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Document type
Working Paper No.1

This version is available at
http://nacanalytica.com/images/macro/Papers/A_Macroeconometroc_Model_for_Kazakhstan.pdf

Citation details
Abilov, Nurdaulet, Tolepbergen, Alisher and Klaus Weyerstrass. 2019. A Macroeconometric Model for Kazakhstan. NAC Analytica Working Paper. No.1.

A Macroeconometric Model for Kazakhstan

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Abstract

The paper builds a structural macroeconometric model for Kazakhstan to generate short-term and medium-term forecasts for main macroeconomic variables and conduct scenario analyses based on dynamic simulation of the model. Due to the poor quality of quarterly data on GDP and its expenditure components, they have been adjusted using volume indexes. The model consists of aggregate supply, aggregate demand, labor market, asset market, the central bank policy and government side equations. Most equations are estimated via econometric techniques and identities are explicitly introduced in line with economic theory. We combine all the regression equations into a single model and solve for the baseline scenario from 2003 to 2017. The simulation results show that the structural macroeconometric model approximates Kazakhstani economy reasonably well. Ex-ante forecasts under oil prices remaining around 50 and 60 US dollars per barrel are generated and compared with the baseline forecast of the National Bank of the Republic of Kazakhstan.

Keyword: Macroeconometric model; Cowles Commission approach; Forecasting; Simulation.

JEL code: B22, E17, E27.

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1. Introduction

Aggregate indicators of economic well-being have always been of interest to economists studying the field from the standpoint of aggregate behavior of individuals, firms and government agencies. As it has always been, macroeconomics attempts to describe the dynamics of an economy in terms of country level data, and heavily exploits mathematical tools to represent structural relationships in the economy via a system of equations. One of the first attempts to describe the entire economy via structural equations was made by Tinbergen in 1930s. Although the first attempt to construct a structural model of the economy was made almost a century ago, similar models are still in use in most of the research centers around the world.

In economics, structural models describe the economy's architecture through the interrelationships among endogenous variables. There exist wealth of literature on structural macroeconometric models. But most of these models are based on structural equation estimation and use ordinary least squares (OLS) technique neglecting endogeneity problems in the equations specified. This usually happens because the gain from using robust techniques is so small that one prefers using the more efficient OLS technique (see Dougherty (2011)). Also, there exist a paucity of models on emerging countries and none on Kazakhstan. Although attempts have been done by research institutes to build a structural macroeconometric model for Kazakhstan based on solid economic theory, they became unpublished and unknown to wider research community. The purpose of this work shall be constructing a macroeconomic model based on structural equation estimation and evaluating the performance of the model in ex-post simulation. The model is also used for ex-ante forecasting macroeconomic variables in the economy.

Although structural macroeconometric models are clearly useful and quite flexible in use, most economists have given preference to building dynamic stochastic general equilibrium (DSGE) models since 1980s. These models contain explicit microfoundations, because behavioral equations are derived from optimizing behavior of economic agents. This is the main advantage they have over macroeconometric models. However, structural macroeconometric models are more useful tools for simulating baseline scenario and generating ex-ante forecasts under a variety of assumptions. Therefore, the paper is focused on producing the structural macroeconometric model for Kazakhstan.

First, we provide main literature on structural macroeconometric models to clarify on the state of modeling. Most of the famous macroeconometric models are presented and discussed in detail. Second, we provide data description and discuss main obstacles encountered in data compilation. Most of this section is devoted to explaining how the data problems have been handled. Third, methodology of the model is presented and estimated equations are explained based on economic theory and empirical observations. Fourth, the model properties are assessed using an ex-post simulation. Finally, ex-ante forecasts are generated for main macroeconomic variables under different oil price scenarios and concluding remarks are made.

2. Literature review

One of the most excellent treatments of macroeconometric modeling is given in the textbook by Fair (1984). He essentially builds a macroeconomic model for the US economy using standard econometric techniques, and in doing so, takes economic theory as the starting point in moving from theoretical consideration to econometric specification of the structure of the US economy. The textbook devotes a chapter for discussing implications of rational expectations, as proposed by Muth (1961). The criticism in Lucas (1976) is important in this setup, since it was the driving force in the rejection of macroeconometric models in academic society as a tool for policy analysis. Rational expectations in the Fair model are treated in a traditional way with the inclusion of lagged dependent variables. This is motivated by the assumption of adaptive or partial adjustment nature of expectations.

Another famous macroeconometric model on the US economy is the FRB/US model which is used to generate forecasts and conduct policy simulations for the Federal Reserve Board. Brayton and Tinsley (1996) give an excellent treatment of the model. This large-scale macroeconometric model consists of over fifty stochastic equations and two hundred fifty identities. The construction of the model equations is mainly based on equilibrium relations among the set of variables suggested by the theory, arbitrage relations in the financial markets, dynamic adjustment equations for endogenous variables describing their short-run behavior and the way expectations are formed. Most of the equations contain lead variables due to the nature of equations being specified and forward-looking behavior of households and firms. This in turn means that expectations play an important role in this model. One of the key features of the FRB/US model is the presence of price and wage stickiness in dynamic adjustment equations for these variables.

The model considered in Powell and Murphy (1997) is the quarterly macroeconometric model known as the Murphy model for the Australian economy. The Murphy model (hereafter MM) is in the spirit of Fair model for the US economy. It is also based on single-equation estimation but using a much wider variety of techniques: ordinary least squares (OLS), non-linear least squares (NLS), full information maximum likelihood (FIML) and instrumental variable (IV) estimation methods. They also allow for rational (model-consistent) expectations behavior in financial markets due to the sophisticated nature of institutions in these markets whereas other non-financial market participants are assumed to have simpler expectation formations.

Dreger and Marcellino (2007) build a macroeconometric model using aggregate data on the supra-national level for the Euro area instead of constructing the model for each Euro area member, and combining them in a large-scale model. Hence, the paper treats the Euro area as a single economy, which is quite reasonable given the rapid economic integration that has started since 1990s. The model for the Euro area follows a very standard theoretical framework in macroeconomic theory. All the equations are constructed in error correction form as presented in Engle and Granger (1987) due to the non-stationarity of variables used in regression equations.

Weyerstrass et al. (2018) present a structural macroeconometric model for Slovenia. Most of the equations in the model are estimated via OLS in the error correction form since most variables exhibit non-stationary features. They run several tests to prove the exogeneity of variables on the right-hand side and stability of parameters in the equations over time. The test results indicate that endogeneity and parameter instabilities are not critical issues in the equations estimated.

Fair (2012) and Blanchard (2018) give neat discussions on the current state of macroeconomics as a science. Fair (2012) compares the modern general equilibrium models with structural macroeconometric models. He criticizes current DSGE models for their less data-oriented nature and aggregation of main macroeconomic variables which are usually disaggregated in structural macroeconometric models. It is also asserted that the benchmark DSGE model (Smets and Wouters (2007)) is misspecified and turns out to be a poor approximation to the structure of the economy. Blanchard (2018) recognizes that the DSGE models are flawed due to their failure during the Great Recession. However, he also asserts that despite being flawed DSGE models contain the right foundations and should be improved further to get better insight into the structure of economy. Although Blanchard is a proponent of using the general equilibrium framework he also advocates partial equilibrium modeling for complementing the general equilibrium models.

3. Data description

Most of the reliable macroeconomic data for Kazakhstan is available only from 2001. Thus, the data is collected starting from 2001 to 2017 on quarterly basis and consists of 68 observations for most of the variables. The data is gathered from the public sources of the Committee on Statistics of the Ministry of National Economy, the Ministry of Finance, the National Bank of the Republic of Kazakhstan and Bloomberg.

The data on Gross Domestic Product (GDP) and expenditure components are released by the Committee on Statistics.[1] The main approach to calculating GDP figures is the production side method at the Committee on Statistics. Hence, there is a statistical discrepancy between the GDP figures calculated from the production side and expenditure side. According to the methodology of the Commitee on Statistics, the statistical discrepancy is added into the change in inventory in gross capital formation to make the real GDP from expenditure side coincide with the production side real GDP. As a result, official bulletins of the Committee on Statistics contain a change in inventory falling up to negative 60 % of GDP at constant prices in some quarters. These numbers must be taken with caution, since it implies that the demand for domestic goods and services exceeded production by more than half in some quarters. Although this is theoretically possible, it does not happen in practice and such numbers would have implied some problems in the economy. In this case, it is more likely to be related to the inaccuracy in calculating price deflators of expenditure components which resulted in unrealistic numbers for statistical discrepancy between the production and expenditure side GDP at constant prices. Due to the unreliable quality of the official data we adjust the expenditure components of GDP in real terms and build a model using these variables.

We take the base period to be the first quarter of 2010. The Committee on Statistics publishes data on volume indexes for GDP and expenditure components on quarterly basis. The volume index shows the quarterly growth rate of real GDP and its expenditure components. This index is used as official statistics on the annual growth rate of GDP in Kazakhstan. The equations below clarify the way GDP and its components have been calculated in 2010 prices using the volume indexes for output and expenditure components of GDP.

$$X_{i,t} = P_i^{2010} Q_{i,t} \tag{1}$$

[1]Expenditure components of GDP: private consumption, gross fixed capital formation, government spending, exports and imports.

$$V_{i,t+1} = \frac{Q_{i,t+1}}{Q_{i,t}}100 \tag{2}$$

$$X_{i,t-1} = \frac{X_{i,t}}{V_{i,t+1}}100 \tag{3}$$

$$X_{i,t+1} = \frac{X_{i,t}\ V_{i,t+1}}{100} \tag{4}$$

where i refers to GDP and expenditure components of GDP; $X_{i,t}$ is the value of a variable in 2010 prices; P_i^{2010} is the price deflator; $V_{i,t}$ is the volume index; $Q_{i,t}$ is the quantity variable. The first quarter of 2010 is used as a starting point for generating GDP and expenditure components of GDP in 2010 prices. In other words, t is initially set equal to the first quarter of 2010. Equation 1 explains how GDP and other expenditure components are calculated in 2010 prices. Equation 2 shows the way the volume indexes, which are published in the official bulletins of the Committee on Statistics, are calculated. Equation 3 and Equation 4 show the way GDP and expenditure components of GDP in 2010 prices have been calculated for periods before and after the base period. In addition, official statistics also publish volume indexes in different measurement methodologies for periods before and after 2008. The likely cause is the change in base year prices which affected volume indexes: the volume indexes in the first quarter of 2008 are out of historical pattern. That is, all components of GDP tend to fall in the first quarter of a given year relative to the fourth quarter of the previous year due to the presence of seasonality. But this is not the case only for the first quarter of 2008 throughout the sample. Hence, adjustment terms for GDP and expenditure components have been calculated and applied to the variables before 2008 to reconcile these figures with actual observations and fully convert them into 2010 prices. Finally, the difference between GDP and sum of expenditure components of GDP is taken to be the change in inventory investment. In comparison with official statistics this figure has been improved to negative 14 % of real GDP which is more plausible than the negative 60% of real GDP published in official statistics.

In addition, there is an issue related to obtaining capital stock data for Kazakhstan. There is no official statistics available on capital stock. Therefore, capital stock variable is derived via the Perpetual Inventory Method (PIM) by using the initial capital-output ratio and depreciation rates available for Kazakhstan. According to the PIM, the capital stock at the end of the current period (K_t) is equal to the capital stock from the previous period (K_{t-1}) less depreciation (δK_{t-1}) and plus investment in the current period (I_t). That is,

$$K_t = I_t + (1 - \delta)K_{t-1} \tag{5}$$

In order to apply the PIM to calculate capital stock variable within the sample, the initial value of the capital stock (K_0) has to be determined. Due to the unavailability of the official data on capital stock for Kazakhstan, the data from the Penn World Table is used. Feenstra et al. (2015) provide the value of capital stock, depreciation rates of capital and GDP at constant national prices. Using the capital-output ratio of 2.66 in 2001 from the table we calculate the initial stock of capital for Kazakhstan. Then the varying depreciation rates from the Penn World Table are used in the PIM to come up with quarterly observations for capital stock from 2001 to 2017. There is no data on depreciation rate in the Penn World Table for 2015-2017, and we assume a constant depreciation rate of 3% per annum for this period.

The data on total population and working age population (from 15 to 64 years) are available only at annual frequency. We make an assumption that both variables grow at a constant rate each quarter in a given year to make the annual growth rate equal to the actual growth rate published in official statistics. In this way, we convert variables with annual frequency into the variables with quarterly frequency. The list of all variables is provided in Appendix A.

4. The model

The macroeconometric model for Kazakhstani economy is based on structural equation estimation. Economic theory is used to guide the specification of equations, and most of them explicitly include long-run relations. The model consists of equations for aggregate variables in goods, labor and foreign exchange markets. In addition, there are also interest rate equations representing the bond market and central bank policy rule, and price equations to characterize the evolution of prices in the economy. Some important variables in the public sector are also modeled via regression techniques. Other variables are determined via identities within the model (see Appendix B).

It is essential to analyze properties of the data when starting to build a model, because the specification of equations depend on the properties of variables. If variables are non-stationary and unit root processes, then it is highly undesirable to build regression equations in levels, since the cause of significant coefficients could be due to the spurious nature of the relationships (see Engle and Granger (1987)). Therefore, all variables are checked for stationarity using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. Appendix C presents unit root test results of the variables in levels and year over year (YoY) measures.[2] According to the results of the aforementioned tests, most variables are non-stationary in levels but stationary in year over year measures. Thus, most of the variables may have cointegrating relations with a set of other variables. This implies that some equations can be specified in error correction form.

Most of the model equations use an year over year measure of logarithm of dependent and independent variables rather than their logarithmic first differences. This preference is justified due to the presence of seasonality in most important variables in the model such as private consumption, investment, GDP deflator etc. One can also deseasonalize variables and model them in first differ-

[2] Year over year (YoY) measure of a variable is defined as $X_t - X_{t-4}$.

ences, but deseasonalizing the data has been refrained from, because they may lead to a loss of some relevant characteristics of the data for modeling. There are also other equations where dependent variables are specified in levels due to their stationary nature. Further, almost all estimated equations contain dummy variables to account for structural breaks and shifts present in the data.

In addition, there is a need to justify the use of error correction technique before specifying and estimating equations in this form. That is, we conduct tests for stationarity of residuals from the long run equations. Appendix C presents the results of unit root tests of residuals from the long run equations. That is, if the residuals are stationary, then there exists a linear combination of variables that is stationary. This is precisely the justification for the presence of cointegrating relations between variables. Most of the model equations are estimated in one-step procedure as outlined in Stock and Watson (1993) to avoid the finite sample bias of two step procedure.

The model consists of the supply side, goods market, labor market, bond market, central bank policy equation, prices and the government sector. The main component of the supply side of the model is an equation for potential output. We assume Cobb-Douglas production function with constant returns to scale to derive potential output. The production function is given below.

$$Y_t = BA_t K_t^{\alpha} L_t^{1-\alpha} \tag{6}$$

K_t, L_t and A_t refer to capital stock, labor and technical progress respectively. B is any normalizing constant. Further, it is assumed that the technical progress in the production function is Hicks neutral and the share of capital in production is $\alpha = 0.44$. The share of capital in production has been calculated by IMF staff using the firm-level data for Kazakhstan.[3] Hence, the equation for production function is estimated with a restriction, the only estimated parameter being the constant term. Residuals from this regression are referred to as total factor

[3]International Monetary Fund, 2017, *"Kazakhstan: Selected Issues"*

productivity (TFP). The potential output is calculated assuming full capital utilization and using the natural level of employment together with TFP trend.

We also estimate equations for labor force, non-accelerating inflation rate of unemployment (NAIRU) and trend TFP to be able to calculate potential output within the model. The labor force and NAIRU are used to calculate the full employment level, and the trend of TFP contributes to potential output over the long run. TFP trend is found by applying the Hodrick-Prescott filter to the residuals from the regression equation for production function. As a result, the supply side of the model consists of equations for potential output, labor force, NAIRU and trend TFP.

1) Cobb-Douglas production function equation

$$\log(Gdpr_t) = 6.468 + 0.44\ \log(Capsr_t) + 0.56\ \log(Emp_t)$$

2) Potential output equation

$$\log(Ypot_t) = 6.468 + 0.44\ \log(Capsr_t) + 0.56\ \log(Lforce_t\,(1 - Hp\_nairu_t)) + \log(Hp\_tfp_t)$$

3) Labor force equation

$$\frac{Lforce_t}{Pop1564_t} = \underset{(0.040)}{0.127} + \underset{(0.056)}{0.818}\,\frac{Lforce_{t-4}}{Pop1564_{t-4}} + \underset{(0.010)}{0.023}\,\log\left(\frac{Wageavr_t}{Wageavr_{t-4}}\right)$$

$SIC = -7.576$

4) NAIRU trend equation

$$\Delta^2\,(Hp\_nairu_t) = \underset{(0.000)}{1.76 \cdot 10^{-05}} + \underset{(0.066)}{1.529}\,\Delta^2\,(Hp\_nairu_{t-1}) - \underset{(0.078)}{0.576}\,\Delta^2\,(Hp\_nairu_{t-2}) + \underset{(166.818)}{1.771}\,\epsilon_{t-1} + \underset{(188.339)}{0.99}\,\epsilon_{t-2}$$

$Adj.R^2 = 0.997,\ \ SIC = -23.93$

5) TFP trend equation

$$\Delta^3 \left(Hp\_tfp_t\right) = \underset{(0.000)}{1.10 \cdot 10^{-5}} + \underset{(0.051)}{1.734}\, \Delta^3 \left(Hp\_tfp_{t-1}\right) - \underset{(0.065)}{0.818}\, \Delta^3 \left(Hp\_tfp_{t-2}\right)$$

$$+ \underset{(0.068)}{0.942}\, SAR(4) - \underset{(215.97)}{0.539}\, \epsilon_{t-1} - \underset{(285.46)}{0.461}\, \epsilon_{t-2}$$

$Adj.R^2 = 0.87, \;\; SIC = -18.4$

Goods market of the model consists of equations for private consumption, investment, oil exports, non-oil exports and imports. These are the expenditure components of GDP with the exclusion of government consumption. The government consumption is treated as exogenous within the model. Private consumption of households is the major component of aggregate demand and requires special attention. The private consumption equation has been estimated in the error correction form. There is a long run relationship between consumption and disposable income as in the Keynesian consumption function. The interest rate variable has been refrained from including into the consumption equation because it tends to distort the behavior of consumption in further simulations. There is also a lagged consumption variable on the right-hand as a regressor which represents habit formation in consumption as introduced by Abel (1990) and Ferson and Constantinides (1991). The positive coefficient of lagged consumption indicates that there is indeed persistence as the empirical study on consumption behavior suggests. In addition, there is also current disposable income appearing as a regressor and it has a significant positive coefficient. This is interpreted as the short run (or temporary) effect of disposable income on private consumption.

6) Private consumption equation

$$\log\left(\frac{Cr_t}{Cr_{t-4}}\right) = \underset{(0.144)}{0.431} + \underset{(0.079)}{0.144}\log\left(\frac{Cr_{t-1}}{Cr_{t-5}}\right) + \underset{(0.081)}{0.277}\log\left(\frac{Incomer_t}{Incomer_{t-4}}\right)$$

$$-\underset{(0.072)}{0.265}\log(Cr_{t-4}) + \underset{(0.063)}{0.195}\log(Incomer_{t-4}) + \underset{(0.037)}{0.226}\,dum3 - \underset{(0.029)}{0.194}\,dum4$$

$Adj.R^2 = 0.76,\;\; F - stat = 29.07,\;\; LM(2) = 1.87$

The investment equation is estimated with a restriction via NLS technique. The investment equation is also specified in error correction form in which the long run relation is between investment and demand for domestic goods and services. We have also put a restriction that the elasticity of investment with respect to demand is 0.5% in the long-run relation. There are also short-run effects of demand for domestic goods and services, real interest rate and output gap on investment. The demand for domestic goods and services and output gap increase the investment because firms tend to add more capacity in response to higher demand and rising positive output gap. In contrast, the real interest rate has a significant negative impact on investment as predicted by the standard theories of investment (e.g. Brainard and Tobin (1976)).

7) Investment equation

$$\log\left(\frac{Invr_t}{Invr_{t-4}}\right) = \underset{(0.083)}{0.333} + \underset{(0.179)}{0.772}\log\left(\frac{Demandr_t}{Demandr_{t-4}}\right) - \underset{(0.044)}{0.159}\,(\log(Invr_{t-4})$$

$$-0.5\log(Demandr_{t-4})) - \underset{(0.322)}{1.078}\,(Midgovb_t - Infl_t) + \underset{(0.357)}{1.109}\,(Ygap_t - Ygap_{t-4})$$

$$+\underset{(0.062)}{0.215}\,dum5 - \underset{(0.064)}{0.420}\,dum6 - \underset{(0.064)}{0.287}\,dum7$$

$Adj.R^2 = 0.68,\;\; F - stat = 20.03,\;\; LM(2) = 1.02$

International trade with the rest of the world is captured by oil exports, non-oil exports and imports equations. Exports are divided into oil exports and non-oil exports due to the important role of exports of crude oil in Kazakhstani economy. As a result, there is a need to divide exports into constituent parts, because oil exports and non-oil exports tend to depend on different variables. The equation for exports of oil is determined by the lagged values of the dependent variable, crude oil price and world trade. There exists a cointegrating relation between exports of oil and oil price. According to economic theory, the price of oil is taken as given whereas the supply of crude oil is upward sloping. Hence, an increase in the price of oil should lead to increased exports of oil. This is precisely the case in the equation for oil exports. The price of oil and world trade have both significant positive effects on the exports of oil in the short run.

8) Oil exports equation

$$\log\left(\frac{Exoilr_t}{Exoilr_{t-4}}\right) = \underset{(0.494)}{2.751} + \underset{(0.084)}{0.173}\ \log\left(\frac{Exoilr_{t-1}}{Exoilr_{t-5}}\right) + \underset{(0.039)}{0.196}\ \log\left(\frac{Oilpusd_t}{Oilpusd_{t-4}}\right)$$
$$- \underset{(0.095)}{0.524}\ \log(Exoilr_{t-4}) + \underset{(0.050)}{0.222}\ \log(Oilpusd_{t-4}) + \underset{(0.209)}{0.582}\ \log\left(\frac{Wtrade_t}{Wtrade_{t-4}}\right)$$
$$+ \underset{(0.040)}{0.188}\, dum8$$

$Adj.R^2 = 0.76,\ \ F - stat = 33.74,\ \ LM(2) = 3.59$

Exports of non-oil goods and services depend more on real exchange rate and world trade. Hence, the equation for non-oil exports is estimated with the use of lagged value of non-oil exports, real exchange rate, world trade index as regressors and the error correction term where the cointegrating relation is between these three variables. The real exchange rate has a significant coefficient and negatively affects non-oil exports both in the short run and long run. This means a real appreciation of the domestic currency leads to a fall in non-oil exports. However, the world trade has a significant positive effect on non-oil exports in both the short run and long run. That is, an expansion of the world trade should lead to an increase in exports over time.

9) Non-oil exports equation

$$\log\left(\frac{Exotherr_t}{Exotherr_{t-4}}\right) = \underset{(0.014)}{0.003} + \underset{(0.075)}{0.336}\ \log\left(\frac{Exotherr_{t-1}}{Exotherr_{t-5}}\right) - \underset{(0.121)}{0.388}\ \log\left(\frac{Reer38_t}{Reer38_{t-4}}\right) + \underset{(0.186)}{0.325}\ \log\left(\frac{Wtrade_t}{Wtrade_{t-4}}\right)$$
$$-0.820\,(\log(Exotherr_{t-4}) - 7.62 + 0.570\ \log(Reer38_{t-4}) - 0.413\ \log(Wtrade_{t-4})) + \underset{(0.065)}{0.277}\, dum9 - \underset{(0.064)}{0.306}\, dum10$$

$Adj.R^2 = 0.72,\ \ F - stat = 26.91,\ \ LM(2) = 2.32$

The other side of international trade includes domestic agents demanding foreign output. Imports equation is determined by the lagged value of itself, domestic output, real exchange rate and error correction term. The error correction term captures a cointegrating relation between imports, domestic output and real exchange rate. In this case, all coefficients have expected signs in line with economic theory. Both a real appreciation and an increase in domestic output lead to increases in imports in the short run and long run.

10) Imports equation

$$\log\left(\frac{Impr_t}{Impr_{t-4}}\right) = -\underset{(0.707)}{2.986} + \underset{(0.079)}{0.269}\ \log\left(\frac{Impr_{t-1}}{Impr_{t-5}}\right) + \underset{(0.242)}{0.894}\ \log\left(\frac{Gdpr_t}{Gdpr_{t-4}}\right)$$
$$+ \underset{(0.107)}{0.365}\ \log\left(\frac{Reer38_t}{Reer38_{t-4}}\right) - \underset{(0.087)}{0.440}\ \log(Impr_{t-4}) + \underset{(0.096)}{0.461}\ \log(Gdpr_{t-4})$$
$$+ \underset{(0.145)}{0.498}\ \log(Reer38_{t-4}) - \underset{(0.035)}{0.163}\, dum11 + \underset{(0.046)}{0.240}\, dum12$$

$Adj.R^2 = 0.64,\ \ F - stat = 19.54\ \ LM(2) = 0.46,$

The labor market consists of equations for nominal wage and employment. The wage equation is determined by lagged value of the nominal wage, domestic CPI and the long run relation between nominal wage and unemployment rate. There is persistence in nominal wage shown by the positive and significant coefficient of the lagged dependent variable whereas prices affect nominal wages positively as expected. The cointegrating relation in the estimated equation implies that the fall in unemployment rate has a tendency to raise nominal wages over the long run.

The employment equation is specified in a simpler manner where the dependent variable is employment to labor force ratio. It is estimated as depending on its own lagged value, year over year measure of real GDP and real wage growth. Output growth has a significant and positive coefficient whereas the real wage growth has a negative impact on the dependent variable. The employment equation is estimated in the form of tobit regression in comparison with the regression equations already considered, because there are upper and lower bounds of employment to labor force ratio.[4] Overall, the labor market has been considered both from the perspective of workers and firms, and consist of the nominal wage and employment equations.

11) Nominal wage equation

$$\log\left(\frac{Wageav_t}{Wageav_{t-4}}\right) = \underset{(0.457)}{1.406} + \underset{(0.100)}{0.409} \log\left(\frac{Wageav_{t-1}}{Wageav_{t-5}}\right) + \underset{(0.411)}{0.157} \log\left(\frac{Cpi_t}{Cpi_{t-4}}\right)$$

$$-\underset{(0.034)}{0.106} \log(Wageav_{t-4}) - \underset{(1.336)}{2.921}\, Unemprate_{t-4} + \underset{(0.040)}{0.180}\, dum13 + \underset{(0.039)}{0.121}\, dum14$$

$Adj.R^2 = 0.64, \ \ F - stat = 19.54, \ LM(2) = 0.46,$

12) Employment equation

$$\frac{Emp_t}{Lforce_t} = \underset{(0.016)}{0.117} + \underset{(0.017)}{0.877} \frac{Emp_{t-4}}{Lforce_{t-4}} + \underset{(0.005)}{0.013} \log\left(\frac{Gdpr_{t-1}}{Gdpr_{t-5}}\right)$$

$$- \underset{(0.004)}{0.007} \log\left(\frac{Wageavr_t}{Wageavr_{t-4}}\right) + \underset{(0.001)}{0.005}\, dum15$$

$SIC = -9.50$

[4]Employment to labor force ratio lies between 0 and 0.99

There is also a price block in this model where equations for price dynamics are fitted. The main equations in the price block are CPI and GDP deflator equations. The CPI equation is specified in growth rates, meaning that the annual rate of inflation has actually been modeled as depending on the lagged value of itself, lagged average nominal wages, nominal exchange rate and growth rate of real GDP. Economic theory states that the inflation rate depends on inflation expectations and output gap. In this case, it has been assumed that the inflation expectations are formed in an adaptive manner, justifying the presence of the lagged inflation rate in the equation for CPI, and the output gap is approximated by real GDP growth rate. The average nominal wages and nominal exchange rate are introduced for empirical reasons, since prices in the economy are related to these variables through trade and cost-push channels. In the same manner, the GDP deflator is also prone to be related to exogenous variables such as price levels in China, Russia and the US. There is a sound explanation for the inclusion of all these variables on the right-hand side of the equation. China and Russia are the main trading partners of Kazakhstan and price fluctuations in these countries tend to spill over to the domestic economy through trade channels. The US CPI affects the price deflator in Kazakhstan due to the pegged exchange rate regime with respect to the US dollar which prevailed for a long time in Kazakhstan. Other price equations are constructed for private consumption deflator, government consumption deflator, exports and imports deflator.

13) CPI equation

$$\log\left(\frac{Cpi_t}{Cpi_{t-4}}\right) = -\underset{(0.006)}{0.002} + \underset{(0.056)}{0.683}\log\left(\frac{Cpi_{t-1}}{Cpi_{t-5}}\right) + \underset{(0.014)}{0.094}\log\left(\frac{Kztusd_t}{Kztusd_{t-4}}\right) + \underset{(0.043)}{0.221}\log\left(\frac{Gdpr_{t-1}}{Gdpr_{t-5}}\right) + \underset{(0.033)}{0.061}\log\left(\frac{Wageav_{t-4}}{Wageav_{t-8}}\right) + \underset{(0.014)}{0.076}\,dum16$$

$Adj.R^2 = 0.84,\ \ F - stat = 62.90,\ LM(2) = 0.39$

14) GDP deflator equation

$$\log\left(\frac{Gdpdef_t}{Gdpdef_{t-4}}\right) = \underset{(0.019)}{0.023} - \underset{(0.362)}{1.854} \log\left(\frac{Cpir_t}{Cpir_{t-4}}\right) + \underset{(0.592)}{1.140} \log\left(\frac{Uscpi_t}{Uscpi_{t-4}}\right)$$
$$+ \underset{(0.529)}{1.952} \log\left(\frac{Uscpi_{t-1}}{Uscpi_{t-5}}\right) + \underset{(0.373)}{1.744} \log\left(\frac{Cpir_{t-1}}{Cpir_{t-5}}\right) + \underset{(0.331)}{1.413} \log\left(\frac{Cpic_t}{Cpic_{t-4}}\right)$$
$$- \underset{(0.024)}{0.168}\, dum18 + \underset{(0.024)}{0.148}\, dum19$$

$Adj.R^2 = 0.81,\ \ F - stat = 37.95,\ \ LM(2) = 0.62$

15) Private consumption deflator equation

$$\log\left(\frac{Cdef_t}{Cdef_{t-4}}\right) = \underset{(0.198)}{0.509} + \underset{(0.104)}{0.293} \log\left(\frac{Gdpdef_t}{Gdpdef_{t-4}}\right) - \underset{(0.097)}{0.881} \log(Cdef_{t-4})$$
$$+ \underset{(0.134)}{0.608} \log(Cpi_{t-4}) + \underset{(0.087)}{0.191} \log(Gdpdef_{t-4}) + \underset{(0.035)}{0.218}\, dum20 - \underset{(0.049)}{0.203}\, dum21$$
$$- \underset{(0.048)}{0.19}\, dum22$$

$Adj.R^2 = 0.67,\ \ F - stat = 19.30,\ \ LM(2) = 1.67$

16) Government consumption deflator equation

$$\log\left(\frac{Gdef_t}{Gdef_{t-4}}\right) = \underset{(0.131)}{0.820} + \underset{(0.065)}{0.132} \log\left(\frac{Gdef_{t-1}}{Gdef_{t-5}}\right) + \underset{(0.148)}{0.325} \log\left(\frac{Gdpdef_t}{Gdpdef_{t-4}}\right)$$
$$- \underset{(0.077)}{0.850} \log(Gdef_{t-4}) + \underset{(0.072)}{0.727} \log(Gdpdef_{t-4}) - \underset{(0.105)}{0.689}\, dum23 + \underset{(0.053)}{0.421}\, dum24$$

$Adj.R^2 = 0.76,\ \ F - stat = 34.12,\ \ LM(2) = 1.53$

17) Exports deflator equation

$$\log\left(\frac{Expdef_t}{Expdef_{t-4}}\right) = \underset{(0.269)}{-0.719} + \underset{(0.066)}{0.377}\log\left(\frac{Expdef_{t-1}}{Expdef_{t-5}}\right) + \underset{(0.371)}{1.299}\log\left(\frac{Cpi_t}{Cpi_{t-4}}\right)$$
$$+ \underset{(0.161)}{0.808}\log\left(\frac{Gdpdef_t}{Gdpdef_{t-4}}\right) - \underset{(0.078)}{0.388}\log(Expdef_{t-4}) + \underset{(0.154)}{0.310}\log(Cpi_{t-4})$$
$$+ \underset{(0.116)}{0.201}\log(Gdpdef_{t-4}) + \underset{(0.066)}{0.266}\,dum25 - \underset{(0.068)}{0.239}\,dum26$$

$Adj.R^2 = 0.84,\ \ F - stat = 35.74,\ \ LM(2) = 3.07$

18) Imports deflator equation

$$\log\left(\frac{Impdef_t}{Impdef_{t-4}}\right) = \underset{(0.217)}{-0.059} + \underset{(0.097)}{0.302}\log\left(\frac{Impdef_{t-1}}{Impdef_{t-5}}\right)$$
$$+ \underset{(0.072)}{0.352}\log\left(\frac{Kztusd_t}{Kztusd_{t-4}}\right) - \underset{(0.039)}{0.185}\log(Impdef_{t-4}) + \underset{(0.053)}{0.188}\log(Kztusd_{t-4})$$
$$+ \underset{(0.051)}{0.178}\,dum27 + \underset{(0.061)}{0.255}\,dum28$$

$Adj.R^2 = 0.57,\ \ F - stat = 14.69,\ \ LM(2) = 0.38$

The asset markets in the model consist of bond and foreign exchange markets. The bond market is represented by domestic government bonds. The medium term government bond yield is the reference interest rate in the economy which affects investment in the model. The government bond yield equation is specified in levels and depends on lagged values of itself and of the central bank policy interest rate. The underlying framework behind this relation is one of the most important consequences of expectations theory of interest rates which states that interest rates in a given economy tend to move in unison. As a result, the policy interest rate in the equation has a significant positive impact on the medium term government bond yield in line with expectations theory of interest rates. On the foreign exchange market side, the real exchange rate is modeled instead of the nominal exchange rate. The real exchange rate depends on its own lagged value, domestic CPI, policy interest rate differential and bilateral nominal exchange rates with other countries. According to the coefficients of the equation, there is inertia in percentage changes of real exchange rate. In addition, an increase in domestic CPI or relative interest rate leads to real appreciation of the domestic currency as the economic theory predicts (e.g. Mundell-Fleming model).[5]

19) Medium-term government bond yield equation

$$Midgovb_t = \underset{(0.002)}{-0.0003} + \underset{(0.147)}{1.232}\, Midgovb_{t-1} - \underset{(0.145)}{0.293}\, Midgovb_{t-2} + \underset{(0.026)}{0.046}\, Nbrkr_t$$

$Adj.R^2 = 0.97, \;\; F - stat = 823.25, \;\; LM = 6.01$

20) Real exchange rate equation

$$\log\left(\frac{Reer38_t}{Reer38_{t-4}}\right) = \underset{(0.013)}{-0.024} + \underset{(0.056)}{0.213}\,\log\left(\frac{Reer38_{t-1}}{Reer38_{t-5}}\right)$$
$$-\underset{(0.039)}{0.305}\,\log\left(\frac{Kzteur_t}{Kzteur_{t-4}}\right) - \underset{(0.050)}{0.159}\,\log\left(\frac{Kztusd_t}{Kztusd_{t-4}}\right) - \underset{(0.039)}{0.207}\,\log\left(\frac{Kztrub_t}{Kztrub_{t-4}}\right)$$
$$+\underset{(0.129)}{0.308}\,\log\left(\frac{Cpi_t}{Cpi_{t-4}}\right) + \underset{(0.193)}{0.328}\,(Nbrkr_t - Fedr_t)$$

$Adj.R^2 = 0.95, \;\; F - stat = 167.90, \;\; LM(2) = 1.49$

One of the most important equations in the model is the central bank policy interest rate equation. The policy interest rate depends on its own lagged value and inflation rate in the economy. The inclusion of inflation rate represents the mandate of the central bank to maintain price stability in the economy. Economists tend to include also output gap into the central bank interest rate equation in the spirit of the Taylor rule.[6]. There are also equations for government revenue components such as corporate income taxes, VAT taxes, excises and other taxes. These equations are estimated to get the best empirical fit and represent responses of government revenues to changes in the endogenous variables of the model.

[5] Mundell (1963) and Fleming (1962)

[6] Taylor (1993)

21) Central Bank policy rate equation

$$Nbrkr_t = \underset{(0.002)}{0.008} + \underset{(0.037)}{0.788}\, Nbrkr_{t-1} + \underset{(0.026)}{0.099}\, Infl_t + \underset{(0.004)}{0.054}\, dum29$$

$R^2 = 0.95,\;\; F - stat = 22.38,\;\; LM(2) = 1.47$

22) Corporate income taxes equation

$$\log\left(\frac{Inctaxcorp_t}{Inctaxcorp_{t-4}}\right) = \underset{(0.345)}{0.268} + \underset{(0.076)}{0.357}\, \log\left(\frac{Inctaxcorp_{t-1}}{Inctaxcorp_{t-5}}\right)$$
$$+ \underset{(0.293)}{1.114}\, \log\left(\frac{Gdpn_t}{Gdpn_{t-4}}\right) - \underset{(0.078)}{0.399}\, \log(Inctaxcorp_{t-4}) + \underset{(0.069)}{0.208}\, \log(Gdpn_{t-4})$$
$$- \underset{(0.158)}{0.620}\, dum30 - \underset{(0.161)}{0.533}\, dum31$$

$Adj.R^2 = 0.67,\;\; F - stat = 22.39,\;\; LM(2) = 4.23$

23) VAT equation

$$\log\left(\frac{Vat_t}{Vat_{t-4}}\right) = \underset{(0.186)}{0.164} + \underset{(0.082)}{0.140}\, \log\left(\frac{Vat_{t-1}}{Vat_{t-5}}\right) + \underset{(0.282)}{0.937}\, \log\left(\frac{Vatrate_t Cn_t}{Vatrate_{t-4} Cn_{t-4}}\right)$$
$$- \underset{(0.094)}{0.672}\, \log(Vat_{t-4}) + \underset{(0.091)}{0.576}\, \log(Vatrate_{t-4}\, Cn_{t-4}) - \underset{(0.187)}{0.937}\, dum32 - \underset{(0.187)}{0.498}\, dum33$$

$Adj.R^2 = 0.64,\;\; F - stat = 19.49\;\; LM(2) = 0.59$

24) Excise tax equation

$$\log\left(\frac{Excises_t}{Excises_{t-4}}\right) = -\underset{(0.246)}{0.587} + \underset{(0.096)}{0.210}\, \log\left(\frac{Excises_{t-1}}{Excises_{t-5}}\right)$$
$$+ \underset{(0.096)}{0.225}\, \log\left(\frac{Excises_{t-2}}{Excises_{t-6}}\right) - \underset{(0.071)}{0.175}\, \log(Excises_{t-4}) + \underset{(0.056)}{0.154}\, \log(Cn_{t-4})$$
$$- \underset{(0.073)}{0.295}\, dum34 + \underset{(0.106)}{0.435}\, dum35$$

$Adj.R^2 = 0.52,\;\; F - stat = 11.81,\;\; LM(2) = 1.79$

25) Other tax equation

$$Othertax_t - Othertax_{t-4} = -\underset{(20.384)}{10.596} + \underset{(0.082)}{0.259}\,(Othertax_{t-1} - Othertax_{t-5})$$

$$+\underset{(0.011)}{0.035}\,(Gdpn_t - Gdpn_{t-4}) - \underset{(0.119)}{0.690}\,Othertax_{t-4} + \underset{(0.005)}{0.024}\,Gdpn_{t-4} - \underset{(49.172)}{212.584}\,dum36$$

$Adj.R^2 = 0.63$, $F - stat = 21.70$, $LM(2) = 2.76$

Combining all the regression equations and identities into a single model grants us with an opportunity to run simulations and generate forecasts for endogenous macroeconomic variables. The simulation results and forecasts of the model are discussed in detail in further sections.

5. Simulation

The model is simulated starting from 2003 to 2017. Figure F.1 to Figure F.6 in Appendix F present the dynamics of actual observations and baseline simulation results of the model for real GDP growth, potential output growth, inflation rate, unemployment rate, real wage growth and real exchange rate. Solid lines show actual observations and dashed lines represent baseline simulations. The simulation results are interpreted as ex-post forecasts of the model, since forecast values of endogenous variables and actual values of exogenous variables are taken to solve the model.

Figure F.1 in Appendix F presents the annual GDP growth rate from actual data and model simulation results. The figure clearly shows that the model overshoots real GDP growth rate in expansions and recessions after 2010. For example, the model predicts a more significant expansion of output in 2011-2012 and more severe contraction of economic activity in 2015. The economy indeed experienced several quarters of free fall in output in 2015, but the annual growth rate of real GDP remained positive. However, the model simulation shows that the economy should have contracted by almost 4% that year. The model also predicts a faster growth after the recession than actually observed after 2015.

The potential output growth in Figure F.2 is approximated almost perfectly by the model.

Actual and baseline inflation rates follow similar dynamics between 2004 and 2008, but they tend to differ from each other afterwards (see Figure F.3). This could be due to the structural break appearing in the crisis period when there were external shocks not captured by the model. Baseline simulation of other important macroeconomic variables such as unemployment rate, real wage growth and real exchange rate resemble actual observations of these variables.

6. Forecasts and scenarios

Simulation results in the previous section show that the dynamics of most important endogenous variables are tracked satisfactorily by the model. Hence, the model can be used for forecasting and scenario analyses for Kazakhstani economy. The models are solved to generate ex-ante forecasts from 2018 to 2020, since there is data only until the last quarter of 2017. For the purposes of ex-ante forecasting some reasonable assumptions are made on exogenous variables within the model. Among all the most important assumptions being about future paths of oil prices, nominal exchange rates, foreign price levels, US federal funds rate, world trade and population growth.

Table 1 shows ex-ante forecasts for real GDP growth, potential output growth, inflation rate and unemployment rate from 2018 to 2020 under the scenario of oil prices remaining at 60 dollars per barrel from the fourth quarter of 2018. The model predicts GDP growth rates of 3.8 % in 2018 and 2.8 % in 2019. But it falls dramatically to 1.8% around 2020 due to the contraction of world trade. Inflation rate forecasts are 5.9%, 4.3% and 2.4% for 2018-2020. The central bank set the target inflation rate at 5-7% for 2018 and 4-6% for 2019. Forecasts on unemployment rate and potential output growth do not vary much over time.

Table 2 presents ex-ante forecasts under the oil price being at 50 dollars per barrel from the fourth quarter of 2018. The model forecasts GDP growth

	Real GDP growth	Potential output growth	Inflation rate	Unemployment rate
2018	3.8%	3.8%	5.9%	4.9%
2019	2.8%	3.9%	4.3%	4.8%
2020	1.8%	3.7%	2.4%	4.7%

Table 1: Ex-ante forecasts under the scenario of oil price 60 dollars per barrel

rates of 3.6%, 1.9% and 1.5% for 2018-2020 with inflation rates falling below the forecasts in Table 1. Potential output growth and unemployment rate forecasts do not differ in the two scenarios.

	Real GDP growth	Potential output growth	Inflation rate	Unemployment rate
2018	3.6%	3.8%	5.9%	4.9%
2019	1.9%	3.8%	3.8%	4.8%
2020	1.5%	3.6%	2.1%	4.8%

Table 2: Ex-ante forecasts under the scenario of oil price 50 dollars per barrel

The reason for generating forecasts for macroeconomic variables under a variety of oil price scenarios is simple. Kazakhstani economy is heavily dependent on the exports of oil. In turn, this means that external shocks such as an oil price increase or decrease have a significant impact on domestic economic conditions. At the time these forecasts are made, there is a bulk of uncertainty over where the oil market may head. On the one hand, the world economy is strong and expanding at above 3%, which stimulates demand for oil. In addition, sanctions on Iran further stimulate oil price increases. On the other hand, the trade war between the US and China may slow down the world economy by decreasing the demand for energy resources. All of these factors make it hard to predict with reasonable accuracy the price of oil that will prevail in the future. The world trade has also been assumed to contract at 1% every quarter from the beginning of 2019 in the above forecasts. The possibility of generating of ex-ante forecasts under a variety of scenarios justifies the use of macroeconometric models, even though they are largely neglected in current academic literature.

It is essential to give reasonable explanations for the difference between ex-ante forecasts under oil price scenarios given above. The scenarios substantially differ in their forecasts of real GDP growth rate for 2019. The oil price of 60 dollars per barrel implies a higher output growth rate than in the scenario with oil price being at 50 dollars. This makes perfect sense given that higher oil prices stimulate aggregate demand and output via net exports.

Figure F.7 shows contributions of each expenditure component of GDP to output growth in the model. The figure shows that private consumption contributed to real GDP growth the most in 2012 and 2013, but its contribution fell from 2014 to 2017. Oil exports contributed negatively to output growth from 2014 to 2016, when the oil price was substantially low, and its contribution turned positive from 2017, when the oil price started rising. Non-oil exports counteracted the negative influence of oil exports on output growth in 2014 with private consumption and investment contributing to real GDP growth negligibly. The model also forecasts that the main driver of output growth should be private consumption and oil exports in 2018, the share of private consumption growth in real GDP growth rising thereafter by contributing more than half.

7. Conclusion

Structural macroeconometric models are very useful tools for understanding the behavior of macroeconomic variables and making forecasts under a variety of assumptions. This kind of models take more data-oriented approach to explain the structure of the economy, and conclusions are derived by applying econometric techniques to empirical data. One of the main advantages of the models is their objective nature, since the data determines most of the structure of the model. However, the main advantage of structural macroeconometric models is also their most important weakness: measurement errors and poor quality of the data could drive a model in the wrong direction. Hence, one has to be always careful with the data when drawing conclusions from it. In this work, the poor quality of the data has been the issue to overcome. Hence, the data on GDP and its expenditure components have been adjusted for modeling the entire economy via econometric techniques backed by economic reasoning.

The model has been constructed using standard economic theory as the main instrument in choosing left-hand side and right-hand side variables in behavioral equations. The equations have been checked and corrected, if necessary, for any pathologies such as heterskedasticity and autocorrelation. The performance of the model in ex-post simulation over the period 2003-2017 seem to follow satisfactorily the behavior of most important macroeconomic variables. As a result, the model is used for generating ex-ante forecasts for all endogenous variables in the model from 2018 to 2020. The results indicate that the model predicts reasonable growth rates of real GDP, potential output and prices as well as the level of the unemployment rate.

Specifically, the model has been used to generate forecasts for macroeconomic variables under different scenarios for oil price and contracting world trade. The economic growth is forecast to be at 3.8 % and 2.8% in 2018-2019, if the oil price remains at 60 dollars per barrel. If the oil price falls to 50 dollars per barrel from the fourth quarter of 2018, the real GDP growth is predicted to be 3.6 % and 1.9%. The former scenario coincides with the baseline scenario of the National Bank of Kazakhstan.[7] According to the National Bank of Kazakhstan reports, the forecast real GDP growth rates are 3.5% and 2.7% for 2018 and 2019 under the baseline scenario. The inflation rate forecast of the model is 4.3% and the central bank predicts the inflation rate in the range of 4-6% with the expectation that it would remain closer to the upper bound. Overall, there is some consensus on the output growth and inflation rate prospects for 2018 and 2019. The slight divergence in inflation forecasts over 2020 makes sense given the increased uncertainty as forecast horizon gets farther. Moreover, there are differences in assumptions on future paths of other exogenous variables which

[7] National Bank of Kazakhstan, Press-Release #28, On inflation forecast - http://www.nationalbank.kz

could contribute significantly to the distinction in ex-ante forecasts.

The model has performed quite good in ex-post and ex-ante simulations. Advantages of using this kind models are clear, since they are flexible in use and able to encompass structural characteristics of the economy. Despite the lack of quality of macroeconomic data for Kazakhstan, the model based on empirical observations of relevant variables adequately approximates the economy. The macroeconometric model in this work serves as a useful tool for generating baseline scenario for the economy and should be a good starting point for building more advanced macroeconomic models for Kazakhstan.

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Appendix A.

Variables	**Definitions**	**Units of measurement**	**Source**
Endogenous			
Balance	Budget balance	Billion KZT	MF
Can	Current account, nominal	Billion KZT10	NBRK
Capsr	Capital stock, real	Billion KZT10	Own
Cdef	Private consumption deflator	Index	Own
Cn	Private consumption, nominal	Billion KZT	STAT
Cr	Private consumption, real	Billion KZT10	Own
Cpi	Consumer price index, 2010 = 100	Index	STAT
Demandr	Final demand, real	Billion KZT10	Own
Emp	Number of Employees	Thousands	STAT
Excises	Excises Revenues	Billion KZT	MF
Exn	Exports, nominal	Billion KZT	STAT
Exoiln	Exports of oil, nominal	Billion KZT	Trade Map
Exoilr	Exports of oil, real	Billion KZT10	Own
Exothern	Exports of other, nominal	Billion KZT	Own
Exotherr	Exports of other, real	Billion KZT10	Own
Expdef	Exports deflator	Index	Own
Exr	Exports, real	Billion KZT10	STAT
Gdef	Government consumption deflator	Index	Own

Gdpdef	GDP deflator	Index	STAT
Gdpn	GDP by expenditure, nominal	Billion KZT	STAT
Gdpr	GDP by expenditure, real	Billion KZT10	Own
Gr	Government consumption, real	Billion KZT10	Own
Hp_nairu	NAIRU	Percentage	Own
Hp_tfp	TFP	Level	Own
Impdef	Imports deflator, nominal	Billion KZT	Own
Impn	Imports of goods and services, nominal	Billion KZT	STAT
Impr	Imports of goods and services, real	Billion KZT10	Own
Income	Disposable income of private households, nominal	Billion KZT	Own
Incomer	Disposable income of private households, real	Billion KZT10	Own
Inctaxcorp	Corporate Income Tax Revenues	Billion KZT	MF
Inctaxpers	Personal Income Tax Revenues	Billion KZT	MF
Infl	Inflation rate	Percentage	Own
Invr	Gross Fixed Capital Formation, real	Billion KZT10	Own
Lforce	Labor force	Thousands	STAT
Midgovb	Midterm government bond rate	Percentage	NBRK

Nbrkr	Policy interest rate of the National Bank	Percentage	NBRK
Otherrev	Other government revenues	Billion KZT	MF
Othertax	Other tax revenues	Billion KZT	MF
Prod	Labor productivity	10000 KZT10 per employee	Own
Reer38	Real effective exchange rate index, group of 38 countries	Index	NBRK
Soctax	Social tax revenues	Billion KZT	MF
Tgen	Total government expenditures	Billion KZT	MF
Tgrn	Total government revenues	Billion KZT	MF
Ucc	User cost of capital	Index	Own
Ulc1	Unit labor cost	Index	Own
Unemp	Unemployment	Thousands	STAT
Unemprate	Unemployment rate	Percentage	Own
VAT	VAT revenues	Billion KZT	MF
Wageav	Average gross wage per employee, nominal	KZT	STAT
Wageavr	Average gross wage per employee, real	KZT10	Own
Ygap	Output gap	Billion KZT	Own
Ypot	Potential output	Billion KZT10	Own
Exogenous			
Cpic	CPI in China	Index	Bloomberg
Cpir	CPI in Russia	Index	Bloomberg

Depr	Capital stock depreciation rate	Percentage	Own
Fcapsale	Proceeds capital sale	Billion KZT	MF
Fedr	Federal funds rate	Percentage	Bloomberg
Gn	Government consumption	Billion KZT	STAT
Inctaxrate	Average personal income tax rate	Percentage	Own
Inventr	Change in inventory, real	Billion KZT10	Own
Kzteur	Nominal exchange rate KZT/EUR	KZT	NBRK
Kztrub	Nominal exchange rate KZT/RUB	KZT	NBRK
Kztusd	Nominal exchange rate KZT/USD	KZT	NBRK
Nontaxrev	Non-tax revenues	Billion KZT	MF
Oilpusd	Oil price, Brent	USD/Barrel	Bloomberg
Otherexp	Other government expenditures	Billion KZT	MF
Pop1564	Working age population, 15 to 64 years		STAT
Socsec	Social assistance and social security	Billion KZT	MF
Soctaxrate	Social tax rate	Percentage	MF
Swftrans	Transfers from Sovereign Wealth Fund	Billions KZT	MF
Uscpi	CPI in the USA	Index	Bloomberg
VATrate	VAT Rate	Percentage	MF

Wtrade	World trade index, 2010=100	Index	Bloomberg

Table A.1: List of Variables

Appendix B.

$$Gr_t = \frac{Gn_t}{Gdef_t} 100\% \tag{B.1}$$

$$Capsr_t = Capsr_{t-1}(1 - Depr_t) + Invr_t \tag{B.2}$$

$$Ygap_t = \frac{Gdpr_t - Ypot_t}{Ypot_t} \tag{B.3}$$

$$Gdpr_t = Cr_t + Gr_t + Invr_t + Exoilr_t + Exotherr_t - Impr_t + Inventr_t \tag{B.4}$$

$$Exr_t = Exoilr_t + Exotherr_t \tag{B.5}$$

$$Exoiln_t = Exoilr_t \frac{Expdef_t}{100\%} \tag{B.6}$$

$$Exothern_t = Exothern_t \frac{Expdef_t}{100\%} \tag{B.7}$$

$$Impn_t = Impr_t \frac{Impdef_t}{100\%} \tag{B.8}$$

$$Exn_t = Exoiln_t + Exothern_t \tag{B.9}$$

$$Can_t = Exn_t - Impn_t \tag{B.10}$$

$$Demandr_t = Cr_t + Invr_t + Gr_t + Exoilr_t + Exotherr_t \tag{B.11}$$

$$Gdpn_t = Gdpr_t \frac{Gdpdef_t}{100\%} \tag{B.12}$$

$$Cn_t = Cr_t \frac{Cdef_t}{100\%} \tag{B.13}$$

$$Prod_t = \frac{Gdpr_t}{Emp_t} \tag{B.14}$$

$$Wageavr_t = \frac{Wageav_t}{Cpi_t} 100\% \tag{B.15}$$

$$Ulc1_t = \frac{Wageav_t}{Prod_t} \tag{B.16}$$

$$Income_t = Gdpn_t + Socsec_t - Inctaxpers_t - Inctaxcorp_t - Vat_t - Excises_t - Othertax_t \tag{B.17}$$

$$Incomer_t = \frac{Income_t}{Cpi_t} 100\% \tag{B.18}$$

$$Infl_t = \frac{Cpi_t}{Cpi_{t-4}} - 1 \tag{B.19}$$

$$Ucc_t = Midgovb_t - Depr_t + Infl_t \tag{B.20}$$

$$Unemp_t = Lforce_t - Emp_t \tag{B.21}$$

$$Unemprate_t = \frac{Unemp_t}{Lforce_t} \tag{B.22}$$

$$Tgrn_t = Vat_t + Inctaxpers_t + Inctaxcorp_t + Soctax_t + Excises_t + Othertax_t + Otherrev_t \tag{B.23}$$

$$Tgen_t = Gn_t + Pubinvn_t + Socsec_t + Otherexp_t \tag{B.24}$$

$$Balance_t = Tgrn_t - Tgen_t \tag{B.25}$$

$$Soctax_t = 3 \cdot Soctaxrate_t \cdot Emp_t \cdot Wageav_t \tag{B.26}$$

$$Inctaxpers_t = 3 \cdot Inctaxrate_t \cdot Wageav_t \cdot Emp_t \tag{B.27}$$

$$Otherrev_t = Nontaxrev_t + Swftrans_t + Fcapsale_t \tag{B.28}$$

Appendix C.

Variable (level)	**ADF (c)**	**ADF (c,t)**	**PP (c)**	**KPSS**
Balance	-6,557***	-7,591***	-7,369***	0,757+++
Can	-2,654*	-3,691**	-2,461	0,72++
Capsr	1,506	-0,554	6,092	1,033+++
Cdef	3,05	-1,031	-1,403	1,052+++
Cn	5,325	-1,014	-1,195	1,026+++
Cpi	3,176	-0,857	3,443	1,061+++
Cpic	-0,111	-4,016**	0,484	1,064+++
Cpir	1,138	-1,916	1,446	1,061+++

Cr	-0,101	-1,964	-1,65	1,055+++
Demandr	-1,279	-2,614	-1,313	1,045+++
Emp	-2,043	-0,921	-2,463	1,034+++
Excises	4,752	2,974	3,874	0,938+++
Exn	-0,234	-3,25*	0,5	1,058+++
Exoiln	-1,201	-2,93	-0,924	0,96+++
Exoilr	-2,388	-2,116	-2,259	0,525++
Exothern	1,193	-1,731	2,777	1,043+++
Exotherr	-3,909***	-4,456***	-3,966***	0,448+
Expdef	-0,103	-3,271*	0,846	1,063+++
Exr	-3,03**	-3,645**	-2,934**	0,753+++
Fcapsale	-1,378	-2,438	-3,913***	0,597++
Fedr	-2,641*	-3,478*	-2,097	0,437+
Gdef	-0,216	-3,077	-2,716*	1,042+++
Gdpdef	1,193	-2,683	0,55	1,076+++
Gdpn	1,745	-1,624	0,32	1,062+++
Gdpr	-1,182	-2,194	-1,208	1,076+++
Gn	3,769	-2,086	1,092	1,048+++
Gr	-0,707	-7,434***	-3,01**	1,041+++
Impdef	0,434	-1,68	-0,544	1,014+++
Impn	0,782	-2,851	0,211	1,057+++
Impr	-1,151	-1,158	-1,857	0,984+++
Income	2,083	-1,673	0,26	1,061+++
Incomer	-0,732	-1,978	-2,374	1,067+++
Inctaxcorp	-1,161	-3,325*	-4,107***	0,982+++
Inctaxpers	3,177	-1,843	2,204	1,047+++
Inctaxrate	-4,138***	-8,204***	-8,437***	0,207
Infl	-3,663***	-3,621**	-2,948**	0,092
Inventr	-2,158	-2,708	-8,446***	0,349+
Invr	-0,663	-2,494	-6,692***	1,11+++

Kzteur	1,306	-2,033	0,892	0,808+++
Kztrub	-3,586***	-3,514**	-3,005**	0,064
Kztusd	0,332	-0,972	0,976	0,614++
Lforce	-1,946	-1,32	-2,162	1,024+++
Midgovb	-2,991**	-1,865	-4,269***	0,572++
Nbrkr	-3,143**	-3,211*	-2,531	0,113
Nontaxrev	-3,22**	-8,706***	-6,341***	0,944+++
Oilpusd	-2,091	-1,992	-2,01	0,458+
Otherexp	2,254	1,021	-5,655***	0,92+++
Otherrev	2,121	-7,294***	-3,611***	0,969+++
Othertax	0,122	-5,269***	0,021	1,05+++
Pop1564	-1,162	-2,282	-1,003	1,048+++
Prod	-1,197	-2,578	-1,954	1,067+++
Reer38	-3,213**	-3,163	-2,37	0,219
Socsec	2,818	-9,248***	-0,654	1,067+++
Soctax	1,747	-0,498	-0,314	1,001+++
Soctaxrate	-2,346	-1,677	-2,703*	0,946+++
Swftrans	2,01	-7,297***	-3,942***	1,07+++
Tgen	3,557	1,215	-0,699	1,057+++
Tgrn	2,72	0,485	-0,748	1,048+++
Ucc	-4,802***	-5,201***	-4,477***	0,327
Ulc1	0,266	-5,191***	-0,311	1,064+++
Unemp	-1,266	-0,899	-3,837***	1,06+++
Unemprate	-4,455***	-0,353	-3,529**	1,047+++
Uscpi	-1,305	-1,596	-1,602	1,064+++
Vat	0,381	-2,532	-0,475	1,039+++
Vatrate	-3,784***	-4,06**	-3,958***	0,976+++
Wageav	2,652	-2,937	0,882	1,065+++
Wageavr	-1,952	1,189	-1,699	1,023+++
Wtrade	-1,334	-3,479*	-0,828	1,002+++

Ygap	-3,633***	-3,628**	-12,31***	0,119
Ypot	-2,487	-1,334	-7,198***	1,076+++

Table C.2: Unit root test results of variables in levels

Variable (YoY)	**ADF (c)**	**ADF (c,t)**	**PP (c)**	**PP (c,t)**	**KPSS**
Balance	-6,871***	-6,79***	-7,678***	-7,665***	0,062
Can	-4,406***	-4,335***	-3,561***	-3,51**	0,058
Capsr	-0,781	-3,253*	-0,653	-3,234*	0,982+++
Cdef	-7,562***	-6,27***	-7,596***	-8,238***	0,466++
Cn	-5,151***	-7,417***	-5,482***	-7,425***	0,904+++
Cpi	-2,976**	-3,967**	-2,467	-3,105	0,628++
Cpic	-2,203	-1,992	-3,106**	-3,036	0,156
Cpir	-2,637*	-3,919**	-2,325	-2,326	0,371+
Cr	-7,408***	-7,348***	-7,406***	-7,345***	0,149
Demandr	-5,671***	-5,764***	-5,788***	-5,87***	0,142
Emp	-2,837*	-3,18*	-3,031**	-3,18*	0,452+
Excises	-2,79*	-4,342***	-2,679*	-4,397***	0,828+++
Exn	-3,316**	-3,27*	-3,275**	-3,282*	0,067
Exoiln	-3,286**	-3,244*	-3,516**	-3,477*	0,066
Exoilr	-4,024***	-4,374***	-4,008***	-4,345***	0,444+
Exothern	-3,286**	-3,636**	-2,759*	-2,922	0,328
Exotherr	-4,752***	-4,712***	-4,016***	-3,98**	0,055
Expdef	-3,604***	-2,459	-3,604***	-3,65**	0,094
Exr	-4,634***	-4,953***	-4,485***	-4,633***	0,383+
Fcapsale	-5,103***	-5,08***	-5,204***	-5,171***	0,058
Fedr	-2,955**	-2,916	-2,604*	-2,566	0,084
Gdef	-4,887***	-4,859***	-4,562***	-4,523***	0,088
Gdpdef	-4,54***	-4,847***	-4,155***	-4,324***	0,407+
Gdpn	-3,563***	-4,515***	-3,481**	-4,373***	0,725++

Gdpr	-4,389***	-4,486***	-4,471***	-4,486***	0,163
Gn	-5,796***	-3,761**	-6,071***	-7,462***	0,79+++
Gr	-8,418***	-8,354***	-10,154***	-10,064***	0,106
Impdef	-4,347***	-4,413***	-4,393***	-4,466***	0,191
Impn	-2,606*	-2,849	-3,832***	-3,901**	0,209
Impr	-4,764***	-4,82***	-4,855***	-4,899***	0,139
Income	-4,025***	-5,187***	-3,931***	-5,065***	0,795+++
Incomer	-4,613***	-4,594***	-4,6***	-4,581***	0,119
Inctaxcorp	-4,758***	-4,716***	-4,758***	-4,716***	0,047
Inctaxpers	-2,857*	-4,288***	-5,694***	-7,244***	0,776+++
Inctaxrate	-9,043***	-9,304***	-8,956***	-9,195***	0,26
Infl	-2,005	-1,991	-3,615***	-3,598**	0,054
Inventr	-8,036***	-7,979***	-8,038***	-7,98***	0,049
Invr	-9,208***	-9,169***	-9,426***	-9,424***	0,115
Kzteur	-1,777	-2,399	-2,646*	-2,681	0,255
Kztrub	-4,9***	-4,869***	-3,639***	-3,678**	0,114
Kztusd	-2,452	-3,777**	-2,978**	-3,236*	0,411+
Lforce	-2,834*	-3,091	-3,016**	-3,091	0,332
Midgovb	-0,218	-1,455	-0,364	-1,165	0,664++
Nbrkr	-3,195**	-3,14	-2,596*	-2,498	0,127
Nontaxrev	-6,775***	-6,775***	-7,666***	-7,609***	0,039
Oilpusd	-4,233***	-4,448***	-3,542***	-3,646**	0,245
Otherexp	-7,658***	-8,218***	-7,657***	-8,218***	0,481++
Otherrev	-8,035***	-8,562***	-8,047***	-8,558***	0,39+
Othertax	-5,545***	-5,645***	-5,675***	-5,721***	0,117
Pop1564	-3,742***	-3,958**	-3,88***	-3,97**	0,17
Prod	-4,799***	-4,861***	-4,799***	-4,957***	0,165
Reer38	-2,366	-3,55**	-2,997**	-2,981	0,141
Socsec	-0,733	-2,605	-11,69***	-12,204***	0,62++
Soctax	-3,858***	-4,304***	-6,237***	-6,503***	0,328

Soctaxrate	-3,473**	-4,42***	-7,587***	-8,049***	0,564++
Swftrans	-7,814***	-8,266***	-7,835***	-8,265***	0,352+
Tgen	-0,506	-1,723	-6,914***	-7,858***	0,671++
Tgrn	-6,745***	-7,476***	-6,907***	-7,548***	0,475++
Ucc	-6,543***	-6,612***	-4,001***	-4,026**	0,191
Ulc1	-5,939***	-5,926***	-5,931***	-5,918***	0,283
Unemp	-3,042**	-3,331*	-4,335***	-4,268***	0,452+
Unemprate	-3,436**	-3,566**	-4,817***	-5,381***	0,728++
Uscpi	-3,457**	-3,577**	-3,58***	-3,577**	0,225
Vat	-4,786***	-4,992***	-5,269***	-5,343***	0,134
Vatrate	-5,779***	-5,672***	-5,818***	-5,693***	0,575++
Wageav	-5,648***	-6,323***	-5,574***	-6,38***	0,651++
Wageavr	-2,81*	-5,43***	-4,889***	-5,545***	0,444+
Wtrade	-5,653***	-5,67***	-2,965**	-2,991	0,083
Ygap	-5,001***	-4,961***	-5,102***	-5,063***	0,044
Ypot	-2,012	-2,846	-2,128	-3,064	0,615++

Table C.3: Unit root test results of variables in year over year measure

Appendix D.

Equation	**JB**	**BPG**	**ARCH**	**LM**
Average nominal wage equation	1.334	5.94	1.836	0.461
Consumer price equation	11.4***	4.368	0.349	0.398
Consumption deflator equation	0.219	9.305	0.043	1.673
Consumption equation	0.266	8.576	0.26	1.873
Corporate income taxes equation	0.678	6.44	0	4.227

Employment equation	0.772	-	-	-
Excises revenues equation	0.24	6.16	1.382	1.788
Exports deflator equation	2.404	5.957	0.15	3.077
GDP deflator equation	5.245*	4.623	0.021	0.616
Government spending deflator equation	2.798	5.499	0.59	1.531
Imporst deflator equation	6.219**	4.525	0.102	0.386
Imports equation	1.968	12.893	0.002	0.265
Investment equation	1.26	7.553	0.101	1.024
Labour force equation	0.736	-	-	-
Medium term interest rate equation	156.018***	6.317*	0.002	6.019**
NAIRU trend equation	27.61***	-	-	-
Oil exporst equation	0.916	6.869	1.911	3.599
Non-oil exports equation	1.077	7.241	4.475**	2.321
Other taxes equation	0.247	9.733*	1.707	2.763
Policy interest rate equation	22.378***	20.527***	0.128	1.475
Real effective exchange rate equation	0.441	15.048**	0.271	1.49
Total factor productivity	394.813***	-	-	-
VAT equation	0.007	5.886	0.038	0.586

Table D.4: Normality, heteroskedasticity and autocorrelation tests

Appendix E.

Equation	**ADF**	**PP**	**KPSS**
Average nominal wage equation	-1,184	-7,218***	0,474++
Corporate income taxes equation	-3,134**	-5,594***	0,167
Excises revenues equation	-0,663	-5,676***	0,272
Exports deflator equation	-2,989**	-4,904***	0,233
Government spending deflator	-7,44***	-9,512***	0,131
Imports deflator equation	-2,744*	-2,978**	0,64++
Imports equation	-6,125***	-6,123***	0,196
Investment equation	-0,996	-10,596***	0,19
Oil exports equation	-5,826***	-5,748***	0,267
Non-oil exports equation	-5,289***	-5,253***	0,063
Other taxes equation	-6,568***	-6,524***	0,214
Private consumption deflator equation	-7,32***	-7,363***	0,19
Private consumption equation	-1,736	-6,96***	0,455+
VAT equation	-5,911***	-6,086***	0,2

Table E.5: Unit root tests of residuals from long-run equation (test for cointegration)

Appendix F.

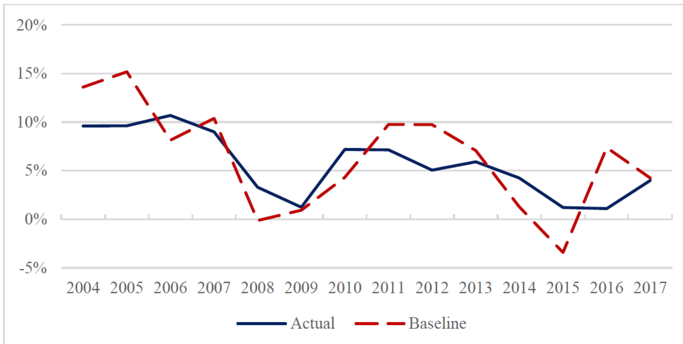

Figure F.1: Real GDP growth rate

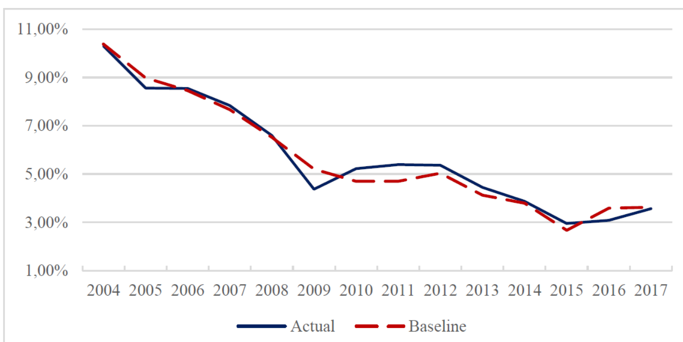

Figure F.2: Potential output growth

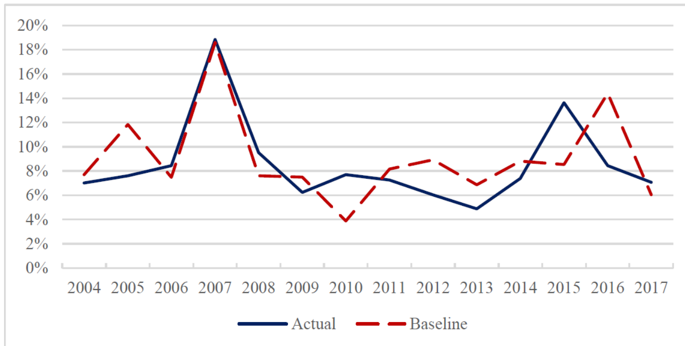

Figure F.3: Inlflation rate

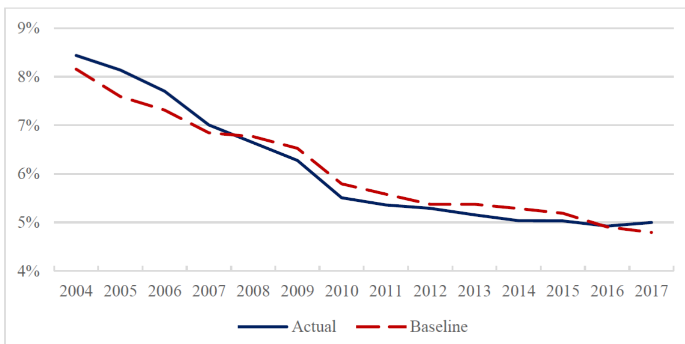

Figure F.4: Unemployment rate

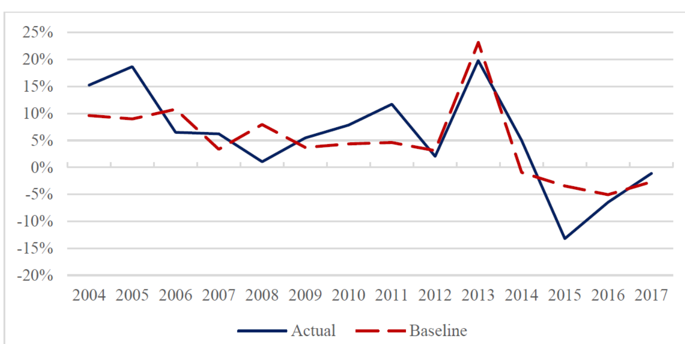

Figure F.5: Real wage growth rate

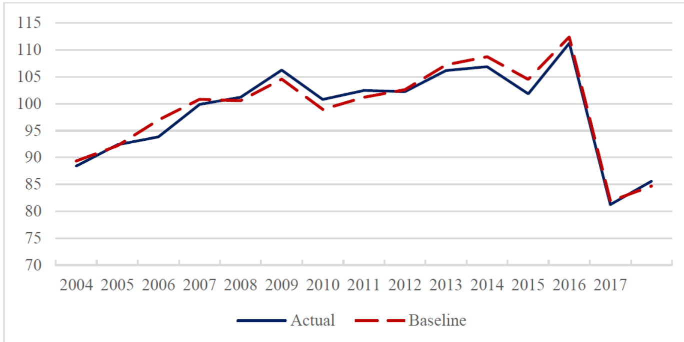

Figure F.6: Real exchange rate

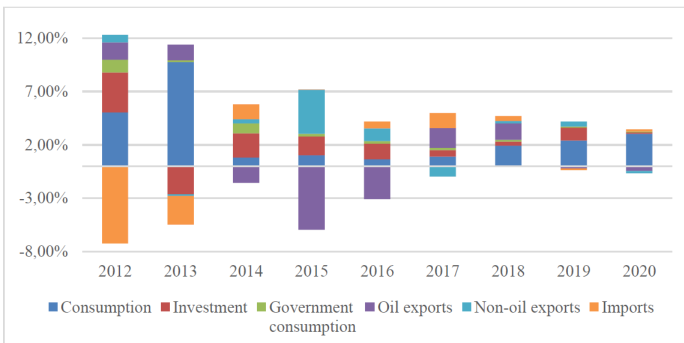

Figure F.7: Real GDP growth decomposition