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Contagion effects of U.S. Dollar and Chinese Yuan in forward and spot foreign exchange markets

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ABSTRACT

Financial contagion in forex markets is modeled by the application of a bivariate Hawkes stochastic jump process. The self-exciting and mutually exciting properties of the jump-clustering model allow for illustrating internal and cross-sectional transmission processes. The results obtained suggest stronger effects from US to mutual markets than in the reverse case. Cross-sectional excitation dynamics in the spot markets are larger than in the forward markets. As a central result, we can observe that the results for the Hawkes-model parameters are more significant in the forward markets. Transmission dynamics beyond volatility determine the likelihood of contagion occurrence. The significance of the decay parameters towards the long term jump intensities supports the importance of abrupt fluctuations in the contagion discourse.

1. Introduction

Empirically founded analysis of financial contagion is comprehensively studied and various techniques are presented in the literature (Grubel and Fadner, 1971; King and Wadhwani, 1990; Eichengreen et al., 1994). Empirical research by Baig and Goldfajn (1999), Forbes and Rigobon (2002), and Favero and Giavazzi (2002) identify the conditions for rejecting parameter stability upon financial transmission processes mainly by using vector autoregressive models (VAR). The related literature can be analyzed under currency comovements, stochastic volatility, and exchange rate variance properties.

In terms of volatility and correlation in exchange rates various results are identified. Amira et al. (2011) quantify the relationship between return, volatility, and correlation using the generalized impulse response function and GARCH models; they tested for the asymmetries in the return-correlation and volatility-correlation relationships. For short and intermediate horizons, they find that the impact of volatility on correlation is asymmetric: volatility seems to have a greater impact on correlation during market downturn periods than during market upturn periods. Further, the increase in the correlation is more related to the market direction than the level of volatility. During downturn markets the level of correlation increases and the association between large volatilities and high correlations is mainly due to the simultaneous effect of bad news on both variables. Chiang et al. (2007) find higher correlation during crisis periods for Asian markets with the help of multivariate GARCH. Ang and Bekaert (2002) find international evidence for high-volatility correlation regimes during bear markets; they observe higher volatility than correlation. Multiple interpretations for exchange rate volatility; such as purchasing power parity (PPP) and regime explanations are given in Frenkel and Goldstein (1988).

Pioneering studies of stochastic volatility models are made by Bates (1996) and Heston (1993), relying on currency option pricing. Melino and Turnbull (1990) derive a stochastic volatility model for foreign exchange rate options and achieve a better fit to the data than empirical methods. Andersen et al. (2003) constructs a GMM estimator for a jump diffusion model and derives accurate and reliable results. A summary for FX options models is given in Wystup (2013). Carr and Wu (2007) developed and estimated subclasses of models, which capture stochastic skew behavior of currency options outperforming traditional jump-diffusion models. Clark (2011) supports that stochastic volatility improves accuracy of forecasts. Aït-Sahalia et al., 2014 tested policy interventions credit default swaps (CDS) by the contagion jump feedback model.

The related explanations of exchange rate volatility are analyzed by various streams in the literature. Caporale and Pittis (1995) explain the basis for the link between exchange rate volatility to exchange rate regimes; he observes the rise of volatility when a country moves from a fixed to a flexible exchange rate regime, especially because of nominal exchange rate movements. Baxter and Stockman (1989) identified the variability of output, trade variables, and both private and government consumption under alternative real exchange rate regimes using different detrending techniques; and find evidence that the real exchange rate depends on real exchange-rate regimes. VAR and variance decomposition models to estimate relative contribution of real and nominal shocks to real exchange fluctuations are presented by Clarida and Gali (1994), Enders and Lee (1997), and Rogers (1999). A common focus is given on the

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fundamental determinants of long-run equilibrium real exchange rate fluctuations. Long run real exchange rate dynamics and fundamentals are analyzed by Ricci et al. (2013) and deviations from PPP are given in Mendoza (1995) and Rogoff (1996). Explicit time-varying nature of market data is captured in Aboura and Chevallier (2015). Increasing mutual dependencies and comovements in the financial markets lead to models of connectedness (Diebold and Yilmaz, 2014, 2015) and mutual excitements (Aït-Sahalia et al., 2014, 2015) in recent studies.

This study gains new insight into the propagation dynamics of spillover effects in international forex markets. We apply the stochastic jump diffusion model proposed by Aït-Sahalia et. al. (2015) to spot and forward forex markets. In this study, we apply a Hawkes (1971) diffusion model to contagious effects in bilateral exchange rates. The Hawkes process is a mutually dependent and self-exciting process, which allows for the simulation of cross-sectional and serial dependence clustering. This property enables us to model lagged transmissions of financial turbulence. The detailed specifications of the spillover dynamics are aimed to give evidence about the role of the transmission of contagion shocks. This study proceeds as follows. Section 2 gives a description and analysis of the data. In Section 3, we pursue the risk evaluation of the currencies. Section 4 introduces the contagion model. The results for spot and forward exchange rate model specifications are documented in Section 5. Finally, Section 6 concludes and summarizes the results.

2. Data description

2.1. Data sample

The following exchange rate returns are used in the model implementation: 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). In sequel, the exchange rates are denominated as domestic exchanges against the U.S. Dollar (USD) rate. We use logged differences of the exchange rates ($\log e_t - \log e_{t-1}$). The data sample spans the period from 04/2004 to 04/2011. The data sample contains several periods of economic volatility regimes; such as shrinkage in the oil production, the Iraq war, the mortgage crisis and the subsequent macroeconomic recovery period. The aim of the data sample choice is to achieve an international diversified representation of different country market sizes. The data are obtained from the Thomson Reuters Datastream database, FRED and BIS. In the spot market, we use the U.S. Dollar and The 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. Since we are aware of the bilateral nature of exchange rates, we intend to achieve a filtered unilateral effect by introducing some exogenous notion in the applied time series. Therefore we do not test, i.e. CNY/USD on JPY/USD, we test CNY (and USD respectively), expressed as broad trade-weighted bilateral exchange rate and use them to build a benchmark against the remaining currencies in our models. The resulting effect will show filtered effect of CNY (and USD respectively) on each single exchange rates, accounting for their specific dynamics in the international forex markets. To achieve an exogenous variable series role of benchmark we calculate a trade weighted exchange rate in the forward currency market. The trade weighted exchange rate is calculated as the percentage weight of the trade volume (import + export) multiplied by the bilateral exchange rate e. The benchmark forward exchange rates (USD and CNY) are calculated according to trade percentage weights collected from BIS for CNY and FRED for USD.[1]

2.2. Descriptive statistics

The descriptive statistics for the spot market exchange rates are given in Table 1. The highest skewness values are observed for CAD, DKK, and MXN in the spot exchange markets. The highest kurtosis values are given for CAD, CNY, DKK, and MXN. In the forward exchange rates the largest skewness values are observed for BRL, CNY, and MXN. The largest kurtosis values are observed for CAD, CNY, MXN and USD. The results for the Jarque-Bera test reveal that we find significant skewness and excess kurtosis for all currencies. A more accurate illustration of contagion dynamics can give the exceedance correlation and copula with higher moments generating dynamics which are described in the next section.

3. Risk evaluation

3.1. Exceedance correlations

In this section, we document the presence of nonlinear dependence by using exceedance correlations as proposed by Longin and Solnik (2001) and Ang and Chen (2002). We assume that we have two 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:

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

In Fig. 1 exceedance correlation is illustrated as follows. The vertical axis gives the correlation between two assets given that both exceed that quantile. The horizontal axis shows the probability distribution in a given interval from (0 to 0.5) and (0.5 to 1). The exceedance correlation is estimated from the underlying data distribution. We implement the risk evaluation section for the major currencies, which are assumed to be of central importance in the contagion discourse. The results with regard to the distribution of exceedance correlation are presented subsequently. The results for the USD spot market are given as follows (Fig. 2). The results for EUR and JPY show a nonlinear shape but are symmetric. MXN and CAD have almost linear shape and symmetric distribution for upper and lower quantiles Fig. 3. The results for CNY fall somewhat apart, right skewed with stronger exceedance towards the upper quantiles (0.7–0.8).

In the CNY spot markets (Fig. 4), we observe a right skewed and nonlinear shape of the exceedance correlation towards the right extreme for all currencies. The results for the USD forward markets reveal a nonlinear shape for CNY, Euro, and CAD. CNY is right skewed towards the right extreme quantiles; CAD is left skewed and EUR is symmetric. In the CNY forward markets, the EUR is slightly right tailed and nonlinear, JPY is peaked and right tailed, MXN lower peaked, right tailed and nonlinear, and CAD has a nonlinear shape and is left skewed Fig. 5.

In sum, right extreme high exceedance correlations for CNY markets can be observed. USD and MXN are linear and symmetric in the spot, as well as, in the forward markets. In general, spot markets exhibit higher exceedance correlation values.

3.2. Copulas

More formally, we can express nonlinear dependence in the form of copulas. Copulas support the shape and direction of the exceedance correlations and can be expressed as follows:

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

[1] We use the following calculation method: $E = \sum_{i=1}^{n} w_i e_i$ where w_i, is the percentage weight of trade volume and e, is the bilateral exchange rate. In the case of the Chinese Yuan, the weighted forward exchange rate is normalized through the division by the CNY/USD forward exchange rate: $E = (\sum_{i=1}^{n} w_i e_i)/e_{\mathrm{norm}}$, where e_{norm} is the CNY/USD forward rate.