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FX co-movements: disentangling the role of global market factors, carry-trades and idiosyncratic components

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* This presentation reflects the views of the author and not necessarily those of the BIS or of central banks participating in the meeting.

FX Comovements: Disentangling the Role of Market Factors, Carry-Trades and Idiosyncratic Components

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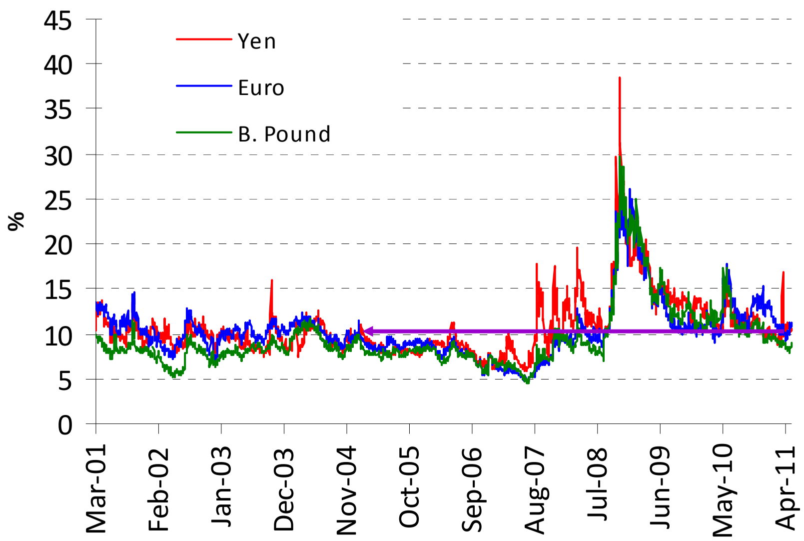
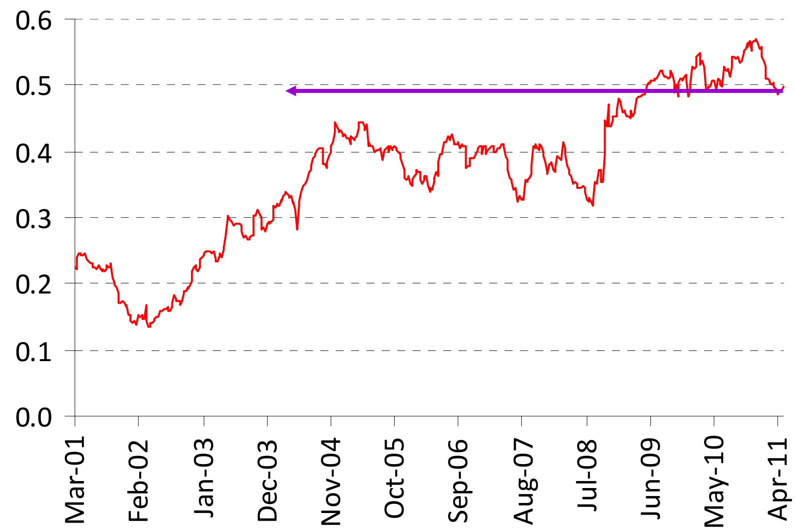
Comovements in FX Markets

One-month Implied Volatilities



Average FX Correlations



1/ One-year moving average correlation based on weekly FX excess returns of 29 currencies (Jan:1999-April:2010). All of them are with respect to the US dollar.

Literature and contribution

- Comovements in FX markets have been empirically explored in Diebold and Nerlove (1989), Kroner and Sultan (1993), Tong (1996), Sheedy (1998), Gagnon, Lypny and McCurdy (1998), and Chang and Kim (2001), among others.
- FX volatility studies include Domowitz and Hakkio (1985), Jorion (1988), Engle, Ito and Lin (1990), Andersen and Bollerslev (1998), Andersen et al. (2003), and Berger et al. (2009).
- None of these papers separate term components of FX correlations and volatilities.
- Examines linkages between long-term trends in comovements and FX fundamentals. In particular, this paper studies time series and cross-sectional determinants of FX idiosyncratic volatilities.

Other related literature

- Non-stationary models for asset volatilities and correlations that can capture long-term dynamic behavior.
  - Univariate: Engle and Rangel (2008), Engle, Ghysels and Sohn (2009)
  - Multivarite: Rangel and Engle (2009), Hafner and Linton (2010), Colacito, Engle and Ghysels (2010), Christoffersen, Errunza, Jacobs and Langlois (2011)
- Find convenient to use a factor correlation model that is able to separate heterogeneous systematic and idiosyncratic components of FX volatilities and correlations
  - Rangel and Engle (2009)

Approach

- Characterize high and low frequency correlation dynamics in FX markets.
  - Use Factor-Spline-GARCH model of Rangel and Engle (2009)
- Need a factor currency pricing model:
  - Follow Lustig, Roussanov and Verdelhan (2010)
- Link low frequency correlation components with economic fundamentals
  - Apply panel and SUR models to analyze time series and cross sectional variation of FX idiosyncratic volatilities

Factor currency pricing model

Excess returns (local currency per US dollar)

$$rx_{t+1} = f_t - s_{t+1} \approx i_t^* - i_t - \Delta s_{t+1}$$

where f=log forward price, s=log spot price, i^*=foreign nominal interest rate, i=domestic nominal interest rate

Following Backus, Foresi and Telmer (2001):

$$(1+\Delta s_{t+1}) \approx \frac{S_{t+1}}{S_t} = \frac{M_{t+1}}{M_{t+1}^*}, \quad where$$

M_{t+1}=US stochastic discount factor, M^*_{t+1}=foreign stochastic discount factor.

Assume that (log) SDFs are linear in pricing factors

Factor currency pricing model

Lustig et al. (2010) suggest two factors:

1. RX=Average currency excess return (equally weighted portfolio of currencies)
2. HML_{FX}=Return on a zero-cost strategy that goes long in the highest interest rate currencies and short in the lowest interest rate currencies (carry-trade)

In addition, include an equity market factor

3. Rm=Global equity market portfolio

Intuition:

RX is a “dollar risk factor” that mainly account for variation in m_{t+1} (US stochastic discount factor), HML_{FX} and Rm are common global components of m^*_{t+1} (country *i* stochastic discount factor).

Factor-Spline-GARCH (FSG-DCC) approach (Rangel and Engle 2009)

- Factor model: $\mathbf{r}x_t \mid F_t, \Phi_{t-1} \sim N(BF_t, \Sigma_{u,t}), \quad F_t \mid \Phi_{t-1} \sim N(\eta, \Sigma_{F,t})$
- Following Engle and Rangel (2008), factors are described by asymmetric spline-GARCH processes:

(1) $$f_{k,t} - E_{t-1}(f_{k,t}) = \sqrt{\tau_{f,k,t} g_{f,j,t}} \varepsilon_{f,j,t}, \ \varepsilon_{f,j,t} \sim N(0,1)$$

$$g_{f,j,t} \sim Asymmetric\ GARCH, \ \tau_{f,j,t} \sim Exponential\ Cuadratic\ Spline$$

- Also, idiosyncratic terms show asymmetric spline-GARCH dynamics:

(2) $$u_{i,t} = \sqrt{\tau_{i,t} g_{i,t}} \varepsilon_{i,t}, \ \varepsilon_{i,t} \sim N(0,1)$$

$$g_{i,t} \sim Asymmetric\ GARCH, \ \tau_{i,t} \sim Exponential\ Cuadratic\ Spline$$

- Add effects of time-varying betas and latent unobserved factors:

(3) $$\boldsymbol{\varepsilon}_t = (\varepsilon_{1,t}, \varepsilon_{2,t}, \ldots, \varepsilon_{N,t}, \varepsilon_{f,1,t}, \varepsilon_{f,2,t}, \varepsilon_{f,3,t})' \sim DCC\ Model\ of\ Engle\ (2002)$$

Low frequency covariance

- Given $\mathbf{rx}_t = (rx_{1t}, \ldots, rx_{Nt})'$ satisfying the FSG-DCC model, then

$$V_{t-1}(\mathbf{rx}_t) \equiv H_t = B\Sigma_{F,t}B' + B\,\mathrm{cov}_{t-1}(F_t, \mathbf{u}_t{}') + \mathrm{cov}_{t-1}(\mathbf{u}_t, F_t{}')B' + \Sigma_{u,t}$$

mean reverts toward the low frequency covariance:

$$\Upsilon_t = B\Gamma_{f,t}B' + \Gamma_t^{1/2}\bar{R}_{r,r}\Gamma_t^{1/2},$$

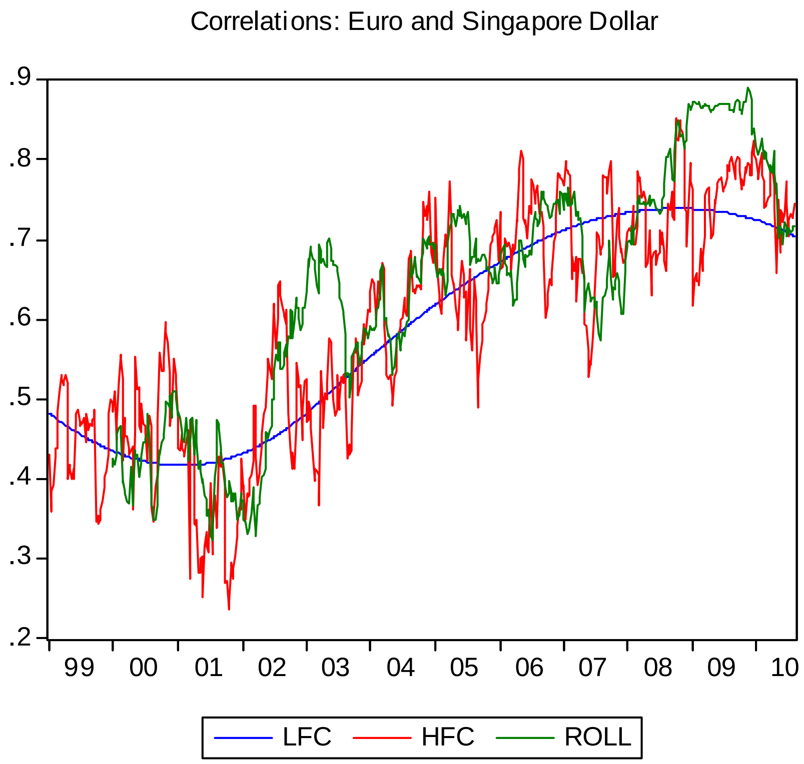
$$\Gamma_{F,t} = diag\{\tau_{f,j,t}\},\ \ \Gamma_{u,t} = diag\{\tau_{i,t}\},$$

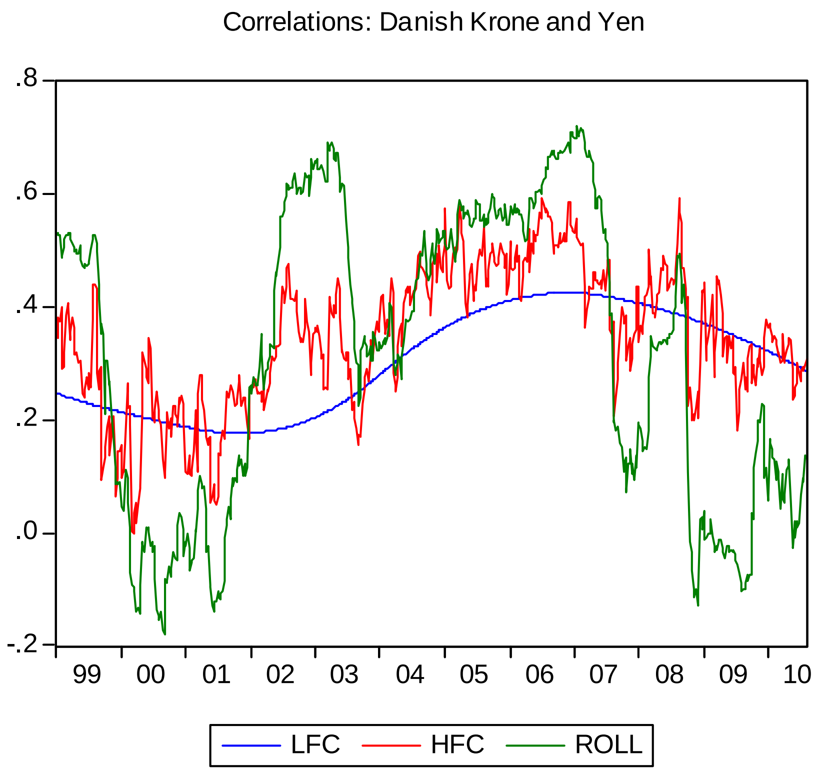
$$\bar{R}_{r,r} = sample\ correlation\ of\ (\varepsilon_{1,t}, \ldots, \varepsilon_{N,t})'$$

Data

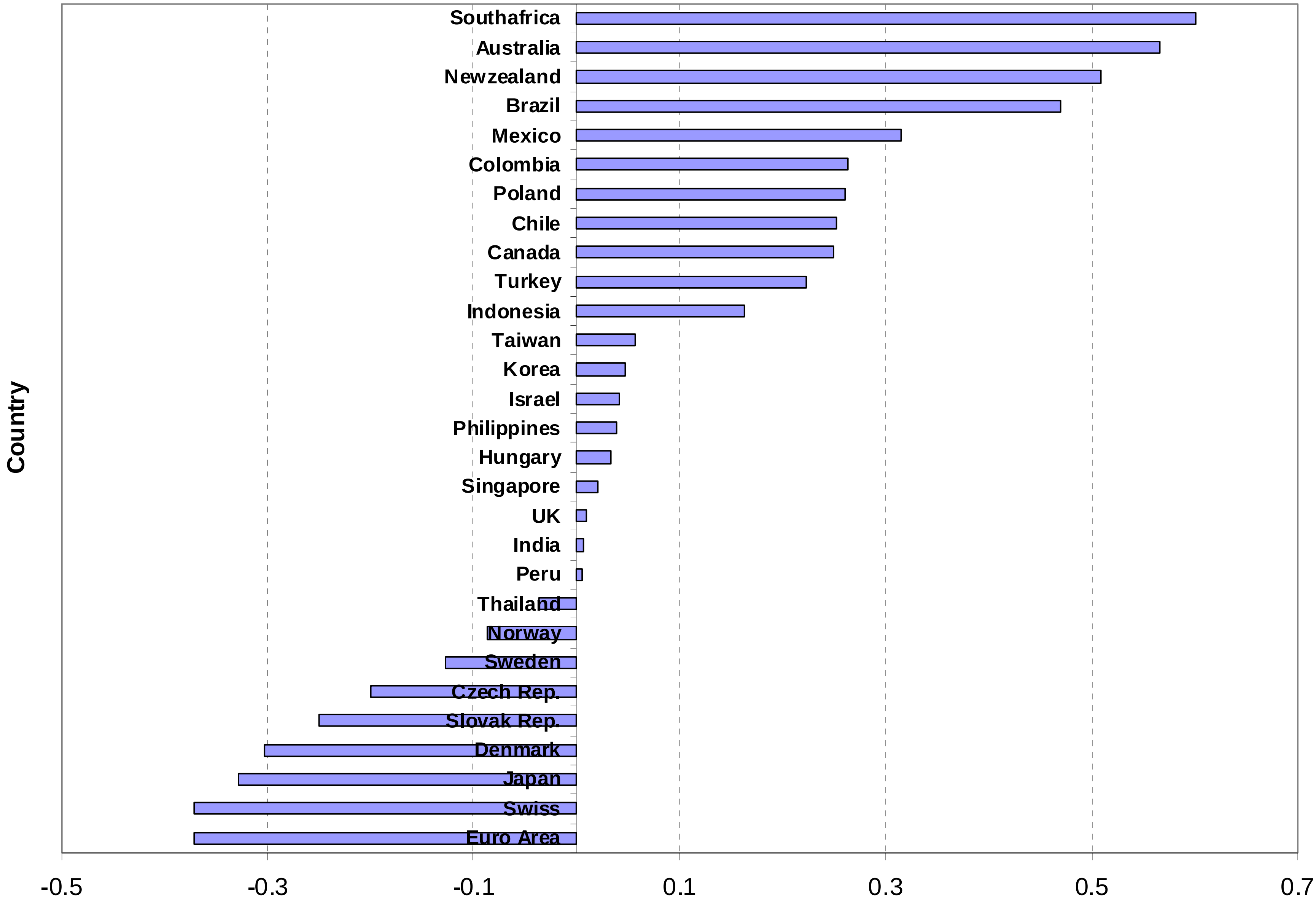
- 29 exchange rates (forward and spot prices). They correspond to countries with no fixed exchange rates (include developed and emerging markets).
- The sample goes from January 1999 (entry date of the Euro) to August 2010. Data is also at a weekly frequency.
- The carry-trade and the FX market portfolio are constructed using an extended sample of 52 countries. It includes the 48 currencies considered in Menkhoff et al. (2009) plus the cases of Chile, Colombia, Peru, and Turkey.
- The MSCI World Index is used as a proxy for the equity market factor.
- Quarterly data on GDP, inflation (measured through consumer price indices), money supply (defined as M2), and short-term interest rates (source: IFS database).

Estimation Results: Correlation dynamics (examples)

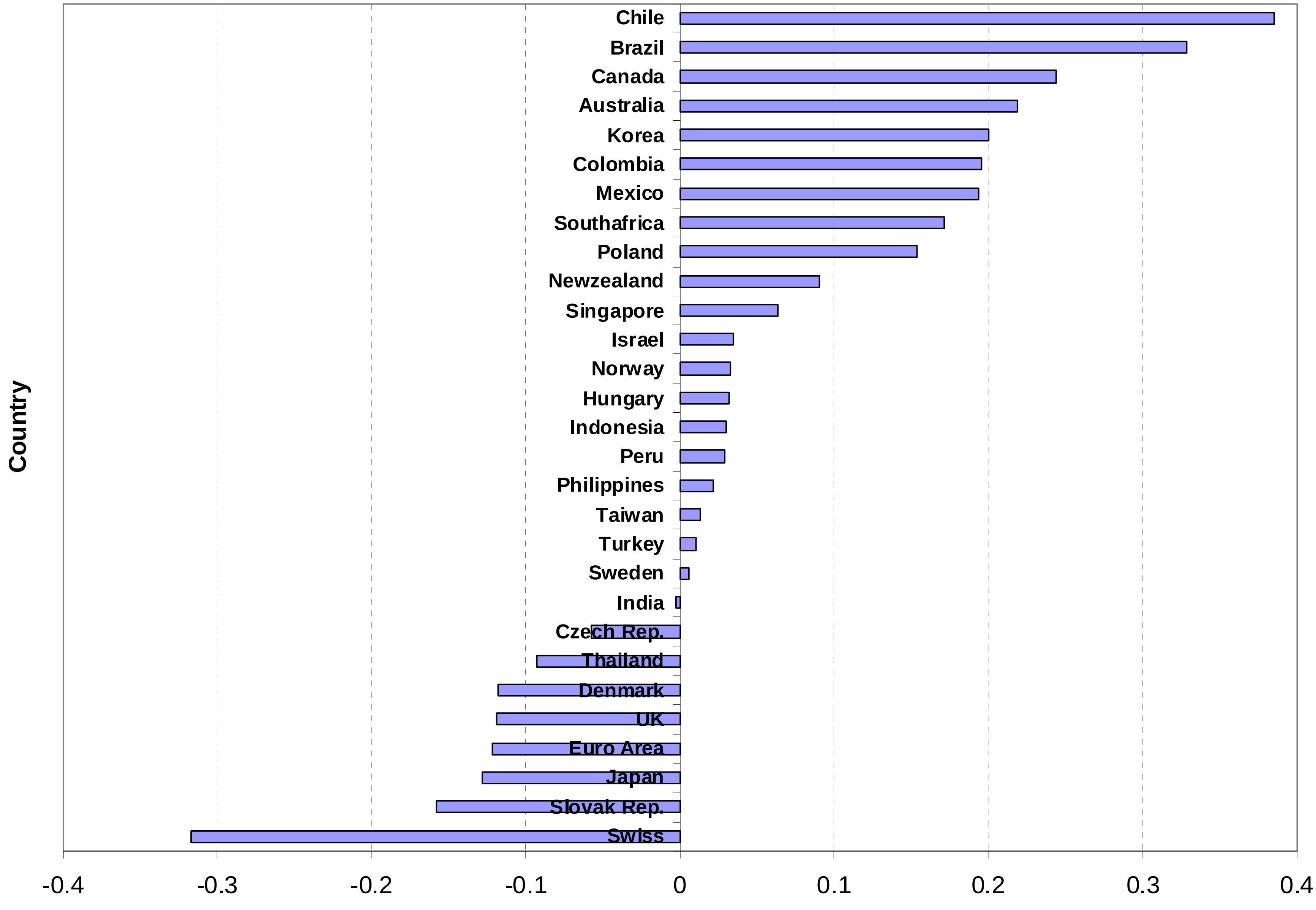




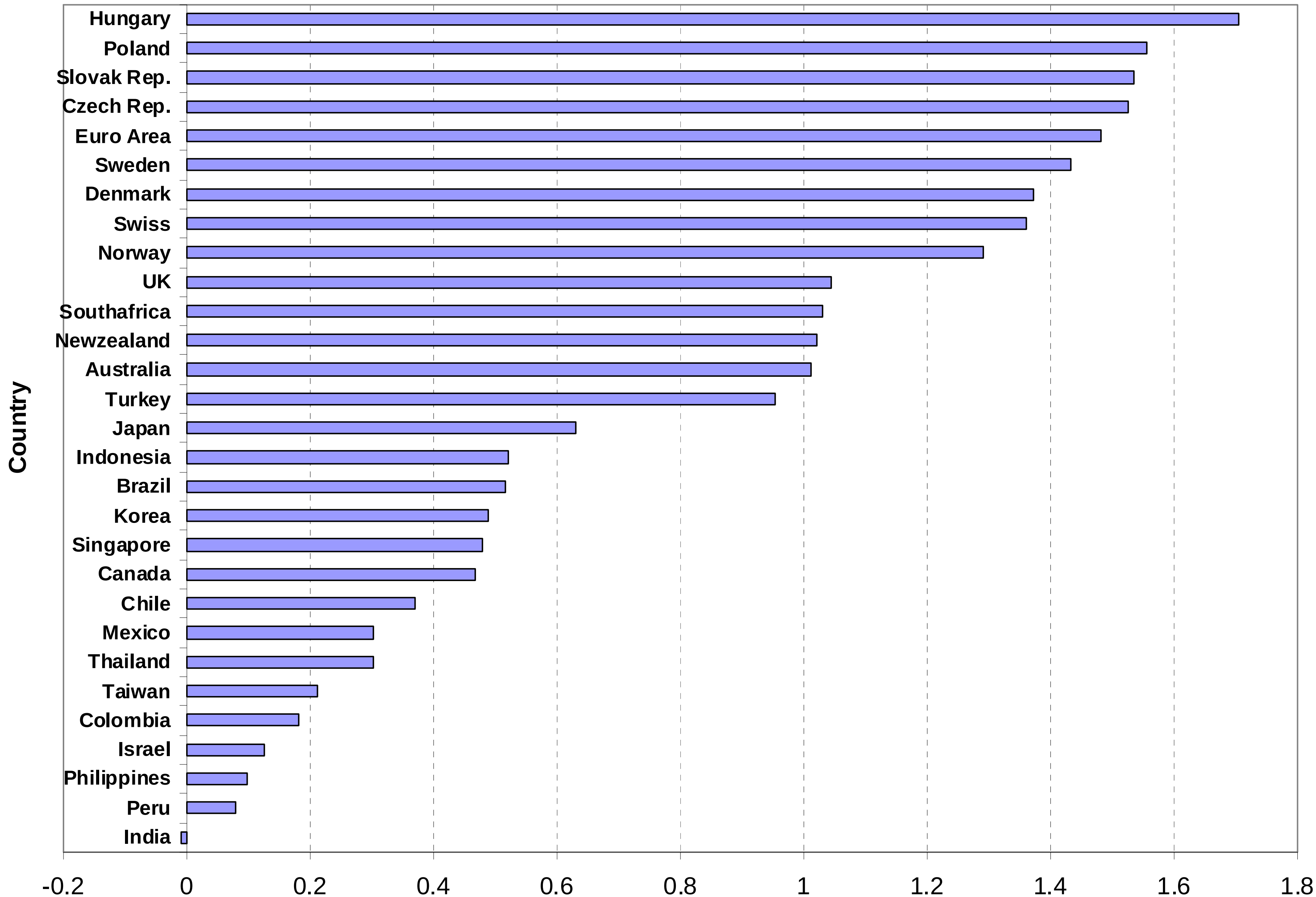
Estimation Results: Carry-trade betas



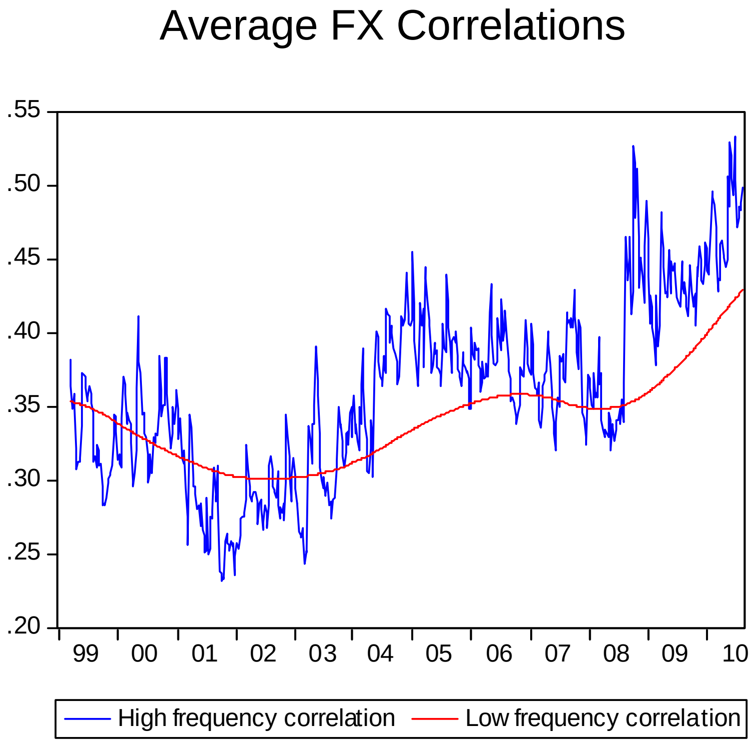
Estimation Results: Equity market betas

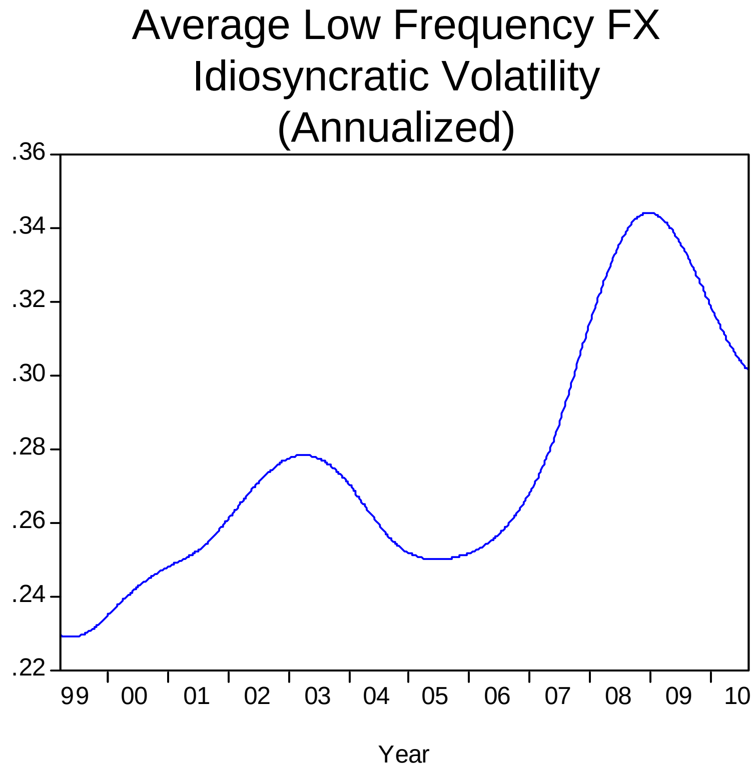


Estimation Results: FX market betas

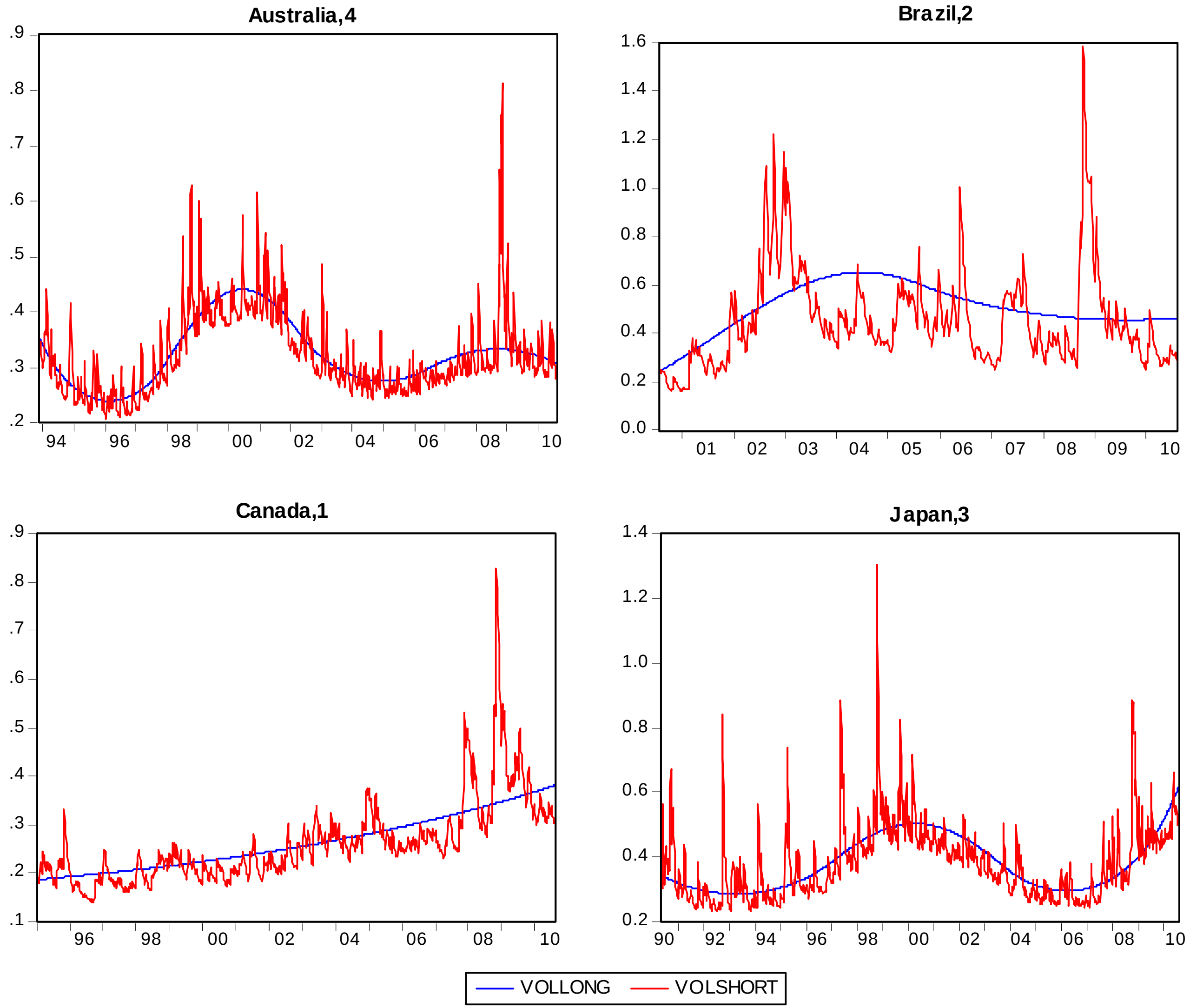


Estimation Results: Average FX correlations and low frequency idiosyncratic volatility





Estimation Results: low frequency idiosyncratic volatilities



Measures of long-term FX idiosyncratic volatility

For year *t* and currency *i*:

$$Lvol_{i,t} = \left(\frac{1}{52} \sum_{d=1}^{52} \tau_{i,t,d} \right)^{1/2},$$

$$Rvol_{i,t} = \left(\sum_{d=1}^{52} u_{i,t,d}^{2} \right)^{1/2},$$

Estimate two systems:

$$Lvol_{i,t} = \underline{x}'_{i,t}\, \beta_t + \mu_{i,t},\ t = 1, 2, ..., T,\ i = 1, 2, ..., N_t,$$

$$Rvol_{i,t} = \underline{x}'_{i,t}\, \beta_t + \upsilon_{i,t},\ t = 1, 2, ..., T,\ i = 1, 2, ..., N_t$$

- Two econometric strategies: SUR and panel models with time fixed effects and AR(1) innovations.

Explanatory variables

Table 3

Explanatory Variables

Name	Description
grgdp	Real GDP Growth Rate
gcpi	Inflation Rate
gm2	Money supply (M2) growth
vol_grgdp	Volatility of GDP*
vol_gcpi	Volatility of Inflation*
vol_gm2	Volatility of money supply growth*
vol_irate	Volatility of Short-Term Interest Rate*

Notes: All the variables (with exception of short-term interest rates) were adjusted for seasonality using standard ARIMA methods.
*Volatilities are obtained from the residuals of AR(1) models.

Following Engle and Rangel (2008), the volatility of macroeconomic variable y is estimated from:

$$\Delta \log\left(y_t\right) = c + u_t, \quad u_t = \rho u_{t-1} + e_t,$$

$$\sigma_{y,t}^2 = \frac{1}{4} \sum_{j=t-2}^{t+1} \left|e_j\right|.$$

Estimation results

FX Idiosyncratic Volatility Regressions				
	SUR model		Panel model	
Exp. variable	*Low frequency volatility*	*Realized volatility*	*Low frequency volatility*	*Realized volatility*
grgdp	-1.7435	-1.7185	-1.5822	-1.4196
	(0.603)**	(0.9395)*	(0.6629)**	(1.0804)
gcpi	2.2178	3.0819	2.0080	3.8677
	(0.684)**	(0.8991)**	(0.7714)**	(1.2042)**
gm2	0.2644	-0.2847	0.1773	-0.2571
	(0.1756)	(0.2258)	(0.1918)	(0.322)
vol_gm2	0.4994	0.6403	0.0748	0.2676
	(0.2409)**	(0.3596)*	(0.292)	(0.4499)
vol_grgdp	-0.7478	-1.1495	0.2085	-0.6321
	(0.5072)	(0.7249)	(0.591)	(0.8408)
vol_gcpi	1.0858	1.8040	0.6928	1.5785
	(0.6979)	(0.8932)**	(0.8455)	(1.145)
vol_irate	0.0046	0.0272	0.0012	0.0040
	(0.0081)	(0.0108)**	(0.0087)	(0.0134)
Average r^2	0.11	0.14		

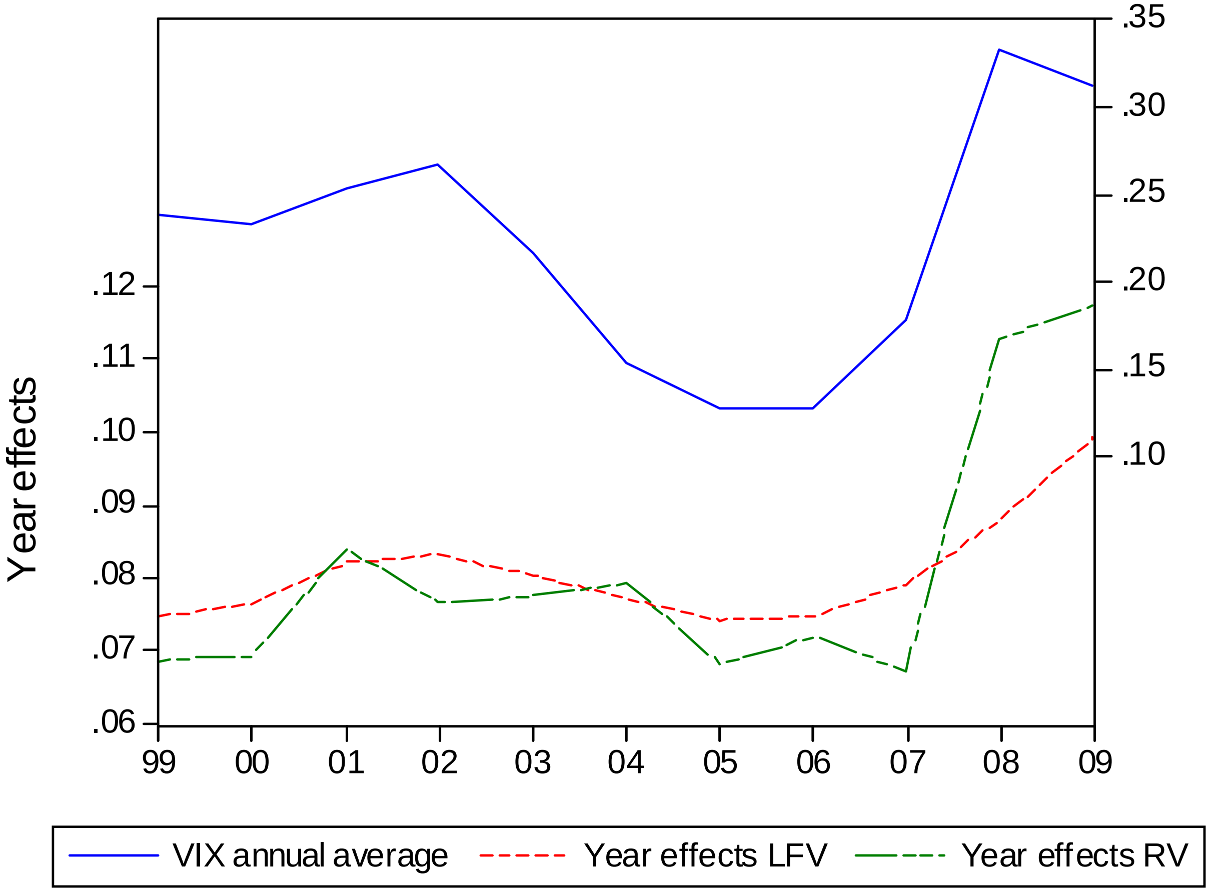
Estimation results (net of transaction costs)

$$rx_{t+1}^{l} = f_t^{b} - s_{t+1}^{a},$$

FX Idiosyncratic Volatility Regressions (Net of Transaction Costs)

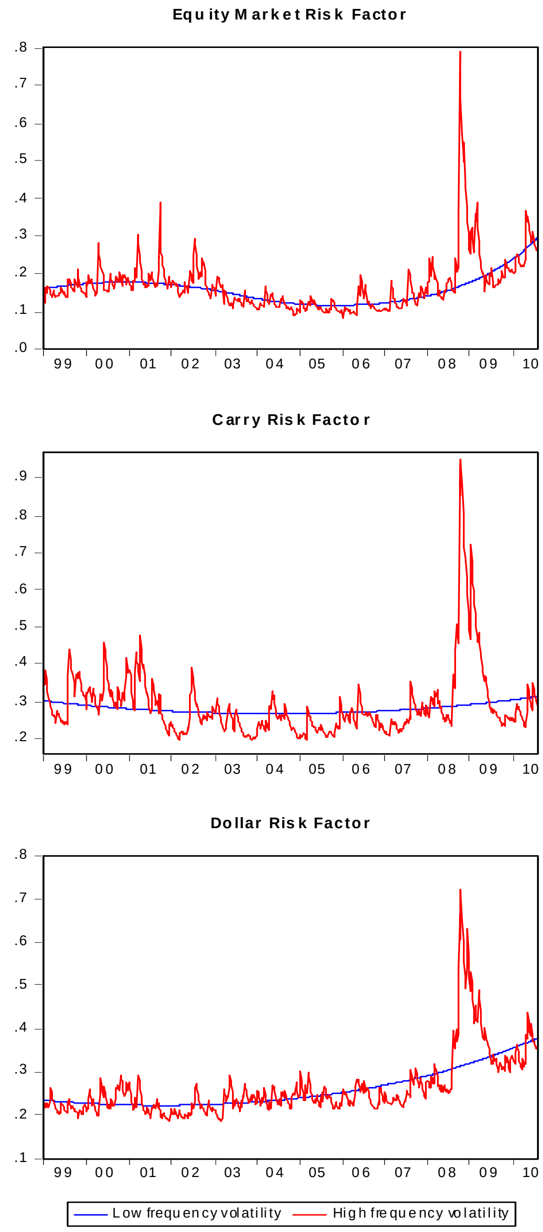
	SUR model		Panel model	
Exp. variable	*Low frequency volatility*	*Realized volatility*	*Low frequency volatility*	*Realized volatility*
grgdp	-0.3548	-0.7039	-0.2426	-0.5343
	(0.1488)**	(0.2331)**	(0.1359)*	(0.264)**
gcpi	0.6690	0.7435	0.4349	0.7641
	(0.1595)**	(0.2398)**	(0.157)**	(0.2959)**
gm2	0.0059	-0.1548	0.0100	-0.1273
	(0.039)	(0.0603)**	(0.0394)	(0.0782)
vol_gm2	0.0462	0.3040	0.0445	0.1873
	(0.0561)	(0.0927)**	(0.0594)	(0.1109)*
vol_grgdp	-0.2754	-0.5100	-0.1583	-0.5607
	(0.1237)**	(0.1823)**	(0.1188)	(0.2095)**
vol_gcpi	0.7831	0.7797	0.5477	0.6027
	(0.1475)**	(0.2275)**	(0.168)**	(0.2864)**
vol_irate	-0.0004	0.0025	0.0009	-0.0012
	(0.0018)	(0.0027)	(0.0018)	(0.0033)
Average r^2	0.20	0.18		

Year fixed effects and VIX



Concluding Remarks

- This paper models term correlation patterns in FX markets.
- The framework allows us to capture empirical features of the data and provides reasonable estimation results.
- By combining a factor currency pricing model with Factor-Spline-GARCH dynamics, this paper separates systematic and idiosyncratic components that drive the variation of FX comovements, and links their long-term component to economic fundamentals.
- Inflation and real growth are robust determinants of long-term FX idiosyncratic volatilities.
- An omitted factor may be related to VIX.
- Moderate R^2s.


Equity Market Risk Factor
.8
.7
.6
.5
.4
.3
.2
.1
.0
99 00 01 02 03 04 05 06 07 08 09 10
Carry Risk Factor
.9
.8
.7
.6
.5
.4
.3
.2
99 00 01 02 03 04 05 06 07 08 09 10
Dollar Risk Factor
.8
.7
.6
.5
.4
.3
.2
.1
99 00 01 02 03 04 05 06 07 08 09 10
Low frequency volatility
High frequency volatility