2%
Russia*	62.9%	na	63.2%	63.0%
Slovakia	3.0%	0.0%	0.0%	7.9%
Emerging Europe	**47.3%**	**na**	**46.8%**	**48.1%**
Argentina	96.0%	82.8%	100.0%	98.8%
Brazil	71.3%	82.1%	74.6%	73.0%
Chile	89.6%	89.6%	93.1%	91.2%
Colombia	95.6%	100.0%	98.9%	97.0%
Mexico	100.0%	100.0%	100.0%	100.0%
Peru	94.8%	99.1%	96.7%	95.6%
Venezuela	100.0%	100.0%	100.0%	100.0%
Latin America	**91.1%**	**92.9%**	**92.9%**	**92.1%**
Jordan	94.9%	94.9%	95.4%	95.6%
Kuwait	89.4%	na	90.6%	93.3%
Saudi Arabia	99.1%	na	98.1%	98.1%
South Africa	60.6%	60.6%	58.6%	62.8%
Turkey	76.8%	70.2%	73.6%	80.1%
Middle East & Afr.	**80.9%**		**79.0%**	**83.0%**
China	97.0%	na	97.9%	97.3%
India	97.5%	97.5%	98.1%	97.7%
Indonesia	30.8%	45.4%	42.5%	35.0%
Korea, South	80.4%	79.4%	83.3%	81.5%
Pakistan	92.4%	92.5%	93.6%	92.8%
Philippines	89.5%	100.0%	93.6%	91.0%
Thailand	58.7%	66.4%	62.5%	60.1%
Asia	**90.9%**	**na**	**92.6%**	**91.5%**
Asia ex China	**79.9%**	**na**	**82.9%**	**81.0%**
All EME's	**83.9%**	**na**	**85.0%**	**84.6%**
All EME's ex China	**73.7%**	**na**	**75.0%**	**74.8%**

Source: Authors'calculations.

Notes: Real returns are computed with the CPI as deflator. Sudden stops for individual countries from Rothenberg and Warnock (2006). Regional and global sudden stops are computed as sum over the respective countries divided by the number of countries. No short-sales are allowed. Regional aggregates are weigted by reserve levels as of end-2005. * Results for Russia based on Jan.2004 to Dec. 2005 due to change in currency basket.

Table 5: Optimal dollar share for the 2-asset minimum variance portfolio, end 2005. Only dollar debt.

	Without transaction motive	With transaction motive		
	-	Country-specific S	Regional S	Global S
Country	**(1)**	**(2)**	**(3)**	**(4)**
Czech Republic	0.0%	0.0%	0.0%	0.3%
Hungary	20.1%	20.1%	17.2%	24.1%
Poland	42.3%	42.3%	40.4%	44.8%
Russia*	62.9%	na	63.3%	63.0%
Slovakia	3.0%	0.0%	0.0%	9.3%
Emerging Europe Total	**47.3%**	**na**	**46.9%**	**48.4%**
Argentina	96.0%	84.8%	100.0%	99.9%
Brazil	71.3%	82.5%	75.2%	73.6%
Chile	89.6%	89.6%	93.7%	91.8%
Colombia	95.6%	100.0%	99.6%	97.6%
Mexico	100.0%	100.0%	100.0%	100.0%
Peru	94.8%	99.4%	97.1%	96.0%
Venezuela	100.0%	100.0%	100.0%	100.0%
Latin America Total	**91.1%**	**93.3%**	**93.2%**	**92.4%**
Jordan	94.9%	94.9%	95.5%	95.8%
Kuwait	89.4%	na	91.0%	94.4%
Saudi Arabia	99.1%	na	98.2%	98.2%
South Africa	60.6%	60.6%	59.0%	63.5%
Turkey	76.8%	71.9%	74.1%	81.0%
Middle East and Africa Total	**80.9%**		**79.3%**	**83.7%**
China	97.0%	na	98.1%	97.5%
India	97.5%	97.5%	98.3%	97.8%
Indonesia	30.8%	48.3%	43.9%	35.9%
Korea, South	80.4%	79.7%	84.0%	81.9%
Pakistan	92.4%	92.6%	93.9%	93.0%
Philippines	89.5%	100.0%	94.5%	91.5%
Thailand	58.7%	66.9%	63.2%	60.5%
Asia Total	**90.9%**	**na**	**92.9%**	**91.7%**
Asia ex China	**79.9%**	**na**	**83.5%**	**81.3%**
All Emerging Markets in sample	**83.9%**	**na**	**85.3%**	**84.9%**
All Emerging Markets ex China	**73.7%**	**na**	**75.4%**	**75.1%**

Source: Authors'calculations.

Notes: Real returns are computed with the CPI as deflator. Sudden stops for individual countries from Rothenberg and Warnock (2006). Regional and global sudden stops are computed as sum over the respective countries divided by the number of countries. No short-sales are allowed. Regional aggregates are weigted by reserve levels as of end-2005. * Results for Russia based on Jan.2004 to Dec. 2005 due to change in currency basket.

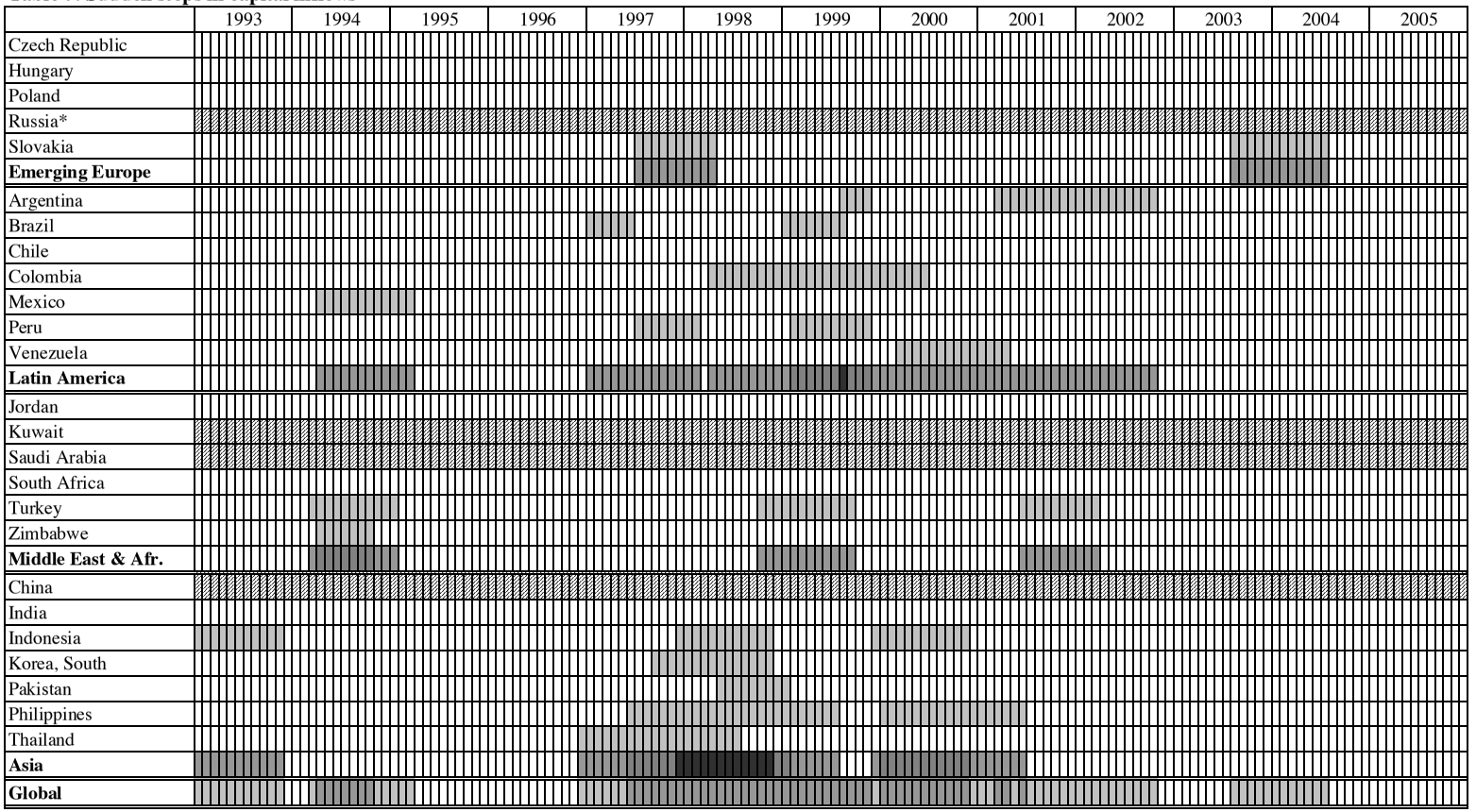
Table 6: Optimal dollar share for the 2-asset minimum variance portfolio with import deflators used for real returns, end 2005

	Without transaction motive	With transaction motive			Memo:
	-	Country-specific S	Regional S	Global S	Start of sample
Country	**(1)**	**(2)**	**(3)**	**(4)**	
Czech Republic	0.0%	0.0%	0.0%	0.0%	Jan-98
Hungary	0.0%	0.0%	0.0%	0.0%	May-03
Poland	36.0%	36.0%	33.8%	39.0%	Jul-99
Russia	na	na	na	na	
Slovakia	na	na	na	na	
Argentina	na	na	na	na	
Brazil	96.2%	100.0%	99.1%	97.8%	Jan-93
Chile	na	na	na	na	
Colombia	na	na	na	na	
Mexico	100.0%	100.0%	100.0%	100.0%	Jan-93
Peru	84.9%	89.4%	87.1%	86.0%	Jan-93
Venezuela	na	na	na	na	
Jordan	100.0%	100.0%	100.0%	100.0%	Jan-97
Kuwait	na	na	na	na	
Saudi Arabia	na	na	na	na	
South Africa	na	na	na	na	
Turkey	41.3%	36.1%	38.5%	45.2%	Jan-93
China	na	na	na	na	
India	na	na	na	na	
Indonesia	na	na	na	na	
Korea, South	84.5%	83.3%	87.8%	85.8%	Jan-93
Pakistan	na	na	na	na	
Philippines	na	na	na	na	
Thailand	55.4%	62.6%	59.3%	57.0%	Jan-93

Source: Authors'calculations.

Notes: Short-sale constraints are taken into account for optimal dollar shares as reported in this table. Real returns are computed with the import price index as deflator. Sudden stops for individual countries from Rothenberg and Warnock (2006).

Table 7: Sudden stops in capital inflows

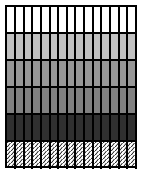


Sources: Rothenberg & Warnock (2006) and authors' calculations.

Notes: The sudden stop dates refer to true sudden stops as defined in Rothenberg and Warnock (2006), i.e. they exclude episodes dominated by capital ourflows of local investors (sudden flights).

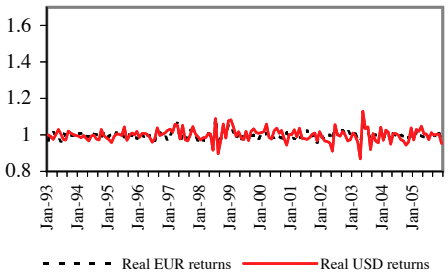
Legend:

No sudden stop
Sudden stop in one country or less than 10% in region
Sudden stops between 10% and 30% in region
Sudden stops between 30% and 50% in region
Sudden stops in more than 50% in region
No data

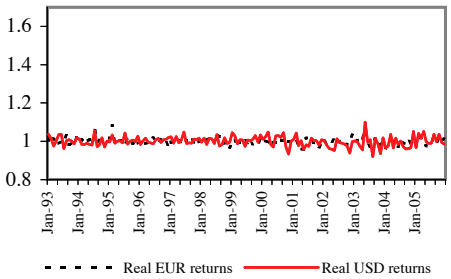


Appendix 7.3
Dollar and euro returns by region
Emerging Europe
(Monthly returns in real CPI-deflated local currency units)

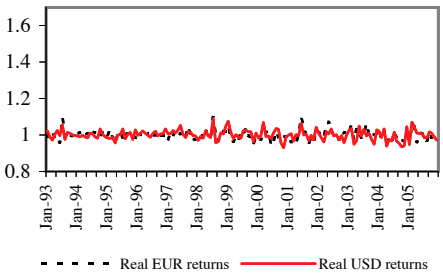
Czech Republic



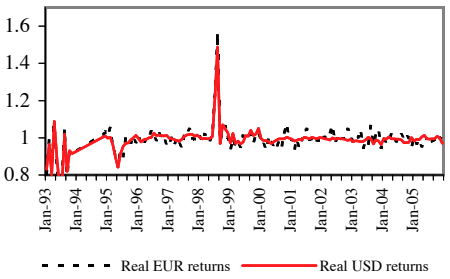
Hungary



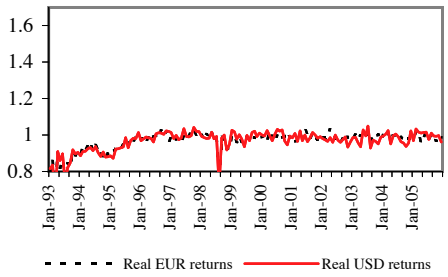
Poland



Russia



Slovakia



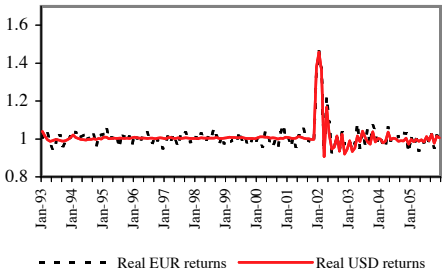
Appendix 7.3

Dollar and euro returns by region

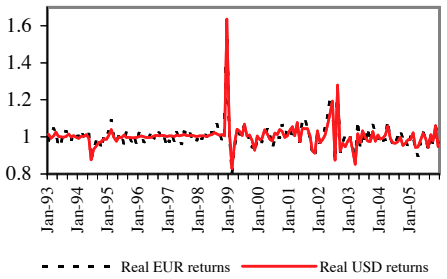
Latin America

(Monthly returns in real CPI-deflated local currency units)

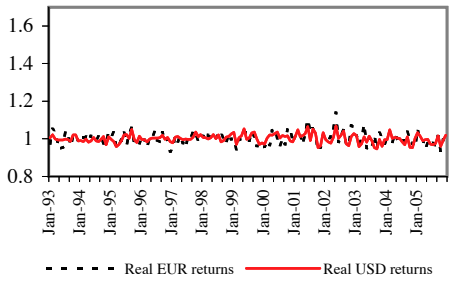
Argentina



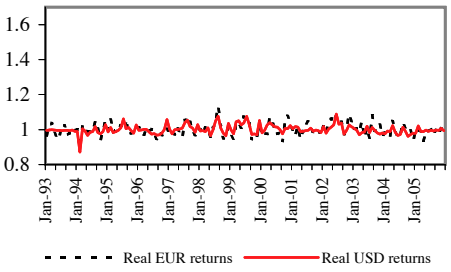
Brazil



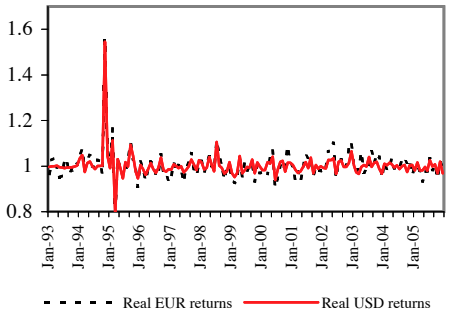
Chile



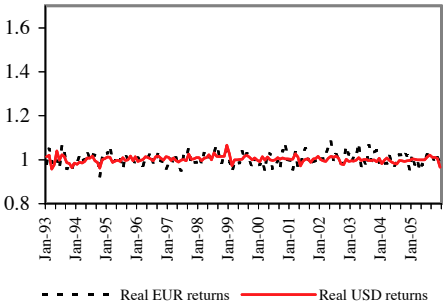
Colombia



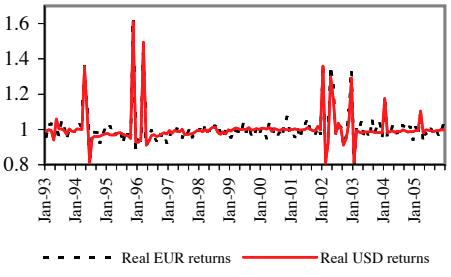
Mexico



Peru



Venezuela



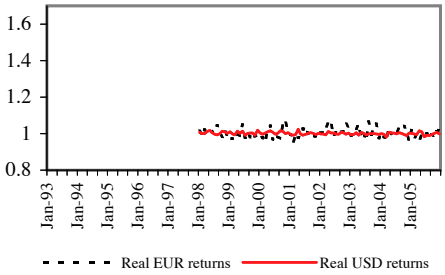
Appendix 7.3

Dollar and euro returns by region

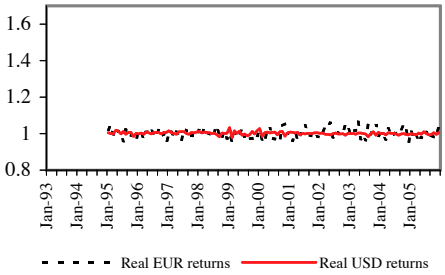
Middle East and Africa

(Monthly returns in real CPI-deflated local currency units)

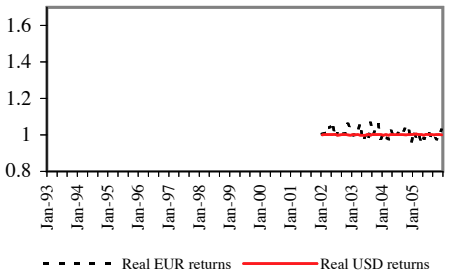
Jordan



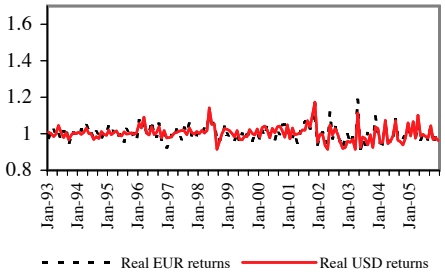
Kuwait



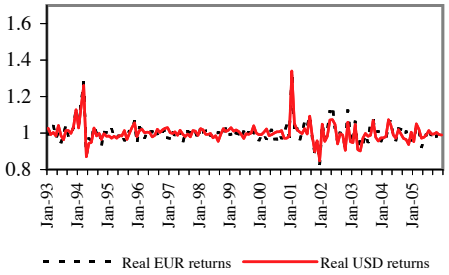
Saudi Arabia



South Africa

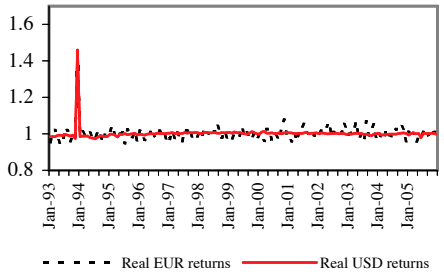


Turkey

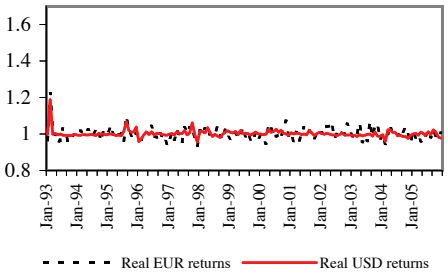


Appendix 7.3
Dollar and euro returns by region
Asia
(Monthly returns in real CPI-deflated local currency units)

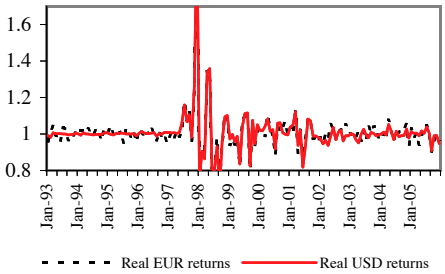
China



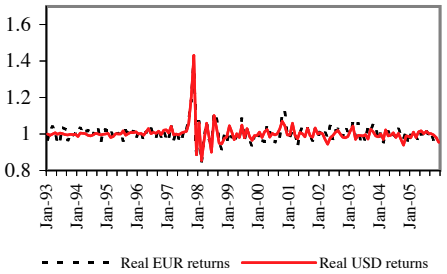
India



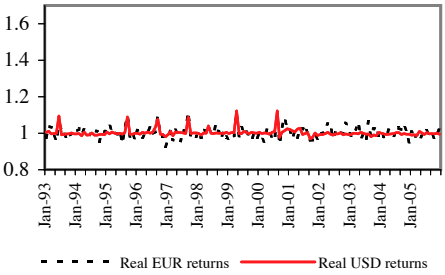
Indonesia



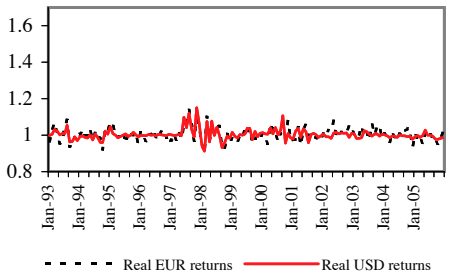
Korea (South)



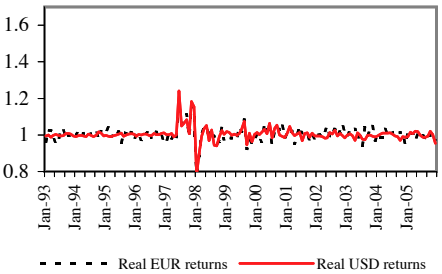
Pakistan



Philippines



Thailand



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