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3. Comparing Monetary Policy Rules in the Romanian Economy: A New Keynesian Approach[1]

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Abstract

A New Keynesian model of open economy is estimated and discussed in the case of Romania. The model is estimated using quarterly data on a post-2000 sample. The paper focuses on the monetary policy analysis and compares several specifications for the monetary policy within the Bayesian framework. The issue whether the National Bank reacts to the exchange rate is also discussed.

Keywords: New Keynesian models, small open economy, monetary policy, Taylor rules, Bayesian methods

JEL Classification: C11, E32, E52

1. Introduction

The financial crisis led to a reemergence of the debates regarding the contagion and transmission of financial crisis. In this context, the role of central banks, especially for the small open economies, becomes even more important. While most of the economies in Central and Eastern Europe adopted the inflation targeting regime, the practical experience shows that the central banks of these economies paid attention not only to the output evolution, but also to changes in the exchange rates. The issue became even more critical as the current crisis challenged most of the conventional wisdom regarding the design and use of monetary policy. In this question, we would like to test whether the central bank did react to the exchange rate movements.

The question of whether the central bank reacts or not to the movements in the exchange rate is well debated in the literature; see Clarida, Gali and Gertler (1998), Calvo and Reinhart (2002) for early results using linear regression and Ball (1999) for

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a discussion on the meaning and on the benefits of different policy options. In a recent paper, Lubik and Schorfheide (2007) studied this issue for a set of small open economies model. Based on a Bayesian estimation of a small structural model of a small open economy estimated for several countries, Australia, Canada, New Zealand and the UK, they performed posterior odds tests through which they tested whether the central banks did respond to the exchange rates. They found that among the countries included in the sample, only the Bank of Canada responded to the exchange rates movements.

A similar exercise was carried out by Eschenhof (2009) for the Euro Area. The model was basically that of Lubik and Schorfheide (2007). She found that, generally, a monetary policy that included the expected inflation rate as well as the output gap performed best and that there was evidence in support of the idea of responses by the ECB to the exchange rate movements.

This question is also very relevant for the case of Central and Eastern Europe (CEE hereafter) economies. Under the inflation targeting regime adopted by many of the countries in Central and Eastern Europe, including Romania, the central bank is preoccupied first of all with price stabilization. However, as the experience showed, given the commitment of these countries to join the euro on medium term, the central banks pay some attention to the exchange rate, too.

However, in the case of the Central and Eastern economies this issue was less studied, especially from the perspective of dynamic stochastic general equilibrium (DSGE, hereafter) models. Some studies were made by estimating Taylor rules for selected CEE economies; see Maria-Dolores (2005) and Farell (2007). Maria-Dolores (2005) estimated Taylor rules for selected CEE economies and found that the Taylor rule is a good representation of how central banks in countries with floating exchange rates set the interest rates (namely, the Czech Republic, Hungary and Poland). Farell (2007) asked the question whether the central banks from the Visegrad group (the Czech Republic, Hungary, Poland and Slovakia) set the interest rates according to the Taylor rule using different specifications, and found that, except for Slovakia, the exchange rate has a prominent role in the Taylor rule, as well as that measures are sensitive to the measure of inflation that is used.

In this paper, the question of whether the Central Bank of Romania reacted or not to exchange rate movements is answered within a DSGE framework. The DSGE framework is useful as it allows for an answer to the problem within a structural macroeconomic model. Combined with the Bayesian econometric framework it allows for an estimation of key relationships for the Romanian economy and, by considering different specifications for the Taylor rules, it makes possible to compare the models featuring different Taylor rules by using Bayesian model.

This paper is organized as follows. The second section presents the model and discusses its building blocks, as well as the different monetary policy rules considered. The third section presents the data to be used in the estimation and the results of the Bayesian estimation. In the fourth section, a comparison of the different versions of the baseline model featuring different monetary policy rules including or not the exchange rate are discussed. A discussion of the results and some policy implications are presented in the last section.

2. A New Keynesian Model of Open Economy

The model is based on the reference NK model proposed by Lubik and Schorfheide (2007). This particular model was chosen since, first of all, it embeds the basic ingredients of a NK model; second, it is already tested and estimated for several small open economies (like Romania), and, last but not least, it was already used to carry a similar exercise in testing whether the central banks do react or not to the exchange rate movements. The model is presented below and it is already in a log-linear form:

$$\begin{aligned} y_t &= E_t y_{t+1} - \left[\tau + \alpha\left(2-\alpha\right)\left(1-\tau\right)\right]\left(r_t - E_t \pi_{t+1}\right) - \rho_z z_t - \\ &\alpha\left[\tau + \alpha\left(2-\alpha\right)\left(1-\tau\right)\right] E_t \Delta q_{t+1} - \alpha\left(2 - \alpha\frac{1-\tau}{\tau}\right)\Delta y^*_{t+1} \end{aligned} \tag{1}$$

$$\pi_t = \beta E_t \pi_{t+1} + \alpha\beta E_t \Delta q_{t+1} - \alpha \Delta q_t + \frac{\kappa}{\tau + \alpha\left(2-\alpha\right)\left(1-\tau\right)}\left(y_t - \bar{y}_t\right) \tag{2}$$

$$\bar{y}_t = \left[\frac{-\alpha\left(2-\alpha\right)\left(1-\tau\right)}{\tau}\right] y^*_t \tag{3}$$

$$\pi_t = \Delta e_t + \left(1-\alpha\right)\Delta q_t + \pi^*_t \tag{4}$$

$$r_t = \rho_r r_{t-1} + \left(1-\rho_r\right)\left(\psi_1 \pi_t + \psi_2 y_t + \psi_3 \Delta e_t\right) + \varepsilon^r_t \tag{5}$$

$$\Delta q_t = \rho_q \Delta q_{t-1} + \varepsilon^q_t \tag{6}$$

$$z_t = \rho_z z_{t-1} + \varepsilon^z_t \tag{7}$$

$$y^*_t = \rho_{y^*} y^*_{t-1} + \varepsilon^{y^*}_t \tag{8}$$

$$\pi^*_t = \rho_{\pi^*} \varepsilon^{\pi^*}_{t-1} + \varepsilon^{\pi^*}_t \tag{9}$$

The first equation is an IS equation for an open economy of New Keynesian type. The domestic output, $y_{t,}$ is characterized by the dependence of expected output, real interest rate, terms of trade, q_t, world technology (or productivity), $z_{t,}$ and foreign output, y_t^*. E_t is the expectations operator.

Equation (2) introduces the New Keynesian Phillips curve. The current inflation, π_t , depends on expected inflation, π_{t+1}, expected changes in terms of trade, q_t, and the output gap, as the difference between potential output, $\bar{y}_t$, and actual output, y_t.

The potential output is given in equation (3): the potential output is the output realized under lack of nominal rigidities and when technology is non-stationary.

Equation (4) implies that PPP holds, with current inflation depending on changes in the nominal exchange rate, Δe_t, changes in terms of trade, $q_{t,}$ as well as world inflation, π_t^*. The changes in terms of trade are modeled in equation (6) using a standard approach. ε_t^q is the error term.

The Taylor rule is given in equation (5), with current nominal interest rate, r_t, depending on the past interest rate, on current inflation, on current output and on changes in nominal exchange rate. The variable ε_t^r stands for the error term.

Equations (7) to (9) describe the dynamics of the exogenous variables, namely the world inflation, π_t^*, world output, y_t^*, and world technology, z_t. They are all supposed to be AR(1) models. The terms ε_t^z, $\varepsilon_t^{y^*}$ and $\varepsilon_t^{\pi^*}$ represent the error terms associated to each AR(1) process.

As an alternative to the baseline monetary policy rule, we propose two alternative specifications, starting from suggestions in Lubik and Schorfheide (2007), as well as in Eschenhof (2009). The first one uses the output gap instead of output, as presented below:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)\left(\psi_1 \pi_t + \psi_2 (y_t - \bar{y}_t) + \psi_3 \Delta e_t\right) + \varepsilon_t^r \qquad (10)$$

In the third specification, the expected inflation is introduced instead of current inflation, as stated below:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)\left(\psi_1 E_t \pi_{t+1} + \psi_2 (y_t - \bar{y}_t) + \psi_3 \Delta e_t\right) + \varepsilon_t^r \qquad (11)$$

3. Model Estimation

The model is estimated using quarterly data available for Romanian for a post-2000 sample. The shorter sample is due to data availability. At the same time, it represents a more stable period for the economy, when Romania enjoyed economic growth up to 2009. The sample data ranges between the first quarter of 2000 and the second quarter of 2010. The data series used include the GDP, the inflation, the interest rate, the exchange rate and the foreign output. The quarterly GDP is given by the quarterly GDP in constant 2000 prices, in millions national currency. The quarterly inflation is given by the quarterly average of monthly inflation. The quarterly interest rate is the quarterly average of the National Bank's interest rate. The foreign output is proxied by the Euro Area quarterly GDP in constant 2000 prices. Finally, the exchange rate is given by the quarterly average of the exchange rate of RON to EUR. All the series were seasonally adjusted and filtered using the Hoddrik-Prescott filter.

Due to the limited sample, many of the parameters were calibrated. Essentially, calibration implies setting certain values, based on the judgment or previous estimations in the literature, for parameters that are hard to estimate. The calibration was based on data from literature or on previous estimations for the case of Romania. For example, the discount parameter β was set to 0.99. The standard deviations for the domestic nominal interest rate, as well as the terms of trade were set according to data features. The standard deviations and autocorrelation coefficients for the world economy variables, i.e. the Euro Area, were set according to a previous estimation for a two-country, small open economy model, where the large economy represented the Euro Area, see Caraiani (2011). The final set of parameters to be estimated is given below:

$$\left\{\alpha, \tau, \kappa, \psi_1, \psi_2, \psi_3, \rho_r, \rho_q\right\}$$

The prior and posterior were set following basically the proposals from Lubik and Schorfheide (2007) and Eschenhof (2009). They reflect the usual approaches in the literature and they can represent a good starting point for any estimation.

3.1. The Model with a Baseline Taylor Rule

The estimation used two Metropolis-Hastings chains, each one featuring 500000 extractions. The average acceptance ratio was 34.54% for the first chain and 34.50% for the second one. Annexes A to E present the results of estimations. As one may see, the convergence statistics based on the Brooks-Gelman approach indicate that convergence was achieved.

The monetary policy is estimated to be active, as the coefficient is much higher than unit, as well as conservative. There are high values for both the output coefficient and the exchange rate coefficient in the monetary policy rule.

3.2. The Model with an Alternative Taylor Rule with Output Gap

The second estimation assumed a monetary policy rule as in (10), with the output gap included. All the other equations remained as in the baseline version.

The estimation was based on the same prior distributions. Again, two Metropolis-Hastings chains, each of 500.000 extractions were used. The average acceptance ratios were 34.39% and 34.56%, respectively. The univariate and multivariate convergence statistics, as well as the posterior distributions are presented in the Annexes.

There is a remarkable similitude with respect to the posterior means relative to the first estimation. Again, there are significant differences between the posterior and prior distributions. Overall, the estimation passed the convergence tests and it led to meaningful results.

3.3. The Model with an Alternative Taylor Rule with Output Gap and Expected Inflation

The third estimation implies the use of a monetary policy rule as in (11), with the output gap included, as well as the expected inflation included in the specification. All the other equations remained as in the baseline version.

The estimation was based on the same prior distributions. Two Metropolis-Hastings chains, each of 500.000 extractions were used. The average acceptance ratios were 34.48% and 34.48%, respectively. The univariate and multivariate convergence statistics, as well as the posterior distributions are presented in the Annexes.

Again, the estimation is good in terms of posterior differences of distributions relative to the prior distributions, as well as of convergence statistics. However, the log-Likelihood is much lower as compared to the previous model. At the same time, there are some minor differences with respect to the estimates of posterior mean for a few parameters. This may be correlated with the slight differences in the posterior estimates of the parameters.

4. Comparing Alternative Monetary Policy Rules

We would like to test whether the central bank did react to the exchange rate movements using the results from the Bayesian estimations for each model. In order to conduct this test, we consider that the exchange rate element is absent in the above-mentioned monetary policy specifications. The three alternative models are then estimated using the same specifications, on the same sample as for the baseline versions. For simplicity, only log-Likelihood functions are presented, see Annex A.

The models are compared using the Bayesian factor expressed in logs, following Jeffreys (1961). We find the log-Bayes factors of around 10.00 for the baseline model, which includes the exchange rate against the version without the exchange rate, implying that we would need a prior probability over 20000 (=$e^{9.97}$) times larger than the prior probability of M1, the model without the exchange rate, to prefer M2 based on posterior odds. This can be interpreted as decisive evidence in the favor of the model featuring the exchange rate. A similar result is obtained for the second version of the model, with the Taylor rule featuring output gap.

For the third case, the Log Bayes factor is also much larger when compared to the specification without the exchange rate. However, the Log Bayes factor is lower than the ones for the first two versions.

5. A Discussion of the Results

The Bayesian estimation of the different specifications of the NK model, as well as the Bayesian comparison of the models, led to several significant results.

The monetary policy was found to be conservative, since inflation coefficients related to monetary policy were estimated at over 2.5, as well as active, since the estimated coefficient was found to be higher than unit. These results were not influenced by the changes in the specification of monetary policy rule.

Central banks reacted to output dynamics, as well as to the exchange rates, as suggested by the estimated Taylor rules. The coefficients associated to the exchange rate movements are very strong. Moreover, as seen from Annexes B, B1 to B3, the confidence interval does not contain zero and it is well above the zero value. This can also be seen as a first answer to the question addressed in this paper.

With respect to the coefficient related to the smoothing of the interest rate, a coefficient around 0.5 was found, which is usually interpreted as indicating a moderate gradualism of the central bank.

The Bayesian comparison of the models with and without exchange rate in the Taylor rules suggested that the models with exchange rate clearly outperformed those that did not feature the exchange rate in the monetary policy rule.

Generally, based on the estimated coefficients of the exchange rate variable in the Taylor rules for each models, as well as from the Bayesian comparison of different models, we can affirm that the central bank of Romania did react to the movements in the exchange rates.

6. Conclusion

Whether the central banks respond or not to the exchange rate movements still is an important question. We approached this issue for the case of Romania within a DSGE framework that allowed not only estimations of Taylor rules within a structural model, but also for a Bayesian comparison of different specifications.

The research done here suggests that the National Bank of Romania reacted to the exchange rate movements. This hypothesis was tested for different types of monetary rules, and in all cases it was decisive evidence that the monetary policy rule including the exchange rate performed better than the monetary policy rules without the exchange rate.

Some further understanding could come from more complex models that would feature financial variables and specific features of a small open economy like Romania. It would be important to test if the findings here are influenced by the overall specification of the structural model or by the different imperfections taken into account. Not least, the research done here should be extended to the case of other CEE economies.

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Annex A

Comparing Models with Alternative Monetary Policy Rules

NK Model with Different Monetary Policy Rules	Model Log Marginal Data Densities		Log-Bayes Factor
	ψ_3=0	ψ_3>0	
Baseline Taylor Rule	67.55	76.52	*9.97*
Taylor Rule with Output Gap	67.58	76.57	*9.99*
Taylor Rule with Expected Inflation	45.53	54.63	*11.10*

Annex B

Model Estimates

B.1. NK Model with Baseline Taylor Rule

Parameters	Prior mean	Posterior mean	Confidence interval	Confidence interval	Prior distribution	Standard deviation
α	0.50	0.60	0.49	0.71	Normal	0.10
κ	0.50	1.57	1.26	1.89	Normal	0.25
ψ_1	1.50	2.54	1.95	3.12	Normal	0.50
ψ_2	0.25	0.36	0.11	0.60	Normal	0.15
ψ_3	0.25	0.64	0.41	0.87	Normal	0.15
τ	0.50	0.70	0.42	0.96	Normal	0.25
ρ_r	0.70	0.49	0.37	0.61	Beta	0.10
ρ_g	0.40	0.45	0.34	0.56	Beta	0.20

B.2. NK Model with a Taylor Rule Featuring the Output Gap

Parameters	Prior mean	Posterior mean	Confidence interval	Confidence interval	Prior distribution	Standard deviation
α	0.50	0.60	0.49	0.71	Normal	0.10
κ	0.50	1.57	1.25	1.89	Normal	0.25
ψ_1	1.50	2.54	1.94	3.11	Normal	0.50
ψ_2	0.25	0.36	0.11	0.60	Normal	0.15
ψ_3	0.25	0.64	0.41	0.88	Normal	0.15
τ	0.50	0.69	0.42	0.96	Normal	0.25
ρ_r	0.70	0.49	0.37	0.61	Beta	0.10
ρ_g	0.40	0.45	0.34	0.56	Beta	0.20

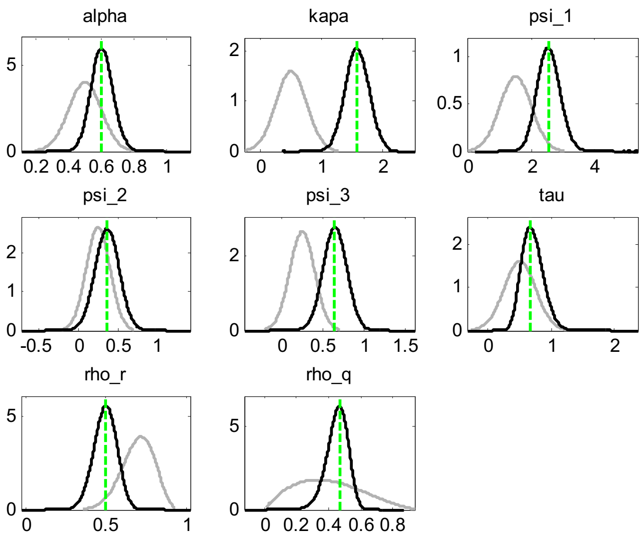
B.3. NK Model with a Taylor Rule Featuring the Output Gap and Expected Inflation

Parameters	Prior mean	Posterior mean	Confidence interval	Confidence interval	Prior distribution	Standard DeviaTION
α	0.50	0.55	0.44	0.66	Normal	0.10
κ	0.50	1.29	0.95	1.61	Normal	0.25
ψ_1	1.50	2.29	1.55	3.02	Normal	0.50
ψ_2	0.25	0.49	0.25	0.74	Normal	0.15
ψ_3	0.25	0.85	0.63	1.07	Normal	0.15
τ	0.50	0.66	0.38	0.93	Normal	0.25
ρ_r	0.70	0.42	0.30	0.55	Beta	0.10
ρ_g	0.40	0.48	0.37	0.59	Beta	0.20

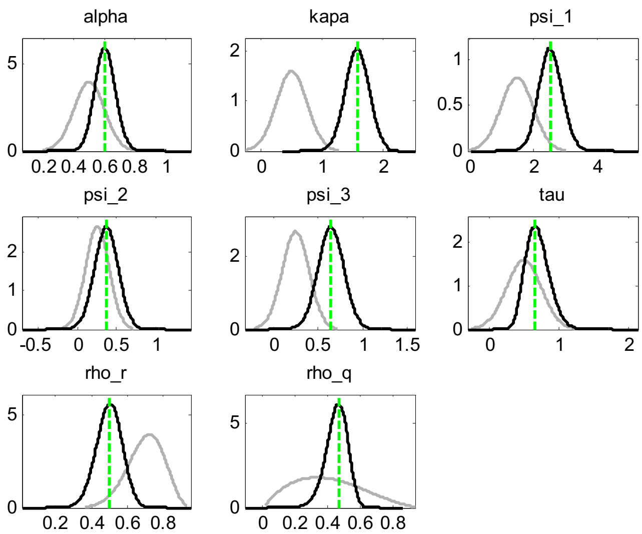
Annex C

Posterior Distributions

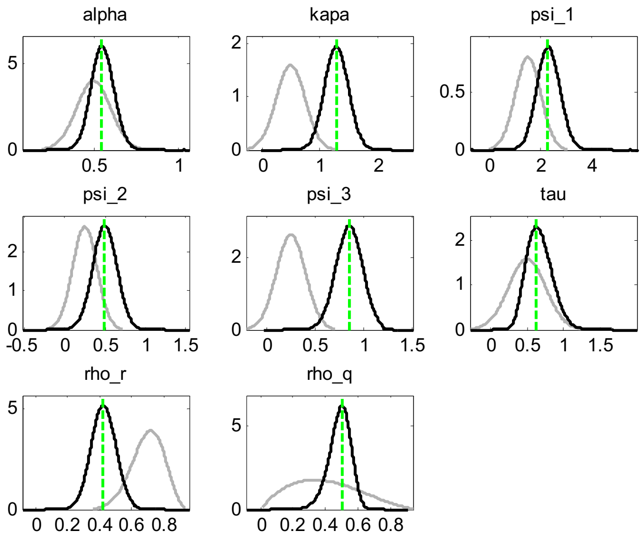
C.1. NK Model with Baseline Taylor Rule



C.2. NK Model with Taylor Rule Featuring the Output Gap



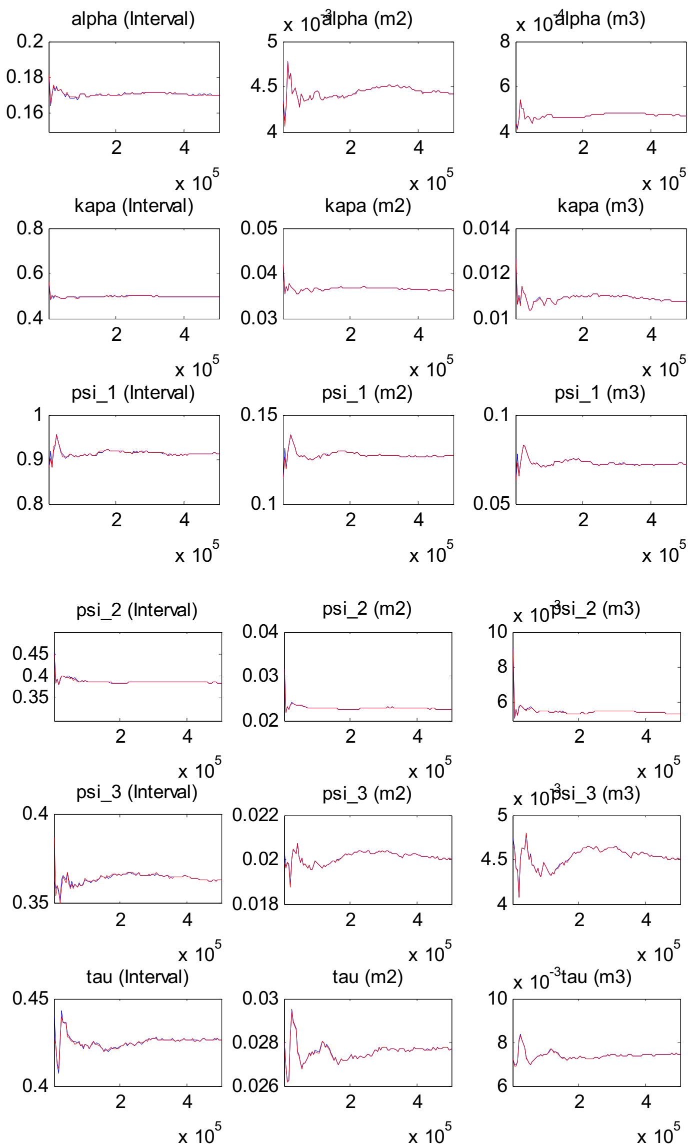
C.3. NK Model with Taylor Rule Featuring the Output Gap and Expected Inflation

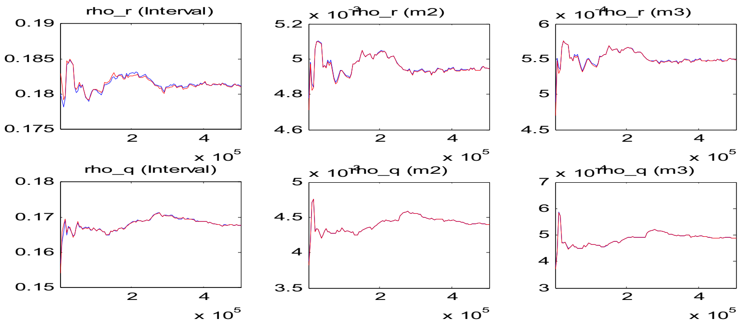


Annex D

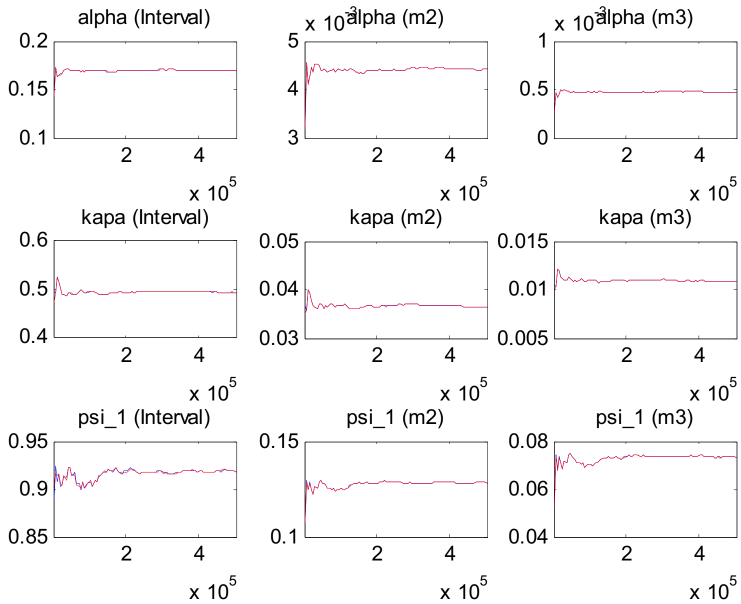
Univariate Convergence Statistics

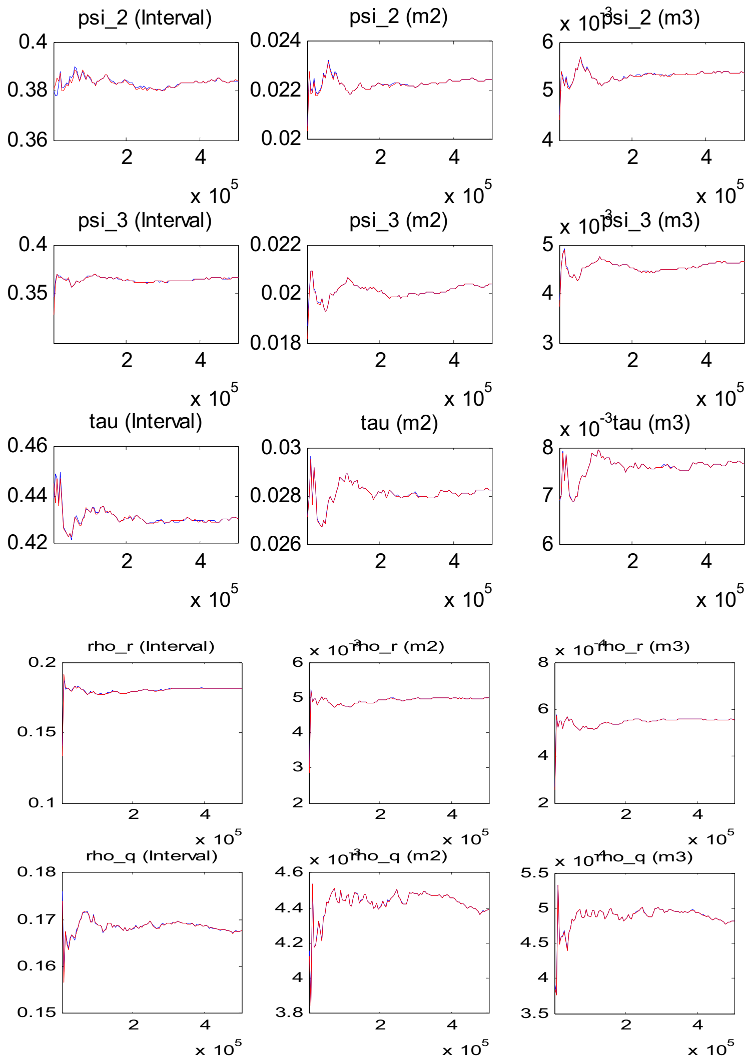
D.1. NK Model with Baseline Taylor Rule



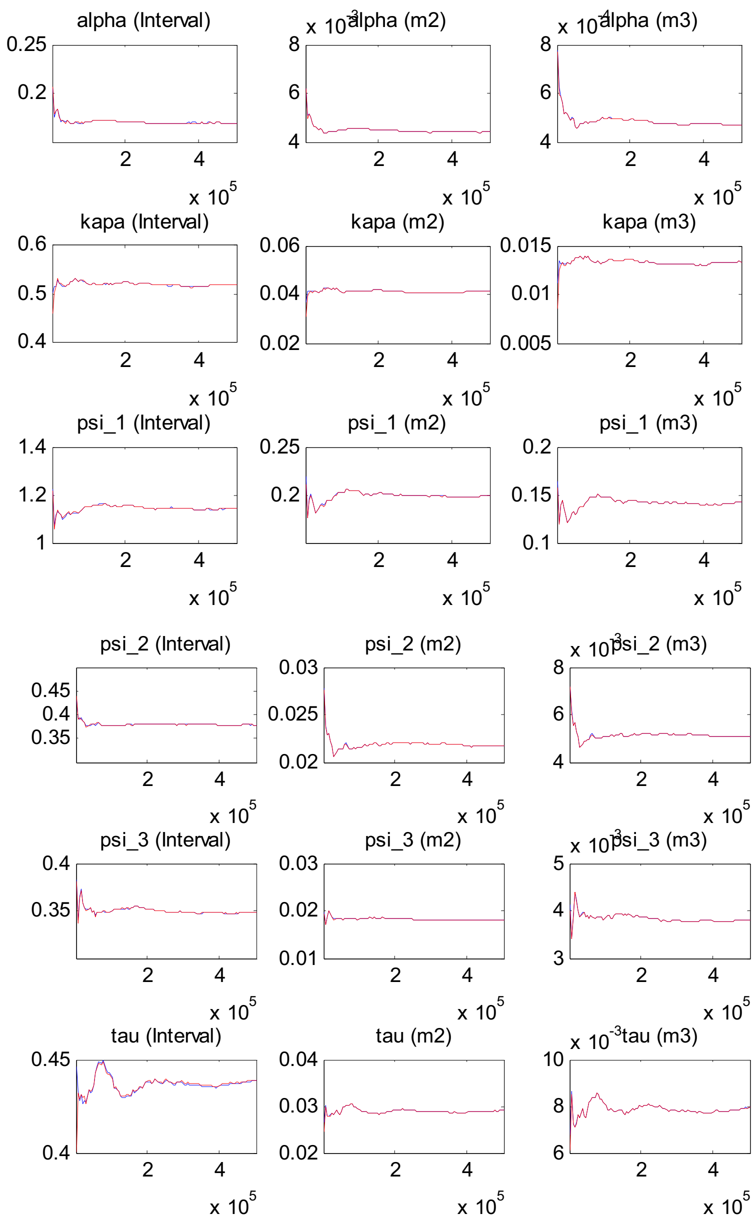


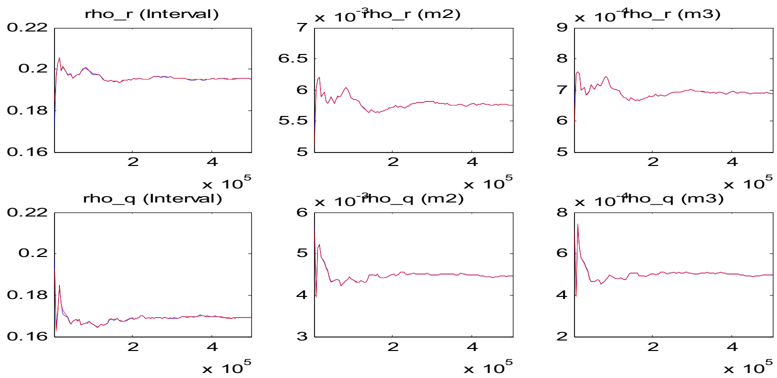
D.1. NK Model with Taylor Rule Featuring the Output Gap




psi_2 (Interval)
psi_2 (m2)
psi_2 (m3)
psi_3 (Interval)
psi_3 (m2)
psi_3 (m3)
tau (Interval)
tau (m2)
tau (m3)
rho_r (Interval)
rho_r (m2)
rho_r (m3)
rho_q (Interval)
rho_q (m2)
rho_q (m3)
x 10^5

D.3. NK Model with Taylor Rule Featuring the Output Gap and Expected Inflation

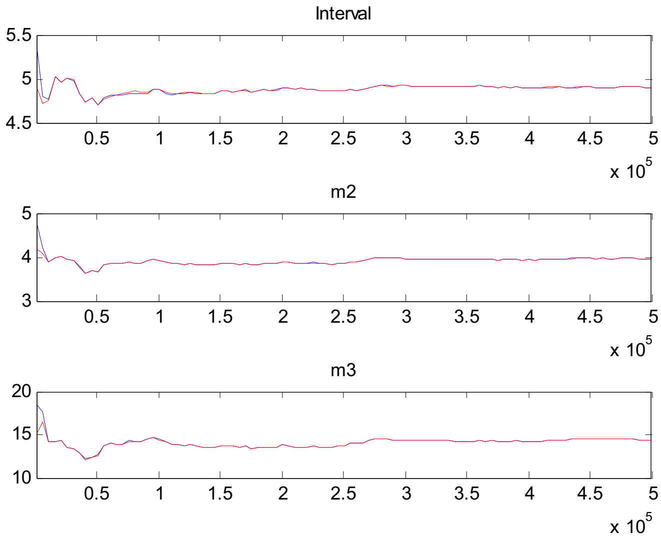



rho_r (Interval)
rho_r (m2)
rho_r (m3)
rho_q (Interval)
rho_q (m2)
rho_q (m3)
x 10^5

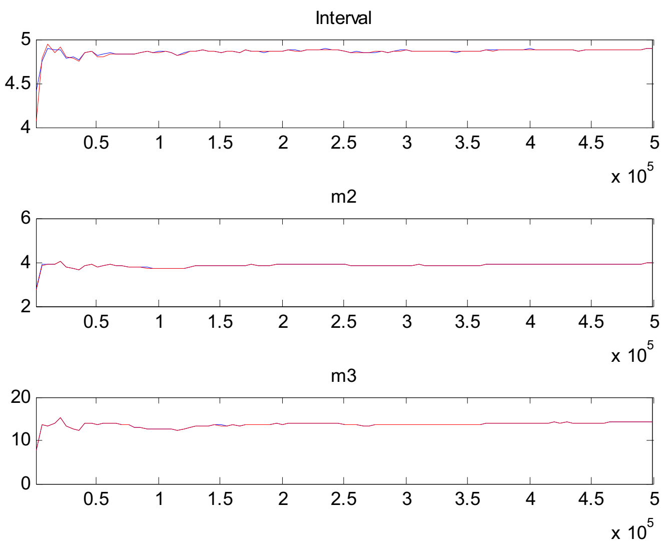
Annex E

Multivariate Convergence Statistics

E.1. NK Model with Baseline Taylor Rule



E.2. NK Model with Baseline Taylor Rule and Output Gap



E.3. NK Model with Taylor Rule Featuring the Output Gap and Expected Inflation