

The role of money in crisis periods: the Euro area case

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Objective of the paper

- To analyse the role of money, monetary policy and risk aversion on output and inflation during crisis periods.
- By testing two models of the Euro zone based on the New-Keynesian DSGE framework...
- ... where money is introduced explicitly in two different ways.

Baseline New Keynesian Model

- Inflation explained by the expected inflation rate and by the output gap.
- Output explained by its expectations and the real interest rate.
- The Interest rate is established via a Taylor rule in function of inflation and output gaps.
- Money does not explicitly appear as an explanatory factor of the output gap, inflation dynamics (Clarida, Galí and Gertler, 1999; Woodford, 2003; Galí and Gertler, 2007; Galí, 2008).
- In this framework, monetary policy impacts inflation and output, only through change in the real interest rate.

The Question of Money

- The N.K. view of the transmission mechanism neglects the behavior of real money balances:
 - There may exist a real balance effect on aggregate demand resulting from a change in prices.
 - As individuals re-allocate their portfolio of assets, the behavior of real money balances induces relative price adjustments on financial and real assets. In the process, aggregate demand changes, and thus output.

The Question of Money (follow up)

- Thus, by affecting aggregate demand, real money balances become part of the transmission mechanism.
- The interest rate alone is thus not sufficient to explain the impact of monetary policy and of money, and the role played by credit and financial markets (Meltzer, 1995, 1999, Brunner and Meltzer, 1968).
- The role of real money balances may change with risk aversion.

What do we do?

- We compare two types of NK models in a DSGE framework.
- We test the models by using bayesian techniques on Eurozone data.
- Over 3 different crisis periods.
- We analyse changes in parameters and in variance decomposition.
- We study the forecasting performances of the two models during these periods.

Micro foundations of the models

- 3 types of agents: households, firms and central bank.
- Households maximize the expected present value of utility.
- Firms maximize profits.
- The central bank determines the nominal interest rate.

The Baseline Model

For the baseline model, we use a standard separable utility function such as:

$$U_t = e^{\varepsilon_t^P} \left(\frac{C_t^{1-\sigma}}{1-\sigma} + \frac{\gamma e^{\varepsilon_t^M}}{1-\nu} \left(\frac{M_t}{P_t} \right)^{1-\nu} - \frac{\chi N_t^{1+\eta}}{1+\eta} \right) \quad (3)$$

Budget constraint:

$$P_t C_t + M_t + Q_t B_t \leq B_{t-1} + W_t N_t + M_{t-1} \quad (2)$$

Production function:

$$Y_t(i) = A_t N_t(i)^{1-\alpha} \quad (7)$$

The non-separable model

- CES Utility function:

$$U_t = e^{\varepsilon_t^P} \left(\frac{1}{1-\sigma} \left((1-b) C_t^{1-\nu} + b e^{\varepsilon_t^M} \left(\frac{M_t}{P_t} \right)^{1-\nu} \right)^{\frac{1-\sigma}{1-\nu}} - \frac{\chi}{1+\eta} N_t^{1+\eta} \right) \quad (11)$$

Here real money balances affect
the marginal utility of consumption

- The budget constraint and the production function
are the same as in the baseline model

Resolution of the model

- By optimizing the utility function with the budget constraint ...
 - ... and by adding a Taylor type rule equation to complete the model,
 - we obtain 6 macro-equations with 6 unknown variables : output, inflation, nominal interest rate, real money balances, flexible-price output, flexible price interest rate (for the baseline model) and flexible-price real money balances (for the separable model).

Separable model: solution

$$\hat{y}_t^f = \frac{1 + \eta}{\sigma(1 - \alpha_n) + \eta + \alpha_n} \varepsilon_t^a + \frac{(1 - \alpha_n) \left(\log(1 - \alpha_n) + \rho_n - \log\left(\frac{\varepsilon}{\varepsilon - 1}\right) \right)}{\sigma(1 - \alpha_n) + \eta + \alpha_n} \quad (4)$$

$$\hat{i}_t^f = \rho_c + \sigma E_t \left[\Delta \hat{y}_{t+1}^f \right] \quad (5)$$

$$\hat{\pi}_t = \beta E_t [\hat{\pi}_{t+1}] + \frac{(1 - \theta)(1 - \beta\theta)(\sigma(1 - \alpha_n) + \eta + \alpha_n)}{\theta(1 - \alpha_n + \alpha_n \varepsilon)} \left(\hat{y}_t - \hat{y}_t^f \right) \quad (6)$$

$$\hat{y}_t = E_t [\hat{y}_{t+1}] - \sigma^{-1} (\hat{i}_t - E_t [\hat{\pi}_{t+1}] - \rho_c) - \sigma^{-1} E_t [\Delta \varepsilon_{t+1}^P] \quad (7)$$

$$\widehat{m}p_t = \frac{\sigma}{\nu} \hat{y}_t - \frac{a_2}{\nu} \hat{i}_t - \frac{\rho_m}{\nu} + \frac{1}{\nu} \varepsilon_t^M \quad (8)$$

$$\hat{i}_t = (1 - \lambda_i) \left(\lambda_\pi (\pi_t - \pi^*) + \lambda_x (y_t - y_t^f) \right) + \lambda_i \hat{i}_{t-1} + \varepsilon_t^i \quad (9)$$

where

$$\rho_m = -\log(\gamma) + a_1$$

$$\rho_n = -\log(\chi)$$

$$\rho_c = -\log(\beta)$$

$$\text{with } a_1 = \log\left(1 - e^{-\frac{1}{\beta}}\right) - \frac{\frac{1}{\beta}}{e^{\frac{1}{\beta}} - 1} \text{ and } a_2 = \frac{1}{e^{\frac{1}{\beta}} - 1}.$$

Non-Separable model: solution

$$\hat{y}_t^f = v_a^y \hat{a}_t + v_m^y \widehat{mp}_t^f - v_c^y + v_{sm}^y \varepsilon_t^M \quad (12)$$

$$\widehat{mp}_t^f = v_{y+1}^m E_t [\hat{y}_{t+1}^f] + v_y^m \hat{y}_t^f + \frac{1}{\nu} \varepsilon_t^M \quad (13)$$

$$\hat{\pi}_t = \beta E_t [\hat{\pi}_{t+1}] + \kappa_x (\hat{y}_t - \hat{y}_t^f) + \kappa_m (\widehat{mp}_t - \widehat{mp}_t^f) \quad (14)$$

$$\begin{aligned} \hat{y}_t = & E_t [\hat{y}_{t+1}] - \kappa_r (\hat{i}_t - E_t [\hat{\pi}_{t+1}]) + \kappa_{mp} E_t [\Delta \widehat{mp}_{t+1}] \\ & + \kappa_{sp} E_t [\Delta \varepsilon_{t+1}^P] + \kappa_{sm} E_t [\Delta \varepsilon_{t+1}^M] \end{aligned} \quad (15)$$

$$\widehat{mp}_t = \hat{y}_t - \kappa_i \hat{i}_t + \frac{1}{\nu} \varepsilon_t^M \quad (16)$$

$$\hat{i}_t = (1 - \lambda_i) \left(\lambda_\pi \hat{\pi}_t + \lambda_x (\hat{y}_t - \hat{y}_t^f) \right) + \lambda_i \hat{i}_{t-1} + \varepsilon_t^i \quad (17)$$

Non-Separable model: solution (follow up)

where

$$v_a^y = \frac{1+\eta}{(\nu - (\nu - \sigma)a_1)(1-\alpha) + \eta + \alpha}$$

$$v_m^y = \frac{(1-\alpha)(\nu - \sigma)(1-a_1)}{(\nu - (\nu - \sigma)a_1)(1-\alpha) + \eta + \alpha}$$

$$v_c^y = \log\left(\frac{\varepsilon}{\varepsilon-1}\right) \frac{1-\alpha}{(\nu - (\nu - \sigma)a_1)(1-\alpha) + \eta + \alpha}$$

$$v_{sm}^y = \frac{(\nu - \sigma)(1-a_1)(1-\alpha)}{((\nu - (\nu - \sigma)a_1)(1-\alpha) + \eta + \alpha)(1-\nu)}$$

$$v_{y+1}^m = -\frac{a_2}{\nu} (\nu - (\nu - \sigma)a_1)$$

$$v_y^m = 1 + \frac{a_2}{\nu} (\nu - (\nu - \sigma)a_1)$$

$$\kappa_x = \left(\nu - (\nu - \sigma)a_1 + \frac{\eta + \alpha}{1-\alpha}\right) (1-\alpha) (1-\beta\theta) \frac{(1-\theta)}{\theta(1-\alpha + \alpha\varepsilon)}$$

$$\kappa_m = (1-\alpha) (1-\beta\theta) (\sigma - \nu) (1-a_1) \frac{(1-\theta)}{\theta(1-\alpha + \alpha\varepsilon)}$$

$$\kappa_r = \frac{1}{\nu - a_1(\nu - \sigma)}$$

$$\kappa_{mp} = \frac{(\sigma - \nu)(1-a_1)}{\nu - a_1(\nu - \sigma)}$$

$$\kappa_{sp} = -\frac{1}{\nu - a_1(\nu - \sigma)}$$

$$\kappa_{sm} = -\frac{(1-a_1)(\nu - \sigma)}{(\nu - a_1(\nu - \sigma))(1-\nu)}$$

$$\kappa_i = \frac{a_2}{\nu}$$

$$\text{with } a_1 = \frac{1}{1 + (b/(1-b))^{1/\nu} (1-\beta)^{(\nu-1)/\nu}} \text{ and } a_2 = \frac{1}{\exp(1/\beta) - 1}.$$

Bayesian Estimations

- We define three different periods in order to analyze three different crises:
 - 1990Q1 to 1993Q4, during the speculative attacks on currencies in the European Exchange Rate Mechanism (Black Wednesday crisis);
 - 2000Q1 to 2003Q4, during the burst of the Dot-com bubble (Dot-com crisis);
 - and 2006Q1 to 2009Q4, during the Subprime's crisis period.
- Each period is of 16 quarters, and for every quarter of each period we run a Bayesian estimation by using the 25 observations before each respective quarter.

Methodology and Results

- These estimates provide the values of micro and macro parameters explaining the dynamics of the models.
- We estimate variance decompositions of variables with respect to shocks (money, monetary policy, technology, preferences).
- Finally, we run DSGE forecasts after each estimation in order to compare the forecasting performances of the two models over 4 out-of-sample periods.

Black Wednesday Crisis

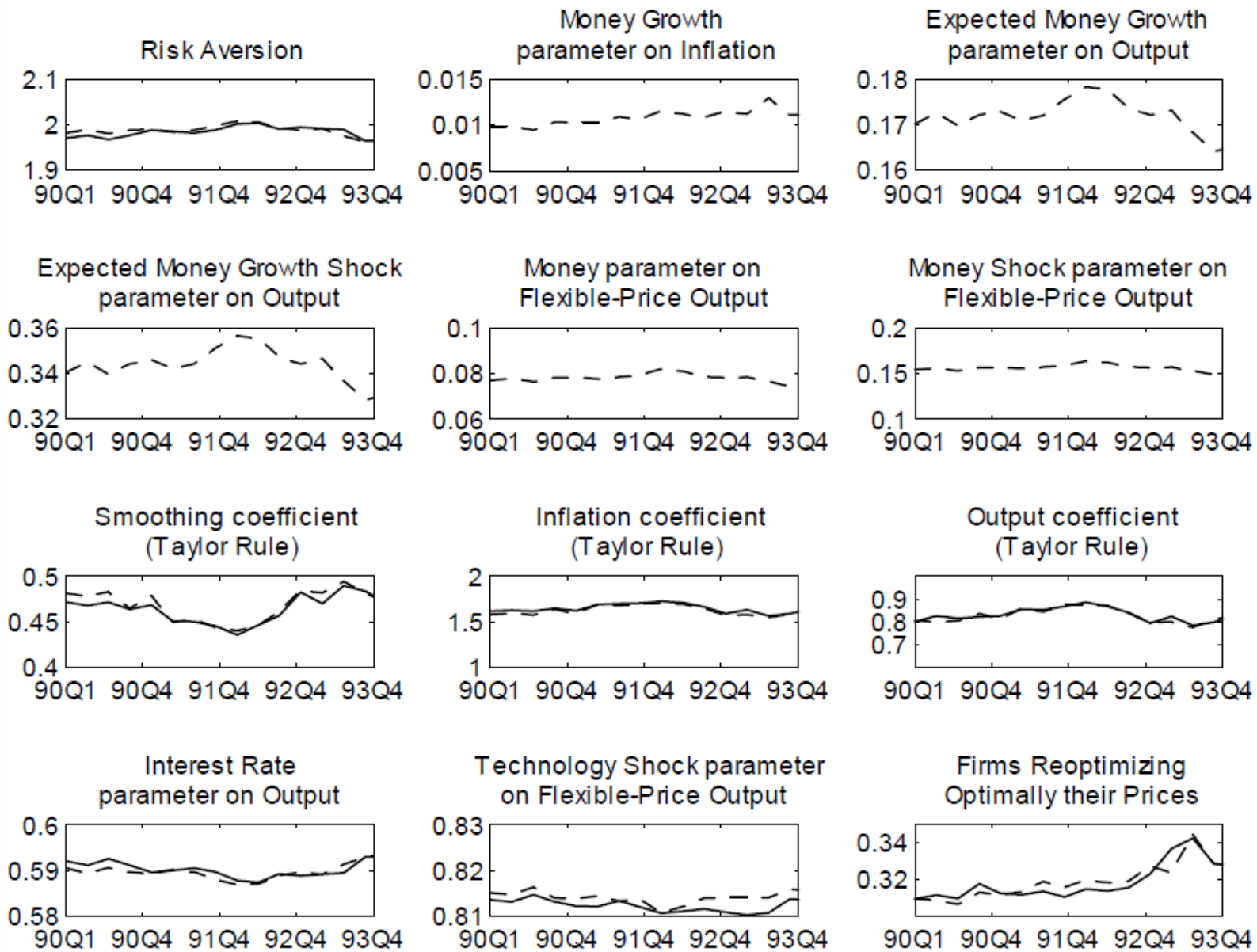


Figure 2: Parameters variations (1990Q1 to 1993Q4)

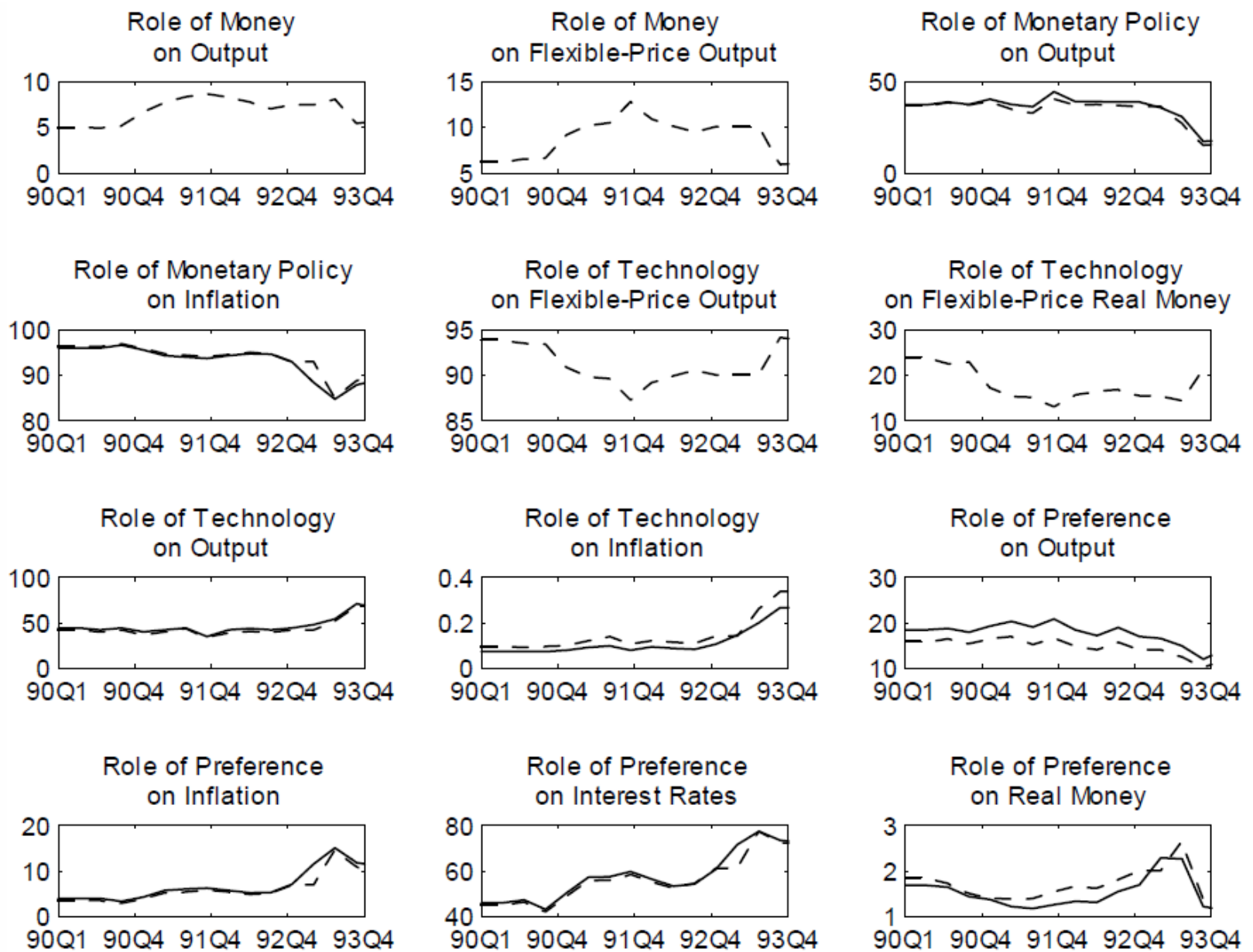


Figure 3: Variance decomposition in percent (1990Q1 to 1993Q4)

Dot-com Crisis

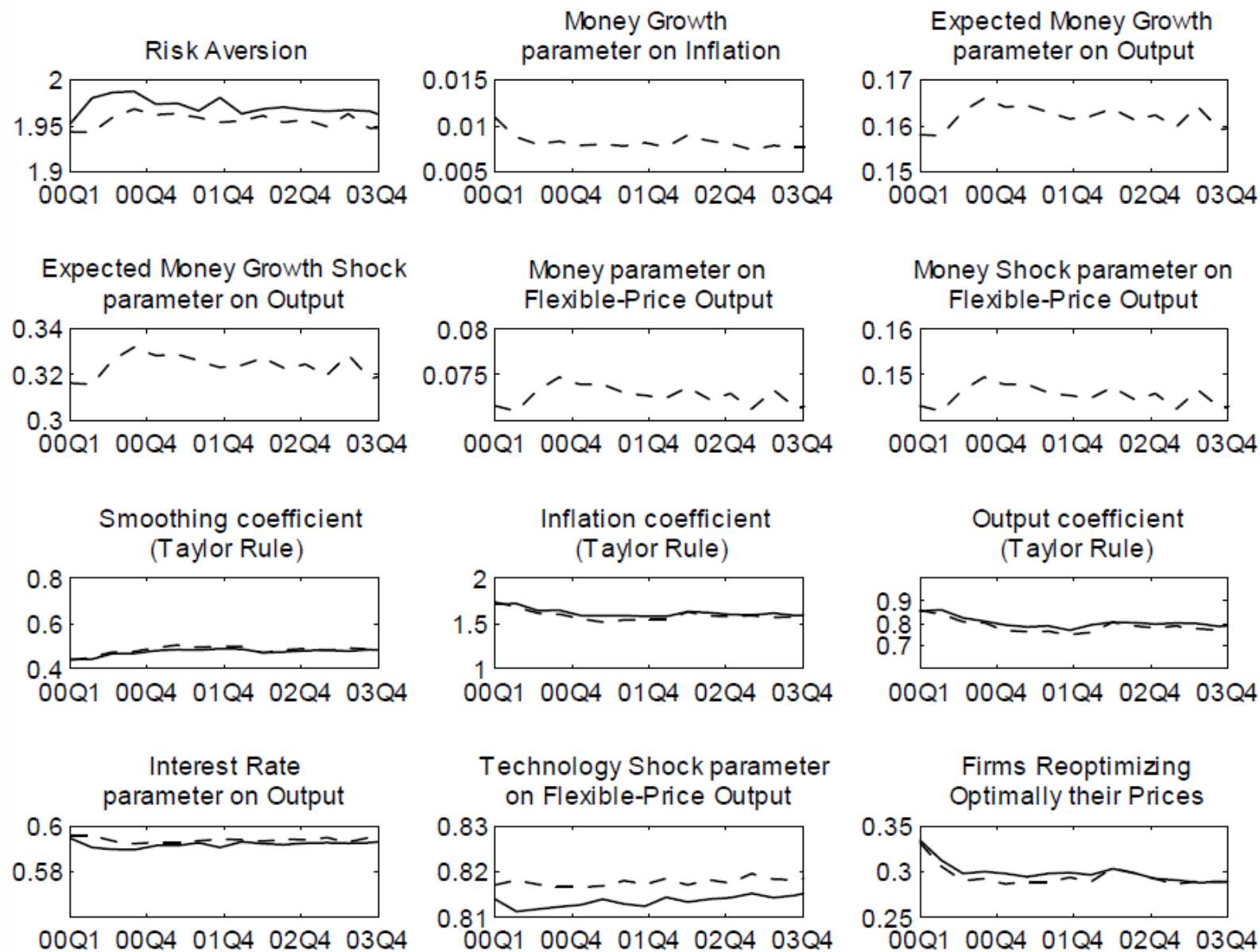


Figure 5: Parameters variations (2000Q1 to 2003Q4)

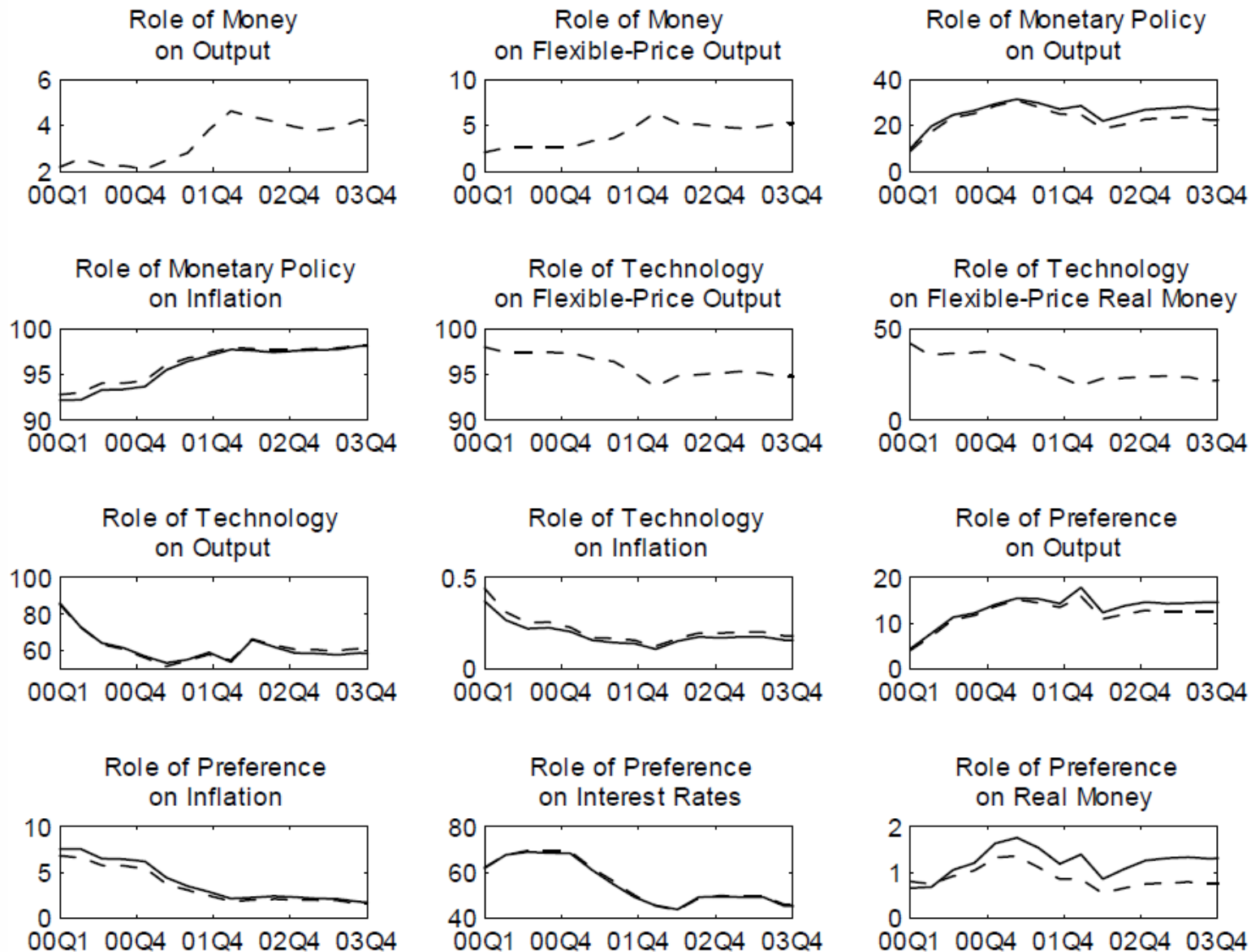


Figure 6: Variance decomposition in percent (2000Q1 to 2003Q4)

Subprime Crisis

Parameter Analysis

- Figure 8 shows that risk aversion reaches a maximum around 2008Q1-2008Q2. Then, risk aversion falls for the two models.
- From about the same period, all the money related parameters on output and inflation also fall.

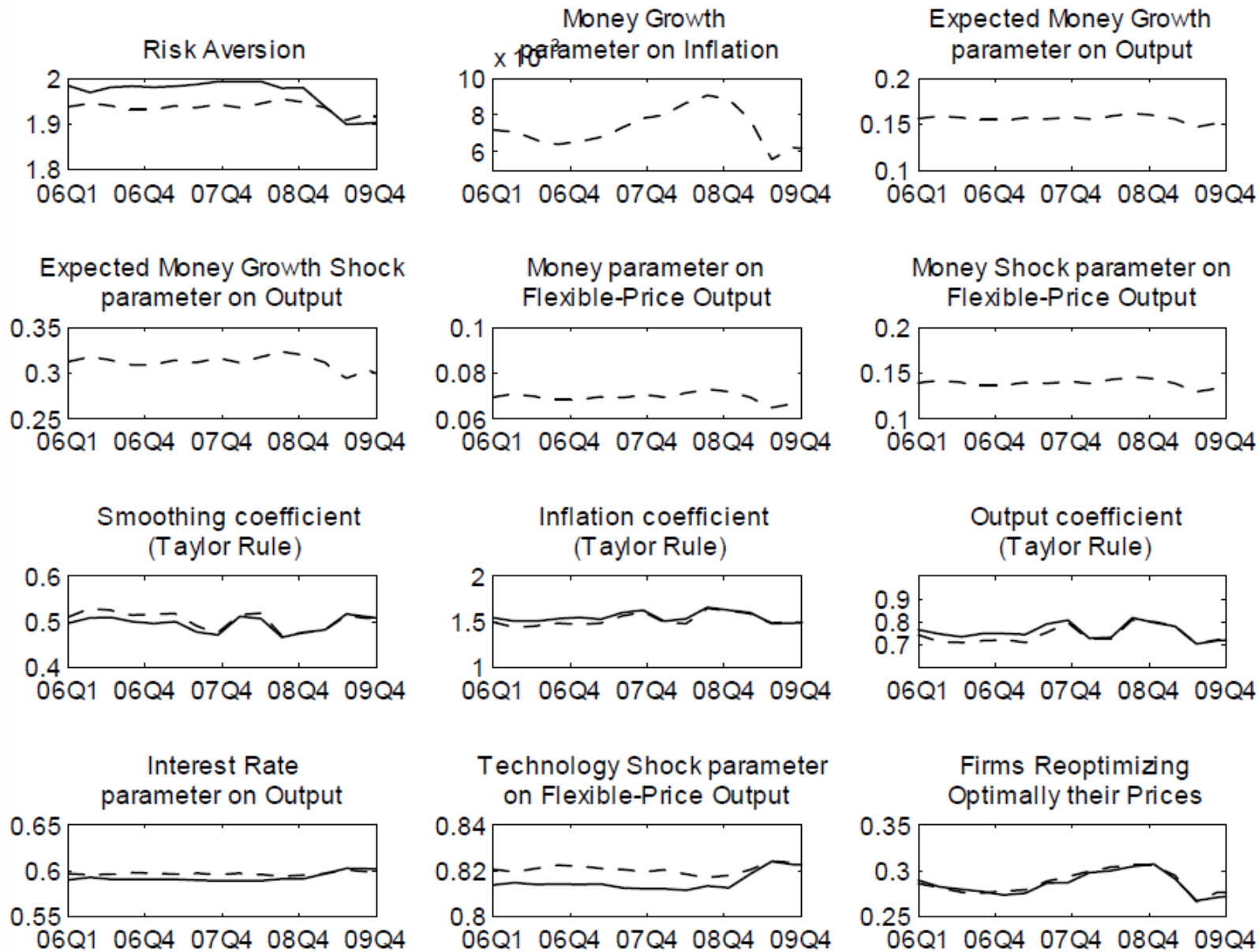


Figure 8: Parameters variations (2006Q1 to 2009Q4)

Variance decomposition

- The role of the money shock on output increases in 2007 to reach a peak in 2008Q2. It explained around 5% of the variance in 2006Q4, reaches 12% in 2008Q2 and goes back to 4% in 2009Q4.
- The impact of money on the flexible price output follows about the same dynamic path.
- Contrary to other studies (Ireland, 2004; Andrès and al., 2006;), this result shows that money had a significant role to play during the financial crisis.
- It is interesting to notice that the role of the monetary policy shock is also in the same vein, but it reaches its peak a little earlier.
- Monetary policy explains most of the inflation variance, but changes along the same lines as above with the crisis.

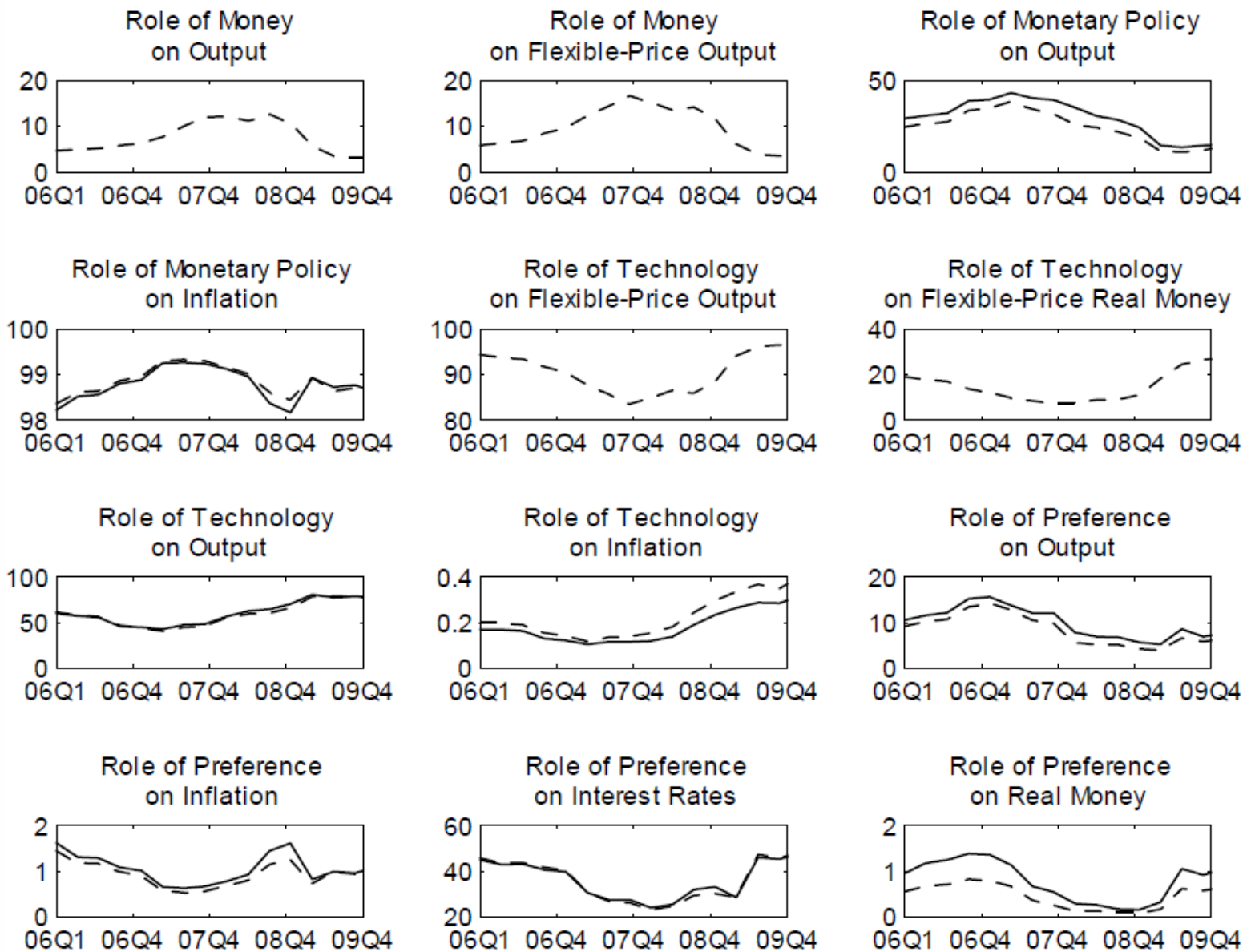


Figure 9: Variance decomposition in percent (2006Q1 to 2009Q4)

Forecasting performances

- Measurement: the difference in the RMSD of the 2 models with respect to the actual values.
- The non-separable model provides the best forecasting performance for output during the subprime crisis, especially at the top of the financial crisis (mid 2007 to mid 2008).
- The forecasting performance of the two models is not different as far as inflation is concerned.

Comparison of output and inflation DSGE forecast errors
Positive bar: Non-Separable model is better
Negative bar: Baseline model is better

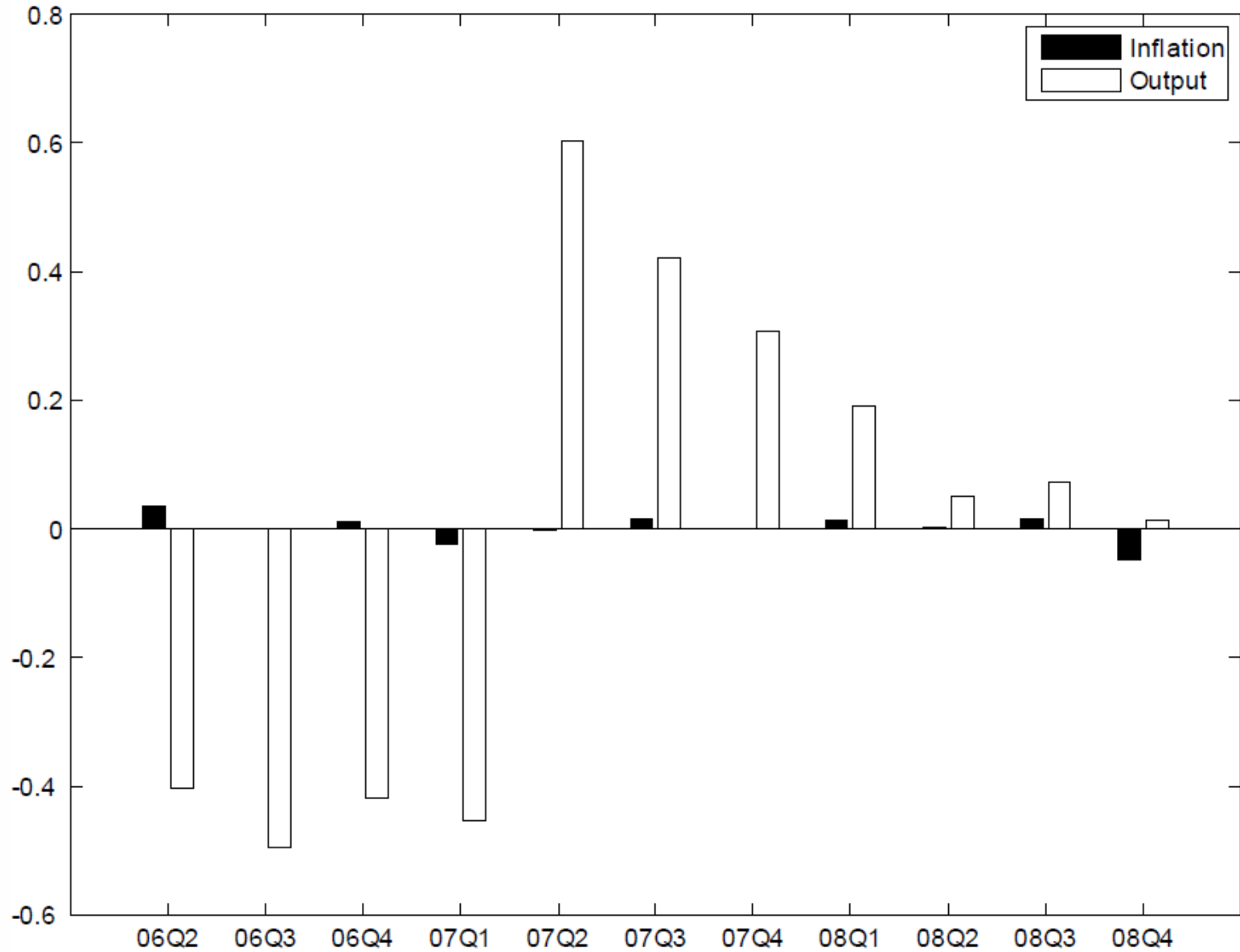


Figure 10: Out-of-sample forecasting errors (DSGE Forecast)

Forecasting performance for other periods

- Dot-com crisis: 2000Q1 to 2003Q4, burst of the dot-com bubble.
- -Black Wednesday crisis: 1990Q1 to 1993Q4, speculative attacks on the European Exchange Rate System.

Comparison of output and inflation DSGE forecast errors
Positive bar: Non-Separable model is better
Negative bar: Baseline model is better

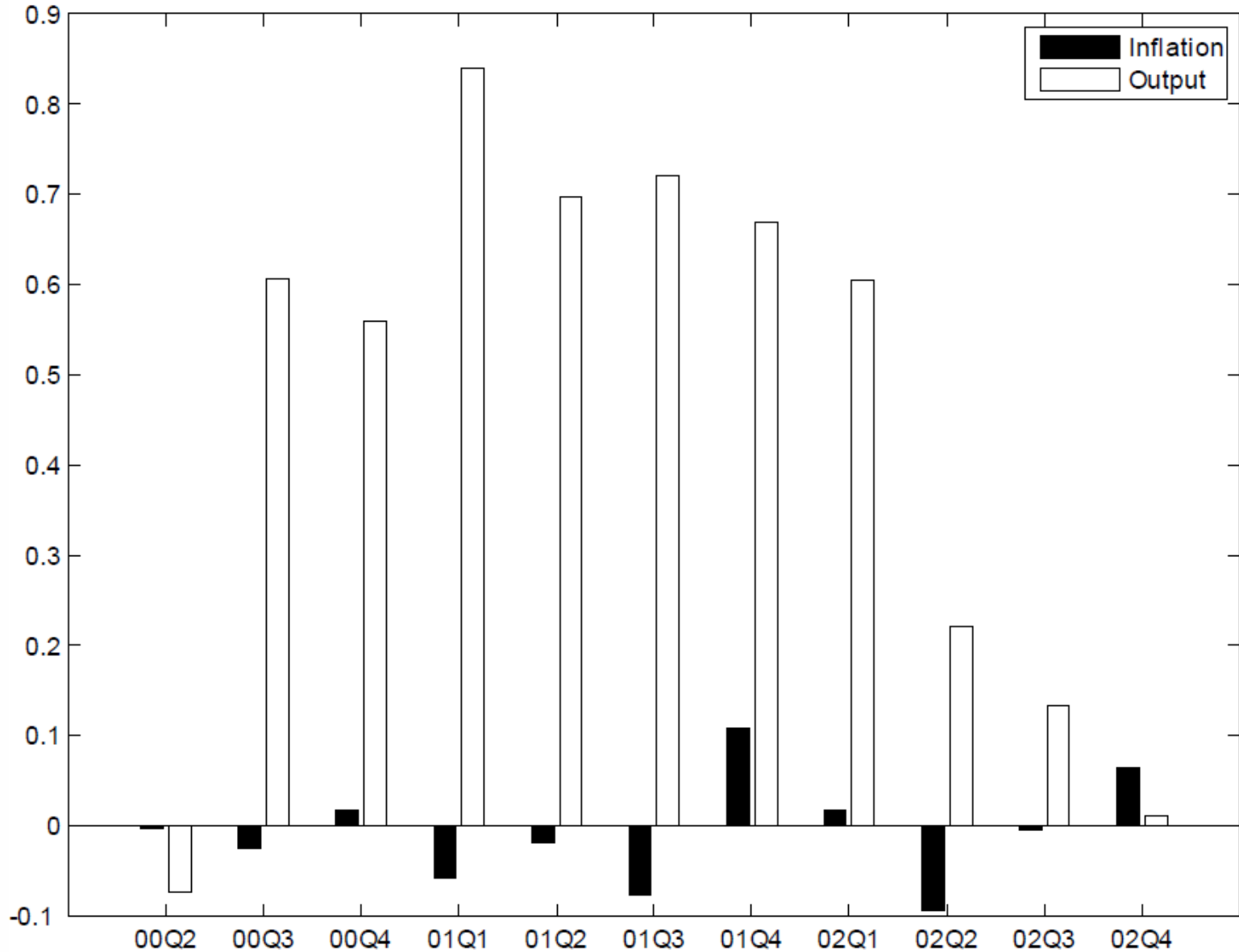


Figure 7: Out-of-sample forecasting errors (DSGE Forecast)

Comparison of output and inflation DSGE forecast errors
Positive bar: Non-Separable model is better
Negative bar: Baseline model is better

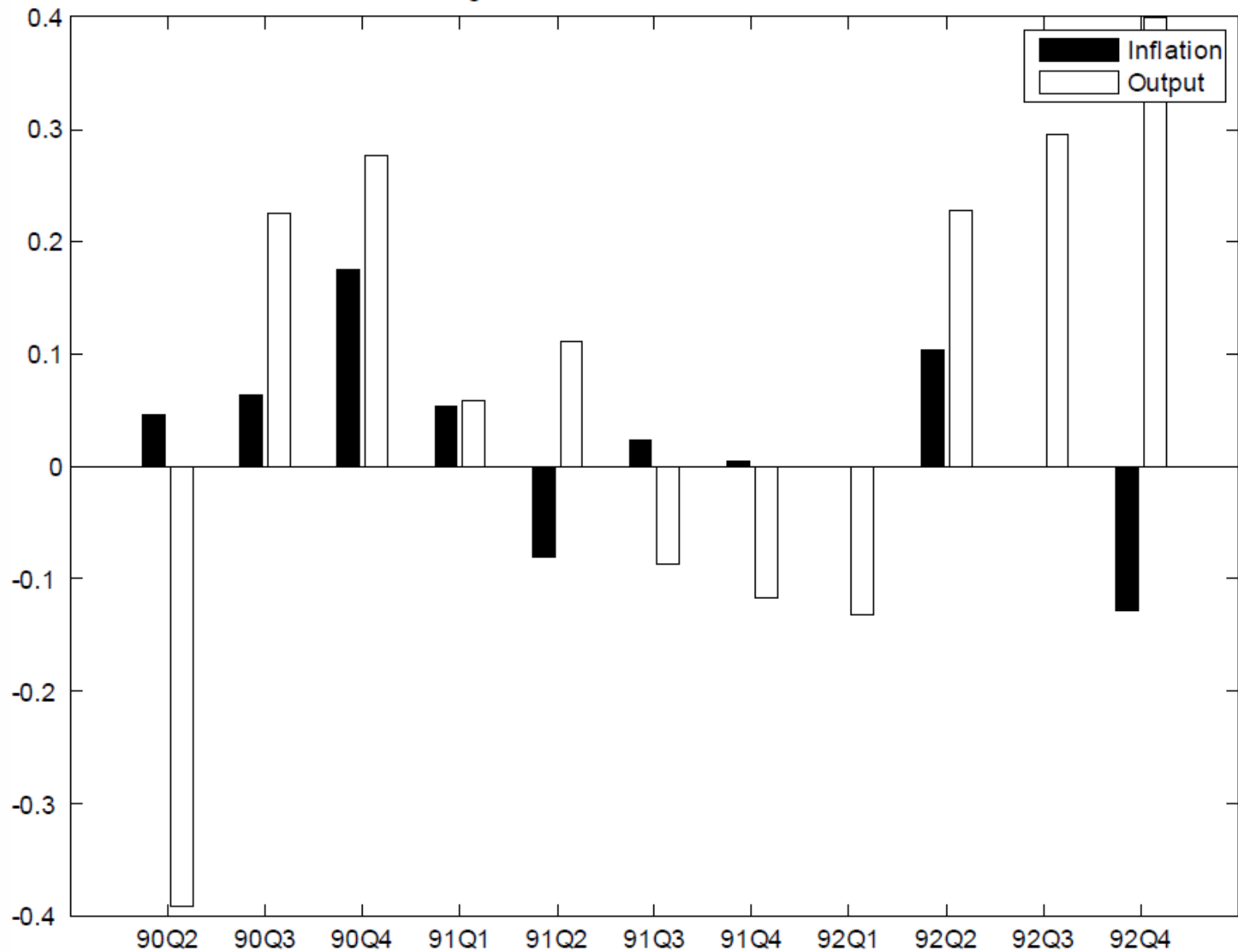


Figure 4: Out-of-sample forecasting errors (DSGE Forecast)

Conclusion

- (We compared 2 DSGE models, one baseline model with separable preferences (Galí, 2008) and another with non-separable preferences (Benchimol and Fourçans, 2009), during 3 crisis periods: Black Wednesday crisis, Dot-com crisis and Subprime crisis.
- We tested the two models by using successive Bayesian estimations, so as to shed light on the evolution of parameters, of variance decomposition and of forecasting performances of the two models over the 3 crises.)

Conclusion (follow up)

- Our analysis shows that **money has a significant role to play in explaining output during crises**. The role of money related variables increase during these periods.
- **The role of monetary policy on output decreases significantly during crisis periods.**
- **Inflation does not seem to be affected** directly by money variables. It is mainly explained by monetary policy, but its impact also varies during crises.