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ABSTRACT

ECB Repo Rate Setting During the Financial Crisis*

I estimate a reaction function for the ECB using an ordered logit model for the period 1999-2009. Allowing for a smooth transition from one set of parameters to another, I detect a rapid change in middle of 2008.

JEL Classification: C2 and E52
Keywords: ECB, ordered logit, reaction functions, smooth transition

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1. Introduction

Following the decline of inflation to low levels in many countries around the turn of the millennium, much research studied how monetary policy should be conducted if interest rates threatened to reach zero, the "zero lower bound" (ZLB).[1] Reifschneider and Williams (2000) hypothesise that it would be optimal for central banks to cut interest rates sharply and pre-emptively if a worsening of economic conditions suggested that the ZLB might become binding. From the perspective of an econometrician studying central bank interest rate setting, this would appear as a shift in the empirical reaction function. Using dynamic programming techniques, Orphanides and Wieland (2000) demonstrate that this conjecture is correct: as inflation falls towards zero, the optimal parameter on inflation in the reaction function rises at an increasing rate until the ZLB starts to bind when, of course, it turns to zero. A main conclusion in this literature is thus that a linear reaction function will not fit well if economic conditions deteriorate to the extent that the central bank comes to believe that the ZLB might become binding.

The global financial crisis offers an opportunity to explore the validity of this proposition. We estimate a reaction function for the ECB's repo rate, its main policy instrument, using an ordered logit model for the period February 1999 to November 2009 and allow for a smooth transition from one set of parameters to another, with the timing and speed of the switch determined by the data.

The analysis seeks to answer three questions. First, was the sharp reduction of the repo rate from 4.25% from September 2008 to 1% in May 2009 simply a response to drastically worsening macroeconomic conditions or did the ECB's reaction function also change? Second, if the reaction function shifted, when did the switch occur and

[1] In practice, central banks may view the ZLB as reached when short-term market rates fall to a very low, but positive, level, say in the range of 0.1 – 0.2%.

how rapid was it? Third, how do the reaction functions estimated on data from the pre-crisis and the crisis periods differ?

2. The Model

We start from the ordered probit model used by Gerlach (2007) to study the ECB's interest rate decisions before the crisis. Let i_t denote the repo rate and i_t^T the ECB's "target" for the repo rate, which may differ because the repo rate is set in "steps" 0.25% apart. Letting π_t, y_t, μ_t and ε_t denote inflation, real economic activity, money growth and the rate of appreciation of the nominal effective exchange rate, we assume (omitting a constant):

$$(1) \qquad i_t^T = \alpha_y y_t + \alpha_\pi \pi_t + \alpha_\mu \mu_t + \alpha_\varepsilon \varepsilon_t$$

where α_y, α_π, and $\alpha_\mu > 0$ and $\alpha_\varepsilon < 0$.[2] Gerlach (2007) allows for gradual adjustment as in Judd and Rudebusch (1998):

$$(2) \qquad i_t - i_{t-1} = \beta_0 \left(i_t^T - i_{t-1} \right) + \beta_1 \Delta i_{t-1} + e_t$$

where e_t is a residual. Equation (2) implies that changes in interest rates should be distributed continuously. However, because the ECB sets interest rates in steps, only discrete changes are observed. Using equations (1) and (2), and incorporating the fact that the ECB sets interest rates in steps, we have that:

$$(3) \qquad i_t^* - i_{t-1} = \tilde{\alpha}_y y_t + \tilde{\alpha}_\pi \pi_t + \tilde{\alpha}_\mu \mu_t + \tilde{\alpha}_\varepsilon \varepsilon_t - \beta_0 i_{t-1} + \beta_1 \Delta i_{t-1} + e_t,$$

where $\tilde{\alpha}_i \equiv \alpha_i \beta_0$ and the asterisk, *, indicates that the interest rate should be thought of as a latent variable. We observe the actual change in the interest rate, which depends on where the latent variable is relative to a set of threshold values, γ_i. We observe six different policy choices:

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[2] Svensson (1997) presents a model in which the target interest rate depends on the output gap and the deviation of inflation from the central bank's objective.

$$
\begin{aligned}
&\Delta i_t = -0.75\% && \text{if } i_t^* - i_{t-1} \le \gamma_1 \\
&\Delta i_t = -0.50\% && \text{if } \gamma_1 < i_t^* - i_{t-1} \le \gamma_2 \\
&\Delta i_t = -0.25\% && \text{if } \gamma_2 < i_t^* - i_{t-1} \le \gamma_3 \\
(4)\quad &\Delta i_t = 0 && \text{if } \gamma_3 < i_t^* - i_{t-1} \le \gamma_4 \\
&\Delta i_t = +0.25\% && \text{if } \gamma_4 < i_t^* - i_{t-1} \le \gamma_5 \\
&\Delta i_t = +0.50\% && \text{if } \gamma_5 < i_t^* - i_{t-1}
\end{aligned}
$$

We rewrite equation (3) as:

$$(5)\qquad i_t^* - i_{t-1} = \Theta Z_t + e_t,$$

where Θ is a row vector of parameters and Z_t a column vector containing the regressors.

3. Structural change

We follow Mankiw, Miron and Weil (1987) and allow for a smooth transition from the pre-crisis parameters, Θ, to the parameters in force during the crisis, Ω:

$$(6)\qquad i_t^* - i_{t-1} = \omega_t \Theta Z_t + (1-\omega_t)\Omega Z_t + e_t,$$

where $\omega_t = 1/(1+\exp(\delta(\tau_t - \lambda)))$ and τ_t is a time trend. The parameter δ captures the speed of the change: the time between one quarter and three quarters of the adjustment occurred is given by $\log(9)/\delta$. The midpoint of the change is given by λ.

4. Estimates

We first reestimate the model on pre-crisis data. Three comments are warranted. First, Gerlach (2007) finds that inflation is insignificant and interprets this as indicating that most of the variation of inflation was due to price level shocks of little significance for monetary policy. Since this is the case also in our sample, we drop inflation from the model. Second, since the real GDP data needed to construct output

gaps are only available with long lags, Gerlach (2007) uses Eurostat's Economic Sentiment Indicator, which is available with a one month lag, to capture the state of the business cycle. Here we use the Purchasing Managers' Index (PMI) for the euro area. Third, in contrast to Gerlach (2007) we use an ordered logit, rather than an ordered probit, model.[3] [4]

Column 1 in Table 1 contains estimates for the pre-crisis period which spans February 1999 to July 2007, when the global financial markets crisis started with tensions developing in interbank markets. All parameters are significant and have the expected signs. Thus, if the ECB raised interest rates last month, it is less likely to do so this month; if the interest rate was high last month, the ECB is more likely to cut it this month; if economic activity was strong, the growth rate of M3 high, or the effective exchange depreciated last month, the ECB is more likely to raise the repo rate this month. We assess the fit of the model using the pseudo R-squared, which is 0.44.

To interpret these estimates, suppose that the PMI rose by one (pre-crisis) standard deviation, that is, by 3.76 units. In this case, if the interest rate increased by 3.76*0.74/0.81 = 3.43 percentage points, there would be no further pressure for interest rates to rise. Thus, the ratio $\tilde{\alpha}_j / \beta_0$ can be used as a measure of the sensitivity of the interest rate to the *j:*th exogenous variable.

Column 2 contains estimates for the period February 1999 to November 2009. While the parameters remain highly significant, the pseudo R-squared falls to 0.36 and many parameters change by several standard errors relative to the pre-crisis estimates, suggesting that the pre-crisis model does not fit the crisis period well.

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[3] While the ordered probit and logit models yield similar estimates in the pre-crisis period, in the full period the ordered probit model leads to much lower values of the likelihood function.

[4] As in Gerlach (2007), we measure money growth by M3 growth over twelve months and the rate of appreciation by the rate of change over twelve months of the nominal effective exchange rate. To account for reporting lags, we lag all variables by one month, except money growth, which we lag by two months.

To explore more formally whether a shift has occurred, Column 3 presents the estimates when the parameters are allowed to change. A likelihood ratio test yields 40.04, which is far above the critical value for a $\chi^2(7) = 14.07$, implying that the hypothesis of a stable reaction function is rejected. As expected, the parameters determining the ω_t weights are highly significant. Below we use simulations to study how uncertainty about δ and λ translates into uncertainty about ω_t.

The parameters from the pre-crisis regime are similar to those estimated on the data spanning February 1999 to July 2007 and we do therefore not comment on them. Turning to the crisis regime, we note that the lagged repo rate is ten times larger (in absolute value) than before and highly significant. The lagged change of the repo rate is now significant but positive, indicating that a change in the repo rate in one direction was likely to be followed by another, given the state of the economy. While the parameter on the PMI is similar to in the pre-crisis regime, that on M3 growth is now much larger, suggesting that money growth became a more important determinant of policy during the crisis. The parameter on the rate of exchange rate appreciation remains significant but is now positive.[5]

Since the global financial crisis is commonly seen as having started in August 2007, we forced the crisis period to start at that time and reestimated the model.[6] The likelihood function then falls to -58.05, implying that this restriction is rejected ($p = 0.00$).

Finally we consider the regime switch. The point estimate of δ is 4.56, implying that the time between one quarter and three quarters of the switch took 0.5 months and thus was quite rapid. The switch point (when $\omega_t = 0.5$) is estimated to be 221.42, that is, in June 2008, when the trend equals 221. This is between the collapse of Lehman Brothers in September 2009 that led the crisis to intensify and August 2007, when the

[5] This may be because of reserve causality.

[6] I am grateful to the referee for suggesting this exercise.

crisis is commonly seen as having started. Figure 1, shows a 95% confidence band for ω_t.[7]

5. Conclusions

Our estimates suggest that the sharp cuts in the ECB's repo rate during the current financial crisis reflect a combination of a sharp worsening of the macroeconomic environment and a shift in the ECB's reaction function. Such a shift is compatible with the idea that the ECB grew concerned about reaching the zero lower bound and therefore cut interest rates aggressively.

[7] The graph is constructed by drawing 10000 realisations of δ and λ, using the estimated mean and covariance matrix. The graph uses the median as the measure of central tendency.

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Table 1
Quasi-maximum likelihood estimates of ordered logit model

Sample period	**Feb. 1999 – July 2007**	**Feb. 1999 – Nov. 2009**	**Feb. 1999 – Nov. 2009**	
Regime			**Pre-crisis**	**Crisis**
Lagged repo rate	-0.81 (0.46) [0.08]	-1.02 (0.31) [0.00]	-1.09 (0.39) [0.00]	-11.79 (2.05) [0.00]
Lagged change in repo rate	-9.70 (2.75) [0.00]	-4.03 (1.73) [0.02]	-10.47 (2.89) [0.00]	3.83 (2.87) [0.18]
PMI	0.74 (0.16) [0.00]	0.52 (0.10) [0.00]	0.85 (0.17) [0.00]	0.85 (0.18) [0.00]
M3 growth	0.72 (0.24) [0.00]	0.31 (0.14) [0.03]	0.65 (0.17) [0.00]	4.86 (0.93) [0.00]
Nom. eff. exchange rate	-0.32 (0.07) [0.00]	-0.20 (0.07) [0.00]	-0.34 (0.08) [0.00]	1.00 (0.17) [0.00]
Intercept (λ)			221.42 (0.26) [0.00]	
Trend (δ)			4.56 (2.03) [0.04]	
Log likelihood	-44.76	-70.90	-50.88	
Pseudo R-squared	0.44	0.36	0.54	

Notes: Robust standard errors in parenthesis, (); p-values in brackets, [].

Figure 1
Median and 95% confidence band from the simulated distribution of the weight function