Contagion Effects of USD and Chinese Yuan in Spot and Forward FOREX Markets

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Outline

Motivation

- Modeling of abrupt fluctuations
- Gains new insight into the propagation dynamics of spillover effects in international forex markets. .
- Hawkes (1971) diffusion model to contagious effects in bilateral exchange rates in spot and forward forex markets.
- The Hawkes process is a mutually dependent and self-exciting process, which allows for the simulation of cross-sectional and serial- dependence clustering.

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Literature Review

Empirical Studies on Financial Contagion

- Financial Contagion is comprehensively studied
- Various techniques are presented in the literature (Grubel and Fadner, 1971; King and Wadhwani, 1990; Eichengreen et al., 1994)
- Identify the conditions for rejecting parameter stability upon financial transmission processes mainly by using vector autoregressive models, Baig and Goldjain (1999), Forbes and Rigobon (2002), and Favero and Giavazzi (2002)
- Volatility and Correlation in exchange rates
  - Quantify the relationship between return, volatility, and correlation using the generalized impulse response functions and GARCH models
  - Test for the asymmetries in the return-correlation and volatility-correlation relationships, Amira et al. (2011)

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Literature Review

Stochastic Volatility and Forex Markets

- Stochastic volatility relying on currency option pricing, Bates (1996) and Heston (1993)
- Stochastic volatility model for foreign exchange rate options and fit to the data than empirical methods, Melino and Turnbull (1990)
- GMM estimator construction for a jump diffusion model, Andersen (2003)
- A summary for FX options models, Wystup (2006)
  - Stochastic skew behavior of currency options outperforming traditional jump-diffusion models, Carr and Wu (2007)
  - Stochastic volatility improves accuracy of forecasts, Clark (2011)
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Literature Review

Exchange rate variance properties

- Variability of output, trade variables, and both private and government consumption under alternative real exchange rate regimes using different detrending techniques, Baxter and Stockman (1989)
- VAR and variance decomposition models to estimate relative contribution of real and nominal shocks to real exchange fluctuations, Clarida and Gali (1994), Enders and Lee (1999), and Rogers (1999).
- A common focus is given on the fundamental determinants of long-run equilibrium real exchange rate fluctuations.
  - Long run real exchange rate dynamics and fundamentals, Ricci et al. (2008)
  - Deviations from PPP, Mendoza (1995), Rogoff (1996)
  - Explicit time-varying nature of market data, Aboura and Chevallier (2015)
  - Models related to connectedness (Diebold and Yilmaz, 2014, 2015) and mutual excitements (Ait-Sahalia et al., 2014, 2015)

Data Sample

Exchange rate returns from 04/2004 to 04/2011: Australian Dollar (AUD), Brazilian Real (BRL), Canadian Dollar (CAD), Chinese Yuan Renminbi (CNY), Danish Krone (DKK), Euro (EUR), Japanese Yen (JPY), Mexican Peso (MXN), British Pound (GBP), U.S. Dollar (USD)

- U.S. Dollar and Chinese Renminbi Yuan, expressed as broad trade-weighted bilateral exchange rates and use them to build a benchmark against the remaining currencies in our models.
- Achieve a filtered unilateral effect by introducing some exogenous notion in the applied time series.
  - Resulting effect will show filtered effect of CNY (USD respectively) on each single exchange rate

Risk Evaluation I

- Presence of nonlinear dependence by using exceedance correlations as proposed by Longin and Solnik (2001) and Ang and Chen (2002)
- Exchange rate returns X and Y which have been standardized with mean zero and variance one. Exceedance correlation measures the correlations of two stocks as being conditional on exceeding some threshold, that is:

$$\tilde{\rho}(\mathrm{p}) = \begin{cases} \mathrm{Corr}\left[X, Y | X \leq Q_x(\mathrm{p}) \text{ and } Y \leq Q_y(\mathrm{p})\right], & \text{for p} \leq 0.5 \\ \mathrm{Corr}\left[X, Y | X > Q_x(\mathrm{p}) \text{ and } Y > Q_Y(\mathrm{p})\right], & \text{for p} > 0.5, \end{cases} \quad (1)$$

- In general, spot markets exhibit higher exceedance correlation values

Risk Evaluation II

- Express nonlinear dependence in the form of copulas. Copulas support the shape and direction of the exceedance correlations:

$$C(u, v, \rho, \upsilon) = \Phi_\rho\left(\Phi^{-1}(u), \Phi^{-1}(v); \rho, \nu\right) =$$

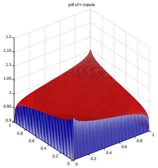
$$= \int_{-\infty}^{\Phi^{-1}(u)} \int_{-\infty}^{\Phi^{-1}(v)} \frac{1}{2\pi\sqrt{1-\rho^2}} \left(1 + \frac{x^2 + y^2 - 2\rho xy}{\nu(1-\rho^2)}\right)^{-\frac{\nu+2}{2}} \mathrm{dy}\,\mathrm{dx}.$$

where, u, v are the exchange rates, Φ^{-1} is the inverse cumulative distribution function of a standard univariate Student-t distribution with ν is the degrees of freedom, and Φ_ρ is the joint cumulative distribution of a multivariate Student-t distribution with zero mean vector and covariance matrix equal to the correlation matrix ρ.

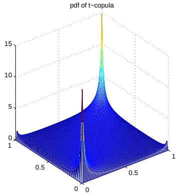
Risk Evaluation II

- In the USD spot market, we observe similar results for CAD, MXN, and the EUR: correlation at the extremes, lower correlation for the middle quantiles, and more correlation
- CNY spot exchange market, in the case of EUR, JPY, and MXN moderate correlation is given, where more higher correlation at the extremes can be observed
- Forward and spot markets show almost the same dynamics, whereas MXN spot exchange markets have more extreme correlation
- USD forward creates strong extreme correlation effects, especially in the forward markets
- CNY forward are more moderate; however, some extreme correlation effects can be observed

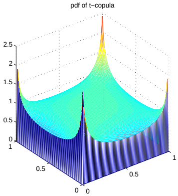
Copula Probability Densities in Spot Markets (USA originated)



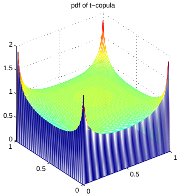
USD-CNY



USD-JPY



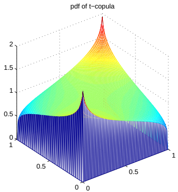
USD-MXN



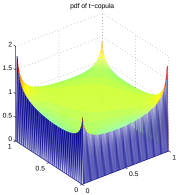
USD-CAD

Copula Probability Densities in Forward Markets (USA originated)

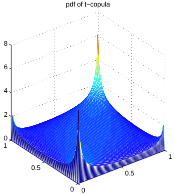
USD-CNY



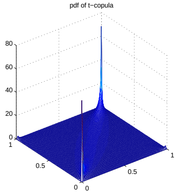
USD-JPY



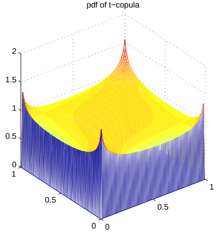
USD-MXN



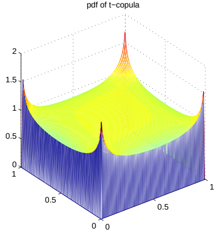
USD-CAD



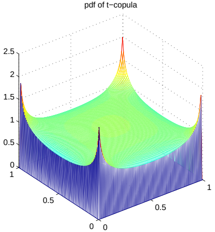
Copula Probability Densities in Spot Markets (CNY originated).



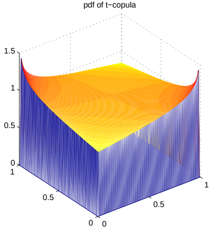
CNY-EUR



CNY-JPY

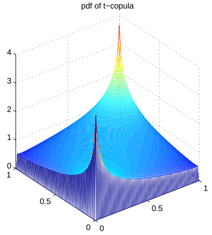


CNY-MXN

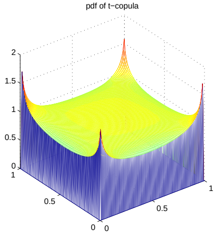


CNY-CAD

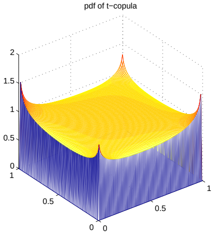
Copula Probability Densities in Forward Markets (CNY originated).



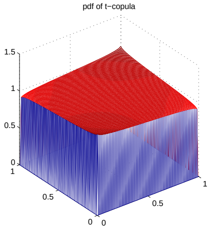
CNY-EUR



CNY-JPY



CNY-MXN



CNY-CAD

Backtesting

- We estimate GARCH-models to implement the VaR approach. We use a rudimentary GARCH(1,1) model specification:
$$\sigma^2_{t+1} = \omega + \alpha Y^2_t + \beta \sigma^2_t \,. \qquad (2)$$
- Violation ratios is the actual number of VaR violations compared with the expected value of number of violations:
$$\mathrm{VR} = \frac{v_1}{p \times \mathrm{W}_T}$$
$$\eta_t = \begin{cases} 1 & \text{if } y_t \leq -\mathrm{Va}R_t \\ 0 & \text{if } y_t > -\mathrm{Va}R_t \end{cases}$$

where, the estimation window W_T is the number of observations used to forecast risk, v is the number of instances, $v_i, i = 0,1$ number of violations ($i = 1$) and no violations ($i = 0$) observed in $\{\eta_t\}$, $v_1 = \sum \eta_t$, $v_0 = \mathrm{W}_T - v_1$, p is the probability level of the VaR estimation, $\eta_t = 0,1$ indicates whether a VaR violation occurs, (for violation $\eta_t = 1$).

- If the actual return on a particular day exceeds the VaR forecast the VaR limit is violated.

Backtesting Model Results

VaR Violation ratio	CAD/USD	CNY/USD	Euro/USD	JPY/USD	MXN/USD
Spot	1.063	2.83	1.41	1.53	0.94
Forward	4.61	1.41	0.000	1.53	0.95

Hawkes Jump Diffusion Model

- We use the following bivariate Hawkes diffusion model for implementation of our contagion model:

$$\begin{cases} dX_{1,t} = \mu_1 dt + \sqrt{V_{1,t}} dW^X_{1,t} + Z_{1,t} dN_{1,t} \\ dX_{2,t} = \mu_2 dt + \sqrt{V_{2,t}} dW^X_{2,t} + Z_{2,t} dN_{2,t} \\ dV_{1,t} = \kappa(\theta_1 - V_{1,t})dt + \eta_1 \sqrt{V_{1,t}} dW^V_t \\ dV_{2,t} = d\left(\frac{\theta_1}{\theta_2}\right) V_{1,t} \\ d\lambda_{1,t} = \alpha_1(\lambda_{1,\infty} - \lambda_{1,t})dt + \beta_{11} dN_{1,t} + \beta_{12} dN_{2,t} \\ d\lambda_{2,t} = \alpha_2(\lambda_{2,\infty} - \lambda_{2,t})dt + \beta_{21} dN_{1,t} + \beta_{22} dN_{2,t} \end{cases} \tag{3}$$

with $\mathbb{E}\left[dW^X_{1,t} dW^X_{2,t}\right] =: \rho\, dt$ and $\mathbb{E}\left[dW^X_{i,t} dW^V_t\right] =: \rho^v_i\, dt$, $i = 1, 2$. The corresponding integral equation for $\lambda_{i,t}$ is defined as

$$\lambda_{i,t} = \lambda_{\infty,i} + \int_{-\infty}^{t} \beta_{i,1} e^{-\alpha_i(t-s)} dN_{1,s} + \int_{-\infty}^{t} \beta_{i,2} e^{-\alpha_i(t-s)} dN_{2,s}\,, \quad i = 1, 2.$$

- domestic and foreign asset return dynamics $dX_{1,t}$ and $dX_{2,t}$ and the stochastic volatilities $dV_{1,t}$ and $dV_{2,t}$

Hawkes Jump Diffusion Model

- Stochastic volatilities are interconnected with the correlation coefficient $\rho = dW_1 dW_2$.
- Domestic jump intensity is driven by the domestic market jump amplitude, β_{11}, and the foreign market transmission jump amplitude, β_{12}, which can be considered as the contagious spillover process.
- Precise effect of a jump in currency j on the jump intensity of currency i, is determined by the parameter $\beta_{i,j}$, $i = 1, ..., m$. Foreign jump intensity is driven by domestic transmission jump amplitude, β_{21}, and the internal foreign counterpart, β_{22}, respectively.
- Intensities $\lambda_{i,t}$ and the associated counting processes $N_{i,t}$, $i = 1, ..., m$ as a multivariate Hawkes process (mutually exciting jump process) with exponential decay.
  - mean reversion with the jump intensity decaying back to $\lambda_{i,\infty}$ at rate α_i.
- The following parameter restrictions are imposed: $0 \leq \gamma_i \leq 1$, $\lambda_{i,t} \geq \lambda_{i,\infty} \geq 0$, and $\alpha_i > \beta_{i,j} \geq 0$, $i, j = 1, ..., m$, $\alpha_1 = \alpha_2 =: \alpha$ and $\lambda_{1,\infty} = \lambda_{2,\infty} =: \lambda_\infty$.

Hawkes Jump Diffusion Model

μ_1, μ_2, rate of return of the asset, β_{ij}, jump amplitude are responsible for mutually exciting process, $\alpha = \alpha_1 = \alpha_2$, speed of jump mean reversion, λ_1, λ_2, jump intensity, $\lambda_{1,\infty} = \lambda_{2,\infty}$, long term jump intensity, $\sqrt{\theta_1}$, $\sqrt{\theta_2}$, volatility, ρ, correlation coefficient, and $1/\gamma_1$, $1/\gamma_2$, jump size parameters. Identification is achieved by equalizing the adjustment parameters as $\alpha = \alpha_1 = \alpha_2$ and the long-term jump intensities, $\lambda_\infty = \lambda_{1,\infty} = \lambda_{2,\infty}$

The country specific jump intensities, λ_1,λ_2, are estimated via endogenous simulation. In case of self- excitation and mutually excitation, jump excitation parameters α, β are estimated using the maximum likelihood, while λ_∞ is estimated such that the unconditional expected jump intensity $E[\lambda]$ is equal to the average jump occurrences per year.

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Hawkes Jump Diffusion Model

The hypothesis of cross-sectional contagion is tested as

$$H_0^I : \beta_{i,j} = 0, i \neq j \; i,j = 1,2.$$

Identification of further excitation jump dynamics:
$H_0^{II} : \beta_{i,j} = 0, \; i,j = 1,2$, $H_0^{III} : \beta_{i,i} = 0, \; i = 1,2$

Model Results Tables

1	USD	*1*	USD
2	JPY/USD	*2*	JPY/USD
α	35.47***	$\sqrt{\theta_1}$	0.13***
	(0.07)		(0.00)
β_{11}	0.00	$\sqrt{\theta_2}$	0.16***
	(0.25)		(0.01)
β_{12}	0.01	ρ	0.59***
	(0.01)		(0.18)
β_{21}	1.28**	μ_1	0.00
	(0.55)		(0.01)
β_{22}	26.63***	μ_2	0.00
	(0.07)		(0.02)
λ_∞	0.00	$1/\gamma_1$	0.35**
	(0.00)		(0.08)
λ_1	0.00	$1/\gamma_2$	0.07
λ_2	0.00		(1.75)

Model Results Tables

- Stronger contagion effects from US to other markets than in the reverse case
- Reversal effect on the jump intensity of the USD from other markets, however in weaker form
- US contagion: spot exchange rate returns are higher than parameter values for forward exchange rate returns
- CNY contagion: parameter values for internal excitation parameters (β_{11},β_{22}) are higher for the forward market and the parameters are higher for crossover excitations (β_{12},β_{21}) in the spot exchange rate market

Conclusion I

- Contagion occurs in most cases beyond volatility.
- In terms of expectations of future exchange rate dynamics, we should emphasis the unexpected part in these dynamics.
  - The contagion dynamics do not evolve constantly. Being far from a continuous process, contagion occurs in the case when we observe abrupt dynamics
- In this regard, asymmetry in these expectations is involved. The asymmetry depends on each currency pair. Internal market dynamics, as well as the transmission of country-specific dynamics are important features in determining the exact impact of the asymmetry on the evolution of these parameters.
  - dependent on the joint occurrence of specific market conditions, which analyzed model parameters try to mimic.

Conclusion II

- Mean reversion in the contagion debate is a further aspect that needs to be paid attention to.
- As contagion occurs according to specific market conditions, it is of transitory nature, whenever these conditions are no longer given.
- The decay parameter α, gives some indication about the mean reversion dynamics in our model.
- For high values of the α-parameter, we observe rapid decay of the jump intensity.

Conclusion III

- Long-term jump intensity, that can be seen as an equilibrium dynamic in the jump intensity.
- High volatile markets such as the GBP prevail significant volatility terms ($\sqrt{\theta_1}, \sqrt{\theta_2}$) and long term jump intensities and high mean version parameters in all model specification results.

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