PROJECT REPORT

CORRELATION & CO VARIANCE COEFFICIENT OF ASIAN CURRENCIES LAST

15 TO 20 YEARS

SUBMITTED TO

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Introduction

The recent turmoil in currency markets in Asia, Latin America, and Europe and the explosion of international capital flows that preceded these crises have ignited, once again, the debate on whether restrictions to international capital mobility can help reduce the perhaps excessive euphoria of investors, attenuate the severity of the crises, or limit contagion. Many have argued that globalization has gone too far, with international capital markets becoming extremely erratic after liberalization. One of the most ardent defender of the old order has been Joseph Stiglitz, who as the World Bank's chief economist, clamored for developing countries to put some limits on capital inflows in order to moderate the “excessive” boom-bust pattern in financial markets.Even controls on capital outflows, not long ago dismissed as ineffective, have become fashionable again. Paul Krugman, for instance, has argued that they may help in managing, at least temporarily, an otherwise disorderly retreat of investors.Others have challenged these views, arguing that financial repression is a symbol of a bygone era that promotes corrupt and unstable financial systems and is incapable of preventing massive speculative capital attacks against the domestic currency.3

The debate has not been merely theoretical. Some countries have reversed their earlier liberalization attempts, while others have resisted turning back the clock to the times of capital controls. Prominent among the first group is Malaysia. In August 1997 —in the midst of the Asian crisis and following Malaysian Prime Minister Mahathir Mohamad’s attacks on “rogue speculators”— Malaysia introduced restrictions on capital outflows, which later were severely reinforced in September 1998, following the Russian crisis. Less drastic, but still quite restrictive, were Chile's and Colombia's restrictions on capital inflows in the early 1990s. Argentina and Peru, by contrast, have refrained from reintroducing capital account controls even in the presence of severe speculative attacks against their domestic currencies.

But do capital controls, in fact, limit international financial integration and help central banks regain monetary independence? While the heat of the debate has generated an immense and still growing empirical literature on the effectiveness of capital controls, the answer is far from clear. Some studies suggest that controls do insulate domestic financial markets; others conclude that controls are ineffective in stopping the international transmission of shocks. Most of these studies, however, examine individual country episodes.With each study using a different methodology and a different country episode, it is difficult to evaluate whether these conflicting results are evidence that country experiences are in fact different or simply the product of different techniques. Multicountry studies could unravel the causes of this lack of consensus. The only impediment is the lack of a comprehensive database on capital controls.Another limitation of previous empirical work is that the research has concentrated on examining the extent of the co-movement of domestic and foreign returns (of stocks or bonds) at very high frequencies, be it daily or weekly, ignoring the co-movements at longer horizons. Thus it has been impossible to capture evidence on the long-sustained belief that legal restrictions tend to be circumvented more often the longer they stay in place. Finally, because of the relative availability of the data, most empirical work has examined the transmission of shocks in equity markets.However, one of the most appealing aspects of capital controls (at least, in theory) is that they can allow central banks to maintain an autonomous monetary policy.This was the goal of Colombia, Chile, and Brazil when they introduced restrictions to capital inflows during the early 1990s and of Malaysia when it restricted capital outflows after the Russian crisis. To examine whether controls did, in fact, insulate emerging markets from global interest-rate shocks, more attention should be devoted to co-movements between domestic and world interest rates.

Capital Account Controls: Theory and Evidence

One of the most profound and far-reaching economic developments of the 1990s has been the explosive growth of international financial transactions. Globalization has been clearly beneficial to the extent that it has allowed capital to flow to its most attractive destination. However, this same globalization of capital markets has been associated with severe financial crises.10 The role of international capital flows in triggering crises has generated once again a heated debate on the pros and cons of restrictions to capital mobility.

Theory

Under the efficient markets hypothesis, it would be pointless to discuss capital account controls. Liberalization is always perceived as beneficial to investors.11 The rationale for restricting international capital flows, by contrast, is grounded in the belief that market failures and distortions pervade capital markets around the world. One of the most often cited distortions is that of information asymmetries. Information asymmetries are present in goods markets, but it is in asset markets that they become pronounced. Although a firm producing a good is more knowledgeable about the quality of the product than is the buyer, it is not so difficult for a buyer to monitor the quality of, say, the computer chips produced in Taiwan or in Thailand. Asymmetric information is, by contrast, at the core of the existence of different agents in capital markets. Banks, for example, exist because of their superior knowledge about the value of the firms to which they lend. Problems of asymmetric information are more rampant in international capital markets, where geographical and cultural differences make harder the task of obtaining information. Moreover, imperfections in international markets are magnified by the difficulties in enforcing contracts across borders.

Capital Account Restrictions: A Chronology

This section describes the chronology of capital account controls for six country cases: Brazil, Chile, Colombia, Malaysia, Thailand, and Venezuela. We focus our analysis on the developments of the 1990s, since daily data on stock prices and overnight interest rates start only approximately in 1990.

Brazil

In the late 1980s, Brazil embarked on a liberalization plan, relaxing restrictions on capital inflows and outflows. The first liberalization steps were implemented in 1987, when foreign investors were granted limited tax exemptions on dividends and capital gains. In June 1990 the government announced a gradual liberalization of remittances abroad of dividends, profits, and capital. Liberalization was further reinforced in 1992 by exempting foreign investors from taxation on capital gains and dividends. Foreign investors were allowed to participate in derivative markets, and domestic firms were allowed to issue American depository receipts (ADRs). The liberalization process was strengthened by a reduction in the required minimum length of stay (from twelve years to six) for foreign capital invested in Brazil through privatization auctions.

Chile

Chile introduced restrictions on capital inflows in June 1991. Initially, all portfolio inflows were subject to a 20 percent reserve deposit that earned no interest. For maturities of less than a year, the deposit applied for the duration of the inflow, while for longer maturities, the reserve requirement was for one year. In July 1992 the reserve requirement on portfolio inflows was raised to 30 percent, and the holding period was set at one year, independent of the flow’s length of stay. During that same month, reserve requirements were extended to trade credits and loans related to direct foreign investment. In 1995 capital controls were extended to cover Chilean stocks traded on the New York Stock Exchange and to international issues of bond. With markets in turmoil and the Chilean peso under attack, in June 1998 the reserve requirement was lowered to 10 percent, and in September of that year reserve requirements were eliminated. Chile has also regulated foreign direct investment. Foreign direct investment was subject to a three-year minimum stay in the country until 1992,when the minimum stay was reduced to one year.

Colombia

During the early 1990s Colombia underwent a dramatic process of liberalization. In December 1990, the Congress passed a law allowing the executive branch to implement a wideranging reform package that included the liberalization of the capital account and the reduction of tariff rates. In January 1991 a new foreign investment code was approved, granting foreigners the same rights, such as equal access to local credit as well as export incentives, as domestic investors. From that point forward, foreigners could have 100 percent ownership of domestic financial institutions. The liberalization of the capital account, however, was not long-lasting. As early as July 1992, a 10 percent withholding tax on transfers and nonfinancial private services was introduced to reduce the use of certain current account transactions for speculative purposes. Capital controls in the form of unremunerated reserve requirements on external borrowing were introduced in September 1993. Initially the unremunerated reserve requirement was limited to loans with maturities up to eighteen months and the reserve requirement was set at 47 percent. In 1994 the maturity of the loans for which the unremunerated reserve deposit was required was extended to five years. In the following years, the reserve requirements were changed several times to better target shorter-term inflows, and the tax was rate was modified as well. Following the crisis in Asia, the restrictions were substantially reduced to contain the speculative attacks against the Colombian peso. For example, in January 1998, foreign loan nonremunerated deposit requirements were reduced to 25 percent of the loan and the minimum maturity of such loans was shortened to twelve months. In September the reserve requirements were further reduced to 10 percent, and the minimum maturity of foreign loans was shortened to six months.

Malaysia

Malaysia underwent a process of liberalization of the capital account in 1986–87. Portfolio inflows and outflows were freed. Cross-border activities in ringgit were also treated liberally, including the use of ringgit in trade, financial transactions with nonresidents, and offshore trading in securities listed on local exchanges. As a result, an active offshore ringgit market developed. Until 1997 local banks could provide forward cover against ringgit to nonresidents, facilitating arbitrage between domestic and offshore markets.

This liberal regime was partly abandoned in 1994. Starting on January 17, banks became subject to a ceiling on their nontrade- or noninvestment-related external liabilities. On January 24 the Malaysian central bank approved a resolution that prohibited residents from selling shortterm monetary instruments to nonresidents. Restrictions were tightened in February, with commercial banks required to place the ringgit funds of foreign banking institutions with the central bank. Banks were prohibited from undertaking nontrade-related swap and outright forward transactions.

Thailand

Thailand's capital account was quite liberalized in the early 1990s. Although portfolio inflows were unrestricted, portfolio and foreign direct outflows were limited. With the exception of net open position limits, banks foreign borrowing was also unrestricted; residents were free to borrow offshore, although proceeds were required to be repatriated to authorized banks or placed in foreign currency accounts. Inflows to Thailand surged during the 1990s, most of them short term (accounting for about 60 percent of the total in 1993), and concentrated in banks borrowing through the Bangkok International Banking Facility (BIBF). In August 1995 the authorities started to introduced restrictions on capital inflows. The measures included a 7 percent reserve requirement (held at the central bank) on nonresident baht accounts with less than one-year maturity and on finance companies' short-term foreign borrowing. Also reporting requirements were imposed for short foreign currency positions. Further tightening of the restrictions occurred from April to June 1996, when the 7 percent reserve requirement was extended to new short-term offshore borrowing with maturity of less than one year by commercial banks and BIBF banks. As a prudential measure, the minimum capital adequacy requirement for commercial banks was also raised. Toward the end of 1996, all restrictions on foreign borrowing were eliminated.

Venezuela

In 1989 Venezuela began a sweeping financial liberalization, both domestic and external. Ceilings on interest rates were removed (as were controls on credit), the system of multiple exchange rates was abolished, and virtually all forms of exchange controls were eliminated. The liberalization did not last long, however. In the midst of its banking crisis, Venezuela reimposed drastic controls on capital outflows to stop the severe speculative attacks against the bolivar. On June 27, 1994, the foreign exchange market was closed and outright prohibitions on capital outflows (excluding flows related to the amortization of external debt and the repatriation of capital by foreigners) were introduced. The controls also restricted the availability of foreign exchange for import payments and established surrender requirements on foreign exchange receipts from exports of goods and services. Surrender requirements were also imposed on capital inflows. Although the controls were not abolished until April 22, 1996, a de facto currency convertibility for the repatriation of capital and income was created when the government allowed Brady bond trading to resume on June 22, 1995

Literature Review

Economic theory connects exchange rates to a number of macroeconomic factors. Theuncoveredinterestrateparity(UIP)links,intheory,theexpectedexchangerate return to the nominal interest rate differential between two countries, although the empirical evidence speaks mostly against the UIP theory. In a larger framework, the monetary model with ﬂexible prices connects the level of the exchange rate of two currencies in the long run not only to their interest rate differential, but also to the differences in the stock of money and in the real income.

Methodology

DCC Model

Our model presented in this section is based on the DCC model by Engle and Sheppard (2001). In analyzing the effect of macroeconomic factors, we include additional variables in the mean and variance equations of the GARCH model but refrain from doing so for the equation specifying the correlation structure (Equation (2.5) below). However, through the mean and variance equation, the economic factors inﬂuence the standardized residuals which serve as input for the DCC model itself.

We deﬁne rt as the log-return of the exchange rated e nominated in U.S.dollars. The mean equation is then given by

rt =φ0Xt +ut with ut|Ωt−1 ∼N(0,Ht)

where Ωt stands for the information set available at timet; the residuals ut are the result of some ﬁltration Xt. Initially Engle andSheppard (2001) consider the mean or an ARMA process as a possible ﬁltration. They note however that the choice of the ﬁltration should not have an impact on the standard errors of the model when using the normal likelihood. In the present case, we choose the following speciﬁcation

Xt ={1;rt−1;Zt−1}

Zt is a k×1 vector of macroeconomic factors and will be deﬁned in more detail in Section below. Although our focus lies primarily on the volatility and correlation of exchange rates, we not only include the macroeconomic factors in the variance equation but also in the mean equation. This should overcome the possibility that the macroeconomic variables included in the variance equation might proxy for the possible inﬂuence of the variables in the mean equation. It is generally accepted and largely documented that exchange rates exhibit some degree of auto correlation. MeeseandSingleton(1982)document for instance that daily exchange rates can be modeled quite well by an autoregression with one unit root and Woo (1985) improves the monetary model by including the lagged exchange rate. He ﬁnds this new set-up to outperform the random walk model for up to a year ahead and justiﬁes the lagged endogenous variable by the slow adjustment of money demand. For exchange rate returns, the evidence has been mixed and depends primarily on the frequency chosen. While monthly returns usually tend to show less signs of autocorrelation, it is common practice to model daily returns with at least one auto regressive lag. The same applies to the exchange rate returns in our sample: neither for monthly nor for weekly returns do we ﬁnd any strong evidence for auto correlation ,except for the weekly returns on the British pound; hence we only include the lagged returns rt−1 in the mean equation of this latter currency, but not for any of the other four currencies.

While the monetary model stipulates the simultaneity of the change in the exchange rate and the change in the variables, economic factors enter the conditional meanandvarianceequationswithatleastaone-periodlagtoaccountfortheavailability of data and information to investors, as these statistics are not immediately available to investors but are typically published with some delay , some times actually even longer than just one month.

The conditional covariance matrix Ht is deﬁned as

Ht ≡DtRtDt

where Rt stands for the k×k time-varying correlation matrix and Dt is the k× k diagonal matrix of time-varying standard deviations from univariate GARCH models with√hit as the ith element of the diagonal. The variance is obtained with the following univariate GARCH speciﬁcation

hit =ωi +P i ∑ p=1αipu2 it−p +Qi ∑ q=1βiq hit−q +γ0 iZit−1

where ut are the residuals from the mean equation in (2.1). If γ is set to zero, we obtain Bollerslev’s (1986) standard GARCH model; correspondingly, in the mean equation, all terms butφ1 would be set to zero. The use of an EGARCH model instead of GARCH is also considered ; ano table advantage of the EGARCH model is that it always ensures a positive conditional variance so that no restrictions need to be placed on the coefﬁcients (with the exception of the coefﬁcient of the lagged logarithm of the variance (logσ2 t−1) set to |β1|< 1). Additionally, the EGARCH model is better in capturing asymmetric effects as the volatility depends on the size and on the sign of the lagged residuals. In preliminary tests, we ﬁnd no improvement in signiﬁcance of the macroeconomic factors (i.e. γ in the equation above) and we choose therefore to keep the more parsimonious GARCH model for this paper. This corresponds to the ﬁndings of Davis and Kutan (2003) who mostly favor the GARCH over the EGARCH model when including macroeconomic factors in the variance equation.

Model Forecasts

The forecasts of a standard GARCH model have been sufﬁciently documented in the literature. When including additional factors in the GARCH model, the r-step ahead forecast changes to

Et[σ2 t+r] =r−2 ∑ p=0ω(α+β)p +(α+β)r−1σ2 t+1+r−1 ∑ i=1γ0(α+β)r−1−iEt[Zt+i]

The ﬁrst two terms correspond to the forecasts of a standard GARCH model; in such a situation, multi period volatility forecasts for t +r, are relatively easy to compute, as they only depend on the estimated parameters as well as onσ2 t and ut (needed to obtain σ2 t+1). However, the inclusion of macroeconomic factors makes this computation more difﬁcult, as multi period volatility forecasts do not depend only on the values at time t but also on the forecasts of the macroeconomic variables upto the period of interest. For reasons of simplicity , we use avector auto regression (VAR) to produce these forecasts, using all variables included in vector Zt. On the one hand, this does not ascribe enough information to investors, as it most certainly leaves out some variables that the market would typically use for predicting economic factors; on the other hand, the model ascribes also too much information to the investors as it assumes they know the parameters of the statistical process. The optimal lag length p is selected based on the Akaike (1974) and Schwarz(1978)informationcriteria;aftertestingforonetotwelvelags,theresults speak in favor of using a simple model with only one lag, both in the monthly and in the weekly setting.

In addition to the variance forecasts, the DCC framework allows us to forecast the correlation matrix as well. However, since the DCC process given by Equation is non-linear,ther step ahead forecast to f correlation can not be conveniently solved forward. To overcome this, Engle and Sheppard (2001) suggest two methods, each based on a certain set of approximations. The ﬁrst consists in forecasting Qt+r and obtaining the correlation matrix through Equation. the alternative is to forecast the correlation matrix Rt+r directly, under the approximation that Qt+1 ≈Rt+1. Engle and Sheppard (2001) analyze both methods and ﬁnd that solving directly for Rt+r has better bias properties and produces a smaller bias than solving forward for Qt+r, although both biases are very small. Therefore, we choose to forecast the correlation matrix directly.

Realized Volatility and Correlation

To evaluate the performance of the forecasts, we need a measure of the true variance and correlation. As the true parameters of these processes are unobservable, the actual variance and correlation can only be approximated. A number of alternatives have been suggested, but the largest part of the literature has focused on realized variance and correlation as a measure of equity or foreign exchange variability. The basic idea is that the true variance between two points in time t and t +1 can be approximated by the squared (log) return for this time interval. Similarly,the covariance would be the multiplication of the two returns of interest.

More recently, the idea has been introduced that estimates of the true, latent volatility can be improved using returns of a higher frequency than the frequency of interest(see in particular And ersen and Bollerslev1998a,Andersenetal. 2001b, 2003a, and Barndorff-Nielsen and Shephard 2002). Instead of using just one squared log return to compute the realized volatility over a given trading day, the cumulative intraday squared log returns of each day are used as a measure of volatility. The same line of thought applies also to the weekly or monthly variance which can be computed as the sum of squared daily log returns. The researchers cited above ﬁnd that higher frequency data introduces greater variability in the realized volatility and produces smaller errors when used to evaluate the performance of forecasts. The use of an inadequate measure for the true processes might have been one of the reasons why earlier studies have had such difﬁculties in beating a simple random-walk model when analyzing exchange rate volatility.

Data Description

Data and Deﬁnitions

For their investments, carry traders mostly focus on high- and medium-income economies such as Australia, Iceland or New Zealand, but a few emerging market economies such as Brazil and Turkey as well as several smaller Eastern European states have also been at the center of attention. On the other side, the Swiss franc and the Japanese yen are popular choices for funding due to their persistently low interest rates. In our analysis, we examine the following currencies: the Swiss franc (CHF), the Australian dollar (AUD), the Canadian dollar (CAD), the New-Zealand dollar (NZD), and the British pound (GBP), all with respect to the U.S. dollar exchange rate and from the point of view of a U.S. investor. As the focus of the present study lies on carry trades, the currency pairs under consideration for the correlation always include the CHF as a low-interest currency and one high-interest currency (AUD, CAD, NZD or GBP). This represents a total of four currency pairs.

AfterthebreakdownoftheBrettonWoodsagreementsin1971,manycountries moved away from the ﬁxed exchange rate regime in early 1973 to a generalized ﬂoating regime, where the currency ﬂuctuates freely in response to market forces and without too many(ifany) government interventions. A few countries , however, did not transition immediately to a completely free ﬂoat. Australia ﬁrst moves to a peg against a trade-weighted basket of currencies and later to a moving peg, before fully ﬂoating its currency a decade later in December 1983. Similarly, New Zealand adopts a ﬂoating exchange rate in March 1985, after also using a trade weighted basket of currencies since 1973. On the other hand, Canada moves to a ﬂexible exchange rate system already in 1970, even before the general collapse of Bretton Woods, after a short experiment with ﬁxed exchange rates.

Descriptive Statistics

Nominal exchange rate returns can be characterized by a number of stylized facts which have been largely documented in a number of empirical studies.10 First, the distribution of returns is usually leptokurtic with a much sharper peak and fatter tails than the normal distribution. More over ,returns tend to exhibits skewness , although not very much. Third, large changes in exchange rate returns tend to be followed by large changes as well, while in period of relative calm, small changes are typically followed by small changes. This phenomenon, known as volatility clustering, leads to temporal dependencies in the returns and persistence in the volatility. As Limetal.(1998)mention ,volatility clustering is a major contributing factor to the observed leptokurtic distribution.

Our data presents those typical characteristics as well, although they are less pronounced on monthly than on weekly data. presents the basic statistics of the exchange rate return series on a monthly basis. As can be seen, the CHF is right-skewed, while the other four currencies are all left-skewed. Positive (negative) skewness indicates a distribution with an asymmetric tail where there are more values in the right (left) tail than would be expected under a normal distribution. Furthermore, all series exhibit excess kurtosis, even if just barely so for the CHF and CAD.

Consequently, the Jarque-Bera test clearly rejects the hypothesis of a normal distribution, except for the CHF and the CAD. The statistics on weekly data, not presented here, show a stronger rejection of the normal distribution,even for the CHF and the CAD,with much higher Jarque-Bera statistics. This corresponds to previous results, which ﬁnd that kurtosis and skewness are reduced under time aggregation (see for instance De Grauwe and Grimaldi, 2005). As an illustration of these statistics , the distributions of the monthly exchange rate returns are presented in the Appendix. No return series shows any strong signs of autocorrelation, and the Ljung-Box Q-statistic does not reject the null hypothesis of no autocorrelation for any of the currenciesuptoa4-monthlag. This supports our decision not to include an autore.

CHF AUD CAD NZD GBP

Mean -0.0028 -0.0001 -0.0008 -0.0018 -0.0020

Std. deviation 0.0334 0.0300 0.0159 0.0310 0.0297

Maximum 0.1073 0.1370 0.0453 0.1400 0.1317

Minimum -0.0991 -0.0785 -0.0448 -0.0903 -0.1335

Skewness -0.0109 0.7755 0.0969 0.3814 0.2990

Excess Kurtosis 0.1596 2.2190 0.4359 1.8153 2.9411

Jarque-Bera 0.29 82.46 ∗ 2.56 43.62 ∗ 101.33 ∗

AC1 0.0635 0.0274 0.0638 0.0242 0.0474

AC3 -0.0059 0.0028 -0.0518 0.1591 ∗ 0.0076

AC6 -0.0910 0.0749 -0.0422 0.0760 -0.0900

AC12 0.0390 -0.0536 0.1128 -0.0661 0.0491

Ljung-Box (4) 1.50 1.55 1.39 8.86 1.78

ρCHF 0.1390 0.0966 0.3066 0.7132

gressive element in the mean equation and is consistent with the usual random walk hypothesis. We compute also the auto correlation of the absolute returns. While we still do not ﬁnd any statistical signiﬁcance for the CHF, the other exchange rates are not statistically close to zero for any of one to twelve lags, as opposed to before. This evidence favors a GARCH-type structure to model exchange rate return volatilityasitindicatesaratherlongmemoryintheexchangeratereturnsandtime changing conditional volatility.

we also note that all currencies appreciate on average against the U.S. dollar over the sample period. In total, the CHF appreciates the most, for a total of 75.6% against the USD; on the other end, the AUD appreciates only by a mere 2.95%. The currencies all present a monthly volatility of roughly 3%, with the exception of the CAD whose volatility is only half as large.

The unconditional correlations are on average quite low, except for the currency pair CHF/GBP. Their geographical proximity may lead to stronger business ties and similar economic conditions. For a ﬁrst hint of the time dependency of correlations, we plot in the Appendix the monthly realized correlations between the exchange rates. The correlations exhibit a great variability, with several large changes from virtually no correlation up to very high levels. This corresponds to the ﬁndings of van Dijk et al. (2011), described above. While correlations have steadily risen since the mid to late nineties, it appears that there has been a decline again in recent years.

Effects of Controls: Short-Lived or Long-Lasting?

In the previous section, we gave a flavor of the results we can obtain when we isolate the fluctuations in stock prices and interest rates at two specific frequencies. Those results, however, do not address whether controls on capital flows help to insulate the economy from contagion stemming from shocks in other emerging markets. To answer this question, we need to estimate the correlations of the domestic and the regional variables .the correlation coefficients of the filtered series of stock prices and interest rates of the six country cases and the regional indexes using the band-pass filter. The correlations measure co-movements in the short run (8- to 20-day fluctuations) and in the longer run (up to a maximum of 108- to 120-day fluctuations). We examine the behavior of the co-movement during episodes controls on inflows (Chile and Colombia), during episodes of controls on outflows (Venezuela), and during episodes of controls on inflows and outflows (Brazil, Malaysia, and Thailand) relative to the co movements when the controls were removed.the correlation coefficients, their standard errors and a test of equality of the correlation coefficient during periods of capital controls and liberalization. Because the autocorrelation, standard errors are calculated using the heteroskedasticity and autocorrelation consistent variance (VARHC) estimator from den Haan and Andrew Levin.

Interestingly, overall stock indexes in different countries seem to have more of a life of their own at high frequencies but seem to be more coordinated at lower frequencies. For example, the co-movements at frequencies between 18–30 days oscillate around 0.40, whereas co-movements at lower frequencies increase up to 0.70. Although not reported, the co movements between a country index and the indexes of countries in other regions are far smaller than the within-region correlations. This evidence agrees with already documented evidence that contagion is (or at least has been) of a regional nature.The exception is the Chilean stock market, which during the late 1990s was strongly influenced by the developments in Asia.

Overall, our results for the stock market suggest that if capital controls create a barrier between fluctuations in the region and fluctuations in the domestic stock market, this barrier is, at most, present at high frequencies. So, for example, restrictions in Brazil seem to have reduced the co-movements of its stock index with the Latin America index for periodicities of up to twenty days, but this effect disappears for longer cycles. We obtain similar evidence for the episode of controls in Malaysia. Capital controls do not seem to have insulated the Thai stock market even in the short run. Finally, although the Chilean experience with capital controls was advertised as the most successful in preventing contagion, these controls did not manage to segment stock prices in Chile from regional fluctuations. This evidence agrees with the chronologies of capital controls described in the previous section. For example, the chronicle of the controls on inflows in Chile is a story of investors finding loopholes and the authorities introducing more restrictions to close those loopholes. Chile introduced restrictions on capital inflows in June 1991. As noted by Edwards.

Exchange rate movements in episodes of higher volatility

Is there any discernible pattern across currencies in their responses to bouts of rising volatility? Looking back over the past decade, there were several notable episodes of heightened global volatility, as indicated by sharp spikes in indicators such as the widely used VIX index These episodes occurred in August 1998, September 2001, June–July 2002 and May 2006.This last episode did not show up as an especially sharp spike in absolute terms, but it nonetheless represented a larger than normal rise in the volatility index relative to the low levels prevailing at the time. In emerging Asia, the May 2006 episode also saw heavier net sales of equities by non residents than in the earlier episodes. During these four episodes, currencies performed in a manner qualitatively consistent with Irving Fisher’s hypothesis. Relatively low-yielding currencies such as the Swiss franc (traditionally a “safe haven” currency), the yen and the euro generally appreciated against the US dollar, while higher-yielding currencies such as the Russian rouble, Brazilian real and Turkish lira tended to depreciate. The responses of Asia-Pacific currencies in these episodes offer some further evidence in support of this global dichotomy: low-yielding currencies such as the New Taiwan dollar and the Singapore dollar depreciated relatively little or appreciated in some cases, while higher yielding ones such as the Indonesian rupiah and the Philippine peso weakened in most episodes. The moderately high-yielding Australian and New Zealand dollars also tended to depreciate. However, the pattern among other currencies is not as clear-cut. For instance, the Indian rupee and the Korean won reacted in a mixed fashion across episodes. Looking across the episodes, the link between currency performance and average interest rate levels prior to the episode was the tightest during the relatively mild (in terms of the point increase in the VIX) May 2006 episode. Along the least-squares line, currency depreciation over eight business days cost investors about eight months of interest rate premium. Admittedly, industrial economy currencies tended to rise less against the US dollar compared to the experience in the three earlier episodes. In particular, the weakness of the yen against the dollar in May 2006 left emerging Asian currencies especially exposed to the rise in global volatility, given these currencies’ tendency to co-move with the US dollar/yen rate (Kawai (2002), Ho et al (2005)).

Regression analysis of volatility and currency performance

Stepping back from specific episodes, how does currency performance relate to changes in global volatility in general? To assess a currency’s overall sensitivity, we regress the percentage change in the currency’s exchange rate on the change in global volatility. To control for the regular response of the currency to the movements among the major currencies, the percentage changes in the yen and the euro against the US dollar are included as additional explanatory variables. 34 currencies, including 13 Asia-Pacific currencies, are included in the analysis.5 Both the bilateral US dollar exchange rates of these currencies and their nominal effective exchange rates (NEERs) were assessed. Two different volatility indicators are considered: the VIX and a composite implied volatility index (“composite index”). While the VIX is derived from US stock market volatility only, the composite index is a more global indicator averaging eight measures of equity and bond market volatility in four major economies.The regressions were performed on weekly changes (Wednesday to Wednesday) over the period January 2000 to December 2006.

the two sets of estimated coefficients, which indicate the percentage change in the bilateral US dollar exchange rate that is associated with a 1 point change in the two volatility indicators, controlling for changes in the euro’s and yen’s value against the US dollar.For instance, the estimated sensitivity of the Indonesian rupiah towards the VIX of 0.112 means that, on average, the currency would depreciate by 0.56% in the presence of a 5 point rise in the VIX. Unsurprisingly, this period average result is an order of magnitude smaller than the rupiah’s actual movement in May 2006, when the VIX rose by about 5 points.

Regression coefficients relating volatility to US dollar exchange rates

Currency VIX Composite Currency VIX Composite Currency VIX Composite

ARS 0.065 0.074 HKD F 0.005 0.011\* PHP 0.054\*\* 0.085\* AUD 0.140\*\*\* 0.347\*\*\* HUF 0.053\*\* 0.050 PHP NDF 0.035 0.097 BRL 0.144\*\* 0.307\*\*\* IDR 0.112\*\*\* 0.219\*\*\* PLN 0.138\*\*\* 0.299\*\*\* CAD 0.069\*\*\* 0.177\*\*\* IDR NDF 0.159\*\*\* 0.281\*\*\* RUB –0.004 0.024 CHF –0.057\*\*\* –0.114\*\*\*ILS 0.059\*\*\* 0.121\*\*\* SEK 0.089\*\*\* 0.211\*\*\* CLP 0.155\*\*\* 0.298\*\*\*INR 0.020\*\* 0.041\*\* SGD 0.014 0.024 CNY 0.005 0.042 INR NDF 0.045\*\*\* 0.099\*\*\* SKK 0.045\*\*\* 0.108\*\*\* CNY NDF 0.004 0.029\* JPY 0.002 –0.068 THB 0.010 0.056\* COP 0.087\*\*\* 0.186\*\*\* KRW 0.092\*\*\* 0.182\*\*\* TRY 0.285\*\*\* 0.614\*\*\* CZK 0.014 0.071\*\* KRW NDF0.033\* 0.128\*\*\* TWD 0.031\*\* 0.056\*\* DKK 0.000 0.003 MXN 0.065\*\* 0.116\*\* TWD NDF 0.020 0.054\* EUR –0.046 –0.121\* MYR –0.015 0.029 ZAR 0.044 0.236\*\* GBP 0.004 –0.016 NOK –0.000 0.080\*\* PAIF 0.019\*\* 0.059\*\*\* HKD –0.001 0.000 NZD 0.076\*\* 0.204\*\*\*ADXY 0.016\*\* 0.053\*\*\*

There are several notable observations. First, even when the often significant influences of yen and euro movements are controlled for, most of the currencies still exhibit significant sensitivity towards at least one of the two volatility indicators. Estimated sensitivities to the composite index tend to be more statistically significant than those to the more volatile VIX. However, the differences between the two sets of estimated sensitivity should not be overstated – the correlation between the two is 0.96 while the Spearman rank correlation is 0.91.

Second, the regression results are generally in line with observations from the episodic analysis above. The Swiss franc, the euro and to some degree the yen tend to have negative sensitivities towards the volatility indicators, meaning that they tend to strengthen against the dollar when volatility rises .By contrast, emerging market currencies generally depreciate in an environment of elevated volatility. Overall, the Turkish lira stands out for its high sensitivity. Among the Asia-Pacific currencies, the Australian, Indonesian, Korean, New Zealand and Philippine currencies show relatively high sensitivities to changes in global volatility.

Third, there is some, albeit mixed, evidence that currency management constrains exchange rate responses to changes in global capital market volatility. If exchange rate management by the authorities, as in much of Asia for example, constrains the response of the spot exchange rate, it is potentially informative to try to measure the response of forward rates or offshore non deliverable forward (NDF) rates. Ma et al (2004) show that, owing to capital restrictions, Asian NDFs are generally not tightly bound by arbitrage to the more controlled spot exchange rates. Consequently, NDF volatilities tend to be higher than spot rate volatilities. Accordingly, the Indian rupee and Indonesian rupiah NDFs have higher estimated sensitivities than the respective spot rates . Even for the Hong Kong dollar, whose pegged spot rate hardly responds to changes in volatility, the more volatile one-year forward rate shows a small but statistically significant sensitivity to the composite indicator. However, stronger responses are not obtained for the NDFs of the Chinese renminbi, the New Taiwan dollar and the Philippine peso, for which spot market intervention is generally thought to be quite frequent and capital controls still effective.

Finally, the effective exchange rates of most currencies tend to be less sensitive to volatility than their bilateral rates, owing to the collective weight of trading partners’ currencies that also depreciate when volatility rises. For the same reason, currencies with low or negative bilateral exchange rate sensitivities to volatility tend to have effective exchange rates that appreciate even more than their bilateral dollar rates for a given rise in the volatility indicator. The US dollar depreciates very slightly in effective terms in response to rises in the VIX or composite index. Overall, the results using the bilateral US dollar exchange rates and the effective exchange rates are quite similar.

The determinants of currency sensitivity to global volatility

What factors underlie these measured sensitivities to global volatility? As seen already in the episodic analysis, currency reactions seem to relate to the prevailing short-term interest rate levels. To answer this question more systematically, we perform a strictly cross-sectional analysis, relating the estimated sensitivities to various economic characteristics over the entire 2000–06 period.

These variables are chosen to capture four broad types of factors that could potentially affect currency sensitivity to changes in global volatility: “carry” (relative interest rates), depreciation and credit risks, external financing requirements and liquidity. For “carry”, both short-term interest rates and the inflation rate are included to determine whether international investors are attracted by nominal or real returns.Depreciation risk is proxied by the ratio of reserves to imports, while creditworthiness is proxied by the credit rating and GDP per capita. Financing requirements are captured on a stock basis by the net international investment position (NIIP) and on a flow basis by the current account.Liquidity is represented by each currency’s turnover, both in US dollar terms and in relation to trade, to non-resident portfolio investment and to non-resident equity portfolio investment.

Some high bivariate correlations between these economic variables and the estimated currency sensitivities are observed. The short-term interest rate variable shows the strongest correlation (over 0.75), followed by inflation (over 0.6) and NIIP as a ratio to GDP (stronger than –0.44). The credit rating, GDP per capita, current account balance and FX market liquidity show correlations between 0.25 and 0.4 in absolute value.

When these variables showing strong bilateral correlations are made to compete against each other in a multiple regression framework, a remarkably parsimonious empirical account of the sensitivities emerges (Table 2).Two findings stand out.

First, even after controlling for other economic variables, the short-term interest rate dominates, showing a very significant positive association with currency sensitivity. One way of reading this finding is that investment strategies that target high-yielding currencies (eg carry trades) are vulnerable to rises in global volatility. Inflation, which is highly correlated with the level of interest rates across countries, seems to play no independent role. Admittedly, high-inflation and high-interest-rate currencies in the sample (the Brazilian real and the Turkish lira) contribute to this strong cross-sectional relationship between interest rate level and currency sensitivity. But even if these extreme observations are removed from the sample, the positive relationship still holds, indeed, to the exclusion of the other surviving variable in the full-sample case.

Second, balance of payments fundamentals are found to have some, but less consistent, influence over currency sensitivity. The NIIP in relation to GDP (though not the current account) survives the multiple regression analysis of sensitivity to the VIX. The larger an economy’s net international liabilities, the more prone its currency is to depreciation in volatile times. This result lends some support to the widespread view that long currency positions tend to be cut back in periods of rising global volatility, leading to potentially larger declines in currencies with heavier debt burdens to roll over.

The two main findings above help to make sense of the different sensitivities among Asia-Pacific currencies. The Australian and New Zealand dollars, with relatively high interest rates and large external liability positions, are hit hard by upsurges in global volatility. In contrast, even though interest rates are also high in Indonesia and the Philippines, the influence of rising global volatility may be offset to some extent by the ongoing contribution of the two economies’ current account surpluses to their external positions. In the rest of Asia, generally lower interest rates and external surpluses tend to limit currency sensitivity to changes in global volatility.

Table 1

Summary Statistics Carry Trade Portfolios

This table reports summary statistics for portfolios sorted on time t − 1 forward discounts. We also report annualized Sharpe Ratios (SR) and the ﬁrst order autocorrelation coeﬃcient (AC(1)). Portfolio 1 contains 25% of all the currencies with the lowest forward discounts whereas Portfolio 4 contains currencies with the highest forward discounts. All returns are excess returns in USD. DOL denotes the average return of the four currency portfolios, HmL denotes a long-short portfolio that is long in Pf1 and short in Pf4. Data is sampled monthly and runs from January 1999 to February 2011.

Pf1 Pf2 Pf3 Pf4 DOL HmL

Mean -0.1175 0.0202 0.0483 0.1043 0.0138 0.2218

StDev 0.1267 0.0649 0.0763 0.0988 0.0736 0.1300

Skew -2.2605 -0.2741 -0.3402 -1.4752 -0.5363 1.3767

Kurtosis 8.6690 4.2208 5.8966 8.9847 3.9290 6.7569

SR -0.9274 0.3112 0.6331 1.0551 0.1876 1.7058

AC(1) 0.7180 0.0625 0.1573 0.2619 0.3116 0.6625

Table 2

Summary Statistics Variance

This table reports summary statistics for implied and realized volatilities (i.e. the square root of variance, Panels A and B) and the variance risk premium, which is deﬁned as the diﬀerence between the implied and realized variance (Panel C). Implied variances are calculated from daily option prices on the underlying exchange rates. Realized variances are calculated from ﬁve minute tick data on the underlying spot exchange rates. All numbers are annualized. Data is daily and runs from February 1998 to February 2011.

Panel A: Implied Volatility

EUR JPY GBP CHF

Mean 0.1089 0.1199 0.0962 0.1111

StDev 0.0319 0.0379 0.0339 0.0250

Kurtosis 9.0464 8.5052 13.5283 8.5036

Skewness 1.8192 1.7933 2.8592 1.4667

Min 0.0485 0.0612 0.0482 0.0531

Max 0.3018 0.4039 0.3208 0.2637

AC(1) 0.9900 0.9800 0.9923 0.9826

Panel B: Realized Volatility

EUR JPY GBP CHF

Mean 0.1061 0.1148 0.0980 0.1145

StDev 0.0370 0.0502 0.0406 0.0356

Kurtosis 13.7172 33.3336 15.3902 13.5564

Skewness 2.1475 3.6054 2.7993 2.0435

Min 0.0344 0.0267 0.0254 0.0374

Max 0.5264 0.9162 0.4937 0.5038

AC(1) 0.7050 0.7377 0.8074 0.6074

Panel C: Variance Risk Premium

EUR JPY GBP CHF

Mean 0.0001 -0.0001 -0.0009 -0.0015

StDev 0.0084 0.0173 0.0082 0.0080

Kurtosis 267.2600 743.4876 168.3246 49.9990

Skewness -10.5019 -21.3103 -9.1316 -4.8326

Min -0.2484 -0.6764 -0.1975 -0.1188

Max 0.0416 0.0366 0.0412 0.0295

AC(1) 0.2713 0.3868 0.4237 0.3145

Table 3

Summary Statistics Correlation

This table reports summary statistics for implied and realized correlations (Panels A and B) and the correlation risk premium, which is the diﬀerence between the implied and realized correlation (Panel C). Implied correlations are calculated from daily option prices on the underlying exchange rates. Realized correlations are calculated from ﬁve minute tick data on the underlying spot exchange rates. Data is daily and runs from February 1998 to February 2011.

Panel A: Implied Correlation

EURJPY EURGBP EURCHF JPYGBP JPYCHF GBPCHF

Mean 0.3957 0.6742 0.8906 0.2966 0.4667 0.6252

StDev 0.1825 0.1072 0.0835 0.2045 0.1646 0.1466

Kurtosis 3.6678 2.6582 10.4716 3.3690 3.2698 2.3661

Skewness -0.7809 -0.5134 -2.5060 -0.4875 -0.5750 -0.4432

Min -0.4392 0.2559 0.4462 -0.5075 -0.1582 0.1952

Max 0.7622 0.8746 0.9887 0.7387 0.8257 0.8872

AC(1) 0.9832 0.9797 0.9909 0.9851 0.9813 0.9842

Panel B: Realized Correlation

EURJPY EURGBP EURCHF JPYGBP JPYCHF GBPCHF

Mean 0.2930 0.5238 0.7025 0.1858 0.2989 0.4463

StDev 0.2190 0.1564 0.1468 0.1944 0.1905 0.1574

Kurtosis 3.0352 2.8465 2.7149 2.7828 2.4153 2.4422

Skewness -0.5820 -0.8063 -0.6756 -0.2130 -0.1400 -0.3117

Min -0.4211 0.0970 0.2556 -0.3806 -0.2661 0.0487

Max 0.6613 0.7920 0.9401 0.6032 0.7176 0.7677

AC(1) 0.9980 0.9985 0.9968 0.9982 0.9981 0.9979

Panel C: Correlation Risk Premium

EURJPY EURGBP EURCHF JPYGBP JPYCHF GBPCHF

Mean 0.1027 0.1506 0.1883 0.1091 0.1678 0.1779

StDev 0.1349 0.1220 0.1434 0.1360 0.1189 0.1404

Kurtosis 4.6117 2.6784 2.7289 4.1417 3.2539 2.7480

Skewness 0.5151 0.2028 0.7345 -0.4918 0.4372 -0.3144

Min -0.3767 -0.1853 -0.1133 -0.3971 -0.1579 -0.3251

Max 0.6850 0.4748 0.6656 0.5827 0.6010 0.5264

AC(1) 0.9618 0.9808 0.9929 0.9614 0.9569 0.9787

Table 4

Portfolios Sorted on Betas with Correlation and Variance Risk

This table reports summary statistics for portfolios sorted on correlation (variance) risk betas, i.e. currencies are sorted according to their betas in a rolling time-series regression of individual currencies’ daily excess returns on daily innovations in the correlation (variance) risk. Correlation (variance) risk is deﬁned as the residual from an AR(1) process of implied correlation (variance). Portfolio 1 contains currencies with the lowest betas whereas portfolio 4 contains currencies with the highest betas. LmH is long Portfolio 1 and short Portfolio 4. The mean, standard deviation, and Sharpe Ratios are annualized, the rest is per month. We also report pre-formation betas, Pre β. Data is monthly and runs from January 1999 to February 2011.

Panel A: Correlation Risk

Pf1 Pf2 Pf3 Pf4 LmH

Mean 0.0890 0.0681 0.0534 0.0497 0.0393

StDev 0.1259 0.0978 0.0862 0.0769 0.0993

Skew -1.1805 -0.5635 -0.0415 -0.1305 -0.3926

Kurtosis 6.3188 6.2227 3.0149 3.2757 3.4086

SR 0.7071 0.6968 0.6192 0.6456 0.3962

AC(1) 0.2209 0.1026 0.0573 0.1262 0.1477

Pre β -26.814 -1.205 14.499 24.983

Panel B: Variance Risk

Pf1 Pf2 Pf3 Pf4 LmH

Mean 0.1082 0.0296 0.0543 0.0721 0.0361

StDev 0.1206 0.0936 0.0869 0.0842 0.0922

Skew -1.0073 -0.7308 -0.8184 -0.2168 -1.2587

Kurtosis 6.1168 7.2339 4.3523 3.2091 10.3332

SR 0.8972 0.3167 0.6240 0.8562 0.3919

AC(1) 0.2355 0.0693 0.1742 0.0767 0.2071

Pre β -29.779 -6.365 3.805 20.862

Table 5

Estimating the Price of Correlation Risk

FIC and FIV are the mimicking factors for global correlation and volatility innovations, DOL the average carry trade portfolio as in Lustig, Roussanov, and Verdelhan (2011). In Panel A, we report factor betas. Panel B reports the Fama and MacBeth (1973) factor prices on the carry return portfolios. Newey-West standard errors are reported in parentheses. Data is monthly and runs from January 1999 to February 2011.

Panel A: Factor Betas

Pf α DOL FIC FIV R2

1 -0.01 0.96 4.71 0.92

* 1. (0.59) (0.05)

-0.01 1.04 4.99 8.49 0.94

(0.01) (0.04) (0.40) (1.50)

2 -0.01 0.65 2.04 0.92

(0.01) (0.09) (0.95)

-0.01 0.38 1.07 -29.33 0.99

(0.01) (0.01) (0.12) (0.45)

3 -0.01 1.21 -1.98 0.90

* 1. (0.06) (0.73)

-0.01 1.32 -1.60 11.60 0.97

(0.01) (0.05) (0.45) (1.87)

4 -0.01 0.83 -3.94 0.90

(0.01) (0.03) (0.42)

-0.01 0.75 -4.23 -8.59 0.92

(0.01) (0.03) (0.37) (1.67)

Panel B: Factor Prices

DOL FIC FIV χ2

0.163 -0.629 4.25

(0.02) (0.00)

0.172 -0.483 0.623 0.39

(0.02) (0.00) (0.00)

Table 6

Summary Statistics Simulated Conditional RA Sorted

This table reports summary statistics for portfolios sorted on global risk aversion betas using 500 simulations of 240 months for 35 currencies. We also report annualized Sharpe Ratios (SR) and the ﬁrst order autocorrelation coeﬃcient (AC(1)). Portfolio 1 contains 25% of all the currencies with the lowest global risk aversion beta whereas Portfolio 4 contains currencies with the highest global risk aversion beta. All returns are excess returns in USD. HmL denotes a long-short that is long in Pf1 and short in Pf4.

Pf1 Pf2 Pf3 Pf4 HmL

Mean 0.1895 0.0906 -0.0189 -0.1778 0.3674

StDev 0.1347 0.1304 0.1355 0.1642 0.1476

Skew 0.1951 0.1700 0.1490 0.4251 -0.7685

Kurtosis 6.4318 6.9504 6.4408 5.6454 6.7157

SR 1.4340 0.7161 -0.1358 -1.1006 2.5620

AC(1) 0.0040 -0.0329 0.0019 0.0590 0.2318

Table 7

Summary Statistics Simulated Carry Trade Portfolios

This table reports summary statistics for simulated portfolios sorted on time t − 1 forward discounts. We also report annualized Sharpe Ratios (SR) and the ﬁrst order autocorrelation coeﬃcient (AC(1)). Portfolio 1 contains 25% of all the currencies with the lowest forward discounts whereas Portfolio 4 contains currencies with the highest forward discounts. All returns are excess returns in USD. DOL denotes the average return of the four currency portfolios, HmL denotes a long-short that is long in Pf1 and short in Pf4.

Pf1 Pf2 Pf3 Pf4 DOL HmL

Mean -0.1554 -0.0223 0.0752 0.1370 0.0086 0.2925

StDev 0.1429 0.1264 0.1270 0.1407 0.1212 0.1186

Skew 0.4643 0.3234 0.0158 -0.5081 0.0405 -1.2438

Kurtosis 6.7152 6.5610 6.3384 6.1254 6.0466 8.6005

SR -1.1142 -0.1783 0.6126 1.0070 0.0812 2.5176

AC(1) 0.0440 0.0256 -0.0026 0.0294 -0.0118 0.2955

Table 8 Portfolios Sorted on Betas with Realized Correlation and Volatility Risk

This table reports summary statistics for portfolios sorted on correlation (variance) risk betas, i.e. currencies are sorted according to their betas in a rolling time-series regression of individual currencies’ daily excess returns on daily innovations in the correlation (variance) risk. Correlation (variance) risk is deﬁned as the residual from an AR(1) process of realized correlation (variance). Portfolio 1 contains currencies with the lowest betas whereas portfolio 4 contains currencies with the highest betas. LmH is long Portfolio 1 and short Portfolio 4. The mean, standard deviation, and Sharpe Ratios are annualized, the rest is per month. We also report pre-formation betas, Pre β. Data is monthly and runs from January 1999 to February 2011

Panel A: Correlation Risk

Pf1 Pf2 Pf3 Pf4 LmH

Mean 0.0815 0.0573 0.0228 0.0346 0.0469

StDev 0.0787 0.0903 0.1007 0.0938 0.0721

Skew 0.1255 -0.4209 -0.6100 -0.4753 0.5221

Kurtosis 3.4037 7.1746 5.4467 3.6043 3.6421

SR 1.0360 0.6351 0.2264 0.3690 0.6507

AC(1) 0.1629 0.1439 0.1967 0.0879 0.0791

Pre β -104.529 -8.323 47.771 131.896

Panel B: Variance Risk

Pf1 Pf2 Pf3 Pf4 LmH

Mean 0.0920 0.0616 0.0595 0.0490 0.0431

StDev 0.1099 0.1078 0.0947 0.0754 0.0842

Skew -0.2985 -1.5170 -0.2099 0.1411 -0.1717

Kurtosis 3.8256 9.0365 5.8127 3.4792 4.0753

SR 0.8375 0.5711 0.6278 0.6496 0.5114

AC(1) 0.1281 0.2813 0.0579 0.0127 0.1859

Pre β -48.699 -31.298 -19.164 7.997

Table 9

Summary Statistics Real Carry Trade Portfolios

This table reports summary statistics for portfolios sorted on time t−1 real forward discounts. We also report annualized Sharpe Ratios (SR) and the ﬁrst order autocorrelation coeﬃcient (AC(1)). Portfolio 1 contains 25% of all the currencies with the lowest forward discounts whereas Portfolio 4 contains currencies with the highest forward discounts. All returns are excess returns in USD. DOL denotes the average return of the four currency portfolios, HmL denotes a long-short that is long in Pf1 and short in Pf4. Data runs from January 1999 to June 2007.

Pf1 Pf2 Pf3 Pf4 DOL HmL

Mean -0.1778 0.0074 0.0250 0.1640 0.0046 0.3419

StDev 0.1678 0.0743 0.0640 0.0803 0.0744 0.1624

Skew -2.0982 -0.0791 -0.0894 0.3695 -0.4326 1.8471

Kurtosis 6.7164 3.3703 2.4553 3.1241 2.8587 5.9423

SR -1.0601 0.0996 0.3898 2.0418 0.0622 2.1050

AC(1) 0.8035 0.1614 0.1253 0.2857 0.4538 0.7677

Further Research and Improvements

Although the results are not very strong, several extensions are possible. In the weekly setting,the computation of weekly realized variances and correlations based on daily data is unsatisfactory and may produce biased measures. Intraday data would alleviate this problem and allow for a better evaluation of the forecasts; the same goes for option data since implied volatility and implied correlation are a valid replacement for realized measures. Additionally,macro economic factors have been included in the mean and variance equation and enter therefore the estimation of the correlation matrix only indirectly through the standardized residuals of the DCC model. Particularly in the evaluation of the correlation forecast errors in Tables 2.4 and 2.8, it can be seen that with this approach the economic factors do not inﬂuence very much the correlation process of the exchange rates. However it is possible to include the relevant factors directly in Equation which models the process of the correlation structure. This approach has for instance already been successfully implemented by VanLand schoot(2003)for the correlation of bank stock returns, albe it with the BEKK model instead of with the DCC. However, given the mitigated results from the extended GARCH models ,wed on expect the additional DCC factors to have a large (positive) impact on the correlation forecasts. Another possible extension comes from De Grau we and Vansteenkiste’s(2007) recent work. They ﬁnd evidence that low and high inﬂation currencies respond differently to news in the fundamentals. The countries from our sample canal be categorized as low inﬂation currencies, therefore a natural extension would be to an

Conclusion

Findings

Economic theory as well as previous research link exchange rate movements to macroeconomic variables, in particular to interest rates, inﬂation, money aggre gates or measures of national income. To allow for this fact, we include different macroeconomic variables and risk measures as an additional term in a simple GARCH model and our results speak in favour of using these variables to model and forecast exchange rate volatility and correlation. For monthly data, the additional macroeconomic factor is relevant in over half of the estimated models and contributes therefore in a signiﬁcant way to the explanation of volatility movements. Based on standard forecast evaluation measures, the exchange rate volatility forecasts of the Australian dollar, the Canadian dollar and the New-Zealand dollar signiﬁcantly improve, when including additional economic factors, whereas the evidence for the other two exchange rates (Swiss franc and British pound) is only scarce. This holds for forecasts over a one-month horizon as well as for longer time periods but no economic factor consistently provides better forecasts across all ﬁve currencies. With weekly data, on the other hand, the additional term in the GARCH model is mostly in signiﬁcant and no signiﬁcant improvement is visible in the forecasts, independently of the factor or the time-horizon considered.

In this paper, we have proposed a new approach to examine the dynamics of international integration of financial markets. This approach has helped us to evaluate whether controls on capital flows persistently isolate domestic markets from international markets or whether the insulation they provide is just ephemeral. We have examined the evidence using data from six emerging economies during the 1990s.

Our results can be summarized as follows:

First, as to the central issue of short- and long-run integration of these economies with world-financial markets, markets seem to be more linked at longer horizons. Moreover, our results suggest equity prices to be more internationally connected than interest rates.

Second, with regard to the claim that capital controls insulate domestic markets from global spillovers, we find little evidence that controls effectively segment domestic from international markets. When they do, the effects seem to be short lived.

Third, with regard to the insulation they provide, controls on outflows do not seem to differ from controls on inflows. For example, controls on outflows in Venezuela during the 1994 crisis and the unremunerated reserve requirements in Chile and Colombia during the capital inflow episode seem to have shielded domestic markets at the most at very high frequencies.

Both episodic and regression analysis provides evidence of a systematic pattern of sensitivities of various currencies to changes in global capital market volatility. Much of this pattern of currency sensitivities can be accounted for by the level of short-term interest rates and, to a lesser extent, the scale of net international liabilities.

Looking across the Asian currencies, there is some prospect for them to respond more similarly to changes in global volatility. Thus far in this century, the higher interest rate currencies, the Indonesian rupiah and the Philippine peso, have been somewhat sheltered from changes in global volatility by their responsiveness to the yen. Nevertheless, shifts in global volatility tend to strain cross rates between such currencies and lower-yielding Asian currencies. Going forward, the convergence of inflation rates in the region would tend to reduce interest rate differentials. This would in turn tend to narrow the current differences in the response of various currencies in the region to a change in global volatility.

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