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ESTIMATED DSGE MODEL FOR OIL PRODUCING ECONOMY OF KAZAKHSTAN

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Abstract

Fluctuations of oil prices have impact not only on oil-importing countries, but also on oil-producing countries. A dynamic stochastic general equilibrium (DSGE) model for the small open economy of Kazakhstan is estimated using calibration and Bayesian simulation approaches. The model is based on the new Keynesian framework with assumptions on preferences and technology with the Calvo price-setting structure. There are two sectors in the economy, the first sector produces final goods, and the second produces oil. Results show that after a rise of oil price or demand for oil abroad, for both of them there are improvements in final goods production, net exports, interest rate, domestic inflation, terms of trade, consumption, and real exchange rate increase; while output and employment in sector of final goods decrease. However, we can observe opposite changes for oil production, total employment, and real wage. They are positive in case of oil demand shock and negative in case of oil price shock. The study reveals impact of oil shocks for a small open oil-exporting economy.

Keywords: open economy, general equilibrium, stochastic model, monetary policy, macroeconomic shocks

1 Introduction

Economies of developing countries such as Kazakhstan are subject to external and internal shocks. These may be technological shocks, shocks of world prices for resources and demand on them, business activity abroad shocks, and others. External shocks can significantly affect macroeconomic indicators, both of importing countries of hydrocarbons and exporting countries.

In recent decades dynamic stochastic general equilibrium (DSGE) models received considerable development. Originally such a model for real business cycles was presented in the article of F. Kydland and E. Prescott (1982). It is based on analysis of microeconomic agents that optimize their behavior under flexible prices. Price flexibility leaves room only for real values to cause fluctuations in economy. These could be technological shocks or abrupt changes in government spending.

Then a new paradigm for modeling of dynamic stochastic general equilibrium appeared. Elements of nominal rigidities in prices and wages were incorporated in models. Calvo G. (1983) proposed a mechanism for pricing by firms as some stochastic process of making decisions about maintaining price at the same level or its changing. These models were called the new Keynesian DSGE models. They are based on microeconomic analysis of decision-making by households, optimizing behavior of monopolistically competitive firms and regulatory functions of the state. Nominal rigidities in prices and wages provide more consistent results of calculations on the model with real data of short-term macroeconomic fluctuations in the economy, as noted, for example, by Smets F. & Wouters R. (2003).

DSGE models unlike econometric models are not subject to critique of Lucas R. (1976). Thus the commonly used method of vector autoregression and the error correction models, although sometimes useful, have significant drawbacks. To estimate such models rather long time series at constant monetary policy are required, which is not always possible, especially for developing countries. Unstructured approach to modeling based on statistical analysis of data does not justify a change in recommendations for macroeconomic policy. Inflation expectations are not taken into account, which play a crucial role in the behavior of agents. Hardly possible to build a reliable inflation equation, which contains current values of variables and their lags, but do not account inflation expectations of agents.

During the last decade, a whole series of new Keynesian dynamic stochastic general equilibrium models was created. Among the most famous works designed for policy analysis and forecasting several models of central banks could be highlighted: Smets F. & Wouters R. (2003), Dib A. (2001), Cuche-Curtia N., ets. (2009), Medina J. & Soto C. (2007), Tovar C. (2008), and a model of the International Monetary Fund by Kumhof M., ets. (2010). DSGE model has microeconomic rationale with nominal and real rigidities. In such a model households consume, determine the volume of investments and deliver labor on monopolistically competitive labor market. DSGE models have been developed and evaluated in a number of other works of Galí J. & Monacelli T. (2005), Beidas-Strom S., Poghosyan T. (2011), Andrle M. (2010), Guerron-Quintana P. (2010), Curdia V., Woodford M. (2010), Del Negro M. & Schorfheide F. (2008), and Mkrtchyan A., ets. (2009).

The purpose of this study was to construct a dynamic stochastic general equilibrium model with respect to the economy of Kazakhstan, interconnected with the rest of the world. According to it microeconomic justification of DSGE model was performed, model parameters were estimated, and model calculations were carried out to analyze the impact of various shocks on the main macroeconomic indicators of the country.

2 Model

The country's economy consists of a representative household, firms producing final goods, a firm producing oil and an authority that sets monetary policy in the country. The household uses a variety of final goods, offers its labor on market. Labor resources are fully mobile between sector producing final goods and oil sector. Firms produce diversified products under monopolistic competition and nominal price rigidity. The representative household owns firms and receives profit from them. All firms use oil in their production and purchase it at a price prevailing on the world oil market. Oil sector determines the volume of oil production so as to maximize its profits. Part of the volume of produced oil is directed to meet domestic demand of firms producing final goods, and the rest is exported.

2.1 Households

The representative household seeks to maximize the discounted utility obtained from consumption and required expenditures for this labor costs:

$$max\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t - \gamma C_{t-1})^{1-\sigma} - 1}{1-\sigma} - \vartheta_t \frac{L_t^{1+\varphi}}{1+\varphi} \right] \quad (1)$$

under constraints

$$P_t C_t + \mathbb{E}_t\left[Q_{t,t+1} D_{t+1}\right] \leq D_t + W_t L_t + \Pi_t + \Pi_{ot}, \; t = 0, 1, \ldots \quad (2)$$

Here C_t - consumption , L_t – labor supply , β – intertemporal discount factor , σ – inverse elasticity of intertemporal substitution of consumption , φ – inverse elasticity of labor supply on wages , γC_{t-1} – habit formation in consumption, γ – non-negative coefficient , ϑ_t – preference shock variable that affects labor supply , P_t – consumer price index (CPI), $Q_{t,t+1} D_{t+1}$ – discounted value of dividends on securities in the end of period t, W_t – rate of nominal wage , Π_t, Π_{ot} – profits from the production of final goods and oil , $\mathbb{E}_t$ – operator of rational expectations at affordable information in period t.

It is assumed that the behavior of a variable labor supply shock is described by first-order autoregression process:

$$ln\, \vartheta_t = \rho_\vartheta ln\vartheta_{t-1} + \varepsilon_{\vartheta t},$$

and a random variable $\varepsilon_{\vartheta t}$ is a white noise. Hereinafter $\mathbb{E}_t$ is an operator of rational expectations on all available information at time *t*. Since the economy is open, the population can consume both domestic and imported goods. Following Galí J. & Monacelli T. (2005), we define the composite index of consumption

$$C_t = \left[(1-\alpha)^{\frac{1}{\kappa}} C_{Ht}^{\frac{\kappa-1}{\kappa}} + \alpha^{\frac{1}{\kappa}} C_{Ft}^{\frac{\kappa-1}{\kappa}} \right]^{\frac{\kappa}{\kappa-1}},$$

where C_{Ht}, C_{Ft} - indices of consumption of domestic and imported goods, respectively. The parameter κ reflects substitutability between domestic and imported goods in accordance with the preferences of domestic consumer, and the parameter $\alpha \in [0, 1]$ indicates the degree of openness of the economy. The closer α is to 0, the less open is the economy.

For the problem (1)-(2) the first order conditions define the optimal allocation of consumption and labor. In the model they are recorded in the log-linearized form:

$$c_t = \frac{1-\gamma}{\sigma(1+\gamma)}(\rho - i_t + E_t\pi_{t+1}) + \frac{1}{1+\gamma}E_t c_{t+1} + \frac{\gamma}{1+\gamma}c_{t-1}\,, \quad (3)$$

$$w_t - p_t = \sigma[\ln(1-\gamma) + \frac{1}{1+\gamma}(c_t - \gamma c_{t-1}) + \varphi l_t + \xi_t, \quad (4)$$

where $\rho = -ln\beta,\ i_t = -lnQ_{t,t+1}$. Variables are labeled by capital letters, while logarithms of these variables are labeled by small letters hereinafter, except for the rate of inflation, for which

$$\pi_{t+1} = P_{t+1}/P_t - 1 \approx \ln(P_{t+1}/P_t) = p_{t+1} - p_t.$$

Equation (3), which is called the Euler equation, contains expectations of future values of the variables of inflation and consumption. Presence of expectations in equations generates a major challenge in finding solutions.

2.2 Firms' behavior

This section describes behavior of firms. There is a continuum of monopolistically competitive firms producing final goods and indexed by $i \in [0,1]$ in the country H. Each firm uses a technology described by the production function

$$Y_{it} = A_t min\left\{N_{it},\ \frac{1}{\zeta}O_{it}\right\},$$

where Y_{it} – output of final goods of firm i , O_{it} – volume of oil used for production, A_t – coefficient reflecting the effect of technological progress, i.e. total factor productivity , N_{it} – number of employees in a firm, ζ - factor that determines fixed proportions of production factors. Value A_t varies according to the autoregression process AR(1) $ln\ A_t = \rho_a ln A_{t-1} + \varepsilon_{at},$ and ε_{at} is a "white noise". Since a firm does not make excessive expenditures, the following equalities should take place

$$Y_{it} = A_t N_{it},\ O_{it} = \zeta N_{it}.$$

A firm in each period with probability *1-* θ changes the price of its product and with probability θ keeps it unchanged. Let's label the optimal price level of firm that sets its price in period *t* through $\bar{P}_t$. The probability of price to be unchanged during k periods is equal to θ^k. Present value of the firm's profit should be taken into account with the stochastic discounting factor. Consequently, a representative firm determines the optimal price for solving the following optimization problem:

$$\max_{\bar{P}_t}\left\{\sum_{k=0}^{\infty}\theta^k \mathbb{E}_t\left[Q_{t,t+k}\left(\bar{P}_t Y_{it+k|t} - TC^n_{it+k|t}(Y_{it+k|t})\right)\right]\right\}$$

under the market clearing condition

$$Y_{it+k|t} = \left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon} C_{t+k}.$$

Here $Y_{it+k|t}$ - output of a firm in period $t+k$, which changed its price last time in the period t, $TC^n_{it+k|t}(Y_{it+k|t})$ - total nominal costs of a firm in period $t+k$.

With receiving the first order conditions for the problem of the firm by decomposing into a Taylor series and transition to the logarithms of variables we obtain a formula for the optimal price for the firm (Galí & Monacelli, 2005):

$$\bar{p}_t = m + (1-\theta\beta)\sum_{k=0}^{\infty}\beta^k\theta^k\left[mc^r_{t+k|t} + p_{t+k}\right], \quad (5)$$

where $m = -mc^r$. Here $mc^r_{t+k|t}$ is the logarithm of the marginal cost $MC^n_{it+k|t}$ of firms in period $t+k$, which changed its price last time in the period t.

Let's separately consider the *oil sector* in the country H. The firm producing oil maximizes profit at the given wage rate W_t and the world price of oil P_{ot}:

$$\max_{N_{ot}}[P_{ot}O_{st} - W_tN_{ot}] \quad (6)$$

under constraint

$$O_{st} = A_{ot}N^{\mu}_{ot}, \qquad 0 < \mu < 1. \quad (7)$$

Here A_{ot} – coefficient reflecting the impact of technological development in the oil sector, dynamics of which is described by an autoregression process AR (1) of the following form:

$$ln\,A_{ot} = \rho_{\text{ao}} ln\text{A}_{ot-1} + \varepsilon_{\text{aot}},$$

where ε_{aot} is a " white noise". Value N_{ot} is the number of employed in oil production, and O_{st} – the volume of oil supply both for domestic consumption and export.

Out of optimality conditions of the first order the following formulas are obtained in logarithmic form:

$$n_{ot} = \ln N_{ot} = \frac{1}{1-\mu}(\ln\mu + p_{ot} + a_{ot} - w_t),$$

$$o_{st} = \ln O_{st} = \frac{\mu}{1-\mu}\left(\ln\mu + p_{ot} + \frac{1}{\mu}a_{ot} - w_t\right).$$

It can be seen that volume of oil production as number of employees in its production depend positively on world oil price and negatively on wage in the economy.

2.3 Inflation, terms of trade and international risk sharing

Let P_{Ht} and P_{Ft} be price indices of domestic and imported goods, respectively. Log-linearization of consumer price index relative to the steady state for which $P_H = P_F = P$ allows to interconnect terms of trade with inflation. Using decomposition into a Taylor series of the first order with respect to the steady state. Let's proceed to logarithms of the variables, and find the logarithm of the consumer price index:

$p_t = (1-\alpha)p_{Ht} + \alpha p_{Ft}$.

Terms of trade, by definition, are the ratio of price index of a partner country to index of domestic prices of the country H. Since trading condition in the logarithmic form is $s_t = p_{Ft} - p_{Ht}$, then the logarithm of the consumer price index is $p_t = p_{Ht} + \alpha(p_{Ft} - p_{Ht})$ or

$$p_t = p_{Ht} + \alpha s_t \; . \qquad (8)$$

This formula links consumer price index with price index of domestic goods [11]. The relation between rates of CPI inflation with inflation on domestic good prices in the country H is easily derived from it

$$\pi_t = \pi_{Ht} + \alpha \Delta s_t. \qquad (9)$$

For the nominal effective exchange rate e_t and the index of world prices p_t^* in logarithmic form the following equality can be obtained

$$p_{Ft} = e_t + p_t^* \qquad (10)$$

and the formula for the real effective exchange rate is

$$q_t = (1-\alpha)s_t \; . \qquad (11)$$

Obviously, the parameter α, which ranges from 0 to one, can not be equal to one, since this would mean that only imported products are consumed in the country H.

The assumption of perfect markets securities of the first-order condition allows to obtain the equation:

$$c_t - \gamma c_{t-1} = c_t^* - \gamma c_{t-1}^* + \frac{1-\gamma}{\sigma} s_t. \qquad (12)$$

Households can invest by acquiring both domestic securities $B_t$and foreign securities B_t^*. The first order conditions on B_t and B_t^* give an equation which relates the interest rate in the country with the world interest rate:

$$i_t = i_t^* + \mathbb{E}_t \Delta e_{t+1}. \qquad (13)$$

2.4 Equilibrium

For the country producing oil real income Y_{ct} of consists of income Y_t, received from the production of goods by firms and income Y_{ot} received from oil sales abroad. The country cannot use all oil revenues for current consumption. Through δ let's denote the share of oil revenues, which are sent to current consumption of the country H. The rest of the oil revenues are accumulated in a special fund for future use. In Kazakhstan such a fund is the National Fund of Kazakhstan. Then income for current consumption is

$$Y_{ct} = Y_t + \delta Y_{ot} = \left(\int_0^1 Y_{it}^{\frac{\varepsilon-1}{\varepsilon}} di\right)^{\frac{\varepsilon}{\varepsilon-1}} + \delta \frac{P_{ot}O_t^*}{P_t}.$$

For current consumption income Y_{ct} with account of oil revenues is used, not just revenues from firms that produce final goods. A market clearing condition for each good provides a formula (Gali & Monacelli, 2005), in which by replacing y_t with y_{ct} we obtain

$$y_{ct} = c_t + \frac{\alpha\omega}{\sigma} s_t, \quad y_{ct} = g_Y + \psi_Y y_t + (1-\psi_Y) y_{ot}, \ 0 < \psi_Y < 1. \tag{14}$$

Then equation (12) can be rewritten as:

$$y_{ct} = \gamma y_{ct-1} + y_t^* - \gamma y_{t-1}^* + \frac{1}{\sigma_\alpha} s_t - \frac{\gamma\alpha\omega}{\sigma} s_{t-1}, \ \sigma_\alpha = \frac{\sigma}{1-\alpha+\alpha\omega}. \tag{15}$$

Further, for simplification we consider the case of absence of habit formation in consumption, assuming $\gamma = 0$. Let's substitute c_t into the Euler equation and replace CPI inflation rate inflation rate by the inflation rate measured by index of domestically produced goods in the country, we present the equation in the form of:

$$y_{ct} = \mathbb{E}_t y_{ct+1} - \frac{1}{\sigma}(i_t - \mathbb{E}_t \pi_{Ht+1} - \rho) - \frac{\alpha(\omega-1)}{\sigma} \mathbb{E}_t \Delta s_{t+1} \tag{16}$$

This equation is a dynamic IS curve. The real marginal costs of firm are

$$MC_t^r = \frac{W_t + \zeta P_{ot}}{A_t P_{Ht}}, \quad mc_t^r = g_W + \psi_W w_t + (1-\psi_W) p_{ot} - p_{Ht} - a_t, \quad 0 < \psi_W < 1.$$

As for the closed economy, the following equation is valid

$$\pi_{Ht} = \beta \mathbb{E}_t \pi_{Ht+1} + \lambda \widehat{mc}_t^r, \tag{17}$$

where $= \frac{(1-\beta\theta)(1-\theta)}{\theta}$, $\widehat{mc}_t^r = mc_t^r - mc^r$, and mc^r – marginal costs in the steady state [11]. Let τ be subsidies per unit of production. Then marginal costs are adjusted as following:

$$MC_t^r = (1-\tau)\frac{W_t + \zeta P_{ot}}{A_t P_{Ht}}, \qquad mc_t^r = g_W + \ln(1-\tau) + \psi_W w_t + (1-\psi_W) p_{ot} - p_{Ht} - a_t.$$

Given the optimality condition in the oil sector and necessary conditions for optimality in the problem of the household, this formula is transformed to

$$mc_t^r = g_W + \ln(1-\tau) + \psi_W(\sigma c_t + \varphi l_t + \xi_t) + \psi_W \alpha s_t +$$

$$+(1-\psi_W)(\sigma c_t + \varphi l_t + \xi_t + \alpha s_t - \ln\mu - a_{ot} - (\mu-1) n_{ot}) - a_t. \tag{18}$$

In oil production sector entire volume of its revenues is divided by domestic consumption of domestic firms and export abroad:

$$O_{st} = O_t + O_t^*, \quad o_{st} = g_O + \psi_O o_t + (1-\psi_O) o_t^*, \ 0 < \psi_O < 1.$$

Let's assume that prices in the country are correlated with world oil prices, i.e. the difference between them is described by autoregression process of the first order:

$$p_{ot} - p_{Ht} = \rho_{po}(p_{ot} - p_{Ht}) + \varepsilon_{pot},$$

where ρ_{po} – positive coefficient less than one, ε_{POt} – a random variable "white noise". Labor resources are also divided between firms producing final goods, and the oil sector:

$$L_t = N_t + N_{ot}, \; l_t = g_N + \psi_N n_t + (1 - \psi_N) n_{ot}, \;\; 0 < \psi_N < 1 \,.$$

Through $\tilde{y}_t = y_t - y_t^n$ we denote deviation of output under nominal price rigidity from output under flexible prices. Given these formulas and relations (14) and (15) after transformation the following equations can be obtained

$$\pi_{Ht} = \beta \mathbb{E}_t \pi_{Ht+1} + \lambda_\alpha \tilde{y}_t, \; \lambda_\alpha = \lambda \left[\sigma_\alpha \psi_Y + \varphi \psi_N + \varphi(1 - \psi_N) \frac{1}{\mu} \psi_O + (1 - \psi_W) \frac{1-\mu}{\mu} \psi_O \right]. \quad (19)$$

This equation is the New Keynesian Phillips curve for the considered here a small open economy.

Let's return back to the dynamic equation of the IS curve and the Euler equation (16). Taking into account the equality $\tilde{y}_{ct} = \psi_Y \tilde{y}_t$ the equation of the dynamic IS curve can be written in respect to the variable $\tilde{y}_t$:

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \frac{1}{\psi_Y \sigma_\alpha}(i_t - \mathbb{E}_t \pi_{Ht+1} - r_t^n). \quad (20)$$

One of the components of dynamic stochastic general equilibrium models is monetary policy rule: Clarida R., Gali J. & Gertler M. (1997), Drobyshevski & Kozlovskaya S. A. (2002). Not all developing countries are using interest rate as an instrument of monetary policy, but the National Bank of Kazakhstan is using it, Mukhamediyev B. (2007). In this model we adhere to the well-known Taylor rule

$$i_t = \rho + \varphi_\pi \pi_{Ht} + \varphi_y \tilde{y}_t + v_{mt} \,,$$

where φ_π , φ_y – non-negative coefficients, and v_{mt} is a random variable reflecting the monetary policy shocks . Its dynamics is given by a first-order autoregression process $v_t = \rho_{mt} v_{t-1} + \varepsilon_{mt}$ and ε_{mt} is a "white noise".

3 Data and estimation of the model parameters

Following data sources were used: the official websites of government agencies (Statistics Agency, Ministry of Economic Development and Trade, National Bank, Ministry of Finance of the Republic of Kazakhstan), as well as data from the World Bank and the IMF.

There are various ways of assessing or calibrating parameters of the linearized DSGE model. The model presented in the last section includes 24 main parameters. The remaining parameters are calculated in the program based on them. Estimates obtained during calibration and econometric estimation were then refined by Bayesian method using the Metropolis-Hastings' algorithm.

Table 1 shows the estimates of the main parameters.

Table 1 – Estimates of parameters

Parameters	Prior mean	Prior p.d.f.	Post. mean
rhooz	0.700	*beta*	0.9468
phi	3.000	*gamma*	3.0143
alpha	0.660	*beta*	0.6900
eta	5.000	*gamma*	5.8618
sigma	1.000	*norm*	1.0005
nu	5.000	*gamma*	5.0775
eps	6.000	*norm*	6.0045
theta	0.700	*beta*	0.6312
rhoao	0.900	*beta*	0.9008
rhoksi	0.700	*beta*	0.6993
rhov	0.500	*beta*	0.4723
rhoyz	0.700	*beta*	0.6897
rhopo	0.800	*beta*	0.8011

4 Impulse-response analysis

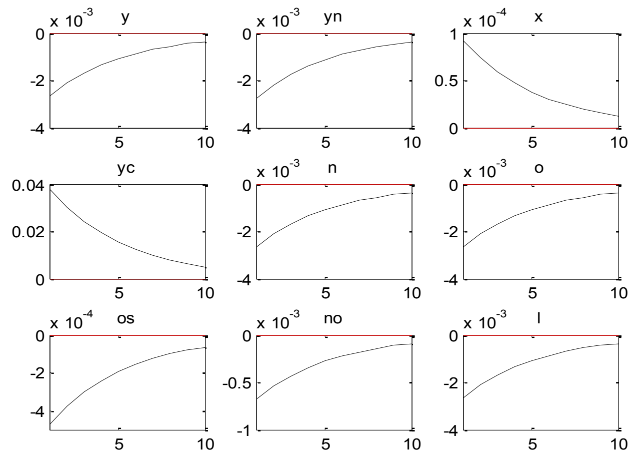
Kazakhstan's oil revenues are sent to the National Welfare Fund, of which about 10 percent of annual income are spent on current expenditures in the economy. Hence, the parameter δ in the first calculation is assumed to be 0.1. Let’s consider responses of variables of macroeconomic models on various shocks. Calculations on the model provided following results.

The oil price shock. Upsurge of world oil price increases costs of firms producing goods. Figure 1 shows that the production of goods in the economy is reduced, with a stronger effect under flexible prices. There is reduction in the use of oil in the economy and in its production, the number of employed falls both in the oil sector and in other sectors of the economy.

In accordance with Figure 2 it could be noticed that the inflation rate increases sharply as on goods produced in the country, as on the consumer price index. The consequence of this is a reduction in real wages. At the same time due to rising oil revenues consumption and interest rates increase. The terms of trade improve the real exchange rate and net exports increase.

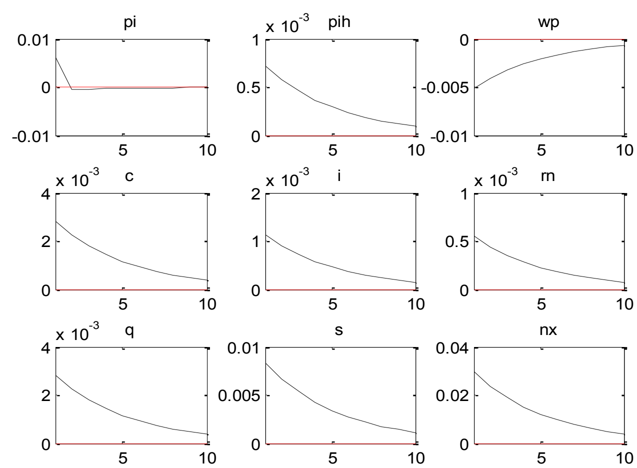
Shock of external demand for oil. Oil production sharply increases and its internal consumption reduces in the country. Accordingly, the number of employees in the sector of oil rises, while it decreases in sectors producing common goods. Overall employment in the economy reduces. Under rigid prices there is a sharp decline in production of goods other than oil, although under flexible prices the volume of production of these goods would have increased due to a rapid price correction by firms.

Figure 1: Impact of oil price shock



Notes: y – output under rigid prices, yn – output under flexible prices, x - difference in the production under rigid and flexible prices, yc - total income used in the economy, n - number of employees in the production of goods, o - domestic oil consumption, os - volume of oil production, no - number of employees in the oil sector, l - total employment in logarithms.

Figure 2: Impact of oil price shock



Notes: pi - rate of inflation CPI, pih - rate of inflation for domestically produced goods, wp - real wages, c - consumption, i - nominal interest rate, rn - real interest rate under flexible prices, q - real exchange rate of the national currency , s - terms of trade, nx - net exports in logarithms.

Rates of inflation fall both on goods produced in the country and measured by consumer price index. Growth in oil production does not compensate for the downturn in other sectors of the economy. According to the Taylor rule, monetary authorities react to the decline in output and inflation by lowering the nominal interest rate. A reduction of the real interest rates takes place. A decrease in employment and output of goods leads to a reduction in average real wages.

Accordingly, consumption decreases. Real depreciation of the national currency occurs. Negative impact of the shock of oil demand abroad on the economy is also revealed in the deterioration of terms of trade, which in turn, leads to a decrease in net exports.

Productivity shock in the commodity sector. This shock of increased productivity leads to a sharp increase in the output of goods under rigid and flexible prices. Besides, the growth under flexible prices is higher than under rigid prices. Increased production of goods causes a rise in domestic oil consumption and in number of employees both in production of goods and in the oil sector. A total number of employed in the economy increases. An output of oil production rises.

The rate of inflation decreases both on domestic products and consumer price index. As a result the total income in the economy, real wages and consumption increase. In response to the decline of inflation and a negative deviation of the output under rigid prices, under flexible prices monetary authorities lower interest rates. Strengthening of the national currency occurs, the terms of trade improve and the net export increases.

Productivity shock in the oil sector. The marginal costs of oil production decrease. The volume of oil production increases while the number of employees in its production reduces. This has a positive impact on output in the goods sector, and the number of employed in the production of domestic goods increases. In general, employment in the economy rises. The total income used in the economy rises. It consists of income earned in the production of goods and the production of oil.

The shock of monetary policy leads to a decline in the production of goods and the number of employees occupied in their production. Correspondingly domestic oil consumption reduces, and its total production falls. As a result there is a reduction in employment in the oil sector, and ultimately a decline in the total number of employed in the economy. The total income used in the economy decreases, since it consists of income derived from the production of goods and production of oil. Real wages decline, and consumption reduces. In response to the decline of production and rate of inflation on domestic goods monetary authorities lower the interest rate. The national currency is experiencing real depreciation. Terms of trade deteriorate and net exports decline.

Shock of labor preferences. If people begin to appreciate more rest and leisure compared to consumption, this will have an impact on the economy. Labor costs in the production of goods reduce, and, as a result, domestic oil consumption goes down. The consequence is a decline in oil production in the country and the number of employees in the oil sector. Also the total number of employed in the economy contracts. There is a rise of inflation rates on prices of domestically produced goods and consumer price index which takes into account prices of imported goods. A decline in production and growth rate of inflation will lead to a sharp decline in real wages. Consumption in the country shortens. In response to inflation growth monetary authorities reacts by lifting interest rates. Also real depreciation of the national currency happens. The terms of trade worsen and net exports of the country reduce.

Shock of one percent increase of output abroad has an impact on the dynamics of macroeconomic variables in the country. In accordance with the condition of international risk sharing a jump in output in the rest world will increase consumption in the country. Balance of aggregate demand

and aggregate supply in this situation provides deteriorating terms of trade and, consequently, a decrease in net exports, which will then grow. Here the effect of oil exports' growth due to rising production abroad, which was discussed above, is not taken into account. Production of goods in the country reduces, the total income used in the economy declines. The initial cut down of inflation rates will change abruptly up. Consumption and real wages increase. Depreciation of national currency happens. As a result of reduction of output employment in the production of goods declines and domestic oil consumption reduces as well. In general, there will be a decline in oil production and a reduction in the number of employed in its production. Total employment also reduces.

5 Conclusions

The article presents the dynamic stochastic general equilibrium model for the economy that produces oil and retains part of oil revenues in the special fund. Along with the final goods sector the model includes the oil sector, which plays an important role in the economy, provides a significant proportion of revenues to the government budget. Firms' factors of production are labor and oil as energy inputs. The oil sector also uses labor for production. The model corresponds to the new Keynesian tradition and the approach of Gali et al. with the formation of Calvo sticky prices. Estimates of model parameters were obtained either by calibration and regression analysis statistical data or by applying Bayesian approach and Metropolis-Hasting algorithm.

Oil producing economy is subject to changes in the world oil price and its demand. This has a significant impact on behavior of macroeconomic indicators. Model calculations yielded predictive responses of variables of the model to various shocks to the economy of Kazakhstan. Analysis of response functions to internal shocks (productivity shock in the final goods sector, productivity shock in the oil sector, labor preference shock, shock of monetary policy) and external shocks (oil price shock, oil demand abroad, production abroad shock). Each endogenous variable responds to shocks differently. Consequently, this impact of shocks on macroeconomic indicators can be predicted and decisions could be made so to eliminate or reduce their consequences.

References

Agency of the RK on statistics. http://www.stat.kz.

Andrle M. (2010). A note on identification patterns in DSGE models // *ECB Working Paper* 123.

Beidas-Strom S., Poghosyan T. (1011). An estimated dynamic stochastic general equilibrium model of the Jordanian economy // *IMF working paper.*– 52 p. // http://www.imf.org/external/ns/cs.aspx?id=28.

Calvo G. (1983). Staggered prices in a utility maximizing framework // *Journal of Monetary Economics.*– №12. – P. 383–398.

Clarida R., Gali J., Gertler M.(1997). Monetary policy rules in practice: some international evidence // *NBER* . - WP 6254.

Cuche-Curtia N., Dellasb H. and J.-M.cNatalc. (2009). DSGE-CH: a dynamic stochastic general equilibrium model for Switzerland, Swiss National Bank // *Economic Studies*. - №. 5.

Curdia V., Woodford M. (2010). Credit spreads and monetary policy // *Journal of Money, Credit and Banking.* – Vol. 42. - No.1. - P. 3-35.

Del Negro M., Schorfheide F. (2008). Forming priors for DSGE models (and how it affects the assessment of nominal rigidities) // *Journal of Monetary Economics*. – 2008. – Vol. 55. - P. 1191-1208.

Dib A. (2001). An estimated Canadian DSGE model with nominal and real rigidities // *Bank of Canada. Working Paper. – 26 p.*

Drobyshevski C., Kozlovskaya A. (2002). Internal aspects of monetary policy in Russia / / *Proceedings of the IET*. - № 45R.

Galí J., Monacelli T. (2005). Monetary policy and exchange rate volatility in a small open economy // *The Review of Economic Studies*. – Vol. 72. - No. 3. – P. 707–734.

Kumhof M., Laxton D., Muir D., Mursula S. (2010). The Global Integrated Monetary and Fiscal Model (GIMF) //*IMF Working Paper.* - WP 1034.

Kydland F. E., Prescott E.C. (1982). Time to build and aggregate fluctuations // Econometrica. – Vol. 50. – P. 1345-1370.

Lucas R. E. (1976). Econometric Policy Evaluation: A Critique // *Carnegie-Rochester Conference Series on Public Policy*. – Vol.1. – P. 19-46.

Medina J., Soto C. (2007). The Chilean business cycle through the lens of a stochastic general equilibrium model // *Central Bank of Chile. Working Papers*. – No. 457.

Mkrtchyan A., Dabla-Norris E., Stepanyan A. (2009). A new Keynesian model of the Armenian Economy // *IMF Working Paper WP/09/66.* – 45 p.

Mukhamediyev B. (2007). Rules of Monetary Policy of National Bank of Kazakhstan // *Quantile.* - № 3. - C. 91-106. (Russia, Moscow).

National Bank of the RK. http://www.nationalbank.kz.

Smets F., Wouters R. (2003). An estimated stochastic dynamic general equilibrium model of the euro area // *Journal of the European Economic Association*. – Vol. 1, No. 5. - P. 123-1175.

Tovar C. (2008). DSGE models and central banks // *BIS Working Papers*. - No. 258.