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DYNAMICS IN A NEW-KEYNESIAN MODEL WITH FINANCIAL ACCELERATOR AND UNCERTAINTY◊

***Abstract**. Several new stylized facts were observed in the aftermath of the recent financial crisis from the view-point of economic thinking. Here we address some of these caveats by considering the relationship between volatility of the main variables in a closed economy and the different stances related to the strength of the interlinkages between real and financial sectors. In this regard we restored a relatively simple model of New-Keynesian inspiration, extended with a financial accelerator. As compared with other models used in the literature to investigate the same kind of problems, we brought a slight modification from a structural viewpoint about which we think that it could determine important implications for the model. Relative simplicity of the model used here was assumed a priori given that our focus was somehow on the field of practical policy analysis. Given the before mentioned considerations, we investigated how different environments regarding the presence of uncertainty affect the volatility of interest variables. Not at least we studied the problem in hand separately for the cases when the short-term interest rate is set on the base of an optimal commitment plan, respectively on the base of simple rules..*

***Keywords**: financial accelerator, commitment, New-Keynesian, rules, uncertainty, volatility.*

JEL Classification: E52, E58, P20

1. Introduction

The recent financial crisis, with all its features, raised a series of questions, in both academic and decision making areas, regarding the economic thinking that exist up to that time. One of the first question was to what extent the famous benchmark 3-equation New-Keynesian model, as that one of Clarida, Gali and Gertler (1999), is able to explain the real business cycle dynamics, given that there

◊Opinions expressed in this paper are those of the authors and should not be associated with the institutions to which they belong.

is no link with financial sector. In fact, this question was addressed not only for the standard 3-equation model, regardless on the type of expectations, but also to bigger models, the focus being on the capacity to explain the new stylized facts brought by the crisis. In this view, afterward the crisis occurrence, an avalanche of papers reinforced the ideas on the very high importance of financial frictions, as it's emphasized among other works by Bernanke and Blinder (1989), respectively Bernanke, Gertler and Gilchrist (1999). For example, at this point we mention the work of Gerali et al (2010), which underlined the endogenous role of financial sector for the economic equilibrium. Cecchetti and Li (2008) and Ceccheti and Kohler (2012) used reduced form model developed somehow ad hoc from a New-Keynesian structure, with much less micro-foundations as in Gerali et al (2010), to emphasize the important interlinkages between financial and real sectors. The other question, related to the first one otherwise, was focused to whether the monetary policy alone is able to address the issues in both real and financial sectors. For this purpose, a series of papers such are Cecchetti and Li (2008), Ceccheti and Kohler (2012), respectively Poutineau and Vermandel (2014) discuss about policy measures focused distinctly on the financial developments, namely about macroprudential policy. Not at least, another question was to what extent a central planner endowed with a simple New-Keynesian model is able to have a full understanding of the developments in real and financial sectors. Hansen and Sargent (2000, 2001, 2002, 2003) and Giordani and Söderlind (2003) described how to use Knightian uncertainty within the process of setting an optimal policy in a macro model. On the other hand, Levin and Williams (2003), Cateau (2006) and Söderström (2009) described how to implement a Bayesian uncertainty setting in a New-Keynesian model. The two approaches of uncertainty admit basically that a central planner has in fact a non-full understanding of the environment, facing uncertainty when in his decisions.

The current paper comes to put together a part of the issues described before in order to achieve different aims related to the understanding of business cycle dynamics in Romanian case. The very first aim was to see the spill-overs on the main macro variables generated by the presence of financial accelerator, considering in this regard different degrees of interconnections between financial and real sectors. Having set the first aim, our next step was to consider how the presence of uncertainty within the decision making process affects the behaviour of macro variables. For this purpose, we considered separately both Knightian and Bayesian types of uncertainty. A third step of our work was to investigate the relationships between different ways of setting the short-term interest rate and the dynamics of macro variables. In this regard, we considered separately that the central planner is using an optimal commitment based decision, respectively a Taylor rule approach. For the optimal commitment, we considered a loss function according to an inflation-targeting behaviour embedded also with cares on output-gap and interest-rate developments. Therefore we assumed a no strict inflation targeting regime. In order to ensure a comparable basis, we specified a Taylor rule with smoothness. Summing up, we analysed the unconditional volatility of the output-gap, inflation and interest rate for each of the before mentioned specification. Importance of our work stems from the fact that, broadly speaking, assumed aim of a central planner is to reduce the magnitude of fluctuations during the business cycle. In this direction, in a famous paper, Lucas (1987) raised the issue on the welfare cost of business cycle owing to volatility. Additionally to aims mentioned before, we were looking to underline some directions of research that we consider very important given the new stylized facts brought by recent financial crisis as well as given the relative scarcity of research in this field for CEE area. Not at least, our goal was to keep the model to be relatively small, in order to be relatively simple to be handled for policy analysis.

2. Macroeconomic model

In this section we proposed a simple model of New-Keynesian inspiration endowed with a financial accelerator to be used in order to investigate the business cycle dynamics and related spill-overs and interlinkages. Presence of the financial accelerator brings several interesting implications on the interaction between real economy and financial markets, respectively between business and financial cycles. The model used in this paper consists in four main linear equations:

$$y_t^{gap} = (1-\alpha)\, y_{t-1}^{gap} + \alpha E_t\left[y_{t+1}^{gap}\right] - \frac{1}{\gamma}\left(i_t - E_t[\pi_{t+1}]\right) - \Phi l_t + \varepsilon_t^D \quad [1]$$

$$\pi_t = (1-\lambda)\, \pi_{t-1} + \lambda\beta E_t[\pi_{t+1}] + (\gamma+\tau)\frac{(1-\theta)(1-\theta\beta)}{\theta} y_t^{gap} + \varepsilon_t^S \quad [2]$$

$$i_t = \mathcal{G}^{C,R}(\Theta) \quad [3]$$

$$l_t - i_t = -\Psi y_t^{gap} + \varepsilon_t^F \quad [4]$$

The first equation is a dynamic IS relation (or Euler equation) for the output-gap evolution, [2] denotes the New-Keynesian Phillips curve, [3] shows the structural way in which short-term interest rates are setting, while the last relation represents the evolution of loan rates in economy. Parameters from [1] – [4] have the following interpretation: $(1-\alpha)$ reveals the importance of output-gap realizations inertia (and implicitly α shows the sensitivity to future expectations), γ is the CRRA parameter (and therefore $\frac{1}{\gamma}$ is the intertemporal rate of substitution), Φ shows the elasticity of output-gap with respect to the loan rate, λ denotes the sensitivity of inflation to future expected realization, β is the subjective discount factor, τ reveals the inverse elasticity of work with respect to its marginal disutility, $(1-\theta)$ shows the probability associated to which intermediate firms that are acting in a monopolistic market are able to change the prices they are practicing in each moment (this mechanism is well known in the literature as a la Calvo setup), while Ψdenotes the elasticity of the interest rate spreads with respect to output-gap. Stochastic part of the model is introduced through the definition of three shocks. ε_t^D and ε_t^Sthat are standard demand and cost-push shocks. The third shock ε_t^F is called a financial based shock and we will explain a bit later its meaning.

$\mathcal{G}^{C,R}(\Theta)$ could be seen here as a functional which take two forms according to the way in which the central bank (planner) is setting the short term rate, with Θ being a vector of model variables and shocks. In the first case, interest rate is resulting from the optimal response of the central planner according to a commitment behavior. In this paper we assumed the following loss function for the central planner:

$$\mathcal{L}_t = \frac{1}{2}\left(\pi_t^2 + \ell^y\left(y_t^{gap}\right)^2 + \ell^i i_t^2\right) \quad [5]$$

where ℓ^y and ℓ^i represent the associated weights for output-gap and interest rate in the planner's loss function. This linear loss function reveals an inflation-targeting behavior which departures from fully strictness as the central planner it is also interested for realizations of the output-gap, respectively interest rate. Given that agents are living forever, mandate of the central planner has also a dynamic setting. Therefore, an optimization problem for the central planner is defined as:

$$\mathcal{J}_t = min\frac{1}{2}E_t\sum_{i=0}^{\infty}\beta^i\left(\pi_{t+i}^2 + \ell^y\left(y_{t+i}^{gap}\right)^2 + \ell^i i_{t+i}^2\right) \quad [6]$$

subject to [1] – [4] and to the three shocks' dynamic laws. By solving the optimal policy [6], we will obtain a commitment based solution of the form $\mathcal{G}^C(\Theta)$ for the short interest rate. On the other hand, the central plan can use a Taylor based rule, where the interest rate is set as a fixed reaction function to movements in inflation, output-gap and past interest rate:

$$i_t = \rho^i i_{t-1} + \left(1-\rho^i\right)\left(\phi_y y_t^{gap} + \phi_\pi \pi_t\right) \quad [7]$$

with ρ^i showing the inertia interest rates, while ϕ_y and ϕ_π represents the sensitivities with respect to output-gap, respectively interest rate. In the primer setting regarding Taylor rule based function no smoothness appears, but here we opt for this specification in order to ensure an analogy with the formulation for $\mathcal{L}_t$ as well due to higher plausibility of such a rule given the empirics.

For the model description we provided before, in the next lines we will provide a succinct view on its underpinnings as well on its meaning. Broadly speaking, the model own to the well-known family of New-Keynesian, but he is expanded in several ways to addressed different issues. First of all, the model is based on hybrid expectations, as compared with standard model of Clarida, Gali and Gertler (1999) which has forward-looking expectations. According to different type of expectations, effects generated by shocks occurrence are quite different as Levin and Williams (2003) underline. A very important extension brought to the New-Keynesian structure of the model consist in introducing a financial accelerator in the spirit of Bernanke, Gertler and Gilchrist(1999), which was further defined closely to the works of Poutineau and Vermandel (2014), Cecchetti and Li (2008), respectively Ceccheti and Kohler (2012). An noticeable difference as compared with the three works mentioned before is that we add the a financial shocks in the equation for interest rates spreads instead of defining an additional elasticity in respect of capital. Our choice was motivated on the base of several reasons. Different studies, as it's the work of Macro-Assesment Group (2010), which elaborated the impact study on regard on the application of Basel III provisions, link the evolution of interest rates spreads by different other variables such are the capital adequacy ratio, macroprudential policy, delinquency rates, housing prices, etc. In this regard, we consider that given the model's relative simplicity (no external sector or risk premia or the variables mentioned before), the use of a shock would provide a more comprehensive image on the interaction between the business and financial cycles. More than that, the use of a shock is more plausible given that we stress here the importance of planner's uncertainty for the business cycle dynamics.

3. Uncertainty in policy design

By starting from the hypothesis that the central planner has at hand the relatively simple model presented above, this section addresses the philosophy on how to account for uncertainty in setting the optimal related decision. Uncertainty surrounding the central planner decisions occurs as result of *a priori* limitation of the model in capturing the real business and financial dynamics, which are very complex, non-linear and deep. Referring to this topic, it is questionable if the presence of uncertainty within the central planner decision making process is inversely related to the size and complexity of the used model or it is natural in the context of impossibility to fully reveal the real dynamics. But this topic is behind our objective here, so we turn back to the problem of interest for us in this paper. According to Svensson (2000), we will present how to account for uncertainty

within the decision making process by using a Bayesian approach, respectively a robust control approach.
The general idea of uncertainty faced by a central planner is that true model of economy is not known with certainty. For this reason, the central planner has to choose from a set *M* of feasible models a particular one, which ensures the effects resulted from related policy achieve a minimum or a maximum, depending on how the costs function is set. The technical differences between Bayesian and robust control approach will be described in the following lines. Bayesian approach supposes the expected loss related to the central planner decisions can be defined as:

$$E^{M}\mathcal{L} = \int_{M^{*}\epsilon M}\mathcal{L}(F, M^{*}, \varrho)d\Gamma \quad [8]$$

where M^{*} is the true model, F is the policy function associated with Bayesian central planner decision, ϱ shows the degree of risk aversion and Γ denotes a probability measures. Given the planner' objective is to minimize the loss, he is facing, the optimal solution in a Bayesian fashion is defined as:

$$F^{B}(\Gamma, \varrho) = \arg\min_{F\epsilon\mathcal{F}} E^{M}\mathcal{L}(F, M^{*}, \varrho) \quad [9]$$

Summing up, the Bayesian central player aims to minimize the average loss across different competing models from a finite set and with known probabilities of occurrence. A bit later we will explain what means the concept of competing models by showing how this approach can be practically implemented.
Robust control approach in a Hansen-Sargent sense is basically founded contrary to the Bayesian approach. More exactly, a robust planner is aiming to minimize the loss associated with his decisions by considering a worst-case scenario. In such a fashion, the planner is endowed with a continuum of models around a reference model, mentioning that it is no possible to attach a probability distribution for the models' occurrence. Therefore the planner is subject of Knightian uncertainty. Robust control approach supposes the running of a two-step approach. The former step consists in identifying the model which performs the worst:

$$M^{\downarrow}(F) = \arg\max_{M^{*}\epsilon M} \mathcal{L}(F, M^{*}, \varrho) \quad [10]$$

where parameters have the same interpretation as in the previous case. In the second step, the central planner is seeking for a policy rule which minimizes the loss in context of a the worst model:

$$F^{R}(\Gamma, \varrho) = \arg\min_{F\epsilon\mathcal{F}} \mathcal{L}\left(F, M^{\downarrow}, \varrho\right) \quad [11]$$

4. Practical implementation of the model with uncertainty

In this section we will describe the practical implementation of the two types of uncertainty. For the Bayesian approach we acted in the same spirit as Levin and William (2003), Cateau (2006) and Söderström (2009), by considering competing models. The main idea behind this approach is that our central planner is not sure on the real nature of expectations in economy. For this purpose it assigns equally weights according to which the true model could have: backward-looking expectations, forward-looking expectations or hybrid expectations. The nature of expectations is very important, because depending on it, the effects of shocks could be significantly different, as Levin and William (2003) underlined. We follow the considerations formulated in Cateau (2006) and defined the following relation for the central planner loss under a Bayesian uncertain environment:

$$\mathcal{T}(\mathcal{L}^* + \Omega) = \sum_{i=1}^{M} E^{M_i} p_{M_i} \mathcal{T}\left(\mathcal{L}_{M_i}\right) \quad [12]$$

where $\mathcal{T}(\mathcal{L}) = \frac{e^{\eta\mathcal{L}}-1}{\eta}$ represents a transformation function which links the loss face by a central planner by his degree of aversion within the seeking for the true model. So, the above relation stated that given an acceptable loss $\mathcal{L}^*$ and a degree of risk aversion η, the main task is to determine a premium Ω for which the central planner would be indifferent between achieving $\mathcal{L}^*$ for sure or being the subject of uncertainty in looking for the true model.

Practically we implemented the Bayesian uncertainty as following. But before to describe how we really proceeded is important to note that as compared with Levin and William (2003) and Cateau (2006) that resorted such an approach for a model with rules, we used it also for the case with commitment. In the case of a model with rules, a central planner is interested in finding the pair of parameters $\{\rho^i, \phi_y, \phi_\pi\}$ which provides the best performance across the three models (which means M = 3 and p_{M_i}= 0.33). The best performance is measuring in terms of the $\mathcal{L}_{M_i}$, that should be as small as possible. Thus, for the optimal set of $\{\rho^i, \phi_y, \phi_\pi\}$ it will result a minimum level of the $(\mathcal{L}^* + \Omega)$. Therefore a Bayesian central planner with a fashion like this one used here will minimize the sum between $\mathcal{L}^*$ and Ω. Once we have the optimal pair of parameters, the unconditional variance of variables is determined separately for each of the three models and after that are computed expected values of the unconditional variances according to the consideredp_{M_i}. In the same way it is possible to proceed further to compute simulations or impulse-response functions.

In the commitment case, used technology is basically the same. The main difference stems from the way in which the short-term rate it is setting. More exactly, we constructed the following novel in this regard. The optimal decisions are associated with a targeting-inflation regime, which is not really strict because the central planner is also interested by dynamics of output-gap and interest rates. On the other hand, as a central idea of Bayesian optimal policy, the central planner doesn't know with certainty which is the true nature of the expectations. In such an environment, the central planner will seek for a pair of parameters $\{\ell^y, \ell^i\}$ in order to get a minimum value for $(\mathcal{L}^* + \Omega)$in order to maintain the same ratio between the degree of importance assigned to inflation and the degree of importance related to the other two variables. Saying otherwise, given that operational framework is described by an inflation-targeting regime, in these circumstances, main goal of the central planner is to look for an optimal pair of parameters which ensure a minimum of the size of $(\mathcal{L}^* + \Omega)$ and which also doesn't alter the ratio $\frac{1}{\ell^y+\ell^i}$. Of course that it is possible to consider another way to implement the Bayesian optimal policy under commitment, but here we focused on a plausible design conditional on the inflation-targeting regime. From here on, the procedure is the same as that one used for the case with rules.

For the case of Knightian uncertainty, in order to compute the unconditional volatility of the main macro variables for the situation when the central planner is using the optimal commitment, respectively simple rule, we use the procedures presented in Hansen and Sargent (2000, 2001, 2002, 2003) and Giordani and Söderlind (2003), which are based on the robust control approach. Presence of the Knightian uncertainty within the decision making supposes a very different technology not only by comparison with no uncertainty case, but also as compared with the Bayesian uncertainty setup. The so well-known Hansen-Sargent robust control is based on the following novel story that supposes the existence of a metaphoric evil agent whose main goal is to distort the performance of a central planner in his attempt to optimally control the economy. In this context, the central planner is aware of the evil agent's existence and goal and more than that the central planner is seeking to adopt an optimal decision designed to be robust to evil agent's action.

Therefore, a major difference from the classical control is that under Knightian uncertainty, the central planner is not looking for the best model, but for the model which ensure the lowest loss in a scenario where the evil agent's action generates the biggest damage possible. Technically speaking, the Hansen-Sargent robust control approach supposes the existence of a two-player zero-sum game. A major implication determined by the presence of Knightian uncertainty is that the certain equivalence principle is no longer valid. In these conditions, the robust-control supposes the existence of two models: an approximating model and a worst-case model. Firstly we will define a setting for the optimal control problem under

Knightian uncertainty and after that we will explain about the meaning of the two models. By calling the standard linear-quadratic approach (LQ), a Hansen-Sargent robust control problem can be formulated as:

$$\min_{\{u\}_0^\infty} \max_{\{\omega\}_1^\infty} E_0 \sum_{t=0}^{\infty} \beta^t (x_t' Q x_t + u_t' R u_t + 2x_t' U u_t) \quad [13]$$
$$\text{subject to } x_{t+1} = Ax_t + Bu_t + C(\varepsilon_{t+1} + \omega_{t+1})$$
$$\text{and } E_0 \textstyle\sum_{t=0}^{\infty} \beta^t \omega_{t+1}' \omega_{t+1} \le \mathcal{S}$$

with Q, R and U being weights in the LQ loss function, while x_t and u_t represents the state vector, respectively the control vector. A, B and C represent matrix used to define evolution of the state-space representation. ε_{t+1} and ω_{t+1} are two sequences of i.i.d. shocks, with ε_{t+1} being associated to the central planner's decisions, while ω_{t+1} denotes the vector of control for the evil agent. The second constraint show an intertemporal measure for the distance between distorted and approximating models, which cannot exceeds a level $\mathcal{S}$that is exogenously set. When the central planner is fully pessimist on his ability to understand the true model, then he chooses the distorted model (worst-case model). On the other hand, in the presence of no misspecification shocks ω_{t+1}, the approximating model is the one used by our central planner. Even in the case of no specification errors, the approximating model doesn't coincide with the fully rational expectations model, as the policy rule in the former is the same with that one from distorted model[1]. Aim of the robust central planner is to construct models that are as close possible to the approximating model. Thus, $\mathcal{S}$ show how much the robust central planner wishes to avoid distorting, which means a higher value for $\mathcal{S}$ coincides to a larger set of models under consideration. An important departure from the Bayesian uncertainty policy is that here the robust planer can choose from a continuum of model that exists near a reference model. By inserting the last constraint in the loss function and further by manipulation[2], the optimal program becomes:

$$\min_{\{u\}_0^\infty} \max_{\{\omega\}_1^\infty} E_0 \sum_{t=0}^{\infty} \beta^t (y_t' Q y_t + u_t' R u_t + 2y_t' U u_t - \theta \omega_{t+1}' \omega_{t+1}) \quad [14]$$
$$\text{subject to } y_{t+1} = Ay_t + Bu_t + C(\varepsilon_{t+1} + \omega_{t+1})$$

[1] For a broader discussion on the technology of robust-control approach in macroeconomics see Hansen and Sargent (2002), as we here provide only a succinct description of the problem.
[2] See Hansen and Sargent (2002) for this derivation.

where θ reveals the preference of our central planner for robustness as for $\theta = \infty$, the optimal solution coincides with a rational expectation solution obtained in the RE framework. By portioning the state vector in predetermined vector of variables $y_{2,t}$ and a vector of jump variables $y_{2,t}$, the following state-space form is derived:

$$\begin{pmatrix} y_{1,t+1} \\ E_t y_{2,t+1} \end{pmatrix} = A \begin{pmatrix} y_{1,t} \\ y_{2,t} \end{pmatrix} + Bu_t + C(\varepsilon_{t+1} + \omega_{t+1}) \qquad [15]$$

Optimal solution to be obtained is necessary to resort a dynamic programming approach. Therefore the following Bellman equation will be formulated:

$$V(y) = \min_{\{u\}} \max_{\{\omega\}} \{y'Qy + u'Ru + 2y'Uu - \beta\theta\omega'\omega + \beta y^{*\prime}Py'\} \qquad [16]$$

where $V(y) = y'Py$ denotes the value function, with P being an idempotent matrix.

5. Calibration and results

We investigated the unconditional volatility of the output-gap, inflation and interest rates in the presence and absence of uncertainty, separately for the two type of uncertainty and for the cases when the central planner is using an optimal commitment, respectively a simple Taylor based rule. Therefore, we analyzed the implications of financial accelerator in a number of six models. Our investigation addressed the problem on how the modification of the interlinkages between financial and real sector matter for dynamics of the interest variables. Basically, we constructed two grids for the elasticity of the output-gap with respect to the loan rates (Φ), respectively for the elasticity of interest rates spread on the output-gap (Ψ). Considering different simultaneous scenarios on the interlinkages strength between financial and real sectors, we were able to investigate how the unconditional volatility is changing conditional on each state.

The general idea that we followed in calibrating the six models was to ensure robustness to final results. For this purpose we proceeded in the following way. Given that levels of the estimated parameters could be sensitive to the economic structure that you assume, we tried somehow to avoid the kind of model-sensitivity and we estimated different versions of the New-Keynesian model with hybrid expectations and a simple Taylor Rule. The subjective discount factor was calibrated for each time. In the first version of estimation, we reduced the Phillips curve slope $(\gamma + \tau)\frac{(1-\theta)(1-\theta\beta)}{\theta}$ to one parameter and estimated it accordingly.

Instead, in the second version of estimation we acted differently. Namely, we used calibrated figures for the parameters that enter into the Phillips curve and determined the level of Phillips curve slope. After that, we treated the Phillips curve slope as a simple parameter, them we calibrated it at the resulted value and estimated the model. The idea followed here was to see counterfactually how the CRRA parameter γ behaves, because it can be found in the Euler equation as well in the Phillips curve slope. We mentioned here that within the Bayesian estimation, γ was set *a priori* at the level at which it was used in calibration for the calculation of the Phillips curve slope. Calibration of the parameters from the Phillips curve slope was done by using as reference the figures found in several papers elaborated on Romanian economy, such are the works of Alupoaiei (2015) and Copaciu *et al* (2016). After that, we repeated these two steps by specifying Taylor rules withsmoothness.

Table 1. Calibration

β	0.992	ρ^i	0.2
γ	2.5	ϕ_y	0.4
α	0.58	ϕ_π	1.6
Φ	(0.1 – 0.4)	ℓ^y	0.4160
λ	0.7	ℓ^i	0.1664
τ	0.4	ρ^D	0.67
θ	2/3	ρ^S	0.71
κ	0.2	ρ^F	0.8
Ψ	(0.1 – 0.75)	σ^D	0.336
θ	30	σ^S	0.383
η	0.6	σ^F	0.8

On the base of obtained estimates, we analyzed the figures and also we investigated further a bit the behavior of some parameters. Putting together all the estimates obtained and by looking also at the parameters obtained by Alupoaiei (2015) and Copaciu *et al* (2016), we set the final figures for calibration. Below can be found the calibrated parameters used to solve for the optimal solution in each of the six cases.

Once the models were calibrated accordingly, the next step consisted solving for the optimal solution on the basis of which we obtained the unconditional variables. Given that our work is somewhat focused on the understanding the interlinkages between financial and real sectors, we discuss the behavior of obtained volatilities and not necessary their levels. Plots with obtained results are reported in Annex. Even that we have six cases, we reported results for eight models as the presence of Knightian uncertainty supposes the existence of an approximating model, respectively of a worst case model. Overall we would like to emphasize a non-linear relationship between the unconditional volatility of the target variables and the level of two elasticities. The non-linearity is observed to be pretty high in some cases. By inspecting figures 1 – 8 we can observe that non-linearity depends a lot on the circumstances.

First of all we will analyze the behavior of variables' volatility for commitment case. In this regard we can see that volatility of the output-gap is increasing in both elasticities, observing that volatility is much higher when the two elasticity records high levels. Instead, for inflation case the situation is completely opposite. By looking at the interest rate we observe that its volatility is increasing in the output-gap elasticity with respect to the interest rates spread and is decreasing in the interest rate elasticity with respect to the output-gap. If we look at the model with Knightian uncertainty we can observe that inflation is increasing in Φ and Ψ for the worst case model. Approximating and Bayesian models show the same pattern for output-gap and inflation volatility as the standard rational expectations model does. Looking at the volatility of interest rates, the two models obtained for the case with Knightian uncertainty differ from the Bayesian model, respectively the rational expectation model. An interesting observation is that for the output-gap, obtained volatility is lower in the worst-case model as compared with the approximating model.

For the case with simple rules we observe very different results as compared with the commitment case. As Cecchetti and Li (2008) underlines, this could be put on the back of an inability of the central planner to capture the real developments within the economy when a simple rule it is used to set the short term interest rate. Another interesting remark is that volatilities obtained with the standard rational expectations model, respectively with the approximating and worst-case models are very low, in comparison with the commitment case where the situation is completely opposite.

6. Conclusion

Present work is intended to underline new lines of research by addressing several stylized facts brought by the recent financial crisis. In this regard we provide a normative work on the way in which the relationship between volatility of interest variables in a closed economy and the strength of interlinkages between financial and real sectors depends on the specified environment. More exactly, the relationship that we mentioned before is very sensitive at the hypothesis on uncertainty you set as well as the way in which the short-term interest rates is setting-up. For this purpose we emphasized that a lot of research it is necessary further in order to get an accurate idea on the interlinkages between financial and real sectors. On the other hand, we showed that when a relatively small model it is used, conclusions on the effects of financial accelerator could be relatively sensitive to the assumed hypothesis. Not at least, our paper could be viewed as a starting reference to address the caveats that we emphasized for the case of emerging economies and in the context of using a relatively simple model for policy analysis.

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REFERENCES

[1] **Alupoaiei, A.(2015),** ***Effects of Knightian Uncertainty on the Term-Structure of Interest Rates***; *Journal of Business Management and Applied Economics, Vol. IV, Issue 3 May 2015*;
[2] **Bernanke, B. and Blinder, A. (1989),** ***Credit, Money, and Aggregate Demand****; National Bureau of Economic Research Cambridge, Mass.;*
[3] **Bernanke, B. , Gertler, M. and Gilchrist, S. (1999),** ***The Financial Accelerator in a Quantitative Business Cycle Framework***; Handbook of Macroeconomics, 1 , 1341–1393;
[4]**Cateau, G. (2006),** ***Guarding against Large Policy Errors under Model Uncertainty***; *Working Paper No. 2006 -13, Bank of Canada*;
[5] **Copaciu, M. Bulete, C. and Nalban, V. (2016),** ***R.E.M. 2.0 A DSGE Model with Partial Euroization Estimated for Romania***; *National Bank of Romania Occasional Papers no. 21*;
[6] **Clarida, R., Galí, J. and Gertler, M. (1999),** ***The Science of Monetary Policy: A New Keynesian Perspective***; *Journal of Economic Literature 37, 1661–1707*;
[7] **Cecchetti, S. and Kohler, M. (2012),*****When Capital Adequacy and Interest Rate Policy Are Substitutes (And When They Are Not)***;*Bank for International Settlements, Working Paper, no. 379;*

[8] **Cecchetti, S. and Li, L. (2008),*Do Capital Adequacy Requirements Matter for Monetary Policy?***; *Economic Inquiry,46 (4), 643–659*;
[9] **Giordani, P. and Söderlind, P. (2004), *Solution of Macromodels with Hansen-Sargent Robust Policies: Some Extensions***; *Journal of Economic Dynamics & Control, 28, 2367 – 2397*;
[10] **Gerali, A., Neri, S., Sessa, L. and Signoretti, F. (2010), *Credit and Banking in a DSGE Model of the Euro Area***; *Journal of Money, Credit and Banking, 42, 107–141*;
[11] **Hansen, L. and Sargent, T.(2000), *Wanting Robustness in Macroeconomics***; *Stanford University manuscript*;
[12] **Hansen, L. and Sargent, T. (2001),*Acknowledging Misspecification in Macroeconomic Theory***; *Review of Economic Dynamics 4, 519–535*;
[13] **Hansen, L. and Sargent, T. (2002),*Robust Control and Model Uncertainty in Macroeconomics***; *Stanford University manuscript*;
[14] **Hansen, L. and Sargent, T. (2003),*Robust Control of Forward-looking Models***; *Journal of Monetary Economics 50, 581–604*;
[15] **Levin, A. and Williams, J. (2003),*Robust Monetary Policy with Competing Reference Models***; *FRBSF Working Paper 2003-10*;
[16] **Lucas, R. (1987), *Models of Business Cycles***; *New York: Basil Blackwell*;
[17] **Macroeconomic-Assessment-Group,(2010),*Assessing the Macroeconomic Impact of the Transition to Stronger Capital and Liquidity Requirements***; *Final Report, Bank for International Settlements, Basel*;
[18] **Söderström, U. (2009),*Model Uncertainty***; *Mimeo*;
[19] **Poutineau, J. and Vermandel, G. (2014), *A Primer on Macroprudential Policy***; *The Journal of Economic Education 46(1):68-82;*
[20] **Svensson, L. (2000),*Robust Control Made Simple***. *Mimeo.*

ANNEX

Figure 1. Unconditional volatility in the rational expectations model with commitment

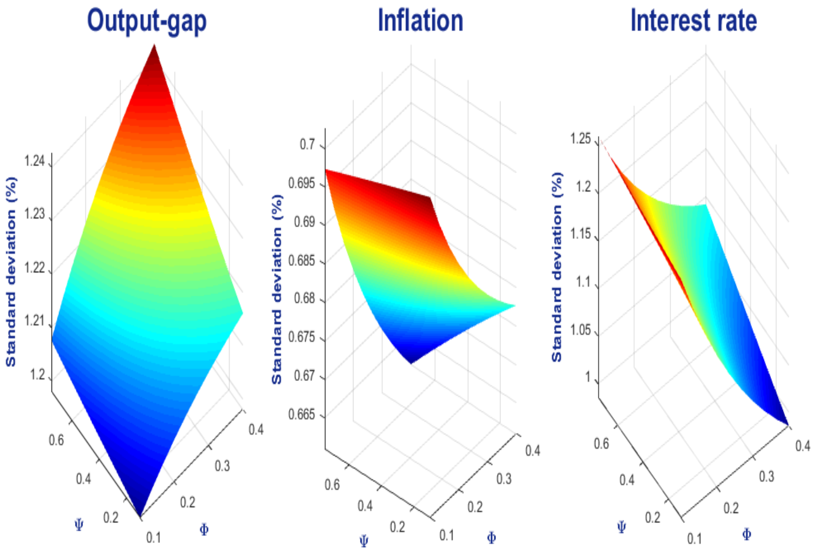

Figure 2. Unconditional volatility in the rational expectations model with Taylor reaction function

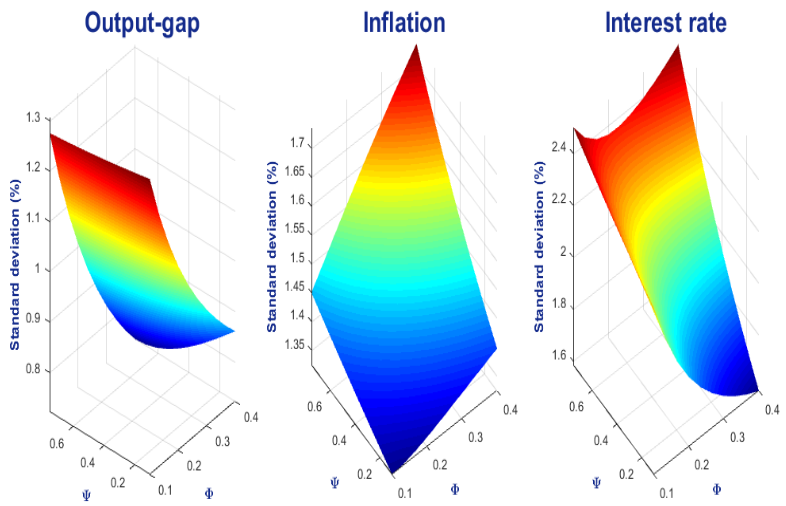

Figure 3. Unconditional volatility in the approximating model with commitment

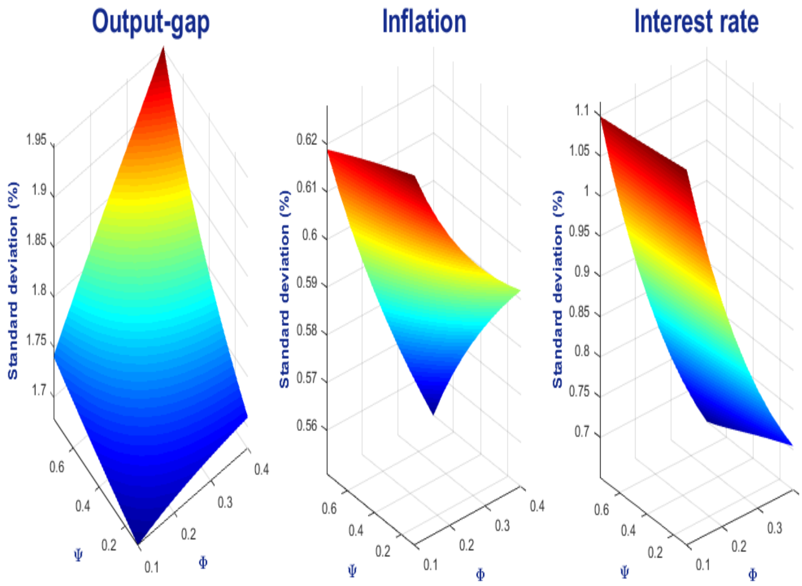

Figure 4. Unconditional volatility in the approximating model with Taylor reaction function

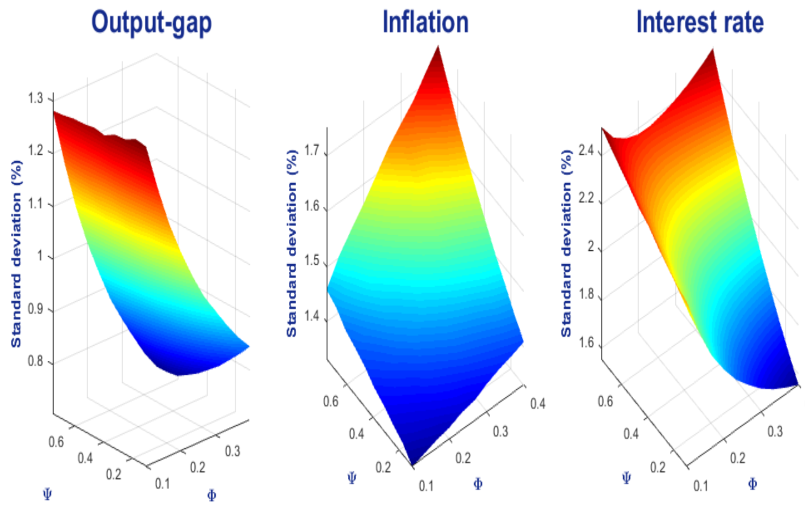

Figure 5. Unconditional volatility in the worst-case model with commitment

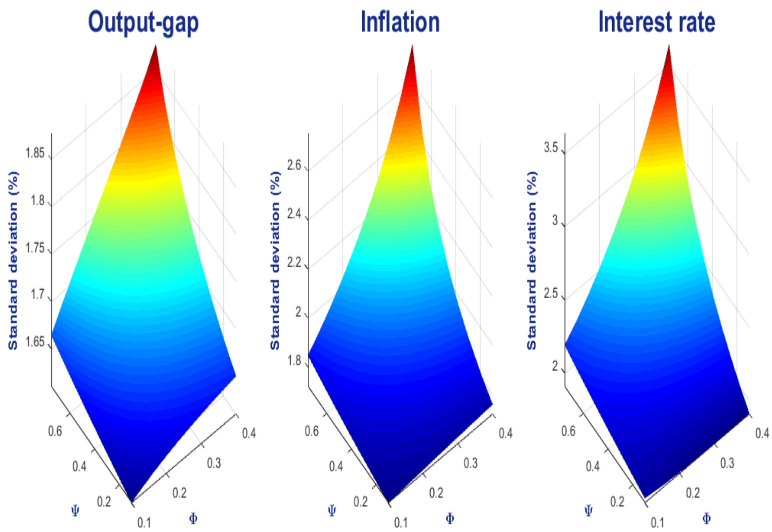

Figure 6. Unconditional volatility in the worst-case model with Taylor reaction function

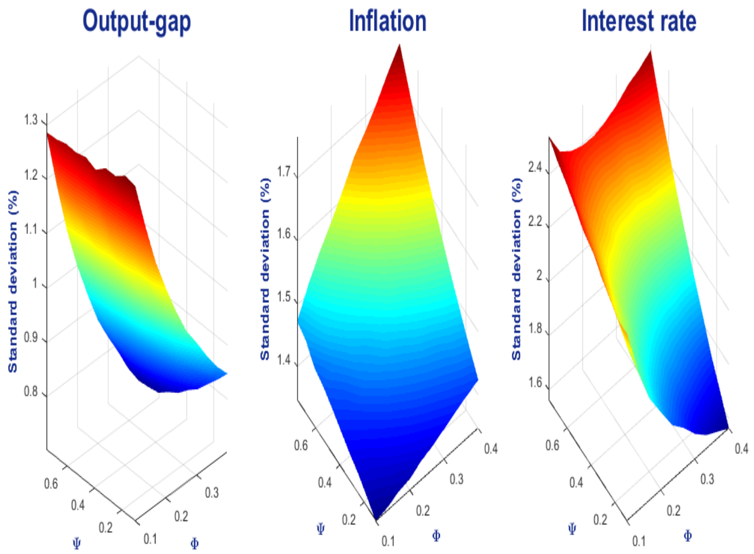

Figure 7. Unconditional volatility in the Bayesian uncertainty model with commitment

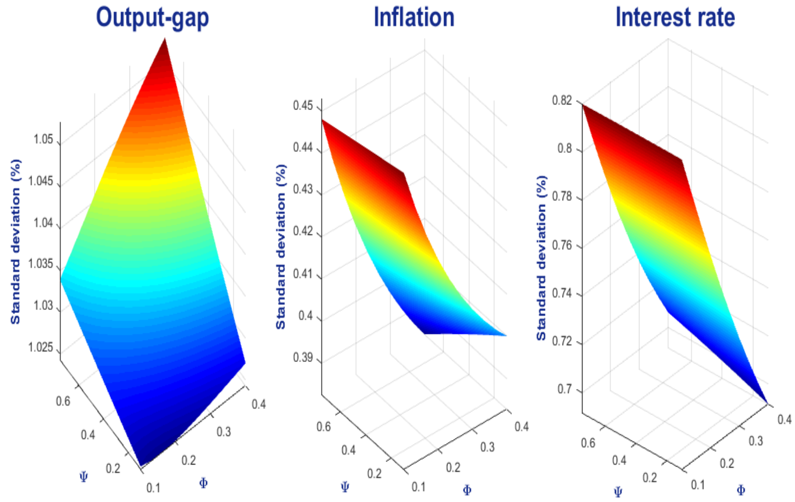

Figure 8. Unconditional volatility in the Bayesian uncertainty model with Taylor reaction function