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DISCUSSION PAPERS/PRIKAZI IN ANALIZE:

CREDIT MARKET FRICTIONS AND RATIONAL AGENTS' MYOPIA:

MODELING FINANCIAL FRICTIONS AND SHOCK TO EXPECTATIONS IN A DSGE SETTING ESTIMATED ON SLOVENIAN DATA

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1 / 2019

Title/*Naslov*: Credit Market Frictions and Rational Agents' Myopia: Modeling Financial Frictions and Shock to Expectations in a DSGE Setting Estimated on Slovenian data

No./*Številka*: 1/2019

Published by/*Izdajatelj*: BANKA SLOVENIJE
Slovenska 35
1505 Ljubljana
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fax: 01/+386 1 25 15 516
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Zbirko PRIKAZI IN ANALIZE pripravlja in ureja Analitsko-raziskovalni center Banke Slovenije (telefon: 01/ 47 19 680, fax: 01/ 47 19 726, e-mail: arc@bsi.si).
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https://www.bsi.si/publikacije/raziskave-in-analize/prikazi-in-analize

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID=299666944
ISBN 978-961-6960-27-4 (pdf)

CREDIT MARKET FRICTIONS AND RATIONAL AGENTS' MYOPIA

Modeling Financial Frictions and Shock to Expectations in a DSGE Setting Estimated on Slovenian data.

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Banka Slovenije

Abstract

Agents' beliefs and their confidence about the current and prospective economic conjecture are relevant drivers of the Slovenian business cycle.

Loss aversion, ambiguity aversion and bounded rationality are the theoretical basement of the model, while shocks to the real discount factor, to the intertemporal elasticity of consumptions and to the myopic factor for firms are the theoretical tools used to implement shifts of confidence for households and capital assets producers in DSGE modeling.

We have realistically assumed that households are myopic so they ignore (or they do not perfectly consider) that the economy is endogenously returning to the equilibrium after a positive or negative business phase in the long run. Hence, they perceive a deviation from the steady state as a permanent structural change and so, while a positive shock will increase their enthusiasm and their propensity to invest and to consume, a negative event induces fear, feeding uncertainty and boosting the bent to save.

The estimated impulse responses confirm that both households' and capital assets producers' myopic shock, as well the shock to the intertemporal elasticity of substitution in consumption, have statistically significant and important effects on the economy.

We implement the financial accelerator set up to consider credit-market frictions, introducing another source of potential instability in the model. Furthermore, we impose that the financial requirements necessary to access the credit market behave procyclically too, extending the original financial accelerator proposed by Bernanke et al. (1999).

Focusing on agents' perception of the policy is the main implication of the research: communication and signaling are powerful and crucial tools for monetary authorities.

After having dissected the business cycle of Slovenia, it is clear that not-fully rational agents, in an economy of self-fulfilling expectations, may neutralize or even overturn the initial goal of policy-makers producing unexpected and protracted consequences, especially when confidence is weak or the perception of the new policy action is distorted.

List of Abbreviations

AD: Aggregate Demand
AS: Aggregate Supply
BoS: Bank of Slovenia
CCI: Consumer Confidence Indicator
DSGE: Dynamic Stochastic General Equilibrium
EA: Euro area
ECB: European Central Bank
EMS: European Monetary System
ESI: Economic Sentiment Indicator
EU: European Union
EUT: Expected Utility theory
FA: Financial Accelerator
FI: Financial Intermediary
FOC: First order condition
GDP: Gross Domestic Product
GLS: Generalized Least Squares
HP: Hodrick-Prescott
IESC: Intertemporal Elasticity of Substitution in Consumption
IR: Impulse Response
KF: Kalman Filter
MCMC: Monte Carlo Markov Chain
MCN: Nominal Marginal Cost
MCR: Real Marginal Cost
MH: Metropolis-Hastings
MRO: Main refinancing operation
MU: Marginal Utility
NK: New Keynesian
OLS: Ordinary Least Squares
OMT: Outright monetary transaction
RBC: Real Business Cycle
RE: Rational Expectations
SOC: Second order condition
vNM: von Neumann-Morgenstern
ZLB: Zero Lower Bound

1 Introduction

The New-Keynesian Dynamic Stochastic General Equilibrium Model (NKDSGE or DSGE) is a framework that reflects the main features of an economy and, despite its inner simplicity, it has become a popular instrument to evaluate the implications of monetary and fiscal policies. The DSGE methodology rests on the idea that the interactions between demand and supply drive the economy to a general equilibrium and the deviations from this steady state result in business cycles.

All agents in the economy behave optimally determining the quantity of consumption, savings and stock of capital to hold according to their specific preferences. Moreover, DSGE modeling theoretically overcomes Lucas' critique (Lucas, 1976) because it is micro-founded, it assumes deep structural parameters that specify the steady state of the economy and it directly considers the leading role of expectations.

Therefore, identifying the micro-foundations of the economy becomes the main challenge. Perfect rationality and the steady state equilibrium are the fundamental concepts, which economists use to investigate the deep and hidden mechanisms that govern the economy. Indeed, we define the steady state as the equilibrium condition in which the variables are not changing in time. More formally, given a generic state variable x_t, the equilibrium is reached when:

$$x_t - x_{t-1} = 0$$

Standard DSGEs assume that all agents are perfectly rational, but empirical evidence shows that "real" decision-makers are far from being fully rational in economic sense.

> "*An action, or a sequence of actions is rational if, when the decision maker is confronted with an analysis of the decision involved, but with no additional information, she does not regret her choices*". (Gilboa, I., & Schmeidler, D., 2001, 17-18).

Perfect rationality implies that decision-makers can attach exact objective (or subjective following Savage, 1954) probabilities to risky events and then acting according to their attitude towards risk, but what is risk?

In EUT, agents are facing risk, random events that can be measured by attaching probability distributions, but when decision-makers cannot determine the chances or the set of possible events, they are facing uncertainty (Knight, 1921).

Ellsberg (1961) illustrates how the EUT fails to represent agents' actions when they are facing uncertainty, clearly showing how decision-makers are averse to ambiguity. Furthermore, Allais (1953) demonstrates that small changes of probabilities consistently affect decision-making. Both experiment show that EUT fails to track down the actual behavior of agents under these conditions. Therefore, there is a vivid interest to investigate non-perfect rationality from a macro prospective, especially for policy implications. The main research question is to what extent the central bank can still rely on agents' anticipating effect to estimate the optimal monetary policy.

Woodford (2013) reviews different methodologies to weaken RE hypotheses. There is no single model that can investigate all deviation from perfect rationality, but the goal is to find monetary policies that are robust according to the widest number of flaws.

Furthermore, Woodford (2010) shows how to include possible misalignment of private sector expectations without defining a specific class of biases, creating a one parameter linear model that measures central bank's concern for agents' misunderstanding of the involved dynamics. Policy with commitment remains optimal and calculating the effect of agents' anticipation of policy is still a relevant factor of analysis.

Gabaix (2017) presented a model in which agents are myopic and the degree of myopia depends on the forecasted time-horizon. The main findings are connected to the impact of monetary and fiscal stimuli, which are significantly more relevant than in standard DSGEs. Especially the fiscal stimulus has important and persistent effects on output, contrarily to models in which the Ricardian equivalence strictly holds. When the Ricardian equivalence holds, consumers expect taxes to rise in the future to compensate current primary deficit, so they do not feel richer and they do not increase their current consumption. Moreover, the unexpected exogenous increase of aggregate demand drives real interest rates upward, pushing households to save more. Together, both effects penalize the effectiveness of lump-sum fiscal stimulus.

However, myopic agents can only partially understand the effect of government spending in the future. Their behavior reflects the following intuition: a fiscal stimulus affects positively output and, consequently, households feel richer and they decide to spend more. Consequently, the real effect of the fiscal stimulus is multiple of the initial government expenditure. Samuelson (1939) formalizes this concept in the Samuelson-Hansen model, defining the positive relation between private consumption and the level of economic activity.

In Gabaix (2017), the price dynamics respects Fisher's property in the long run: initially an increase of interest rates lowers output and inflation, then in the long-term the real interest rate is independent of monetary policy. Indeed, monetary policy is neutral in the long run, but it is effective in the short-term because of both myopic agents and staggered prices environment.

Even though Gabaix (2017) analytically illustrates how myopic individuals form their beliefs, describing how agents react to monetary and fiscal policy shocks, the degree of myopic distortion of reality remains constant over both positive and negative business cycle fluctuations. This is a strong assumption, challenged by both empirical evidence on financial markets (Shiller, 2005) and by the aforementioned literature on biases and emotions’ role to define different risk and ambiguity-aversion profiles.

Gabaix (2017) does not explicitly estimate its behavioral New Keynesian model on a specific dataset, even if he identifies the support of the structural parameters of the model in order to preserve, for example, Fisher's property in the long run. Gabaix (2017) studied the most basic model with myopic agents, although he provides powerful analytical tools to further investigate the effects of bounded rationality from a macroeconomic point of view.

We analytically model and estimate a DSGE framework with time-varying output dependent myopic behavior and financial constraints.

We specify exogenous shocks to consumers' confidence through two channels, acting on the real discount factor (pure myopic shock) and on the intertemporal elasticity of substitution in consumption (IESC). The latter is an important factor which determines saving and consumption decisions and responses to real interest rate shocks (Hall, 1988). Specifying a positive exogenous shock to IESC means increasing the sensitivity of actual consumption to rise of the real interest rate. In fact, fear and pessimism may lead consumers to redefine their intertemporal preferences, making postponing consumption less costly. Following this intuition, we implement a myopic shock to the supply of capital assets too.

Myopia is procyclical in our model: in a positive business phase, agents would be more prone to inflate their decision on the level of consumption and investments, while in a recession, they become sub optimally prudent, assuming the *inertial position* and revising their beliefs downwards. Biases or emotions affect capital assets producers' investment decisions, leading to suboptimal results that may potentially amplify business cycles fluctuations.

Output-dependent myopic discount factor for both households and firms and shock to the IESC are the first original contribution of this paper to economic research, which provides a more realistic description of individuals' behavior.

Contrary to Gabaix (2017), in our model the Ricardian equivalence still holds and a pure exogenous shock to aggregate demand (for example government's lump-sum expenditure) produces contractionary reactions of investments and consumption, which are endogenously determined in the model.

The second original contribution rest on the hypothesis that the financial constraints are output-dependent as well, namely financial institutions ask for stricter financial requirements during economic depressions than during expansionary business cycles.

We must include financial friction in our model not only to provide a more reliable description of the economy, but because shocks to confidence and myopic forecasting produce their main effects through the financial sphere. We decide to focus on credit-market friction following Bernanke et al. (1999), allowing for time-varying risk-premium. This simple extension provides a richer and more realistic framework, extremely important to evaluate the role of monetary policy and economic sentiment as drivers of business cycles.

In section 2, we derive the agents' optimal conditions, implementing myopia and time-varying financial accelerator; therefore in section 3, we estimate the model for the Slovenian economy using Bayesian techniques. In sections 4 and 5, we discuss the results, describing respectively the estimated impulse responses and decomposing Slovenian business cycle. Finally, we summarize the results and the policy implications in section 6.

2 The Model

We proceed describing formally the structure of the DSGE model. In section 2.1, we illustrate the demand side of the economy focusing on the maximization of households' intertemporal utility function, determining the optimal conditions for consumption, leisure and wages. In section 2.2, we move to the supply side, introducing capital-assets producers and computing the optimal unitary price of capital. In section 2,3, we complete the industrial sector by implementing the financial accelerator framework proposed by Bernanke, B., Gertler, M., & Gilchrist S. (1999). Thus, in section 2.4, we determine aggregate output by assuming a unitary continuum of final aggregators in perfect competition following Dixit, A.K., & Stiglitz, J. E. (1977) and we construct the New Keynesian Hybrid Phillips curve as specified by Galí, J., & Gertler, M., (1999). Section 2.5 defines the monetary and fiscal policy in the economy, while section 2.6 provides a detailed description of the variables we treat as exogenous in the model, implementing procyclical financial constraints in 2.8. In section 2.9, we finally recompose the complete model in log-linear form.

2.1 Households

The representative household $j \in [0,1]$ chooses the level of consumption $C_t^*(j)$, leisure $L_t^*(j)$ and savings $\frac{D_t{}^*}{P_t}$ in each period $t = 1, 2 \dots, \infty$ in order to maximize her expected utility. The utility function has the following functional form:

$$U[\, C_t(j), L_t(j)]|_{t=1,2,..\infty} = \sum_{t=0}^{\infty} \frac{1}{1-\gamma_t} C(j)_t^{1-\gamma_t} - \frac{a_L}{1+\gamma_L} \, L(j)_t^{1+\gamma_L}$$

The parameter a_L is a preference parameter for leisure, while γ_t and γ_L are respectively the intertemporal elasticity of substitution of consumption (IESC) and leisure.

The representative household $j \in [0,1]$ maximizes her utility function subjected to the budget constraint:

$$C_t(j) = \frac{W_t}{P_t} \, L_t(j) + \, \pi_t(j) - \, T_t(j) - \frac{\frac{1}{1+i_t} \, D_t(j) - D_{t-1}(j)}{P_t}$$

Households supply undifferentiated labor in the form of working hours. Each $j \in [0,1]$ has access to perfect financial markets, which allow the consumer to allocate consumption over time interval $[0, \infty)$ according to her preferences. Deposits have the same financial structure of one-period zero-coupon bonds, which households can purchase or issue to consume and save according to their preferences over time. Borrowing and lending between households is riskless and the nominal interest rate is i_t. The representative agent j receives profit $\pi_t(j)$ from final good producers (monopolistic competitors) and she pays lump-sum taxes $T_t(j)$. The real unitary wage is $\frac{W_t}{P_t}$.

All households have the same functional form of the utility function and they are binding to the same constraints. This assumption makes aggregation of consumption and labor simpler. Formally, given a general quantity $X(j)_t$ for the agent $j \in [0,1]$, we define the aggregate quantity X_t in the economy as:

$$X_t = \int_0^1 X(j)_t \, dj$$

For the sake of simplicity, we treat aggregate variables directly in the intertemporal maximization of households' expected utility. In fact, since first order derivatives are linear operations, optimizing each quantity for the individual agent and then aggregating or doing it backwards, aggregating and then optimizing, leads to the same result. We follow the same assumption and methodology for capital goods manufacturers. We proceed setting the Lagrangian function to obtain the optimality conditions.

2.1.1 Optimization Problem

The household j maximizes her expected utility by choosing the optimal consumption, the leisure and the amount of savings to invest in one-period deposits. Without any loss of generality, we directly consider the aggregate quantities, since first order differential and the sum are linear operators

Formally:

$$\max_{C_t, L_t, \frac{D_t}{P_t}} \sum_{i=0}^{\infty} (\beta_t)^i \, \mathcal{L}_{t+i}$$

$$\mathcal{L}_t = \sum_{t=0}^{\infty} \frac{1}{1-\gamma_t} C_t^{1-\gamma_t} - \frac{a_L}{1+\gamma_L} L_t^{1+\gamma_L} - \lambda_t \left[-C_t + \frac{W_t}{P_t} L_t + \pi_t - T_t - \frac{\frac{1}{1+i_t} D_t - D_{t-1}}{P_t} \right]$$

We model myopic agents and confidence shocks through two different channels:

1. Time-varying real discount factor:
2. Time-varying intertemporal elasticity of substitution in consumption:

Time-varying real discount factor

$$\beta_t = \beta_0 F_t \,,$$

The myopic discount factor F_t has the following specification:

$$\Delta \ln F_t = \rho_F \Delta \ln F_{t-1} - \rho_{FY} \Delta \ln(Y_{t-1}) + \epsilon_t^F$$

In equilibrium, $F_t = 1 \Rightarrow \beta_t = \beta_0$ and $\beta_0 \in (0,1)$ and we impose $\rho_F, \rho_{FY} \in (0,1)$ in order to guarantee the stationarity of $\Delta \ln F_t$.

In modeling myopic agents, implementing a time-varying real discount factor has two main advantages. Firstly, we can represent a negative shock to households' beliefs by exogenously increase F, describing what happens when the degree of uncertainty in the economy suddenly rises causing the fall of agents' ability to forecast. Secondly, we assume consumers' confidence to be procyclical by indexing the current perception of their forecasting skills in t to the level of output in $t-1$. The parameter ρ_{FY} represents the intensity of the procyclicality.

The idea is simple: extreme negative events may bring uncertainty about future economic conjecture, affecting agents' forecasting skills and triggering temporary, but structural changes of households' preferences. In fact, when a negative shock to households' beliefs occurs, the myopic discount factor may only temporarily exceed $1(a)$, distorting the geometric decay of ${\beta_t}^t$. However, we assume that the myopic shock can only be transitory, imposing $\ln F_t$ to be stationary (b). Thus, we always guarantee that $\lim_{t\to\infty} {\beta_t}^t = 0$. Formally, the domain of B_t is defined as:

$$\begin{cases} \beta_t \in \mathbb{R}_{>0} & (a) \\ \rho_F, \rho_{FY} \in (0,1) & (b) \end{cases}$$

We have realistically assumed that households are myopic so they ignore (or they do not perfectly consider) that, after a shock, the economy is endogenously returning to the equilibrium in the long run. Hence, they perceive a deviation from the steady state a permanent structural change so, while a positive shock will increase their enthusiasm and their propensity to invest and to consume, a negative event causes fear, feeding uncertainty and boosting the bent to save. Uncertainty leads decision-makers not to act, assuming an *inertial position* especially when the likelihood of negative extreme events is not negligible. If $\beta_t > \beta_0$, myopic, but rational agents overweigh future utility, reallocating their consumption decisions to the future, waiting for "better times".

Christiano J. L., Eichenbaum M. and Rebelo S. (2011) follow the same approach to show that the government-spending multiplier can be larger than one when nominal interest rate is binding to the zero-lower bound. In that case, when the deviation of the real discount factor is greater than a certain level, the framework endogenously represents a liquidity-trap scenario with the real interest rate at zero.

Time-varying Intertemporal Elasticity of Substitution in Consumption

$$\ln \gamma_t = \left(1-\rho_\gamma\right) \ln \gamma_0 + \rho_\gamma \ln \gamma_{t-1} - \epsilon_t^\gamma$$

With $\rho_\gamma \in (0,1)$

We analyzed a second transmission mechanism, which rests on the intertemporal elasticity of substitution in consumption (IESC). IESC defines households' sensitivity to a change in real interest rate and it outlines consumers' intertemporal preferences. The exogenous decrease of IESC makes reallocating consumption decision over time less costly, affecting current consumption and investment decisions.

The variables γ_t and F_t are the fundamentals tools we employ to investigate how households' expectations affect business cycle, especially when agents face ambiguity. Shocks to intertemporal elasticity of consumption and to the real discount rate are aimed at explicitly modeling bounded rationality in a DSGE setting, capturing the extensive role of economic sentiment to amplify business cycle fluctuations.

In the next sections, we impose the FOC to determine optimality conditions for households.

2.1.2 Optimal Consumption

In this section, we compute the first order derivative of the Lagrangian with respect to C_t. We notice that given the budget constraint, once we have chosen the optimal consumption strategy at time t, this decision leads to optimality in $t+1, t+2, \dots, t+\infty$ as well. This property is known as envelope theorem and it holds for all intertemporal optimal decisions.

We present the FOC for consumption as follows:

$$\max_{C_t} \sum_{i=0}^{\infty} (\beta_t)^i \mathcal{L}_{t+i} \rightarrow \sum_{i=0}^{\infty} (\beta_t)^i \frac{\partial \mathcal{L}_{t+i}}{\partial C_t} = 0 \ \rightarrow \ C_t^{-\gamma_t} + \lambda_t + \sum_{i=1}^{\infty} (\beta_t)^i \ \frac{\partial \mathcal{L}_{t+i}}{\partial C_t} = 0$$

$$-\, C_t^{-\gamma_t} = \lambda_t \tag{1}$$

2.1.3 Optimal Leisure

Now we proceed taking first order derivatives with respect to L_t.computing the optimality condition for leisure.

$$\max_{L_t} \sum_{i=0}^{\infty} (\beta_t)^i \mathcal{L}_{t+i} \rightarrow \sum_{i=0}^{\infty} (\beta_t)^i \frac{\partial \mathcal{L}_{t+i}}{\partial L_t} = 0 \ \rightarrow -a_L\, L_t^{\gamma_L} - \lambda_t \ \frac{W_t}{P_t} + \sum_{i=1}^{\infty} (\beta_t)^i \frac{\partial \mathcal{L}_{t+i}}{\partial L_t} = 0$$

$$a_L\, L_t^{\gamma_L} = -\lambda_t \ \frac{W_t}{P_t}$$

Combining this result with the optimal condition for consumption (1), we obtain:

$$\frac{a_L\, L_t^{\gamma_L}}{C_t^{-\gamma_t}} = \frac{W_t}{P_t} \tag{2}$$

The optimality condition for leisure is satisfied when the disutility generated by losing one additional hour of leisure is equal to the utility of consuming the additional real units of money he will earn. If $\frac{W_t}{P_t} > (<) \ \frac{a_L\, L_t^{\gamma_L}}{\chi_t\, C_t^{-\gamma_t}}$ the agent finds more (less) convenient earning and consuming the additional real wage than saving one unit of leisure.

2.1.4 Optimal Condition for Deposits

Households allocate their consumption over time according to their preferences by investing or disinvesting any amount D_t of deposits with maturity in $t+1$ and price $\frac{1}{1+i_t}$.

We assume that households have access to perfect and riskless financial market with clearing condition $\forall t \in [0,\infty), \int_0^1 D(j)_t \, dj = 0$. Therefore, we compute the first order derivative of the Lagrangian with respect to $\frac{D_t}{P_t}$ to obtain the optimal condition for savings.

$$\max_{\frac{D_t}{P_t}} \sum_{i=0}^{\infty} (\beta_t)^i \mathcal{L}_{t+i} \rightarrow \sum_{i=0}^{\infty} (\beta_t)^i \frac{\partial \mathcal{L}_{t+i}}{\partial \frac{D_t}{P_t}} = 0$$

$$\rightarrow \lambda_t \frac{1}{1+i_t} + \beta_t \left[\frac{P_t}{P_{t+1}}(-\lambda_{t+1})\right] + \sum_{i=2}^{\infty} (\beta_t)^i \frac{\partial \mathcal{L}_{t+i}}{\partial \frac{D_t}{P_t}} = 0$$

$$\lambda_t = (1+i_t)\beta_t \, E_t\left[\frac{P_t}{P_{t+1}}(\lambda_{t+1})\right] \tag{3}$$

The real discount factor is time-dependent; however, its evolution over time does not depend on $\frac{D_t}{P_t}$, so we treat it as exogenous. In equilibrium, the utility generated by consuming of one additional unit of money at time t must be equal to the discounted expected utility of the consumption of $(1+i_t)E_t\left[\frac{P_t}{P_{t+1}}\right]$ units in $t+1$. The ratio $E_t\left[\frac{P_{t+1}}{P_t}\right]$ is the expected inflation in $t+1$: consumers are interested in the real return on their savings. Using the Fisher equality $1+r_t = \frac{1+i_t}{E[\pi_{t+1}]}$, we can easily rewrite the optimal condition in function of the real interest rate as follows:

$$\lambda_t = (1+r_t)\beta_t E_t[\lambda_{t+1}]$$

2.2 Capital Assets Producers

In standard literature, households produce capital assets choosing the optimal level of investments. Therefore, firms rent capital in order to manufacture wholesale goods, paying the return on capital to households.

In our model, we propose two different agents: households and capital asset producers. Those agents make respectively consumption and investment decisions. In addition, we define a third class of agents: entrepreneurs, who optimize factors' demand given the current business phase, their private wealth and the credit-market conditions and they benefit of the rate of return capital. Contrarily, households invest only in deposits, which yield the risk-free interest rate.

We define K_{t+1} the amount of capital that entrepreneurs demand at time t to produce output in $t+1$. Capital assets K are produced in perfect competition. We assume a unitary continuum of homogeneous capital asset producers $j \in [0,1]$ that minimize the same cost function given the constraint of matching entrepreneurial capital demand $\overline{K}_t$, $\forall t \in [0, \infty)$.

We provide a general production function for capital, including time-dependent capital adjustment cost as specified by Christiano et al. (2005) when investment decisions deviate from the equilibrium. The adjustment-cost depends on the marginal investment (disinvestment) between two consecutives periods.

$$K(j)_{t+1} = (1-\delta)K(j)_t + I(j)_t \left[\Phi\left(\frac{I(j)_t}{I(j)_{t-1}}\right) \right]$$

Capital is homogeneous, so there is no difference from "new" capital produced in t and capital that survived the production process. The cost adjustment function Φ has the following properties in the steady state:

$$\Phi(1) = 1 \qquad \Phi'(1) = 0 \qquad \Phi''(1) = \varphi_{INV} > 0$$

The properties of Φ imply no adjustment costs in a neighborhood of the steady state and the convexity of the adjustment cost function. Without any loss of generality, we directly consider aggregate capital since first order differential and the sum are linear operators.

Perfect competition implies that in equilibrium the marginal cost of capital production must be equal to the price. The production function is time-dependent, so capital producers are interested in finding the intertemporal optimal condition, maximizing the production for $t = 1,2, \dots, \infty$.

Producers are price-taker and they take the demand for capital goods $\overline{K}_{t+1}$as given, so we can express the optimality condition for investment as follows:

$$\min_{I_t} \sum_{i=0}^{\infty} (\beta_t)^i \xi_{t+i} \left\{ I_{t+i} \left[\Phi\left(\frac{I_{t+i}}{I_{t+i-1}}\right) \right] - a \left[K_{t+i+1} - \overline{K}_{t+i+1} \right] \right\}$$

The intertemporal discount rate β_t is defined analogously to the optimal conditions for households (see section 2.1.1) and ξ_t is a specific myopic factor for capital assets producers, which evolves over time according to:

$$\Delta \ln \xi_t = \rho_\xi \, \Delta \ln \xi_{t-1} + \rho_{\xi Y} \, \Delta \ln Y_t + \epsilon_t^\xi$$

With $\rho_\xi, \rho_{\xi Y} \in (0,1)$ to guarantee the stationarity of $\Delta \ln \xi_t$.

Myopic shocks are output-dependent. The distinction between households and capital producers is only formal; in our framework, we explicitly admit the possibility that investment decisions are biased. Both ξ_t and F_t behave analogously: capital assets producers' behavior is affected by emotions, overconfidence or potential biases connected to heuristics. Therefore, ξ_t depends on the current business phase and it amplifies shocks by distorting investment decisions.

We proceed taking the first order derivative with respect to I_{t+i} for $i = 1, 2 \dots, \infty$ and imposing the marginal cost to equal to the unitary price of capital Q_t.

$$\left[\Phi\left(\frac{I_t}{I_{t-1}}\right) - \Phi'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}} \right] - \beta\frac{\xi_{t+1}}{\xi_t}\Phi'\left(\frac{I_{t+1}}{I_{t1}}\right)\left(\frac{I_t}{I_{t-1}}\right)^2 = \frac{Q_t}{\xi_t} \tag{4}$$

We can easily notice that in equilibrium the price per unit of capital $Q_0 = 1$ given the properties of Φ. This result is common achievement in the standard literature and it replicates perfectly the framework in which households directly make investments decisions.

We close the model define the aggregate demand as:

$$Y_t = C_t + I_t + EXO_t + C_t^e \tag{5}$$

The quantity C_t^e represents the entrepreneurial consumption that will be defined later, EXO_t is the exogenous component of the aggregate demand, which includes both next-export and government expenditure.

2.3 The Financial Accelerator Framework

In this section, we present the main characteristics of the financial accelerator setting introduced by Bernanke, Gertler and Gilchrist (1999). The model splits the production process in three stages. Firstly, financially constrained entrepreneurs (or wholesale goods producers) purchase capital and hire labor to produce undifferentiated wholesale goods. Therefore, they sell their output in a perfect competitive market to intermediate good producers at price which equals the marginal cost. Intermediate goods producers act in monopolistic competition, differentiating wholesale goods without additional costs and eventually distributing profits to households. Finally, we assume the existence of final goods producers (or retailers) who aggregate the intermediate goods produced into a single basket of final goods, which they directly sell to consumers. This final stage is necessary to aggregate the output of production.

We report the main results of Bernanke, Gertler and Gilchrist (1999) for the demand of production factors, for the return on capital and evolution of net wealth of entrepreneurs.

2.3.1 Entrepreneurs

Entrepreneurs are the cornerstone of the financial accelerator framework. In each period, they purchase capital assets, hire labor and use the available technology to manufacture wholesale goods. Since their private wealth is insufficient to match their financial needs, they borrow from financial intermediaries the external sources necessary to purchase to optimal amount of physical capital. Entrepreneurs have a fixed probability of surviving to the next period ç (implying an expected lifecycle of $\frac{1}{1-ç}$ quarters) and, when a firm exits the market, it sells back its physical assets to capital producers, consuming the remaining part of its private wealth. Bernanke et al. (1999) make this assumption to capture the continuous process of birth and death of firms and to restrain the circumstance that firms completely self-finance their operations through retained earnings.

Entrepreneurs accumulate wealth through gaining profits and by supplying inelastic labor in the job market. In fact, the production process does not directly employ entrepreneurs, but they invest the initial wealth necessary to start their entrepreneurial activity. They accumulate their initial sources by supplying undifferentiated labor for their own projects.

We assume that entrepreneurs acquire their capital stock as whole in each period and this provides a simple tool to makes financial constraints matter for the entire firm, not only the marginal investments (Bernanke et al., 1999). Entrepreneurs' production function has the following functional form:

$$Y_t = A_t K_t^{\alpha} L_t^{\omega(1-\alpha)} \tag{6}$$

The term A_t represents a free exogenous technology available to all entrepreneurs and its evolution over time follows an autoregressive process of order 1, formally:

$$A_t = (1-\rho_A)A_0 + \rho_A A_{t-1} + \epsilon_t^A$$

The parameter $\alpha \,\epsilon [0,1]$ defines the combination of capital and labor necessary to produce one unit of intermediate goods, while ω specifies the portion of workforce employed in the production process. Entrepreneurs are price-takers and they minimize the cost of production to meet the aggregate demand in each period. We can set the minimization problem as follows.

$$\min_{K_t, L_t} \frac{W_t}{P_t} L_t + R_t^{K\,prod} K_t$$

Subject to $Y_t^* = A_t K_t^{\alpha} L_t^{\omega(1-\alpha)}$

$$\frac{\partial \mathcal{L}_t}{\partial L_t} = 0 \rightarrow \frac{W_t}{P_t} = \tau_t \left(\frac{\omega(1-\alpha) Y_t}{L_t} \right) \tag{7}$$

The Lagrange multiplier τ_t describes how much the cost would increase if the entrepreneur decided to produce one additional unit of output. It is clear that τ_t is the marginal cost of production and since entrepreneurs sell their products in perfect competition, it must be equal to the price, in our case $\tau_t = \frac{1}{X_t} = MC_t^n$.

Combining (2) with (7) and imposing that the marginal cost τ_t must be equal to the price of intermediate goods; we obtain the demand of labor:

$$\frac{a_L \, L_t^{\gamma_L}}{-\lambda_t} = \frac{1}{X_t} \left(\frac{\omega(1-\alpha) Y_t}{L_t} \right) \tag{8}$$

We continue computing the optimality condition for capital.

$$\frac{\partial \mathcal{L}_t}{\partial K_t} = 0 \rightarrow R_t^{K\,prod} = \tau_t \frac{\alpha Y_t}{K_t} \tag{9}$$

However, we are interested in the overall return potentially generated by investing in capital, so capital gains (losses) must be included in the optimality condition. We can compute the marginal productivity of capital by differentiating the Cobb-Douglas production function with respect to the capital K_t and considering the extra return due to capital gain.

$$\frac{\partial Y_t}{\partial K_t} = \frac{\alpha Y_t}{K_t} \tag{10}$$

For each additional unit of intermediate goods, entrepreneurs will earn the price $\frac{1}{X_t}$, therefore the rent paid for the optimal quantity of capital in equilibrium is $\frac{\alpha Y_t}{K_t}\frac{1}{X_t}$. Such rent is the return on capital they would expect to earn in each period if they did not have the opportunity to realize capital gains on capital goods. In fact, entrepreneurs sell the remaining capital to capital assets producers after having produced realized losses or gained profits depending on the current cost of capital. This assumption is both technical and substantial: firstly, it permits the update of firms' leverage in each period, considering the stock of capital as whole and not only the marginal increase or decrease in two consecutive time periods, on the other side it allows us to make leveraging procyclical. In positive business cycles, companies have an incentive to increase their leverage by exploiting the increasing expected return on capital, while entrepreneurs reduce the cost of external financing by deleveraging in negative phases. This is the core of the financial accelerator of Bernanke, Gertler and Gilchrist (1999), where leveraging and deleveraging act as multipliers, amplifying the deviations from the steady state. After having defined δ as the depreciation rate of capital, the ex post return on capital in each period is given by:

$$R_t^K = \frac{\frac{\alpha Y_t}{X_t K_{t-1}} + Q_t(1-\delta)}{Q_{t-1}} \tag{11}$$

2.3.2 External financing contractual problem

Entrepreneurs always need to raise external funds to purchase capital. Each entrepreneur *j* issues one-period bond to match her financial needs and financial intermediaries are willing to invest in these securities if and only if the expected return on corporate lending is equal to the risk-free interest rate given the cost of potential defaults. In fact, the entrepreneur is bearing all the systematic risk of investing in capital, while the financial intermediary can neutralize the idiosyncratic risk of lending to the j^{th} entrepreneur by holding perfectly diversified portfolio of loans. Furthermore, financial intermediaries apply an external financing premium to hedge the expected losses due to corporate lending. Formally, the entrepreneur j for each period $t \in [0, \infty)$ chooses the level of external finance $B_{t+1}^J = Q_t K_{t+1}^J - N_{t+1}^J$, where $N_{t+1}^J$the entrepreneurial net wealth is available to meet financial needs in $t + 1$.

As showed by Bernanke, Gertler and Gilchrist (1999), the optimal contract of external financing implies that the ex-ante expected premium in investing in capital rather than risk free asset is a function of the financial structure of the firm. Formally:

$$\frac{E_t[R_{t+1}^K]}{R_t} = S\left(\frac{N_{t+1}}{Q_t K_{t+1}}\right) \tag{12}$$

The function $S(*)$ is defined on the positive domain $0 < \frac{N_{t+1}}{Q_{t+1}K_{t+1}} < 1$ and it is strictly increasing $S'(*) > 0$. This relation makes the financial structure endogenous in the model: the greater is the contribution of external sources in acquiring capital, the lower is the share of return on capital available for the entrepreneurs (since the cost of external funds increases).

Entrepreneurs need some sort of initial wealth to be operative, to solve this technical issue, the model assumes that entrepreneurs additionally supply inelastic labor.

We compute total labor in the economy as:

$$L_t = L_t^{\omega}(L_t^e)^{1-\omega}$$

The variable L_t^e denotes the entrepreneurial labor and $1-\omega$ indicates the share of entrepreneurial labor. The next step is to define how net wealth of wholesale goods producers evolves over time, formally:

$$N_{t+1} = \text{ç}V_t + W_t^e$$

The parameter ç is the surviving probability and W_t^e represents the income that entrepreneurs receive from supplying labor. As we previously introduced, when a firm exits the market and it consumes the residual V_t without any possibility to borrow again. Aggregate entrepreneurial consumption due to defaults is defined as:

$$C_t^e = (1-\text{ç})N_t \tag{13}$$

We proceed illustrating the evolution of entrepreneurial equity over time. Equity represents what remains after having paid debt back, formally:

$$V_{t+1} = R_{t+1}^K Q_t K_{t+1} - Z_t B_t$$

The variable Z_t is the cost of external founding, which depends on entrepreneurial leverage. Following the illustration of Bernanke, Gertler and Gilchrist (1999), the descriptive process of entrepreneurial equity over time is given by:

$$\hat{n}_{t+1} = \frac{\text{ç}K_0 R}{N_0}(\hat{r}_t^K - \hat{r}_t) + \hat{r}_t + \hat{n}_t \tag{14}$$

2.4 The New Keynesian Hybrid Phillip's curve

We complete the construction of the model by introducing the New Keynesian Phillips curve. We adopted the specifications made by J. Galì, M. Gertler (1999), defining the relation between current level of prices and marginal cost, past and future expected inflation. We remark that entrepreneurs face the same production function and consequently $MC(z)_t^n = MC_t^n$ for every z.

Intermediate goods producers purchase entrepreneurs' output and sell their goods in monopolist competitive market after having costlessly differentiated the products. Their marginal cost is defined as:

$$MC_t^n = \frac{1}{X_t}$$

In order to determine the demand function for the intermediate good $Y(i)_t$, we need to specify how final output is aggregated over the infinite density continuum of retailers whose mass is normalized to one. Following Dixit A. and Stiglitz J. (1977), we assume that the economy consists of a continuum of agents in perfect competition (whose mass is normalized to one as well) who aggregate the intermediate goods produced by retailer into a single basket, which will be directly sold to consumers. Perfect competition implies that each final aggregator z will maximize the production (or minimizing the cost) of the basket subject to the constraint that the consumers' demand is met, formally:

$$\min_{Y(z)_t} \int_0^1 Y(z)_t \, P(z)_t dz$$

$$\overline{Y_t} = \left[\int_0^1 Y(z)_t^{\frac{1-\varepsilon}{\varepsilon}} dz \right]^{\frac{\varepsilon}{1-\varepsilon}}$$

The quantity $\overline{Y_t} = \left[\int_0^1 Y(z)_t^{\frac{1-\varepsilon}{\varepsilon}} dz \right]^{\frac{\varepsilon}{1-\varepsilon}}$ represents the production function of the aggregator given the good z and the constant elasticity of demand ε. This procedure allows us to obtain a conventional demand function for the intermediate producers z which produces the intermediate good z.

$$Y(z)_t = \overline{Y_t} \left(\frac{P(z)_t}{P_t} \right)^{-\varepsilon} \tag{15}$$

In case of perfectly flexibles prices, the intermediate good producer z sets the price by solving the following problem:

$$\max_{Y(z)_t} [P(z)_t - MC_t^n](Y(z)_t)$$

Given the demand function (15).

Retailers set the final price fixed by charging a fixed mark-up (inversely related to the elasticity of demand) on marginal cost, formally:

$$\frac{P(z)_t}{P_t} = \left(\frac{\varepsilon}{\varepsilon - 1} \right) * MC_t^n$$

In a staggered price framework, intermediate goods producers cannot update prices instantaneously after a change of marginal cost, so their optimal price no longer coincides with the result we derived in flexible prices. Firm's problem is the following:

$$\max_{P(z)_t} E_t \sum_{k=0}^{\infty} (\theta\beta)^k A_{t,t+k} [P(z)_t - MC_{t+k}^n] \, Y(z)_{t+k}$$

The term $\frac{1}{\theta}$ represents the average expected time that firms need to update prices to new marginal costs and β is the discount factor. Subject to the demand curve (15). After having imposed FOC and rearranged the equation, we obtain:

$$P(z)_t^* = E_t \sum_{k=0}^{\infty} \ni_{t,t+k} \left(\frac{\varepsilon}{\varepsilon - 1}\right) MC_{t+k}^n$$

$$\ni_{t,t+k} = \frac{E_t (\theta\beta)^k\, A_{t,t+k} (P_{t+k})^{\varepsilon-1} Y_{t+k}}{E_t \sum_{k=0}^{\infty} (\theta\beta)^k\, A_{t,t+k} (P_{t+k})^{\varepsilon-1} Y_{t+k}}$$

We can extend this result for retailer z to the set of intermediate goods producers as whole, since all agents face the same marginal cost and the same demand function and it can be log-linearized to obtain:

$$\widehat{p_t}^* = (1 - \theta\beta) \sum_{t=1}^{\infty} (\theta\beta)^t \widehat{mc}_t^n \quad (16)$$

In this case, retailers set prices following an extension of the standard Calvo's set up (1983). According to Galí, J., & Gertler, M., (1999), we distinguish between forward and back looking firms. While forward-looking producers set prices by accounting for future expected deviations of the nominal marginal costs from the steady state, backward looking firms update prices indexing to past inflation. In the model, each firm i sets new prices with probability $(1 - \theta)$, formally:

$$P(i)_t = (1 - \theta) P(i)_t^* + \theta P(i)_{t-1}$$

The aggregate level of prices is given by computing the aggregate price index:

$$P_t = \left[\int_0^{\theta} P(i)_t{}^{1-\varepsilon}\, di + \int_{1-\theta}^{1} P(i)^*{}_t{}^{1-\varepsilon}\, di \right]^{\frac{1}{1-\varepsilon}}$$

$$P_t = [\theta P_{t-1}^{1-\varepsilon} + (1 - \theta) P_{t-1}^{*\,1-\varepsilon}]^{\frac{1}{1-\varepsilon}} \quad (17)$$

We easily compute the log-linear approximation of (12) around the steady state, obtaining:

$$\hat{p}_t = \theta \hat{p}_{t-1} + (1 - \theta) \hat{p}_t^* \quad (18)$$

A subset w of final producers is backward looking and sets $P_t{}^* = \pi_{t-1} P_{t-1}$ for every t. We can represent the optimal price in log-linear form:

$$\hat{p}_t^{*b} = \hat{\pi}_{t-1} + \hat{p}_{t-1}^* \quad (19)$$

On the contrary, $(1 - w)$ forward looking retailers' optimal price is:

$$\hat{p}_t^{*f} = (1 - \theta\beta)(\theta\beta) \widehat{mc}_t^n + (\theta\beta) E_t [\hat{p}_{t+1}] \quad (20)$$

We can determine the Hybrid Phillips curve for the economy combining (18), (19) and (20) expressing the current inflation in function of deviations of the real marginal cost, expected and past inflation from the steady state.

$$\hat{\pi}_t \; = k\,\widehat{mc}_t^r + \sigma_f E_t\left[\hat{\pi}_{t+1}\right] + \sigma_b \hat{\pi}_{t-1} \tag{21}$$

$$k = \frac{(1-w)(1-\theta)(1-\theta\beta)}{\theta + w[1-\theta(1-\beta)]}$$

$$\sigma_f = \frac{\theta\beta}{\theta + w[1-\theta(1-\beta)]}$$

$$\sigma_b = \frac{w}{\theta + w[1-\theta(1-\beta)]}$$

We notice that if all retailers were forward looking ($w = 0$), the framework would converge to the standard Phillips curve. This setting implies that when retailers have the possibility to update prices, they will not simply adjust them to the new conditions, but they will consider their expectations about future marginal costs. Furthermore, the existence of backward looking firms makes possible to model the phenomenon of the inertia of the price levels over time.

2.5 Monetary Policy Rule and Government Expenditure

2.5.1 Taylor Rule

In this section, we define the interest rate rule that the central bank follows. We assume the short-term interest rate to be the policy instrument considering that the central bank set the interest rate according to the level of inflation and to the output gap, formally:

$$1 + i_t = e^{\rho_i(1+i_{t-1}) + \varphi_\pi E[\,\pi_{t+1}] + \varphi_y\,(y_t - {y_t}^n) + \epsilon_t^{mp}} \tag{22}$$

The difference $y_t - {y_t}^n$ identifies the output gap, the variation between the actual and potential output. We define the potential output or natural output ${y_t}^n$ as the level of production that the economy would reach if there were no frictions. Literature often refers to the natural output as the maximum level of production of goods and services, which is sustainable in the medium period.

According to Clarida R., Galí J. & Gertler (1999), Blattner T.S. & Margaritov (2010) and Galì J. (2015), (22) describes the adjustments of the short-term interest rate assuming that the central bank is targeting inflation or output. Assuming a non-discretionary policy rule has several advantages as, for example, the possibility to act directly on expectations through commitment and credibility, strengthening the real effect of monetary policy. It is easily noticeable that the greater the commitment of the central bank in output targeting is, the smaller is the role of the financial frictions in amplifying shocks. In this case, the interest rate needs to decrease to counterbalance a negative shock on output, lowering the cost of debt and weakening the pressure on financially constrained firms. Moreover, there is no linkage between interest rates and money supply, because we assumed that the central bank supplies any physical stock of money required by the financial system at a given interest rate i_t. This is what happens nowadays with the scheduled open-market operations enhanced by the central bank.

However, assuming a monetary policy rule in the form of (22) has one specific drawback: we assume that the monetary policy for Slovenia depends on Slovenian output-gap and price dynamics, which is not true during the period 1997Q1:2016Q4. In fact, after having joined the EA, the monetary policy should be treated as exogenous, since it is operated by the ECB. One solution is to consider an exogenous path of the nominal interest rates and to adjust it with a risk premium for the Slovenian economy; however, this solution does not lack of criticism as well. After the ECB has introduced non-conventional measures, the short-term interest rate is not anymore suitable proxy of the monetary policy because of the zero-lower bound; therefore, we would need to specify other proxies such as short shadow rates, which do not lack of critics too, since they are an estimated category and rely on the availability of a complete yield curve for Slovenia. We decide not to include any proxy of nominal interest rate in the model and to estimate the nominal interest rate that would be implied if a standard Taylor rule was applied. This shortcut overcomes the problem of identifying a monetary policy rate and dealing with the zero-lower bound.

2.5.2 Fiscal Policy

Fiscal policy is purely exogenous in our framework and it evolves according to the following autoregressive process:

$$\ln gov_t = (1-\rho_G)G_0 + \rho_G \ln gov_{t-1} + \epsilon_t^{gov}$$

Furthermore, we assume that taxes T_t adjust in each period to keep in balance the government budget.

We can classify the aforementioned fiscal policy rule into a set of components, which exogenously affect the aggregate. We include shocks to the commercial balance in this class, partially overcoming the limitation of not directly modeling Slovenia as a small open economy. Formally, we model the set of exogenous components of the aggregate demand as:

$$\ln exo_t = (1-\rho_{exo})exo_0 + \rho_{exo} \ln exo_{t-1} + \epsilon_t^{exo} \tag{23}$$

We can justify the choice of not directly modeling exports and imports for Slovenia because we are mainly interested in showing the impact of exogenous shocks to expectations, which is identified by an unexpected increase of the degree of agents' myopia. Modeling a small open economy in all its features would have not enriched our model, but it would have certainly increased its complexity and would have made the DSGE estimation heavier.

We consider the role of imports and exports by defining exogenous component of aggregate demand that captures the impact of shocks to Slovenian commercial balance, as well as the lump-sum government expenditures. This shortcut allows us to improve models’ ability to fit the data and it overcomes the criticism of not directly modeling an open economy for the Slovenian case.

2.6 Natural Level of Output

We analytically obtain the definition of the output gap in our framework. We decided to explain the natural level of output in term of technology, return on capital and employment. We recall the optimal conditions necessary to derive the natural level of output.

Production Function (a)	Demand of Labor (b)	Optimal condition for wages (c)
$Y_t = A_t K_t^{\alpha} L_t^{\omega(1-\alpha)}$	$\frac{W_t}{P_t} = \tau_t \left(\frac{\omega(1-\alpha)Y_t}{L_t}\right)$	$\frac{a_L\, L_t^{a_L}}{-\lambda_t} = \frac{W_t}{P_t}$

Firstly, we combine (a) and (c) obtaining:

$$Y_t = A_t K_t^{\alpha} {a_L}^{-\omega(1-\alpha)} \left(-\lambda_t\, \frac{W_t}{P_t}\right)^{\frac{\omega(1-\alpha)}{\gamma_L}} \tag{d}$$

Therefore, we substitute (b) into (d):

$$Y_t = A_t K_t^{\alpha} {a_L}^{-\omega(1-\alpha)} \left(-\tau_t \left(\frac{\omega(1-\alpha)Y_t}{L_t}\right)\lambda_t\right)^{\frac{\omega(1-\alpha)}{\gamma_L}} \tag{e}$$

We defined the natural level of output as the level of production, which the economy would endogenously reach if there were no frictions in the economy. We recall the optimal price for intermediate goods producers in a flexible prices environment:

$$\frac{P(z)_t}{P_t} = \left(\frac{\varepsilon}{\varepsilon-1}\right) * \frac{1}{X_t} \tag{f}$$

If prices are flexible, each retailer instantaneously updates her price after a shock, so we can rewrite (f) as:

$$1 = \left(\frac{\varepsilon}{\varepsilon-1}\right) * \frac{1}{X_t} \rightarrow \frac{\varepsilon-1}{\varepsilon} = \frac{1}{X_t}$$

$$\tau_t = \frac{1}{X_t} = \frac{\varepsilon-1}{\varepsilon} = \frac{1}{X_0} \tag{g}$$

The marginal cost is constant and we can plug (g) into (e) to obtain the analytical form for the potential output. The superscript *n* denotes the natural level of output.

$${Y_t}^{n} = A_t K_t^{\alpha} {a_L}^{-\omega(1-\alpha)} \left(-\frac{1}{X_0}\left(\frac{\omega(1-\alpha){Y_t}^{n}}{L_t}\right)\lambda_t\right)^{\frac{\omega(1-\alpha)}{\gamma_L}} \tag{31}$$

2.7 Exogenous Processes

In this section, we specify the autoregressive processes, which describe the evolution over time of the exogenous variables in the model, given the steady state of variables. The standard equation for the evolution of the aggregate capital in the economy is given by:

$$K_{t+1} = (1-\delta)K_t + \; I_t \Phi\left(\frac{I_t}{I_{t-1}}\right) \tag{24}$$

Government spending, productivity and IESC shocks evolve according to standard autoregressive processes of first order

$$\ln A_t = \; (1-\rho_A)\ln A_0 + \rho_A \ln A_{t-1} + \epsilon_t^A \tag{25}$$

$$\ln \gamma_t = \; \left(1-\rho_\gamma\right)\ln \gamma_0 + \rho_\gamma \ln \gamma_{t-1} + \epsilon_t^\gamma \tag{26}$$

Households' and capital assets producers' myopic shocks depend on the current level of output making sentiment procyclical.

$$\Delta\ln F_t = \rho_F \,\Delta\ln F_{t-1} - \rho_{FY}\,\Delta\ln Y_{t-1} + \epsilon_t^F \tag{27}$$

$$\Delta\ln \xi_t = \rho_\xi \;\Delta\ln \xi_{t-1} + \rho_{\xi Y}\Delta\ln Y_{t-1} + \epsilon_t^\xi \tag{28}$$

Both channels (27 and 28) endogenously accelerate business cycles fluctuations. Combining (27) with (3), we can state our first intuition: the unexpected rise of myopia due to an exogenous event drives down the private consumption. This has a negative effect on output and self-fulfills households' beliefs, leading the economy to a vicious spiral. The process (28) describes the distorted decision-making process of capital assets producers. In fact, they behave procyclically exactly as households, being exuberant in positive cycles and depressed in negative phases.

2.8 Procyclical credit-market conditions.

In our model, we have slightly modified the original financial accelerator (FA) set up to model time-varying credit-market conditions. The idea is simple: as households and capital assets producers overreact to business cycle fluctuations, financial intermediaries behave similarly, strengthening (weakening) the minimum financial requirements necessary to grant corporate loans during negative (positive) business cycles.

The original FA specifies the relation:

$$\frac{E_t[R_{t+1}^K]}{R_t} = S\left(\frac{N_{t+1}}{Q_t K_{t+1}}\right) \tag{12}$$

The function $S(*)$ is defined on the positive domain $0 < \frac{N_{t+1}}{Q_{t+1}K_{t+1}} < 1$ and it is strictly increasing ($S'(*) > 0$). The following formal representation of $S\left(\frac{N_{t+1}}{Q_t K_{t+1}}\right)$ respects the properties required by Bernanke et al. (1999).

$$\frac{E_t[R_{t+1}^K]}{R_t} = \left(\frac{N_{t+1}}{Q_t K_{t+1}}\right)^{s_0}$$

The constant parameter $s_0 \in (0,1)$ and describes the intensity of the financial frictions in the economy, namely, the greater is the sensitivity of the cost of debt to changes in the financial structure, the lower s is.

$$\frac{E_t[R^K_{t+1}]}{R_t} = \left(\frac{N_{t+1}}{Q_t K_{t+1}}\right)^{s_t} \tag{29}$$

It is straightforward to extend this formulation to a procyclical representation of the credit-market conditions, assuming $s_t = f(s_{t-1}, Y_t)$. The function f is a twice-differentiable function defined as follows:

$f: \mathbb{R} \to \mathbb{R}$ (I)	$f_{s_{t-1}}(*) > 0$ (II)	$f_{Y_t}(*) > 0$ (III)
$\mathbb{H}$[1](f) is definite (IV)	$\lvert\lambda_{s_{t-1}}\rvert < 1$ (V)[2]	$\lvert\lambda_{Y_t}\rvert < 1$ (VI)

Condition (I) defines domain and codomain, (II) and (III) specify respectively the persistence and the procyclical behavior of the credit-market frictions. The requirements (IV), (V) and (VI) are necessary not to violate the Blanchard-Khan conditions (Blanchard & Khan, 1980), which impose the existence of a unique stable equilibrium with $s_t = s_0$.

In our framework, we implement output-dependent credit condition using the following functional form:

$$\Delta \ln S_t = \rho_s \Delta \ln S_{t-1} + \rho_{sY} \Delta \ln Y_t \tag{30}$$

With $\rho_s, \rho_Y \in (0,1)$

The process (31) satisfies both Blanchard-Khan conditions and the theoretical economic baseline that we have previously illustrated. In a positive business phase, (31) impose the contraction of the external finance risk premium, increasing the entrepreneurial incentive to increase the leverage; contrarily in a recession, it stiffens financial constraints.

2.9 The Complete Log-Linearized Model

We have now all the equations which characterize the economy and we can present the complete model. The model is micro-founded and we obtain the steady state relations by investigating the equilibrium that the economy reaches when $t \to \infty$.

The main advantage of the model is to combine credit market friction with shock to myopic behavior, using the Hybrid Phillips curve to describe the dynamics of prices, illustrating how the financial and myopic accelerators amplify an exogenous shock.

$$\hat{\lambda}_t = -\gamma_0 \hat{c}_t - \gamma_0 \, lnC_0 \, \hat{\gamma}_t \tag{1}$$

$$\hat{\lambda}_t = \gamma_L \hat{L}_t - \widehat{w}_t \tag{2}$$

$$\hat{\lambda}_t = \hat{r}_t + E\left[\hat{\lambda}_{t+1}\right] + \hat{F}_t \tag{3}$$

$$\hat{q}_t - \hat{\xi}_t = -(1+\beta)\widehat{inv}_t + \widehat{inv}_{t-1} + \beta E[\widehat{inv}_{t+1}] \tag{4}$$

[1] The notation $\mathbb{H}(*)$ indicates the Hessian matrix of a twice-differentiable function.
[2] We define $\lambda_{s_{t-1}}$ and λ_{Y_t} as the eigenvalues of the characteristic polynomial of $f(s_{t-1}, Y_t)$.

$$\hat{y}_t = \frac{C_0}{Y_0}\hat{c}_t + \frac{I_0}{Y_0}\widehat{inv}_t + \frac{exo_0}{Y_0}\widehat{exo}_t + \frac{{C^e}_0}{Y_0}\hat{C}^e_t \tag{5}$$

$$\hat{y}_t = \hat{a}_t + \alpha\hat{k}_t + (1-\alpha)\omega\hat{l}_t \tag{6}$$

$$\hat{y}_t - \hat{x}_t + \hat{\lambda}_t = (1+\gamma_L)\hat{l}_t \tag{8}$$

$$E_t[\hat{r}^K_{t+1}] = (1-\varepsilon)\big(\hat{y}_t - \hat{k}_{t+1} - \hat{x}_t\big) + \varepsilon E[\hat{q}_{t+1}] - \hat{q}_t \text{ with } \varepsilon = \frac{1-\delta}{1-\delta+\frac{\alpha\, Y_0}{X_0 K_0}} \tag{11}$$

$$E_t[\hat{r}^K_{t+1}] - \hat{r}_t \;= -S_0\big(\hat{k}_{t+1} + \hat{q}_t - \hat{n}_{t+1}\big) - \ln\frac{K_0}{N_0}\,\hat{s}_t \tag{29}$$

$$\hat{C}^e_t = \hat{n}_t \tag{13}$$

$$\hat{n}_{t+1} = \frac{ç K_0 R}{N_0}(\hat{r}^K_t - \hat{r}_t) + \hat{r}_t + \hat{n}_t \tag{14}$$

$$\hat{\pi}_t \;= k\,\widehat{mc}^r_t + \sigma_f E_t\big[\hat{\pi}_{t+1}\big] + \sigma_b\hat{\pi}_{t-1} \tag{21}$$

with $k = \frac{(1-w)(1-\theta)(1-\theta\beta)}{\theta+w[1-\theta(1-\beta)]}$; $\sigma_f = \frac{\theta\beta}{\theta+w[1-\theta(1-\beta)]}$ and $\sigma_b = \frac{w}{\theta+w[1-\theta(1-\beta)]}$

$$\hat{\iota}_t = \rho_i\hat{\iota}_{t-1} + \varphi_\pi E[\hat{\pi}_{t+1}] + \varphi_y(\hat{y}_t - {\hat{y}_t}^n) + \widehat{mp}_t \tag{22}$$

$$\widehat{exo}_t = \rho_{exo}\widehat{exo}_{t-1} + \hat{\epsilon}^{exo}_t \tag{23}$$

$$\hat{k}_{t+1} = \delta\widehat{inv}_t + (1-\delta)\hat{k}_t \tag{24}$$

$$\hat{a}_t = \rho_A\hat{a}_{t-1} + \hat{\epsilon}^A_t \tag{25}$$

$$\hat{\gamma}_t = \rho_\gamma\hat{\gamma}_{t-1} + \hat{\epsilon}^\gamma_t \tag{26}$$

$$\hat{F}_t = \rho_F\hat{F}_{t-1} - \rho_{FY}\hat{y}_{t-1} + \hat{\epsilon}^F_t \tag{27}$$

$$\hat{\xi}_t = \rho_\xi\hat{\xi}_{t-1} + \rho_{\xi Y}\hat{y}_{t-1} + \hat{\epsilon}^\xi_t \tag{28}$$

$$\hat{s}_t = \rho_S\hat{s}_{t-1} + \rho_{SY}\hat{y}_t \tag{30}$$

$$\left[\frac{\gamma_L}{\omega(1-\alpha)} - 1\right]\hat{y}^n_t = \frac{\gamma_L}{\omega(1-\alpha)}\big(\hat{a}_t + \alpha\hat{k}_t\big) + \hat{\lambda}_t - \hat{l}_t \tag{31}$$

The condition (1) defines the optimal consumption for households, while equations (2) and (3) represent respectively the optimal condition for wages and the Euler equation for deposits, setting the equilibrium conditions for households. The relation (4) gives the unitary price of capital asset and (5) the aggregate demand. Equation (6) is the log-linear Cobb-Douglas production function and (8) gives the entrepreneurial demand for factors (capital assets and labor), while (11) represents the return on capital in both its components: standard profits from production and capital gains. Equation (29) is the cornerstone of the financial accelerator framework and it gives the relation between the actual return on capital available for entrepreneurs and firms' financial structure. Relations (13) and (14) are respectively the entrepreneurial consumption due to wholesale producers exiting the market, and the evolution of net-wealth over time. Equation (21) illustrates the price dynamics, while the monetary policy rule is given by (22). All the other equations describe the evolution of exogenous variables over time: (23) describes the exogenous component of the aggregate demand, (24) the evolution of capital assets and (25) the exogenous technology freely available in the industry; moreover, (26) specifies exogenous processes of IESC. The processes (27) and (28) describe the output-dependent behaviors of households and capital assets producers. Relation (30) illustrates time-varying credit-market condition and (31) the log-linear analytical expression of potential output.

3 Model Estimation

We proceed calibrating and estimating the main structural parameters, which characterize the Slovenian economy. We use Bayesian econometric tools to estimate the unknown structural parameters of the economy by inferring from a sample of observed macroeconomic variables[3].

Univariate and multivariate diagnostics (Gelman and Brooks test) do not underline problems, but the standard deviation of the monetary policy shock has difficulties to converge to the true value. We can solve this problem by dropping the monetary policy shock in the model and considering only, productivity, exogenous components of demand, and the implemented shocks to myopia and IESC at a cost of losing important information. The contribution of $\widehat{mp}_t$ is statistically significant, but small in size and it represents the original impulses of the central bank, which have not already been captured by the shocks to beliefs (ϵ_t^F, ϵ_t^γ and ϵ_t^ξ). We could have expected these potential problems just looking at model's structure. In fact, we saw that the monetary policy shock produces real effects through the same channels of households' and capital asset producers' myopia, as well IESC shocks (Euler equation for bonds/deposits). We remark that both these shocks reflect how agents perceive and react to the occurrence of an exogenous event, policy actions included. Furthermore, if assuming a constant standard deviation for all the structural shock in the economy is a strong hypothesis in general, it will be much stronger in a time interval with at least two major crises. The apparent problem of identification and stability is indeed the main achievement of the research: monetary policy act through the agents, who endogenously amplify, underreact or distort the original impulses: fiscal and monetary actions produce real effects in the short term if and only if they affect individuals' decisions.

3.1 Observed Variables

The estimation rests on the idea of extracting the structural parameters of the economy by few observed variables. We identify real GDP and Gross Capital Formation to be respectively our proxies for output and investments. Furthermore, we assume Households final consumption expenditure,

[3] We apply Ratto's algorithm[3] to optimize the likelihood function and we employ 4 distinct MCMCs with 4000000 iterations in the Metropolis-Hastings algorithm. However, most of MCMC estimates have already converged to the estimated posterior distributions after 400.000 draws. We fix the scale parameter of the MH algorithm to 0.35 to obtain an overall acceptance ratio between 0.25 and 0.33. We show the diagnostics in the appendix.

abbreviated as HFCE, to represent households' consumption, while total working hours is a natural substitute of the employment L_t. Finally, core HICP describes the prices dynamics in the economy.

Variables in levels are not suitable for the analysis, since optimal conditions consider percentage deviation from the steady state; therefore, we must de-trend the variables, distinguishing between the trend and the cyclical component of the business cycles.

We can consider growth rates of the observed variable by taking log-differences as in Smets & Wouters (2003). This method has two main advantages: firstly, it reduces the degree of subjectivity due to the choice of any smoothing parameter[4], secondly the resulting business cycle fluctuations are small enough to be appropriately described by a linear model. The following table summarizes the descriptive statistics of then observed variables in the model.

	GDP (Y)	GCF (INV)	HFCE (C)	Worked Hours (L)	Inflation (π)
Mean	0,258	0,151	0,2041	0,0457	0,336
Median	0,303	0,175	0,122	0,0180	0,188
Maximum	1,570	6,456	1,881	2,531	1,948
Minimum	-1,984	-6,919	-1,561	-3,379	-0,241
Std. Dev.	0,510	1,964	0,534	0,862	0,4432
Skewness	-1,678	-0,4788	-0,151	-0,220	1,634
Kurtosis	8,939	5,854	4,492	5,699	5,712
Jarque-Bera	153,187	29,825	7,631	24,619	59,362
Probability	0,000	0,000	0,022	0,000	0,000
Observations	79	79	79	79	79

Table 1 Descriptive statistics of quarterly percentage growth rate of the observed variables for Slovenia in the sample 1997Q2:2016Q4. Source: Author's Calculations.

3.2 Priors and Posterior Estimates

We specify our priors following the main achievement in the literature (Del Negro & Schorfheide, 2004 and Smets & Wouters, 2007). We assume the standard deviation of stochastic shocks to follow an inverse-gamma distribution with mean 1 (1% shock), and the persistence coefficients of the autoregressive processes ρ follow a beta distribution with mean 0.5 and standard deviation 0.2.

We set some of the parameters according to the main achievements in the literature or to empirical evidence on Slovenia. Indeed, estimating all parameters would raise identification issues (Canova, F., & Sala, L., 2006 and Smets, F. & Wouters, R., 2007). The contribution of households' consumption is 55%, of investments 21% and we impose the complementary share of entrepreneurial consumption $\frac{C_0{}^e}{Y_0} = 0.01$ following the standard financial accelerator set up (Bernanke et al., 1999). Consequently, the

[4] In theory, the smoothing parameter of HP-filter should be set to 1600 for quarterly data, however for MA and exponential smoothing allow for a higher degree of subjectivity.

residual exogenous component of the aggregate demand is 23% and it considers both government expenditures and net-export, which we assumed to be exogenous in this model.

We define leverage as the ratio between total stock of capital and entrepreneurial net-wealth and it is set equal to $\frac{K_0}{N_0} = 4$ in the steady state. This value is obtained by computing the long-term average of total assets and equity (share + retained earnings) for Slovenian companies as reported in their balance sheet. The equilibrium mark-up $X_0 = 1.1$ and the quarterly real discount factor is $\beta = 0.989$, based on the estimation of the annual long-run real interest rate $R = 4{,}524\%$. The quarterly depreciation rate is δ=4.67%, assuming that capital assets have an average expected life of 5 years. This is coherent with the current accounting standard in place in Slovenia. The capital share in the production function (α) is 0.35. The share of manpower employed in the production is $\omega = 0.99$, while the probability of surviving is $ç = 1 - 1.5871\%$ (quarterly). The implied probability of default is coherent with the estimation of the yearly average probability of default in the Slovenian economy of 6.501% in the period 2007-2010 (Volk, 2014). We impose $\rho_{\xi Y}$ and ρ_{FY} to be 0.1, while we set $\rho_{sY} = 0.5$, assuming the financial sphere to be more volatile and particularly influenced by business cycle fluctuations. We restrict those parameters in order to ease the estimation and to solve identification issues which would emerge. The following table illustrates the prior distribution and the posterior estimates of the remaining parameters in the model.

Parameters

	Prior mean	Post. mean	90% HPD	interval	Prior shape	Prior st. dev.
γ_L	3.00	5.20	2.30	8.02	norm	3.00
γ_0	4.00	6.55	4.27	8.91	norm	3.00
ρ_i	0.50	0.32	0.19	0.45	beta	0.20
s_0	0.50	0.35	0.27	0.42	beta	0.20
ρ_Y	0.50	0.15	0.03	0.27	beta	0.20
ρ_F	0.50	0.74	0.62	0.86	beta	0.20
ρ_{exo}	0.50	0.33	0.17	0.49	beta	0.20
ρ_ξ	0.50	0.06	0.01	0.11	beta	0.20
ρ_S	0.50	0.82	0.68	0.97	beta	0.20
ρ_A	0.50	0.18	0.04	0.31	beta	0.20
k	0.40	0.10	0.07	0.14	beta	0.20
σ	0.60	0.94	0.90	0.99	beta	0.20
$\frac{1}{\varphi}$	0.25	0.43	0.27	0.59	beta	0.10

Standard Deviations Shocks

	Prior mean	Post. mean	90% HPD	interval	Prior shape	Prior st. dev.
$\widehat{mp}_t$	0.001	0.0021	0.001	0.0038	invg	Inf
$\hat{\epsilon}_t^{exo}$	0.001	3.2307	2.7702	3.683	invg	Inf
$\hat{\epsilon}_t^{A}$	0.001	1.1812	1.0286	1.3324	invg	Inf
$\hat{\epsilon}_t^{\xi}$	0.001	19.9171	12.1672	27.4557	invg	Inf
$\hat{\epsilon}_t^{F}$	0.001	0.6547	0.2308	1.0341	invg	Inf
$\hat{\epsilon}_t^{\gamma}$	0.001	0.34	0.2842	0.3957	invg	Inf

Table 2 Priors and posterior estimates of parameters. Dataset in Quarterly Growth Rates (%).

In the appendix, we show prior and posterior distributions of the estimated parameters and the diagnostics tests showing the convergence of the distributions generated by MH algorithm to $P(\theta|X)$.

4 Estimated DSGE model.

We defined six different aggregate shocks: government spending shock, monetary policy shock, productivity shock, myopic shock for households and capital assets producers and shock to the intertemporal elasticity of consumption. For the ease of illustration, we standardize the impulse responses to have the same intensity (1%) for all shocks. We notice that impulse responses of investment are hump-shaped and this characteristic is due to the adjustment cost function we assumed, imposing time-dependency of investments decisions. We can make a similar consideration about inflation: the hybrid Phillip's curve explains current inflation both with expected and past level of prices, making inflationary effects persistent after a shock.

4.1 Restrictive Monetary Policy Shock (+1% Nominal Interest rate) $\widehat{mp}$

In figure 1, we show that an increase of the nominal interest rate (+1%) has a negative effect on output (-1%), on output gap (-1.57%) and on investments (-1.5%) and this is in line with theoretical and empirical research (Bernanke et al., 1999 and Smets & Wouters, 2003). The increase of nominal (and real) interest rates lowers private consumption through IESC (-0.2%), however the restrictive effects of the monetary policy shock run out after 2 quarters, diminishing the overall impact. These results scale down the theoretical negative relation between interest rates and private consumption for the Slovenian economy, since the IR is either statistically insignificant or unimportant for its size. Inflation (-0.3%) takes time to recover completely from the contractionary patter, but this is a direct consequence of the New-Keynesian Hybrid Phillips curve. Monetary policy shock has a severe impact on the average financial structure in the economy: leverage increases (+10%) and this important effect is due to the financial accelerator and output-dependent financial conditions, which amplify the initial impact, bolstering financial constraints. Impulse responses forecast firms' needs to deleverage, reducing their size, describing what the unpredicted weakening of credit market conditions may cause. For the sake of completeness, we must specify that the financial accelerator (Bernanke et al., 1999) does not consider the rationing of credit (credit-crunch), which would significantly amplify the real impact of financial frictions on the economy. Even if this mechanism is simpler than assuming liquidity constraints and endogenous probabilities of default, its ability to amplify the effects of a tightening monetary policy is still powerful, especially assuming agents that overreact to business cycle fluctuations.

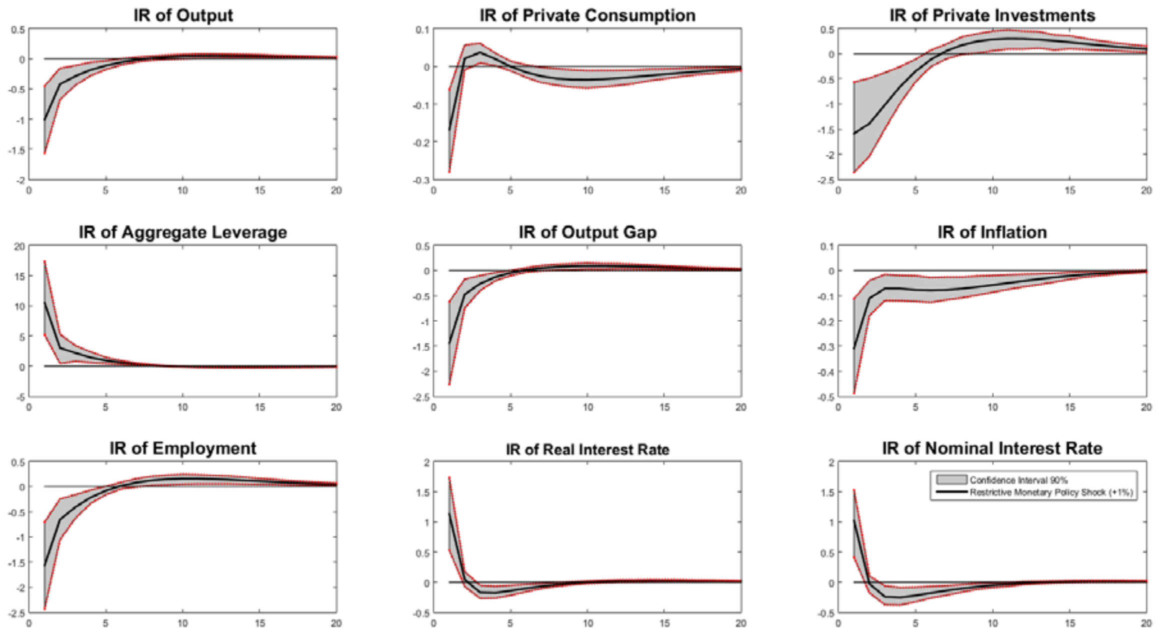

Figure 1 Standardized Impulse responses to +1% Nominal Interest Rate, Restrictive monetary policy shock. Confidence intervals 90%. Source: Author.

4.2 Households' Myopia: Postponing Current Consumption Decisions $\hat{\epsilon}^F$

This shock represents an expected increase of what we called "rational agents' myopia", identifying the state of the world where some unexpected event pushes households to postpone their consumption, overweighting future utility. Figure 2 shows the impulse response of the main macroeconomic variables to 1% shock to Households' myopia

The shock to the real discount factor is a good proxy to model the behavioral responses of households after the burst of real-estate bubble in 2008 (Lehman Brothers bankruptcy September, 15th 2008), which froze agents, provoking diffused panic in the demand side of the economy. Looking at figure 2, we can see that the initial impact on output growth is important (-0.4%), mainly driven by the contraction of consumption (-0.25%). The effect on private investments is positive but generally statistically insignificant (peak of +0.2%) and it is directly connected to the contrasting actions of myopia and to the real interest rate: the pessimistic reaction of capital assets producers to the contraction of output is compensated by the decrease of the real interest rate (-0.5%). Employment decreases (-0.6%) and inflation goes persistently down (-0.6%). On the supply side, entrepreneurs adjust their financial structure by reducing their leverage (+4%) which suddenly increased because of entrepreneurial premium's downturn, which smashed firms' equity.

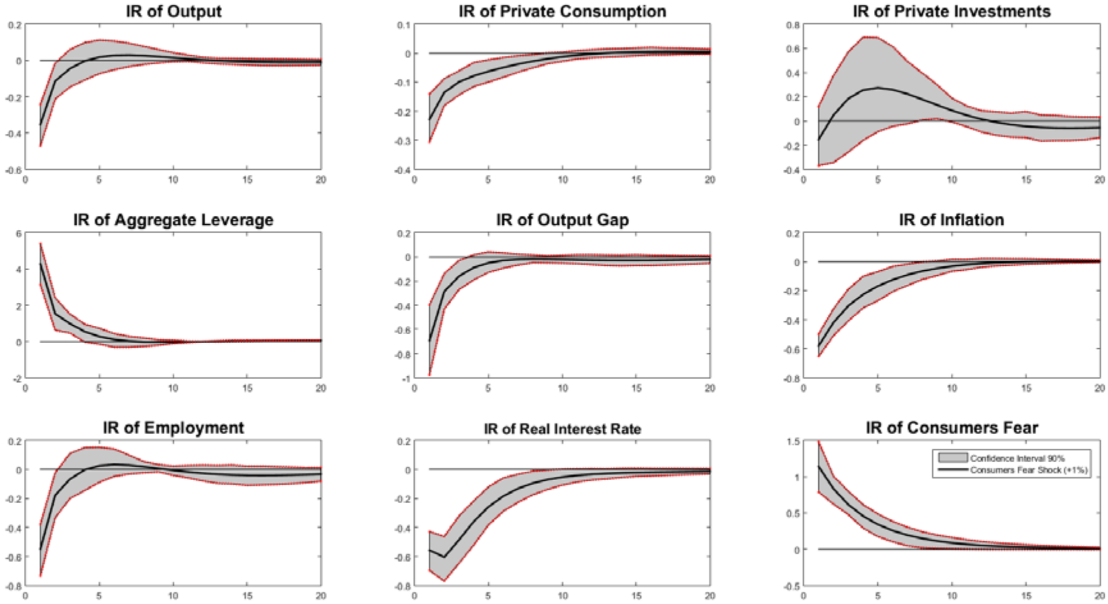

Figure 2 Standardized Impulse responses to +1% shock to Households' degree of myopia. Confidence intervals 90%. Source: Author.

4.3 Shock to Intertemporal Elasticity of Consumption $\hat{\epsilon}^{\gamma}$

While households' fear shock showed how the economy responses to a drop of confidence in future economic situation, a shock to intertemporal elasticity of consumption changes the sensitivity of actual consumption decisions to the real interest rate, representing a structural shift of households' intertemporal preferences. We simulate the effects of the unexpected decrease of the marginal utility of consumption, which pushes households to reallocate their preferences of consumption towards the future. In fact, when some exogenous event scares households, they can suddenly think to consume too much relatively to what they can currently afford. From figure 3, we see that the immediate effect will be a collapse of private consumption (-3.6%) with a consequent contraction of output (-1.5%).

The economy endogenously reacts by lowering the real interest rate (-0.8%) in order to reduce the incentive to save. The low level of the real interest rate pushes entrepreneurs to ask for more capital, raising investments (+0.75%). The shock has contractionary effects on employment (-2.2 %), but the positive inflationary trend (+0.05%) is statistically insignificant.

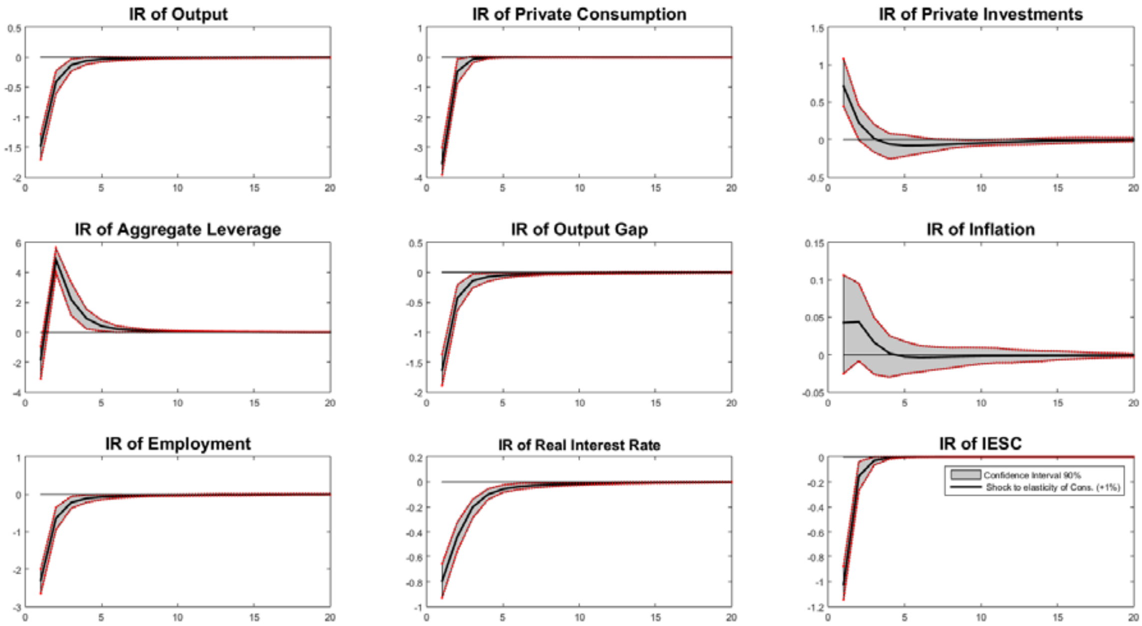

Figure 3 Standardized Impulse responses to +1% shock to IESC. Confidence intervals 90%. Source: Author.

4.4 Uncertainty Shock: Capital Assets Producers' Fear $\hat{\epsilon}^{\xi}$

In the previous sections, we focused on the demand side of the economy, analyzing the responses to the unexpected increase of Households' Myopia and the shock to IESC. Now, we move to the supply side, studying the impact of the myopic shock to capital assets producers. In this case, we define the uncertainty shock as the unforeseen downturn of capital assets producers' ability to forecast. We exogenously provoke a drop of investments, simulating the effects of an exogenous and important increase of uncertainty in the stock market. Agents believe that the current level of investment is too high relatively to what the economy endogenously demand, so they disinvest.

For the ease of explanation, we present impulse responses after 1% increase of myopia, but this specific shock has been considerably rescaled: the estimated intensity is 19.92 % and this explains why the impact of this shock is small (but always statistically significant) in size. Moreover, this shock for capital assets producers is not very persistent, since it runs out after 3 quarters ($\rho_{\xi} = 0.06$), but it produces protracted and relevant effects on all macroeconomic variables because of the financial accelerator and output-dependent myopia. Looking at figure 4, we see that output (-0.05%) decrease because of the contraction of private investments (-0.3%). Initially, output gap (-0.04%) falls too and inflation (peak -0.01%) significantly decreases. The aggregate leverage (+0.2%) endogenously increases after the first quarter and private consumption initially grows (+0.01%) because of the lower incentive to save induced by the decreasing real interest rate (-0.03%). Therefore, consumption turns negative because of households' output dependent myopic behavior, sustained by the swelling incentive to save caused by the mid-term path of the real interest rate. Employment initially decreases (-0.06%).

We clearly see how even a temporary (not persistent) myopic shock can produce relevant and severe real effects, triggering a procyclical pattern by influencing other agents' expectations.

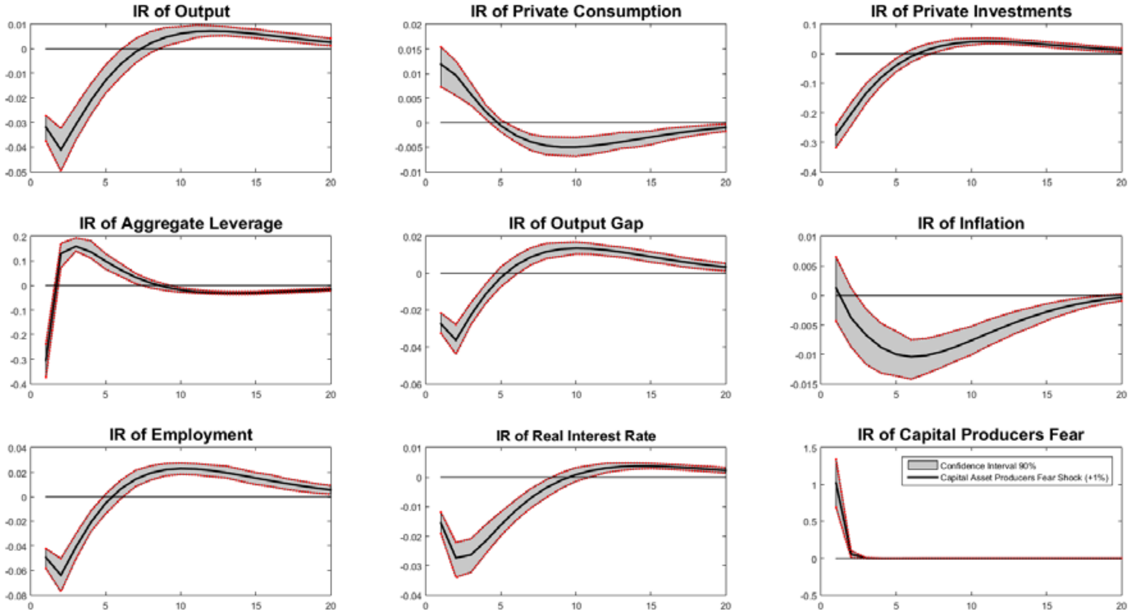

Figure 4 Standardized Impulse responses to +1% increase of Capital Assets Producers' Myopia. Confidence intervals 90%. Source: Author.

4.5 Estimates of the shocks: Households' Myopia and IESC

We present the estimated shocks of the myopic components and IESC. In a DSGE framework, we observe only few of whole set of variables; therefore, we estimate the remaining ones by applying the Kalman filter. These estimates describe the expected path of these unobserved variables given the information extracted by the observations and the structure of the model.

Focusing on the time interval 2006Q1 and 2016Q4, we clearly notice some interesting features of the Slovenian economy. Firstly, households tend to anticipate their decisions of consumption and this habit is consistent over time. They persistently overweight their future utility only in few cases, namely: 2008Q4-2009Q3 (subprime financial crisis) and 2010Q2-Q3, when the peripheral countries Euro Area were hit by the sovereign debt crisis.

We recall that a negative shock to the IESC or the increase of the myopic discount factor cause an expected contraction of private consumption, which drives output down. The most evident difference between the two series is in the sovereign debt crisis period. In fact, while agents move their consumption towards the present, their structural preferences completely changed. Between 2010Q4 and 2012Q3, IESC significantly captures the changes of consumers' sensitivity to the real interest rate. Indeed, despite households overweight current utility and $\widehat{r}_t$ decreases affecting positively private consumption, IESC contrasts and overturns this effect, explaining the fall of Slovenian HFCE (Households' Final Consumption Expenditure).

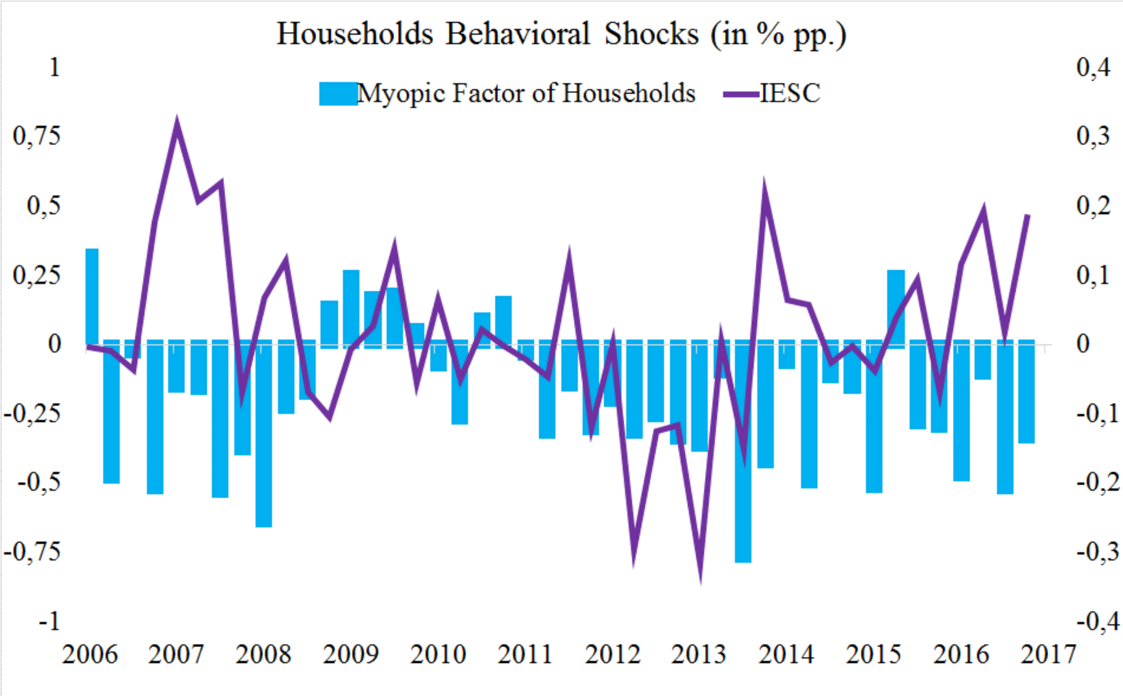

Figure 5 Estimated path of the myopic discount factor $\hat{f}_t$ and of the IESC $\hat{\gamma}_t$ (%).Source: Author.

The shock to households' structural preferences is not very persistent ($\rho_\gamma = 0.15$); therefore, the exogenous component of the IESC $\hat{\epsilon}_t^{\gamma}$ is the factor that explains most of the behavior of $\hat{\gamma}_t$.

Moving to $\hat{f}_t$, both its persistence and the exogenous component are the main drivers of the myopic discount factor (figure 6). However, $\hat{f}$ not only captures households' attitude to overweight/underweight future consumption, which depends on bounded rationality and emotions. In fact, the central bank affects households' behavior by influencing the real interest rate, acting on exactly the same channel of the myopic discount factor; therefore, the exogenous component $\hat{\epsilon}_t^{F}$ captures the monetary policy actions which achieved the ultimate goal of influencing consumers' decisions. Nevertheless, if the central bank does not succeed in affecting consumers' behavior, the myopic discount factor will counteract the effort of policy-makers, which anyway will be captured by the standard monetary policy shock.

Figure 7 shows that monetary policy affects $\hat{f}$, but its strength varies in different sub-intervals. For example, the monetary policy shocks, aimed at making Slovenian interest rates converge to the EA average before 2007, are undoubtedly captured by the myopic discount rate and the restrictive shocks in 2008Q3 and 2008Q4 are more persistent in $\hat{f}$. However, the pure exogenous component $\hat{\epsilon}_t^{F}$ is not only amplifying the monetary shock, but it is contrasting the exogenous shock to the nominal interest rate during both the subprime and the sovereign debt crises.

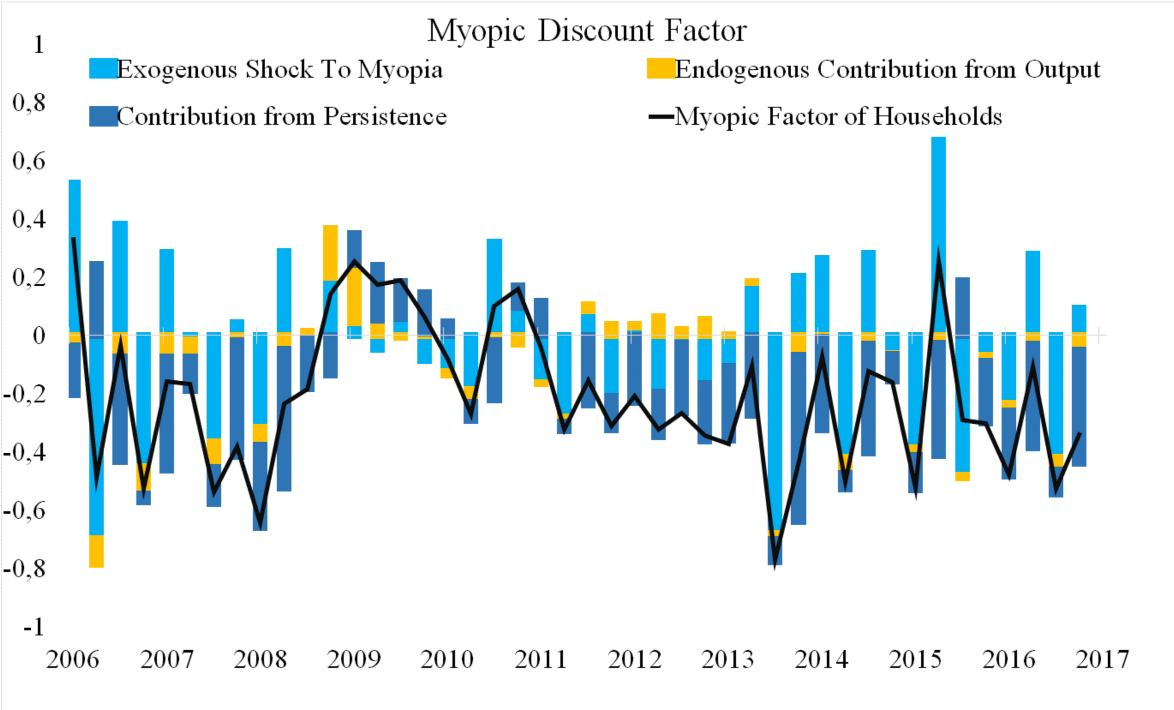

Figure 6 Decomposition of the Myopic Discount Factor $\hat{f}$ into its exogenous shock, persistency and procyclical component. Source: Author.

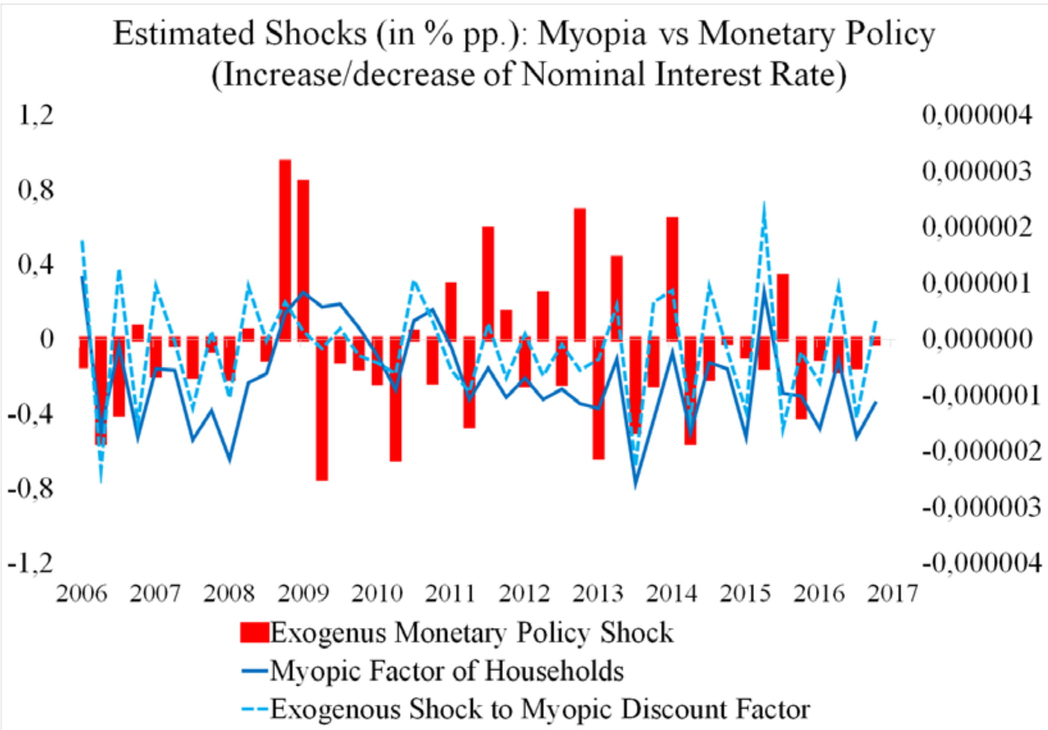

Figure 7 Myopic discount factor of households and standard monetary policy shock. Source: Author. Right axis measures $\widehat{mp}$ (% pp.), while the left one both $\hat{f}$ and $\hat{\epsilon}_t^F$ (% pp.).

We saw that the central bank affects households' myopic behavior, but when the degree of uncertainty in the economy is high, the channel of the transmission of the monetary policy may be less effective because of both consumers' tendency to postpone private consumption and because of structural changes in their preferences. We remark that $\hat{\epsilon}_t^{F}$ and $\hat{\epsilon}_t^{\gamma}$ do not only capture how households perceive monetary policy actions, but a broader set of exogenous events such as changes in fiscal regime or policy directed to labor market. For example, Slovenian HFCE remained considerably high after 2008Q3 because of the automatic stabilizers in the labor market and the fiscal stimulus, which included cuts in payroll and corporate taxes, subsidies to firms, R&D subsidies, and the increase public investment. This explains the positive global contribution of $\hat{\gamma}_t$ and $\hat{f}_t$ in in 2009Q3:2011Q3 (figure 8, next section). Private consumption dropped only on 2011Q3 in the peak of the sovereign debt crisis, when the government enhanced a structural spending review.

Generally, the increase of the exogenous component of the aggregate demand exemplifies only lump-sum government expenditures, which induce a substitution effect on private consumption and investment as specified by the Ricardian equivalence. However, any measure that directly affects consumptions decisions and which is not specifically modeled, is globally captured by the myopic discount factor and the time-varying intertemporal elasticity of consumption.

In this research, we focus on how important are households' and firms' behavioral components at explaining business cycle fluctuations. Together shocks to agents' myopic discount factors and to the intertemporal elasticity of consumption define a proxy of the economic sentiment in the economy. Combining the idiosyncratic shocks with their impulse responses, we obtain a measure of how much beliefs affect the Slovenian economy. This approach permits us to decompose the growth rate of Slovenian GDP in its structural components.

4.5.1 DSGE behavioral components and Economic Sentiment Indicator

It is interesting to study if there is any relation between the aggregate behavioral component, which we estimated for the Slovenian economy and the Economic Sentiment Indicator (ESI).

ESI is a surveys-based measure of confidence and expectations. Interviewers ask if the surveyed expects an improvement/contraction/no-significant changes in the next/past business phase, assuming the date of the interview as reference point. We define the aggregate behavioral component or the DSGE-Implied Sentiment as the sum of the contributions of $\hat{\gamma}_t$, $\hat{f}_t$ and $\hat{\xi}_t$ to the growth rate of GDP. This measure is methodologically and theoretically completely different from the Economic Sentiment Indicator (ESI), which is based on surveys and that compares expectations with the current economic conjecture. Contrarily, the DSGE behavioral components benchmark agents' beliefs with a unique and absolute steady state (equilibrium) which is not time-dependent. Figure 8 compares the standardized measures of sentiment and we can immediately capture a common pattern that clearly identifies how agents' beliefs evolved over time for the Slovenian economy. The standardization dos not invalidate our analysis since we are interested in comparing the co-movements of ESI and DSGE implied sentiment.

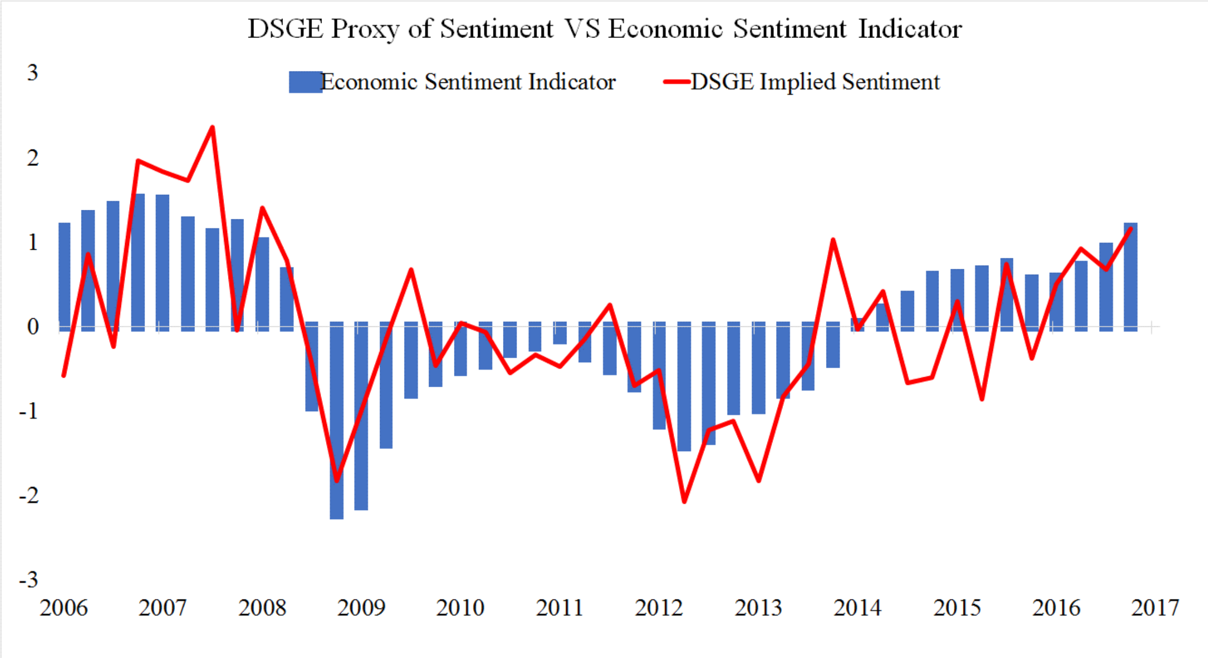

Figure 8 Economic Sentiment Indicator and the Behavioral Component of the Business Cycle. Source: Statistical office of the Republic of Slovenia and Author's Calculations.

5 Decomposition of GDP growth

DSGE models are macroeconomic frameworks aimed at decomposing the business cycle fluctuations of the economy into its structural components. More precisely, we try to identify the hidden and unobserved factors which explain the growth of Slovenian GDP in 2006Q1:2016Q4.

In figure 9, we consider the aggregate contribution of the shock to the IESC and to the myopic discount factor in order to have a clearer idea of how not-fully rational households influence the fluctuations of business cycle; contrarily, we distinguish between $\hat{\epsilon}_t^F$ and $\hat{\epsilon}_t^\gamma$ in figure 10.

Firstly, we can outline that the productivity shock contributes positively to GDP growth in 2006Q1-2007Q4, but its impulse runs out in 2008Q1-Q3. Both shocks to IESC and to the myopic discount factor are important drivers of the growth before 2008Q3, underlining how households were moving their consumption decisions towards the present. The common direction and the intensity of $\hat{\epsilon}_t^F$ and $\hat{\epsilon}_t^\gamma$ identify a phase of exuberance, in which households have "high hopes" about the forthcoming economic conjecture.

Firms' myopic factor capture the same optimistic tendency for the supply side of the economy: entrepreneurs over-invest, ignoring the possibility that the economy over-heats. The contribution of the exogenous factors in the aggregate demand is relevant too: Slovenia is a small open economy and the constant growth of export has been one of the most important drivers of positive trend of GDP before the burst of the financial crisis.

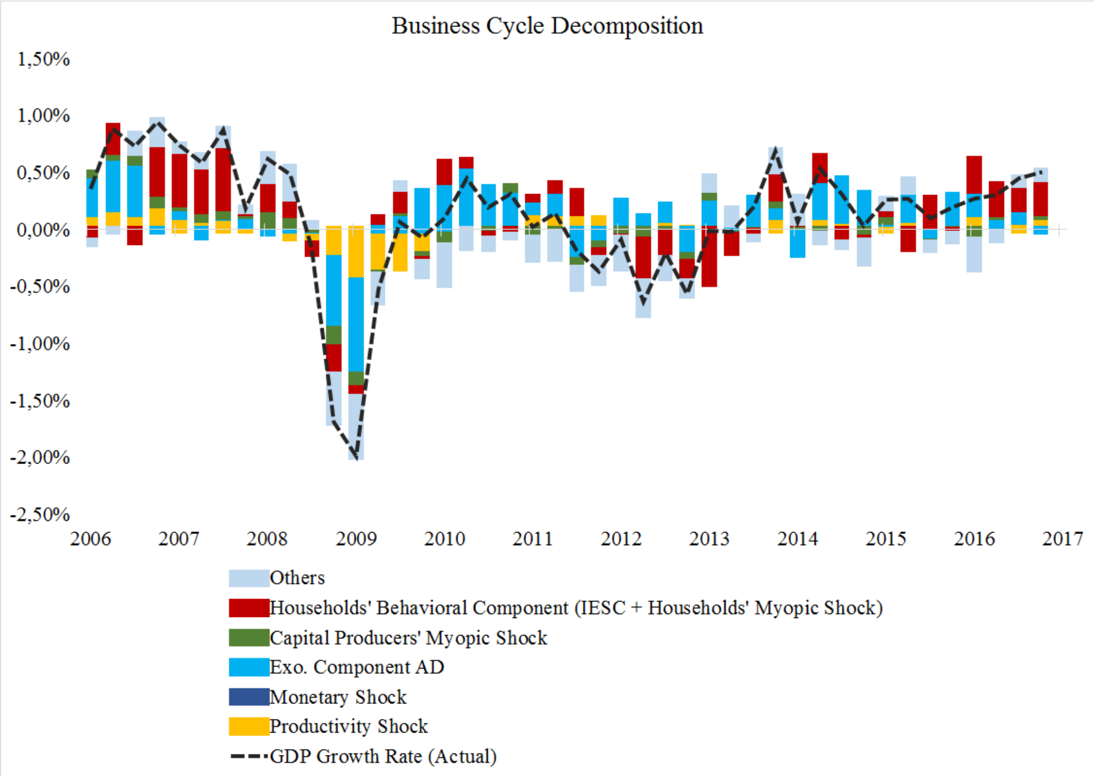

Figure 9 Decomposition of Quarterly GDP growth rate. Aggregate contribution of both shock to households behavioral (myopic discount factor and intertemporal elasticity of substitution in consumption). Source: Author.

The financial crisis, exploded in the USA with the bubble of the subprime mortgages, overwhelmed Europe and Slovenia, which formally joined the EA in January 2007, causing a severe contraction of GDP. Productivity and exports' collapse drive down the growth rate of GDP; moreover, the delay of ECB's actions necessary to limit the devastating effects of the financial crisis and the peak of uncertainty in the economy explain the first significant downturn of agents' sentiment and its importance in deepening the recession. However, after the drop in 2008Q4 and 2009Q1, households' myopic component overestimates Slovenian growth opportunities, predicting an unusual high GDP growth rate. The effects of the automatic stabilizers, the loosening fiscal policy and hike of wages in public sector, negotiated just before the crisis, may explain the apparent contradiction of the positive contribution of both $\hat{\epsilon}_t^F$ and $\hat{\epsilon}_t^\gamma$. Contrarily, firms' myopic shock contributes negatively to GDP till 2013Q1, capturing the first stage of the banking crisis.

The exogenous component of the aggregate demand leads the growth of GDP between 2010Q1 and 2011Q2; however, it turns to be a negative driver after the enhancement of the austerity measures in depths of the sovereign debt crisis. Households' behavioral component explains the important contraction of output in 2011Q3:2012013Q3, capturing the downturn of consumers' confidence (illustrated in figure 9). The exogenous component of aggregate demand and in particular exports are the main drivers of the economy recovery after 2014Q1, while the contribution of households' confidence becomes significant after 2015Q3. In addition, firms' myopic shock and productivity start contributing positively in 2016, amplifying the growth of output. Together, productivity and confidence, as well exports, are relevant determinant of the economy recovery since 2015 and it is noticeable how relevant the role of productivity is to create sustainable positive cycles.

Focusing only on 2016, households' behavioral component (shock to IESC and to the myopic discount factor) is the main driver of the positive trend of GDP, capturing the growth of consumers' confidence. Productivity is particularly important for the sustainability of the economic growth in the mid-term, while the exogenous component of the aggregate demand it captures the increase of export.

We notice that the contribution of the monetary policy shock to real GDP is negligible compared to the other set of structural shocks (figure 9). We remark that, regardless of goal of monetary policy, central bank's actions are aimed at influencing the real interest rate in order to affect households' final consumption and saving decisions, as well as firms' investments choices. Monetary policy shock, shock to IESC and the myopic discount factor act on the same transmission channel (Euler equation for bonds/deposits or entrepreneurial premium); indeed, the behavioral components $\hat{\epsilon}_t^F$, $\hat{\epsilon}_t^\gamma$ and $\hat{\epsilon}_t^\xi$ are more likely to capture the effects of exogenous events, monetary policy included, that affect households' and entrepreneurs' final decisions.

The behavioral shocks $\hat{\epsilon}_t^F$, $\hat{\epsilon}_t^\gamma$ and $\hat{\epsilon}_t^\xi$, regardless of central bank's intentions, may amplify, nullify or overturn the initial policy-makers' action, identifying a potential break in the transmission of monetary policy (figure 7), which is particularly evident when agents face uncertainty and explains why the size of the monetary policy shock is negligible in our model.

6 Conclusions

In this paper, we create a DSGE model by first deriving and then estimating the optimality conditions for the Slovenian economy. We implemented output-dependent myopia specifying exogenous shocks to consumers' confidence through two channels, acting on the real discount factor (pure myopic shock) and on the intertemporal elasticity of substitution in consumption, as well a specific myopic factor for capital assets producers.

Myopia is procyclical in our model: in a positive business phase, agents would be more prone to be hind sighted with inflated decision about the current level of consumption and investments, or more depressed in a recession. Biases or emotions affect capital assets producers' investment decisions, leading to suboptimal results that may potentially amplify business cycles fluctuations.

We impose financial condition to be time-varying as well, assuming that financial intermediaries strengthen (weaken) the minimum financial requirements necessary to grant corporate loans during negative (positive) business cycles. Together non-fully rational individuals and conjecture-dependent credit market conditions provide a more realistic description of the economy with non-perfectly rational agents, enriching the standard literature on DSGE modeling.

This simple and restricted DSGE model supports the main achievements in the literature and provides a simple tool to produce policy simulation for a small economy. Together with the exogenous factors of the aggregate demand (export and government spending), shocks to agents' ability to forecast and changes in households' intertemporal decisions are the main drivers of the business cycle for Slovenia.

The estimated cumulative impulse responses to the behavioral shocks have shown that even a non-persistent or unimportant in size shock may produce severe effects for the economy. Their significance and intensity should push policy-makers to evaluate carefully the impact on agents' expectations and beliefs and to forecast potential source of instability in the economy, signaling phases of exuberant and depressed economic sentiment.

We compare the estimated DSGE myopic shocks with the Economic Sentiment Indicator, finding some similarities that clearly identifies how agents’ beliefs evolved over time for the Slovenian economy.

Policy Implications

The central bank can still count on the anticipating power of expectations when players are myopic, but, if agents perceive the new policy as a new source of uncertainty or if the new monetary regime simply underlines a preexisting potential cause of ambiguity, confidence's fall will nullify or overturn the initial policy-makers' action, producing unexpected and potentially risky effects.

Policy-makers should focus on how a new policy is communicated to the economic actors than how the action is practically implemented, especially when agents' degree of confidence is weak and their beliefs are volatile. This framework underlines the importance of a combined action between fiscal and monetary authorities to restore confidence, fundamental intermediate step necessary to strengthen financial condition and to pursue price stability in the mid-term.

7 Literature

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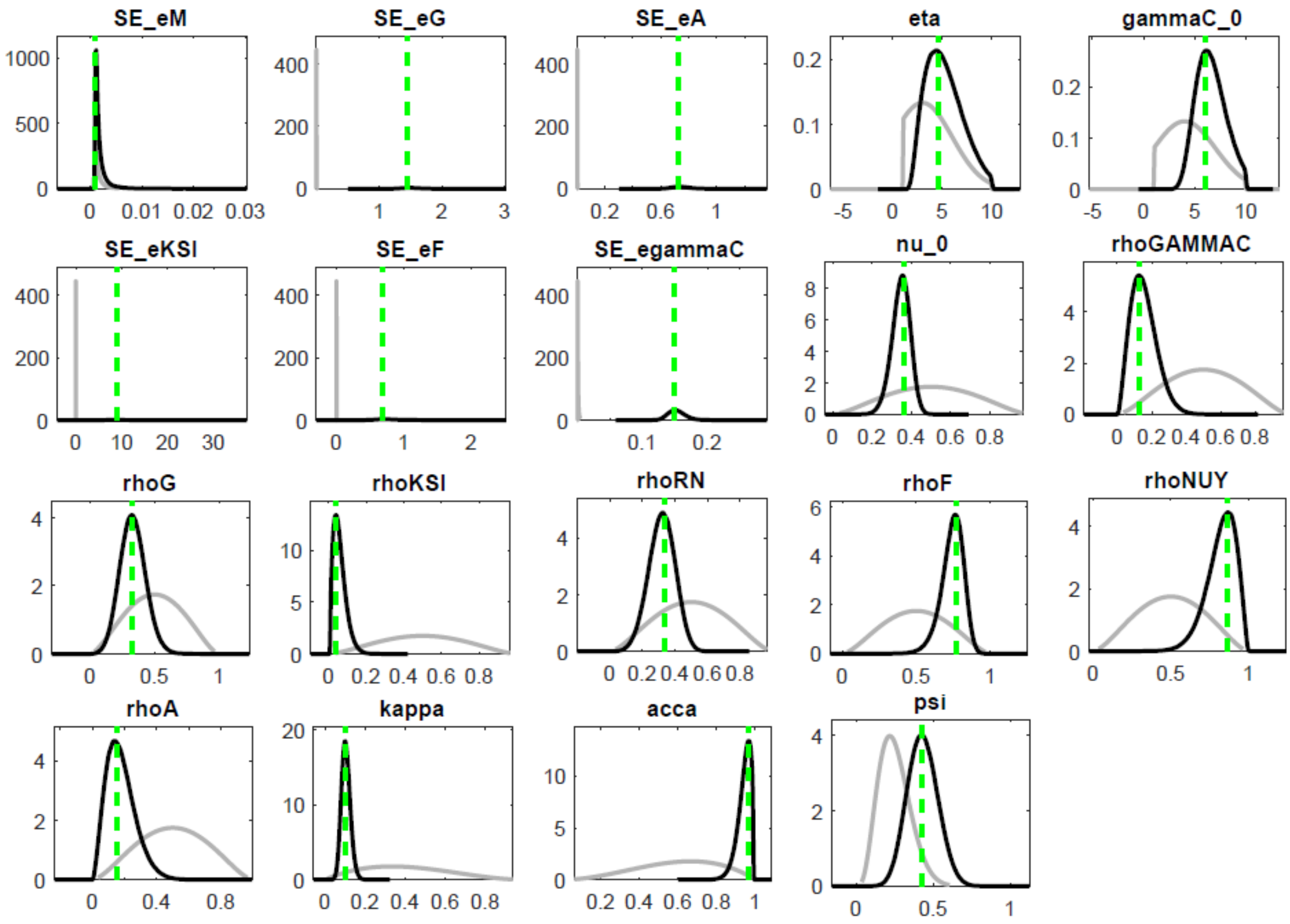
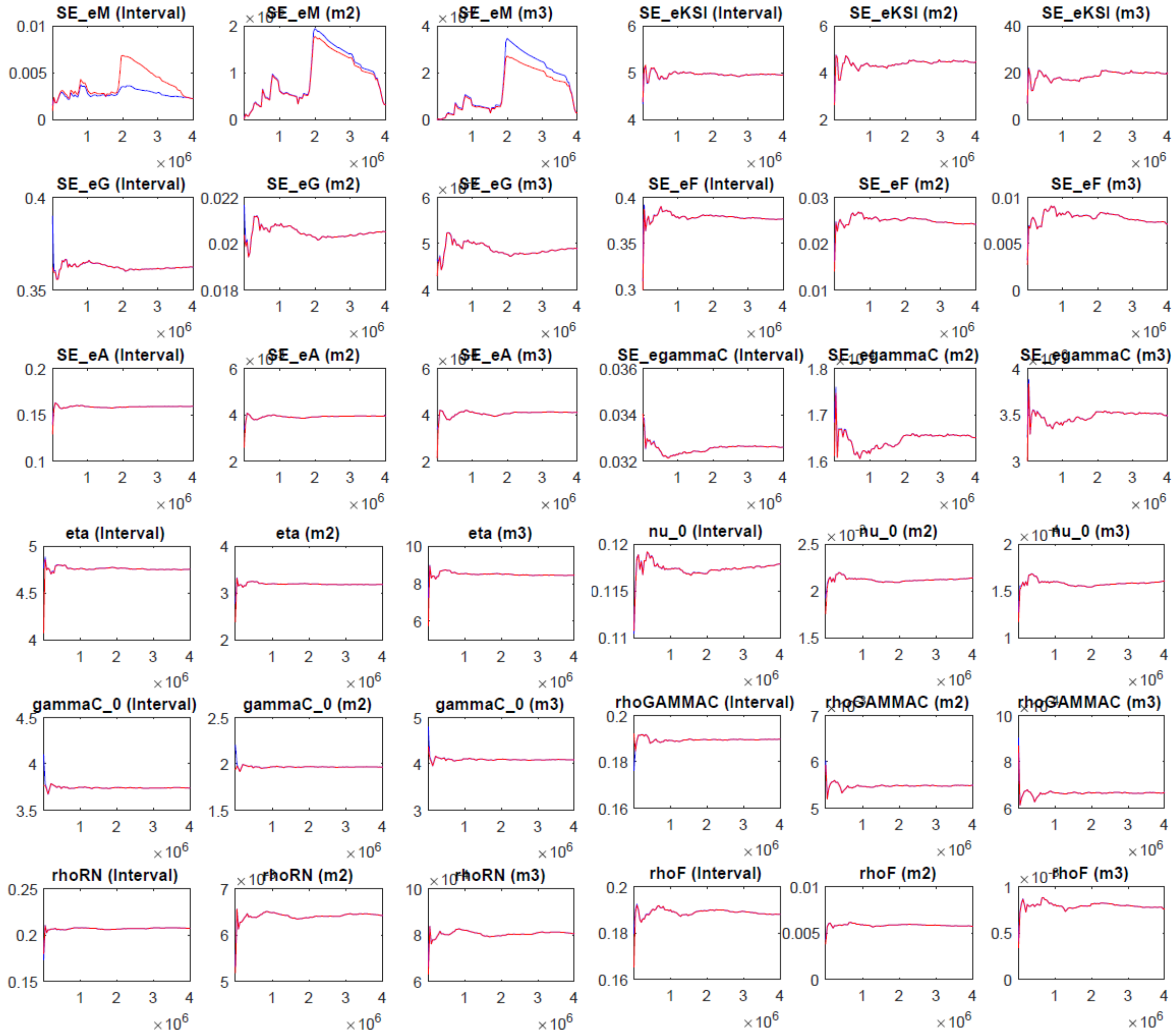
8 Appendix

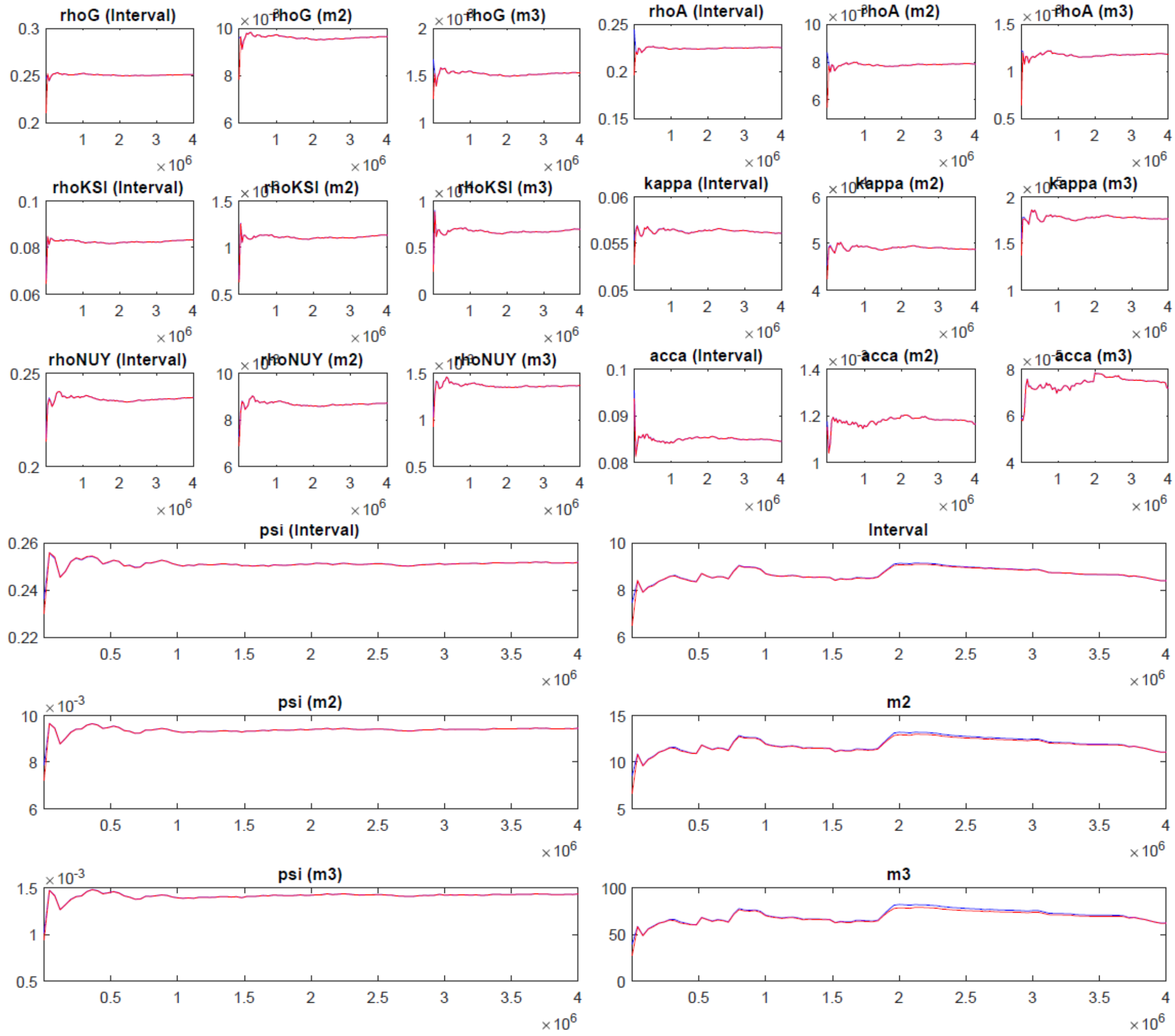
8.1 Priors and Posterior distributions of the Estimated Parameters in the DSGE



$eta = \gamma_L$ $nu_0 = s_0$ $rhoNUY = \rho_{SY}$

8.2 DSGE Diagnostics Tests: MCMC Univariate and Multivariate Convergence




rhoG (Interval)
rhoG (m2)
rhoG (m3)
rhoA (Interval)
rhoA (m2)
rhoA (m3)
rhoKSI (Interval)
rhoKSI (m2)
rhoKSI (m3)
kappa (Interval)
kappa (m2)
kappa (m3)
rhoNUY (Interval)
rhoNUY (m2)
rhoNUY (m3)
acca (Interval)
acca (m2)
acca (m3)
psi (Interval)
Interval
psi (m2)
m2
psi (m3)
m3