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INFLATION PERSISTENCE AND DSGE MODELS. AN APPLICATION ON ROMANIAN ECONOMY

Abstract. *In this paper I study the inflation persistence in Romanian economy using the DSGE approach. I estimate two monetary DSGE models, a standard CIA model and CIA model with endogenous money. The results show that the standard CIA model outperforms the augmented model in terms of predictions on inflation persistence. At the same time, while the standard model can reproduce inflation inertia for short periods of time, its performance is poor for higher lags. This suggests that a more complex model might better predict the inflation persistence phenomenon in Romanian economy.*
Keywords: *inflation persistence, DSGE models, monetary models, Bayesian techniques, Romania.*

JEL Classification: E31, E32, E52.

1. Introduction

For Romania, which has as a long term objective the adoption of Euro, one of the policy objectives is the nominal convergence. One of the criteria of nominal convergence is the convergence of inflation. The recent experience of CEE countries with respect to inflation shows that the disinflation process is much harder to manage than thought. Since unexpected shock in inflation seem to lead to long responses of inflation, it is important to have an analysis of inflation in terms of persistence. Inflation persistence was not too much studied for the case of Romania, much less from a dynamic stochastic general equilibrium (DSGE, hereafter) perspective.

Most of the studies on the inflation dynamics in Romania were realized under the standard econometric framework, using either VAR models, like in Pelinescu and Ţurlea (2004), or Pelinescu and Dospinescu (2005) or a nonlinear approach, as in Albu (2001).

In this paper I use the DSGE framework to study inflation dynamics. Recently, several authors discussed dynamic general equilibrium models for Romania, like Caraiani (2007b), or Stancu and Ungureanu (2007), but inflation dynamics were not discussed in depth.

I study the inflation persistence phenomenon in Romania using a monetary DSGE approach. I also investigate if extensions of a standard monetary DSGE model, can replicate better the nominal features of real data. The econometric approach is a Bayesian one, which allows not only for estimates of the parameters, but also for model comparison in terms of posterior odds ratio. I compare the models in terms of their capacity to replicate the second order moments in the real data, namely the inflation persistence, which is approximated through the autocorrelation function. I also draw some possible implications for monetary policy in Romania.

The paper is organized as follows. In section two I present the standard monetary model and the augmented version featuring endogenous money. In the third section I estimate the two models using Bayesian techniques. I also compare the model in terms of log marginal densities and discuss the predictions of the model in terms of inflation persistence. In the fourth section I conclude and draw some possible policy implications. I also discuss future extensions of this paper.

2. The Models

The real business cycles (RBC) models appeared as successful in modeling the real side of the economy. However, this approach proved unable to account for the monetary features of the business cycles, Christiano (1991). Two different approaches emerged as an alternative to the real business cycle models augmented with money, namely the sticky price New Keynesian models and the limited participation model. Unfortunately they also appeared as having only a mild success in replicating features of the real data like inflation persistence, output-inflation correlations, or the liquidity effect.

Several recent papers, like Ireland (2003) or Dittmar, Gavin and Kydland (2005), showed that actually the real business cycles augmented with money can replicate features in the data like inflation persistence, or inflation-output relation, if such models feature Taylor rules, or endogenous money.

These results favor the choice of a monetary DSGE model, namely the standard CIA model, to study inflation persistence in Romania. In this section I present the model I use in the subsequent analysis. I sketch the building blocks of the model, the final linearized model to be estimated and the main differences between the alternative models.

2.1. The CIA Model

The model is a standard cash-in-advance (CIA, hereafter) model which is taken from Walsh (2003). There is a closed economy where there is a finite number of infinitely lived identical agents. The households maximize the utility under a typical budget constraint and a cash-in-advance constraint. The economy technology is a Cobb Douglas production function with constant returns to scale. The economy is hit by two types of shocks, a productivity shock affecting the production function through the TFP and a monetary shock.

The equations below present the log-linearized version of the model. Each variable is measured in percentage deviations from the steady state.

$$y_t = \alpha k_{t-1} + (1-\alpha)h_t + z_t \quad (1)$$

This equation is the linearized production function. There are two factors of production, the capital and the hours worked. The production of function is of constant returns to scale type, α standing for the capital share.

$$0 = \frac{\bar{y}}{\bar{k}} y_t - \frac{\bar{c}}{\bar{k}} m_t - \delta x_t \tag{2}$$

$$\frac{\bar{y}}{\bar{k}} y_t = -\frac{\bar{c}}{\bar{k}} m_t + k_t - (1-\delta) k_{t-1} \tag{3}$$

The second equation is the linearized resource constraint relation. It implies that the output is either consumed or invested. Equation (3) below shows the dynamic of the investments.

$$r_t = \alpha \left(\frac{\bar{y}}{\bar{k}} \right) (E_t y_{t+1} - k_t) \tag{4}$$

The marginal product of capital is expressed in equation (4).

$$\lambda_t = E_t \lambda_{t+1} + r_t \tag{5}$$

$$y_t + \lambda_t = \left(1 + \psi \frac{hs}{1-hs} \right) h_t \tag{6}$$

$$\lambda_t = i_t - E_t \pi_{t+1} + E_t \lambda_{t+1} \tag{7}$$

$$\lambda_t = -E_t (\phi m_{t+1} + \pi_{t+1}) \tag{8}$$

Equations (5) to (8) are derived from the first order conditions of the optimization problem of the household. Thus equation (5) stands for the typical Euler equation which results from the optimal choice of consumption. The next equation shows the intra-temporal optimal choice with respect to labor-leisure. Equation (7) is the Fisher equation, while equation (8) is the marginal utility of consumption.

$$m_t = m_{t-1} - \pi_t + em_t \tag{9}$$

Equation (9) expresses the dynamic of the money supply which is a random walk processes and is influenced by inflation and the money supply shocks.

$$c_t = m_t \tag{10}$$

Equation (10) is the linearized cash-in-advance constraint.

$$em_t = \rho_m em_{t-1} + u_t \tag{11}$$

$$z_t = \rho_z z_{t-1} + e_t \tag{13}$$

Finally, equations (11) and (13) express the two shocks, on the money supply and on the PTF, as AR(1) processes.

2.2. The CIA Model with endogenous money

I introduce here a slight variation on the standard CIA model. The change implies the introduction of a Taylor rule within the model. Similar research was done by Dittmar et al. (2003), Chen (2003), or Suh (2004). Here I follow the approach of Suh (2004) who extended the standard CIA model with a Taylor rule.

Suh (2004) shows that one of the proper ways to introduce the Taylor rule in the CIA model is to keep the Fisher equation and combine it with the Taylor rule. Thus, equation (7) becomes:

$$0 = \left(\frac{\omega_1 - 1}{\omega_1}\right) i_t + \frac{\omega_2}{\omega_1} y_t + E_t \lambda_{t+1} - \lambda_t \qquad (14)$$

3. The Estimation of the Models

In this section I estimate the models I presented in the last section. The estimation was done using Bayesian techniques. Several parameters were calibrated for each of the model according to the results in the literature.

3.1. The Estimation of the CIA Model

The set of parameters to be estimated is given by $\{\alpha, \beta, \delta, \phi, \psi, hs, \rho_a, \rho_u, yk, ck, \sigma_u, \sigma_a\}$. Following Caraiani (2007a), I can calibrate α, β and δ. α, the share of capital, is calibrated to 0.4. The discount factor β is calibrated to 0.98. The quarterly depreciation rate of capital δ was computed at 0.024. As for the time allocated to work, the data in Romanian economy suggest that an is equal to 0.28 is a reasonable choice. The parameters yk and ck, corresponding to the steady state ratio between output and capital, and consumption and capital, are computed from the values of the other parameters.

The remaining parameters, namely $\{\phi, \psi, \rho_a, \rho_u, \sigma_a, \sigma_u\}$, are estimated using Bayesian techniques. The data series which are used are the GDP and the inflation. The data series are between 2000 quarter one and 2007 quarter four. The GDP series is the quarterly GDP in 1995 constant prices. The inflation rate is proxied by the GDP deflator. All the initial series were logged, de-seasonalized and then filtered with the Hodrick Prescott filter.

The Bayesian estimation was done through two chains of 100.000 Metropolis Hastings draws. The final acceptance ratio for the first block was of 81.1%, while for the second block it was of 81.7%. The multivariate statistics indicated that the convergence was achieved, Annex A.

Table 1

The results of the Bayesian Estimation for the standard CIA model

Parameters	*Media Prior*	*Media Posterior*	*Confidence Interval*	*Confidence Interval*	*Prior Distribution*	*Standard Deviation*
φ	1.5	2.63	1.89	3.33	Normal	0.50
ψ	1.5	1.51	0.66	2.34	Normal	0.50
ρ_u	0.5	0.80	0.65	0.96	Beta	0.25
ρ_a	0.5	0.98	0.96	0.99	Beta	0.25
e_a	0.10	0.017	0.013	0.021	Inverted Gamma	Inf.
e_u	0.10	0.026	0.020	0.032	Inverted Gamma	Inf.

Source: Own Computations

Table 1 shows that the estimation produced high autocorrelation coefficient for both the technological and monetary AR processes.

The estimated values for φ and ψ are much higher than in Walsh (2003). For example, the coefficient of the relative risk aversion is estimated at 2.63, while Walsh (2003) calibrated the coefficient at 2.

3.2. The Estimation of the CIA Model with endogenous money

The same subset of parameters namely $\{\alpha, \beta, \delta, hs\}$ is calibrated as in the previous section.The remaining parameters, namely $\{\phi, \psi, \rho_a, \rho_u, \sigma_a, \sigma_u, \omega 1, \omega 2\}$, are estimated using Bayesian techniques.

The Bayesian estimation was done through two chains of 100.000 Metropolis Hastings draws. The final acceptance ratio for the first block was of 6.60%, while for the second block it was of 7.78%. The multivariate statistics indicated that the convergence was achieved, Annex B

Table 2

The results of the Bayesian Estimation for the augmented CIA model

Parameters	*Media Prior*	*Media Posterior*	*Confidence Interval*	*Confidence Interval*	*Prior Distribution*	*Standard Deviation*
ω1	1.5	1.55	1.26	1.96	Normal	0.25
ω2	0.25	0.20	-0.14	0.52	Normal	0.25
φ	1.5	2.55	1.82	3.27	Normal	0.50
ψ	1.5	1.47	0.65	2.24	Normal	0.50
ρ_u	0.5	0.85	0.72	0.93	Beta	0.25
ρ_a	0.5	0.96	0.95	0.99	Beta	0.25
e_a	0.10	0.016	0.013	0.019	Inverted Gamma	Inf.
e_u	0.10	0.025	0.020	0.030	Inverted Gamma	Inf.

Source: Own Computations

The estimation of the inflation parameter in the Taylor rule, Table 2, confirms the fact that the National Bank of Romania followed first of all the price stabilization. While officially adopted in 2004, Romania prepared the adoption of the new regime a few years before. The estimation confirms this behavior. It also appears that, for the considered period, less importance was given to the output gap fluctuations.

The second estimation shows close values for the common parameters with the first model, confirming thus the first estimation.

3.3. A Bayesian Comparison of the Models

It is also interesting the compare the two estimations in terms of posterior odds ratio. I present the log-marginal likelihoods in the table below. The log-marginal likelihoods are the result of the Bayesian estimations. Table 3 presents the results from the two estimations.

Table 3

Bayesian Comparison

Model	***Log Marginal Likelihood***	***Log Bayes Factor***
Standard CIA Model	*144.90*	-
CIA Model with Endogenous Money	*144.89*	*-0.01*

Source: Own Computations.

We can use Jeffreys (1961) thumb rule to discriminate between the models. According to this rule, a log-Bayes factor higher than two is decisive against the alternative model.

We can see that the two models have approximately equal qualities of fit. Thus it appears that the introduction of the endogenous money does not improve the quality of fit. Since in economics we follow the parsimonious principle, it follows that we should favor the simpler model, namely the standard CIA model.

3.4. Inflation Persistence

I turn now to the analysis of the implications of the estimated models on the inflation persistence. I analyze the inflation persistence by using the autocorrelation function in the real data and the theoretical autocorrelation functions predicted by the models.

Table 4

Autocorrelation Function of Inflation

Model	***Autocorrelation Function***				
	ρ(2)	***ρ(2)***	***ρ(3)***	***ρ(4)***	***ρ(5)***
Real Data	*0.67*	*0.46*	*0.43*	*0.16*	*0.03*
Standard CIA Model	*0.68*	*0.54*	*0.43*	*0.34*	*0.28*
CIA Model with Endogenous Money	*0.41*	*0.23*	*0.12*	*0.06*	*0.04*

Source: Own Computations.

In table 4, I present the autocorrelation function from the real data, from the standard CIA model and from the CIA model with endogenous model. I computed the autocorrelation function for five periods corresponding to five quarters, which is a reasonable span for analyzing the inertia of inflation. In figure 1, we can see the same autocorrelations function as a graphic. The figure gives us a better image of how well the models can reproduce the real data patter.

We can notice that the real data is characterized a strong persistence in the first periods. Afterwards, the autocorrelation in inflation decreases in an accelerate way. Thus, we can see the persistence of autocorrelation in Romania is characterized by an unusual pattern in the medium run.

The standard CIA model leads to very good prediction of the inflation persistence for the first three lags. But for higher lags, it cannot reproduce the accelerated decrease of autocorrelation in the real data.

The CIA model with endogenous model leads to a lower persistence for all the five lags considered. We can notice that the autocorrelation coefficients are sensibly lower than those in the real data or those predicted by the standard CIA. However at lag five, the model succeeds to produce a good fit, but this appears more as a result of a coincidence.

The autocorrelation function in real data and the alternative CIA models

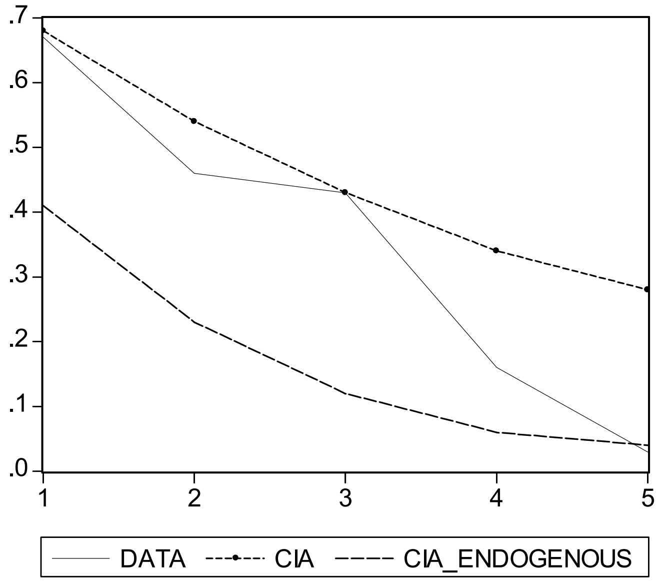

Figure 1

Source: Own Computations.

Again, the standard CIA model is favored over the CIA model with endogenous money. Here the results are much clearer, as the standard CIA model succeeds to reproduce the persistence in real data for the first three moments. However, the autocorrelation function in real data is also characterized by unusual decrease in the medium run (lags 4 and 5) which is harder to reproduce with the CIA model in both forms.

4. Conclusions

The purpose of this paper was to investigate the inflation persistence in Romanian economy using a monetary DSGE model. While simpler in its structure, the standard CIA model can account for inflation persistence in Romanian economy, for shorter spans of time.

Introducing endogenous money, while shown in the literature to improve the predictions of the model, does not lead to better predictions for the case of Romania. In terms of Bayesian comparison, the standard CIA model performance is relatively the same as the CIA model augmented with endogenous money. However, based on the principle of parsimony, the standard CIA model should be preferred for analyzing the inflation persistence in Romania.

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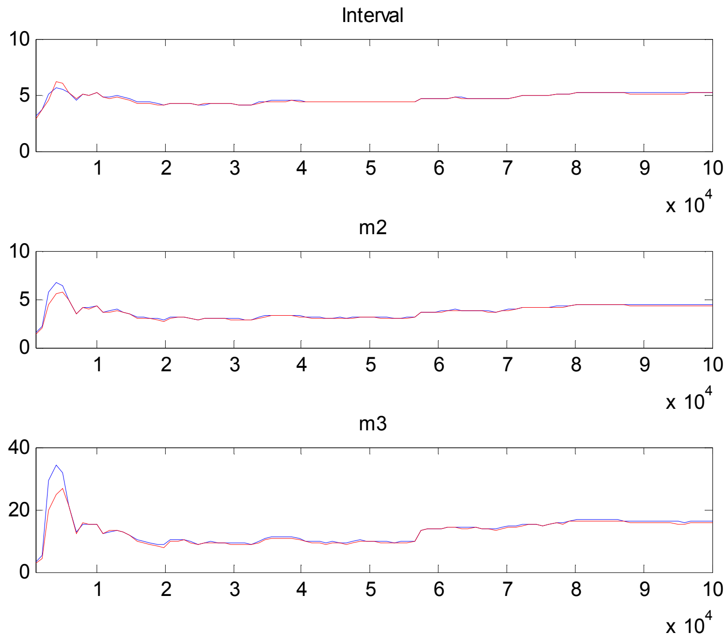
ANNEX A. Multivariate convergence diagnostics for CIA Model



ANNEX B. Multivariate convergence diagnostics for CIA Model with Endogenous Money