7 AN ANALYSIS OF THE FLUCTUATIONS IN THE ROMANIAN ECONOMY USING THE REAL BUSINESS CYCLES APPROACH

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Abstract

In this paper I calibrate and simulate the standard Real Business Cycles model for the Romanian economy. In this respect, I use a set of estimated data for capital stock and GDP at quarterly frequency for the period 1991-2002. The results show that the standard RBC can be a starting point for simulating the macroeconomic dynamics in the Romanian economy. Standard deviations in the simulated model are close to those in the real economy, except for consumption. Correlations for most of the simulated variables are in a close range to those of the real variables, except again for consumption. There are also some results specific to the Romanian economy, as capital is moderately procyclical and consumption is more volatile than output.

Keywords: real business cycles, total factor productivity, transition economies.

JEL Classification: E32, E37.

1. Introduction

One of the stylized facts of the economic transition in Eastern Europe is that of the initial fall of output. All the countries that started the reform process had first to pass through a deep recession. Although some macroeconomic adjustments may have seemed naturally, the actual dimensions of the initial recessions proved to be very severe in the end.

While the first stylized fact was a common and somehow expected feature for all transition economies, a particular phenomenon proved to be the fact that some of the Eastern European transition economies experienced an actual W shape dynamics of the GDP, Romania being among these countries. Most of the international experts predicted a J shape macroeconomic dynamics, which was actually the case of most of the transition economies. The expectations about a J shape came from the argument

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that once the economies start the reform process and the market mechanisms are put in place, the GDP will have a positive dynamics.

In a previous study, Caraiani (2004) documented the fluctuations in the Romanian economy using the now standard approach of Kydland and Prescott (1990). The paper showed that with respect to volatility, co-movement, duration and persistence one may conclude that business cycles in Romanian economy between 1991 and 2004 did exist. Using monthly data (with the industrial production index as a proxy for output) I also analyzed the stylized facts of the business cycles. The results seem to support the real business cycles (RBC hereafter) hypothesis in several aspects: the real wages are pro-cyclical, employment is pro-cyclical and the level of prices is counter-cyclical. At the same time, the real balances (M2 deflated by CPI) are pro-cyclical, but this does not necessarily imply a counter-argument against the RBC hypothesis (see King and Plosser (1984) for a detailed discussion).

In this article I analyse the fluctuations in the Romanian economy using the modern business cycles framework. In this sense, I use one of the standard tools in modern macroeconomics, namely the Real Business Cycles approach. Most of the business cycle literature was developed for the advanced economies. However, there is a recent trend of expanding the area of business cycle research to the emerging economies case (see, for example, Agenor *et al*. (2000)). This paper continues this tendency of expanding the area of applied business cycles research, focusing on the case of Romania.

The second section makes a very concise presentation of the RBC model used in this paper. In the third section I detail the data set used and I motivate the values of the parameters set in the calibration process. Some of the specific problems of calibration for the Romanian economy are also discussed. I simulate the model and present the results in the fourth section. I analyse the results of the simulated model both with respect to the real data from the Romanian economy and also relatively to the results for United States from reference studies, namely Kydland and Prescott (1982) and Hansen (1985). In the last section I resume the main findings and sketch some possible future developments for the application of the RBC to the Romanian economy.

2. Methodology

I use the standard stochastic neoclassical model, which is one of the most studied models in the empiric work and also the starting point even for the most complex stochastic DGE (dynamic general equilibrium) models. In this paper I make use of Uhlig's (1995) notation.

The model consists of a finite number of infinitely lived representative agents who maximize their lifetime utility. In each period the agent chooses optimally consumption and capital stock, given his budget constraint.

The lifetime utility of the representative agent is given by the following expression:

$$\max E_0\left[\sum_{t=0}^{\infty}\beta^t \frac{C_t^{1-\eta}-1}{1-\eta}\right] \quad (1)$$

where: β is the discount factor, C_t is the consumption and η is the coefficient of relative risk aversion.

In each period the agent has the following budget constraint:

$$C_t + K_t = Y_t + (1-\delta)K_{t-1} \tag{2}$$

where: Y_t is the production in t, K_t is the capital stock in t and δ is the depreciation rate.

I assume a Cobb-Douglas production function, with the following specification:

$$Y_t = Z_t K_{t-1}^{\alpha} N_t^{1-\alpha} \tag{3}$$

where: N_t is the labor input in period t, Z_t is the total factor productivity and α is the capital share. I use a production function with constant returns to scale.

One commonly used specification for the dynamics of the TFP is that it evolves according to:

$$\log Z_t = (1-\rho)\log \overline{Z_t} + \rho \log Z_{t-1} + \varepsilon_t \tag{4}$$

The parameter ρ is the persistence of the technological progress. The error term in the above equation is a white noise process. It represents the innovations in the technological progress.

The assumption that the technological progress evolves as in equation (4) implies that I model the technological progress as growing at a steady state rate in each period, with the technological innovations following a stochastic process. This specification is in line with the fact that the advanced economies have a long-run tendency of growth. As most of the work in the field, I model the technological shocks as following an AR (1) model.

There are several approaches for finding the solution to this problem. I follow here Uhlig's (1995) approach in using the Lagrangian method to derive the necessary First Order Conditions (FOC).

In terms of the social planner's problem, it can be formulated using the following Lagrangian:

$$L = \max E\left[\sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\eta} - 1}{1-\eta} - \lambda_t (C_t + K_t - Z_t K_{t-1}^{\alpha} - (1-\delta)K_{t-1}) \right)\right] \tag{5}$$

Then one may simply derive the FOCs by computing the first order derivatives of the objective function with respect to the choice variables K_t, C_t and λ_t:

$$\frac{\partial L}{\partial \lambda_t} = 0 \Rightarrow C_t + K_t - Z_t K_{t-1}^{\alpha} - (1-\delta)K_{t-1} = 0$$

$$\frac{\partial L}{\partial C_t} = 0 \Rightarrow C_t^{-\eta} - \lambda_t = 0 \tag{6}$$

$$\frac{\partial L}{\partial K_t} = 0 \Rightarrow -\lambda_t + \beta E_t\left[\lambda_{t+1}\left(\alpha Z_{t+1} K_t^{\alpha-1} + (1-\delta)\right)\right] = 0$$

From these FOCs, together with the transversality condition, we can determine the steady state. In order to derive the steady state solution, we should rewrite the necessary first order conditions as:

$$C_t = Z_t K_{t-1}^{\alpha} + (1-\delta)K_{t-1} - K_t = 0 \tag{7}$$

$$R_t = \alpha Z_t K_{t-1}^{\alpha-1} + (1-\delta) \tag{8}$$

$$1 = E_t\left[\beta\left(\frac{C_t}{C_{t+1}}\right)^{\eta} R_{t+1}\right] \tag{9}$$

$$\log Z_t = (1-\rho)\log \overline{Z_t} + \rho \log Z_{t-1} + \varepsilon_t \tag{10}$$

where R_t is the gross rate of return.

We can now derive the steady state solution by fixing the variables with respect to time. The following equations describe the steady state of the system:

$$\overline{R} = \frac{1}{\beta} \tag{11}$$

$$\overline{K} = \left(\frac{\alpha \overline{Z}}{\overline{R} - 1 + \delta}\right)^{\frac{1}{1-\alpha}} \tag{12}$$

$$\overline{C} = \overline{Y} - \delta \overline{K} \tag{13}$$

$$\overline{Y} = \overline{Z}\,\overline{K}^{\alpha} \tag{14}$$

Once we got the steady state solution we can proceed to the log-linearization of the system in order to get a system of linear equations. By the log-linearization, the equations are transformed by means of a first order Taylor expansion into linear ones. This method is described in detail in Uhlig (1995) and Campbell (1994). After log-linearizing the system we can use the method of undetermined coefficients to write the variables as functions of the predetermined variables, namely the capital stock and the technology shock, and solve this system. I use the approach described in Uhlig (1995).

3. Data and Calibration

This section describes the data set used in the empiric analysis and the procedure by which the calibration was made. I use a set of estimated quarterly data for the period 1991-2002. Although there is no official quarterly data on the GDP and its components or capital stock, there is one very reliable data set which was made available by Prof. Emilian Dobrescu (Romanian Academy).

The variables in the model are: C_t, I_t, Y_t, K_t and N_t, denoting private consumption, private investments, gross domestic product, capital stock and the population over 15 years. In order to eliminate the influence of population growth I use per capita variables denoted by: c_t, i_t, y_t and k_t, which stand for consumption, investment, output and capital stock, all the variables being in per capita terms and obtained by dividing the aggregate variables by N_t. All the variables are deseasonalized (using Census X12) and expressed in logs.

As it may have appeared clearly from the last section, the model is constructed for a closed economy where the government and the external sector are absent. To account for these features, I exclude both government consumption and investments, and the external flows. Thus I compute a private business output, composed of private consumption and business investments.

Private investments are composed of aggregate investments by firms to which I add aggregate investments by households. Private consumption is the aggregate consumption of household, excluding government consumption. Then the GDP is simply the sum of these two components.

Since there is no official estimate of the capital stock in the Romanian economy, either at annual frequency or quarterly frequency, I had to estimate a capital stock. The computation was based on a methodology proposed by Dobrescu (2006). He argued for the use of the official estimates of tangible fixed assets in the economy, which are available at an annual frequency, from the balance of tangible fixed assets in the Statistical Yearbook. This set allows us to extract two essential pieces of information. The first one regards the reference (or initial) capital stock while the second essential information regards the depreciation rate of the capital stock.

The reference capital stock, as proposed by Dobrescu (2006), should be the level of the tangible asset in the reference year in the prices of the respective year, which can be taken from the Statistical Yearbook. From the initial level of the capital stock, I compute an annual series of capital stock in 1995 constant prices using the standard sequential capital stock equation.

The computations imply the use of an average depreciation rate. This is also derived from the balance of tangible assets using the formula proposed by Dobrescu (2006):

$$\delta = \frac{K_{out}}{K_{in} + K_{entr}} \qquad (15)$$

where: K_{out} is the level of fixed tangible assets that went out of use during an year, K_{in} is the initial level of fixed tangible assets and K_{entr} stands for the new entries of fixed tangible assets. Using the data given in the balance of tangible assets I computed an annual depreciation rate.

In order to derive the quarterly series, I start from the level of capital stock for the year 1990 in 1995 constant prices and use the sequential capital stock equation with a quarterly average depreciation derived from the annual average depreciation and each period investments equal to the investments in the economy in that quarter.

The second issue with which this section deals is the calibration process. The parameters to be calibrated in this model are: steady state technology coefficient, capital share α, depreciation rate for capital stock δ, the real interest rate R, the autocorrelation of the technology shock ρ and the standard deviation of technological shocks $\sigma\varepsilon$.

With regard to steady state technology, following the usual approach, I set the steady state technology coefficient to 1. This is just a conventional normalization.

The capital share is a bit difficult to estimate. One approach would be to use the data regarding the compensation for employees in the national accounts, from which the labor share, and afterwards the capital share could be computed. However, the estimates in the national accounts would result in a labor share of only 0.43. This is in contradiction with another source of data, namely the AMIGO survey on households, which is also more accurate. Since the data from AMIGO on household revenues indicate that the actual labor compensation is about 0.6 (an average for 1991-2002 period), I set the capital share to 0.4. One may seem surprised that the actual level of labor share of Romania is so high, but actually Romania was not and it is not a developing economy, for which a lower labor share is the rule.

The depreciation rate δ was already discussed in the paragraphs were I discussed the estimation of the capital stock. Using the formula presented and explained there, I find a series for annual depreciation rates. I average this series to get the annual average depreciation rate, and then derive the quarterly average depreciation rate. The estimated quarterly depreciation rate is 2.4%.

One of the early misunderstandings about the real business cycles approach was related to the real interest rate. Thus, Summers (1986) was puzzled by the fact that Prescott (1986a) used a quarterly interest rate of 1.01% for the American economy. Summers (1986) argued that the real interest rate computed from the T-bills is actually 1% at an annual level. But, as Prescott (1986b) argued, the real interest rate in the RBC frameworks is derived as the return on tangible assets and it can be computed from National Accounts. If one combines the first order condition for capital with the steady state, then one can compute a real interest rate using the formula:

$$r = \alpha\left(\frac{\bar{y}}{\bar{k}}\right) + 1 - \delta \qquad (16)$$

Using this formula I find a quarterly real interest rate of 1.013% for the Romanian economy, as an average for the studied period. I don't discount it by the growth rate of output, since this is approximately zero for this period.

While the parameters discussed up to now have their importance in the dynamics of the model, it is the calibration of the technology shocks that proves essential in the final results, with respect to the simulated standard deviations, cross-correlations or the impulse response function.

As stated above, the first step in deriving the parameters related to the technology shocks is to estimate the total factor productivity. I follow in this paper the conventional view and estimate the total factor productivity as a residual between the total output in the current period and the capital stock contribution and labor force contribution to the production in the current period.

Once Z_t has been estimated according to (4), I extract a linear time trend from total factor productivity, using the next equation:

$$Z_t = a_0 + a_1 t + z_t$$

Here t is the time trend and z_t stands for the technological shock. I then proceed to derive the estimates of the persistence and volatility of the technological shock by estimating an AR(1) process for z_t :

$$z_{t+1} = \rho z_t + \varepsilon_t$$

I estimate ρ to be 0.68 and the volatility of the shocks σ_ε to be 0.046. The persistence parameter is significantly lower than in the developed economies.

4. An Empiric Analysis

In this section, I analyze how the standard RBC fits the stylized facts of business cycles in the Romanian economy for the period 1991-2002. The question of fitting the real data is of central importance in the business cycle theory. Ever since Kydland and Prescott (1982) remodeled the questions of business cycles theory and showed that the RBC approach can explain the main facts of the economic fluctuations, the testing of a model with respect to the real stylized facts has become a standard procedure in the business cycles modeling.

In order to test the quality of the model presented in this paper I analyze the results of the simulation in three directions. First of all, I analyze the standard deviations of the simulated variables compared to the real data, and also the volatility relative to the output variability. The second aspect regards the analysis of cross-correlations of the simulated and real data. A third problem is the dynamic response of the variables in the model to a one time technology shock.

I report below the standard deviations in the real data, the volatility of variables relative to the output and the cross-correlations with the output. In order to reveal the common features of the data for Romania to the standard literature but also the peculiarities, I also compare the statistics with the results for the United States, using the findings in Kydland and Prescott (1982) and Hansen (1985) as benchmarks.

Table 1

The Stylized Facts for the Romanian economy, quarterly data, 1991-2002

	Std. Deviation	Volatility Relative to Output	Cross-Correlations								
			-4	-3	-2	-1	0	1	2	3	4
Capital	0.82	*0.16*	-0.45	-0.39	-0.24	0.04	**0.19**	0.37	0.35	0.43	0.49
Consumption	5.44	*1.06*	0.22	0.21	0.31	0.48	**0.89**	0.54	0.36	0.30	0.45
Interest Rate	0.18	*0.03*	0.39	0.33	0.38	0.53	**0.98**	0.48	0.31	0.25	0.33
Output	5.12	*1*	0.35	0.29	0.35	0.52	**1.00**	0.52	0.35	0.29	0.35
TFP	6.50	*1.26*	0.43	0.42	0.44	0.55	**0.89**	0.49	0.34	0.30	0.35

Source: *Dobrescu data set and own computations*.

There are some features that are common to Romania and the United States. However, the results also show how Romania diverges in several important aspects relative to the stylized facts for the US. First of all, the output is much more volatile. This comes mostly from the dimensions of the initial fall in output, but also from the second recession, which was a severe one. The obtained volatility of the Romanian economy is line with that of the emerging economies, as one may see from Agenor *et al*. (2000)

The interest rate behavior in terms of volatility is close to that of in the United States, but the correlation is much stronger than in the US. Capital stock has a low volatility relative to output, but what is special for Romania is that there is a significant positive correlation between output and capital stock.

Consumption has a strong correlation with output at lag zero, close to that in the American economy. What is different is not only that consumption is very volatile, but that it is even more volatile than the output. This is against not only the common feature of business cycles in the US (or other developed economies) but also against the basic RBC framework, as one may see in the next table that presents the same statistics as in Table 1, but this time for the simulated RBC.

Table 2

RBC simulation results, quarterly frequency

	Std. Deviation	Volatility Relative to Output	Cross-Correlations								
			-4	-3	-2	-1	0	1	2	3	4
Capital	1.20	*0.22*	-0.46	-0.41	-0.29	-0.05	**0.33**	0.53	0.60	0.59	0.54
Consumption	0.74	*0.13*	-0.39	-0.30	-0.12	0.19	**0.67**	0.65	0.58	0.49	0.40
Interest Rate	0.20	*0.03*	0.04	0.16	0.34	0.61	**0.98**	0.48	0.13	-0.07	-0.19
Output	5.38	*1.00*	-0.06	0.06	0.26	0.57	**1.00**	0.57	0.26	0.06	-0.06
TFP	5.43	*1.01*	-0.02	0.10	0.29	0.59	**1.00**	0.54	0.21	0.01	-0.11

Source: *Own computations.*

The results of the RBC simulation with respect to volatility and cross-correlations are partially valid. Regarding the standard deviations and relative volatility, the model provides very good predictions regarding output and interest rate. Thus, the predicted standard deviation of output is 5.32%, while the real one is 5.1%. The standard deviations of the TFP and capital stock are not as good, but they are still close to the results for the real data.

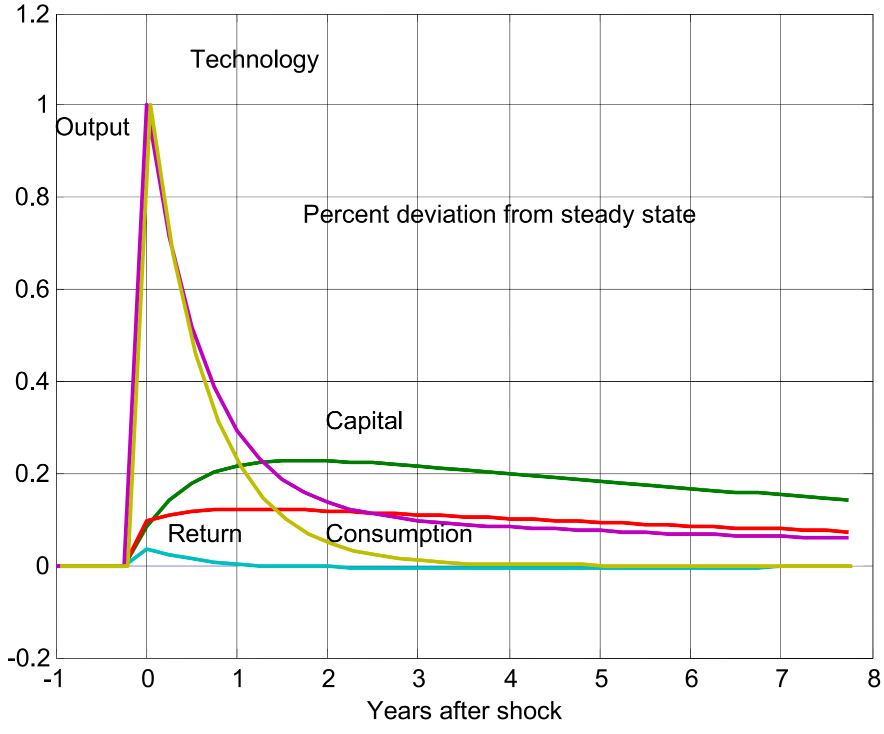
Some discussion deserves the predicted volatility of consumption. The class of real business cycle models predicts a low volatility of consumption. The result in my calibrated model is in line with this feature. But this result fails to come close to the real behavior of data in the Romanian economy. One possible explanation may come from the fact that part of the consumption is actually financed by means of debt and it originates from the imports, so that its behavior is not captured by this simplified model. This feature should be further studied in the light of adding some extensions to the standard RBC that reveal the characteristics of the Romanian economy.

With respect to the correlations, there are no important failures of reproducing the actual behavior of the economy, at least regarding the sign of correlation coefficients. The model estimates correctly that the TFP and the interest rate are almost perfectly correlated with output (within some range to the actual results). The correlation of capital with output is significant and positive (though there is a gap between the predicted and the actual correlation coefficient). The only major deficiency of the prediction regards again the behavior of the consumption. The correlation in the real economy is 0.89, while the predicted correlation is significantly weaker, only 0.67.

The third aspect I study is the behavior of the impulse response functions of the variables to a technology shock. The below figure draws the impulse response functions for a 32 quarters horizon.

Figure 1

Impulse responses to a shock in technology



The shape of the impulse response functions is typical for a RBC model. Output and technology (TFP) have their peak at the moment that the shock is produced. Afterwards, the impact slowly dies out, for the case of the output after three years.

The consumption response reaches a maximum after one year, stays at this level for about two years and it slowly diminishes afterwards. The capital stock rises fast after the shock and reaches the highest level after about one year. The effect fades out very slowly in the long run.

5. Conclusion

In this paper I calibrated and simulated a RBC at quarterly frequency for the Romanian economy. Then I compared the results with the actual behavior of the economy with respect to standard deviation, correlations with output and impulse response functions.

The results show that the RBC framework can be a starting point in modelling fluctuations in the Romanian economy. While some of the stylized facts of the Romanian economy could not be predicted with the standard RBC, most results are in a close range to those in the real economy.

The RBC offers good predictions regarding the standard deviations of output, capital stock, real return and TFP, and also regarding the correlations between output and capital, TFP or real return. However, it also fails to offer good approximations regarding the consumption volatility or the correlation between consumption and output.

Future models of business cycles in the Romanian economy should take into account other factors in order to improve the predictions of the model. On the one hand, the basic RBC can be expanded by introducing indivisible labor, government consumption or the external sector. Another direction to explore is to account for the nominal rigidities specific to the Romanian economy. Such developments should also be accompanied by a corresponding work at the microeconomic level, necessary in order to make the calibration sound.

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