Explaining the Euro Exchange Rate: The Role of Policy Uncertainty, Asymmetric Information and Hedging Opportunities

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BACKGROUND

1998: USD, 87% of FX transactions
      EUR legacy currencies 53%

2001: USD, 90%
      EUR, 38%

Hau, Killeen, Moore:
  • avg daily volume compared to DEM
    o 9% lower for USD/EUR
    o 44% lower for JPY/EUR
    o 25% lower for CHF/EUR
  • EUR has wider spreads than DEM
    o may explain role of EUR

Questions:
  • Why would EUR have wider spreads?
  • What is role of ECB in demand for EUR?
  • Has market “learned” about EUR?
FX TRADING PRE- AND POST-EURO

Model with marketmakers, informed traders, and uninformed traders

Pre-euro

3 currencies: dollar (A), mark (G), and franc (F)

Marketmaker for each currency pair: AG, AF, FG
Timing:

- **period 1:**
  - market maker AG quotes spread about midprice $P_{AG}^M$
  - informed and uninformed submit demands
  - temporary inventory imbalance for marketmaker

- **period 2:**
  - trading occurs in AF & FG
  - marketmakers quote spreads about $P_{AF}^M$ and $P_{FG}^M$
  - marketmaker AG shares inventory imbalance with AF & FG

- **period 3:**
  - inventories liquidated at prices
    \[ P_{AG}^L = P_{AG}^M + \varepsilon_G \]
    \[ P_{AF}^L = P_{AF}^M + \frac{\varepsilon_G}{P_{FG}^M} \]
    \[ P_{FG}^L = P_{FG}^M \]
  - pre-euro shocks to liquidation prices come from G central bank
  - fixed exchange rate for FG, F & G in currency union
Marketmaker AG receives orders
  - \(O^I\) from informed and \(O^U\) from uninformed
  \[O^I(s) = f(s)\chi^I\]
  \[O^U(s) = f(s)\chi^U\]
  - \(\chi^I\) and \(\chi^U\) assumed iid
  - can take –1 or 1 (sell or buy) with prob 1/2
  - \(f(s) > 0\) continuous and decreasing in spread \(s\)
  - uninformed have no info on innovation \(\varepsilon\)
    but respond to spread changes
  - informed orders contain information about \(\varepsilon\)
    \[\text{Cov}(\chi^I, \varepsilon) = \gamma^G > 0\]

Marketmaker cannot identify trader types
  - manage risk by AF trades since FG is has fixed exchange rate
Marketmaker utility

\[ U(\Pi_i) = E(\Pi_i) - \frac{1}{2} \rho \text{Var}(\Pi_i) \]

for \( i = AG, AF, FG \).

Expected profit has 2 components:
- normal profit for providing liquidity: the spread
  \[ E(\Pi^S_{AG}) = s/2 \ E[(1-h)(|O^I| + |O^U|)] = (1-h)sf(s) \]
- loss from providing quotes to informed
  \[ E(\Pi^L_{AG}) = -E[(1-h)(|O^I| + |O^U|)\varepsilon_G] = -(1-h)f(s)\gamma^G \]
For profit variance:
- total order flow can take 3 values

\[ |O^I| + |O^U| = \begin{cases} 
2f(s) & \text{prob} = 1/4 \\
0 & \text{prob} = 1/2 \\
-2f(s) & \text{prob} = 1/4 
\end{cases} \]

- calculate uncond. var. as weighted avg of conditional variance

\[
Var(P_{AG}^L) = \frac{1}{4} Var\left[2(1-h)f(s)\epsilon_g\right] + \frac{1}{4} Var\left[-2(1-h)f(s)\epsilon_g\right]
\]

\[
= (1-h)^2 f(s)^2 \sigma_{\epsilon_g}^2 + (1-h)^2 f(s)^2 \sigma_{\epsilon_g}^2
\]

\[
= 2(1-h)^2 f(s)^2 \sigma_{\epsilon_g}^2
\]

Marketmaker utility:

\[
U(P_{AG}) = (1-h)sf(s) - (1-h)f(s)\gamma^G - \rho(1-h)^2 f(s)^2 \sigma_{\epsilon_g}^2
\]

Pre-euro spread:

\[
s^G = \gamma^G + \rho(1-h)f(s^G)\sigma_{\epsilon_g}^2
\]
Euro period

now 2 currencies: A & E
  o marketmakers AG & AF not trade AE
  o no hedging opportunities (h=0)
  o both AE dealers observe inventory shock

shock to liquidation prices from E central bank

Same approach as before:

\[
\begin{align*}
E\left(\Pi_{AE}^S\right) &= \frac{S}{2} \ E\left(|O^I| + |O^U|\right) = sf(s) \\
E\left(\Pi_{AE}^L\right) &= -E\left[\left(|O^I| + |O^U|\right)\varepsilon_E\right] = -\gamma^E f(s) \\
Var\left(\Pi_{AE}^L\right) &= Var\left[\left(|O^I| + |O^U|\right)\varepsilon_E\right] = 2f(s)^2 \sigma_{\varepsilon_E}^2 \\
U\left(\Pi_{AE}\right) &= sf(s) - \gamma^E f(s) - \rho f(s)^2 \sigma_{\varepsilon_E}^2 \\
s^E &= \gamma^E + \rho \left(s^E\right) \sigma_{\varepsilon_E}^2
\end{align*}
\]
Pre-euro versus euro period

for $\gamma^E = \gamma^G$ and $\sigma_{\varepsilon_E}^2 = \sigma_{\varepsilon_G}^2$ pre-euro spread < euro spread

- due to lack of hedging opportunities and exposure to inventory risk

$$\gamma^E + \rho f(s^E)\sigma_{\varepsilon_E}^2 > \gamma^G + \rho (1-h) f(s^G)\sigma_{\varepsilon_G}^2$$

with no hedging ($h-\theta$) anytime, still get greater pre-euro spread if

- ($\gamma^E > \gamma^G$)
  - more leaks from ECB?
  - multinational board
  - tips to home govt or institutions?

- ($\sigma_{\varepsilon_E}^2 > \sigma_{\varepsilon_G}^2$)
  - no prior info on ECB policymaking
  - wider range of potential policy actions
Empirical Evidence on Spreads

Data: Reuters indicative quotes
   - EUR 1999
   - DEM 1994
   - 8:00-17:00 GMT
   - Table 1 descriptive stats
     - volatility about the same
     - USD/EUR spread level about twice USD/DEM
     - percentage spread about the same
   - Table 2 spread started high in 1999 and then fell
   - Figure 1 daily spreads fall in levels not percentage

Buba, Fed, and ECB meeting days
   - ECB changed rates 2 times in 1999
   - Buba changed rates 8 times in 1994
   - Fed changed rates 6 times in 1999
   - volatility peaks greater for ECB than Buba
   - evidence of market anticipating first ECB change
   - no anticipation for Buba
   - Fed volatility comparable to ECB
   - Fed evidence of market anticipation
Exchange Rate Level

Focus on ECB credibility and learning
  - did inflation process change?

Assume exchange rate changes due to inflation differential between Europe and US and stochastic shock
  - pre-euro: \( P_{AG}^L = P_{AG}^M + \varphi_o + \eta_G \)
  - euro: \( P_{AE}^L = P_{AE}^M + \varphi_n + \eta_E \)

old inflation process: \( \varphi_{o,t} = \delta_o + \xi_{o,t} \)
  - 1990-93 monthly inflation mean = 0.00334, variance=0.000015

new inflation process: \( \varphi_{n,t} = \delta_n + \xi_{n,t} \)
  - 2% max. or monthly mean = 0.00166
\( P_{n,t} \) probability that process changed from \( \delta_o \) to \( \delta_i \)

\( P_{o,t} \) probability that inflation process not changed

Observe inflation rate each month and update according to Bayes’ law:

\[
\frac{P_{n,t}}{P_{o,t}} = \frac{P_{n,t-k} \cdot f(\varphi_t, \ldots, \varphi_{t-k} \mid \delta_n)}{P_{o,t-k} \cdot f(\varphi_t, \ldots, \varphi_{t-k} \mid \delta_o)}
\]

Exchange rate function of learning process

Since probabilities recursive function of likelihood ratios, can pick a probability at any point in time and iterate back or forward to create unique path of probabilities

- rather than guess initial probability in Jan. 1999, assume market knows new process exists by July 2002 (3.5 years sufficient to learn about ECB)

Calculate backwards according to:

\[
\frac{P_{n,t-k}}{P_{o,t-k}} = \frac{P_{n,t} \cdot f(\varphi_t, \ldots, \varphi_{t-k} \mid \delta_n)}{P_{o,t} \cdot f(\varphi_t, \ldots, \varphi_{t-k} \mid \delta_o)}
\]
Constructing probabilities
  o “old” process taken as pre-EMI mean and variance
  o “new” process taken as 2% mean and variance from Jan. 1999 to June 2002

Table 3 estimated probabilities
  o less than 1% prob. until Dec. 1999
  o by Nov. 2000 market convinced with prob. of 62% that inflation governed by new process
    o never drops below 50% again

Figure 3 estimated probabilities and exchange rates
Learning and the Euro Exchange Rate

Can monthly change in probability of new inflation process explain euro exchange rate?

Estimate $\Delta \log E = a + b\Delta PROB$
- USD/EUR, GBP/EUR, JPY/EUR
- regime shift in Nov. 2000
- Table 4
- USD and JPY indicate shift in structure in Nov. 2000
- estimates imply 10% increase in $\Delta PROB$ from Nov. 2000 associated with depreciation against EUR of
  - 1.4% for USD
  - 0.95% for GBP
  - 2.61% for JPY
CONCLUSION

Theory identifies 3 determinants of spread:
   o policy uncertainty
   o informed traders with prior knowledge
   o reduced hedging opportunities

Spread was higher at first but then fell
   o evidence weaker for % spreads

Weak evidence of info leakage during ECB meetings
   o info asymmetry as result of ECB unlikely

Evidence suggests market learns about ECB policymaking process by November 2000

Increases in probability of new inflation process associated with EUR appreciation
### Table 1

**DESCRIPTIVE STATISTICS FOR THE MARK AND THE EURO**

#### 1.a. Level of the exchange rate

<table>
<thead>
<tr>
<th></th>
<th>Dollar/DM</th>
<th>Dollar/Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.61578</td>
<td>1.06114</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.67310</td>
<td>1.19000</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.56561</td>
<td>0.99965</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.02974</td>
<td>0.03592</td>
</tr>
</tbody>
</table>

#### 1.b. First difference of the Log-level of the exchange rate

<table>
<thead>
<tr>
<th></th>
<th>Dollar/DM</th>
<th>Dollar/Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.762 E-07</td>
<td>-8.18 E-08</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.003223</td>
<td>0.00742</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.005350</td>
<td>-0.00772</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.000198</td>
<td>0.00019</td>
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</table>

#### 1.c. Spreads

<table>
<thead>
<tr>
<th></th>
<th>Dollar/DM</th>
<th>Dollar/Euro</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.00025</td>
<td>0.00047</td>
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<tr>
<td>Maximum</td>
<td>0.00225</td>
<td>0.00360</td>
</tr>
<tr>
<td>Minimum</td>
<td>6.408 E-05</td>
<td>0.00001</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.00009</td>
<td>0.00019</td>
</tr>
</tbody>
</table>

#### 1.d. % Spreads

<table>
<thead>
<tr>
<th></th>
<th>Dollar/DM</th>
<th>Dollar/Euro</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.00040</td>
<td>0.00045</td>
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<tr>
<td>Maximum</td>
<td>0.00383</td>
<td>0.00304</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.00011</td>
<td>9.295 E-06</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.00015</td>
<td>0.00018</td>
</tr>
<tr>
<td>Month</td>
<td>Spread</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>January 1999</td>
<td>0.000548174</td>
<td></td>
</tr>
<tr>
<td>February 1999</td>
<td>0.000497459</td>
<td></td>
</tr>
<tr>
<td>March 1999</td>
<td>0.000517254</td>
<td></td>
</tr>
<tr>
<td>April 1999</td>
<td>0.000503020</td>
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<td>May 1999</td>
<td>0.000493815</td>
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<td>June 1999</td>
<td>0.000474562</td>
<td></td>
</tr>
<tr>
<td>July 1999</td>
<td>0.000464078</td>
<td></td>
</tr>
<tr>
<td>August 1999</td>
<td>0.000472378</td>
<td></td>
</tr>
<tr>
<td>September 1999</td>
<td>0.000463324</td>
<td></td>
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<tr>
<td>October 1999</td>
<td>0.000444362</td>
<td></td>
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<tr>
<td>November 1999</td>
<td>0.000461528</td>
<td></td>
</tr>
<tr>
<td>December 1999</td>
<td>0.000466082</td>
<td></td>
</tr>
</tbody>
</table>
Table 3
PROBABILITY THAT THE INFLATION PROCESS HAS SWITCHED

The probabilities were calculated assuming that the final probability of the old process with mean $\delta_o = 0.00334483$ is $P_{o,f} = 0.01$ and the final probability of the new process with mean $\delta_n = 0.0016666$ is $P_{n,f} = 0.99$.

<table>
<thead>
<tr>
<th>Month</th>
<th>$P_n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 99</td>
<td>1.78 E-05</td>
</tr>
<tr>
<td>February 99</td>
<td>2.73 E-05</td>
</tr>
<tr>
<td>March 99</td>
<td>4.33 E-05</td>
</tr>
<tr>
<td>April 99</td>
<td>6.88 E-05</td>
</tr>
<tr>
<td>May 99</td>
<td>0.00011</td>
</tr>
<tr>
<td>June 99</td>
<td>0.00024</td>
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<tr>
<td>July 99</td>
<td>0.00047</td>
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<td>August 99</td>
<td>0.00094</td>
</tr>
<tr>
<td>September 99</td>
<td>0.00203</td>
</tr>
<tr>
<td>October 99</td>
<td>0.00399</td>
</tr>
<tr>
<td>November 99</td>
<td>0.00858</td>
</tr>
<tr>
<td>December 99</td>
<td>0.01715</td>
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<tr>
<td>January 00</td>
<td>0.02729</td>
</tr>
<tr>
<td>February 00</td>
<td>0.05360</td>
</tr>
<tr>
<td>March 00</td>
<td>0.08382</td>
</tr>
<tr>
<td>April 00</td>
<td>0.09225</td>
</tr>
<tr>
<td>May 00</td>
<td>0.17992</td>
</tr>
<tr>
<td>June 00</td>
<td>0.32139</td>
</tr>
<tr>
<td>July 00</td>
<td>0.23910</td>
</tr>
<tr>
<td>August 00</td>
<td>0.38911</td>
</tr>
<tr>
<td>September 00</td>
<td>0.55699</td>
</tr>
<tr>
<td>October 00</td>
<td>0.45969</td>
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<tr>
<td>November 00</td>
<td>0.62678</td>
</tr>
<tr>
<td>December 00</td>
<td>0.73409</td>
</tr>
<tr>
<td>January 01</td>
<td>0.85629</td>
</tr>
<tr>
<td>February 01</td>
<td>0.90258</td>
</tr>
<tr>
<td>March 01</td>
<td>0.76842</td>
</tr>
<tr>
<td>April 01</td>
<td>0.79401</td>
</tr>
<tr>
<td>May 01</td>
<td>0.73254</td>
</tr>
<tr>
<td>June 01</td>
<td>0.51021</td>
</tr>
<tr>
<td>July 01</td>
<td>0.69208</td>
</tr>
<tr>
<td>August 01</td>
<td>0.77856</td>
</tr>
<tr>
<td>September 01</td>
<td>0.87405</td>
</tr>
<tr>
<td>October 01</td>
<td>0.92077</td>
</tr>
<tr>
<td>November 01</td>
<td>0.94789</td>
</tr>
<tr>
<td>December 01</td>
<td>0.96606</td>
</tr>
<tr>
<td>January 02</td>
<td>0.98309</td>
</tr>
<tr>
<td>February 02</td>
<td>0.98581</td>
</tr>
<tr>
<td>March 02</td>
<td>0.99337</td>
</tr>
<tr>
<td>April 02</td>
<td>0.96561</td>
</tr>
<tr>
<td>May 02</td>
<td>0.95518</td>
</tr>
<tr>
<td>June 02</td>
<td>0.97871</td>
</tr>
</tbody>
</table>
Table 4

THE EFFECT OF INFLATION LEARNING ON THE EXCHANGE RATE

An OLS regression was estimated with $\Delta \log(E)$ as the dependent variable, where the exchange rate includes the dollar/euro, pound/euro, and yen/euro, and the independent variable is $\Delta Prob$, the probability that the market assigns to euro-area inflation following a new process under the ECB. Since this probability rises, once-and-for-all, above 50 percent in November 2000, a dummy variable that switches from 0 to 1 at November, 2000 is interacted with $\Delta Prob$ to test for a change in the learning effect once the market appears to give a greater than 50 percent chance that the process has switched. P-values are in parentheses.

<table>
<thead>
<tr>
<th>Exchange Rate</th>
<th>Constant</th>
<th>$\Delta Prob$</th>
<th>$\Delta Prob$*Dummy</th>
<th>$R^2$</th>
<th>Q(20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$$/€$</td>
<td>-0.006 (0.24)</td>
<td>0.064 (0.27)</td>
<td></td>
<td>0.030</td>
<td>0.25</td>
</tr>
<tr>
<td>£/€</td>
<td>-0.004 (0.22)</td>
<td>0.086 (0.05)</td>
<td></td>
<td>0.093</td>
<td>0.21</td>
</tr>
<tr>
<td>¥/€</td>
<td>-0.006 (0.21)</td>
<td>0.156 (0.02)</td>
<td></td>
<td>0.135</td>
<td>0.85</td>
</tr>
<tr>
<td>$$/€$</td>
<td>-0.005 (0.29)</td>
<td>-0.095 (0.32)</td>
<td>0.239 (0.04)</td>
<td>0.131</td>
<td>0.49</td>
</tr>
<tr>
<td>£/€</td>
<td>-0.004 (0.24)</td>
<td>0.068 (0.35)</td>
<td>0.027 (0.75)</td>
<td>0.095</td>
<td>0.17</td>
</tr>
<tr>
<td>¥/€</td>
<td>-0.006 (0.25)</td>
<td>-0.055 (0.57)</td>
<td>0.316 (0.01)</td>
<td>0.272</td>
<td>0.71</td>
</tr>
</tbody>
</table>
Figure 1
Daily average bid-ask spread on the dollar/euro exchange rate
Figure 2: Exchange Rate Volatility on Days of ECB, Federal Reserve, and Bundesbank Policy Actions

The figures plot exchange rate volatility as measured by the square of the change in the log of the dollar/euro exchange rate sampled at 1-minute intervals (multiplied by 10,000,000). Figures are shown for days when target interest rates were changed for 3 groups: a) ECB meeting days in 1999 and the dollar/euro exchange rate; b) FOMC meeting days in 1999 and the dollar/euro exchange rate; and c) Bundesbank meeting days in 1994 and the dollar/mark exchange rate. Vertical lines in each figure indicate the time of day when the Bloomberg news service reported the change in interest rates resulting from the meeting.

a) ECB Meeting Days:

b) BUBA Meeting Days
c) FOMC Meeting Days

- **June 15, 1994**
- **July 27, 1994**
- **February 3, 1999**
- **June 30, 1999**
- **August 24, 1999**
- **October 5, 1999**
- **November 16, 1999**
- **December 21, 1999**
Figure 3: The Probability of a New ECB Inflation Regime and Exchange Rates

- **GBP/EUR**
- **JPY/EUR**
- **USD/EUR**

Probability vs. Month

Exchange Rate Indexes

<table>
<thead>
<tr>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.65</td>
</tr>
<tr>
<td>0.7</td>
</tr>
<tr>
<td>0.75</td>
</tr>
<tr>
<td>0.8</td>
</tr>
<tr>
<td>0.85</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

Month:
- Jan-99
- Feb-99
- Mar-99
- Apr-99
- May-99
- Jun-99
- Jul-99
- Aug-99
- Sep-99
- Oct-99
- Nov-99
- Dec-99
- Jan-00
- Feb-00
- Mar-00
- Apr-00
- May-00
- Jun-00
- Jul-00
- Aug-00
- Sep-00
- Oct-00
- Nov-00
- Dec-00
- Jan-01
- Feb-01
- Mar-01
- Apr-01
- May-01
- Jun-01
- Jul-01
- Aug-01
- Sep-01
- Oct-01
- Nov-01
- Dec-01
- Jan-02
- Feb-02
- Mar-02
- Apr-02
- May-02
- Jun-02
Reference:

http://www.public.asu.edu/~mmelvin/