# INFLATION INERTIA AND INFLATION PERSISTENCE IN ROMANIA USING A DSGE APPROACH

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**Abstract**

*In this study we propose to analyze the monetary policy of the Romanian central bank and to evaluate the inflation inertia and persistence. Thus, we estimate two DSGE models, a simple neokeynesian standard model built around a forward-looking component and in order to offer a more complex perspective we also estimated a DSGE model that captures the inflation inertia. The results show that the prices evolution reflects the difficulties of eliminating the inflation inertia. In Romania, the historic inflation evolution has a major impact on the way the inflation expectations are formed. Even if the inflation decreased at a moderate level, its persistence continues for a long period of time.*

**Keywords:** inflation persistence, inflation inertia, DSGE models, monetary policy analysis, Taylor rule
**JEL classification:** C11, E31, E52

## 1. INTRODUCTION

All known empirical studies are confirming the importance of knowing the monetary policy transmission mechanism and the existing literature admits that. Knowing the inflation dynamics is also crucial in the monetary analysis. A deep monetary analysis offers important information both to decision factors as well as to consumers and investors. Within this article we propose to emphasize some inflation-related aspects in Romania. More exactly, we will try to evaluate the inflation persistence and the inflation inertia. Furthermore, we will analyze the interest rate channel in Romania and we will hold out the prospect on the central bank behavior through Taylor's rules.

Knowing the degree of inflation persistence (i.e. the period where inflation tends to reach its steady state level after a shock) offers to central bank vital information about how the interest rate must be adjusted in order to reach a desired target for the inflation rate. Moreover, the nature of the inflation dynamics, as well as the efficiency of monetary policy dynamics depends to a great extent on the pattern and the characteristics associated to the formation of prices. That is why it is important to determine the degree of inflation inertia and its persistence.

The inflation inertia can be defined as being the process through which the current inflation is determined by its past history, being perceived through a prices slow reaction to the disinflationary policies. The inertia can be caused by the mechanism particularities of establishing the prices or the wages, by the importance which the backward looking component has in forming the inflationary expectations, but also by the national banks policy concerning the exchange rate (Edwards, 1998). The inflation persistence is defined as a slow dissipation of the second round effects after the shocks. We should mention that inertia differs from persistence (Cespedes, Kumhof, Parrado, 2003). Inertia is defined as the speed of reaction of inflation to the unanticipated shocks, while the persistence is measured through the period of time necessary for these shocks effects, once transmitted, to disappear.

In order to analyze the inflation persistence and inertia, as well as the central bank's monetary policy in Romania, we will utilize two dynamic stochastic general equilibrium (DSGE) models. The recurrence to this type of analysis is motivated by two reasons. Firstly, the use of DSGE model in the case of Romania is rather reduced. Caraiani (2009a, 2009b) estimated a set of such models to detect the Romanian economic dynamics. Secondly, the DSGE models are tools that offer a coherent framework for the monetary analysis, allowing the link stability between the economy structural characteristics and the model parameters. In the last 15 years, the premises of a remarkable progress in specifying and estimating these models were created. Thus, the central banks in the developed and emergent economies are using such kind of models for analyzing the economy dynamics as well as for making forecasts.

There is a significant number of empirical studies and theoretical analyses that approach the inflation evolution and offer a perspective on the monetary policy in Romania. Scutaru and Stănică (2005) used a structural autoregressive vector to capture the output gap evolution in Romania and they evaluated the effects of the inflationist shocks to the Romanian economy. A Philips relation between unemployment and inflation is also emphasized in the article. Boţel (2010) used an univariate approach to capture CORE3 inflation inertia in Romania. Caraiani used a range of DSGE models to analyze the Romanian economy dynamics. Thus, Caraiani (2009a) tackled the problem of the inflation persistence in Romania, using a standard CIA model and an augmented CIA model. The author concludes that although with a simple structure the standard CIA model can replicate the inflation persistence from Romania but on periods smaller than a year. Caraiani (2009b) also estimated the Romanian economy's output gap using the DSGE model. The author concludes that, in comparison with the output gap estimated with the Hodrick-Presscot filter, the results of the DSGE approach offer a better and more consistent image of the output gap with the Romanian economy dynamics.

The paper is structured as it follows. In the second section the utilized DSGE models are presented. The third section comprises references to the obtained results as well as a monetary policy evaluation concerning Romania using the parameters from Taylor's rule and using the impulse response function extracted from the DSGE analysis. In the last section the conclusions are specified.

## 2. DSGE MODELS

We will consider a simple DSGE model containing three equations: an IS curve, a Philips curve and the Taylor's rule. The IS curve is derived by maximizing the expected value of the utility function: $U(C_t, 1-N_t)=\frac{C_t^{1-1/\sigma}}{1-1/\sigma}-\frac{N_t^{1+\tau}}{1+\tau}$. To this problem of maximization, the following budgetary constraint is associated: $C_t+\frac{B_t}{P_t}=\left(\frac{W_t}{P_t}\right)(N_t)+(1+i_{t-1})\left(\frac{B_{t-1}}{P_t}\right)+\Pi_t$, where $C_t$ is the composite consumption good, $N_t$ is hours worked, $\Pi_t$ is real profits received from the firms, and $B_t$ are the bonds for which a nominal interest rate is paid, $i_t$, for a period of time. The IS curve is:

$$y_t=(1-\delta)y_{t-1}+\delta E_t y_{t+1}-\sigma(i_t-\pi_{t+1})+\varepsilon_t^y \quad (1)$$

The demand curve differs of the IS standard curve by including the expectations and the forward-looking elements. The reason for including the previous output gap is explained by Fuhrer (2000) who argues that this extension generates more persistence.

The Phillips curve has the following form:

$$\pi_t=(1-\alpha)\pi_{t-1}+\alpha\pi_{t+1}+\kappa y_t+\varepsilon_t^\pi \quad (2)$$

The multiple factors can constitute inflation causes. The inflation fluctuation can be determined by extrinsic factors, such as the marginal cost or the output gap and by the intrinsic factors such as dependence on the past history. An important role in forming the inflation is also held by the inflationary expectations. Each of these three factors can be associated with one of the three elements of Phillips curve where the actual inflation depends on the past inflation, on the expectations concerning the future inflation and the output gap. We should mention, that even if this equation includes a backward looking component, it`s value, $(1-\alpha)\pi_{t-1}$, depends on the estimated parameter of the forward looking parameter, $\alpha\pi_{t+1}$.

The model is closed by specifying a Taylor's rule of monetary policy. The Taylor's equation represents a hypothetic but representative description of the monetary policy complexity. On the other hand, Taylor (1993) pointed out that nobody would or should imagine that the monetary authorities follow these rules mechanically. The equation has the following form:

$$i_t=\rho_r i_{t-1}+(1-\rho_r)(\varphi_\pi\pi_t+\varphi_y y_t)+\varepsilon_t^i \quad (3)$$

Within this equation we assume that the central bank set the interest rate as a function of the interest from the previous period, $\rho_r$ , element which will surprise the gradualism of monetary policy, inflation rate from the actual period and output gap. Taking into consideration the fact that we wish to offer a deeper perspective on the Taylor's rule we will estimate the model also with another monetary policy rule. For that purpose, we will eliminate the parameter that surprises the gradualism of monetary policy, the interest rate being established according to the inflation from the actual period and the output gap. The rule shape will be the following:

$$i_t = \varphi_\pi \pi_t + \varphi_y y_t + \varepsilon_t^i \tag{4}$$

The models that use a neokeynesian Phillips curve were criticized due to the difficulties to reproduce the dynamics of an output gap and inflation when a certain degree of inflexibility is supposed (Gali and Gertler, 1999). The critics state that a neokeynesian Phillips curve will not succeed in generating the observed persistence of the data relative to inflation and production.

These considerations became the fundamentals in conceiving models that capture the inflation inertia. That is why through the following more complex model we will try to highlight the influence of inflation inertia on the output and prices dynamics. For that purpose we will estimate a dynamic stochastic general equilibrium model built around some specificities that capture the inflation inertia. Our estimated model is a little bit modified in comparison with the one proposed by Gali (2008). The model has six equations. The first equation represents the aggregate demand, and $r_t^n$ is the real natural rate of interest, defined here as being the equilibrium real rate in default of any friction. In contrast with the previous model, the inflation equation is built around a backward looking component. The third equation is a Taylor's rule of monetary policy. The last three equations are representation of shocks that follow an AR (1) process.

$$y_t = E_t y_{t+1} - \sigma\left(i_t - \pi_{t+1} - r_t^n\right) \tag{5}$$

$$\pi_t = \kappa y_t + \beta\left(\pi_{t+1} - \gamma\pi_t\right) + \gamma\pi_{t-1} + u_t \tag{6}$$

$$i_t = \rho_r i_{t-1} + \left(1 - \rho_r\right)\left(\varphi_\pi \pi_t + \varphi_y y_t\right) + e_t \tag{7}$$

$$r_t^n = \phi_r r_{t-1}^n + \varepsilon_t^r \tag{8}$$

$$u_t = \phi_u u_{t-1} + \varepsilon_t^u \tag{9}$$

$$e_t = \phi_r e_{t-1} + \varepsilon_t^i \tag{10}$$

In both models, the Phillips curve combines both backward looking and forward looking elements. Including only a backward looking component would have made the estimation simpler and would have corresponded to the historical data. On the other hand, this specification would be vulnerable to Lucas critique and his predictive power would be weak taking into consideration the recent changes in the monetary policy. The utilization of a forward looking component would solve the instability problem. Additionally, more credibility added by the inflation targeting behavior - more the inflationary expectations tend to converge with the central bank target. However, such a specification raises difficulties in accurately measuring the expectations, especially when expectations-related data don't exist.

### 3. MODELS ESTIMATION AND RESULTS

The data used to estimate the two models are the real gross domestic product, the consumer price index and the central bank reference interest rate. The data are quarterly, the gross domestic product being expressed in the prices of year 2000 and concerns the period between 2000.Q1 and 2010.Q3. The interest rate is calculated as a three months average of the refinancing interest rate. All the initial series were logged, seasonally adjusted and then filtered using the Hodrick Prescott filter. For estimating the two models we will use the Bayesian technique. The estimation was made using two Metropolis Hastings chains, of 500.000 iterations, the final rate of acceptance being 36,68% and 36,31%, in the case of the first model and of 33,34% and 33,36%, in the case of the second model. The rates of acceptance are situated in the widely accepted range that is 20%-40%. For both models the multivariate and especially the univariate convergence statistics indicates the convergence. The multivariate convergence diagnostics are presented in Annex 1 and Annex 2.

#### *3.1. Estimation of the simple neokeynesian model*

In this section we will estimate the model given by the equations 1-3. The set of parameters which we estimate is {$\delta$, $\sigma$, $\alpha$, $\kappa$, $\rho_r$, $\varphi_\pi$, $\varphi_y$, $\varepsilon_t^y$, $\varepsilon_t^\pi$, $\varepsilon_t^i$}. The estimation results are presented in Table 1.

The parameter corresponding to the influence that expectations concerning the output evolution have on the gross domestic product in the actual period has a decreased value, of 0.1884. The output gap formation is influenced, significantly, by its evolution in the past. The real interest rate coefficient, equal with the difference between the nominal interest rate and the anticipated inflation rate, has an estimative value of 0.1367. The interest real rate affects the population choice between the alternatives represented by consumption and saving.

*Table no. 1 The results of the Bayesian estimation*

| Parameters | Prior mean | Posterior mean | Confidence interval | Confidence interval | Prior distribution | Standard deviation |
|---|---|---|---|---|---|---|
| $\delta$ | 0.400 | 0.1884 | 0.0837 | 0.2873 | Beta | 0.1000 |
| $\sigma$ | 0.240 | 0.1367 | 0.0756 | 0.1939 | Gamma | 0.1000 |
| $\alpha$ | 0.650 | 0.8163 | 0.7236 | 0.9114 | Beta | 0.1000 |
| $\kappa$ | 0.130 | 0.1218 | 0.0416 | 0.1997 | Gamma | 0.0500 |
| $\rho_r$ | 0.500 | 0.4967 | 0.3845 | 0.6129 | Normal | 0.1000 |
| $\varphi_\pi$ | 1.500 | 1.7504 | 1.4433 | 2.0724 | Normal | 0.2000 |
| $\varphi_y$ | 0.500 | 0.6545 | 0.4196 | 0.9050 | Normal | 0.1500 |
| $\varepsilon_t^y$ | 0.500 | 0.0712 | 0.0603 | 0.0814 | Inverse Gamma | 2.0000 |
| $\varepsilon_t^\pi$ | 0.500 | 0.0738 | 0.0603 | 0.0844 | Inverse Gamma | 2.0000 |
| $\varepsilon_t^i$ | 0.500 | 0.1362 | 0.1110 | 0.1610 | Inverse Gamma | 2.0000 |

*Source:* own computations using Dynare software

The expectations of inflation have a significant importance in forming the prices, the parameter associated to these being estimated at 0.8163. In our opinion, in Romania, the expectations of inflation are adaptive, based on learning process. They are not built around the central bank inflation target, but they are strongly influenced by the high level of prices from the past.

Inflation targeting strategy is based on stability and on an accurate value of expectations. The monetary authority is supposed to enjoy a complete credibility from population. On the other hand, the credibility is, however, a limited resource in the transition countries and, generally, in the economies with a high inflation history. The contradictory nature of the credibility demand in Romania results from the fact that it is induced by the past behavior and it is not a function of the actual behavior.

The parameters from Taylor's rule are estimated at 1.7504 for $\varphi_\pi$, 0.6545 for $\varphi_y$ and 0.4967 for $\rho_r$. The estimation of the same model, but replacing the equation 3 with 4 leads to similar results. The parameter that surprises the importance which the central bank gives to inflation has a value of 1.7516, and the output gap parameter is of 0.8685. These results indicate the fact that the Romania's central bank establishes the interest rate giving a significant weight to inflation behavior rather than to the output gap or to the interest rate from the previous period. These results are in line with the inflation targeting strategy adopted by the monetary authority.

*3.2. Estimation of the model that captures the inflation inertia*

Hereinafter we will estimate the model formed of equations 5-10. The set of parameters which we estimate is {$\sigma$, $\kappa$, $\gamma$, $\rho_r$, $\varphi_\pi$, $\varphi_y$, $\phi_r$, $\phi_u$, $\phi_r$}. Before we apply the Bayesian estimation we will adjust the $\beta$ parameter at 0.99, a standard value that is widely accepted. The results of the estimation are presented in Table 2.

*Table no. 2 The results of the Bayesian estimation*

| **Parameters** | **Prior mean** | **Posterior mean** | **Confidence interval** | **Confidence interval** | **Prior distribution** | **Standard deviation** |
|---|---|---|---|---|---|---|
| $\sigma$ | 0.800 | 0.0650 | 0.0473 | 0.0817 | Normal | 0.3750 |
| $\kappa$ | 0.130 | 0.1520 | 0.1203 | 0.1841 | Normal | 0.0200 |
| $\gamma$ | 0.800 | 0.8121 | 0.7784 | 0.8454 | Normal | 0.0200 |
| $\rho_r$ | 0.500 | 0.1430 | 0.0261 | 0.2599 | Normal | 0.1000 |
| $\varphi_\pi$ | 1.500 | 1.6525 | 1.4549 | 1.8491 | Normal | 0.1250 |
| $\varphi_y$ | 0.500 | 0.5174 | 0.4363 | 0.6003 | Normal | 0.0500 |
| $\phi_r$ | 0.350 | 0.3955 | 0.3638 | 0.4272 | Normal | 0.0200 |
| $\phi_u$ | 0.600 | 0.5709 | 0.5384 | 0.6031 | Normal | 0.0200 |
| $\phi_r$ | 0.700 | 0.6592 | 0.6297 | 0.6897 | Normal | 0.0200 |

*Source:* own computations using Dynare software

In Phillips curve the parameter that surprises the output gap influence on the inflationist process has a value of 0.1520, a value close to the one obtained in the previous model. The estimated value for $\gamma$ a parameter that captures the inflation inertia is of 0.8121. This estimation is close to the one obtained by Boţel (2010). It underlines the important role which the backward-looking component has in forming the prices. In our opinion, more the inflation will get close to values of 2%-4% a bigger weight in forming the anticipation will be held by the central bank target and the high weight of inflation inertia will diminish.

The parameters form Taylor's rule that capture the importance the central bank gives to inflation and to the output gap, have values close to the previous estimated parameters. The parameter concerning the monetary policy gradualism has a lower value than the one obtained in the previous model.

*3.3. The impulse response functions to shocks*

Hereinafter, we propose to compare the impulse response functions and to reflect the persistence degree of the variables included in the study to an IS shock, to a cost shock and to an interest rate shock. The impulse response functions are presented in Annex 3 and Annex 4.

An IS curve shock, presented within the first model, leads to a growth of inflation and of output gap. As a response to this growth, the central bank will raise the interest rate in order to stabilize the economy.

As we notice, a cost shock leads to an inflation growth in both models. However, in the second model the persistence of inflation is more obvious, the inflation rate returns to the steady state level much more gradually, in approximately 15 trimesters. In our opinion, the second estimated model is more consistent with the reality. In both models, the central bank responds to the inflation growth with an interest rate growth. A shock in the Phillips curve will lead to a contraction of the output gap. The most persistent effect on the output gap appears rapidly: after 2-3 trimesters. In our opinion, one of the reasons of this rapid response is related to the to the interest rate growth. Central bank reacts to higher prices by raising interest rate, a decision consistent with the inflation targeting strategy.

It is well known that the NK standard models don't succeed in generating a hump-shaped response of inflation to a monetary shock. Within both models, an interest rate shock will lead to a decrease in inflation rate and output gap. Inflation will diminish almost instantaneously in the first model. In the second model, the outcome consists in a more delayed and gradual response of inflation due to a monetary shock, in fact the largest impact appearing after 3 trimesters.

## 4. CONCLUSIONS

Within this study we used two DSGE models for analyzing the inflation inertia and persistence as well as the monetary policy effects in Romania. We used, firstly, a neokeynesian standard model built around a forward-looking component. Afterwards, in order to offer a more complex perspective we also estimated a DSGE model that captures the inflation inertia. In our opinion, the second model is more consistent with the reality.

After estimating the two models, we noticed that the prices evolution reflects the difficulties of eliminating the inflationary inertia. In Romania, the historic inflation evolution has a major impact on the way the inflation expectations are formed. Even if the inflation decreased at a moderate level, its persistence continues for a long period of time. Factors such as inflation inertia, the domination of the backward-looking expectations contribute to this fact. In the future, more the inflation will stabilize around a diminished equilibrium value - more the backward-looking component importance will diminish in favor of the forward-looking component. This fact, since the monetary policy gradually affects the economy, will mark the transit to a forward-looking monetary policy. In such forward-looking kind of environment, the central bank forecast and the inflationary expectations will have higher influence on inflation.

The analysis of the obtained results through the Taylor's rule indicates that the primary objective of the central bank was the price stability - such a goal being in accordance with the adopted monetary policy strategy.

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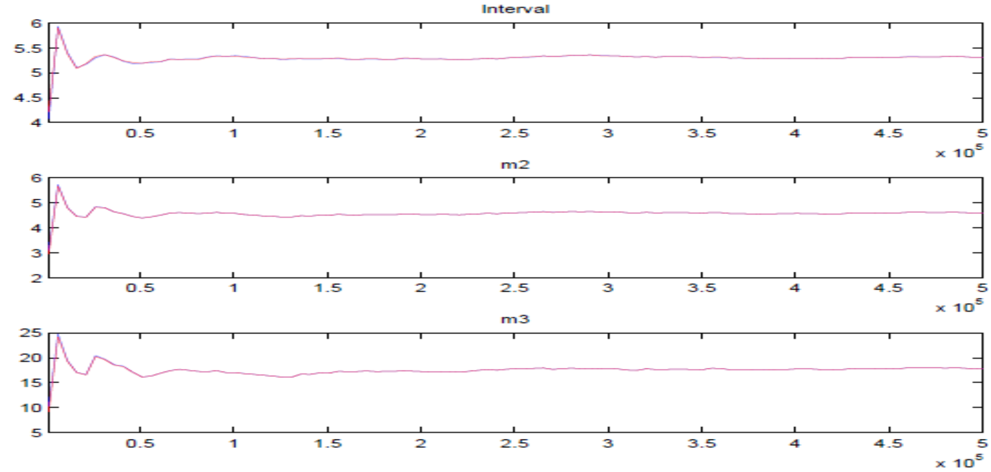
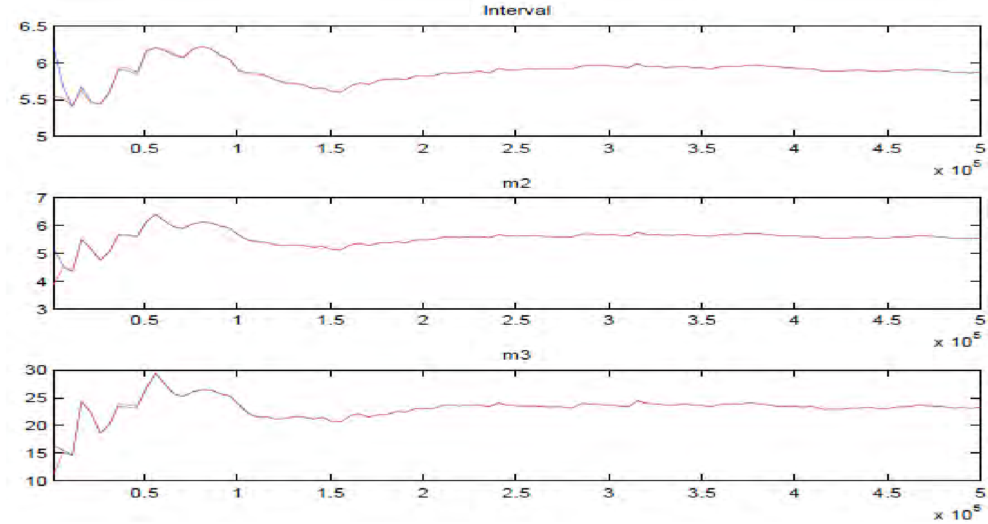
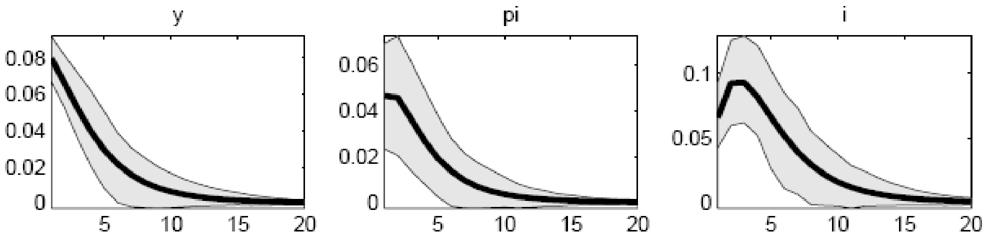
**Annex 1** Multivariate convergence diagnostics for the simple neokeynesian model



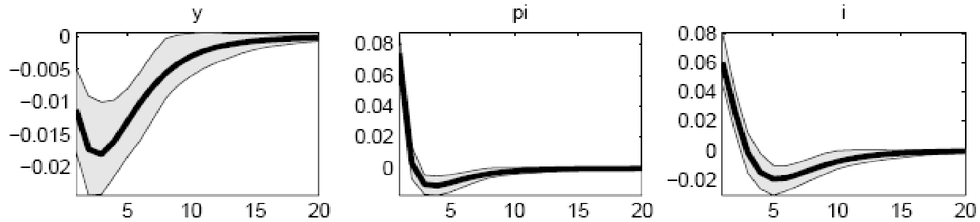

**Annex 2** Multivariate convergence diagnostics the model that captures the inflation inertia



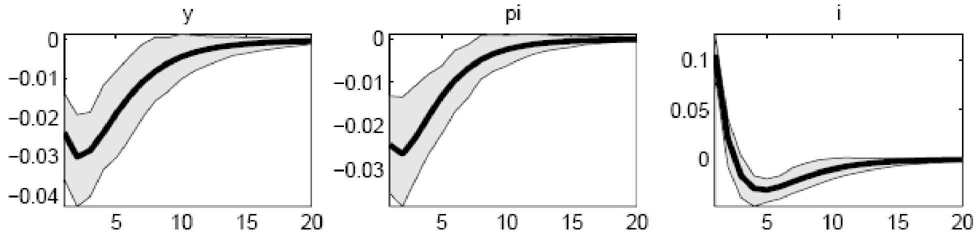

**Annex 3** The impulse response functions of the simple neokeynesian model
The impulse response functions to an IS curve shock



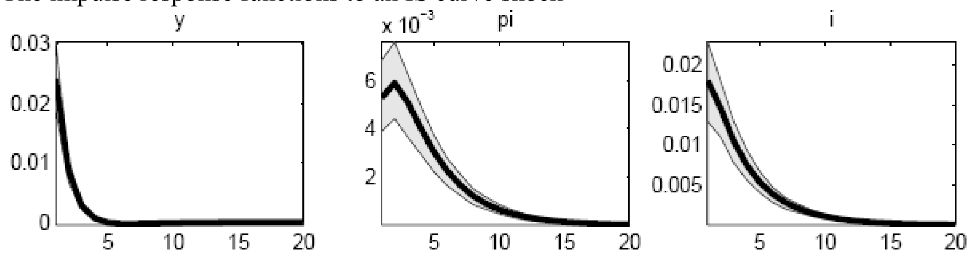
The impulse response functions to a cost shock



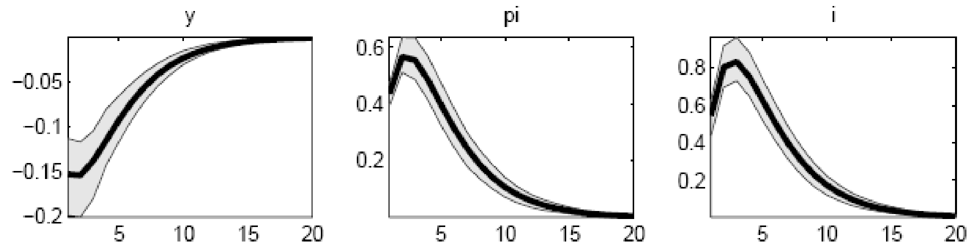

The impulse response functions to an interest rate shock




**Annex 4** – The impulse response functions of the model that captures the inflation inertia
The impulse response functions to an IS curve shock




The impulse response functions to a cost shock




The impulse response functions to an interest rate shock