Optimal Currency Shares in International Reserves: The Impact of the Euro and the Prospects for the Dollar[†]

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Abstract

Foreign exchange reserve accumulation has risen dramatically over the past five years. The introduction of the euro and the increased liquidity in other major currencies has increased the pressure on central banks to diversify away from the dollar. This could have substantial implications for the international financial system. In this paper we use a mean-variance framework to estimate optimal weights among the main international currencies and assess how the euro has changed this allocation over time. We also incorporate rebalancing costs, which we proxy with (mean and extreme) currency bid-ask spreads. The results indicate that the recent drop in euro spreads fully compensated for the diversification losses associated with fewer currencies. We then perform some simple simulations for the optimal currency allocation of four large emerging market countries (Russia, Brazil, China and India) incorporating a central bank's desire to hold a sizable portion of its portfolio in the currencies of its foreign debt and international trade. The constrained optimization suggests that the euro potentially rivals the dollar as an international reserve currency. Actual dollar allocations are far greater than the optimizer implies, consistent with the current dominant role of the dollar as a reserve currency. But the increased tendency of many developing countries to issue euro-denominated assets and trade with the euro zone may shift this equilibrium and put pressure on the dollar.

[†] The views expressed in the paper are the authors', and do not reflect those of the European Central Bank and Barclays Capital.

1. Introduction

The euro has been in existence for almost seven years, and euro notes and coins have been in circulation for almost four years. Although it is still premature to evaluate the full implications of the only major currency established for more than a century, its successful introduction has already brought significant consequences for international finance. For example, a growing number of firms raise external finance issuing euro-denominated securities. In addition the use of the euro as a currency for the settlement or invoicing of international trade transactions has shown a notable increase in recent years (ECB 2004, 2005). The question among politicians, academics, and the public, however, is whether the euro will eventually displace the dollar as the leading international currency.

This prospect seemed unlikely just a decade ago, when the first stages of European Monetary Union were designed. Some argued that the euro could achieve the prerequisites for a major international currency (Alogoskoufis and Portes, 1991, 1992, 1997; Portes and Rey, 1998; Bergsten, 1997), but the dominant view held that the euro's international impact would be small (*e.g.*, Frankel, 1995; Eichengreen, 1998). Indeed, many were sceptical even about its legal and technical foundations, its short- to medium-term viability in the face of currency market pressures, and its long-run impact inside Europe (*e.g.*, Feldstein, 1997). Those who doubted that the euro would be successful stressed that the euro zone was not an "optimal currency area" and could therefore lead to tensions among member states in the conduct of monetary policy. The non-unified political voice of Europe would impede the euro's internationalization. Its role would be little more than that of the Deutsche mark – both theory (network externalities) and history (dollar and sterling) suggested insuperable inertia in the international status of currencies. The incumbent dollar was so dominant that only a cataclysmic shock could threaten its hegemonic status.

Nowadays, however, the prospect that the euro will at least challenge the dollar's role in global markets sounds less implausible. The euro zone is comparable with the U.S. economy in terms of GDP and trade openness, and it may even become larger than the U.S. economy when non-Eurozone EU members join in. Moreover, the European Central bank (ECB) has kept inflation expectations low, minimizing fears that it might abandon the anti-inflationary tradition of the "core" countries. Perhaps most important, the rising current account deficit and external debt of the United States create pressure on the dollar. For example, in a recent survey of central banks (RBS, 2005), most respondents said that they intended further diversification away from the dollar,

due to their fear of a hard landing. As the size of dollar-denominated external obligations rises, international portfolio holders perceive a rising "concentration risk" (Greenspan, 2004). On the other hand, the reluctance of the UK to adopt the euro and remaining obstacles to the full integration of euro-area government bond markets are both important negative factors for euro internationalization (Portes and Rey, 1998).

This paper contributes to the ongoing policy and academic debate on the euro's international role by studying its effect on the composition of central banks' foreign exchange reserves. Although we focus here on only one feature of a currency's international use, reserve composition, our analysis will also touch on other interrelated dimensions. Figure 1 reports the 2x3 box proposed by Peter Kenen (1983, 2003) that summarizes the key features of an international currency.[1] Studying international reserve holdings will lead us to explore how changes in the invoicing of financial and international trade transactions affect the composition of reserves.

Foreign exchange reserves are just one of the international roles of currencies. It may indeed be secondary to the vehicle currency role, which itself may rest on the standing of currencies in financial markets and the level of development of these markets (Portes and Rey, 1998). Yet there are very close links among these various roles (Kenen, 2003). Thus studying the effect of the euro on the composition of foreign exchange reserves may also bring new insights on other aspects of internationalization. One reason for looking now at foreign exchange reserves, as do Chinn and Frankel (2005), is their increasing importance in the international financial system. Reserve growth in recent years has been dramatic. Figure 2 illustrates this. In August 2005 the stock of international reserves exceeded 4 trillion dollars, more than twice the level when the euro was introduced in 1999. The supply comes primarily from US current account deficits. On the demand side, this rapid accumulation comes from the developing countries, which have almost tripled their reserves since the end of 1998. Current account surpluses in export-oriented developing countries have been supplemented by capital inflows. Emerging economies have accumulated foreign assets as protection against financial crises and as a consequence of foreign exchange market intervention to prevent appreciation of their own currencies. But their currency portfolio allocation also affects exchange rates among major industrial countries (Blanchard *et al.*, 2005) and is relevant to the recent debate on the sustainability of the U.S. current account (*e.g.*, Gourinchas and Rey, 2005a,b; Obstfeld and Rogoff, 2005; Folkerts-Landau and Garber, 2003, 2005). Decisions by even a

[1] Analogous matrices can be found in Hartmann (1999) and Chinn and Frankel (2005).

handful of central banks to shift their reserve composition away from the dollar could result in sizable dollar depreciation.

To assess the impact of the euro on international reserve holdings, we employ a mean-variance currency portfolio optimizer in a before-after event study framework. Using a dynamic optimizer that allows for dynamic correlations and serial dependence in the variance-covariance matrix of returns, we obtain the optimal portfolio composition of central banks' foreign exchange reserves before and after the introduction of the euro. We study the five main international currencies, namely the U.S. dollar (USD), the euro (EUR), the Swiss franc (CHF), the British pound sterling (GBP), and the Japanese yen (JPY), to assess how the *optimal* share of the Euro altered after 1999, compared to optimal pre-1999 allocation to the three main European currencies, the French franc (FFR), the Deutsche mark (DEM) and Dutch guilder (NLD). We then compare the estimated "optimal" shares with the actual aggregate shares communicated by the International Monetary Fund in its Annual Report. (Table1).

Central banks are unique institutions, however, and a simple mean-variance optimization that might look suitable for a global investor is clearly inappropriate. Anecdotal evidence, survey data and the scant empirics (discussed in the next Section) all suggest that central banks need to be highly liquid and want to hold a sizable fraction of their reserves in the currencies of their main trading partners and the currencies of their international debts. We therefore augment the currency optimizer with constraints reflecting these needs. This approach has some nice features. First, the portfolio diversification methodology is both intuitive and theoretically driven (in a micro-founded International CAPM). Second, it is also consistent with what we empirically observe. Central banks consult asset management experts and explicitly argue that maximizing returns (given their high risk aversion) is one of their primary objectives. Third, this methodology is flexible enough to allow us to add specific constraints reflecting the central banks' special needs. To quantify liquidity needs during periods of turmoil periods, for example, we add rebalancing transaction costs, which we proxy with extreme bid-ask spreads. Fourth, this methodology allows us to perform some simulations on the actual composition of a particular central bank's reserve holdings. Fifth comparing the actual reserve composition (from aggregate IMF data) and the allocations we obtain from the optimization gives us a rough measure of currency internationalization.

Our main results are: First, the currency optimizer yields allocations that significantly depart from actual reserve holdings. The optimization routine yields similar allocations in the five main international currencies (and gold), while the actual dollar share is almost fifty percentage points higher than what predicted. Specifically the optimizer yields a share in the dollar approximately 15%-20%, while the actual share of the dollar in total reserves in 2003 and 2004 was 65% (Table 1). This difference quantifies the dollar's international role as the main reserve currency, but also illustrates the huge foregone diversification losses.

Second, we incorporate rebalancing costs, which we proxy by mean and extreme bid-ask spreads in the foreign exchange market. The descriptive evidence suggests that during the past three years the spreads on the euro have fallen significantly. Although the optimal share in the euro compared to the allocation to the three main euro zone currencies before 1999 falls, since there are now fewer diversification opportunities, when we incorporate into the optimizer rebalancing costs then the optimal weight in euro slightly increases.. This suggests that the enhanced liquidity that the euro brought in the currency markets fully compensated the global investor for the diversification losses associated with the replacement of the individual currencies by the euro. In addition spreads have also narrowed significantly in other industrial countries' currencies, thus making diversification away from the dollar even more attractive than before.

Finally, we augment the currency optimizer with constraints capturing the desire of central banks to hold a sizable portion of their holdings in the currency of their external debt and in the trade invoicing currency, and we perform some simple simulations for four developing countries that have recently accumulated large amounts of foreign reserve assets: Brazil, Russia, China, and India – the BRICs (Goldman Sachs, 2004, 2005). For trade shares, the constrained optimization results assign large weights to the Euro, which now gets a similar and if anything a larger share than the dollar. For example the optimizer tells us that the euro should be the main reserve currency for Russia and Brazil. The optimizer yields almost equal shares of the dollar, the euro and the yen for Chinese reserves. These simple simulations illustrate that if we incorporate debt and trade considerations, the dominant position of the dollar might be challenged much sooner than expected. This is because the euro zone is now the main trading partner of many emerging market countries (Russia, Brazil and India in our sample) that run large current account surpluses. In addition an increasing number of non-EU residents and government issue euro-denominated assets.

The rest of the paper is structured as follows. In the next Section, we review the evidence on what determines foreign exchange reserves. In Section 3 we describe our empirical framework and discuss the main features of the data. In Section 4 we present the preliminary results from the mean-variance analysis, and we add liquidity-transaction costs in rebalancing. In Section 5 we incorporate the desire of central banks to hold a sizable fraction of their foreign exchange reserves in the currency of their main trading partners and in the currency of their external debt. To do so we present some simple simulations on the BRICs. In Section 6 we summarize, offering some avenues for future research.

2. Related literature on the currency composition of foreign reserves

2.1. History

Those who see a growing international role for the euro point out that history provides other examples of leading international currencies losing their dominant status. Most recently, during the gold standard era, the pound sterling enjoyed a dominant international role similar to that of the dollar since the early fifties. Yet both economic policies and the two world wars weakened the British economy and its external finances, enabling the dollar to replace sterling as the leading international currency. The development of the New York financial markets in the 1920s and the establishment of the Federal Reserve System were also major factors in the rise of the dollar. Eichengreen (2005) points out that although some theoretical analyses based on network externalities may suggest that there will be only one international currency, this argument does not apply to the currency of denomination of reserves. This is because the need for diversification forces private agents and central banks away from only one currency.[2] History also suggests that the primary considerations for the composition of reserves have been market liquidity (which in turn depends on central banks' willingness to ensure it, currency convertibility, financial crises, and the underlying development of financial markets) and a dominant position in international trade. Diversification and market liquidity are key features in our approach. Yet besides these economic reasons, geo-political factors are also important. Sterling's internationalization occurred after the United Kingdom established itself as an imperial power, while the dollar ascended after the United States emerged as the dominant military power.

[2] Eichengreen (2005) writes that "It may pay to hold reserves in the most liquid market, which tends to be the market in which everyone else holds reserves, but market liquidity is not all that matters. It may worth tolerating a bit less market liquidity in return for the benefits of greater diversification…"

2.2. Regression evidence

Large sample evidence based on regression techniques on the determinants of reserve composition is scant. Attempts to directly address this question by regressing actual currency shares on macroeconomic, monetary and financial factors are hampered by the unwillingness of central banks to release data on their actual composition.

In a recent paper, Chinn and Frankel (2005) use aggregate IMF data (similar to those presented in Table 1) on the share of seven main currencies in total identified official reserve holdings during the 1973-1998 period to investigate determinants of the global composition of international reserves. Their main finding is that the share of major currencies in global reserve holdings is very persistent (their coefficient on the lagged dependent variable is between 0.85 and 0.96). In addition, the lagged depreciation rate and inflation (or exchange rate volatility) enter with negative and significant coefficients, while income enters with a significantly positive coefficient.[3] Frankel and Chinn also perform an out-of-sample forecast and compare it with the actual realized share of the Euro. Their projections suggest that it will take at least 25 years for the euro to challenge the dominance of the dollar as a major reserve currency, unless there is a major deterioration in the stability of the dollar (depreciation, inflation).

Although this approach is informative, it is not fully reliable mainly due to data problems. First, it is based on coarse aggregate data. The IMF does not provide data from individual central banks, which are unwilling to reveal this information. Although the IMF also provides a disaggregation between industrial and developing countries, this separation is again coarse, and data quality problems are still present. The more reliable data from the industrial group are not fully suitable, since these countries cannot hold their own currencies as reserves. On the other hand, data for developing countries, which are more appropriate to judge the international role of currencies, are recorded with substantial error (BIS 2004).[4] Second, the extrapolation procedure implicitly assumes that the same dynamics govern the composition of reserves before and after the introduction of the euro. Third, as the authors acknowledge, most of the forecast is generated by the lagged dependent variable, while the most interesting question would be to understand what drives this huge persistence (see also Truman, 2005, on this point).

[3] Eichengreen and Frankel (1996), Eichnegreen (1998) and Chinn (1999) reach similar results in slightly different samples.
[4] For a similar point see Chinn and Frankel (2005) and Eichengreen and Mathieson (2000).

Thus we may get more information from the studies of Dooley, Lizondo and Mathieson (1989) and more recently Eichengreen and Mathieson (2000) that utilized confidential IMF data on shares of the major international currencies in reserve holdings in a large number of industrial and developing countries since the late seventies to investigate the high persistence. This work finds that currency pegs, the direction of trade, and the currency of foreign debt can explain the high inertia in reserve composition. Not only are these factors highly significant and robust determinants of the currency composition of reserve holdings, but their importance is very stable across time. Dooley, Folkerts-Landau and Garber (2003, 2004) also emphasize the role of trade links and currency pegs as the key reasons behind East Asian and Latin America central banks' unwillingness to follow a pure textbook diversification strategy.[5]

2.3. Case study and survey evidence

Although central banks appear quite reluctant to release data on the actual composition of their reserves, they are becoming increasingly transparent on their general asset management strategies. Recent collections of articles (RBS, 2003, 2005; ECB, 2004) provide interesting information from central bank asset management practitioners as well as survey data on their reserve policies. The main message from these collections is that central banks do follow a portfolio optimization strategy for their reserves, while also taking into account the unique features of monetary authorities.

The reviews by Reddy (2003) and De León (2003) of the asset management practices of the Indian and the Canadian central banks respectively suggest that these institutions pursue mean-variance portfolio diversification policies in their main international holdings.[6] This is further emphasized in Naameh's (2003) overview of developing countries. Naameh also presents evidence that constraints associated with trade, debt composition and the currency peg are particularly important for emerging and under-developed countries: "A country in the CFA zone may need to service its debt in US dollars, pay for its net imports in Japanese yen and intervene in the foreign exchange market in euros. In such a case, the portfolio will be severely constrained, so the best available assets and their relative weights will not determine its return and risk." Along related lines, Gmuer

[5] Dooley *et al*. (2003, 2004) argue that if the dollar peg and export growth are the key objectives of East Asian economies that should limit diversification away from the US dollar.

[6] Diversification is also stressed by Hansen, Olgaard and Hensen (2003) review of the Danish Central bank approach. They write: "The ratio between yield and risk can be improved by spreading the krone duration into additional currencies. …The smaller the degree of covariation between the interest rates of the currencies in which the reserve is places, the greater the diversification gain. Distribution on several currencies also spreads the liquidity risk."

and Cavegn (2003) rationalize the practice of the Swiss central bank to hire external portfolio managers by the absence of such constraints.

This country-specific case-study evidence is confirmed in the 2003 and 2005 central bank surveys conducted by Pringle and Garver on behalf of the Royal Bank of Scotland (RBS 2003, 2005). Besides validating the importance of pegs, trade, external debt as well as geopolitical factors in reserve composition, there is some tentative indication that central banks are shifting towards euro-denominated securities.[7] For example, 39 central banks out of the 45 replied that they have increased their exposure to the euro, while only 15 central banks increased exposure to the US dollar and 29 reduced this exposure. In addition most respondents stated that they were considering alternative currencies for further diversifying their risk, such as the Swedish and the Norwegian krona or the Australian and Canadian dollar, which offered higher returns and lower correlation with the other major currencies, while being highly liquid. This suggests that despite the high inertia, the dollar's dominant position might be challenged sooner rather than later.

2.4. Key findings on reserve composition

To summarize, the main findings on reserve composition that we will try to incorporate in our currency optimization framework are:

1) There is high inertia in reserve composition. Thus any change towards increasing the euro's role will probably occur gradually rather than abruptly. This conjecture is also supported by sterling's gradual loss of its international status to the dollar. But a major shock provoking a sudden fall of the dollar and rise in US inflation could change the picture.
2) Monetary authorities hold a high share of their reserves in the currency of their main trading partner(s). This suggests that the role of the dollar will continue to be important. It also implies, however, that protectionist policies on either side of the Atlantic could have direct effects on reserve holdings.
3) The currency composition of foreign debt is a major factor in the allocation of central banks' reserve holdings. Since government and private issuance in euro-denominated securities has increased greatly since 1999, this would imply that central banks will raise the proportion of their reserves in euros to match country assets with liabilities.

[7] Pringle and Garver (2005) thus conclude that "diversification from dollar-denominated to euro-denominated assets appears to be taking place more rapidly than had been anticipated two years ago (in the 2003 survey), although this result may to some extent reflect revaluation changes".

4) Central banks that peg domestic currencies to a given currency tend to hold larger shares of their reserves in that currency. Although the dollar is still the main anchor currency, the importance of the euro is steadily increasing. Currently almost 50 countries have officially pegged their exchange rate to the euro (ECB 2005). Although pegging to the euro is mainly observed in the new EU member states and EU neighbouring regions, countries with sizable reserve holdings outside the European sphere of influence, like Russia and Libya, are using the euro in their basket peg (or basket reference value, like China).
5) Central banks pursue portfolio diversification strategies, but with a very high risk aversion and a desire to have liquidity especially during periods of turmoil. From a diversification standpoint, the introduction of the euro reduced diversification opportunities, and thus *ceteris paribus* one should have expected a fall in euro share after 1999. But the euro market has become more liquid and deeper (especially vis-a-vis the currencies of the periphery).

3. Methodology and data

Following the empirical evidence, we propose a dynamic mean-variance framework with constraints and transaction costs.[8] Modern portfolio theory rests on two fundamental observations: (1) investors like returns but dislike risks; and (2) there is an inherent trade-off between expected return and risk: investments offering high expected returns tend also to carry higher risks. Against this background, a natural question is whether an investor can systematically improve his expected risk-adjusted returns. Diversification turns out to be the answer to this question. To take advantage of this feature we build a currency "optimiser" that maximizes the following Lagrangian:

$$MaxE_t \sum_{i=1}^{I} \left[r_{,i,t} w_{i,t} + r_{f,t} w_{f,t} \right] - \lambda \underline{w_t} V_t \underline{w'_t}$$

$$s.t.$$

$$\sum_{i=1} w_{i,t} + w_{f,t} = 1$$

$r_{i,t}$ is the return to currency i in time (year) t, w_i is the weight in the portfolio of currency i, and λ is a risk aversion parameter. For the risk-free (cash) asset, we use the US dollar. The weights in the currencies should sum to 1.

There are two main challenges in performing this optimisation routine: First, exchange rates are hard to predict, especially over short horizons (Meese and Rogoff, 1983; Obstfeld and Rogoff,

[8] For newly developed methodology on FX portfolio optimisation see Codirla, Siourounis and Woo (2005).

1996).[9] For simplicity and expositional clarity we assume that all assets (currencies) converge to their implied one-year forward rates (interest parity holds), thus the expected asset appreciation or depreciation over this holding period is zero.[10]

Second, we need to make a reliable projection of the variance-covariance matrix of currency returns (V_t). The forecast of the variance-covariance matrix (VCM) is at the heart of the mean-variance optimisation framework, since the estimated shares (w_i) appear sensitive to even small changes in the elements of the VCM matrix. For robustness we follow three different computational methodologies to produce estimates of the VCM: Simple historical; Constant Correlation multivariate GARCH (CC-GARCH) (Bollerslev, 1990); and Dynamic Conditional Correlation multivariate GARCH (DCC-GARCH) (Engle, 2002; Engle and Kroner, 2001).[11] The difference between simple historical and CC-GARCH is that the latter allows for time-varying volatility. The difference between CC-GARCH and DCC-GARCH is that the latter allows for time-varying correlations. For precision we use daily data (from Bloomberg) and estimate the VCM matrix using a five-year window. The Computational Appendix provides more details on these estimation techniques.

We study five currencies, the US dollar, the Swiss franc, the Japanese yen, the British pound sterling, and the euro. Before 1999, we replace the euro with the three main international EMU currencies, the Deutsche mark, the French franc and the Dutch guilder. We estimate the above model in the decade surrounding the introduction of the euro (the period 1995-2005) and then compare the "optimal" share in the euro currencies (DEM, FRF, NLG) in the years before 1999 and the five years after when these currencies are replaced by the euro.[12]

We start by estimating the unconstrained model. We then add constraints reflecting central banks' special needs (for a similar approach, see Fischer and Lie, 2004). To quantify the desire of central banks for liquidity, especially during turmoil periods, we add rebalancing costs proxied by (mean

[9] See Siourounis (2005) and Hau and Rey (2005) for some empirical VAR models, linking exchange rates with equity returns and capital flows, that beat a random walk for some currency pairs and some horizons.
[10] Another approach would be to use historical returns or perform simulations. We leave this for future research.
[11] We avoid using BEKK (named after Baba, Engle, Kraft and Kroner) as suggested by Engle and Kroner (1995) due to its undesirable convergence properties when modelling spot and future prices (see Lien, Tse and Tsui, 1998).
[12] Similar optimisers have been developed by many investment banks. See among others Fischer and Lie (2004) and Ferket and Zwanenburg (2004) in the ECB volume on risk management for central bank foreign reserves.

and extreme) bid-ask currency spreads.[13] Transaction costs affect returns and can also affect strategic reallocation if the market outlook suddenly changes and a potential bail-out of a given position is required. Below, we present the modified objective function, which takes transaction costs into account (see also Codirla, Siourounis and Woo, 2005). The modified objective function is a reduction in expected returns by the loss due to the transaction costs:

$$\mu_p = \underline{\mu} \cdot \underline{w}^{new} - \sum_i Spread_i \left| w_i^{new} - w_i^{old} \right|.$$

The dynamic aspect of portfolio re-allocation is captured in the transition from the old set of weights to the new. This further implies that the initial starting portfolio does affect the final outcome. If $Spread_i$ is significant (as it is in the beginning of our sample) the optimal allocation given transaction costs will be significantly different from that without. Adding thus rebalancing costs will capture part of the high persistence of portfolio weights in the dollar.

We next study how the pattern of trade and the currency composition of external debt influence the "optimal" composition of reserves in four large emerging market countries: Brazil, India, China, and Russia (the BRICs). We first obtain data on trade flows (from the International Monetary Fund Direction of Trade Database) for these four countries with the US, the euro area, Japan, the UK and Switzerland. We then construct a vector of constraints for each central bank of the four developing countries. These constraints reflect Central Bank's need to hold at least a fraction *x* of their reserves in the same currency as their trade share with each of the five (seven prior to 1999) countries included in the optimiser. We repeat this exercise by using the composition of foreign debt, obtaining data on foreign debt composition from the World Bank Global Development Finance Database. Data coverage stops at the end of 2003, and we note that there are some reporting gaps and problems during 1999-2001. The next sections report the results of our analysis.

4. Base case results

4.1. A first look at currency spreads

[13] Mean spreads are calculated from daily data retrieved from Bloomberg for each year prior to the optimisation. Extreme spread is the maximum bid/ask spread observed in the year prior to optimisation. Both spreads are expressed as percentages of spot FX prices. See also Section 4.1 and Table 2.

Table 2 presents bid-ask spreads from Bloomberg of the main international currencies from 1995 until October 2005 against the US dollar. Bid-ask spreads proxy for liquidity and transaction costs on the foreign exchange market. The Table presents the mean bid-ask spreads based on daily data over the last year, as well as the maximum value over the previous year. In an early assessment of the effect of the euro on the foreign exchange markets, Hau *et al.* (2002a, 200b) found that bid-ask spreads (as well as turnover) for most bilateral euro markets during 1999 were systematically higher than they were during 1998 for bilateral markets for the German mark. Detken and Hartmann (2002) found similar results (but of lower magnitude) in a larger sample.

The data in Table 2 are partly in line with these early findings. Mean spreads in the USD/DEM exchange rate were 0.04% in 1998, while mean spreads in the EUR/USD market were 0.05% and 0.07% during the first two years of the euro. But mean spreads in the euro market have fallen to minimal levels in the past two years (at 0.01%), indicating that the market has gained liquidity and efficiency. Although spreads have fallen in all major currency markets, the euro and the pound sterling markets are consistently the most efficient during the past two years. Still, mean spreads might not reflect accurately the transactions costs of rebalancing, since central banks often need to intervene in the market in periods of turmoil. Thus in Table 2 we also present the maximum bid-ask spread over the previous year. The data clearly indicate that the euro has brought sizable gains in this regard, since extreme spreads have narrowed drastically. For example, during the four years before the introduction of the euro, the maximum spread in the Deutsche mark, the French franc and the Dutch guilder were 0.68%, 0.44% and 0.53% respectively.[14] Yet since the beginning of 2001, the maximum bid-ask spread in the EUR/USD market was 0.11%. Thus foreign central banks now have a much more attractive alternative, since even in periods of liquidity crunch the euro foreign exchange markets seem highly liquid, with a quite low transaction cost.[15] In addition other major currencies have enhanced their liquidity and spreads have also fallen, as for the two Scandinavian currencies and the Canadian dollar. This makes diversifying away from the US dollar particularly attractive, since these currencies are not so correlated with the dollar and are now relatively cheap to trade.

4.2. Benchmark portfolio allocations with and without transaction costs

[14] On 2 October 2000, sterling experienced some very large shock linked to the overall negative environment of global asset markets. In 2003, the Swiss franc had a day of very wide spreads when the announcement from the central bank regarding the inflation and growth outlook was a big surprise for market participants.

[15] Of course our analysis just compares bid-ask spreads in the foreign exchange markets against the dollar. Clearly to get a full picture of the effect of the euro in lowering transaction costs, one needs to examine turnover and spreads in other markets as well.

In Table 3 we present some simple portfolio allocations for a global investor in the currency market. We assume that the five main international currencies have the same risk characteristics, so the interest parity condition holds, dictating that the returns (interest plus exchange rate movement) should be equal among the main currencies. Although a vast literature suggests that UIP does not hold (see Sarno and Taylor, 2004), we like others take it as a good starting point. In addition, central banks typically do not speculate on short-term fluctuations among the main international currencies and follow a medium-term portfolio strategy (Pringle and Carver, 2005). So the portfolio weights reported in Table 3 are based on minimizing the variance of the portfolio. Throughout the paper, we set this at a conservative value of 5.4%. We report three estimates, based on different assumptions and methods in estimating the variance-covariance matrix. n Panel A we estimates the variance-covariance matrix with the constant correlation GARCH method (Bollesrlev, 1990), while in Panels B and C we apply the Dynamic Conditional Correlation (DCC) GARCH method proposed by Engle (2002) and Engle and Sheppard (2002), which is particularly suitable for asset returns. In addition in Panel C we add gold to the currency optimizer. We do not believe that central banks mechanically follow such an optimization approach. It is useful, however, to have a first look at what a benchmark, textbook approach suggests. This approach gives also a first estimate of the foregone diversification gains.

First, the optimizer allocates similar weights to all the assets. For example for the last year, the estimates in Panel C reveal approximately equal weights in the five main currencies and gold. This clearly indicates the disproportionate role of the dollar, since the actual reserve composition (see Table 1) suggests a gap of approximately 50%. While the optimizer allocates approximately 15% to USD for 2004 and 2005 the actual share in dollars was around 65%-66%. Second, the optimal weight in the single European currency compared to the sum of the allocations to the mark, the French franc and the guilder has fallen. This comes as no surprise in this framework, since *ceteris paribus* there are now less diversification opportunities for the global investor. Third, the dollar's weight has fallen most likely due to higher volatility in the last two years, mainly to the benefit of sterling and the yen.[16]

A key feature of an international currency is low transaction costs (Portes and Rey, 1998). Transaction costs are also a key factor behind the recent micro-approach to the FOREX market

[16] This is most likely driven by the market interventions of the BoJ, which kept the yen's volatility quite low.

(e.g. Lyons, 2004). In Tables 4 and 5 we augment the currency optimizer with rebalancing transaction costs. In Table 4 we proxy transaction costs with standardized mean bid-ask spreads over the previous year, while in Table 5 we use the extreme values of bid-ask spreads in the previous year. Since central banks are interested in providing liquidity in abnormal market periods, we believe that proxying transaction costs with extreme spreads is more informative than using the means. In addition, there is more variation (both across and within) in extreme spreads. Thus the results given in Table 4, where we use mean bid-ask spreads, are quite similar to the previous results in Table 3 without any form of rebalancing costs. Studying the results using extreme transaction costs, however, as reported in Table 5, we find that now the optimal share of the euro does not fall after 1999. This implies that the gains due to enhanced liquidity fully compensate for the loss arising from having fewer assets among which to diversify.

5. Incorporating the currency composition of external debt and the direction of trade in the currency optimizer: simulated results for the BRICs

As we have seen, besides diversification a central bank wishes to hold a significant share of its reserves in the currencies of its country's external debt and in the currencies of its main trading partners. A priori these two factors can at least partly explain the significant share of the dollar since the seventies, when the American economy was by far the largest market for developing countries' exports, and the dollar was the main currency of security issuance. But during the last three years issuance in euro-denominated securities has increased substantially. In addition, the euro zone is of comparable weight to the US in international trade. To assess the impact of the currency composition of foreign debt and the direction of trade we augment the currency optimiser with constraints reflecting the debt and trade desiderata. We focus on Brazil, Russia, India, and China, all of which have been accumulating foreign assets rapidly. The next two sections discus the results for the two new sets of constraints.

5.1. Currency composition of external debt

We begin by incorporating into the optimiser constraints that each of the four countries has to hold a portion x of its reserves in the currency of its external debt. In Table 6 we report estimates imposing that Central Banks want to hold reserves in the currencies of the country's external debt at levels equal to 50% or 75% of the share of the debt in each currency. For example, in 1997 Russia had 65% of its external debt issued in USD and 29% issued in DEM. For that year, we thus

impose as a constraint that the Russian central bank would want to hold at least 32.5% (or 48%) of its reserves in dollars and 14.5% (or 22%) of its reserves in Deutsche marks. The 50% and 75% thresholds are of course ad hoc, and the optimisation problem becomes severely constrained.[17] Since we impose the same constraint across all major currencies, however, we can still make some inference over time, assessing how the replacement of the French franc and the Deutsche mark by the euro changed the composition of international reserve holdings. Our preferred comparisons are between the pre-1999 years and 2002 and 2003, since there are some data limitations regarding the foreign debt statistics for the 1999-2001 period. We also find more appealing the results with the less restrictive 50% threshold.

Table 6 presents the results of the constrained optimization problem. We continue to assume constant returns; the variance-covariance matrix is estimated with DCC-GARCH, and we proxy the rebalancing costs with the maximum bid-ask spreads. First, the results indicate that the optimal share of the euro has increased significantly in Russia and Brazil. Quite interestingly when we impose the more reasonable 50% constraint the optimal share of the euro in Russian reserves for the last three years is around 35%, which is exactly that the share that the Russian Central Bank has recently (august 2005) assigned to the euro in its basket peg. For China and India the role of the yen has increased whereas the role of the dollar has remained stable. Specifically, the role of the euro seems to have increased significantly in Brazil, where when we impose the more reasonable 50% constraint the optimiser implies that in 2003, the Central Bank should hold more than 50% of its reserves in euro. The similar, although less pronounce, pattern applies for Brazil. Second, the role of the dollar remains significant, especially when we impose the very restrictive 75% threshold. Third, the yen seems to be the big winner for the Asian countries given the increased role Japan plays as an economic partner.

5.2. Direction of international trade

Of great interest is also to examine how the pattern of trade influences the optimal allocation. The direction of trade is relatively most stable over time and recent evidence show that countries issue and trade securities with the same countries that they tarde goods (e.g. Aviat and Courdacier, 2004; Rose and Spiegel, 2004; Lane, 2005). We proceed by incorporating the desire of the BRIC central banks to manage their reserves partly depending on the trade share (imports plus exports as

[17] To ensure convergence of the numerical algorithm used to evaluate the Maximum Likelihood in the second step of the DCC-GRACH we allow constraints to vary by a small value (less than 1%). We also experiment with other threshold values.

a percentage of total trade with the world) with each of the four developed countries included in our optimiser. Since the direction of trade is unlikely to change drastically, we impose less restrictive thresholds of 25% and 50%. For example, in 2004 the share of Brazilian trade with the US and the Eurozone was the almost the same at 20%. We thus impose that the Brazilian central bank wants to hold at least 5% or 10% of its reserves in dollars and in euros. Table 7 reports the actual shares of trade. Data are retrieved from IMF's Direction of Trade Database until 2004. In 2004 the euro zone was the main trading partner for Russia, accounting for more than 45% of Russian exports and imports. It was also the main trading partner of India and Brazil, although the actual shares of trade were not significantly higher than that with the US. China on the other hand had approximately the same trade shares with the G-3 countries.

The constrained optimisation results are given in Table 8. The optimal allocation to euros has increased significantly in all four countries (most notably in Russia and Brazil), reflecting the increasing weight of the euro zone in international trade. The results when we impose the less restrictive 25% constraint indicate that if central banks pursue this constrained optimisation routine, then they should allocate around 30% of their reserves to the euro. This is somewhat higher than what the actual IMF data report for 2004, which is around 25%. If this 5% gap is indeed a valid proxy of a currency's internationalization, then this implies that the international impact of the Euro is starting to emerge. Regarding the role of the dollar, the optimal weights further validate the disproportionate role of the dollar in reserve holdings. While on average, among the four developing countries, the optimization gives the dollar a weight of 20%-25%, the actual share is forty percentage points higher at 65% (see Table 1). Although this difference might reflect non-economic factors, like military power, international prestige, and political stability that are relatively stable over time, the results clearly point out that central banks are losing sizable diversification gains due to this dollar bias.

6. Conclusion

Foreign exchange reserves have grown rapidly in recent years, and there is as yet no sign that the rate of accumulation will fall. Currently two-thirds of global international reserves are held in US assets. The reserve currency status of the dollar also confers an "exorbitant privilege" on the United States (Kenen, 2002; Gourinchas and Rey, 2005b), which can run large and prolonged current account deficits, financing them in its own currency. Nowadays, however, academics and money managers encourage developing countries' central banks to diversify their assets, switching

away from the dollar. Recent developments in international financial markets add pressure on the dollar. First, the emergence of the euro offers a new currency representing an economic area of the same size as the US. Moreover, after the first years, transaction costs in the euro currency markets have fallen drastically. Many other industrial countries' currencies have also enhanced their liquidity and thus offer attractive alternative assets for further diversification. Portfolio rebalancing away from the dollar would have immediate implications for the US and the global economy.

The starting point of our approach is to estimate what a simple textbook currency optimizer implies for the composition of foreign reserves. This is helpful to get a first crude proxy of how large the dollar bias is and how much diversification gains Central Banks forego. Not surprisingly, the allocations are far away from the actual shares. For example while a simple mean variance framework in the five main international currencies and gold yield a share in the dollar of approximately 15%-20%, the actual share of the dollar in 2004 and 2005 has been around 65%. This difference can be seen as a rough proxy of the currency's international role. Then we incorporate transaction costs in the optimization framework. Since central banks need to provide liquidity in abnormal market times, we use extreme bid-ask spreads to measure rebalancing costs. Finally, we bring into the optimization framework the needs of central banks to hold a sizable portion of their holdings in the currencies of their external debt and in the currencies of their main trading partners. We performed some simple simulations for four large developing countries, Brazil, Russia, India, and China. Although these constraints are ad hoc, we are able to assess the impact over time of the introduction of the euro. The results suggest that since an increasing number of countries issue euro-denominated securities in the international markets and the euro zone is the main trading partner of many developing countries, the optimal share in the euro has increased significantly in recent years. The optimal weights we obtain further illustrate that developing countries' central banks forego sizable diversification benefits by over-investing in dollar assets.

We believe that starting with a theoretically grounded, simple mean-variance framework and properly modifying it to incorporate the specific needs of monetary authorities can bring new insights about the prospects of adjustment. Evidence suggests that an increasing number of central banks pursue similar optimization strategies, consulting or even hiring money managers to assist them. Besides rebalancing the currency composition of foreign reserves, there is currently increasing pressure on central banks to invest in higher return assets, such as mortgage and asset-

backed securities, highly rated corporate bonds and even equity. It would be thus very interesting to extend our framework allowing for currency returns in the money markets as well as government bonds, commercial paper and equity of each of the main industrial countries.

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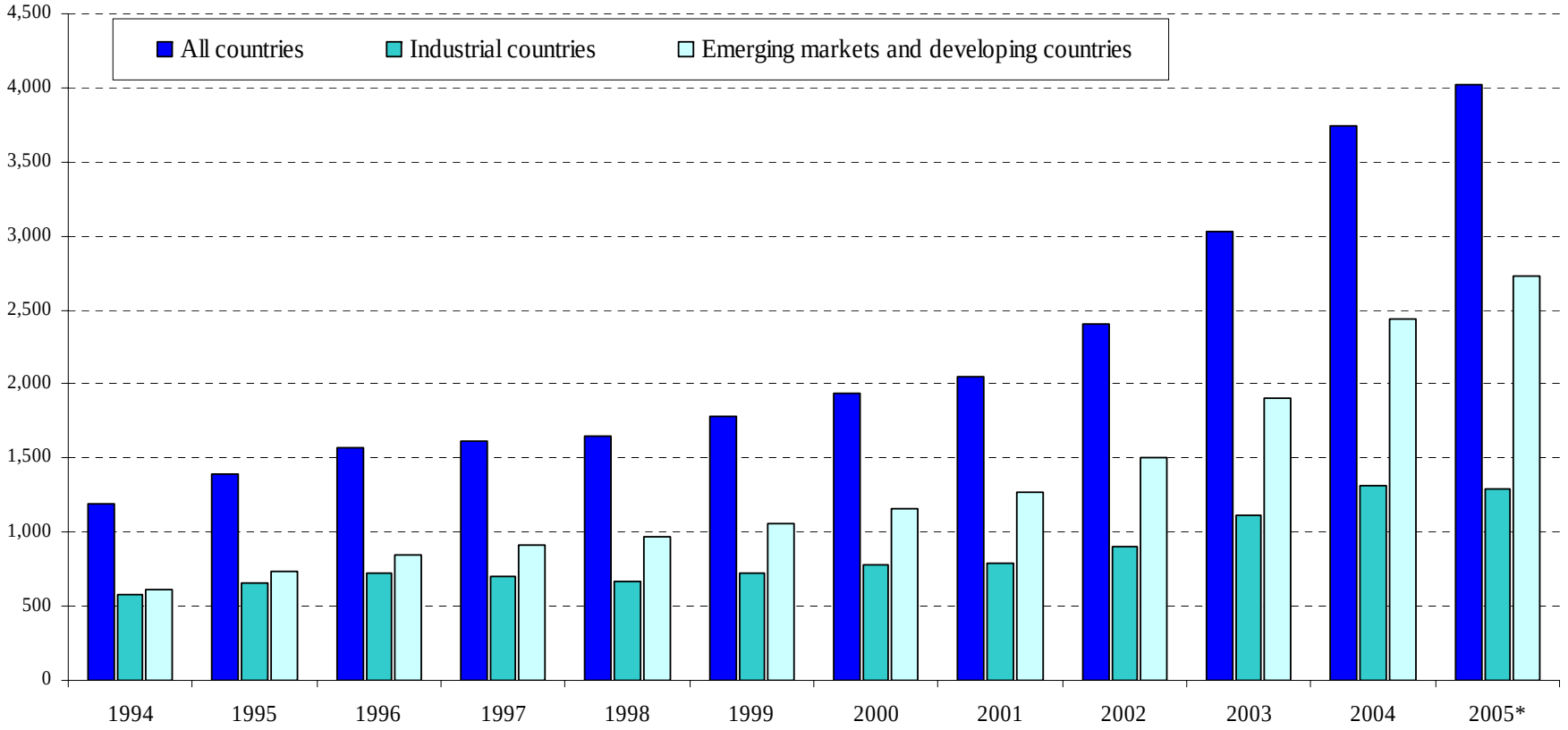
Figure 1: Functions of an International Currency

Function of Money	Government	Private Agents
Store of Value	International Reserves	Investment Currency (incl. currency substitution)
Medium of Exchange	Vehicle Currency for Foreign Exchange Intervention	Invoicing (vehicle) currency for trade in goods and assets.
Unit of Account	Anchor for currency peg	Quotation currency for trade in goods and assets.

Notes: The Figure summarizes the main functions of an international currency (Kenen, 1983).

Figure 2: Global Foreign Exchange Reserves

(USD billions, year-end)



Sources: IMF (2005) *August 2005

Table 1: Share of Main Currencies in Total Identified Official Holdings of Foreign Exchange

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
All countries										
U.S. dollar	59.00	62.10	65.20	69.40	71.00	70.50	70.70	66.50	65.80	65.90
Japanese yen	6.80	6.70	5.80	6.20	6.40	6.30	5.20	4.50	4.10	3.90
Pound sterling	2.10	2.70	2.60	2.70	2.90	2.80	2.70	2.90	2.60	3.30
Swiss franc	0.30	0.30	0.30	0.30	0.20	0.30	0.30	0.40	0.20	0.20
Euro	—	—	—	—	17.90	18.80	19.80	24.20	25.30	24.90
Deutsche mark	15.80	14.70	14.50	13.80	—	—	—	—	—	—
French franc	2.40	1.80	1.40	1.60	—	—	—	—	—	—
Netherlands guilder	0.30	0.20	0.40	0.30	—	—	—	—	—	—
ECU	8.50	7.10	6.00	1.20	—	—	—	—	—	—
Other currencies	4.80	4.30	3.80	4.50	1.60	1.40	1.20	1.40	1.90	1.80
Industrial Countries										
U.S. dollar	52.30	57.40	59.10	67.60	73.50	72.50	72.70	68.90	70.50	71.50
Japanese yen	6.70	5.70	5.90	6.90	6.70	6.50	5.60	4.40	3.80	3.60
Pound sterling	2.10	2.10	2.00	2.10	2.20	2.00	1.90	2.10	1.50	1.90
Swiss franc	0.10	0.10	0.10	0.20	0.10	0.20	0.30	0.60	0.20	0.10
Euro	—	—	—	—	16.10	17.10	18.00	22.40	22.10	20.90
Deutsche mark	16.60	15.90	16.20	13.40	—	—	—	—	—	—
French franc	2.30	1.70	0.90	1.20	—	—	—	—	—	—
Netherlands guilder	0.20	0.20	0.20	0.20	—	—	—	—	—	—
ECU	13.60	12.30	11.20	2.30	—	—	—	—	—	—
Other currencies	6.00	4.70	4.40	6.20	1.40	1.60	1.50	1.70	1.90	2.00
Developing Countries										
U.S. dollar	70.30	68.50	72.40	71.20	68.20	68.20	68.60	64.00	60.70	59.90
Japanese yen	7.00	8.10	5.70	5.60	6.00	6.00	4.90	4.70	4.40	4.30
Pound sterling	2.20	3.50	3.30	3.30	3.70	3.60	3.60	3.80	3.90	4.80
Swiss franc	0.70	0.60	0.60	0.50	0.40	0.30	0.30	0.20	0.20	0.20
Euro	—	—	—	—	19.90	20.60	21.80	26.10	28.90	29.20
Deutsche mark	14.40	13.00	12.50	14.30	—	—	—	—	—	—
French franc	2.40	2.00	2.10	2.10	—	—	—	—	—	—
Netherlands guilder	0.50	0.30	0.50	0.40	—	—	—	—	—	—
ECU	0.00	0.00	0.00	0.00	—	—	—	—	—	—
Other currencies	2.60	3.90	3.00	2.70	1.70	1.30	0.90	1.20	1.90	1.60

Source: International Monetary Fund (IMF) 2005 Annual Report.

Notes: Country coverage changes slightly every year. ECU reserves held by the monetary authorities existed in the form of claims on both the private sector and the European Monetary Institute (EMI), which issued official ECUs to European Union central banks through revolving swaps against the contribution of 20 percent of their gross gold holdings and U. S. dollar reserves. On December 31, 1998, the official ECUs were unwound into gold and U.S. dollars; hence, the share of ECUs at the end of 1998 was sharply lower than a year earlier. The remaining ECU holdings reported for 1998 consisted of ECUs issued by the private sector, usually in the form of ECU deposits and bonds. On January 1, 1999, these holdings were automatically converted into euros.

Table 2. Bid/Ask Spreads

	Dec-95		Dec-96		Dec-97		Dec-98		Dec-99		Dec-00		Dec-01		Dec-02		Dec-03		Dec-04		Oct-05	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
EUR	—	—	—	—	—	—	—	—	0.04%	0.20%	0.05%	0.11%	0.07%	0.11%	0.05%	0.10%	0.04%	0.08%	0.01%	0.04%	0.01%	0.04%
JPY	0.08%	0.39%	0.05%	0.09%	0.04%	0.38%	0.07%	0.44%	0.05%	1.07%	0.05%	0.09%	0.05%	0.21%	0.04%	0.09%	0.04%	0.09%	0.02%	0.06%	0.02%	0.05%
GBP	0.04%	0.06%	0.04%	0.29%	0.05%	0.30%	0.03%	0.30%	0.04%	0.31%	0.10%	12.32%	0.05%	0.07%	0.04%	0.08%	0.04%	0.07%	0.01%	0.04%	0.01%	0.06%
CHF	0.09%	0.09%	0.06%	0.15%	0.04%	0.40%	0.07%	0.11%	0.04%	0.09%	0.05%	0.07%	0.04%	0.11%	0.05%	0.08%	0.05%	1.21%	0.02%	0.06%	0.02%	0.08%
NLG	0.11%	0.29%	0.11%	0.24%	0.10%	0.28%	0.09%	0.53%	—	—	—	—	—	—	—	—	—	—	—	—	—	—
DEM	0.08%	0.28%	0.05%	0.68%	0.04%	0.28%	0.09%	0.42%	—	—	—	—	—	—	—	—	—	—	—	—	—	—
FRF	0.02%	0.06%	0.05%	0.14%	0.03%	0.15%	0.04%	0.09%	—	—	—	—	—	—	—	—	—	—	—	—	—	—
GOLD	0.14%	0.26%	0.13%	0.38%	0.17%	0.43%	0.17%	0.52%	0.21%	1.04%	0.25%	1.10%	0.19%	0.36%	0.15%	0.29%	0.12%	1.32%	0.13%	0.23%	0.14%	0.43%
SEK	0.12%	0.15%	0.20%	0.75%	0.12%	0.66%	0.37%	0.37%	0.10%	0.42%	0.04%	0.11%	0.06%	0.16%	0.06%	0.20%	0.07%	1.29%	0.06%	0.33%	0.04%	0.13%
NOK	0.05%	0.08%	0.16%	0.63%	0.20%	0.69%	0.07%	1.56%	0.07%	0.12%	0.05%	0.11%	0.06%	0.18%	0.07%	0.36%	0.07%	0.86%	0.04%	0.27%	0.04%	0.10%
CAD	0.07%	0.07%	0.05%	0.58%	0.04%	0.07%	0.07%	0.13%	0.05%	0.10%	0.05%	0.07%	0.05%	0.06%	0.05%	0.12%	0.06%	0.09%	0.03%	0.07%	0.03%	0.08%
AUD	0.07%	0.13%	0.07%	0.19%	0.08%	1.61%	0.16%	1.64%	0.08%	0.46%	0.10%	1.31%	0.10%	0.20%	0.08%	0.18%	0.06%	0.20%	0.04%	0.13%	0.04%	0.13%

Notes: Mean spreads are calculated from daily data for the preceding year. We first calculate the mean spread and we then express it as a fraction of the mid asset price. Max spreads represent the maximum value over the past year, expressed as a fraction of the mid asset price. We assume that the risk free asset does not have any transaction cost. The sample starts at 01/01/1995 and ends at 31/10/2005. *Source:* Bloomberg. *Currency abbreviations:* Euro (EUR); Swiss franc (CHF); British Pound (GBP); Japanese Yen (JPY); French Frank (FFR); Deutsche Mark (DM) and Dutch Guilder (NLD); Swedish Krona (SEK); Norwegian Krone (NOK); Canadian Dollar (CAD); Australian Dollar (AUD); GOLD stands for Gold.

Table 3: Optimal allocations

	Dec-95	Dec-96	Dec-97	Dec-98	Dec-99	Dec-00	Dec-01	Dec-02	Dec-03	Dec-04	Oct-05
					Panel A: CC GARCH						
USD	18.74%	16.51%	21.47%	23.96%	19.35%	18.97%	15.03%	14.79%	14.11%	13.52%	8.97%
JPY	13.21%	13.08%	8.72%	9.43%	20.96%	20.86%	22.86%	29.31%	29.31%	25.83%	30.13%
GBP	23.23%	18.57%	25.86%	29.08%	20.24%	19.85%	20.90%	19.45%	24.15%	26.54%	36.84%
CHF	8.61%	11.61%	8.70%	5.18%	19.35%	20.52%	17.63%	17.53%	9.47%	10.22%	8.95%
DEM	10.68%	12.64%	9.92%	9.07%	—	—	—	—	—	—	—
FRF	14.63%	14.85%	15.30%	14.53%	—	—	—	—	—	—	—
NLG	10.91%	12.73%	10.01%	8.75%	—	—	—	—	—	—	—
EUR	36.22%	40.23%	35.24%	32.35%	20.10%	19.80%	23.57%	18.91%	22.95%	23.89%	15.11%
					Panel B: DCC GARCH						
USD	19.97%	24.48%	25.73%	23.50%	16.66%	14.99%	12.64%	16.53%	15.79%	15.52%	9.54%
JPY	13.02%	11.53%	12.00%	12.04%	28.86%	26.28%	24.69%	29.60%	30.36%	29.42%	60.44%
GBP	24.31%	24.79%	29.99%	29.67%	19.62%	27.03%	27.72%	18.14%	16.52%	17.90%	17.87%
CHF	7.33%	5.18%	6.53%	5.91%	16.74%	11.26%	11.70%	22.42%	25.34%	25.68%	9.37%
DEM	10.20%	9.32%	7.82%	9.63%	—	—	—	—	—	—	—
FRF	15.08%	14.97%	9.96%	10.00%	—	—	—	—	—	—	—
NLG	10.08%	9.72%	7.98%	9.24%	—	—	—	—	—	—	—
EUR	35.36%	34.01%	25.75%	28.86%	18.11%	20.44%	23.25%	13.31%	11.99%	11.48%	9.29%
					Panel C: DCC GARCH plus Gold						
USD	15.14%	15.05%	22.46%	18.31%	16.03%	13.51%	14.89%	16.59%	14.05%	15.38%	15.64%
JPY	11.52%	11.32%	10.30%	10.53%	17.07%	18.60%	17.11%	16.58%	16.18%	14.25%	15.62%
GBP	17.49%	15.14%	25.56%	22.82%	17.24%	20.09%	18.33%	16.95%	18.17%	18.62%	17.51%
CHF	8.56%	9.40%	4.72%	6.12%	14.66%	9.85%	13.73%	16.15%	10.05%	13.03%	14.01%
DEM	10.01%	10.61%	6.05%	8.71%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
FRF	12.53%	12.38%	7.97%	9.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NLG	9.94%	10.68%	6.13%	8.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GOLD	14.79%	15.42%	16.80%	15.84%	18.00%	20.41%	18.20%	16.76%	23.85%	20.90%	19.28%
EUR	32.49%	33.67%	20.15%	26.37%	17.01%	17.53%	17.74%	16.98%	17.70%	17.82%	17.92%

The Table reports the currency weights of an optimal asset allocation based on a mean-variance optimization routine and assuming zero expected returns (UIP holds). In Panel A the variance-covariance matrix is estimated with a constant correlation GARCH. In Panel B and Panel C the variance-covariance matrix is estimated with a dynamic correlation multivariate GARCH.
For currency abbreviations see notes in Table 2. In Panel C besides the five main international currencies the optimizer also includes Gold. Before 1999 the share of the Euro is the sum of the shares in DM, NLG, and FFR. Accepted risk is set to 5.4% annually. The USD is set as the risk free rate.

Table 4: Optimal allocations and transaction costs measured by mean bid-ask spreads

	Dec-95	Dec-96	Dec-97	Dec-98	Dec-99	Dec-00	Dec-01	Dec-02	Dec-03	Dec-04	Oct-05
					Panel A: CC GARCH						
USD	19.42%	16.54%	21.98%	24.70%	19.67%	19.16%	16.65%	15.72%	11.23%	11.94%	7.66%
JPY	13.00%	13.06%	8.68%	9.02%	20.55%	20.69%	22.20%	28.32%	33.52%	33.79%	36.25%
GBP	22.90%	18.58%	25.38%	28.32%	19.86%	19.68%	19.70%	18.18%	21.26%	24.32%	32.95%
CHF	8.92%	11.69%	8.78%	5.73%	20.18%	20.75%	21.83%	20.42%	16.10%	12.21%	7.63%
DEM	11.02%	12.69%	9.98%	9.25%	—	—	—	—	—	—	—
FRF	13.57%	14.83%	14.98%	14.05%	—	—	—	—	—	—	—
NLG	11.12%	12.61%	10.22%	8.93%	—	—	—	—	—	—	—
EUR	35.71%	40.12%	35.17%	32.23%	19.71%	19.72%	19.62%	17.36%	17.87%	17.72%	15.50%
					Panel B: DCC GARCH						
USD	21.05%	24.98%	25.84%	23.85%	17.10%	8.85%	10.09%	16.58%	15.93%	15.64%	12.87%
JPY	12.86%	11.35%	11.66%	12.89%	28.45%	31.83%	30.13%	29.51%	30.06%	29.30%	43.73%
GBP	23.60%	23.80%	29.71%	29.63%	18.35%	22.57%	25.43%	18.08%	16.37%	17.73%	13.42%
CHF	7.83%	5.60%	6.51%	6.71%	19.16%	19.25%	19.17%	22.54%	25.60%	25.77%	15.83%
DEM	10.88%	9.84%	7.96%	8.44%	—	—	—	—	—	—	—
FRF	13.39%	14.30%	10.13%	10.20%	—	—	—	—	—	—	—
NLG	10.34%	10.13%	8.17%	8.28%	—	—	—	—	—	—	—
EUR	34.61%	34.27%	26.26%	26.92%	16.89%	17.48%	15.18%	13.30%	12.04%	11.56%	14.15%
					Panel C: DCC GARCH plus Gold						
USD	15.56%	15.18%	21.48%	19.08%	17.34%	13.14%	15.80%	16.57%	14.05%	15.41%	15.67%
JPY	11.47%	12.05%	10.16%	10.89%	19.74%	20.49%	19.59%	16.76%	16.09%	14.11%	15.61%
GBP	17.41%	16.03%	21.01%	22.66%	26.36%	26.38%	23.79%	16.78%	17.95%	18.35%	16.89%
CHF	8.68%	9.31%	4.97%	5.13%	10.39%	10.18%	11.55%	16.46%	10.27%	13.34%	14.63%
DEM	10.15%	10.56%	5.93%	7.02%	—	—	—	—	—	—	—
FRF	12.27%	12.46%	12.45%	11.24%	—	—	—	—	—	—	—
NLG	9.88%	9.91%	9.87%	9.87%	—	—	—	—	—	—	—
GOLD	14.52%	14.49%	14.11%	14.11%	14.11%	14.12%	13.83%	16.86%	24.18%	21.30%	20.03%
EUR	32.31%	32.93%	28.26%	28.13%	12.02%	15.68%	15.45%	16.56%	17.45%	17.48%	17.18%

The Table reports the currency weights of an optimal asset allocation based on a mean-variance optimization routine and assuming zero expected returns (UIP holds) and transaction rebalancing costs proxied by mid bid/ask spreads in the previous year. In Panel A the variance-covariance matrix is estimated with a constant correlation GARCH. In Panel B and Panel C the variance-covariance matrix is estimated with a dynamic correlation multivariate GARCH.

For currency abbreviations see notes in Table 2. In Panel C besides the five main international currencies the optimizer also includes Gold. Before 1999 the share of the Euro is the sum of the shares in DM, NLG, and FFR. Accepted risk is set to 5.4% annually. The USD is set as the risk free rate.

Table 5: Optimal allocations and transaction costs measured by maximum bid-ask spreads

	Dec-95	Dec-96	Dec-97	Dec-98	Dec-99	Dec-00	Dec-01	Dec-02	Dec-03	Dec-04	Oct-05
						Panel A: CC GARCH					
USD	49.87%	5.44%	21.04%	25.91%	25.42%	17.81%	16.99%	15.54%	12.71%	13.92%	7.64%
JPY	0.00%	21.81%	15.02%	15.02%	15.02%	15.30%	22.13%	28.24%	32.04%	30.53%	30.56%
GBP	33.15%	33.15%	33.12%	33.11%	33.04%	33.03%	18.98%	18.21%	20.20%	24.03%	30.35%
CHF	0.00%	18.36%	18.34%	13.51%	26.45%	18.78%	21.85%	20.62%	20.62%	9.51%	8.49%
DEM	0.20%	0.20%	0.18%	0.18%	—	—	—	—	—	—	—
FRF	16.74%	21.00%	12.27%	12.26%	—	—	—	—	—	—	—
NLG	0.00%	0.00%	0.00%	0.00%	—	—	—	—	—	—	—
EUR	16.95%	21.20%	12.44%	12.44%	0.00%	15.06%	20.02%	17.38%	14.43%	21.99%	22.97%
						Panel B: DCC GARCH					
USD	33.14%	31.22%	32.42%	31.06%	27.18%	15.81%	5.90%	16.44%	16.52%	15.61%	13.18%
JPY	0.00%	1.93%	1.93%	1.94%	1.95%	24.44%	24.59%	29.55%	33.02%	29.45%	33.53%
GBP	26.71%	26.47%	26.47%	26.46%	26.42%	26.42%	29.55%	18.15%	16.30%	17.65%	16.65%
CHF	18.31%	18.59%	18.59%	18.64%	44.34%	10.04%	16.66%	22.48%	22.49%	25.63%	26.49%
DEM	0.00%	0.00%	0.00%	0.01%	—	—	—	—	—	—	—
FRF	21.80%	21.78%	20.59%	21.88%	—	—	—	—	—	—	—
NLG	0.00%	0.00%	0.00%	0.00%	—	—	—	—	—	—	—
EUR	21.80%	21.78%	20.58%	21.89%	0.00%	23.24%	23.29%	13.35%	11.67%	11.64%	10.15%
						Panel C: DCC GARCH plus Gold					
USD	33.16%	31.63%	33.74%	33.14%	51.52%	32.82%	22.62%	11.55%	7.21%	19.03%	15.17%
JPY	0.00%	1.35%	1.35%	1.36%	1.36%	0.00%	4.63%	1.89%	1.58%	0.44%	0.47%
GBP	25.19%	25.15%	25.15%	25.14%	46.86%	45.16%	45.97%	60.85%	65.56%	38.59%	37.96%
CHF	19.86%	19.88%	19.88%	19.94%	0.00%	21.73%	22.47%	21.37%	21.37%	18.77%	23.24%
DEM	0.39%	0.39%	0.39%	0.84%	—	—	—	—	—	—	—
FRF	21.35%	21.53%	19.42%	19.51%	—	—	—	—	—	—	—
NLG	0.00%	0.00%	0.00%	0.00%	—	—	—	—	—	—	—
GOLD	0.00%	0.07%	0.07%	0.07%	0.07%	0.07%	0.29%	0.30%	0.30%	0.29%	0.31%
EUR	21.74%	21.92%	19.80%	20.35%	0.01%	0.00%	4.00%	4.03%	3.99%	22.86%	22.85%

The Table reports the currency weights of an optimal asset allocation based on a mean-variance optimization routine and assuming zero expected returns (UIP holds) and transaction rebalancing costs proxied by maximum bid/ask spreads in the previous year. In Panel A the variance-covariance matrix is estimated with a constant correlation GARCH. In Panel B and Panel C the variance-covariance matrix is estimated with a dynamic correlation multivariate GARCH.

For currency abbreviations see notes in Table 2. In Panel C besides the five main international currencies the optimizer also includes Gold. Before 1999 the share of the Euro is the sum of the shares in DM, NLG, and FFR. Accepted risk is set to 5.4% annually. The USD is set as the risk free rate.

Table 6: Simulated Optimal Allocations for Selected Developing Countries with Currency Composition of External Debt as Constraint

	Dec-95		Dec-96		Dec-97		Dec-98		Dec-99		Dec-00		Dec-01		Dec-02		Dec-03	
	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%
Panel A: Russia																		
USD	41.97%	47.96%	38.64%	42.44%	46.15%	50.30%	47.11%	51.90%	45.56%	53.63%	50.68%	60.41%	47.50%	59.01%	45.16%	52.12%	42.62%	51.63%
JPY	1.00%	1.50%	2.14%	3.84%	2.14%	3.73%	2.14%	3.73%	2.13%	3.73%	5.50%	3.67%	5.50%	1.47%	0.31%	0.07%	2.40%	0.11%
GBP	11.59%	7.93%	11.58%	8.01%	11.58%	8.01%	12.82%	8.01%	12.82%	6.77%	12.82%	6.77%	15.64%	9.83%	19.09%	0.00%	20.50%	0.00%
CHF	14.33%	8.58%	14.65%	8.58%	14.26%	8.51%	14.15%	7.28%	15.69%	6.79%	8.14%	5.81%	2.35%	0.00%	0.00%	0.00%	0.00%	0.00%
DEM	17.10%	25.65%	18.90%	28.35%	16.81%	27.83%	16.79%	27.82%	—	—	—	—	—	—	—	—	—	—
FRF	13.93%	8.28%	14.08%	8.75%	9.05%	1.60%	6.99%	1.26%	—	—	—	—	—	—	—	—	—	—
EUR	31.03%	33.93%	32.98%	37.10%	25.86%	29.43%	23.78%	29.08%	23.79%	29.08%	22.85%	23.34%	28.93%	29.63%	35.43%	48.38%	34.47%	49.01%
Panel B: India																		
USD	41.33%	50.43%	38.18%	45.51%	43.61%	53.23%	47.04%	57.87%	42.61%	50.42%	40.49%	51.38%	35.26%	52.75%	44.01%	55.89%	51.48%	57.12%
JPY	7.40%	11.10%	10.54%	15.91%	8.74%	15.91%	8.74%	15.91%	8.74%	15.91%	23.83%	37.52%	39.65%	40.77%	29.42%	35.22%	30.66%	40.00%
GBP	12.05%	5.02%	12.04%	5.02%	11.93%	5.03%	11.94%	5.03%	11.94%	5.02%	11.94%	5.03%	12.69%	2.58%	7.87%	3.15%	1.56%	1.54%
CHF	20.54%	17.66%	20.58%	17.73%	17.80%	17.73%	14.75%	14.00%	19.18%	21.44%	7.16%	0.66%	0.67%	0.25%	13.65%	0.43%	13.65%	0.33%
DEM	3.41%	4.95%	3.41%	5.06%	8.73%	5.05%	8.72%	5.04%	—	—	—	—	—	—	—	—	—	—
FRF	15.20%	10.75%	15.23%	10.76%	9.15%	3.04%	8.80%	2.15%	—	—	—	—	—	—	—	—	—	—
EUR	18.61%	9.38%	18.64%	15.82%	17.87%	8.09%	17.53%	7.19%	17.53%	7.20%	16.57%	5.39%	11.66%	4.08%	5.02%	5.30%	2.65%	3.42%

Table 6 (cont.)

	Dec-95		Dec-96		Dec-97		Dec-98		Dec-99		Dec-00		Dec-01		Dec-02		Dec-03	
	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%	50%	75%
Panel C: China																		
USD	45.82%	55.58%	41.36%	49.88%	48.41%	62.22%	50.88%	61.65%	46.33%	53.71%	45.59%	53.61%	42.62%	55.57%	44.22%	55.80%	41.78%	53.30%
JPY	10.35%	15.53%	14.37%	21.36%	14.33%	14.42%	14.30%	14.36%	14.30%	14.35%	22.69%	23.14%	31.80%	40.27%	30.10%	31.43%	34.60%	42.30%
GBP	7.96%	1.88%	7.97%	2.49%	8.00%	2.59%	8.05%	2.88%	8.05%	2.87%	8.08%	2.87%	9.21%	0.10%	5.76%	1.07%	3.70%	0.00%
CHF	19.07%	17.47%	19.31%	17.19%	19.28%	16.72%	9.11%	16.43%	13.66%	24.34%	9.69%	0.96%	13.93%	0.08%	13.04%	6.98%	13.04%	0.00%
DEM	0.85%	1.28%	0.89%	1.27%	0.86%	1.05%	1.15%	1.72%	—	—	—	—	—	—	—	—	—	—
FRF	15.88%	8.18%	16.09%	7.80%	9.11%	2.95%	16.50%	2.95%	—	—	—	—	—	—	—	—	—	—
EUR	16.73%	9.46%	16.98%	9.07%	9.97%	4.00%	17.64%	4.43%	17.64%	4.71%	13.94%	19.38%	2.40%	3.60%	6.87%	4.70%	6.87%	5.30%
Panel D: Brazil																		
USD	48.71%	62.31%	42.64%	56.58%	49.16%	59.47%	52.90%	64.48%	48.13%	58.07%	48.75%	62.95%	39.79%	53.59%	41.16%	54.85%	38.70%	58.00%
JPY	4.30%	6.45%	9.62%	6.67%	9.61%	6.63%	9.59%	6.62%	9.59%	6.62%	17.02%	6.61%	17.04%	6.60%	37.20%	35.99%	3.50%	3.39%
GBP	7.71%	1.35%	7.70%	1.65%	7.70%	1.72%	7.69%	1.73%	7.69%	1.72%	7.69%	1.72%	15.73%	1.08%	6.47%	0.40%	0.56%	0.00%
CHF	21.20%	21.31%	21.25%	26.28%	21.24%	25.19%	14.57%	20.51%	19.35%	26.91%	11.52%	22.31%	0.18%	1.28%	2.33%	0.10%	1.42%	0.00%
DEM	2.55%	3.82%	2.85%	4.27%	2.84%	3.82%	2.85%	3.82%	—	—	—	—	—	—	—	—	—	—
FRF	15.47%	4.70%	15.93%	4.53%	9.43%	3.15%	12.39%	2.84%	—	—	—	—	—	—	—	—	—	—
EUR	18.02%	8.53%	18.78%	8.80%	12.27%	6.98%	15.24%	6.66%	15.24%	6.67%	15.00%	6.41%	27.19%	37.37%	12.81%	9.03%	55.74%	39.57%

The Table reports the currency weights of an optimal asset allocation based on a constrained mean-variance optimization routine and assuming zero expected returns (UIP holds) for four selected developing economies. The variance-covariance matrix is estimated with a dynamic correlation multivariate GARCH. Accepted risk is set to 5.4% annually. Before 1999, EUR is the summ of allocations in DM, FFR and NLG. For currency abbreviations see notes in Table 2. The USD is set as the risk free rate.

Panel A reports the allocations for Russia, Panel B the allocations for India, Panel C the allocations for China and Panel D the allocations for Brazil. The constraints are based on the currency composition of external debt. Specifically the table reports the weights based on two ad hoc threshold constraints. That the Central Banks hold at least an identical share of their reserves in the currency of the external debt (75%) and that they hold at least half of the share of the external debt denominated in this currency (50%).

Table 7: Actual Trade Shares

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
					Panel A: Russia					
US	6.24%	7.24%	6.56%	8.79%	8.58%	7.80%	7.66%	6.18%	4.79%	4.91%
EUR (ex UK)	41.23%	39.03%	41.25%	39.06%	40.19%	42.32%	46.99%	43.47%	44.80%	46.81%
Japan	3.17%	3.01%	2.85%	2.61%	2.50%	2.44%	2.72%	1.81%	2.24%	3.15%
UK	3.39%	3.34%	3.15%	3.61%	3.41%	4.04%	3.49%	3.21%	3.29%	3.27%
Switzerland	3.58%	3.46%	3.10%	3.19%	3.68%	3.11%	1.60%	3.78%	3.33%	3.59%
Germany	10.17%	9.26%	9.58%	9.71%	10.10%	9.59%	11.63%	9.52%	9.70%	10.14%
France	2.09%	2.24%	2.34%	2.65%	2.33%	2.27%	2.71%	2.96%	3.07%	3.05%
Netherlands	3.89%	3.36%	4.19%	4.23%	4.10%	3.71%	3.94%	5.41%	5.20%	7.04%
					Panel B: India					
US	13.30%	13.70%	13.84%	14.19%	13.94%	13.16%	12.95%	13.20%	12.03%	10.74%
EUR (ex UK)	20.32%	20.43%	19.53%	19.55%	18.00%	16.18%	16.51%	15.93%	15.48%	14.38%
Japan	6.71%	6.16%	5.40%	5.41%	5.01%	4.07%	3.98%	3.37%	3.11%	2.76%
UK	5.48%	5.79%	5.94%	5.94%	5.58%	5.69%	5.08%	4.70%	4.45%	3.88%
Switzerland	1.62%	1.78%	3.46%	4.22%	3.61%	3.70%	0.71%	2.61%	2.59%	3.25%
Germany	7.00%	6.72%	5.99%	5.42%	4.39%	3.92%	4.14%	3.97%	3.87%	3.57%
France	2.12%	2.18%	2.04%	2.06%	1.92%	1.79%	2.04%	1.91%	1.73%	1.63%
Netherlands	1.79%	2.03%	1.69%	1.63%	1.58%	1.43%	1.30%	1.29%	1.28%	1.23%
					Panel C: China					
US	14.54%	14.79%	15.08%	16.97%	17.05%	15.71%	15.80%	15.67%	14.87%	14.72%
EUR (ex UK)	12.49%	11.59%	11.13%	12.53%	12.81%	12.07%	12.88%	12.28%	13.15%	12.93%
Japan	20.44%	20.71%	18.71%	17.90%	18.35%	17.53%	17.22%	16.42%	15.69%	14.54%
UK	1.69%	1.75%	1.78%	2.03%	2.18%	2.09%	2.02%	1.83%	1.69%	1.71%
Switzerland	0.48%	0.48%	0.46%	0.44%	0.47%	0.47%	0.47%	0.43%	0.42%	0.45%
Germany	4.88%	4.54%	3.90%	4.43%	4.47%	4.15%	4.60%	4.48%	4.92%	4.69%
France	1.60%	1.43%	1.72%	1.86%	1.86%	1.62%	1.56%	1.35%	1.58%	1.53%
Netherlands	1.44%	1.54%	1.69%	1.85%	1.78%	1.67%	1.71%	1.71%	1.81%	1.86%
					Panel D: Brazil					
US	20.10%	20.93%	20.64%	21.68%	23.21%	22.78%	23.86%	24.06%	21.74%	19.79%
EUR (ex UK)	24.88%	23.63%	23.64%	25.55%	25.72%	22.16%	23.75%	23.02%	22.30%	21.81%
Japan	6.64%	5.70%	5.76%	5.05%	4.88%	4.71%	4.45%	4.17%	4.00%	3.55%
UK	2.38%	2.53%	2.37%	2.61%	2.70%	2.35%	2.54%	2.89%	2.54%	2.16%
Switzerland	1.15%	1.21%	1.01%	1.05%	1.03%	1.53%	1.26%	1.28%	1.07%	0.92%
Germany	7.28%	6.88%	6.76%	7.66%	7.50%	6.08%	6.47%	6.57%	6.11%	5.76%
France	2.53%	2.24%	2.44%	3.01%	3.32%	3.13%	3.29%	3.07%	2.91%	2.85%
Netherlands	3.53%	3.91%	3.81%	3.08%	3.15%	2.93%	2.86%	3.36%	3.78%	3.95%

The Table reports the share of trade of Russia, India, China and Brazil against the main industrial countries relatively to the total volume of trade. Source: IMF Direction of Trade Statistics (2005).

Table 8: Simulated Optimal Allocations for Selected Developing Countries with Direction of Trade as a Constraint

	Dec-95		Dec-96		Dec-97		Dec-98		Dec-99		Dec-00		Dec-01		Dec-02		Dec-03		Dec-04	
	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%
Panel A: Russia																				
USD	36.27%	31.03%	36.90%	32.12%	38.72%	35.80%	27.94%	36.35%	41.40%	32.40%	16.22%	16.97%	57.79%	56.44%	18.84%	19.85%	16.67%	21.06%	18.42%	17.51%
JPY	0.79%	1.59%	0.75%	1.54%	0.75%	1.55%	0.76%	1.55%	0.76%	1.55%	0.77%	9.63%	0.82%	4.80%	6.19%	6.51%	8.25%	5.07%	10.60%	11.53%
GBP	22.59%	22.40%	22.59%	22.40%	22.59%	22.33%	33.31%	22.33%	35.73%	23.98%	35.73%	23.96%	12.10%	1.74%	25.96%	15.10%	27.44%	15.28%	24.19%	17.25%
CHF	29.64%	22.95%	29.12%	22.00%	29.12%	19.58%	27.33%	19.08%	0.92%	2.61%	17.70%	10.39%	0.64%	0.80%	6.72%	6.73%	6.72%	6.73%	8.85%	8.54%
DEM	2.54%	5.09%	2.54%	5.09%	2.53%	4.91%	2.53%	4.90%	—	—	—	—	—	—	—	—	—	—	—	—
FRF	7.13%	14.93%	7.13%	14.91%	5.24%	13.72%	7.04%	13.67%	—	—	—	—	—	—	—	—	—	—	—	—
NLG	0.97%	1.95%	0.97%	1.95%	1.05%	2.09%	1.06%	2.11%	—	—	—	—	—	—	—	—	—	—	—	—
EUR	10.65%	21.96%	10.63%	21.94%	8.81%	20.73%	10.62%	20.69%	23.79%	34.04%	22.85%	25.88%	28.62%	36.18%	42.26%	51.79%	40.92%	51.86%	37.93%	45.17%
Panel B: India																				
USD	30.14%	30.24%	30.04%	31.01%	32.01%	34.52%	32.05%	35.28%	23.43%	33.00%	16.86%	19.94%	16.74%	23.64%	15.17%	21.50%	18.26%	21.88%	20.08%	21.68%
JPY	1.68%	3.36%	4.02%	3.08%	4.03%	3.08%	4.02%	3.08%	4.03%	3.09%	12.51%	17.54%	12.50%	17.51%	14.93%	11.41%	14.31%	13.64%	11.87%	11.34%
GBP	25.26%	22.87%	25.27%	22.84%	25.27%	22.84%	25.27%	22.85%	37.71%	27.05%	37.71%	27.04%	38.19%	24.01%	47.94%	28.90%	45.26%	28.45%	28.63%	27.17%
CHF	20.65%	19.92%	19.08%	19.83%	19.06%	19.83%	19.06%	19.33%	6.63%	1.81%	15.29%	8.31%	15.11%	7.68%	4.62%	1.89%	4.62%	1.89%	7.26%	6.89%
DEM	1.75%	3.50%	1.68%	3.51%	1.68%	3.50%	1.67%	3.49%	—	—	—	—	—	—	—	—	—	—	—	—
FRF	20.01%	19.14%	19.38%	18.71%	17.44%	15.23%	17.41%	14.98%	—	—	—	—	—	—	—	—	—	—	—	—
NLG	0.45%	0.90%	0.51%	1.01%	0.51%	1.00%	0.51%	0.99%	—	—	—	—	—	—	—	—	—	—	—	—
EUR	22.21%	23.54%	21.57%	23.23%	19.63%	19.73%	19.59%	19.46%	28.00%	34.87%	17.61%	27.13%	17.46%	27.14%	17.32%	36.28%	17.56%	34.12%	32.13%	32.92%

Table 8 (cont.)

	Dec-95		Dec-96		Dec-97		Dec-98		Dec-99		Dec-00		Dec-01		Dec-02		Dec-03		Dec-04	
	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%
Panel C: China																				
USD	35.67%	32.06%	36.03%	33.05%	31.46%	36.36%	33.07%	39.33%	18.59%	22.89%	17.61%	20.32%	18.05%	19.00%	18.35%	20.12%	13.63%	12.68%	16.06%	17.67%
JPY	5.11%	10.22%	5.18%	10.35%	11.96%	10.35%	11.96%	10.36%	11.96%	10.36%	27.71%	31.27%	32.16%	31.30%	34.51%	35.47%	41.22%	42.09%	42.78%	43.59%
GBP	19.78%	18.71%	19.78%	18.70%	25.42%	18.70%	25.43%	18.70%	25.45%	18.69%	25.45%	18.69%	17.42%	19.26%	14.82%	13.15%	3.09%	13.98%	11.22%	9.83%
CHF	27.31%	20.86%	26.97%	20.56%	22.35%	20.57%	20.93%	18.13%	40.74%	41.56%	9.89%	7.61%	7.25%	6.70%	15.14%	13.15%	15.12%	13.14%	11.58%	9.97%
DEM	1.22%	2.44%	1.22%	2.42%	1.85%	2.41%	1.85%	2.42%	—	—	—	—	—	—	—	—	—	—	—	—
FRF	10.48%	14.90%	10.44%	14.15%	4.40%	10.77%	4.27%	10.12%	—	—	—	—	—	—	—	—	—	—	—	—
NLG	0.36%	0.72%	0.38%	0.77%	2.49%	0.84%	2.48%	0.93%	—	—	—	—	—	—	—	—	—	—	—	—
EUR	12.06%	18.06%	12.04%	17.34%	8.74%	14.03%	8.61%	13.46%	3.20%	6.41%	19.29%	22.06%	25.10%	23.73%	17.17%	18.09%	26.93%	18.10%	18.36%	18.94%
Panel D: Brazil																				
USD	31.21%	32.75%	31.35%	32.20%	34.50%	36.60%	34.57%	38.13%	17.27%	34.71%	16.64%	25.40%	26.91%	25.76%	28.18%	26.17%	20.49%	27.55%	22.80%	25.29%
JPY	1.66%	3.32%	1.61%	3.64%	1.61%	3.64%	1.61%	3.63%	2.52%	3.63%	13.53%	15.74%	13.53%	15.74%	13.44%	10.29%	16.41%	11.44%	11.86%	11.19%
GBP	23.98%	20.15%	23.98%	20.16%	23.98%	20.15%	23.98%	20.15%	42.72%	21.21%	42.72%	21.21%	32.28%	18.51%	32.01%	24.68%	33.44%	22.18%	26.33%	23.30%
CHF	20.19%	19.53%	20.12%	19.59%	20.12%	19.58%	19.98%	18.28%	30.79%	0.51%	7.77%	4.95%	7.97%	7.71%	7.16%	0.64%	1.42%	0.64%	5.93%	5.24%
DEM	1.82%	3.64%	1.82%	3.64%	1.82%	3.63%	1.92%	3.83%	—	—	—	—	—	—	—	—	—	—	—	—
FRF	20.19%	18.77%	20.14%	18.82%	16.99%	14.46%	16.97%	14.04%	—	—	—	—	—	—	—	—	—	—	—	—
NLG	0.88%	1.76%	0.98%	1.96%	0.98%	1.93%	0.98%	1.93%	—	—	—	—	—	—	—	—	—	—	—	—
EUR	22.89%	24.18%	22.94%	24.42%	19.79%	20.02%	19.87%	19.80%	6.51%	39.75%	19.30%	32.67%	19.32%	32.27%	19.20%	38.20%	28.16%	38.19%	33.07%	34.97%

The Table reports the currency weights of an optimal asset allocation based on a constrained mean-variance optimization routine and assuming zero expected returns (UIP holds) for four selected developing economies. The variance-covariance matrix is estimated with a dynamic correlation multivariate GARCH. Accepted risk is set to 5.4% annually. Before 1999, EUR is the summ of allocations in DM, FFR and NLG. For currency abbreviations see notes in Table 2. The USD is set as the risk free rate.

Panel A reports the allocations for Russia, Panel B the allocations for India, Panel C the allocations for China and Panel D the allocations for Brazil. The constraints are based on the trade share with the correspomding developed countries defined as export plus imports devided by the total gross world trade. Specifically the table reports the weights based on two ad hoc threshold constraints. That the Central Banks hold at least 50% and 25% percent of their reserves of the currency of thier main trading partner.