Money and monetary policy in Israel during the last decade

Money Macro and Finance Research Group
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This presentation does not necessarily reflect the views of the Bank of Israel

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[1]Bank of Israel

Layout

- Introduction
  - The question of money
  - Why Israel ? Why DMA ?
  - New Keynesian models
  - Literature review
- The models
  - Model 1 : Baseline model (Galí, 2008)
  - Model 2 : Non-separable model (Benchimol and Fourçans, 2012)
- Results
  - Methodology
  - Estimations
  - Simulations
- Conclusion

The question of money

- In the current New Keynesian literature, the role of monetary aggregates is generally **neglected**.
- The main economic variables of this kind of models are: the output gap, inflation and the interest rate.
- Yet it's hard to imagine money completely "passive" to the rest of the system !

Brunner and Meltzer

- 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.
- 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 the role played by credit and financial markets.
- This monetarist transmission process may also imply a specific role to real money balances when dealing with **uncertainty***.

Money and new Keynesian models

- Most of studies about New Keynesian models ignore money because of separable utilities, such as

$$E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{C_{t+i}^{1-\sigma}}{1-\sigma} + \frac{\gamma}{1-\vartheta} \left(\frac{M_{t+i}}{P_{t+i}} \right)^{1-\vartheta} - \chi \frac{N_{t+i}^{1+\eta}}{1+\eta} \right]$$

- Solving this problem makes money completely recursive to the rest of the system of equations.
- Yet, real money holdings could affect household's consumption under high uncertainty.
- In other words, real money balances are supposed to affect the marginal utility of consumption.
- We have to assume **non-separable utility** between consumption and real money balances.

Selected papers

- Ireland, 2004, **Money's Role in the Monetary Business Cycle**, *Journal of Money, Credit and Banking*.
- Andrés, López-Salido and Vallés, 2006, **Money in an Estimated Business Cycle Model of the Euro Area**, *Economic Journal* + *JEDC* with Nelson (2009).
- Barthélemy, Clerc, and Marx, 2011, **A two-pillar DSGE monetary policy model for the euro area**, *Economic Modelling*.
- Benchimol and Fourçans, 2012. **Money and risk in a DSGE framework: a Bayesian application to the Eurozone**, *Journal of Macroeconomics.*
- Benchimol and Fourçans, forthcoming, **Money and monetary policy in the Eurozone: an empirical analysis during crises**, *Macroeconomic Dynamics*.

Selected similarities and differences

Compared to the literature, we have:

1. Almost the same **utility function**
2. Long and short run variance decomposition analysis
3. Micro-founded NKDSGE analysis *à la* Galí (flexible price economy)
4. Money considerations + [3] : **money in flexible-price**.
5. Price-markup shock + [4]
6. **Short sample** analysis + [3]
7. **Rolling window estimations** + [3]
8. Bayesian analysis + [4]
9. **Forecasting accuracy** analysis + [4]

However, in the literature, we do not have:

10. **Money as a risk indicator**.
11. **Civil instability** phenomenon (intifada) and money considerations.
12. **Divisia monetary aggregates (DMA)** time series. Why ?

What do we do ?

- We compare two types of NKDSGE models.
- We test the models by using Bayesian techniques on Israeli data (rolling-window estimations).
- We analyze changes in parameters, impulse response functions and variance decompositions over the last decade.
- We also study the forecasting performances of the two models during these periods.
- We compare our results with a FCI (Financial Condition Index) and its components for Israel.
- In addition, we analyze our results in the light of political context.

New Keynesian framework

The models consist of economic agents of 3 types :

- Households: supply labor, purchase goods for consumption, hold money and bonds, and maximize the expected present value of utility.
- Firms: hire labor, produce and sell differentiated products in monopolistically competitive goods markets (Dixit and Stiglitz, 1977), and maximize profits.
- Central bank: controls the nominal rate of interest (ad-hoc rule).

NK features: sticky and flexible-price economies *à la* Galí (2008).

Separable money in the utility

- Preferences of the representative household are defined over a composite consumption good C_t, real money balances $\frac{M_t}{P_t}$, and leisure $1 - N_t$, where N_t is the time devoted to market employment.
- Galí's utility function:

$$U_t = \frac{C_t^{1-\sigma}}{1-\sigma} + \frac{\gamma e^{\varepsilon_t^m}}{1-\vartheta}\left(\frac{M_t}{P_t}\right)^{1-\vartheta} - \frac{\chi N_t^{1+\eta}}{1+\eta}$$

- Budget constraint:

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

- Production function:

$$Y_t = A_t {N_t}^{1-\alpha}$$

Non-separable money in the utility

- CES utility function:

$$U_t = \frac{1}{1-\sigma}\left(\left(1-b\right)C_t^{1-\nu} + be^{\varepsilon_t^m}\left(\frac{M_t}{P_t}\right)^{1-\nu}\right)^{\frac{1-\sigma}{1-\nu}} - \frac{\chi}{1+\eta}N_t^{1+\eta}$$

- 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.

Solving the models

- By using Lagrangian method in order to optimize the utility function with respect to the budget constraint (and a solvency condition), we obtain three first-order optimal conditions.
- We log-linearize around the steady state these conditions.
- We add an ad-hoc Taylor type rule equation to close our model.
- Structural shocks are assumed to follow a first-order autoregressive process with an *i.i.d.*-normal error term such as $\varepsilon_t^k = \rho_k \varepsilon_{t-1}^k + \omega_{k,t}$ where $\varepsilon_{k,t} \sim N(0; \sigma_k)$ for $k = \{p, m, i, a\}$.
- ε_t^p is the price-markup shock, ε_t^m is the money shock, ε_t^i is the exogenous component of the interest rate and ε_t^a is the technology shock.
- See Benchimol and Fourçans (JoM, MD) for more details.

$$\hat{y}_t^f = \delta_a \varepsilon_t^a - \delta_c \tag{1}$$

$$\hat{\pi}_t = \beta E_t \left[\hat{\pi}_{t+1}\right] + \delta_{y,t} \left(\hat{y}_t - \hat{y}_t^f\right) \tag{2}$$

$$\hat{y}_t = E_t \left[\hat{y}_{t+1}\right] - \sigma^{-1} \left(\hat{\imath}_t - E_t \left[\hat{\pi}_{t+1}\right]\right) \tag{3}$$

$$\hat{\imath}_t = (1 - \lambda_i) \left(\lambda_\pi \left(\hat{\pi}_t - t_\pi\right) + \lambda_x \left(\hat{y}_t - \hat{y}_t^f\right)\right) + \lambda_i \hat{\imath}_{t-1} + \varepsilon_t^i \tag{4}$$

where

$$\delta_a = \frac{1+\eta}{\sigma(1-\alpha)+\eta+\alpha} \qquad \delta_c = \frac{(1-\alpha)}{\sigma(1-\alpha)+\eta+\alpha} \ln\left(\frac{\varepsilon}{\varepsilon-1}\right)$$

$$\delta_{y,t} = \frac{(1-\theta)\left(\frac{1}{\theta}-\beta\right)(\sigma(1-\alpha)+\eta+\alpha)(1+(\varepsilon-1)\varepsilon_t^p)}{1+(\varepsilon-1)(\alpha+\varepsilon_t^p)}$$

$$\hat{y}_t^f = v_a^y \varepsilon_t^a + v_m^y \widehat{mp}_t^f - v_c^y + v_{sm}^y \varepsilon_t^m \tag{5}$$

$$\widehat{mp}_t^f = v_{y+1}^m E_t\left[\hat{y}_{t+1}^f\right] + v_y^m \hat{y}_t^f + \frac{1}{\nu}\varepsilon_t^m \tag{6}$$

$$\hat{\pi}_t = \beta E_t\left[\hat{\pi}_{t+1}\right] + \kappa_{x,t}\left(\hat{y}_t - \hat{y}_t^f\right) + \kappa_{m,t}\left(\widehat{mp}_t - \widehat{mp}_t^f\right) \tag{7}$$

$$\begin{aligned} \hat{y}_t \quad = \quad & E_t\left[\hat{y}_{t+1}\right] - \kappa_r\left(\hat{\imath}_t - E_t\left[\hat{\pi}_{t+1}\right]\right) \\ & + \kappa_{mp} E_t\left[\Delta \widehat{mp}_{t+1}\right] + \kappa_{sm} E_t\left[\Delta \varepsilon_{t+1}^m\right] \end{aligned} \tag{8}$$

$$\widehat{mp}_t = \hat{y}_t - \kappa_i \hat{\imath}_t + \frac{1}{\nu}\varepsilon_t^m \tag{9}$$

$$\hat{\imath}_t = (1-\lambda_i)\left(\lambda_\pi\left(\hat{\pi}_t - t_\pi\right) + \lambda_x\left(\hat{y}_t - \hat{y}_t^f\right)\right) + \lambda_i \hat{\imath}_{t-1} + \varepsilon_t^i \tag{10}$$

Micro-founded model

$$
\begin{aligned}
\upsilon_a^y &= \frac{1+\eta}{(\nu-a_1(\nu-\sigma))(1-\alpha)+\eta+\alpha} \\
\upsilon_m^y &= \frac{(1-\alpha)(\nu-\sigma)(1-a_1)}{(\nu-a_1(\nu-\sigma))(1-\alpha)+\eta+\alpha} \\
\upsilon_c^y &= \frac{(1-\alpha)}{(\nu-a_1(\nu-\sigma))(1-\alpha)+\eta+\alpha} \ln\left(\frac{\varepsilon}{\varepsilon-1}\right) \\
\upsilon_{sm}^y &= \frac{(1-\alpha)(\nu-\sigma)(1-a_1)}{((\nu-a_1(\nu-\sigma))(1-\alpha)+\eta+\alpha)(1-\nu)} \\
\upsilon_y^m &= 1+\frac{a_2}{\nu}\left(\nu-a_1\left(\nu-\sigma\right)\right) \\
\upsilon_{y+1}^m &= -\frac{a_2}{\nu}\left(\nu-a_1\left(\nu-\sigma\right)\right)
\end{aligned}
\qquad
\begin{aligned}
\kappa_r &= \frac{1}{\nu-a_1(\nu-\sigma)} \\
\kappa_{mp} &= \frac{(\sigma-\nu)(1-a_1)}{\nu-a_1(\nu-\sigma)} \\
\kappa_{sm} &= -\frac{(1-a_1)(\nu-\sigma)}{(\nu-a_1(\nu-\sigma))(1-\nu)} \\
\kappa_i &= a_2/\nu \\
a_1 &= \frac{1}{1+(b/(1-b))^{1/\nu}(1-\beta)^{(\nu-1)/\nu}} \\
a_2 &= \frac{1}{\exp(1/\beta)-1}
\end{aligned}
$$

$$
\kappa_{x,t} = \left(\nu-a_1\left(\nu-\sigma\right)+\frac{\eta+\alpha}{1-\alpha}\right)\frac{(1-\alpha)\left(\frac{1}{\theta}-\beta\right)(1-\theta)(1+(\varepsilon-1)\varepsilon_t^p)}{1+(\alpha+\varepsilon_t^p)(\varepsilon-1)}
$$

$$
\kappa_{m,t} = \left(\sigma-\nu\right)\left(1-a_1\right)\frac{(1-\alpha)\left(\frac{1}{\theta}-\beta\right)(1-\theta)(1+(\varepsilon-1)\varepsilon_t^p)}{1+(\alpha+\varepsilon_t^p)(\varepsilon-1)}
$$

Methodology

- As in Smets and Wouters (2003), An and Schorfheide (2007) and Barthélemy, Clerc and Marx (2011), we apply **Bayesian techniques** to estimate our NKDSGE models.
- We use quarterly **Israeli data** (including DMA) from Bank of Israel's database.

Data

- $\hat{\pi}_t$ is the **inflation** rate, measured as the yearly log difference of the GDP deflator from one quarter to the same quarter of the previous year;
- $\hat{y}_t$ is the **output** per capita, measured as the difference between the log of the real GDP per capita and its linear trend;
- $\hat{\imath}_t$ is the short-term (3-month) **nominal interest rate**;
- $\widehat{mp}_t$ is the **real money balances** per capita, measured as the difference between the real DMA per capita and its linear trend, where real DMA per capita is measured as the log difference between the DMA per capita and the GDP deflator;
- $\hat{y}_t^f$, the **flexible-price output**, and $\widehat{mp}_t^f$, the **flexible-price real money balances**, are entirely determined by structural shock.

Calibration

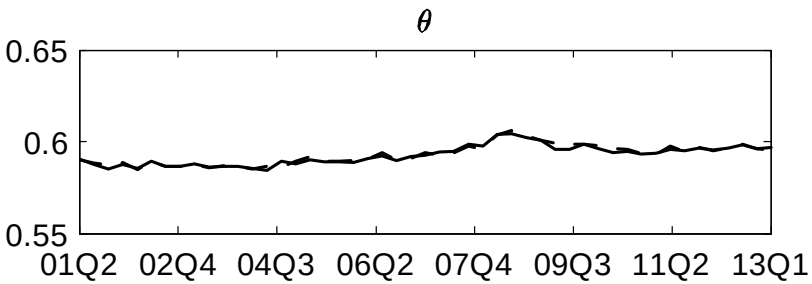
- Following standard conventions, we calibrate **beta** distributions for parameters that fall between zero and one, **inverted gamma** distributions for parameters that need to be constrained to be greater than zero, and **normal** distributions in other cases.
- The calibration of the micro parameters is inspired by Benchimol and Fourçans (2012) and Israeli literature (see the paper).

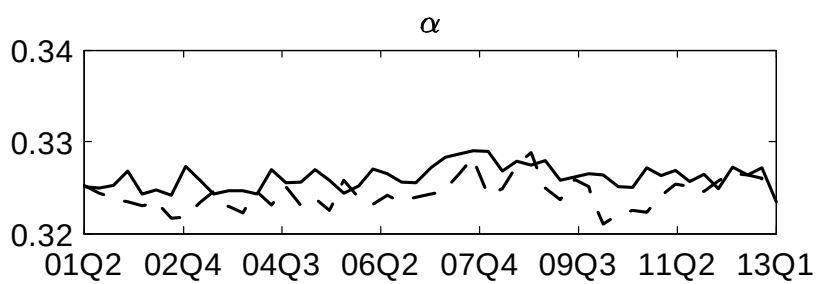
Methodology

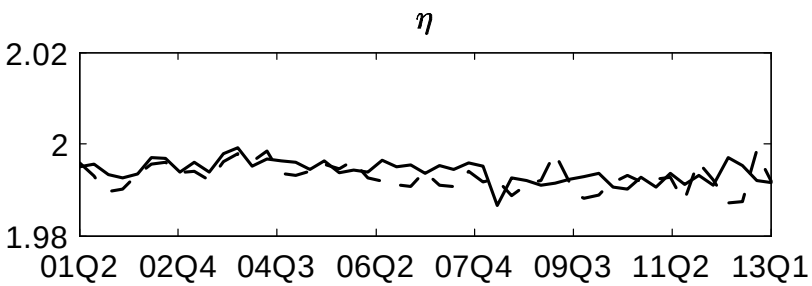
- **Rolling window estimations**
  - For every quarter, we run a Bayesian estimation using the 24 observations (6 years) before each respective quarter.
  - This sample size is validated by Fernandez-Villaverde and Rubio-Ramirez (2004).
- We use data from 1995 Q2 until 2013 Q1 in order to analyze the last decade (2001 Q2 - 2013 Q1):
  - **2000 Q4** to **2005 Q1**, Intifada crisis;
  - **2001 Q1** to **2003 Q1**, Dot-com crisis;
  - and **2007Q4** to **2011Q1**, Subprime crisis.

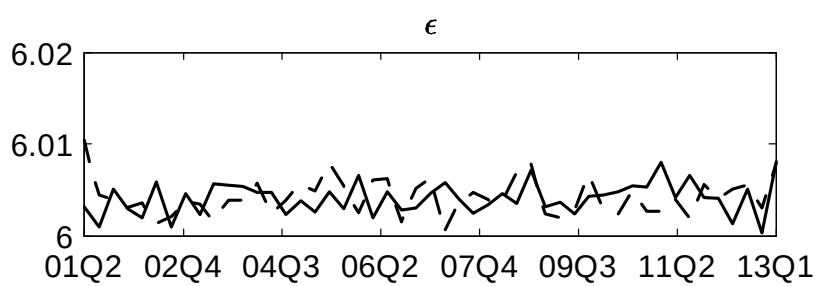
Methodology and results

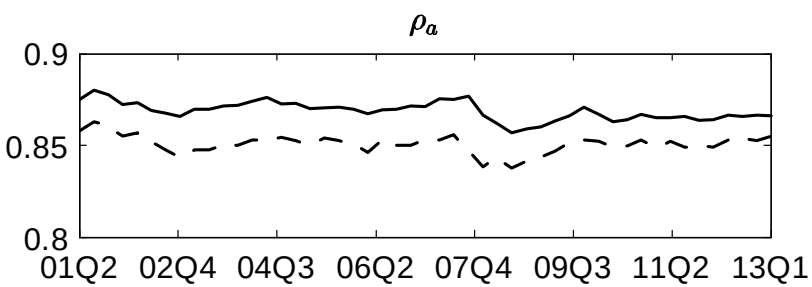
- These estimates provide the values of micro and macro parameters (explaining the dynamics of the models) **over time**.
- Following Iskrev (2010), all estimated parameters are identified for both models.
- We compute variance decompositions of variables with respect to shocks (technology, price-markup, money, and monetary policy).
- We run DSGE forecasts **after each estimation** in order to compare the forecasting performances of the two models over four out-of-sample periods (one year).

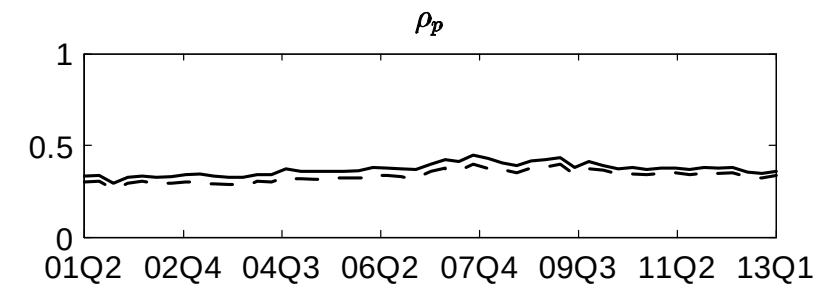




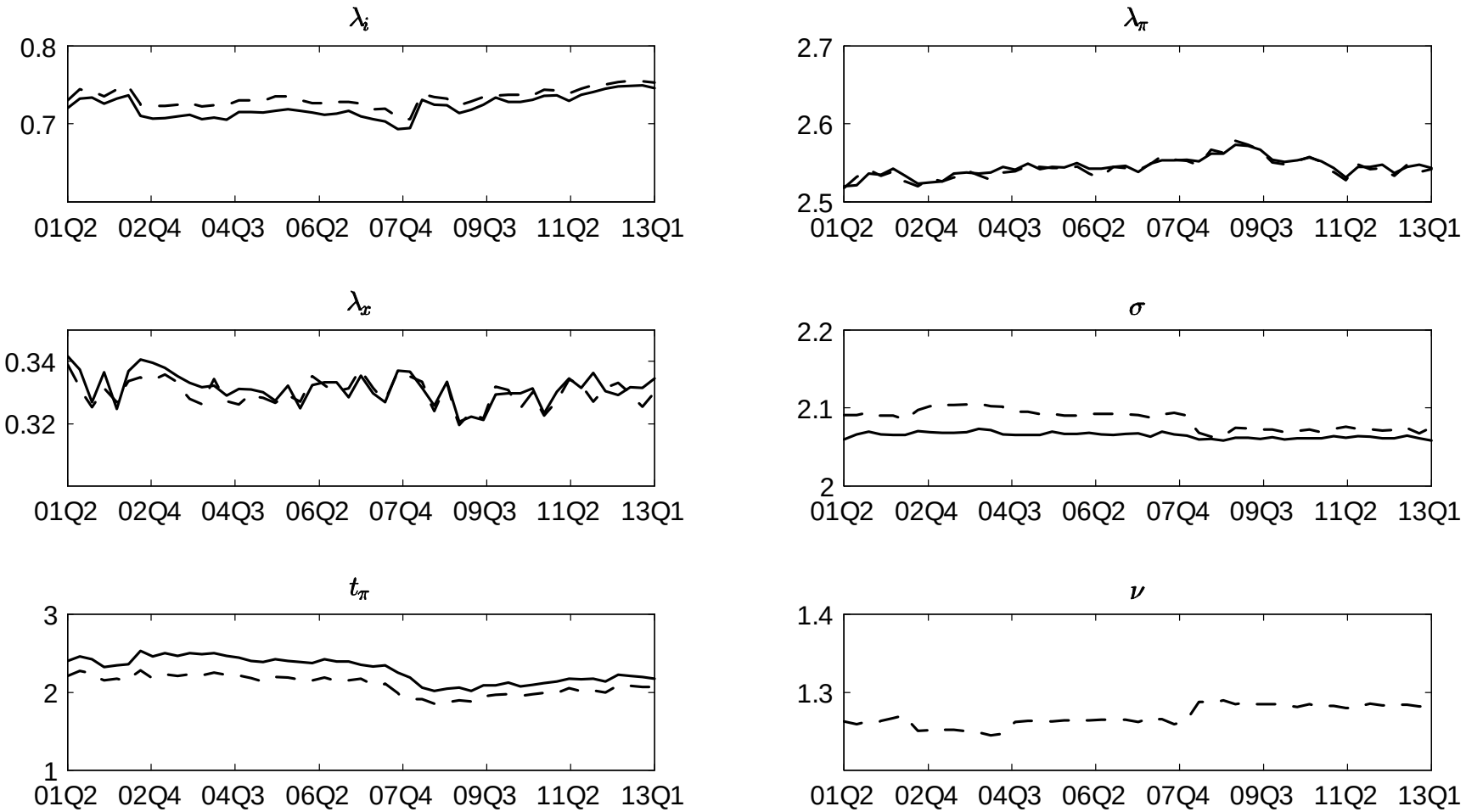


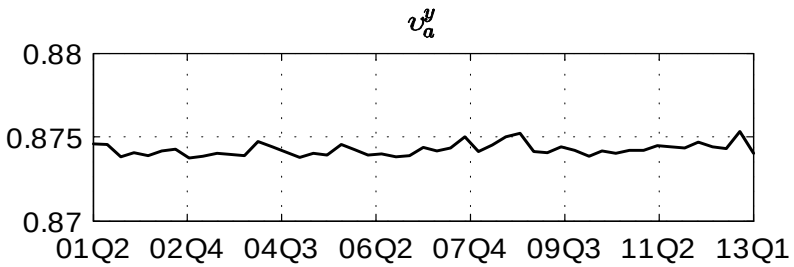


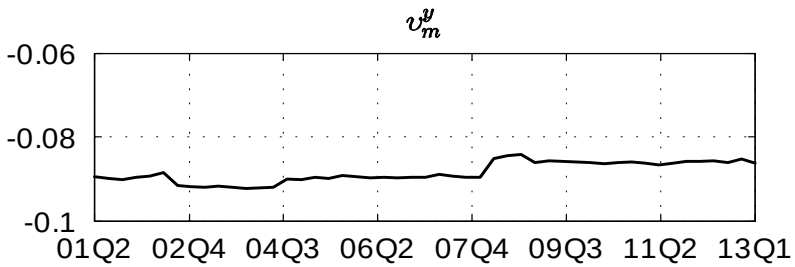


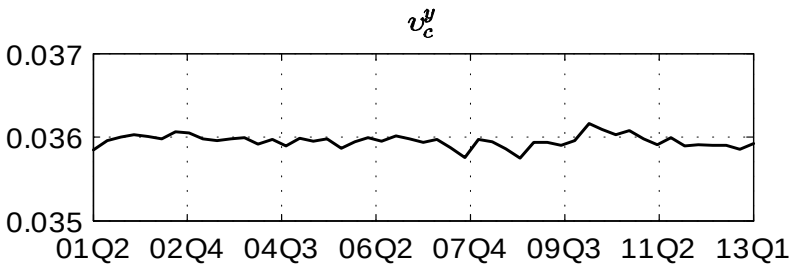


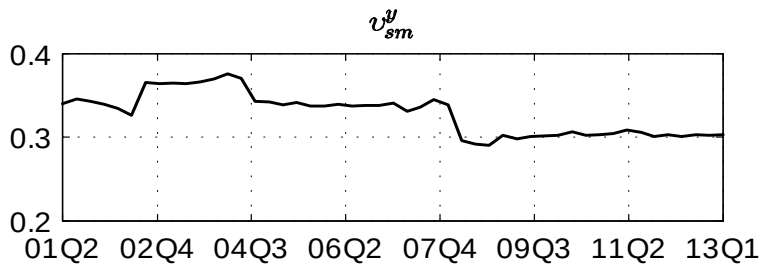
Model 1 — — — Model 2

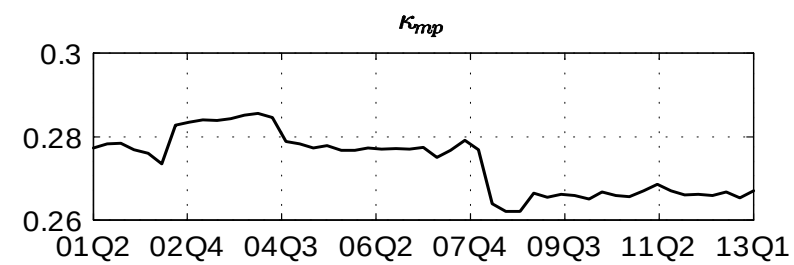

λ_i
0.8
0.7
λ_π
2.7
2.6
2.5
λ_x
0.34
0.32
σ
2.2
2.1
2
t_π
3
2
1
ν
1.4
1.3
01Q2 02Q4 04Q3 06Q2 07Q4 09Q3 11Q2 13Q1
Model 1
Model 2

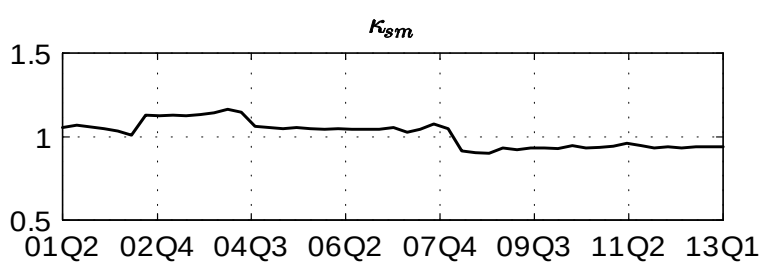

υ_a^y
0.88
0.875
0.87
01Q2 02Q4 04Q3 06Q2 07Q4 09Q3 11Q2 13Q1

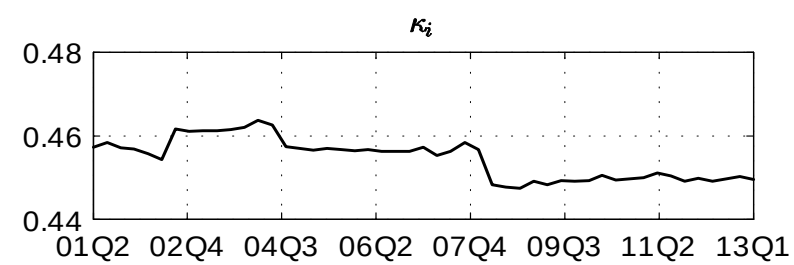

υ_m^y
-0.06
-0.08
-0.1
01Q2 02Q4 04Q3 06Q2 07Q4 09Q3 11Q2 13Q1

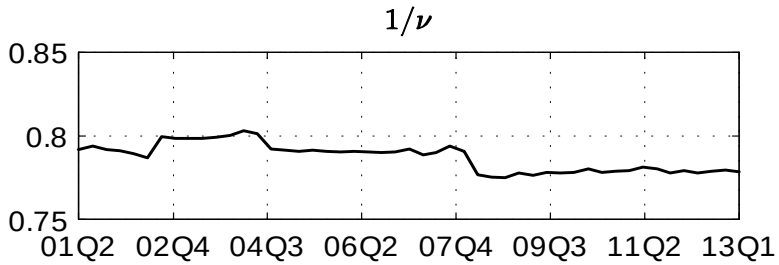

υ_c^y
0.037
0.036
0.035
01Q2 02Q4 04Q3 06Q2 07Q4 09Q3 11Q2 13Q1


υ_{sm}^y
0.4
0.3
0.2
01Q2 02Q4 04Q3 06Q2 07Q4 09Q3 11Q2 13Q1

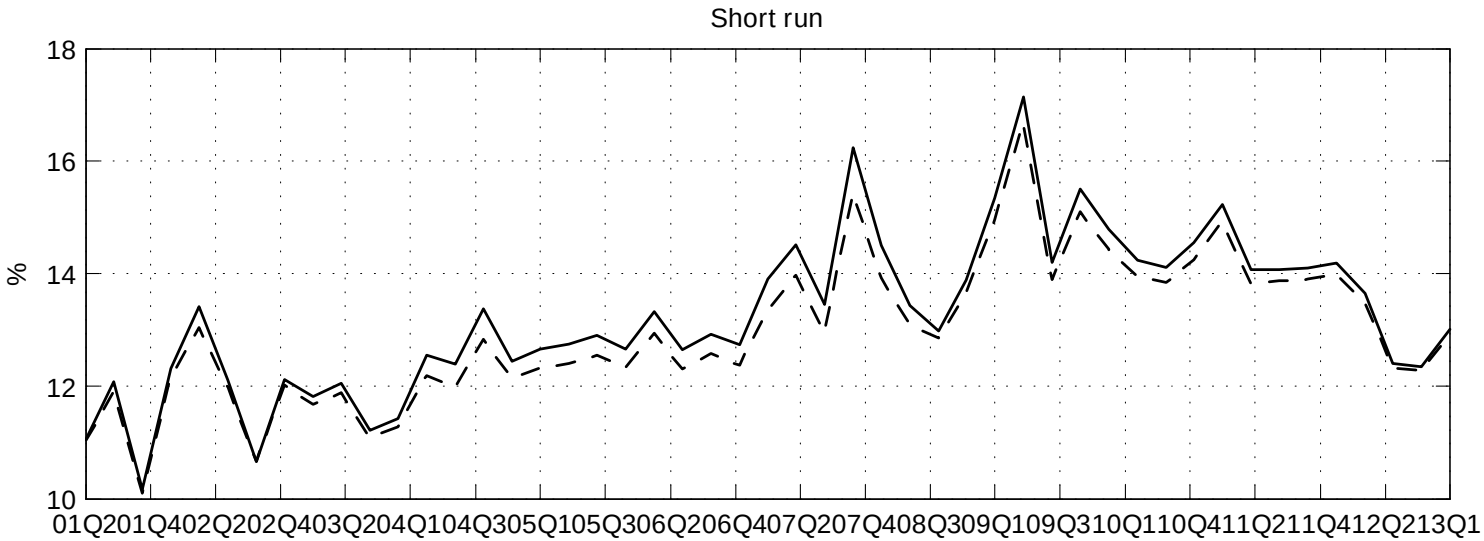

κ_{mp}
0.3
0.28
0.26
01Q2 02Q4 04Q3 06Q2 07Q4 09Q3 11Q2 13Q1

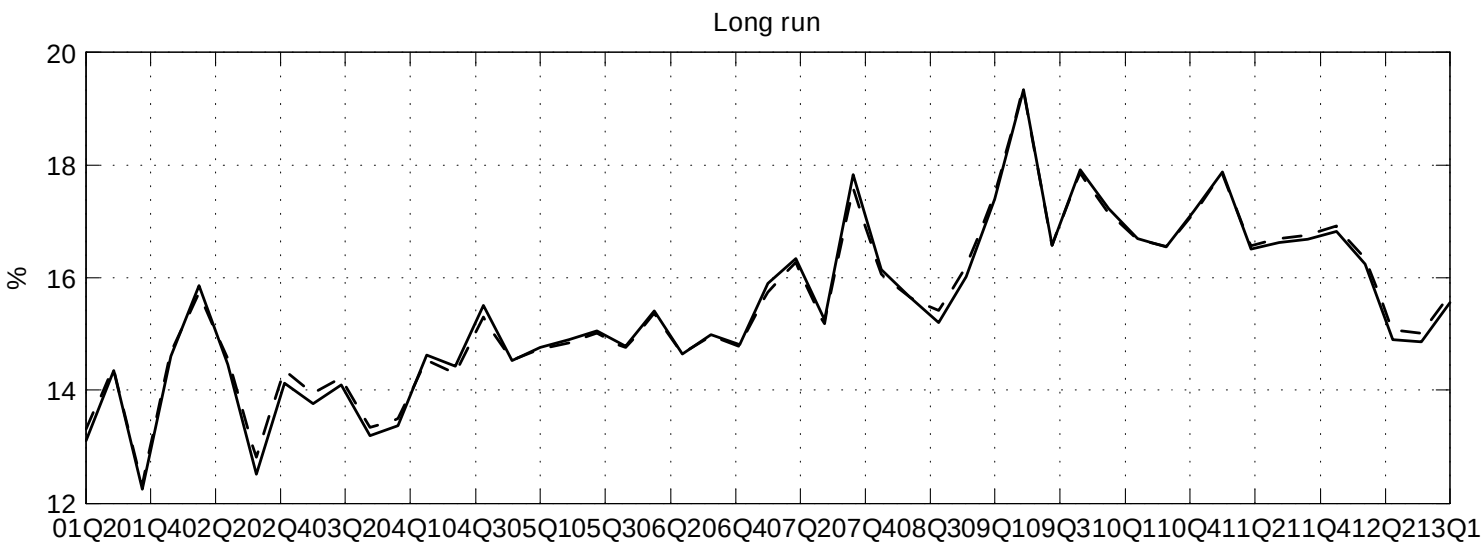

κ_{sm}
1.5
1
0.5
01Q2 02Q4 04Q3 06Q2 07Q4 09Q3 11Q2 13Q1


κ_i
0.48
0.46
0.44
01Q2 02Q4 04Q3 06Q2 07Q4 09Q3 11Q2 13Q1

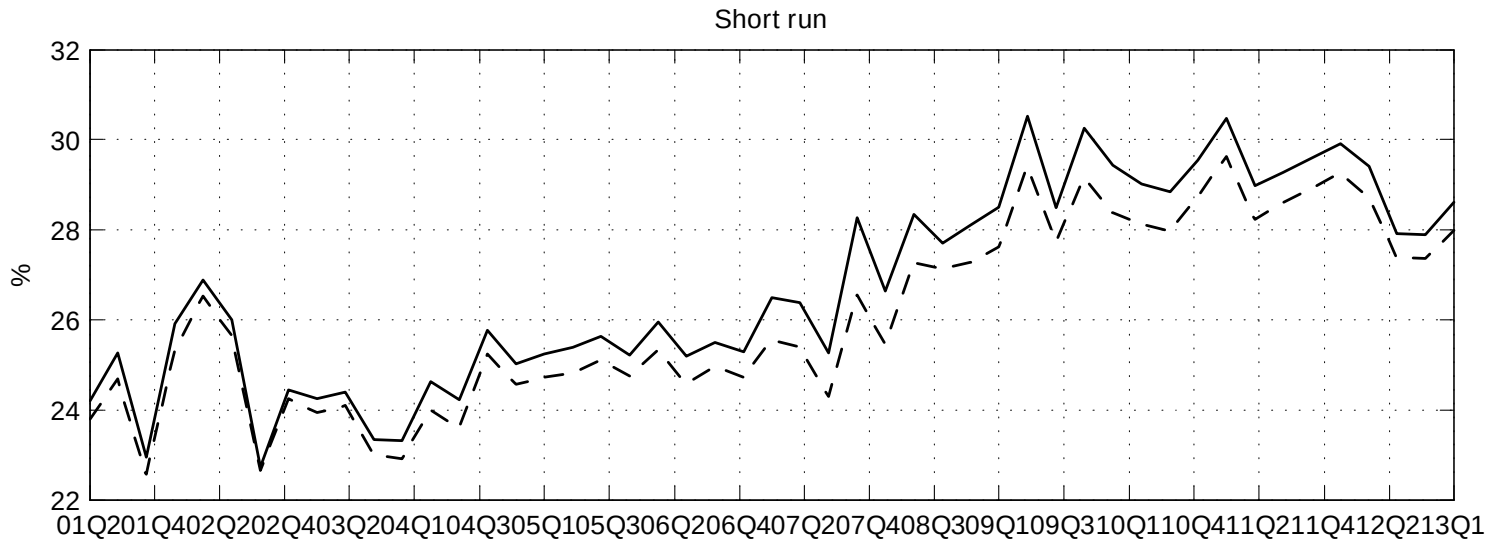

$1/\nu$
0.85
0.8
0.75
01Q2 02Q4 04Q3 06Q2 07Q4 09Q3 11Q2 13Q1

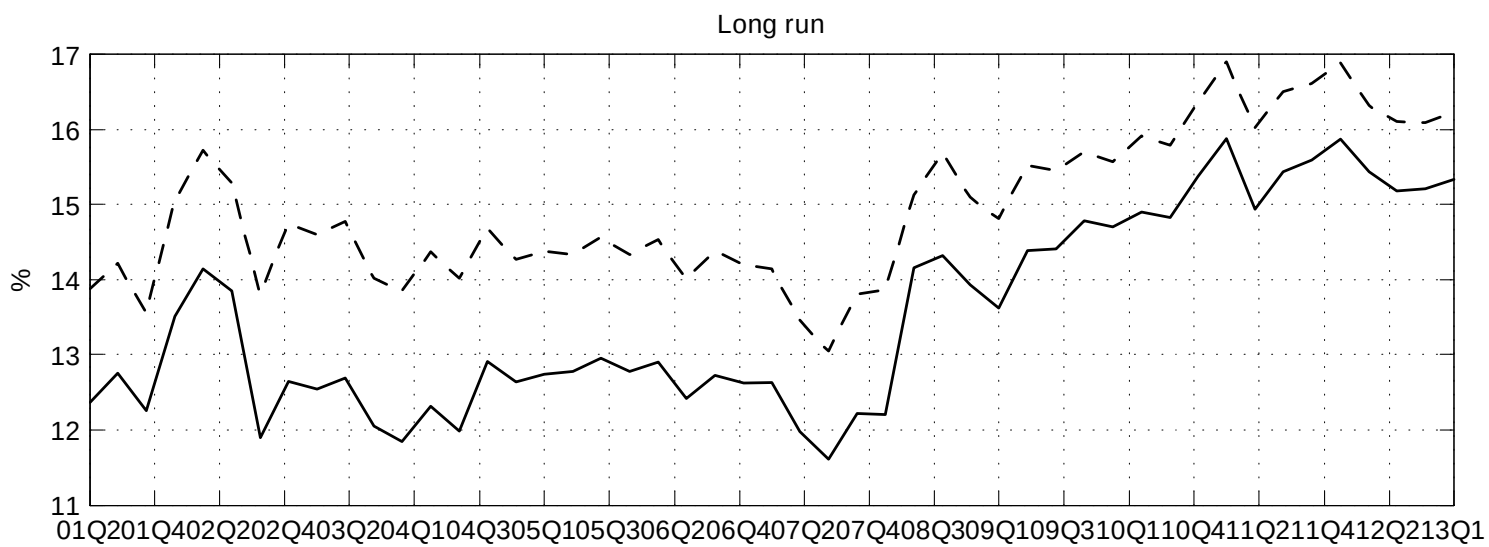
Role of monetary policy on inflation



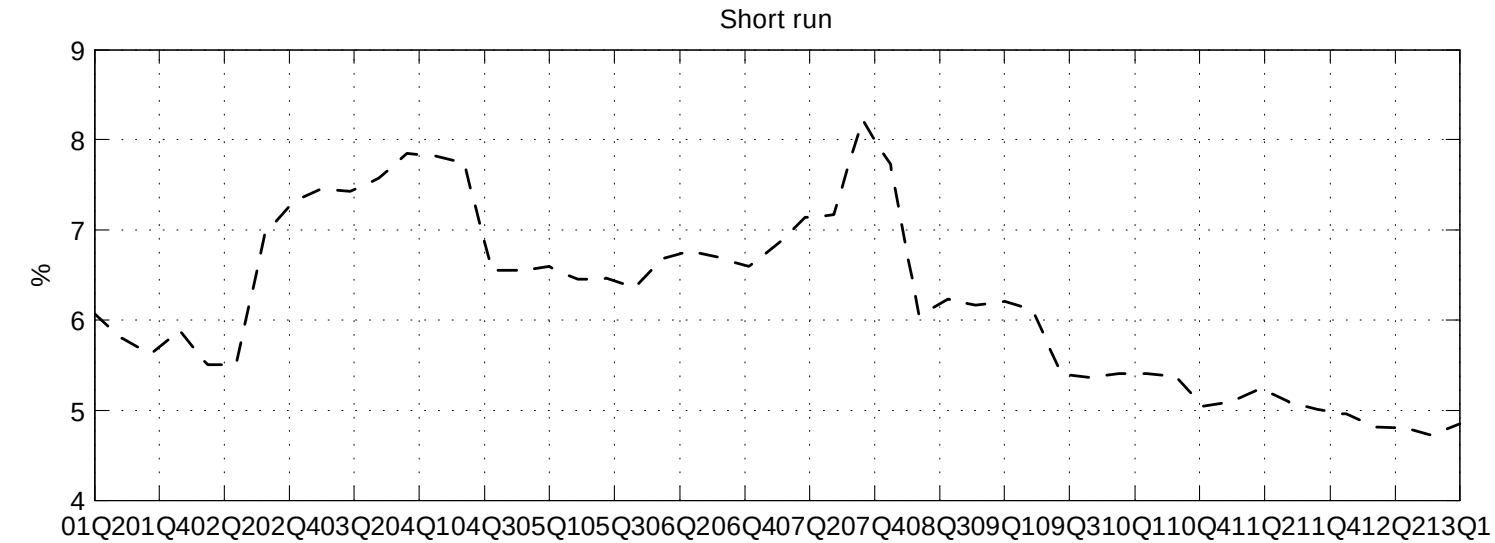


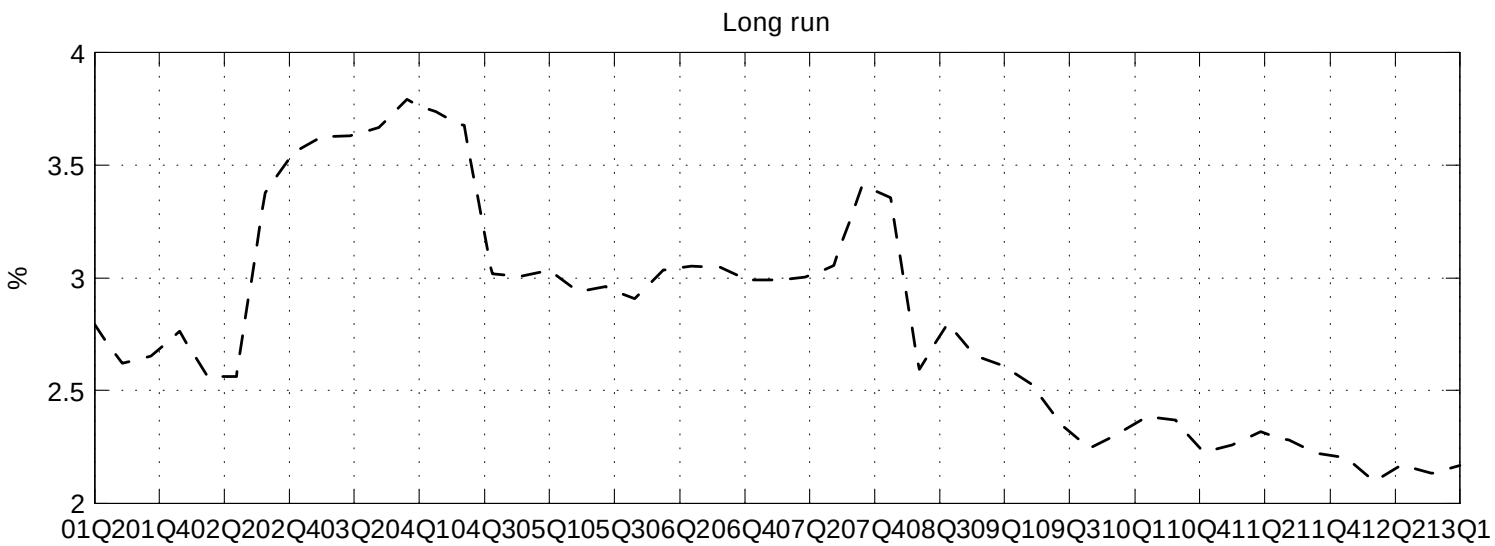
Role of monetary policy on output



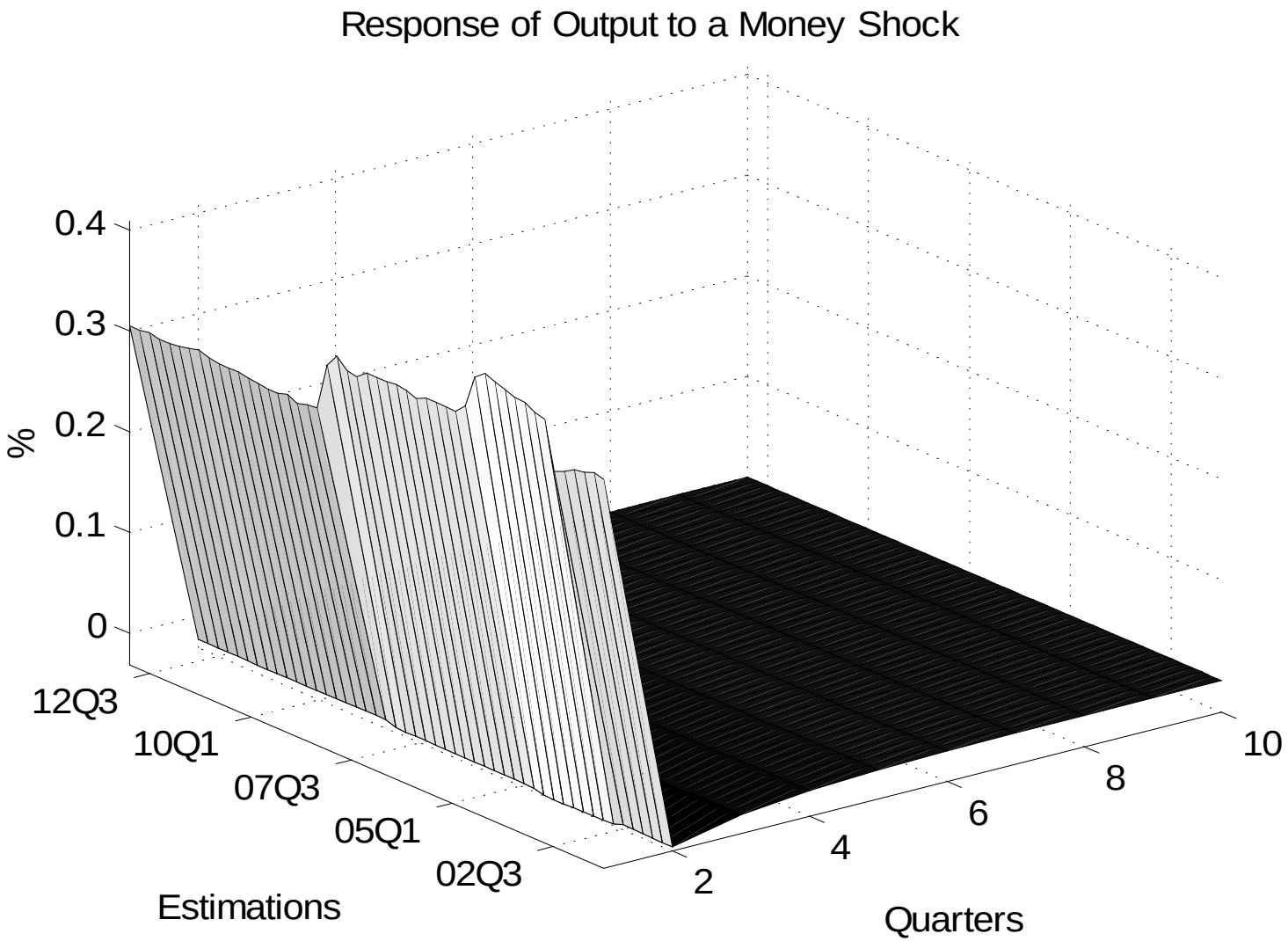


Role of money on output

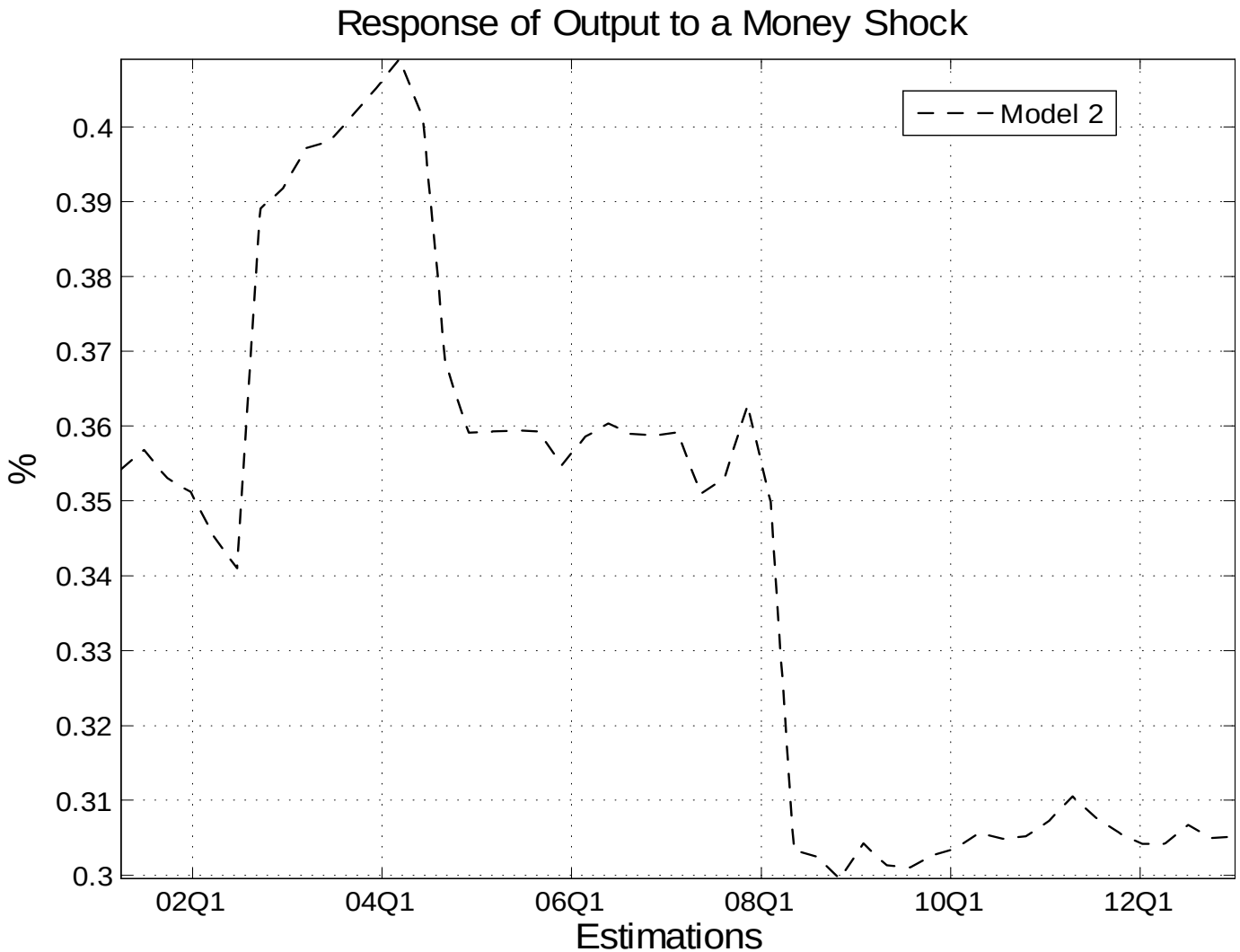




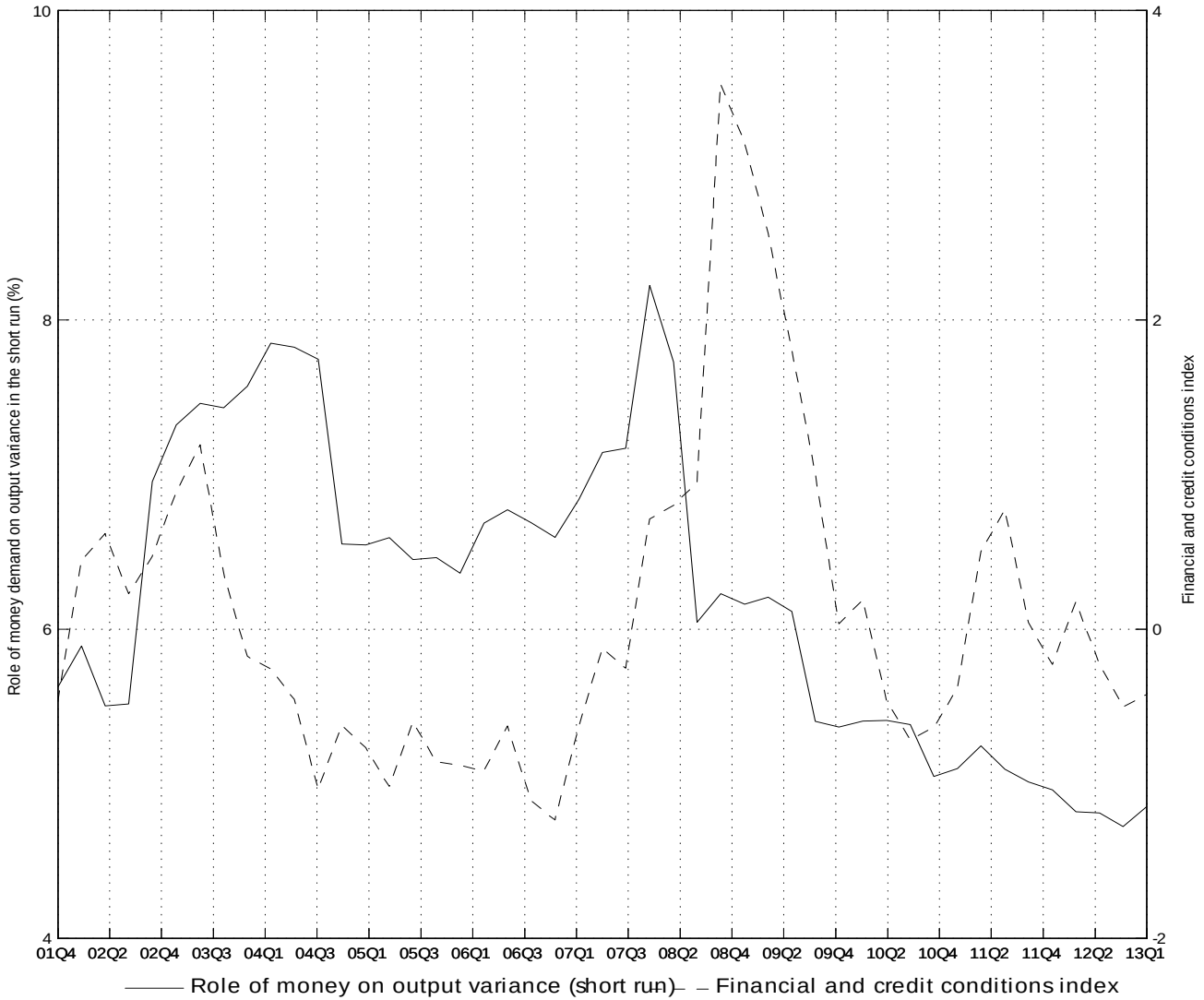
Impulse response function of output with respect to a money shock for Israel



On impact impulse response function of output with respect to a money shock



Comparison of the role of money on output variance and the financial condition index for Israel (Michelson and Suhoy, 2013).



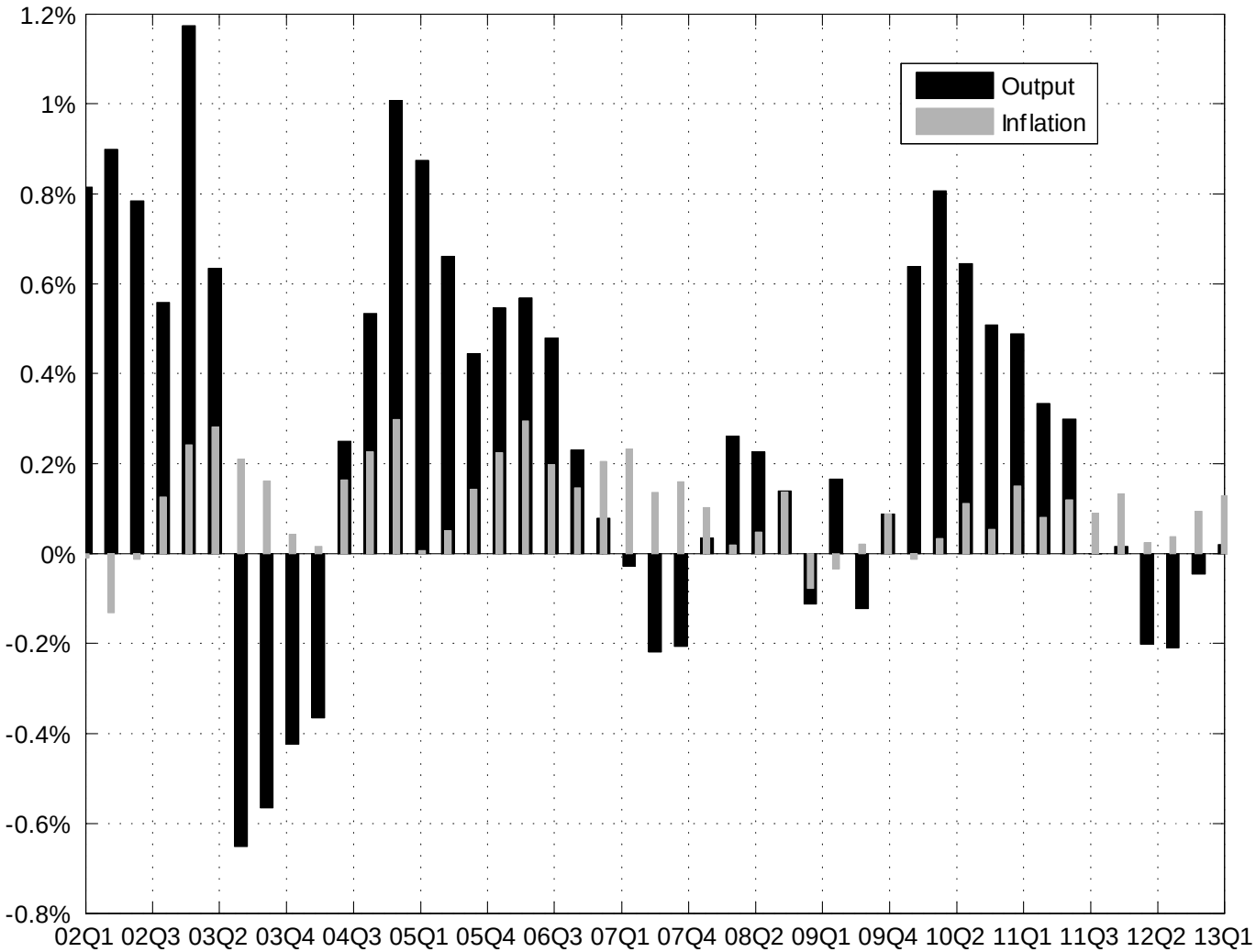
Distance correlations between the role of money on output and the FCI (and its components)

	FCI	Bank	Debt	Forex	Equities	Resid.
Money shock's contribution to output variance	0.299	0.425	0.292	0.336	0.263	0.293

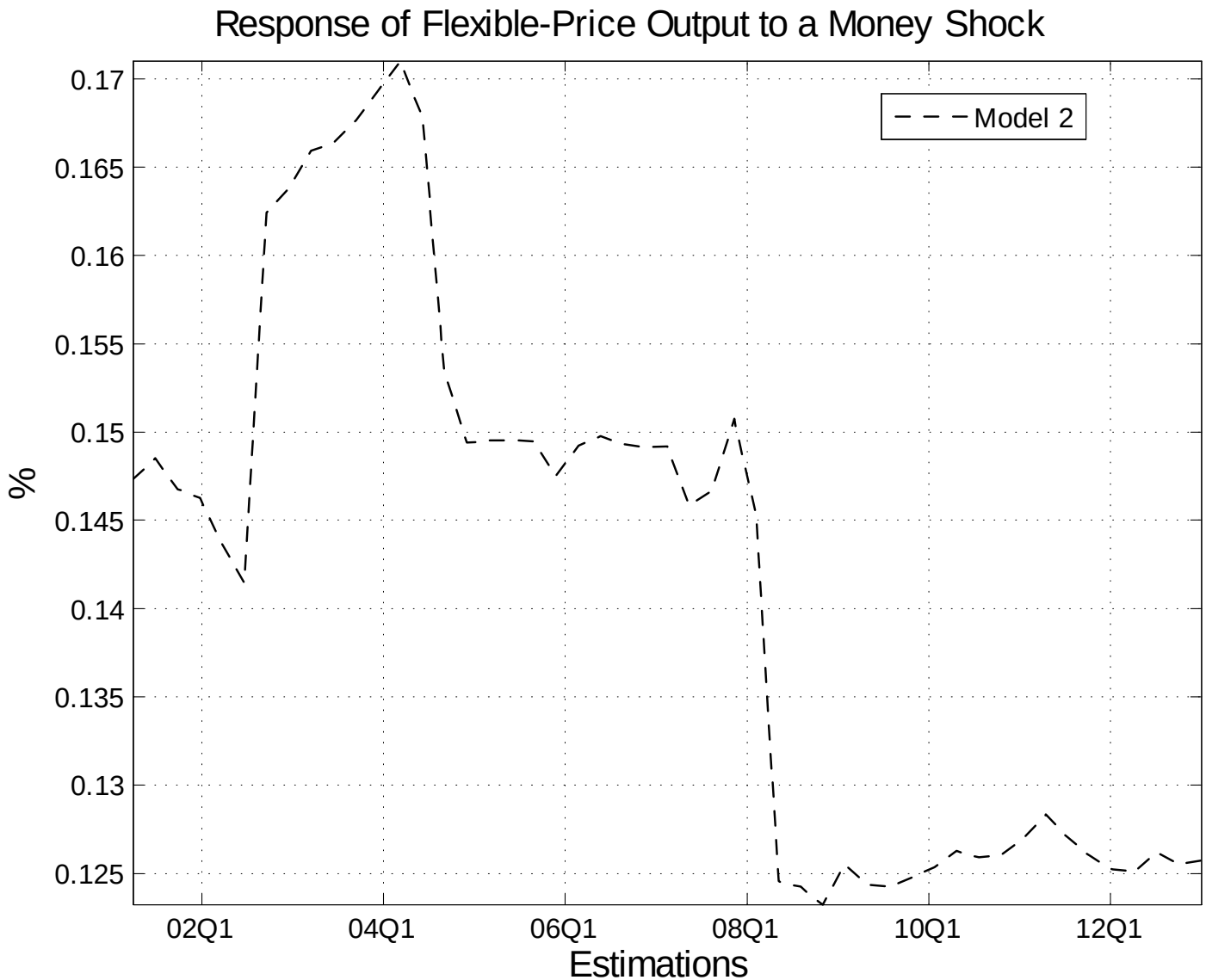
Our indicator, the contribution of a money shock to output's variance:

- is not linearly or non-linearly independent of the FCI or its components.
- Granger-causes bank (F-test: 7.52) and debt (F-test: 3.25) components.
- is not Granger-caused by the FCI or by one of its components.
- seems to be a good predictive indicator of bank and debt risks.

RMSD between Model 1 and Model 2 for output and inflation 1Y forecasts



On-impact IRF of flexible-price output after a money shock



Intifada and Dot-com crises

- During the Intifada period, macroparameters such as κ_{mp} and v_{sm}^{y} reach their maximum.
- The impact of money on the flexible and sticky price output is also high between 2002 Q3 and 2004 Q3.
- The on impact response of output to a money shock is at its maximum before the end of the Intifada crisis (2004 Q1-Q3).
- Contrary to other studies (Ireland, 2004; Andrès and al., 2006;), this result shows that money has a significant role.
- Interestingly, monetary policy's role on output and inflation are very low during the Intifada and Dot-com crises.
- Except during a short period (2003 Q3 - 2004 Q2), forecasting performances of Model 2 are better than those of Model 1, as far as output and inflation are concerned.
- The comparison with the FCI also allows us to distinguish Dot-com and Intifada crises roles.

Subprime crisis

- The role of money on output's variance reached a local maximum in 2007 Q4, period characterized by difficult credit markets conditions and accompanied by renewed volatility and impaired liquidity in most of global financial markets.
- Indeed, 2007 Q4 saw a retrenchment of investor risk appetite amid renewed concerns about marked-to-market losses on structured credit products.
- Coupled with continued hoarding of liquidity by some banks in the face of uncertain funding needs, global money market conditions tightened sharply.
- That's may be one reason why our money shock indicator is so related to Bank and Debt FCI's components.
- The non-separable model provides the best forecasting performance for output and inflation during the subprime and the debt crises.

Comments

- We compared 2 NKDSGE models, one baseline model with **separable preferences** (Galí, 2008) and another with **non-separable preferences** (Benchimol and Fourçans, 2012), during the last decade for Israel.
- We tested the two models by using rolling window Bayesian estimations, so as to shed light on the evolution over time of:
  - parameter
  - variance decompositions
  - forecasting performances
- We compared our results with the FCI of the Israeli economy.

Tests

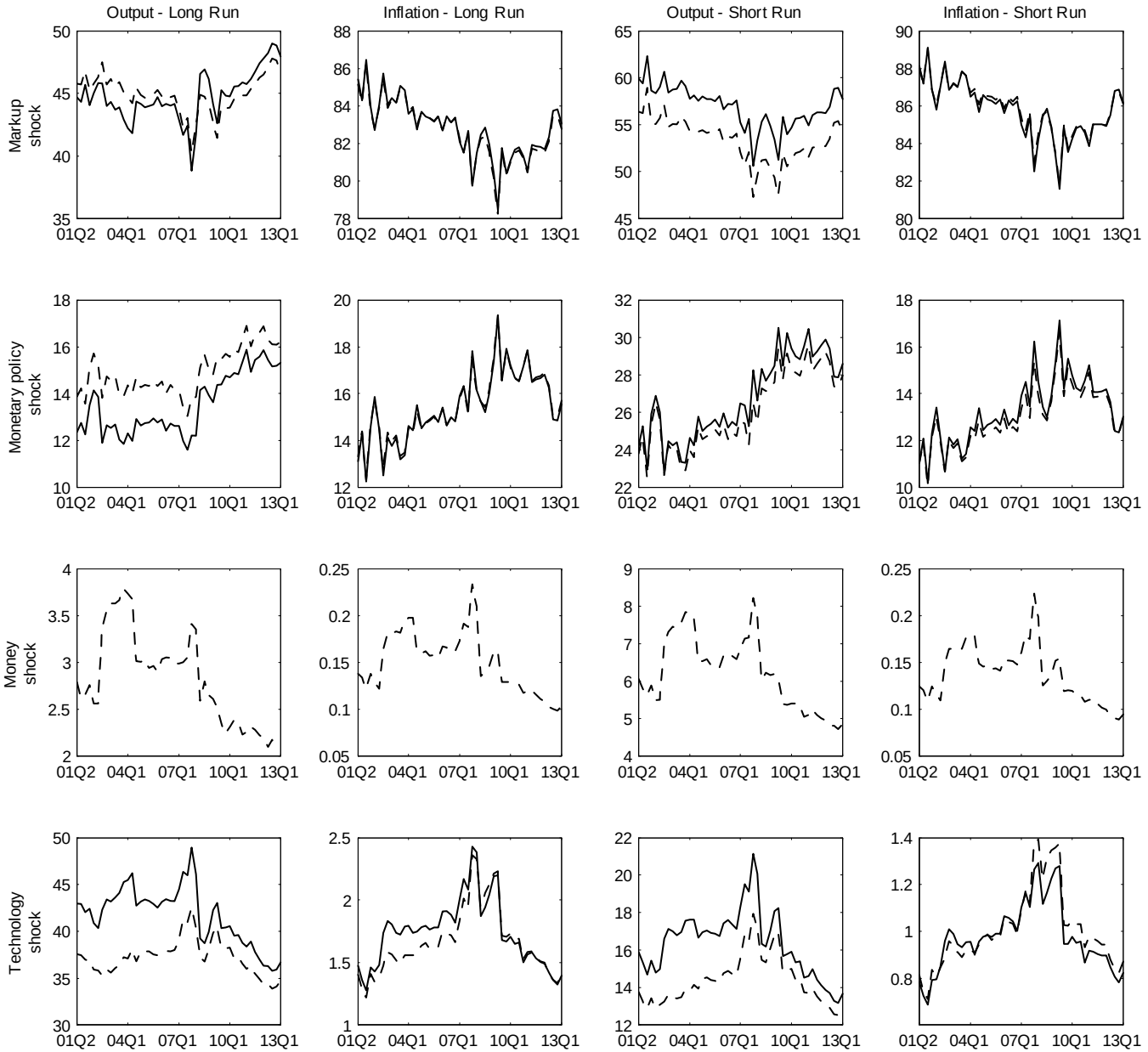
- This study was also conducted by using:
  - a preference shock instead of a price markup shock,
  - other sample sizes (16, 20, 24, 46 obs),
  - model-based detrending methods and measurement equations,
  - Taylor rules with money-related variable,
  - an *ad-hoc* demand shock,
  - other monetary aggregates (M1, M2).
- All these studies lead to similar results.

Conclusion

- Our analysis shows that money has a **significant role** to play in explaining output during crises.
- Inflation does not seem to be affected directly by money shocks. It is mainly explained by monetary policy and price-markup shocks. The explicit money variable does not appear to have a notable direct role in explaining inflation variability.
- During crisis periods, NKDSGE models with non-separability between consumption and real money balances should be **preferred** to separable models as far as **macroeconomic forecasting** is concerned.
- One may infer that by **changing economic agents' perception of risks**, the last Dot-com crisis coupled with the Intifada may have increased the **role of money** in the transmission mechanisms and in output changes.

Further research

- Introduce habits (in consumption, money and leisure), capital, investment and government.
- Introduce micro-foundation of the central bank behavior.
- Risk aversion parameter and its implication in the process should be analyzed through a non-linear model and at least through second-order approximation of the overall model.
- Differentiate between risk aversion and uncertainty.
- SOE model with non-separable MIU.


Output - Long Run
Inflation - Long Run
Output - Short Run
Inflation - Short Run
Markup shock
Monetary policy shock
Money shock
Technology shock
01Q2 04Q1 07Q1 10Q1 13Q1
Model 1
Model 2

Thank you !

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