9 AN ESTIMATED NEW KEYNESIAN MODEL FOR ROMANIA*

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Abstract

In this paper I estimate a New Keynesian Model with sticky prices for the Romanian economy for the period 1991-2002, using quarterly data. The estimation was made in Dynare using the Bayesian approach. The degree of the price stickiness is moderate. The model makes good predictions in terms of correlations and standard deviations. The impulse response functions with respect to the monetary shock show moderate and persistent responses.

Keywords: business cycle, New Keynesians, monetary policy, DSGE models, Bayesian Econometrics.

JEL Classification: C11, C15, E31, E32.

1. Introduction

The standard Real Business Cycles (RBC hereafter) approach is considered to suffer from several major deficiencies. First of all, the standard RBC is in contradiction with the real world market economy. As most of the economic studies show, even the most performing market economies are characterized by imperfections, frictions which make the RBC model to appear as unrealistic. Second, there is a wide consensus that money (quantified under various forms) has real effects on the economy, confirming one of the fundamental propositions of the New Keynesian approach (NK, hereafter).

The NK approach developed as a natural extension of the RBC model. It is based on micro foundations, but it also considers different types of imperfections. In contrast to the RBC approach, it also takes into account several other types of shocks, such as inflationary shocks, monetary shocks, etc.

In this paper, I present a NK model which I estimate and simulate for the Romanian economy. The model I discuss is considered as the standard NK model. The evaluation of this model allows an analysis of the NK paradigm and of its relevance for

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Romania and, at the same time, by underlining the imperfections of the model it can suggest some possible future developments.

The model discussed here is similar to the versions in Gali (2002) and Walsh (2003). I follow here the slightly changed version in Iacoviello (2005).

In the next section I discuss the characteristics of the model and its equations. Section three estimates the model and analyzes the impulse response functions of the endogenous variables to the various shocks. In the last section I draw the conclusions and discuss some possible future refinements of this basic NK model considered here.

2. The Model

The model is composed of four types of agents, namely the households, the final good producers, the intermediate good producers and a monetary authority.

2.1. The Households

As it is typical for the NK models, there is a continuum of households with infinite lives. The total is normalized to one.

The problem of the representative household is to choose the consumption c_t, the labor supply L_t, the money M_t and the bonds B_t so as to maximize the lifetime utility given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\rho}}{1-\rho} - \frac{1}{\eta}(L_t)^{\eta} + \chi \ln \frac{M_t}{P_t} \right) \quad (1)$$

where E_0 indicates the expectations conditional on the information at time zero, while β is the discount factor.

The real terms budget constraint is given by:

$$C_t + \frac{B_t}{P_t} = \frac{R_{t-1}}{P_t} B_{t-1} + \frac{W_t}{P_t} L_t + F_t - \frac{M_t - M_{t-1}}{P_t} + T_t \quad (2)$$

where R_{t-1} is the nominal interest rate, F_t is the dividends received from the intermediate good producers, W_t is the nominal wage and T_t are the transfers.

2.2. Final Good Producers

There are two types of producers, namely final good producers and intermediate good producers. For the final good sector, I assume the existence of a representative firm, which produces a final good Y_t using the intermediate goods Y_{jt}.

The total final goods are given by a CES type aggregated index:

$$Y_t = \left(\int_0^1 Y_{jt}^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \quad (3)$$

where ε>1.

The firms buy inputs given by Y_{jt} and produce final goods to maximize the profit, considering P_{jt} as given:

$$\max Y_t - \frac{1}{P_t}\int_0^1 P_{jt} Y_{jt}\, dj \tag{4}$$

where P_t is an index to be determined throughout the optimization problem.

This problem can also be written as a minimization of the expenditures problem, given the production side constraints. Thus, one may write:

$$L = \int_0^1 P_{jt} Y_{jt}\, dj - P_t\left(Y_t - \left(\int_0^1 Y_{jt}^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \right) \tag{5}$$

One gets in the end P_t as the aggregate index of prices:

$$P_t = \left(\int_0^1 P_{jt}^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}} \tag{6}$$

2.3. Intermediate Goods Producers

The intermediate good sector is modeled in a similar manner. It is assumed the existence of a representative firm. Furthermore, it is assumed that it is a continuum of such firms which are owned by households. Each firm is indexed on the (0,1) interval.

In its decisions, each firm of this sector takes into consideration three kinds of constraints.

The first constraint is from the production function. Each firm uses the labor force to produce, using the following technology:

$$Y_{jt} = A_t L_{jt} \tag{7}$$

This formulation takes into consideration the argument of McCallum and Nelson (1999) that the dynamics of capital stock is irrelevant on the short term for the dynamics of the aggregate economy, and thus it can be excluded from the analysis of the economic cycle.

The second constraint of the intermediate firm is given by the demand curve, each firm of the intermediate sector having a decreasing slope. For firm j, the demand slope is given by:

$$Y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} Y_t \tag{8}$$

The last constraint is related to the inclusion of the price stickiness. I use here the Calvo (1983) specification, which suggests that in each period the prices can be adjusted with a probability 1-θ, only by a fraction of the firms.

In a typical manner for a NK model, the optimization problem can be broken into two separated smaller optimization problems.

The first decision is to minimize the cost by choosing an optimal quantity of labor, under the constraint given by the production function specification. Thus, the problem of minimization is given by:

$$\min \frac{W_t}{P_t} L_{jt} + Z_t (Y_{jt} - A_t L_{jt}) \tag{9}$$

where Z_t is the multiplier associated to the constraint.

By solving this problem I get that the real cost function can be written as:

$$COST_t = \frac{W_t}{P_t} L_{jt} = Z_t Y_{jt} \tag{10}$$

Z_t can be understood as the real marginal cost and its inverse, $X_t = 1/Z_t$ is the real markup.

The next stage involves the price setting decision. Following Calvo's (1983) idea, some of the producers of intermediate goods can change prices while others cannot. Thus, the average price level is an aggregate CES given by:

$$P_t^{1-\varepsilon} = \theta P_{t-1}^{1-\varepsilon} + (1-\theta)(P_t^*)^{1-\varepsilon} \tag{11}$$

where P_{t-1} is the level of prices from the previous period, while P_t^* is the average price level for those who can change the prices.

Let us consider an intermediate producer who has the chance of 1-θ to reset the prices in t. Let P^* be the reset prices. Then, the demand curve is given by:

$$Y_{jt+k}^* = \left(\frac{P_{jt}^*}{P_{t+k}} \right)^{-\varepsilon} Y_{t+k} \tag{12}$$

for any period k>0 for which the price remains.

The profit maximization problem can be written as:

$$\max \sum_{k=0}^{\infty} (\theta\beta) E_t \left(\Lambda_{t,k} \left(\frac{P_{jt}^*}{P_{t+k}} - Z_{t+k} \right) Y_{jt+k}^* \right) \tag{13}$$

where, from the Euler equation we know that:

$$\Lambda_{t,k} = \left(\frac{C_t}{C_{t+k}} \right)^{\rho}$$

In the period t, the producer chooses P_{jt}^* so that to maximize the profit function. By differentiating the profit function, and following a few additional steps (see Iacoviello, 2005), we get the following expression:

$$P_t^* = X \frac{\sum_{k=0}^{\infty} (\theta\beta)^k E_t \left[\Lambda_{t,k} Y_{t,k}^* Z_{t+k}^n P_{t+k}^{-1} \right]}{\sum_{k=0}^{\infty} (\theta\beta)^k E_t \left[\Lambda_{t,k} Y_{t+k}^* P_{t+k}^{-1} \right]} \tag{14}$$

This expression indicates that the optimal price is a weighted average of the current and future marginal costs. The weights depend on the future demand and on how fast do the firms put a discount on profit.

2.4. The Model

To close the model, it is necessary to impose the market clearing condition and to specify a monetary policy rule and the technology process. I assume a Taylor-type monetary policy and a standard AR (1) process for the technology process.

Following the standard log-linearization approach (see Campbell, 1994, and Uhlig, 1995), I can derive the model in the log-linear form, as Iacoviello (2005) suggests:

$$y_t = E_t y_{t+1} - \frac{1}{\rho}(r_t - E_t \pi_{t+1}) \tag{15}$$

$$y_t = \frac{1}{\eta + \rho - 1} z_t + \frac{\eta}{\eta + \rho - 1} a_t \tag{16}$$

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta} z_t + u_t \tag{17}$$

$$r_t = \phi_r r_{t-1} + (1-\phi_r)((1+\phi_\pi)\pi_t + \phi_z z_t + e_t \tag{18}$$

$$a_t = \rho_a a_{t-1} + ua_t \tag{19}$$

As Iacoviello (2005) shows, in order to obtain the standard NK model, we can introduce a new variable, the potential output, and eliminate the marginal costs, using the following equations:

$$y_t^n = \frac{\eta}{\eta + \rho - 1} a_t \tag{20}$$

$$z_t = (\eta + \rho - 1)(y_t - y_t^n) \tag{21}$$

Here, the potential output is that output that would be achieved in the case of perfect flexible prices.

Thus, the final form of the model to be estimated is given by:

$$y_t = E_t y_{t+1} - \frac{1}{\rho}(r_t - E_t \pi_{t+1}) \tag{22}$$

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta}\left(y_t - y_t^n\right) + u_t \tag{23}$$

$$r_t = \phi_r r_{t-1} + (1-\phi_r)\left((1+\phi_\pi)\pi_t + \phi_y\left(y_t - y_t^n\right)\right) + e_t \tag{24}$$

$$a_t = \rho_a a_{t-1} + ua_t \tag{25}$$

The first equation, (22), is the IS curve of the model. However, it differs from the standard IS through the inclusion of the expectations and the forward looking elements. The IS curve stands for the demand side in this model.

The supply side is represented by the Phillips Curve, which differs even more drastically from the traditional Phillips curve. The inflation process is forward looking, and thus the current inflation is a function of the expected inflation. In the primary form, we could see that the NK Phillips curve can also be understood as the present value of current and future marginal costs. Also, it is essential to understand that this Phillips curve was derived from optimizing the agents' behavior, namely the utility maximization of the households and the profit maximization of the firms.

Equation (24) is a Taylor type monetary rule, in which the current interest rate depends on the previous period interest rate, the current inflation and the output gap.

The model is closed by the specification of a dynamics for the productivity shocks, which follow an AR (1) type process, namely equation (25).

3. The Estimation of the New Keynesian Model

In the following, I estimate the model given by equations (20)-(25). The variables in the model are y_t, π_t, a_t, z_t, $ybar_t$ and R_t, which stand for production, inflation, total factor productivity, marginal cost, potential output and interest rate. y_t is the production per capita and it is obtained by dividing total production to the population over 15 years old. π_t is the annualized quarterly inflation rate, while R_t is the quarterly interest rate given by the average refinancing interest rate.

The set of parameters which I estimate is given by $\{\beta, \sigma, \theta, \rho, \eta, \gamma_r, \gamma_\pi, \gamma_z, \sigma_a, \sigma_u, \sigma_r\}$. Before applying the Bayesian estimation, I calibrate, first of all, a subset of this set of parameters. β is calibrated to 0.98. σ_a is calibrated to 0.02, reflecting the higher volatility of the Romanian economy during the analyzed period. σ_u and σ_r are calibrated to 0.009, using standard values from the literature.

The remaining parameters, namely $\{\eta, \sigma, \rho, \theta, \gamma_r, \gamma_\pi, \gamma_z\}$, are estimated using the Bayesian techniques. The data series used are the quarterly GDP, in 1995 constant prices, the quarterly inflation rate and the quarterly interest rate. The series are constructed as explained above. The source of the series is a database with real and estimated data constructed by Academician Emilian Dobrescu, at the National Institute of Economic Research, Romanian Academy.

The estimation was done using the Dynare software (see Juillard, 1996). The number of Metropolis Hastings extraction was 20000 and the final acceptance rate is 29%, which is a good value given that the optimal acceptance rate is 20%.

Table 1

The results of the Bayesian Estimation

Parameters	Prior average	Posterior average	Confidence interval	Confidence interval	Prior distribution	Standard deviation
γ_π	1.5	1.95	1.37	2.54	Normal	0.5
γ_y	0.125	0.38	0.18	0.56	Normal	0.125
γ_r	0.5	0.73	0.66	0.80	Uniform	0.28
σ	1	1.29	1.26	1.31	Normal	0.05
η	1	0.84	0.73	0.93	Normal	0.05
θ	0.75	0.71	0.63	0.80	Normal	0.15
ρ	0.9	0.93	0.92	0.94	Beta	0.1

Source: Author's own computations in Dynare.

The above table shows the results of the Bayesian estimation. The Taylor rule parameters are estimated at 0.73 for γ_r, 1.95 for γ_{pi}, and 0.38 for γ_y. The coefficient for inflation is higher than the usual estimates in the literature. Thus, it is confirmed the fact that the National Bank has pursued, first of all, the inflation stability.

The next stage in the analysis of the NK model is the comparison of the second order moments of the simulated variables relative to the second order moments of the real variables. The tables below show the standard deviations of the real and simulated variables, their volatility with respect to the production and their correlations with production.

Table 2

The real behavior of variables, quarterly frequency

	Correlations		
	Standard Deviation	Volatility Relative to Production	Lag 0
Interest Rate	1.31	0.23	-0.60
Inflation	1.00	0.17	-0.49
GDP	5.6	1.00	1.00
TFP	6.5	1.16	0.89

Source: Dobrescu data set and author's own computations.

Table 3

The results of the simulation of the NK model

	Correlations		
	Standard Deviation	Volatility Relative to Production	Lag 0
Interest Rate	1.18	0.15	-0.75
Inflation	0.82	0.10	-0.31
GDP	7.73	1	1.00
TFP	5.79	0.74	0.97

Source: Author's own computations in Dynare.

The NK model has fairly good predictions in terms of standard deviation of the variables with modest differences for the GDP and the PTF. Thus, the standard deviation for production in the model is 7.73%, while the real value is 5.6%. For TFP, the difference is less significant, the real value of standard deviation being 6.5% while the predicted value was 5.79%.

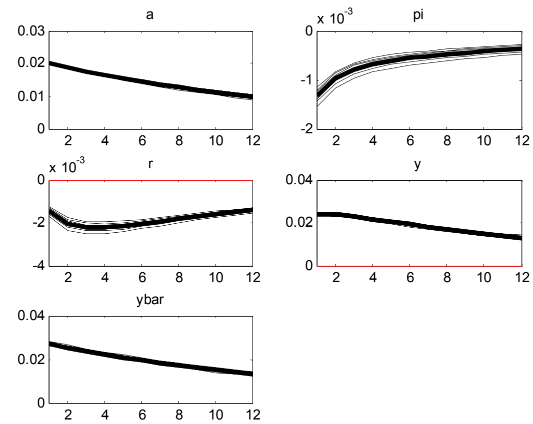
In terms of correlations, the results are better. The correlation between the interest rate and production and that between inflation and production are negative, as in the real data. The negative correlation between inflation and production is not that strong as that between the real variables.

I analyze now the impulse response functions for the estimated NK model. As we have seen, the model comprises three kinds of shocks: a technological shock (like in any RBC model), an inflationary shock (through the Phillips curve) and an interest rate shock (through the Taylor rule).

The figure below shows the impulse response function to a positive technology shock. The impulse responses of the TFP and the GDP are typical. The high persistence of these responses is given by the high value of ρ. The interest rate falls leading to a fall in the inflation, too.

Figure 1

Impulse response function to a productivity shock

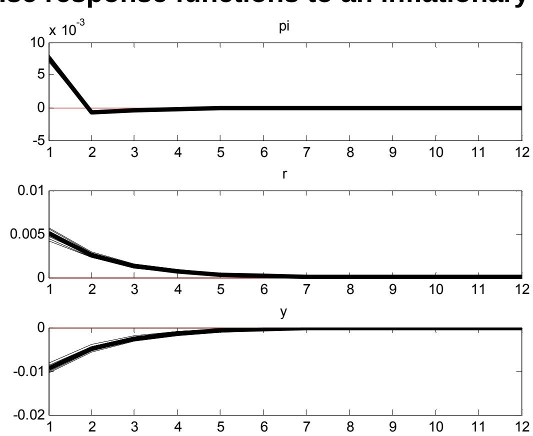


Source: Author's own computations in Dynare.

Figure 2 presents the impulse response function to an inflationary shock. An inflationary shock leads to a higher interest rate. The growth of the interest rate accelerates the effect of the decrease in the effect of the inflationary shock. The higher interest rate also leads to a decrease in production.

Figure 2

Impulse response functions to an inflationary shock

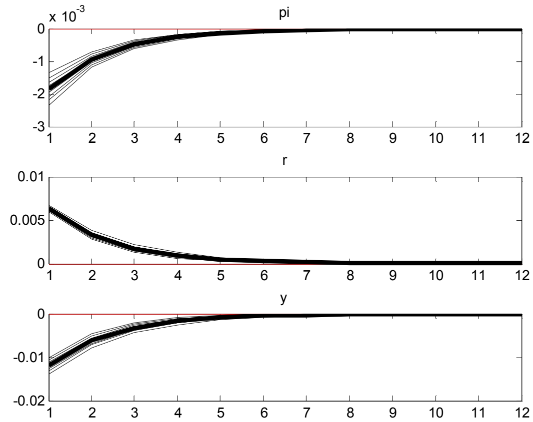


Source: Author's own computations in Dynare.

A shock at the interest rate level leads to a decrease in the inflation rate, as expected. Also, the higher interest rate has a negative effect on production. One may see that, relative to the productivity shocks, the effect of the monetary policy shock diminishes in the short to medium run, and, for a period higher than 7 quarters, it does not have anymore effects on the real or monetary variables.

Figure 3

Impulse response functions to an interest rate shock



Source: Author's own computations in Dynare.

4. Conclusions

The estimation of the NK model revealed a moderate degree of price stickiness, which suggest that the imperfections in the Romanian economy are to be sought either in the wage rigidity or among other types of imperfections, as Fuhrer and Moore (1995), Fuhrer (2000) or Chari, Kehoe and McGrattan (2001) suggest.

The estimation of the Taylor rule implies that the Central Bank paid attention, first of all, to the inflation behavior, as the coefficient related to the inflation parameter is higher than the usual estimates in the literature. At the same time, I get comparable estimates for the autocorrelation coefficient of the interest rate, and for the coefficient related to the output gap.

In terms of second order-moments, the results of the models are good in terms of correlations, both as a sign and as magnitude. There are some differences between the predicted standard deviations of the variables and the real standard deviations, but the estimated results are good. The differences may come from the lack of other types of rigidities or shocks, which would necessarily improve the model fit.

The monetary policy shock shows a moderate degree of persistence, as the impact on inflation and output lasts for about six to seven quarters. At the same time, the positive monetary policy shock leads to a decrease of more than one percent in the output, which is not negligible. The magnitude and the persistence of these impulse response functions may be increased by adding features like wage rigidity or habit formation, as the literature suggests.

The future works in the DSGE modeling of the Romanian economy should take into account not only the character of a small open economy of Romanian also, but also features such as the wage rigidity, variable capital utilization, and other types of frictions specific to Romania. The more complex the DSGE models built for Romania will be the more meaningful will be the implied economic policies.

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