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Optimal Guidance by Central Banks

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Optimal Guidance by Central Banks

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Abstract

Central banks repeatedly state, that they intend to guide analysts through verbal interventions, in order to minimize short–term fluctuations in exchange rates. We derive analytically an optimal rule for guidance, given that irrational traders operate in the market. It turns out, that guidance allows for reconciling the existence of momentum traders with zero serial correlation in exchange rates, and a positive serial correlation in analysts' forecast errors can be explained without requiring herding or under–reaction of analysts. Empirical investigations of the exchange rate between assets in the the European Union and the United States reveal that the demand of currency of momentum traders is positive. The guidance of central banks is found to be the optimal response.

1 Introduction

Central banks aim at guiding analysts through their press releases, briefings and speeches, so as to minimize short–term fluctuations in exchange rates.[1] For instance, Wim Duisenberg has emphasized several times in 2003, that he is seriously concerned about the high short–term volatility in the Euro/Dollar spot rate, and intends to reduce the swings by using the instrument of verbal

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[1]Recently, Gürkaynak, Sack and Swanson (2005) provide evidence that the central banks' "verbal interventions" are very effective.

interventions.[2] Further evidence is provided by Edison (1993), Baillie and Osterberg (1997).

We will analyze verbal interventions of central banks by extending the heterogenous agents model originating in Frankel and Froot (1986), and Day and Huang (1990),[3] by introducing analysts whose expectations are guided by central banks. Optimal control is applied to derive a guidance rule to minimize the volatility in exchange rates, given that momentum traders operate in the market. Notice, that the introduction of central bank guidance allows for reconciling the existence of momentum traders with zero serial correlation in exchange rates.[4] Moreover, the guidance provided by the central banks can produce a positive serial correlation in the forecast error of analysts.[5] Note, that this correlation is usually attributed to underreaction or herding behavior of analysts.

We conduct an empirical study to assess whether momentum traders are in the market, and whether the central banks actually have optimally guided the analysts. Therefore, the deep parameters of the model which comprises the central banks, analysts, and momentum traders in a random dynamic system, are estimated using the indirect inference approach suggested by Gourieroux, Monfort and Renault (1993).

The remainder is organized as follows. Section 2 introduces the foreign exchange rate model incorporating guidance by the central banks, and provides results concerning its optimality, as well as an equilibrium when also momentum traders optimize their profits. In section 3 we test empirically the hypotheses of the model. Section 4 concludes.

2 A Model of Central Bank Guidance

It is a common observation that the true fundamental exchange rates, $\bar{y}_t, \;\; t = 1, 2, \ldots$, and observed exchange rates, $y_t, \;\; t = 1, 2, \ldots$, may deviate significantly. We use the heterogenous agent model originating in Frankel and Froot (1986)or Day and Huang (1990) to explain the main stylized facts of observed changes in exchange rates, Δy_t, and extend the model by analysts who are guided by

[2] Notice, that he carefully has distinguished between short–term volatility and the adaption of the exchange rate to a new fundamental equilibrium.

[3] For recent studies of this model of the foreign exchange market see Brock and Hommes (1998), Lux and Marchesi (1999), or De Grauwe and Grimaldi (2005).

[4] There is evidence based on survey that foreign exchange traders base trading decisions on the past exchange rate movements, see Allen and Taylor (1992), Oberlechner (2001), and Menkhoff (1997). On the other hand, no serial correlation is found in observed exchange rates.

[5] For empirical evidence see Zarnowitz (1985) or Schuh (2001).

press releases and speeches of the central banks. He derives expectations regarding the exchange rate as follows.

Definition 1 (Expectations of the Guided Analyst)**.**

$$\mathrm{E}_t^G(\Delta y_{t+1}) = \mathcal{G}_t, \tag{1}$$

with $\Delta y_{t+1} = y_{t+1} - y_t$ *and guidance* $\mathcal{G}_t = \gamma \Delta y_t$*, where* γ *is a parameter reflecting the intensity of guidance according to recent changes in the value of the currency. The central bank is assumed to choose* $\gamma < 0$*, in order to reduce volatility in short–term exchange rate movements.*

The fundamental analyst is assumed to know the actual fundamental value of the currency $\bar{y}_t$. His expectations are as follows.

Definition 2 (Expectations of the Fundamental Analyst)**.**

$$\mathrm{E}_t^F(\Delta y_{t+1}) = \alpha(\bar{y}_t - y_t),$$

where $\alpha \geq 0$ *is a parameter reflecting the relevance of the fundamentals for the analysts' expectations.*

Momentum traders are assumed to have a demand for currency depending on recent changes in the exchange rate, $\delta \Delta y_t$, where $\delta > 0$ is a parameter reflecting the impact of the momentum traders on the next exchange rate realization.

Applying a widely considered market clearing mechanism in foreign exchange markets, we derive the dynamical system describing exchange rates.

Definition 3 (Market Clearing)**.** *The Walrasian Tattonnement based on overall demand for foreign cash,*

$$\beta(\mathrm{E}_t^G(\Delta y_{t+1}) + \mathrm{E}_t^F(\Delta y_{t+1})) + \delta \Delta y_t, \quad \beta > 0,$$

gives a dynamical system for the evolution of the exchange rate through time

$$\Delta y_{t+1} = \beta(\alpha(\bar{y}_t - y_t) + \gamma \Delta y_t) + \delta \Delta y_t + \varepsilon_t \tag{2}$$

with i.i.d. $\varepsilon_t \sim \mathcal{N}(0, \sigma_\varepsilon)$*.*

Having modelled the dynamics of the exchange rate we are interested in characterizing the optimality of the central banks' efforts to minimize short–term fluctuations in the exchange rate provided that momentum traders are present, yet not optimizing. In Theorem 1 we derive the optimal guidance γ of the central bank.

Theorem 1 (Optimal Guidance)**.** *Central banks reduce squared forecast errors of the analysts by choosing the parameter in the guidance rule as* $\gamma^* = -\frac{\delta}{\beta}$*, which solves*

$$\min_{\gamma} E_t \sum_{\tau=t+1}^{\infty} \bar{\beta}^{\tau} (\Delta y_{\tau})^2$$

subject to (2), with discount factor $\bar{\beta}$*.*

Proof. It follows straight forward from the optimality conditions for linear–quadratic problems in Chow (1975), that $\gamma^* = -\frac{\delta}{\beta}$. □

For the special case of $\alpha = 0$, i.e. fundamental analysts do not determine the exchange rate,[6] and for an optimal choice of guidance, $\gamma = -\frac{\delta}{\beta}$, we are able to derive realistic implications of the exchange rate model (2).

Theorem 2 (No Serial Correlation in Changes in Observed Exchange Rates)**.** *If* $\alpha = 0$ *and* $\gamma = -\frac{\delta}{\beta}$*, then there is no serial correlation in changes in the observed exchange rates, that is,* $cov(\Delta y_t, \Delta y_{t-1}) = 0$*, although momentum traders may operate in the market,* $\delta > 0$*.*

Proof. For $\alpha = 0$ and $\gamma = -\frac{\delta}{\beta}$ we have $\Delta y_{t+1} = \varepsilon_t$. Thus, $cov(\Delta y_t, \Delta y_{t-1}) = 0$. □

Theorem 3 (Serial Correlation in the Forecast Error)**.** *Given the random dynamical system of the exchange rates (2), and suppose of* $\alpha = 0$ *and* $\gamma = -\frac{\delta}{\beta}$*, forecast errors always exhibit positive serial correlation, i.e.,* $\mathrm{E}(z_t z_{t+1}) > 0$*.*

Proof. The consensus forecast error $z_t = y_t - \hat{y}_t = y_{t-1} = ((\beta - 1)\gamma + \delta)\Delta y_{t-1}$, where $\Delta y_t = y_t - y_{t-1}$, $\hat{y}_t = \mathrm{E}_t^W(y_{t+1} - y_t) + \mathrm{E}_t^F(y_{t+1} - y_t)$, and $\alpha = 0$. Since $z_t = \Delta y_t - \gamma \Delta y_{t-1}$, we can write $\mathrm{E}(z_t z_{t+1}) = [(\beta - 1)\gamma + \delta][\mathrm{E}(\Delta y_t^2) - \gamma(cov(\Delta y_t \Delta y_{t+1}) + \mathrm{E}(\Delta y_t)\mathrm{E}(\Delta y_{t-1}))]$. If the process driving the exchange rate changes is stationary, then $\mathrm{E}(\Delta y_t) = \mathrm{E}(\Delta y_{t-1}) = \mu$, and for $\mu = 0$ we have $\mathrm{E}(z_t z_{t+1}) = [(\beta - 1)\gamma + \delta][var(\Delta y) - \gamma(cov(\Delta y_t, \Delta y_{t-1})]$. Thus, $\mathrm{E}(z_t z_{t+1}) > 0$, that is, forecast errors are positively autocorrelated if $\gamma < \frac{-\delta}{\beta - 1}$ and $var(\Delta y_t) > cov(\Delta y_t, \Delta y_{t-1})$. This is true since we have assumed $\gamma < 0$, and $cov(\Delta y_t, \Delta y_{t-1}) = 0$ follows from Theorem 3. □

3 An Empirical Investigation

In the previous section we have derived a nonlinear random dynamical model for exchange rates with heterogenous agents including analysts guided by the central bank. We will apply the indirect

[6] This case is supported in the subsequent empirical analysis.

inference approach of Gourieroux, Montfort and Renault (1993) to estimate the parameters of (2), summarized in $\theta = (\alpha, \beta, \gamma, \delta)$, based on the main empirical stylized facts in exchange rates summarized in the vector ψ_{emp}. The vector of stylized facts of simulated exchange rate time series from the model is denoted by $\psi(\theta)$. The deep parameters are then obtained by minimizing the quadratic distance between observed and replicated moment conditions,

$$\hat{\theta} = \text{argmin}_{\theta} \hat{Q}'(y, \bar{y}, \psi) \hat{W} \hat{Q}(y, \bar{y}, \psi)$$

with $\hat{Q}(y, \bar{y}, \psi) = \psi_{emp} - \frac{1}{H} \sum_{h=1}^{H} \psi$, where H is the number of simulated exchange rate time series of T periods, and $\hat{W}$ is a positive definite matrix which converges in probability to a deterministic positive definite matrix W. Due to the central limit theorem $\hat{\theta}$ is asymptotically normal, $\sqrt{T}(\hat{\theta} - \theta^*) \rightarrow_d \mathcal{N}\big(0, \text{Var}(\hat{\theta})\big)$. The overidentifying restrictions of the model are tested with the Wald statistic

$$\frac{TH}{1+H} Q'(y, \bar{y}, \hat{\psi}) \hat{W} Q'(y, \bar{y}, \hat{\psi}),$$

which is asymptotically follows the chi-square distribution with $dim(\beta) - dim(\theta)) \geq 0$ degrees of freedom.

We make use of the following usual stylized facts as moment conditions:

1. Positive autocorrelation in forecast errors $\rho_{y_{t+1} - \hat{y}_{t,t+1}} > 0$.
2. High volatility in realized and forecast exchange rate deviations, which are $\sigma_{(y_{t+1} - y_t)}$ and $\sigma_{(\hat{y}_{t,t+1} - y_t)}$, respectively.
3. No autocorrelation in exchange rate deviations $\rho_{\Delta y_{t+1}} = 0$.
4. Excess kurtosis in exchange rate deviations $K_{\Delta y_{t+1}} > 0$.
5. Positive skewness of exchange rate deviations $S_{\Delta y_{t+1}} > 0$.

The data sample for the exchange rate y_t is given by the monthly Euro/Dollar reference rate provided by the European Central Bank in Frankfurt, ranging from January 1999 to 2004. Analysts' expectations $\hat{y}_t$ are proxied by the survey of Reuters, which polls foreign exchange traders and analysts of about 50 financial institutions in the City of London, North America and Asia. The survey is taken on the first Monday and Tuesday each month and asks for the forecasts of the exchange rates one, three, six and twelve months ahead. The data is available from January 1999 to 2004.

In order to simulate exchange rate time series from (2), we generate $H = 1,000$ time series of $T = 1,500$ periods. The starting parameters of the dynamic system are generated randomly. The true fundamental exchange rate $\bar{y}_t$ is assumed to follow a random walk where the variance of the disturbances is set to the variance of the disturbances of the euro–dollar exchange rate as observed in the data. We take the spot rate determined by the European Central Bank on January 1, 1999 as starting value for the simulated model. Table 1 provides a summary of the estimation results. The main finding is, that momentum traders do operate in the market. The central bank uses its instrument of guidance, and we will investigate its optimality subsequently.

Table 1: Estimation Results for the Deep Parameters.

	β	α	γ	δ
Mean	0.2236	0.0251	-0.3624	0.0808
Median	0.1948	0.0148	-0.3943	0.0774
StDev	0.1471	0.0329	0.0819	0.0583

The stylized facts generated by the simulated model are reported in Table 2. Basically, the null hypothesis that the estimated model matches the empirical stylized facts cannot be rejected.[7]

Table 2: Estimation Results for the Stylized Facts.

	$\rho_{\hat{y}_{t,t+1}-y_{t+1}}$	$\frac{\sigma_{\Delta y_{t+1}}}{\sigma_{\hat{y}_{t,t+1}-y_t}}$	$\rho_{\Delta y_{t+1}}$	$K_{\Delta y_{t+1}}$	$S_{\Delta y_{t+1}}$	$J(y_t, \hat{y}_t, \beta)$
Mean	0.2742	2.3384	0.0003	-0.0069	-0.0005	4.8553
Median	0.2753	2.3390	0.0000	-0.0011	0.0004	4.5875
StDev	0.0464	0.0046	0.0072	0.0938	0.0617	0.8416
Data	0.2753	2.3390	0.0000	0.0000	0.0000	4.0000
Wald stat						0.1794
						(0.672)

Given that the demand for currency of the momentum traders is positive, we are concerned about the optimality of the central banks' efforts to minimize short–term fluctuations in the Euro/Dollar exchange rate given the estimated parameters of the dynamic system (2). Com-

[7]It can be seen in Table 1, that the conditions for no serial correlation in changes in observed exchange rates (Theorem 2), and conditions for serial correlation in the forecast error (Theorem 3) are satisfied.

paring the solution of the dynamic control problem $\gamma^* = -0.363$, provided in Theorem 1, with the estimated coefficient $\hat{\gamma} = -0.361$, see Table 1, we can conclude that interventions are optimal with respect to the central banks' objective function.

4 Conclusion

Based on an empirical assessment of a heterogenous model of exchange rates with central bank guiding, it is found that momentum traders populate the market for the Euro/Dollar market. We are able to provide evidence that the the central banks respond with optimal guidance in the sense of reducing short–term volatility in the exchange rate, yet minimizing the forecast errors of the analysts.

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