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

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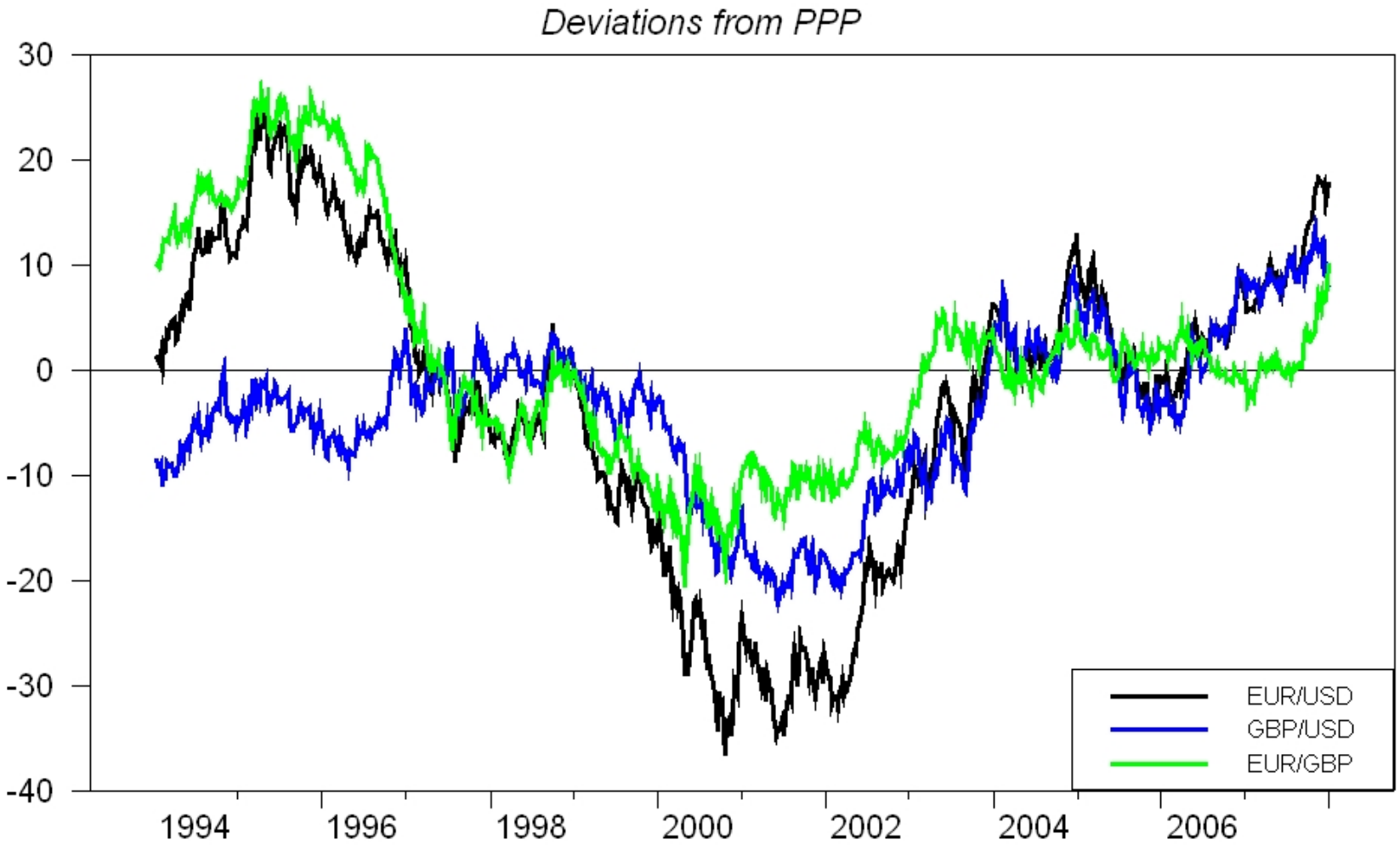
Motivation
Stylized facts (1)

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



Motivation
Stylized facts (2)

Stylized facts - common factors in the short run:

- volatility spillovers between **DEM/ US dollar** and **Yen/ US dollar** (Hong, *JoE* 2001) causality from **DEM/US dollar** and between **Euro(DEM)/ US dollar** and **Pound Sterling/ US dollar** (Brooks/Hinich, *JEF* 1999; Inagaki, *RIBF* 2007), causality from **Euro(DEM)/US dollar** $\rightarrow$ Euro(DEM)/ US dollar as a source of information
- 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**

Motivation
Building blocks

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

$\Rightarrow$ 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?

Outline

Proceeding:

Benchmark model
Triangular framework

Triangular framework:

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

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

$$S_t^{12}/S_t^{13} = S_t^{32} \quad \text{or in logs} \quad s_t^{12} - s_t^{13} = s_t^{32}$$

Fundamental processes:

$$s_t^{ij} = F_t^{ij} = F_t^i - F_t^j \quad \text{with} \quad i \neq j$$

Benchmark model
Triangular framework (2)

Exchange rate determination in a rational expectation benchmark case:

$$s_t^{12} - s_t^{13} = F_t^{12} - F_t^{13} = (F_t^1 - F_t^2) - (F_t^1 - F_t^3) = F_t^3 - F_t^2 = s_t^{32}$$

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Correlations between exchange rates:

(based upon the same denomination currency)

$$\begin{aligned} corr^*(s^{12}, s^{13}) &= \frac{cov(s^{12}, s^{13})}{\sqrt{var(s^{12}) \cdot var(s^{13})}} \\ &= \frac{cov(F^{12}, F^{13})}{\sqrt{var(F^{12}) \cdot var(F^{13})}} \end{aligned}$$

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$$= \frac{cov(F^{12}, F^{13})}{\sqrt{var(F^{12}) \cdot var(F^{13})}}$$

$$= \frac{var(F^1) - cov(F^1, F^3) - cov(F^2, F^1) + cov(F^2, F^3)}{\sqrt{(var(F^1) - 2 \cdot cov(F^1, F^2) + var(F^2)) \cdot (var(F^1) - 2 \cdot cov(F^1, F^3) + var(F^3))}}$$

$$\partial corr / \partial cov(F^{12}, F^{13}) > 0; \partial corr / \partial cov(F^2, F^3) > 0;$$

$$\partial corr / \partial cov(F^1, F^2) < 0; \partial corr / \partial cov(F^1, F^3) < 0; \partial corr / \partial var(F^1) > 0$$

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):

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

Fundamentalists' expectation process:

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

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

$$s_t^{b1j} = u_t + \varepsilon_t^{1j}$$

Behavioural model
Triangular framework

Exchange rate determination processes:

$$s_t^{12} = \gamma_t F_t^{12} + (1-\gamma_t) u_t + e_t^{12} \quad \text{and} \quad s_t^{13} = \lambda_t F_t^{13} + (1-\lambda_t) u_t + e_t^{13}$$

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Triangular framwork:

$$\begin{aligned} s_t^{12} - s_t^{13} &= \gamma_t F_t^{12} + (1-\gamma_t)u_t - \lambda_t F_t^{13} - (1-\lambda_t)u_t \\ &= \gamma_t (F_t^1 - F_t^2) + (1-\gamma_t)u_t - \lambda_t (F_t^1 - F_t^3) - (1-\lambda_t)u_t \\ &= (\gamma_t - \lambda_t)F_t^1 + \lambda_t F_t^3 - \gamma_t F_t^2 + (\lambda_t - \gamma_t)u_t \\ &= s_t^{32}. \end{aligned}$$

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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:

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

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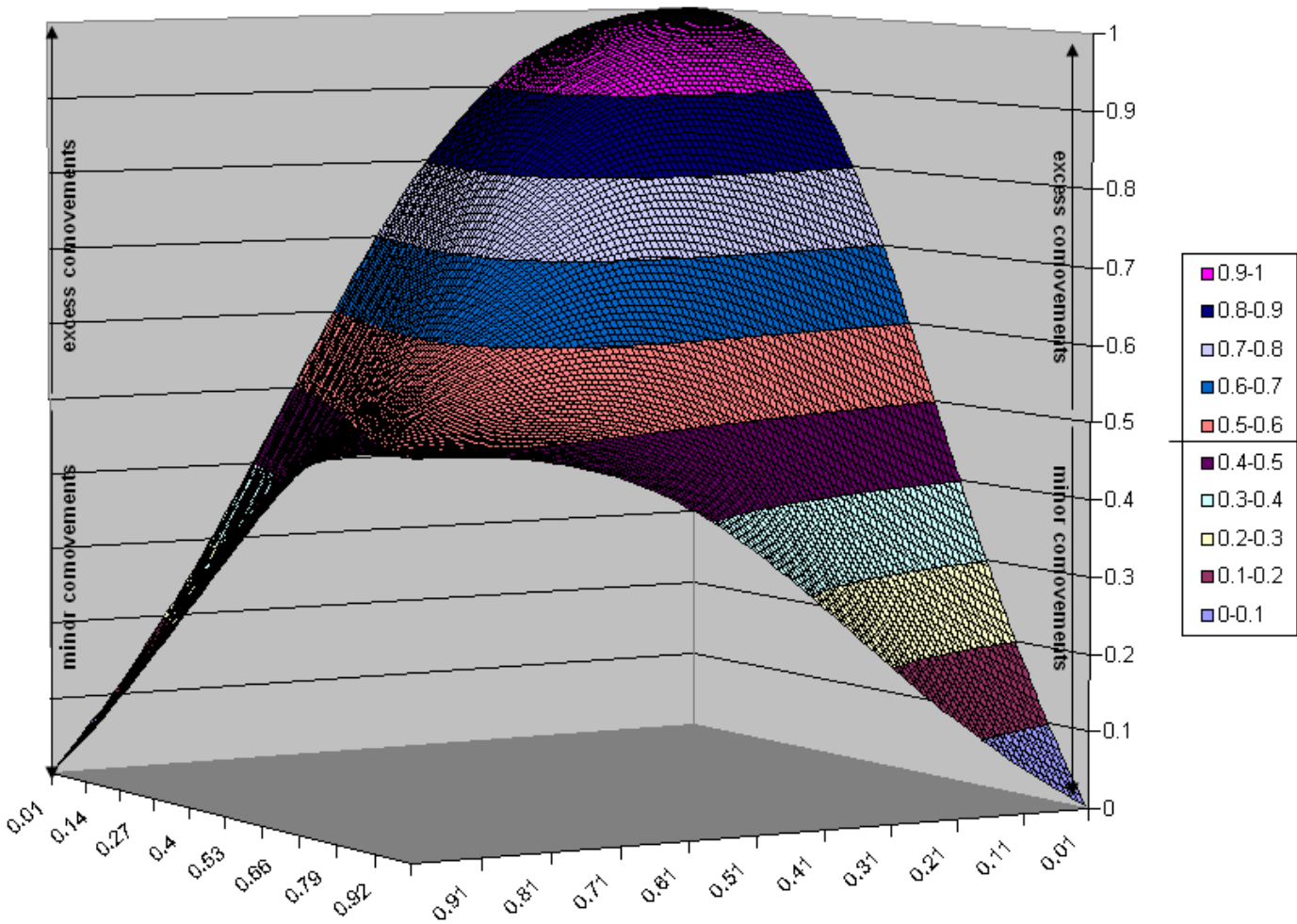

Figure: Fundamental and behavioural correlations with different shares of fundamentalists in both market ($cov(F^{12}, F^{13} = 0.5)$)

Empirical Analysis
Strategy

Strategy:

- Estimation of time-dependent correlations between exchange rates (true correlations), i.e. $corr(s_t^{12}, s_t^{13})$
- Estimation of time-dependent correlations between fundamentals (benchmark correlations), i.e. $corr(F_t^{12}, F_t^{13})$
  Required: benchmark models
  - estimating fundamental benchmark models
  - using results to construct a fundamental process
- comparison of true correlations with benchmark correlations
  $\Rightarrow$ excess comovements: $corr(s_t^{12}, s_t^{13}) > corr(F_t^{12}, F_t^{13})$

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Estimation technique:

- $\rightarrow$ 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
- January 1994 till January 2008
- 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:

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

π rate of inflation; superscript f for foreign variables

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Benchmark models

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Real interest rate differential model (Frankel, *AER* 1979) :

$$\Delta s_t = \alpha + \beta_1 \Delta(m_t - m_t^f) + \beta_2 \Delta(y_t - y_t^f) + \beta_3 \Delta(i_{s,t} - i_{s,t}^f) + \beta_4 \Delta(i_{l,t} - i_{l,t}^f)$$

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

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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 :

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

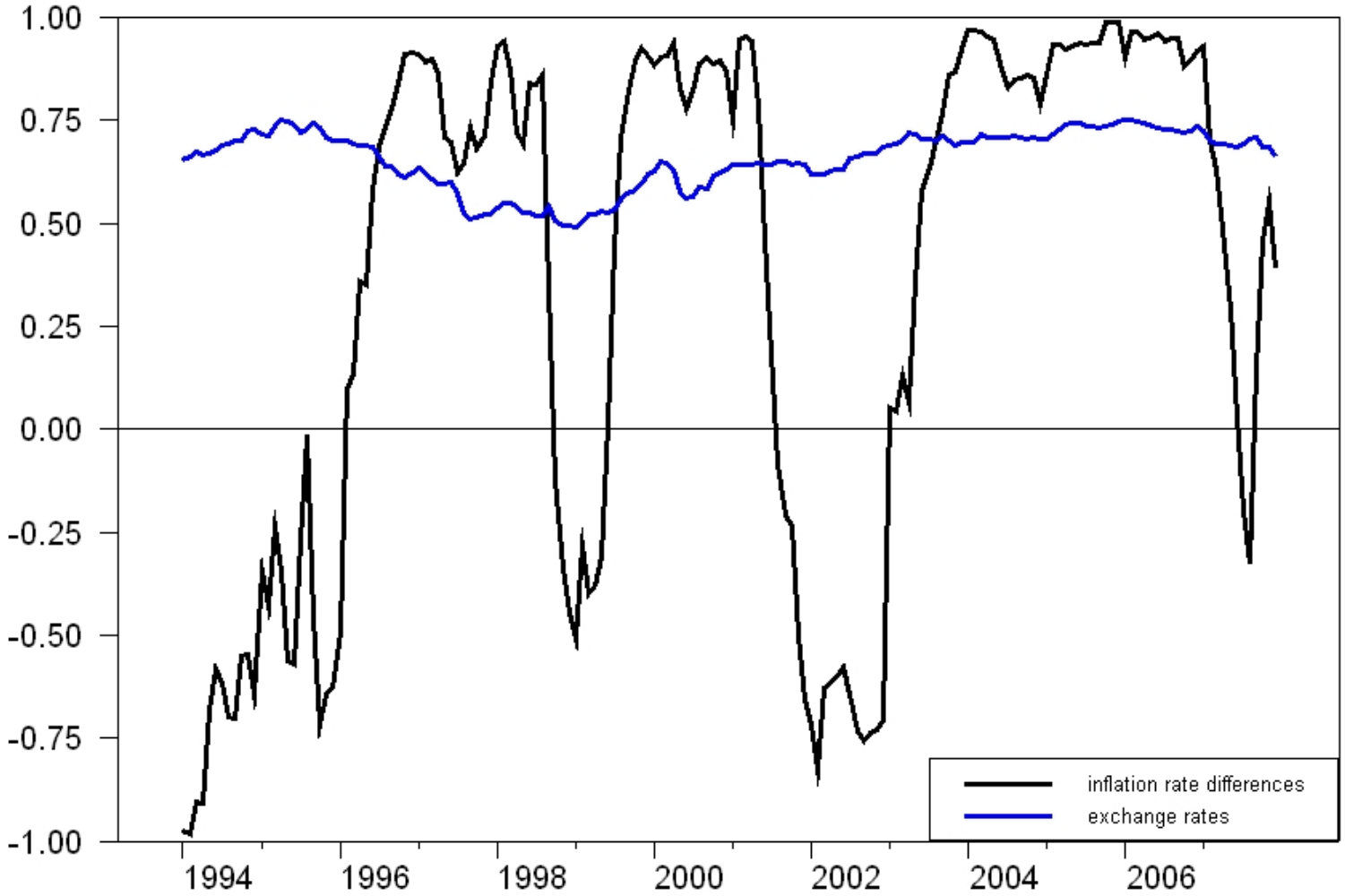
ybc real business cycle component obtained by HP-filter; superscript f for foreign variables

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)

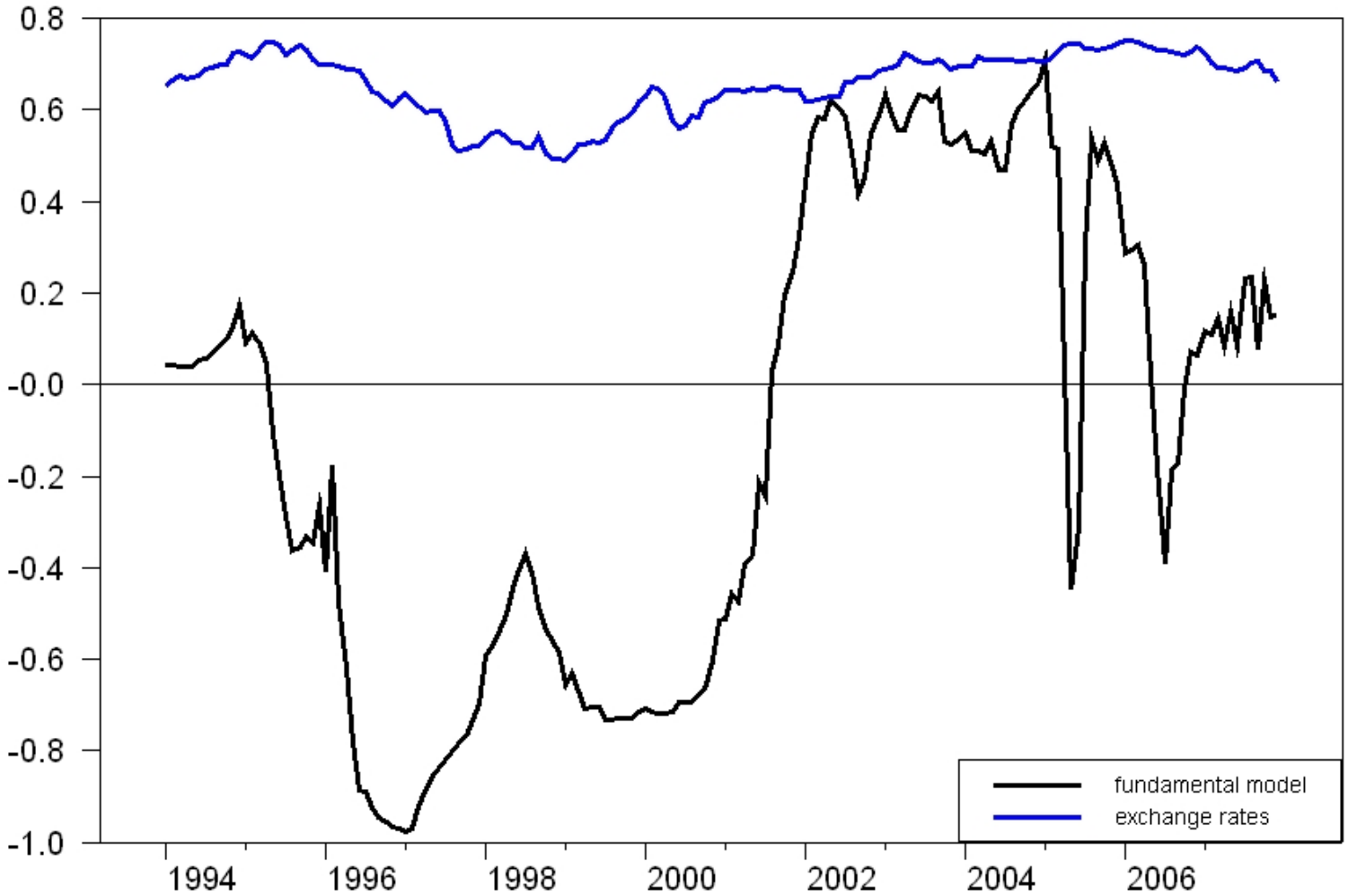
Empirical Analysis

Correlations of differences in inflation rates vs. true correlations



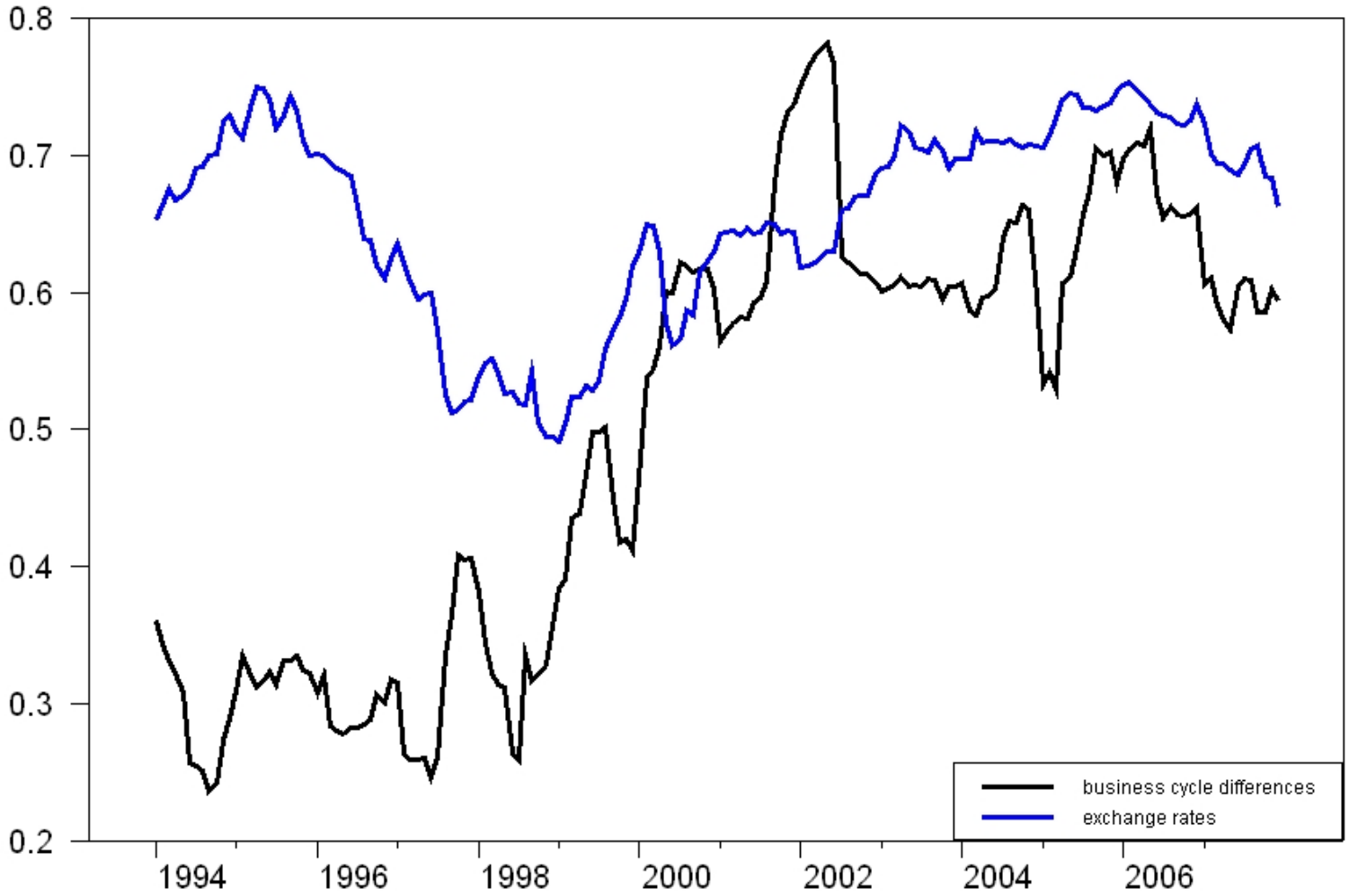
Empirical Analysis

Correlations obtained by fundamental model vs. true correlations



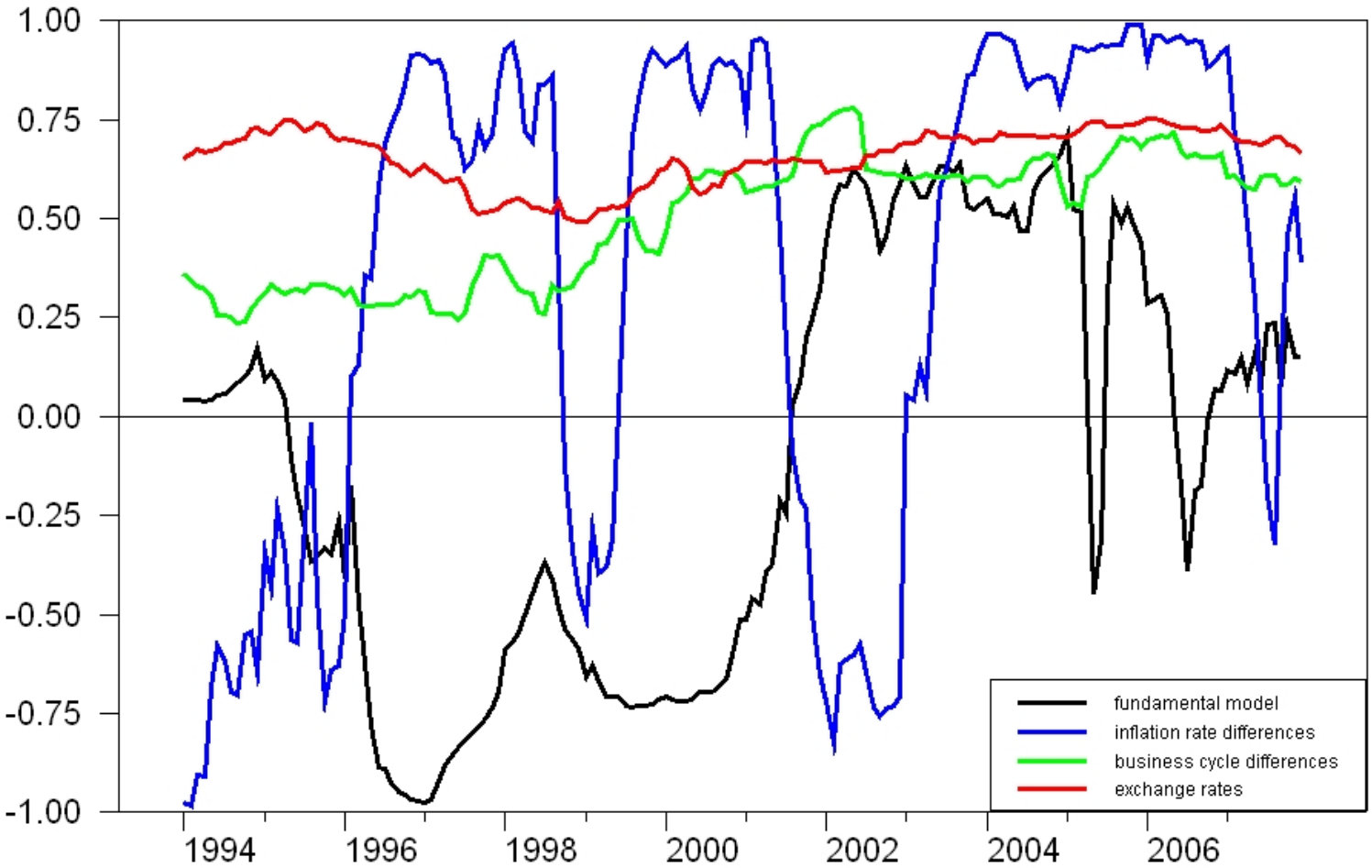
Empirical Analysis

Correlations of differences in business cycles vs. true correlations



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:

$$r_t = \mu + \varepsilon_t \tag{1}$$

$$\varepsilon_t | \Phi_{t-1} \sim N(\mu_t, H_t) \tag{2}$$

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

Covariance matrix:

$$H_t = D_t R_t D_t. \tag{3}$$

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:

$$h_{i,t} = \omega_i + \sum_{p=1}^{P_i} \alpha_i \varepsilon_{i,t-p}^2 + \sum_{q=1}^{Q_i} \beta_i h_{i,t-q}^2 \tag{4}$$

ω_i the mean variance, α and β the coefficients for $i = 1, 2, ..., N$

Empirical Analysis
DCC-GARCH - correlation part

Correlation matrix:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1}. \tag{5}$$

Q_t^* a diagonal matrix of variances' square roots

Covariance process:

$$Q_t = (1 - a - b)\overline{Q} + a z_{t-1} z_{t-1}' + b Q_{t-1} \tag{6}$$

$\overline{Q}$ 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:

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t} q_{jj,t}}} \quad \text{with} \quad i \neq j \tag{7}$$

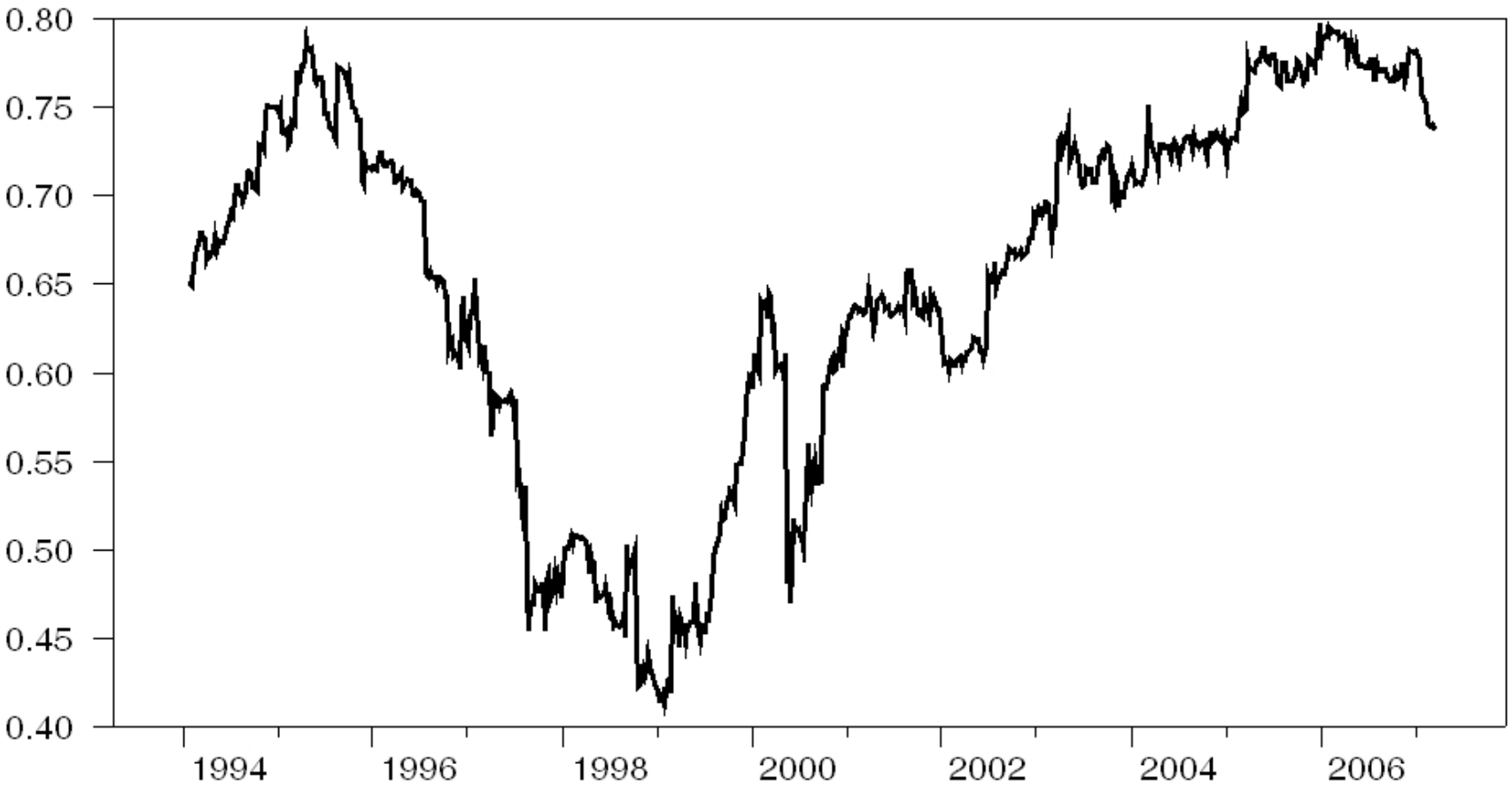
Empirical Analysis
Markov Switching RID

	EUR/USD		GBP/USD	
Regime 1				
constant	-0.173***	(0.000)	-0.104***	(0.000)
$\Delta(m_t - m_t^f)$	1.020***	(0.000)	0.210***	(0.000)
$\Delta(y_t - y_t^f)$	-1.075***	(0.000)	-0.103	(0.817)
$\Delta(i_{s,t} - i_{s,t}^f)$	0.012***	(0.000)	0.003	(0.376)
$\Delta(i_{l,t} - i_{l,t}^f)$	-0.051***	(0.000)	0.006	(0.294)
Regime 2				
constant	0.052***	(0.000)	0.067***	(0.000)
$\Delta(m_t - m_t^f)$	0.504***	(0.001)	-0.320***	(0.000)
$\Delta(y_t - y_t^f)$	-0.312	(0.236)	0.400	(0.108)
$\Delta(i_{s,t} - i_{s,t}^f)$	0.002	(0.698)	-0.019***	(0.000)
$\Delta(i_{l,t} - i_{l,t}^f)$	-0.027**	(0.044)	0.038***	(0.000)
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	

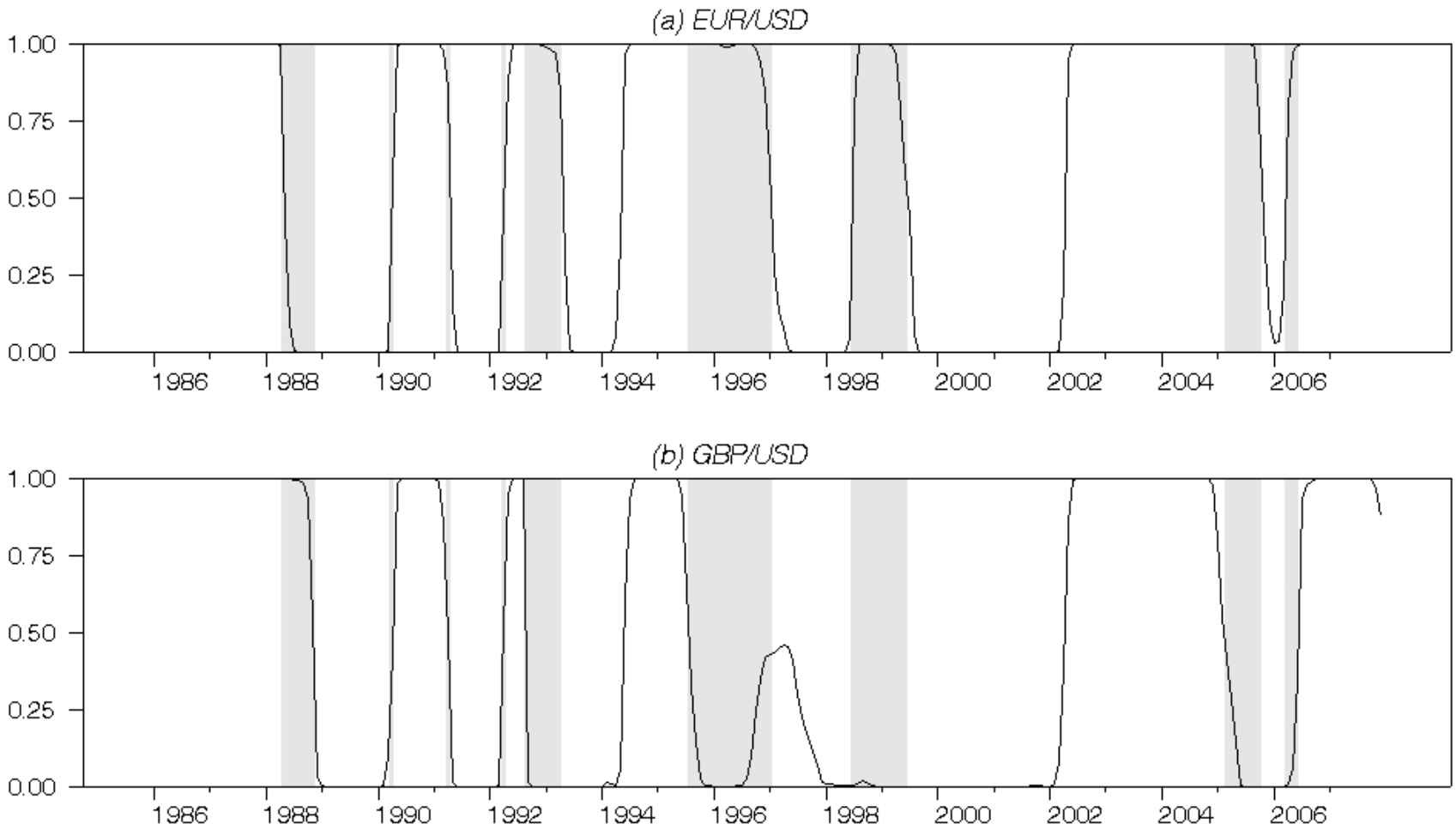
Note: Asteriks *, ** and *** denote the rejection of the null hypothesis at the 10%, 5% and 1% level. Newey-West robust standard errors are used. p-values in brackets. Superscript the foreign fundamentals.

Empirical Analysis

Conditional correlations for exchange rates



Empirical Analysis
Smoothed probabilities



Behavioural model

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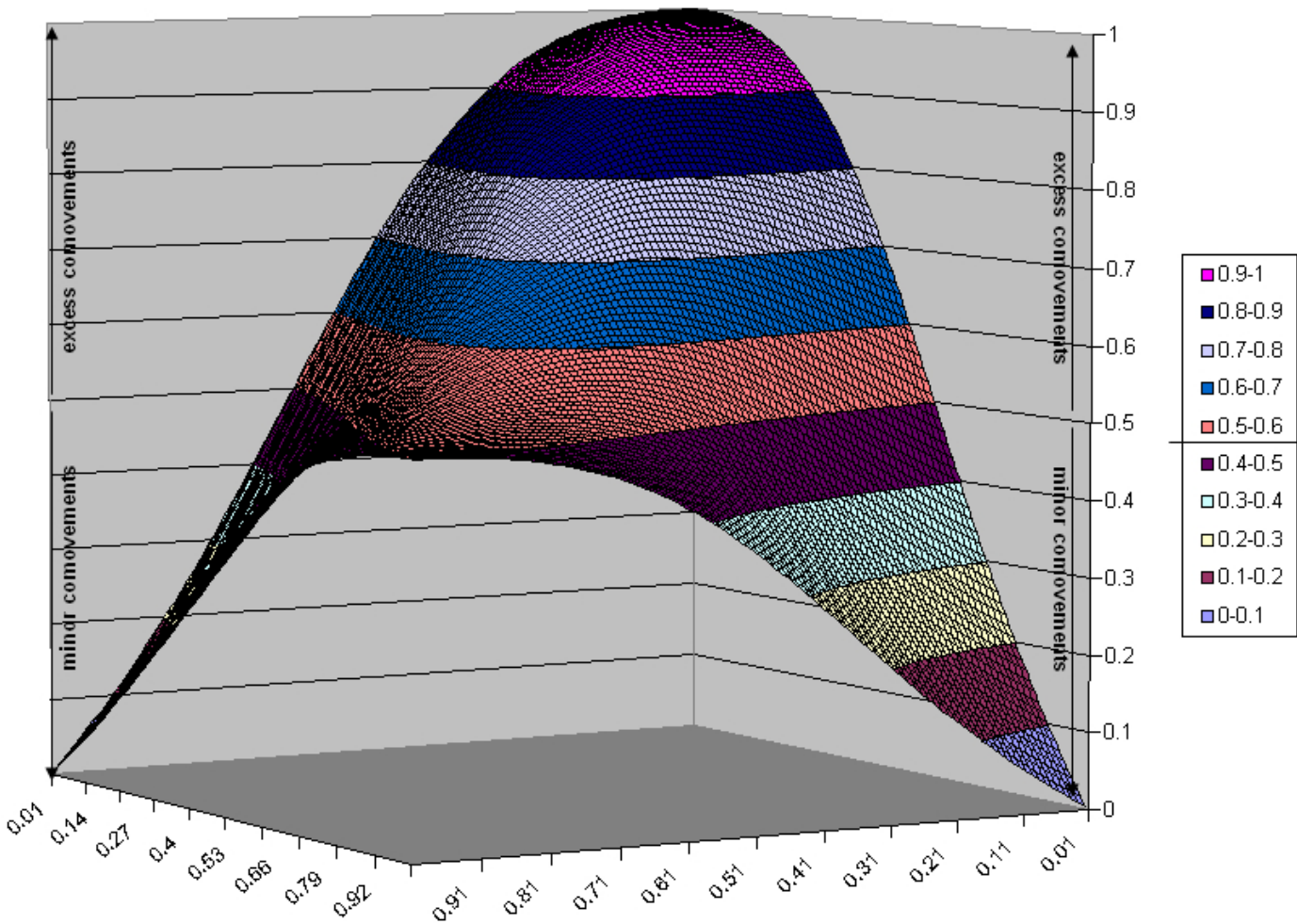

Excess correlations depend on

- variation of sentiments
- variation of fundamentals
- covariation of fundamentals
- weights of fundamentalists in both markets

Motivation
Stylized facts (2)

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)
- volatility spillovers between **DEM/ US dollar** and **Yen/ US dollar** (Hong, *JoE* 2001) causality from **DEM/US dollar** and between **Euro(DEM)/ US dollar** and **Pound Sterling/ US dollar** (Brooks/Hinich, *JEF* 1999; Inagaki, *RIBF* 2007), causality from **Euro(DEM)/US dollar** $\rightarrow$ Euro(DEM)/ US dollar as a source of information
- explanatory power from order flows of a different exchange rate, "informational integration" (Evans/Lyons, *JIMF* 2002)

$\Rightarrow$ informational linkages across markets **with room for non-fundamentals**

Motivation
Stylized facts (3)

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)