Excess Comovements in the Foreign Exchange Market with an Application to the Euro-GBP-USD triplet

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2. FIW-Forschungskonferenz 'International Economics'
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Stylized facts - types of traders:

- fundamental models poor in forecasting (and explaining) exchange rates (e.g. Meese/Rogoff, JIE 1983)
- price determination process on capital markets: interaction between fundamental and non-fundamental traders (e.g. Shleifer/Summers, JEP 1990)
- US dollar in the eighties: dynamics between fundamental and technical traders (e.g. Frankel/ Froot, Econ. Rec. 1986)
- non-linear dynamics between fundamental and technical traders due to transaction costs, profitability of forecasting rule (e.g. De Grauwe/Grimaldi, JEDC 2005, RIE 2005, EER 2006)
- "long-swings in the dollar" (Engel/ Hamilton, AER 1990; Klaasen, JBES 2005)
- although swings similar across different US dollar exchange rates, only models directed to one exchange rate
Motivation

Visual inspection

**Deviations from PPP**

- EUR/USD
- GBP/USD
- EUR/GBP

Excess comovements in the fx market

2. FIW-Forschungskonferenz 'International Economics'
Motivation
Stylized facts (2)

Stylized facts - common factors in the short run:


- explanatory power from order flows of a different exchange rate, "informational integration" (Evans/Lyons, *JIMF* 2002)
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- explanatory power from order flows of a different exchange rate, "informational integration" (Evans/Lyons, JIMF 2002)

Stylized facts-common factors in the medium and long run:

- long-run comovements only for EMS currencies in US dollar before introduction of the Euro but for Australian dollar and Pound Sterling in US dollar to Euro/US dollar since introduction of the Euro (Kühl, 2007)
- for EUR/USD and GBP/USD: evidence in favour of cointegrated fundamentals but room for non-fundamental factors (Kühl, 2008)
- time-varying comovements of exchange rates (Engle, JBES 2002; Tse/Tsui, JBES 2002; Van Dijk/Munandar/Hafner, 2005)

⇒ linkages across markets with room for non-fundamentals
Building blocks

- non-fundamental factors on the market
- linkages in volatility, i.e. in information processing, in the short run
- linkages between exchange rates in the long run not only due to linkages in fundamentals
- room for common non-fundamental factors

⇒ Modelling of common non-fundamental factors neglected!

Open questions:

- Consequences of common non-fundamental factors?
- Under which conditions can excess comovements arise?
- Evidence in favour of excess comovements?
Proceeding:

1. Motivation
2. Benchmark model
3. Behavioural Model
4. Empirical Analysis
5. Conclusion
**Benchmark model**

**Triangular framework**

**Triangular framework:**
- 3 countries, 3 currencies, and flexible exchange rates
- Exchange rate $s_{ij}^t$: one unit of currency $j$ with $j = [2, 3]$ in currency $i$ with $i = 1$

**Triangular arbitrage** (Frenkel/Levich, *JPE* 1975):

$$\frac{S_{12}^t}{S_{13}^t} = S_{32}^t$$

or in logs

$$s_{12}^t - s_{13}^t = s_{32}^t$$

**Fundamental processes:**

$$s_{ij}^t = F_{ij}^t = F_i^t - F_j^t \text{ with } i \neq j$$
Exchange rate determination in a rational expectation benchmark case:

\[ s_{12}^t - s_{13}^t = F_{12}^t - F_{13}^t = (F_1^t - F_2^t) - (F_1^t - F_3^t) = F_3^t - F_2^t = s_{32}^t \]
**Benchmark model**

Triangular framework (2)

**Exchange rate determination in a rational expectation benchmark case:**

\[ s_{t}^{12} - s_{t}^{13} = F_{t}^{12} - F_{t}^{13} = (F_{t}^{1} - F_{t}^{2}) - (F_{t}^{1} - F_{t}^{3}) = F_{t}^{3} - F_{t}^{2} = s_{t}^{32} \]

**Correlations between exchange rates:**

(based upon the same denomination currency)

\[ corr^{*}(s^{12}, s^{13}) = \frac{cov(s^{12}, s^{13})}{\sqrt{var(s^{12}) \cdot var(s^{13})}} \]

\[ = \frac{cov(F^{12}, F^{13})}{\sqrt{var(F^{12}) \cdot var(F^{13})}} \]
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Triangular framework (2)

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\[ = \frac{\text{cov}(F_{t}^{12}, F_{t}^{13})}{\sqrt{\text{var}(F_{t}^{12}) \cdot \text{var}(F_{t}^{13})}} \]
\[ = \frac{\text{var}(F_{t}^{1}) - \text{cov}(F_{t}^{1}, F_{t}^{3}) - \text{cov}(F_{t}^{2}, F_{t}^{1}) + \text{cov}(F_{t}^{2}, F_{t}^{3})}{\sqrt{\text{var}(F_{t}^{1}) - 2 \cdot \text{cov}(F_{t}^{1}, F_{t}^{2}) + \text{var}(F_{t}^{2})) \cdot (\text{var}(F_{t}^{1}) - 2 \cdot \text{cov}(F_{t}^{1}, F_{t}^{3}) + \text{var}(F_{t}^{3}))}} \]

\( \frac{\partial corr}{\partial \text{cov}(F_{t}^{12}, F_{t}^{13})} > 0; \frac{\partial corr}{\partial \text{cov}(F_{t}^{2}, F_{t}^{3})} > 0; \]
\( \frac{\partial corr}{\partial \text{cov}(F_{t}^{1}, F_{t}^{2})} < 0; \frac{\partial corr}{\partial \text{cov}(F_{t}^{1}, F_{t}^{3})} < 0; \frac{\partial corr}{\partial \text{var}(F_{t}^{1})} > 0 \)
Behavioural model

Model description

Market participants:
- fundamentalists: base their expectations upon fundamental models
- noise traders: base their expectation upon sentiments ($u_t$), i.e. non-fundamental factors

Exchange rate formation process (Frankel/Froot, 1986):

$$s_t = \gamma_t E(s_t^r | \Phi_{t-1}^r) + (1 - \gamma_t) E(s_t^b | \Phi_{t-1}^b) \text{ with } \gamma_t = f(\Omega_t)$$

Fundamentalists’ expectation process:

$$s_t^{r1j} = F_t^{1j} + \nu_t^{1j}$$

Noise traders’ expectation process (Barberis/Shleifer/Wurgler, JFE 2005):

$$s_t^{b1j} = u_t + \epsilon_t^{1j}$$
Exchange rate determination processes:

\[ s_t^{12} = \gamma_t F_t^{12} + (1 - \gamma_t) u_t + e_t^{12} \quad \text{and} \quad s_t^{13} = \lambda_t F_t^{13} + (1 - \lambda_t) u_t + e_t^{13} \]
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Triangular framework:

\[ s_{t}^{12} - s_{t}^{13} = \gamma_t F_t^{12} + (1 - \gamma_t) u_t - \lambda_t F_t^{13} - (1 - \lambda_t) u_t \]

\[ = \gamma_t (F_t^1 - F_t^2) + (1 - \gamma_t) u_t - \lambda_t (F_t^1 - F_t^3) - (1 - \lambda_t) u_t \]

\[ = (\gamma_t - \lambda_t) F_t^1 + \lambda_t F_t^3 - \gamma_t F_t^2 + (\lambda_t - \gamma_t) u_t \]

\[ = s_{t}^{32}. \]
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\]

\[
= s_{t}^{32}.
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Motivation

Benchmark model

Behavioural Model

Empirical Analysis

Conclusion

Behavioural model
Triangular framework

Exchange rate determination processes:

\[ s_{t}^{12} = \gamma_{t} F_{t}^{12} + (1 - \gamma_{t}) u_{t} + e_{t}^{12} \quad \text{and} \quad s_{t}^{13} = \lambda_{t} F_{t}^{13} + (1 - \lambda_{t}) u_{t} + e_{t}^{13} \]

Triangular framework:

\[
\begin{align*}
  s_{t}^{12} - s_{t}^{13} &= \gamma_{t} F_{t}^{12} + (1 - \gamma_{t}) u_{t} - \lambda_{t} F_{t}^{13} - (1 - \lambda_{t}) u_{t} \\
  &= \gamma_{t} (F_{t}^{1} - F_{t}^{2}) + (1 - \gamma_{t}) u_{t} - \lambda_{t} (F_{t}^{1} - F_{t}^{3}) - (1 - \lambda_{t}) u_{t} \\
  &= (\gamma_{t} - \lambda_{t}) F_{t}^{1} + \lambda_{t} F_{t}^{3} - \gamma_{t} F_{t}^{2} + (\lambda_{t} - \gamma_{t}) u_{t} \\
  &= s_{t}^{32}.
\end{align*}
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Exchange rate determination processes:

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\[ = (\gamma_t - \lambda_t) F_t^1 + \lambda_t F_t^3 - \gamma_t F_t^2 + (\lambda_t - \gamma_t) u_t \]

\[ = s_t^{32}. \]

Consequences for cross rate:

\[ ds_t^{32} = (\gamma_t - \lambda_t) dF_t^1 + \lambda_t dF_t^3 - \gamma_t dF_t^2 + (\lambda_t - \gamma_t) du_t \]
Behavioural model

Correlations:

\[
corr^t(s^{12}, s^{13}) = \frac{\gamma \lambda \cdot \text{cov}(F^{12}, F^{13}) + (1 - \gamma)(1 - \lambda)\text{var}(u)}{\sqrt{(\gamma^2 \cdot \text{var}(F^{12}) + (1 - \gamma)^2 \text{var}(u)) \cdot (\lambda^2 \cdot \text{var}(F^{13}) + (1 - \lambda)^2 \text{var}(u))}}.
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Empirical Analysis
Strategy

**Strategy:**

- Estimation of time-dependent correlations between exchange rates (true correlations), i.e. $\text{corr}(s_{12}^t, s_{13}^t)$

- Estimation of time-dependent correlations between fundamentals (benchmark correlations), i.e. $\text{corr}(F_{12}^t, F_{13}^t)$

  Required: benchmark models

  - estimating fundamental benchmark models
  - using results to construct a fundamental process

- Comparison of true correlations with benchmark correlations

  $\Rightarrow$ excess comovements: $\text{corr}(s_{12}^t, s_{13}^t) > \text{corr}(F_{12}^t, F_{13}^t)$
Motivation
Benchmark model
Behavioural Model
Empirical Analysis
Conclusion

Empirical Analysis

Strategy

Estimation technique:

→ dynamic conditional correlation GARCH model (DCC-GARCH) by Engle (JBES 2002)

two step procedure to estimate conditional correlations

first step: estimation of conditional variances (univariate GARCH model)
second step: estimation of conditional covariances to obtain conditional correlations
Empirical Analysis

Data

Data - exchange rates:

- purely flexible exchange rates: Euro/ US dollar and Pound Sterling/ US dollar
- weekly data, Wednesday closing rates
- taken from Datastream

Data - fundamentals:

- January 1986 till January 2008
- monthly data
- taken from International Financial Statistics, IMF
Empirical Analysis
Benchmark models

Relative purchasing power parity:

\[ \Delta s_t = \pi_t - \pi_t^f \]

\( \pi \) rate of inflation; superscript \( f \) for foreign variables
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\[ \Delta s_t = \pi_t - \pi_t^f \]
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**Real interest rate differential model** (Frankel, AER 1979):
\[ \Delta s_t = \alpha + \beta_1 \Delta (m_t - m_t^f) + \beta_2 \Delta (y_t - y_t^f) + \beta_3 \Delta (i_{s,t} - i_{s,f}) + \beta_4 \Delta (i_{l,t} - i_{l,f}) \]

\( m \) money supply, \( y \) real income, \( i_{s,t} \) short-term and \( i_{l,t} \) long-term interest rates; superscript \( f \) for foreign variables
Empirical Analysis

Benchmark models

Relative purchasing power parity:

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$m$ money supply, $y$ real income, $i_{s,t}$ short-term and $i_{l,t}$ long-term interest rates; superscript $f$ for foreign variables

Differences in real business cycles:

$$\Delta s_t = ybc_t^f - ybc_t$$

$ybc$ real business cycle component obtained by HP-filter; superscript $f$ for foreign variables

Reasons for the use of differences in real business cycles

- measure for similarities of economies (real side)
- measure for relative profit opportunities (proxy for portfolio flows)
Empirical Analysis
Correlations of differences in inflation rates vs. true correlations

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Excess comovements in the fx market • 2. FIW-Forschungskonferenz ‘International Economics’
Empirical Analysis
Correlations obtained by fundamental model vs. true correlations

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Empirical Analysis
Correlations of differences in business cycles vs. true correlations

Excess comovements in the fx market
Empirical Analysis

Comparison of true and benchmark correlations
Conclusion

Theoretical results:
- impact of common sentiments (in exchange rates denominated in the same currency) on cross rate
- fundamentals of a different country impact the cross rate, i.e., external competitiveness of a country depends on other markets
- various sources of excess comovements, but linked to noise traders

Empirical results:
- evidence in favour of excess comovements between EUR/USD and GBP/USD
- but: different fundamental models provide different conclusions
- correlations of (nominal) exchange rates close to correlations of differences in business cycles

Implications:
- factors of a different exchange rate can help explain exchange rate, i.e., consideration of spill over effects in fundamental models
- in order to evaluate excess comovements correctly, need to specify a more precise fundamental model
Thank you for your attention!
**Empirical Analysis**

**DCC-GARCH - variance part**

**Mean equation:**

\[ r_t = \mu + \varepsilon_t \]

(1)

\[ \varepsilon_t | \Phi_{t-1} \sim N(\mu_t, H_t) \]

(2)

$r_t$ a \((N \times 1)\) vector of time series with $\mu_t$ as vector of means, $\varepsilon_t$ as vector of residuals and $\Phi_{t-1}$ as the information set available at time \((t-1)\), $H_t$ the covariance matrix.

**Covariance matrix:**

\[ H_t = D_t R_t D_t. \]

(3)

$D_t$ an \(N \times N\) diagonal matrix of time-varying standard deviations, $R_t$ an \(N \times N\) matrix of time-varying correlations

**Conditional variances:**

\[ h_{i,t} = \omega_i + \sum_{p=1}^{P_i} \alpha_i \varepsilon_{i,t-p}^2 + \sum_{q=1}^{Q_i} \beta_i h_{i,t-q}^2 \]

(4)

$\omega_i$ the mean variance, $\alpha$ and $\beta$ the coefficients for $i = 1,2,...,N$
Empirical Analysis
DCC-GARCH - correlation part

**Correlation matrix:**

\[ R_t = Q_t^{*-1} Q_t Q_t^{*-1}. \]  \hspace{1cm} (5)

\( Q_t^* \) a diagonal matrix of variances' square roots

**Covariance process:**

\[ Q_t = (1 - a - b) Q + a z_{t-1} z_{t-1}' + b Q_{t-1} \]  \hspace{1cm} (6)

\( Q \) as the unconditional covariances (\( E(z_t z_t') \)) of the standardized residuals \( z_{i,t} = \frac{\varepsilon_{i,t}}{\sqrt{h_{i,t}}} \)

**Correlation estimator:**

\[ \rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t} q_{jj,t}}} \quad \text{with} \quad i \neq j \]  \hspace{1cm} (7)
Empirical Analysis

Markov Switching RID

<table>
<thead>
<tr>
<th>Regime 1</th>
<th>EUR/USD</th>
<th>GBP/USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>(-0.173^{***}) (0.000)</td>
<td>(-0.104^{***}) (0.000)</td>
</tr>
<tr>
<td>(\Delta(m_t - m^f_t))</td>
<td>(1.020^{***}) (0.000)</td>
<td>(0.210^{***}) (0.000)</td>
</tr>
<tr>
<td>(\Delta(y_t - y^f_t))</td>
<td>(-1.075^{***}) (0.000)</td>
<td>(-0.103) (0.817)</td>
</tr>
<tr>
<td>(\Delta(i_{s,t} - i^f_{s,t}))</td>
<td>(0.012^{***}) (0.000)</td>
<td>(0.003) (0.376)</td>
</tr>
<tr>
<td>(\Delta(i_{l,t} - i^f_{l,t}))</td>
<td>(-0.051^{***}) (0.000)</td>
<td>(0.006) (0.294)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regime 2</th>
<th>EUR/USD</th>
<th>GBP/USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>(0.052^{***}) (0.000)</td>
<td>(0.067^{***}) (0.000)</td>
</tr>
<tr>
<td>(\Delta(m_t - m^f_t))</td>
<td>(0.504^{***}) (0.001)</td>
<td>(-0.320^{***}) (0.000)</td>
</tr>
<tr>
<td>(\Delta(y_t - y^f_t))</td>
<td>(-0.312) (0.236)</td>
<td>(0.400) (0.108)</td>
</tr>
<tr>
<td>(\Delta(i_{s,t} - i^f_{s,t}))</td>
<td>(0.002) (0.698)</td>
<td>(-0.019^{***}) (0.000)</td>
</tr>
<tr>
<td>(\Delta(i_{l,t} - i^f_{l,t}))</td>
<td>(-0.027^{**}) (0.044)</td>
<td>(0.038^{***}) (0.000)</td>
</tr>
</tbody>
</table>

\(p_{11}\) | \(0.964^{***}\) (0.000) | \(0.956^{***}\) (0.000) |
\(p_{22}\) | \(0.938^{***}\) (0.000) | \(0.957^{***}\) (0.000) |

Log-likelihood | 348.194 | 369.26 |

Note: Asteriks *, ** and *** denote the rejection of the null hypothesis at the 10%, 5% and 1% level. Newey-West robust standard errors are used. \(p\)-values in brackets. Superscript the foreign fundamentals.
Empirical Analysis
Conditional correlations for exchange rates
Empirical Analysis
Smoothed probabilities

(a) EUR/USD

(b) GBP/USD
**Behavioural model**

**Correlations:**

\[
corr^t(s^{12}, s^{13}) = \frac{\gamma \lambda \cdot \text{cov}(F^{12}, F^{13}) + (1 - \gamma)(1 - \lambda) \cdot \text{var}(u)}{\sqrt{(\gamma^2 \cdot \text{var}(F^{12}) + (1 - \gamma)^2 \cdot \text{var}(u)) \cdot (\lambda^2 \cdot \text{var}(F^{13}) + (1 - \lambda)^2 \cdot \text{var}(u))}}.
\]

Excess correlations depend on:
- variation of sentiments
- variation of fundamentals
- covariation of fundamentals
- weights of fundamentalists in both markets

Figure: Fundamental and behavioural correlations with different shares of fundamentalists both market (\(\text{cov}(F^{12}, F^{13}) = 0.5\)).
Stylized facts - common factors in the short run:

- investigation of volatility directed to information processing in the short run (e.g. Engle/Ito/Lin, *Econometrica* 1990)
- common volatility patterns among exchange rates (e.g. Diebold/Nerlove, *JAE* 1989; Bollerslev, *RES* 1990)
- explanatory power from order flows of a different exchange rate, "informational integration" (Evans/Lyons, *JIMF* 2002)

⇒ informational linkages across markets **with room for non-fundamentals**
Stylized facts-common factors in the medium and long run:

- application of cointegration analysis on exchange rates
- tests for market efficiency (e.g. Hakkio/Rush, JIMF 1989; Baillie/Bollerslev, JoF 1989) and stability of exchange rate systems (e.g. Norrbin, AE 1996; Haug/MacKinnon/Michelis, JIMF 2000)

**long-run comovements** only for EMS currencies in US dollar before introduction of the Euro but for **Australian dollar** and **Pound Sterling** in US dollar to **Euro/US dollar** since introduction of the Euro (Kühl, 2007)

- prices of asset cointegrated if fundamentals cointegrated (Lence/Falk, JIMF 2005)

- for Euro/US dollar and Pound Sterling/ US dollar: evidence in favour of cointegrated fundamentals but **room for non-fundamental factors** (Kühl, 2008)

- **time-varying comovements of exchange rates** (Engle, JBES 2002; Tse/Tsui, JBES 2002; Van Dijk/Munandar/Hafner, 2005)