ECB Repo Rate Setting During the Financial Crisis

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Abstract

This paper estimates a monetary policy reaction function for the ECB's repo rate using an ordered logit model during the period 1999-2009. To model the shift of the reaction function during the financial crisis, we allow for a smooth transition from one set of parameters to another. The estimates show a rapid change in the summer and early fall of 2008.

Keywords: ECB, reaction functions, ordered logit, 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 in a calibrated model: 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 present financial crisis offers an opportunity to explore the validity of this body of theory. This paper estimates a monetary policy 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. To model the potential shift of the reaction function during the financial crisis, we 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 a drastic worsening macroeconomic conditions or did the ECB's reaction function also

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%.

change? Second, if the reaction function was altered, when did the switch occur and 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 in the period 1999 – 2006. 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.[2] Let 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. The target level for the interest rate is given by:

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

where the constant is omitted; and where α_y, α_π, and α_μ are expected to be positive and α_ε negative.[3] Gerlach (2007) allows for gradual adjustment as in Judd and Rudebusch (1998):

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

where e_t is a residual. Equation (2) implies that changes in interest rates should be distributed continuously. However, because 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) $$i_t^* - i_{t-1} = \tilde{\alpha}_y y_t + \tilde{\alpha}_\pi \pi_t + \tilde{\alpha}_\mu \mu_t + \tilde{\alpha}_\varepsilon \varepsilon_t - \beta_0 i_{t-1} + \beta_1 \Delta i_{t-1} + e_t,$$

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. What is observed is the actual change in the interest rate,

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2 Technically, by the "repo rate" we refer to the minimum bid rate.

3 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 target or objective.

which depends on where the latent variable is relative to a set of threshold values, γ_i. In the sample that includes the financial crisis, we observe six different policy choices:

$$\Delta i_t = -0.75\% \qquad \text{if } i_t^* - i_{t-1} \le \gamma_1$$

$$\Delta i_t = -0.50\% \qquad \text{if } \gamma_1 < i_t^* - i_{t-1} \le \gamma_2$$

$$\Delta i_t = -0.25\% \qquad \text{if } \gamma_2 < i_t^* - i_{t-1} \le \gamma_3$$

(4) $$\Delta i_t = 0 \qquad \text{if } \gamma_3 < i_t^* - i_{t-1} \le \gamma_4$$

$$\Delta i_t = +0.25\% \qquad \text{if } \gamma_4 < i_t^* - i_{t-1} \le \gamma_5$$

$$\Delta i_t = +0.50\% \qquad \text{if } \gamma_5 < i_t^* - i_{t-1}$$

Equations (3) and (4) constitute an ordered-response model which states that the repo rate is set depending on inflation, economic activity, money growth, the rate of appreciation, and the lagged level (and the lagged change) of the repo rate.

Before proceeding, we rewrite equation (3) as:

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

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

3. Structural change

To model structural change, we follow Mankiw, Miron and Weil (1987) and assume that the parameters in the reaction function can be characterised by smooth transition from the pre-crisis parameters, Θ, to the parameters in force during the crisis, Ω:

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

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)/δ. The midpoint of the change is given by λ. This weighting function only permits one change between regimes, as seems appropriate in the current context.

4. Estimates

We first reestimate the model proposed by Gerlach (2007) on pre-crisis data. Three comments are warranted. First, Gerlach (2007) finds that headline and core inflation are both insignificant, and interprets this as indicating that in his sample period most of the variation of inflation around the ECB's objective was due to price level shocks of little significance for monetary policy. Preliminary estimates suggested that this is the case also in our sample, which is not surprising given that the bulk of the movements in inflation during the crisis were due to oil price fluctuations. We therefore 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 lag of a few weeks, to measure real economic activity, since that is available with a shorter delay.[4] Here we use the Purchasing Managers' Index (PMI) for the euro area. Third, in contrast to Gerlach (2007) we use ordered logit rather than ordered probit.[5]

Column 1 in Table 1 contains estimates of the reaction for the pre-crisis period February 1999 to September 2008 when Lehman Brothers failed, triggering turmoil in global financial markets. All parameters are significant and have the expected signs.[6] 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 rapid, or the effective exchange

4 Gerlach (2007) also demonstrates that the sentiment indicator is strongly correlated with measures of the output gap.

5 While the two 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.

6 The results are similar if the estimation period ends in July 2007, that is, before the drastic tightening of interbank liquidity in August 2007 when the crisis started.

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 PMI rose by one (pre-crisis) standard deviation, that is, by 3.76 units. In this case, if the interest rate rose 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 variables.

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.

To explore more formally whether a shift has occurred, Column 3 presents the full sample 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 regimes, we note that the lagged repo rate is ten times larger (in absolute value) than before and remains 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 has remained important in the crisis period. The parameter on the lagged rate of exchange rate appreciation remains significant but is now positive.[7]

Finally we consider the regime switch. The point estimate of the adjustment speed 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 (defined as the point in time when half the change had occurred) is estimated to be 221.42, that is, in June 2008, when the trend takes the value of 221. This is well before the collapse of Lehman Brothers in September 2009 that led the crisis to intensify. Figure 1, which shows a 95% confidence band for ω_t, suggests that the switch was rapid and that it occurred in the summer of 2008. Thus, the model divides the data into a pre- and a crisis and a post-Lehman sample.[8]

5. Conclusions

The preliminary estimates presented here suggest that the sharp cuts in the ECB's repo rate during the current financial crisis are best thought of as reflecting a combination of a sharp worsening of the macroeconomic environment and a shift in the ECB's reaction function. Such a shift is perfectly compatible with the idea that the ECB grew concerned about reaching the zero lower bound and therefore cut interest rates aggressively.

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7 This may be because of reserve causality.

8 The graph is constructed by drawing 10000 realisations of δ and λ, using the estimated mean and covariance matrix, and computing the weights. 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