Routes and Trends  
of Romanian Core Economic Variables  

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Abstract

The present paper is centred on the analysis of a basic, classical, closed economy dynamic stochastic general equilibrium model, revealing some core economic variables, captured at the level of our country, both from the perspective of their reaction to the shock on technology and from the one relating to their evolution on medium to long term. After a brief rendering of the problems maximised and solved, given the constraints, by the two economic agents considered, households and firms, as well as subsequent to the presentation of the equilibrium established on the market of goods and services, the final equations are selected and implemented in Dynare, a specific tool of Matlab. The numeric results obtained and the related graphical representations are thereafter construed, the end purpose being the formulation of several suggestions regarding the appropriate economic decisions to be made in the future, by the entitled entities, in order to lay the grounds of a desirable economic growth.

**Keywords:** dynamic stochastic general equilibrium model, real business cycle, closed economy, impulse-response function, forecasting patterns

**JEL codes:** C53, C68, E20, E27

1. Introduction

Used for pure estimation only, for impulse-response function analysis or even for forecasting purposes, the dynamic stochastic general equilibrium models acquired more and more adepts in the entire world.

The studies of Kydland & Prescott (1982), pioneers of the classical side of such models, subsequently improved by Rotemberg & Woodford (1997), as well as those of Smets & Wouters (2003), Christiano et al. (2005) or Adolfson et al. (2005) are just some examples of works dedicated to this last generation modelling approach.

Their echo reverberated also at the level of central banks, Harrison et al. (2005), Erceg et al. (2006) or Christoffel et al. (2007), among many others,
developing models enabling the authorities representing the Bank of United Kingdom, the Federal Reserve Bank or the Central European Bank to take appropriate measures so as to adequately sustain the real economy.

Using microeconomic fundamentals to reach, by aggregation, the macroeconomic space, considering the rationality of economic agents and the well-grounded expectations of the same, capturing the impact of structural shocks at the level of economic variables and accepting the flexibility of prices, wages and interest rate and the rather perfect competition specific to a classical approach or their rigidity in the context of an imperfect market according to the Keynesian thinking, the dynamic stochastic general equilibrium models turned, step by step, into a veritable cornerstone in the matter.

This paper continues a previous study of a classical model, then dedicated to the Bayesian estimation of parameters, with the analysis of the reaction of core variables on the occurrence of the technology shock and with the forecasting of such variables in the medium to long run. If section 2 resumes the model, section 3 gathers information on the data and the methodology used, as well as on the results obtained, and section 4 comes with the work overall conclusions.

2. Model

The model used herein for the analysis of the impulse-response function and for the forecasting of the Romanian economic variables is a simple, classical, real business cycle model designed for a closed economy. This model, previously approached by the undersigned for estimation purposes, is rendered below in brief, so as to capture the preferences of households, maximised under the budget constraint, the benefits pursued by intermediary and final firms, aiming at minimising their production-related costs, and the aggregated equilibrium of the same.

The utility function of households depends positively on consumption and, negatively on the labour time, as in equation [1]:

\[ E_t \sum_{i=0}^{\infty} \beta^i \times [\log c_i + \zeta \times \log(1-l_i)] \]

where \( E_t \) denotes expected value, \( \beta_t \), subjective discount factor, \( c_t \), consumption, \( l_t \), labour time, and \( \zeta \), spare time utility parameter

The budget restriction considers the financial resources, on one hand, and the utilisation of the same by households, taking the following form:

\[ c_t + k_{t+1} = w_t \times l_t + r_t \times k_t + (1-\delta) \times k_t \]

where \( k_t \) denotes capital stock, \( w_t \), real wage, \( r_t \), real interest rate and \( \delta \), depreciation rate

with
\[ i_t = k_t - (1 - \delta) \times k_{t-1} \]  
where it denotes investments

The solution to the maximisation problem provides us with two equations, namely the Euler consumption and the labour supply equations:

\[ \frac{1}{c_t} = \beta \times E \left[ \frac{1}{c_{t+1}}(1 + r_{t+1} - \delta) \right] \]  
\[ \zeta \times \frac{c_t}{1 - l_t} = w_t \]

The intermediary firm \( i \) uses capital and labour, as inputs, in order to produce differentiated products, according to a Cobb-Douglas function:

\[ y_{i,t} = k_{i,t}^\alpha \times \left( e^{z_i} \times l_{i,t} \right)^{1-\alpha} \]

where \( y_{i,t} \) denotes production of firm \( i \), \( \alpha \), capital share in total production and \( z_i \), technology level

with \( z_i \) following a first order autoregressive process:

\[ z_t = \rho \times z_{t-1} + e_t \]  

The resulting capital-labour ratio is as follows:

\[ \frac{k_{i,t}}{l_{i,t}} = \frac{\alpha}{1-\alpha} \times w_t \]

The level of prices established by the above mentioned firms is related to the condition of general mark-up prices, given the monopolistic competition premises:

\[ p_{i,t} = \frac{\varepsilon}{\varepsilon - 1} \times mc_i \times p_t \]  

where \( p_{i,t} \) denotes price set by firm \( i \), \( p_t \), average price and \( mc_i \), real marginal cost

By assuming the adoption, by all intermediate producers, of the average level of prices for their related products, we get:

\[ mc_i = \frac{\varepsilon - 1}{\varepsilon} \]  

Going forward, considering the real marginal cost of firms, arising from their expenses with the input factors:

\[ mc_i = \left( \frac{1}{1-\alpha} \right)^{1-\alpha} \times \left( \frac{1}{\alpha} \right)^a \times w_t^{1-\alpha} \times r_t^\alpha \]

where \( A_t \) denotes total productivity of factors
and the previously referred condition of general mark-up prices, we obtain the real wage and real interest rate equations:

\[ w_t = (1 - \alpha) \frac{y_{lt}}{l_{lt}} \times \frac{e-1}{e} \]  \[ r_t = \alpha \frac{y_{lt}}{k_{lt}} \times \frac{e-1}{e} \]  \[ 12 \]  \[ 13 \]

The production function of the final firms, taking also a Cobb-Douglas type form, is determined by the aggregation of the output of all intermediate firms:

\[ y_t = A_t \times k_t^a \times l_t^{1-a} \]  \[ 14 \]

At equilibrium, on the market of goods and services, we have:

\[ y_t = c_t + i_t \]  \[ 15 \]

3. Data, Methodology and Results

The variables used in the analysed model are explicitly divided, within the Dynare code implemented in Matlab, into nine endogenous variables: production (y), labour time (l), production-labour time ratio, consumption (c), capital (k), investments (i), real wage (w), real interest rate (r) and technology level (z) and one exogenous variable: the shock on technology (\( \varepsilon \)). Among such variables, only one is observable, namely the gross domestic product, analysed quarterly, for a 15-year period, from 2000Q1 to 2014Q2, giving 58 entries, reduced to 57 after the first order differentiation of the said variable in logarithm. The above variable-related data are taken over from the Romanian National Institute of Statistics, being expressed as Million RON average prices of year 2000.

The prior distribution of the model parameters: capital share in production (\( \alpha \)), subjective discount factor (\( \beta \)), capital depreciation (\( \delta \)), technology level autoregressive parameter (\( \rho \)) and spare time utility parameter (\( \zeta \)), as well as the standard deviation of the technology shock (\( \sigma_\varepsilon \)) was set previously to the model transposing into Dynare.

Only 8 such equations are finally selected, more precisely the investment equation [3], the consumption Euler equation [4], the labour supply equation [5], the intermediary firm production function [6], the AR(1) process of the technology level [7], the real wage equation [12], the real interest rate equation [13] and the market equilibrium condition [15].

Below are rendered the results arising from the implementation of these equations.

We start by presenting two figures standing for the validity of our model and the significance of its related output. The structural shock on technology is centred on the zero value, having a relatively constant variance (Figure 2), while the Monte Carlo Markov Chains multivariate diagnostics, measuring the parameter
vectors within chains and between chains (Figure 2), reveals that both lines are rather constant and convergent to each other for the mean confidence interval, variance and skewness.

**Figure 1. Smoothed technology shock**

![Figure 1](image1)

**Figure 2. MCMC multivariate diagnostics**

![Figure 2](image2)

*Figure 3 shows the reaction of the model variables under the impact of a technology shock. If consumption, capital and real wage register a constantly increasing trend, reaching the peak value after about 40 to 55 periods, followed by*
a smoothed return towards the steady state level, being however far from reaching it for the remaining period subject to analysis, investments, labour time and real interest rate react suddenly and strongly when hit by the same shock, thereafter continuously decreasing for the entire 80-period interval and meeting, by the end of the same, their initial equilibrium. Getting into more detail, we could state that a positive technology shock determines immediate and significant investments in the related new technology, which, once acquired, leads to the flattening of interest for it. This pattern is also followed by the labour time. Assimilating the know-how necessary to benefit from such technology involves additional working hours, these one diminishing step by step when the related knowledge is obtained.

On the other side, the level of capital held by firms slowly augments, an obvious tendency given the above-mentioned investments. Increasing capital and decreasing labour force, denoted by labour time, allow the movement of real wags upward, as firms have to pay fewer but more qualified people, in other words more efficient employees. Higher wages generate higher consumption which, as component of gross domestic product, determines the overall increase of the latter.

A superior aggregate demand leads to upper prices, therefore an ascendant inflation rate and, as a consequence, an augmented nominal interest rate. Yet, not only the nominal value of interest rate increases, as, under the impact of suddenly increased investments, its real value quickly goes upward too, relaxing thereafter in line with the same.

As for the technology level, an obvious ascendance is initially remarked, it flattening in time when new technology is expected to replace the old one.

**Figure 3. Impulse-response function to technology shock**

![Figure 3. Impulse-response function to technology shock](image-url)
The forecasted trend of model variables (Figure 4) is encouraging, revealing a significant increase of consumption, doubled by a less intense, still obvious ascendance of investments, which, altogether, contribute to a sustainable growth of gross domestic product. The overall capital increases too, in compliance with the related investments, while the labour time remains practically unchanged, somewhere above the steady state level. The higher demand for products forces the existing firms to produce more. Given the previously mentioned unchanged working time, we assume a superior efficiency of workers, therefore justifying the upward level of wages.

Wages reach a sufficient level for covering the consumption and investments related needs of households and firms, the crediting not being an option. On the other side, such orientation of financial resources leads to a limitation of the volumes of deposits. Given the above mentioned, the real interest rate gently goes down. As we have both an increase of wages and of the aggregated demand for products, the inflation rate augments. Considering this, the overall tendency of the nominal interest rate does not significantly change for the forecasted period, being almost flattened.

As for the technology level, this is the only variable clearly starting from a point lower that its steady state. Even if the route of such variable is ascendant, the related increase is irrelevant, the economy not being able at least to recover its technological equilibrium within the forecasted period.

If we take a look at the graphical representation above, as a whole, we remark the areas where the entitled authorities should intervene in order to strengthen the economic development, namely the encouragement of sustainable
investments, the increase of labour hours, transposed into a reduction of unemployment rate, and a sharp support of new technology acquisition. The policies to be adopted in this regard should be mainly oriented towards the injection of money in the real economy, therefore inducing a lowering of the interest rate and a stimulation of investments on medium to long term, this including the appropriation of new technology, with all its subsequent, extended benefits. As for the unemployment rate, adequate measures, such as tax exemption for firms, under certain circumstances, should be taken so as to determine the same to employ new personnel, therefore lowering the average level of ineffective households.

4. Conclusions

This study is focussed on the analysis of the impulse-response function and on the forecasting of the economic evolution of our country, perceived from the perspective of a basic dynamic stochastic general equilibrium model. The main purpose of the paper is related to the identification of the route and trends of the economic core variables, considering the exogenous forces affecting the same.

For the 80 periods of analysis, subsequent to the occurrence of a technology shock, only two variables, namely labour time and real interest rate, regain their steady state position, the level of investments gets close to it, while the rest of them remains more or less away from equilibrium. On the other hand, all model analysed variables are positively affected by a favourable influence on the technology level, however, some of them, like consumption, capital and real wage, having a soft, constantly increasing evolution immediately after such impact, as opposed to investments, labour hours, gross domestic product and real interest rate which are suddenly affected by the shock.

Concerning the forecasted pattern of the model variables, our predictions reveal a desirable perspective, the Romanian economy going, to a large extend, into the right direction, as, mainly consumption, but also investments and, implicitly, gross domestic product increase progressively for the 100 periods of study. Also, an increase is captured as regards the capital and the technology level, still the latter being far from what we wish to target in the matter. The increase of wages is not at all a sombrous perspective, as it creates the grounds for sustainable consumption and investments, but it should be adequately correlated with a reasonable overall number of employees, therefore avoiding high rates on unemployment.

Given the results obtained, several measures could be forwarded to the entitled authorities, these being specifically related to the decrease of interest rate, by more money supply, this leading to a superior degree of consumption and investments or, in other words, to an increased gross domestic product. Such step, doubled by firms-oriented stimulating decisions, like tax exemption for the same, could greatly solve unemployment-related problems. And, above all, technology quick and significant evolution should be supported by all means, as this is the core
mechanism generating, as arising from the impulse-response function analysis, synergic economic growth.

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