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A Macroeconomic Forecasting Model of the Fixed Exchange Rate Regime for the Oil-Rich Kazakh Economy

Tibor Hlédik, Karel Musil, Jakub Ryšánek, and Jaromír Tonner *

Abstract

This paper presents a semi-structural quarterly projection open-economy model for analyzing monetary policy transmission and macroeconomic developments in Kazakhstan during the period of the fixed exchange rate regime. The model captures key stylized facts of the Kazakh economy, especially the important role of oil prices in influencing the economic cycle in Kazakhstan. The application of the model to observed data provides a reasonable interpretation of Kazakh economic history, including the global crisis, through to late 2015, when the National Bank of Kazakhstan introduced a managed float. The dynamic properties of the model are analyzed using impulse response functions for selected country-specific shocks. The model's shock decomposition and in-sample forecasting properties presented in the paper suggest that the model was an applicable tool for monetary policy analysis and practical forecasting at the National Bank of Kazakhstan. In a general sense, the model can be considered an example of a quarterly projection model for oil-rich countries with a fixed exchange rate.

Abstrakt

Článek představuje semistrukturální čtvrtletní model malé otevřené ekonomiky zaměřený na analýzu měnověpolitického transmisního mechanismu a makroekonomického vývoje v Kazachstánu během režimu fixního kurzu. Model zachycuje základní stylizovaná fakta kazachstánské ekonomiky, především významnou úlohu cen ropy, která ovlivňuje ekonomický cyklus v Kazachstánu. Aplikace modelu na pozorovaných datech ukazuje jeho použitelnost pro interpretaci kazachstánské ekonomické historie, včetně období globální ekonomické krize až do konce roku 2015, kdy Národní banka Kazachstánu zavedla režim plovoucího směnného kurzu. Dynamické vlastnosti modelu jsou analyzovány pomocí impulzních odezev na šoky typické pro kazachstánskou ekonomiku. Šokové dekompozice a historické simulace prezentované v článku ukazují, že tento model byl vhodným nástrojem pro měnověpolitické analýzy a praktické prognózování v Národní bance Kazachstánu. V obecnějším smyslu lze tento model považovat jako příklad čtvrtletního predikčního modelu pro ekonomiky bohaté na ropu s režimem fixního směnného kurzu.

JEL Codes: C50, E17, E32, E52, E58.
Keywords: Fixed exchange rate, Kazakhstan, monetary policy, QPM, stylized facts.

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Nontechnical Summary

The main aim of this paper is to develop a quarterly projection model (QPM) of the Kazakh economy for forecasting and policy analysis work at the National Bank of Kazakhstan (NBK). The presented model captures the transmission mechanism of an oil-exporting country with a fixed exchange rate. Since it has been calibrated to Kazakh data, it represents an analytical tool suitable for performing monetary policy analyses and forecasting at the NBK. The model captures the monetary policy transmission mechanism, with a special emphasis on the country-specific characteristics of the Kazakh economy, including the imperfect functioning of some of its transmission channels. Most importantly, Kazakhstan is a natural resource-rich country that operated under a fixed exchange rate regime until late 2015. The NBK devalued the tenge twice during this period. The economic cycle in Kazakhstan is significantly influenced by the world price of oil and very high import intensity of domestic demand, reflecting a low production base of tradable, non-commodity goods. These Kazakh characteristics make the presented QPM somewhat different from the benchmark models commonly used at central banks.

The model follows a New Keynesian setup based on forward-looking behavioral equations, specified in gap form. This means that the model incorporates nominal and real rigidities and simultaneously identifies the business cycle position and the long-run trends of the economy. The model consists of several blocks: the real economy, price dynamics, monetary policy, and the nominal and real exchange rate. The last block, specifying the exchange rate, is designed to reflect a monetary policy regime based on a fixed exchange rate.

The model structure and properties are tested using several techniques. Filtration of the observed data using the QPM allows the main factors explaining inflation, economic growth, and other macroeconomic variables during the period 2000–2015 to be identified and examined. Rising oil prices resulted in robust economic growth and a stable exchange rate in the first half of the 2000s. However, the high oil revenues led to an overheating of the Kazakh economy before the outbreak of the global crisis, followed by a significant contraction. Deteriorating terms of trade, due to falling oil prices, in early 2009 were closely followed by the first nominal devaluation of the currency. Another devaluation, driven mainly unfavorable external shocks, came in 2015. By the end of the year, the NBK had switched to a managed float. Other tools used to evaluate the structure, calibration, and performance of the model include the reactions of the economy to structural shocks and an assessment of the ex-post mechanistic predictions over the historical sample.

Based on its properties and historical interpretation, the QPM performs well, mainly in terms of providing a better understanding of monetary policy transmission for the period of the fixed exchange rate regime in Kazakhstan. The model was tested during practical monetary policy forecasting rounds at the NBK during that time. After the introduction of the managed exchange rate and the NBK's announcement of a move to inflation targeting, coupled with ongoing structural changes in the Kazakh economy, the current model requires fundamental changes. Nevertheless, the model presented in this paper extends the portfolio of available (semi-)structural modeling techniques that can be used not only for comprehensive policy analysis in Kazakhstan, but also for practical monetary policy applications in oil-exporting countries in general.

1. Introduction

The National Bank of Kazakhstan (NBK) has worked on improving and strengthening its monetary policy framework and implementation over the past several years. This effort has been combined with a switch from a fixed exchange rate to an inflation targeting framework, a strengthening of the role of communication, and a deepening of monetary policy analysis in order to effectively shape inflation expectations. One of the possible ways in which these areas can be effectively enhanced is to introduce a semi-structural macroeconomic model that links monetary policy to economic activity and inflation. Such a model is then integrated into a set of processes and tools (a Forecasting and Policy Analysis System) to prepare coherent macroeconomic and monetary policy analyses, baseline and alternative forecasts, and risk scenarios and thus improve monetary policy decisions.

The goal of this paper is to develop a tractable tool for practical monetary policy analysis and forecasting in oil-producing countries operating under a fixed exchange rate regime, as prevailed in Kazakhstan before August 2015. The model was the result of technical cooperation between the Czech National Bank (CNB) and the NBK and was the first model to be used for practical monetary policy projecting at the NBK. It was also the first semi-structural model to feature forward-looking expectations and to be calibrated to Kazakh data, and it was used actively at the NBK for policy analysis purposes. Some of the modeling choices (such as the highly aggregated structure of the model and the simple treatment of oil prices and their transmission to nominal and real variables) reflect the authors' preference to keep the model tractable. Model simplicity was a high priority in order to be able to bring the model to data and operationalize policy work at a later stage. The paper is therefore expected to inspire economists working at policy-making institutions in oil-producing countries with fixed exchange rates and searching for a tractable policy analysis tool.

The semi-structural gap model developed in this paper belongs to the class of New Keynesian models incorporating model-consistent forward-looking expectations formation and both nominal and real rigidities, as observed in the Kazakh economy. This class of models contains small semi-structural models capturing the most important stylized facts of the economy they focus on, including the key transmission channels of monetary policy. Like all gap models, the model in this paper incorporates the basic principle that the fundamental role of monetary policy is to provide an anchor for inflation expectations. Due to existing nominal and real rigidities in the economy, aggregate demand determines output in the short run; expectations matter for both inflation and output determination. Domestic policy interest rates are set to be consistent with sustainability of the fixed exchange rate and arbitrage-free conditions on the foreign exchange market.

The structural core of the model is similar to that of the workhorse models used at central banks for policy analysis and forecasting, but importantly it enlarges this area in the case of Kazakhstan and for natural-resource-rich countries in general. There have been several attempts to describe the behavior of the Kazakh economy and monetary authority using a modeling approach. Past studies used a macro-econometric framework and were aimed mainly at the period of transition and the 2000s – see, for example, Dufrénot and Sand-Zantman (2004) and Dufrénot et al. (2014). Additionally, analysts from the NBK developed a small macroeconomic model of Kazakhstan (KMOD) in order to produce medium-term forecasts of the main macroeconomic variables, as documented in Agambayeva et al. (2010). This model was amended and updated several times to take account of the changing structure of the Kazakh economy (KazMOD) and still forms part of the Forecasting and Policy Analysis System (FPAS) used at the central bank. A simple semi-structural model-based analysis of monetary policy under a fixed exchange rate and the implications

of varying degrees of exchange rate flexibility for interest rate policy and open market operations in Kazakhstan was presented by Epstein and Portillo (2014). However, this paper focused on understanding the macroeconomic implications of alternative policy regimes, not on forecasting, as the model does not include any forward-looking behavior. The model introduced in this paper was the first semi-structural model to the used for comprehensive policy analysis in Kazakhstan in the period of the fixed exchange rate regime. Moreover, regarding monetary policy modeling in oil-exporting economies in general, efforts have been concentrated mainly on the DSGE approach (see recently the cases of Colombia in Hamann et al. (2016), Norway in Bergholt et al. (2017), Russia in Drygalla (2017), and the U.S. in Melek et al. (2017), among many others). Nevertheless, none of these models is used for practical monetary policy forecasting like the Kazakh model presented in this paper.

This paper is structured to present the macroeconomic model, which reflects stylized facts of the Kazakh economy, and to illustrate its main properties. The following section summarizes the key features of the Kazakh economy that are relevant for designing, calibrating, and evaluating the semi-structural model, which is then introduced in section 3. It provides a detailed description of the model equations, the main economic intuition behind them, and the calibration of the model. Section 4 focuses on the implementation of the model through calibration of a Kalman filter, which is the main tool for identifying all the shocks included in the model, including those determining the unobserved variables. It is followed by sections 5 and 6, discussing the dynamic properties and in-sample forecast characteristics of the model. The last section concludes. Appendices provide a detailed description of the stylized facts of Kazakhstan, which are relevant to the model specification and calibration, and the data used throughout the analysis.

2. An Overview of the Kazakh Economy

This section briefly summarizes the key features of the Kazakh economy that are relevant to the design, calibration, and evaluation of the structural model presented in the following sections. It focuses on the most distinctive characteristics of the economy that are crucial for understanding the main transmission channels of monetary policy and the determinants of the real economy and for enhancing the interpretation of the model-based results.

Besides presenting the stylized facts, this section focuses on those recent main economic characteristics of the Kazakh economy which are not directly integrated into the model framework but which should be incorporated into model-based forecasts via expert judgments. The primary focus of this section is thus the period from 2000 through 2015, which was characterized by impressive economic growth and social progress, a relatively stable political system, and rising extraction of natural resources.

Nevertheless, the paper does not reflect the regime shift introduced in August 2015, when Kazakhstan abandoned the fixed exchange rate and launched a transition to inflation targeting. This is due to the relatively short period of time that has followed this monetary policy regime change, which prevents us from properly translating the new structure of the economy into a new model structure. So, in this paper we will focus solely on the period of the fixed exchange rate.

2.1 Kazakh Economy Characteristics

There are several key features of the Kazakh economy that significantly influence its development and future prospects:

- **Kazakhstan is a natural-resource-rich country: hydrocarbon (particularly oil) output has been increasing, and this trend is expected to continue.** Oil is Kazakhstan's main export commodity and is also a significant source of government revenues. Consequently, Kazakhstan has remained an attractive destination for foreign direct investment (FDI), in the energy sector in particular. Economic performance is thus strongly linked to the world price of crude oil. On the other hand, the country's dependence on oil revenues poses several challenges to its macroeconomic balance.
- **The government has built up an oil fund: the authorities can use the revenues for fiscal stabilization and to bolster the central bank's foreign exchange reserves.** Although economic crises and oil price shocks have hit the Kazakh economy in recent times, the level of external debt remains low. The external debt is allocated mainly within the extractive sector.
- **The financial sector has been facing several challenges: the banking system, which is largely domestically owned, has relied heavily on external financing and is characterized by a low deposit base and high dollarization.** These characteristics influence not only the financial sector, but also the whole economy, so foreign currency risk remains high.
- **Monetary policy transmission channels remain weak: although the fixed exchange rate has provided a nominal anchor most of the time, one-step exchange rate devaluations against the U.S. dollar have made it difficult to build credibility for the national currency.** As a consequence, Kazakhstan still exhibits a high level of dollarization, weakening the main monetary policy transmission channel, and the central bank's benchmark interest rate does not provide a signal about the monetary policy stance. In addition, the underdevelopment of the money market and the absence of market makers determining the yield curve make it difficult for domestic banks to provide tenge-denominated loans at reasonable cost.

Although some of these features are common to natural-rich-resource countries, there are notable differences between other such countries and Kazakhstan. Appendix A describes the main country-specific characteristics of Kazakhstan in detail, with a special emphasis on their incorporation into the model framework and their reflection in the model's dynamic properties.

3. Semi-Structural Model of the Kazakh Economy

The quarterly projection model (QPM) is a highly aggregated, small open economy model of the Kazakh economy.[1] It captures the key macroeconomic relationships in the economy, which operates under a fixed exchange rate regime. This section introduces the core structural equations of the QPM. The QPM is defined in gap form, that is, gap variables are defined as percentage deviations from their trends (or "equilibrium" values). The unobserved trend (equilibrium) values are determined using the Kalman filter.

The price block of the model captures the dynamics of total inflation via its two subcomponents. It consists of three equations (1)−(3), specified below. Equation (1) is a log-linear approximation of an identity

$$\pi_t = \alpha_1^1 \cdot \pi_t^F + (1 - \alpha_1^1) \cdot \pi_t^{NF} + \varepsilon_t^{\pi}, \tag{1}$$

that expresses total inflation, based on the structure of the consumer price index and the definition of food and non-food items, as a weighted sum of food and non-food inflation. Coefficient α_1^1 is

[1] We developed the model jointly with experts from the Research and Statistics Department at the NBK. Those experts subsequently formed a forecasting team responsible for operating the model and using it for policy analysis and forecasting in the Forecasting and Policy Analysis System of the NBK.

an approximation of the share of food items in the CPI. The error term ε_t^{π} captures not only the approximation error stemming from log-linearization, but also the error originating from revisions made to the "constant" weights of the CPI's components by the Agency of Statistics of the Republic of Kazakhstan.

Non-food inflation follows a New-Keynesian Phillips curve quantifying the links between changes in the prices of non-food items in the CPI and their main determinants,

$$\pi_t^{NF} = \alpha_1^2 \cdot E_t \pi_{t+1}^{NF} + (1-\alpha_1^2) \cdot \pi_{t-1}^{NF} + \alpha_2^2 \cdot Y_{gap,t-1} + \alpha_3^2 \cdot Q_{gap,t-1}^{NF} + \varepsilon_t^{\pi^{NF}}. \tag{2}$$

According to equation (2), non-food inflation is a linear combination of non-food inflation expected one quarter ahead and non-food inflation, the output gap, and the real non-food exchange rate gap observed in the previous period. Inflation expectations are derived within the model and are the function of all the exogenous and pre-determined variables in the model. The output gap captures domestic demand-led price pressures, while the real non-food exchange rate gap quantifies the effect of imported prices of non-food items on domestic prices in the same commodity group of the CPI.

The equation for food inflation is based on the same macroeconomic principles as the Phillips curve for non-food inflation,

$$\pi_t^{F} = \alpha_1^3 \cdot E_t \pi_{t+1}^{F} + (1-\alpha_1^3) \cdot \pi_{t-1}^{F} + \alpha_2^3 \cdot Y_{gap,t-2} + \alpha_3^3 \cdot Q_{gap,t-3}^{F} + \varepsilon_t^{\pi^{F}}. \tag{3}$$

The motivation behind equation (3) is similar to that behind equation (2), although domestic demand-led pressures and import prices feed into food price inflation with a somewhat longer delay compared with the Phillips curve for non-food items. The delays fit the empirical properties of the data.

The real economy block captures the key behavioral relationships of the real economy, providing the link between the main expenditure-side items of the national accounts and their macroeconomic determinants. It is captured via equations (4)–(10). The first two equations express the national accounts identity.

$$Y_{gap,t} = \alpha_1^4 \cdot DD_{gap,t} + \alpha_2^4 \cdot G_{gap,t} + \alpha_3^4 \cdot X_{gap,t} + \alpha_4^4 \cdot M_{gap,t} + \varepsilon_t^{Y_{gap}} \tag{4}$$

Equation (4) is a log-linear approximation of the national accounts identity, equating real GDP to the sum of its real expenditure components. As a result of this approximation, the output gap is the sum of the relevant gaps calculated for domestic demand, government spending, exports, and imports (with a negative sign). The corresponding share of each component is calibrated using the observed historical data.

$$\Delta Y_t^{EQ} = \alpha_1^5 \cdot \Delta DD_t^{EQ} + \alpha_2^5 \cdot \Delta G_t^{EQ} + \alpha_3^5 \cdot \Delta X_t^{EQ} + \alpha_4^5 \cdot \Delta M_t^{EQ} + \varepsilon_t^{\Delta Y^{EQ}} \tag{5}$$

Equation (5) is based on the same approximation of the national accounts identity as equation (4) above, but expressed in terms of changes in equilibrium levels.

There are several reasons for disaggregating real GDP in the model into its expenditure components. First, it is useful to capture exports separately due to the importance of commodity exports. At the same time, we need imports separately as well, given the very high import elasticity of demand in the Kazakh economy. The collapsing of private consumption and public and private investment into domestic demand reflects the constraints of shallow financial markets with low financial

intermediation, limited forward-looking behavior, poor efficiency of the interest rate channel, and so on. Conversely, the Kazakh economy has worked with relatively highly centralized redistribution of oil revenues, mainly through fiscal operations (including subsidized loans provided on behalf of the government).

Domestic demand pins down the law of motion for domestic private consumption and public and private investment (excluding government consumption, which is modeled separately),

$$DD_{gap,t} = \alpha_1^6 \cdot DD_{gap,t-1} + \alpha_2^6 \cdot R_{gap,t-1} + \alpha_3^6 \cdot PO_{gap,t-2} + \alpha_4^6 \cdot TR_{gap,t-3} + \varepsilon_t^{DD_{gap}}. \quad (6)$$

Equation (6) shows that the domestic demand gap depends on the domestic demand gap lagged by one quarter, the real short-term interest rate gap, the oil price gap, and the transfers gap. The specified delays reflect correlations in the data. The interest rate channel is very weak at the moment in Kazakhstan. Nevertheless, with more intense communication of monetary policy intentions combined with more systematic interest rate policy of the NBK, this channel has the potential to improve over time. The oil price gap is defined as the percentage deviation of the actual international price of oil from the domestic break-even price.[2] The oil price variable captures the importance of oil revenues for the determination of Kazakh domestic demand. The transfers gap variable captures direct transfers from the national oil fund, which directly affect domestic demand conditions.

The Kazakh economy is linked to the rest of the world through exports and imports,

$$X_{gap,t} = \alpha_1^7 \cdot X_{gap,t-1} + \alpha_2^7 \cdot Q_{gap,t-1}^{NF} + \alpha_3^7 \cdot Y_{gap,t-1}^{W} + \varepsilon_t^{X_{gap}} \quad (7)$$

and

$$M_{gap,t} = \alpha_1^8 \cdot (\alpha_2^8 \cdot DD_{gap,t} + (1-\alpha_2^8) \cdot DD_{gap,t-1}) + \varepsilon_t^{M_{gap}}. \quad (8)$$

The law of motion for the export gap, captured by equation (7), is a rather standard behavioral relationship quantifying the export demand function. The gap in total exports depends on the oil export gap and the real non-food exchange rate gap, both lagged by one period, and foreign demand (approximated by the foreign effective output gap; the effective weights are based on main export markets). Equation (8) is the law of motion for the import demand gap, which depends on the weighted average of the current and previous domestic demand gaps. The import demand equation is an important behavioral relationship. The specification of the two equations, i.e., the export and import gaps, is designed so as to fit and reproduce the observed data and its dynamics.

The real economy block is completed by the government sector – government spending and transfers,

$$G_{gap,t} = \alpha_1^9 \cdot G_{gap,t-1} + \alpha_2^9 \cdot (\alpha_3^9 \cdot PO_{gap,t} + (1-\alpha_3^9) \cdot PO_{gap,t-1}) + \varepsilon_t^{G_{gap}}. \quad (9)$$

Equation (9) determines the main factors of the government spending gap. It depends on the lagged government spending gap and the weighted average of the current and lagged oil price gaps. This equation is based on the correlation between government spending and oil prices observed in the historical data.

$$TR_{gap,t} = \alpha_1{}^{10} \cdot TR_{gap,t-1} + \varepsilon_t^{TR_{gap}}. \quad (10)$$

[2] The domestic break-even oil price captures the level of the world oil price combined with the domestic exchange rate which results in a domestic price enabling domestic oil exporters to operate at zero profit. It is time varying.

The equation above specifies the transfers gap as a function of the lagged transfers gap and the error term $\varepsilon_t^{TR_{gap}}$. The transfers gap is assumed to be exogenous and its forecast is expected to be constructed on the basis of consultations with fiscal authorities.[3]

The monetary policy and exchange rate dynamics specifications reflect the fixed exchange rate regime. Consistently with this

$$\Delta S_t = 0 + \varepsilon_t^{\Delta S} \tag{11}$$

and equation (11) captures the change in the nominal exchange rate under the fixed exchange rate regime. It is the monetary policy rule under the regime. The shock term $\varepsilon_t^{\Delta S}$ is a policy variable quantifying the effect of de- or revaluation of the tenge against USD. Following the arbitrage condition under the fixed exchange rate regime,

$$IR_t = IR_t^W + \alpha_1^{12} \cdot (TOT_{gap,t} + X_{gap,t} - M_{gap,t}) + PREM_t. \tag{12}$$

The short-term interest rate depends on the foreign short-term interest rate and the country risk premium. This country risk premium is composed of two parts: (*i*) its cyclical endogenous component as a function of nominal net exports (i.e., the real net export gap and the terms of trade gap, $TOT_{gap,t}$) and (*ii*) its stochastic exogenous component $PREM_t$. The stochastic part of the risk premium is specified by the following AR(1) process:

$$PREM_t = \alpha_1^{13} \cdot PREM_{t-1} + (1 - \alpha_1^{13}) \cdot PREM^{SS} + \varepsilon_t^{PREM}. \tag{13}$$

The stochastic part of the risk premium $PREM_t$ is captured by equation (13); $PREM_t$ depends on its lagged value, the steady-state risk premium, and the shock term ε_t^{PREM}.

The model is completed by identities and equations for exogenous processes. The identities include the calculation of the growth rates of the model variables in quarterly and annual terms and the decomposition of the business cycle variables into their gaps and long-term equilibria. All the exogenous variables are modeled as AR(1) processes and are available from the authors on request.

A summary of the core variables is presented in the following table. Table 1 provides an overview of the main structural variables as described in this section for the specification of the previous model equations.

[3] Regarding the fiscal policy rule, which usually closes the model, we were unfortunately not able to track down or estimate any systematic, stabilizing fiscal policy rule. The implementation of fiscal policy is based on discretionary fiscal decisions most of the time; systematic fiscal behavior is not applied or communicated. Any model specification assuming a fiscal policy rule would probably not capture the way fiscal policy is implemented in Kazakhstan. Our specification is, of course, a simplification, stressing the importance of oil prices for government consumption and the empirical link between them.

Table 1: Main Model Variables

Variable	Definition
π_t	CPI inflation (%, qoq)
π_t^F	Food inflation (%, qoq)
π_t^{NF}	Non-food inflation (%, qoq)
$Y_{gap,t}$	Output gap (%)
$DD_{gap,t}$	Domestic demand gap (%)
$G_{gap,t}$	Government spending gap (%)
$X_{gap,t}$	Export gap (%)
$M_{gap,t}$	Import gap (%)
$Y_{gap,t}^W$	Foreign demand gap (%)
ΔY_t^{EQ}	Potential output growth (%, qoq)
ΔDD_t^{EQ}	Equilibrium domestic demand growth (%, qoq)
ΔG_t	Equilibrium government spending growth (%, qoq)
ΔX_t^{EQ}	Equilibrium export growth (%, qoq)
ΔM_t^{EQ}	Equilibrium import growth (%, qoq)
$Q_{gap,t}^{NF}$	Real non-food exchange rate gap (%)
$Q_{gap,t}^{F}$	Real food exchange rate gap (%)
$R_{gap,t}$	Real interest rate gap (%)
$PO_{gap,t}$	Oil price gap (%)
$TR_{gap,t}$	Transfers gap (%)
ΔS_t	Nominal exchange rate depreciation (%, qoq)
IR_t	Nominal interest rate (%, p.a.)
IR_t^W	Foreign interest rate (%, p.a.)
$PREM_t$	Country risk premium (%)
$TOT_{gap,t}$	Terms-of-trade gap (%)

A list of all the model-observed variables, including a short description of each of them, is provided in Table B1 in the Appendix. These comprise CPI inflation, its non-food and food components, the domestic break-even oil-price, the terms of trade, real GDP and its spending components, transfers, the Kazakh 3M interbank rate, and the nominal exchange rate of the tenge against the U.S. dollar. The external environment variables are foreign non-energy and food prices, the Brent crude oil price, the U.S. federal funds nominal interest rate, and foreign demand.

The calibration of the main parameters in the model is presented in Table 2. It covers all the structural parameters, coefficients, and steady-state values introduced during the model specification in this section and gives short descriptions of each.

Table 2: Core Model Calibration

Parameter	Value	Description
α_1^1	0.36	Share of food items in CPI
α_1^2	0.55	Expected inflation term in non-food Phillips curve
α_2^2	0.01	Output gap weight in non-food Phillips curve
α_3^2	0.01	Real exchange rate gap weight in non-food Phillips curve
α_1^3	0.60	Expected inflation term in food Phillips curve
α_2^3	0.01	Output gap weight in food Phillips curve
α_3^3	0.01	Real exchange rate gap weight in food Phillips curve
α_1^4	0.87	Share of domestic demand gap in output gap
α_2^4	0.10	Share of government spending gap in output gap
α_3^4	0.37	Share of export gap in output gap
α_4^4	-0.34	Share of import gap in output gap (with minus sign)
α_1^5	0.87	Share of equil. domestic demand growth in potential growth
α_2^5	0.10	Share of equil. government spending growth in potential growth
α_3^5	0.37	Share of equil. export growth in potential growth
α_4^5	-0.34	Share of equil. import growth in potential growth (with minus sign)
α_1^6	0.70	Contribution of lagged term in domestic demand gap eq.
α_2^6	-0.10	Param. on real interest rate gap in domestic demand gap eq.
α_3^6	0.04	Param. on oil price gap in domestic demand gap eq.
α_4^6	0.04	Param. on transfer gap in domestic demand gap eq.
α_1^7	0.20	Contribution of lagged term in export gap eq.
α_2^7	0.10	Param. on real exchange rate gap in export gap eq.
α_3^7	2.00	Param. on foreign output gap in export gap eq.
α_1^8	1.80	Param. on domestic demand gap in import gap eq.
α_2^8	0.50	Share of current domestic demand gap in import gap eq.
α_1^9	0.50	Contribution of lagged term in government spending gap eq.
α_2^9	0.10	Param. on oil price gap in government spending gap eq.
α_3^9	0.50	Share of current oil price gap in government spending gap eq.
α_1^{10}	0.75	Contribution of lagged term in transfer gap eq.
α_1^{12}	0.20	Param. on nominal net export gap to interest rate
α_1^{13}	0.85	Param. on lagged term of risk premium
$PREM^{SS}$	2.00	Steady-state value of country risk premium

The specification of the core structural equations captures the key features and main empirical characteristics of the Kazakh economy until 2015. The specification of the structural equations is based on a combination of macroeconomic theory and an attempt to fit the data well. The latter affects the specification significantly, as the model was designed for practical use at the NBK and was required to describe the behavior of the Kazakh economy. This mainly affected the specification

of the real exchange rate gap lags in the Phillips curve for non-food inflation (equation (3)), the transfer gap lags in domestic demand (equation (6)), and the specification of the import gap equation (equation (8)).

The calibration of the structural model parameters and core structural equations reflects Kazakh empirical characteristics and proper model behavior. The calibration of the parameters combines several iterations among matching observed data, empirical estimates, checks of relevant literature, and testing of the model properties. Guidelines on benchmark calibration, serving as a starting point and cross-check for these types of models, are provided, for example, in Berg, Karam, and Laxton (2006). The model properties are introduced in the following three sections and include historical interpretation using the Kaman filter, an assessment of the reaction of the economy to shocks based on impulse responses, and checks of the predictive power of the model through in-sample simulations. The country specifics reflected by the model calibration include (*i*) oil-exporting country characteristics, (*ii*) weak monetary policy transmission channels combined with a high level of financial dollarization (accompanied by underdevelopment of the money market and an absence of market makers determining the yield curve; see section 2 describing the stylized facts about the Kazakh economy),[4] (*iii*) inflation driven by commodity price boom-and-bust cycles and strong exchange rate pass-through following large depreciations, (*iv*) a relatively weak impact of demand factors on Kazakh inflation, and (*v*) empirical links based on correlations between series that work the best, for example, in the case of imported food prices linked to domestic food prices with a three-quarter lag (similarly for equation (6)).

The calibration of the steady-state values reflects the core characteristics of the economy during the sample period. The value for the exogenous country risk premium (see Table 2), capturing the difference between comparable nominal interest rates used in the QPM, is set to 2.0 percent p.a. The value for steady-state GDP growth is set to 4.7 percent, that for CPI inflation to 5.9 percent, that for real non-food exchange rate appreciation to 0.5 percent per year, and that for the domestic real interest rate to -3.5 percent to capture the historical average.

4. Interpretation of Kazakh Economic History

This section interprets selected historical episodes in Kazakhstan using the semi-structural model introduced in the previous section. It uses historical data and confronts them with model-based estimated results and economic intuition. Using Kalman filtration[5] and the previously introduced model specification and parameter calibration, filter estimates of model-based unobserved variables and structural shocks hitting the economy allow us to assess the business cycle dynamics and the reaction of the economy to historical events. In the case of Kazakhstan, the main driving forces are related especially to changes in oil prices, the global crisis, and developments in its country peers.

We focus on four relatively easily distinguishable and separable historical periods over 15 years starting in 2000. These are (*i*) robust growth driven by favorable terms of trade in the first half of the 2000s, (*ii*) the resulting overheating of the economy before the global crisis, (*iii*) the impact of the world financial crisis on the Kazakh economy after 2008, and (*iv*) the recent developments in 2014 and 2015, when Kazakhstan was adversely influenced by a slump in oil prices followed by devaluations. The description of these periods highlights the relevant estimation results, forming a core macroeconomic story.

[4] This is clear, for example, in equation (6).

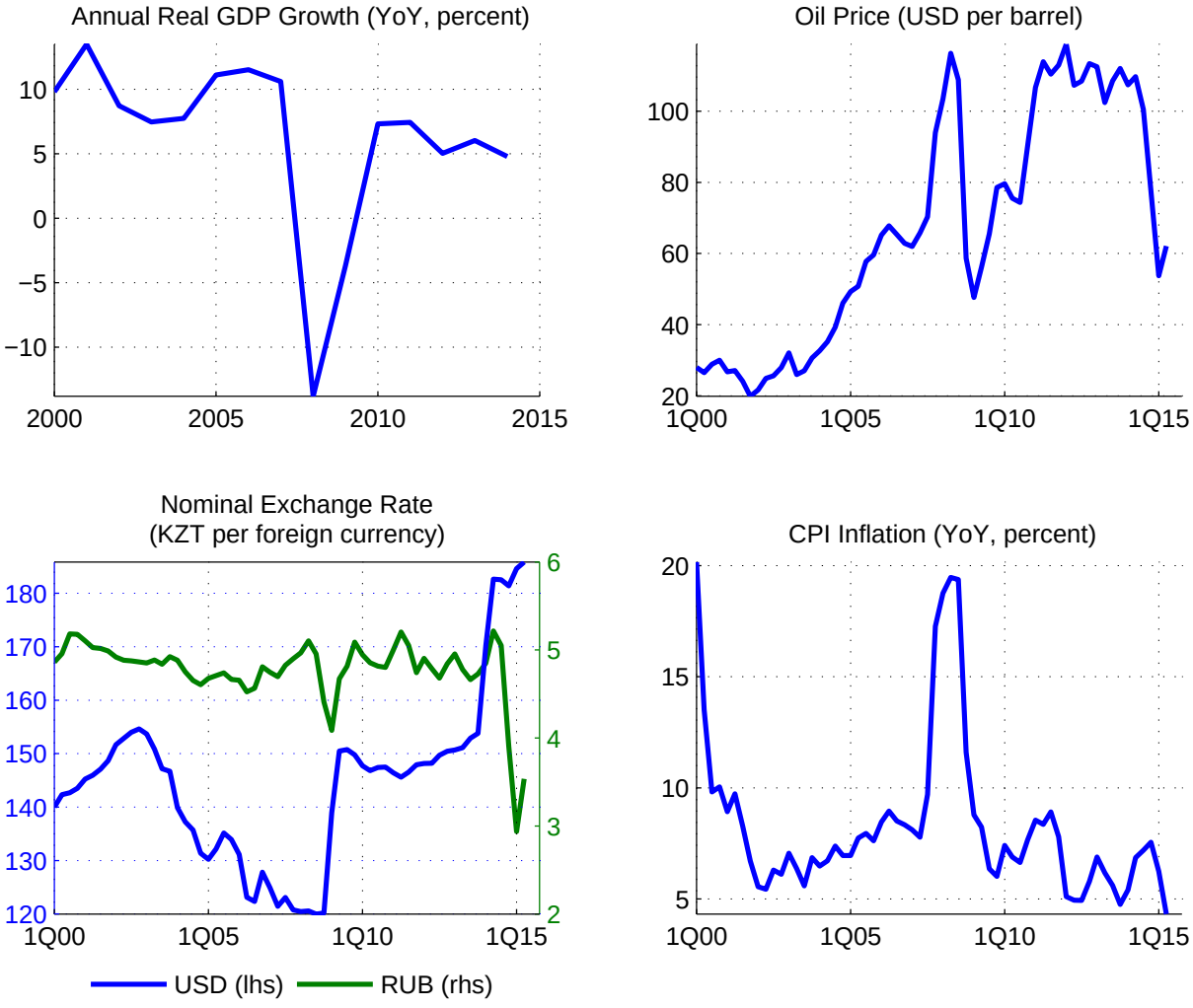
[5] We employ the Kalman filter and its default settings in the Iris toolbox for this type of simulation and analysis.

Although all the periods discussed exhibit specifics and differences, they are well captured by the model. This means that the structure and calibration of the model prove to be satisfactory and the unobserved variables – trends and gaps in particular – coincide with the interpretation.

4.1 The Kazakh Economy during the First Half of the 2000s

The period of about ten years before the global crisis, which hit the country in 2008, was characterized by robust economic growth due to improving terms of trade and by smooth nominal exchange rate dynamics. The growth averaged about 10 percent a year, driven largely by improving terms of trade (a rising price of oil in particular). This allowed the tenge to remain relatively stable against the ruble and the euro and to strengthen significantly against the dollar, especially after 2002, when the price of oil started to rise substantially. Inflation remained stable, floating in the range of 6–8 percent after a period of double figures at the end of the 1990s. For a general picture of the Kazakh economy see Figure 1.

Figure 1: General Macroeconomic Overview of Kazakhstan

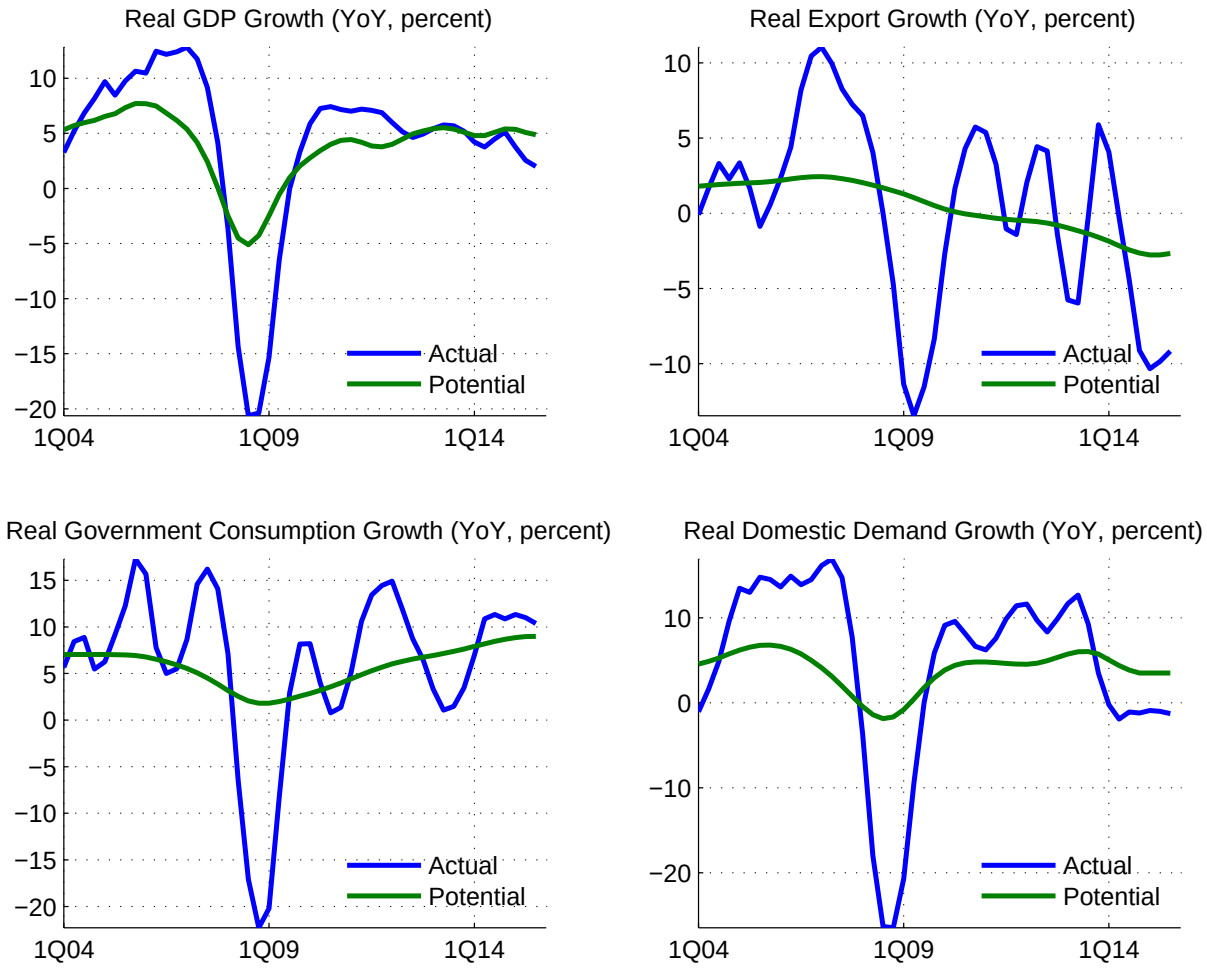


Source: QPM-based results.

The favorable developments fostered an improving overall macroeconomic environment. The strong macroeconomic performance contributed to declining dollarization, growth of the Kazakh stock exchange, stable and robust FDI inflows into the oil sector, and accelerating structural reforms during this period. The model interprets this as a steady and continuous improvement in the equilibrium trends.

Another factor positively affecting the whole economy during this period was a rising oil price. The average annual world oil price increased by around 25 percent in dollar terms during 2000–2007, giving Kazakhstan, an oil exporting country, substantial improvements in its terms of trade. Eight successive years of real GDP growth exceeding 7.5 percent pushed potential growth above 6 percent in 2004–2006 (see Figure 2). This optimism about the favorable long-term potential outlook was driven not only by exports of oil and extraordinary government spending, but also by high investment attractiveness and strong private domestic consumption, further supported by a credit expansion in the banking sector.[6]

Figure 2: Growth of Real GDP and its Main Components

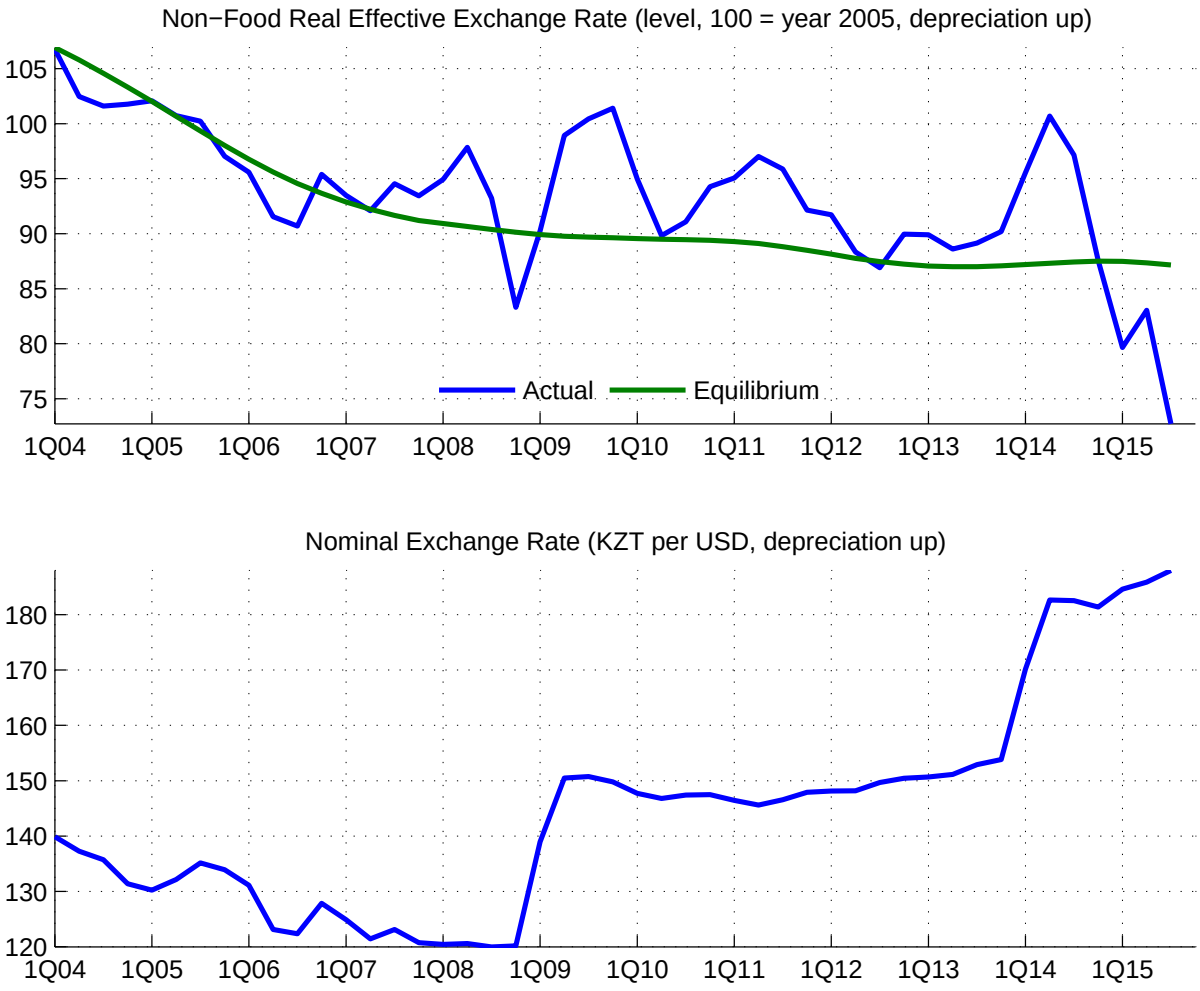


Source: QPM-based results.

[6] Credit growth picked up to an annual pace of about 75 percent in some years in the first half of the 2000s, financed mainly by external borrowing by the banking sector

The tenge strengthened by almost 20 percent against the dollar within five years. This was a consequence of improvements in production capacity and structural transformation toward more productive sectors (an increasing share of the financial and oil extraction sector and a contracting agricultural and manufacturing sector).[7] This ultimately resulted in massive growth and solid appreciation of the non-food real exchange rate and its nominal counterpart (see Figure 3).

Figure 3: Nominal and Real Effective Exchange Rates



Source: QPM-based results.

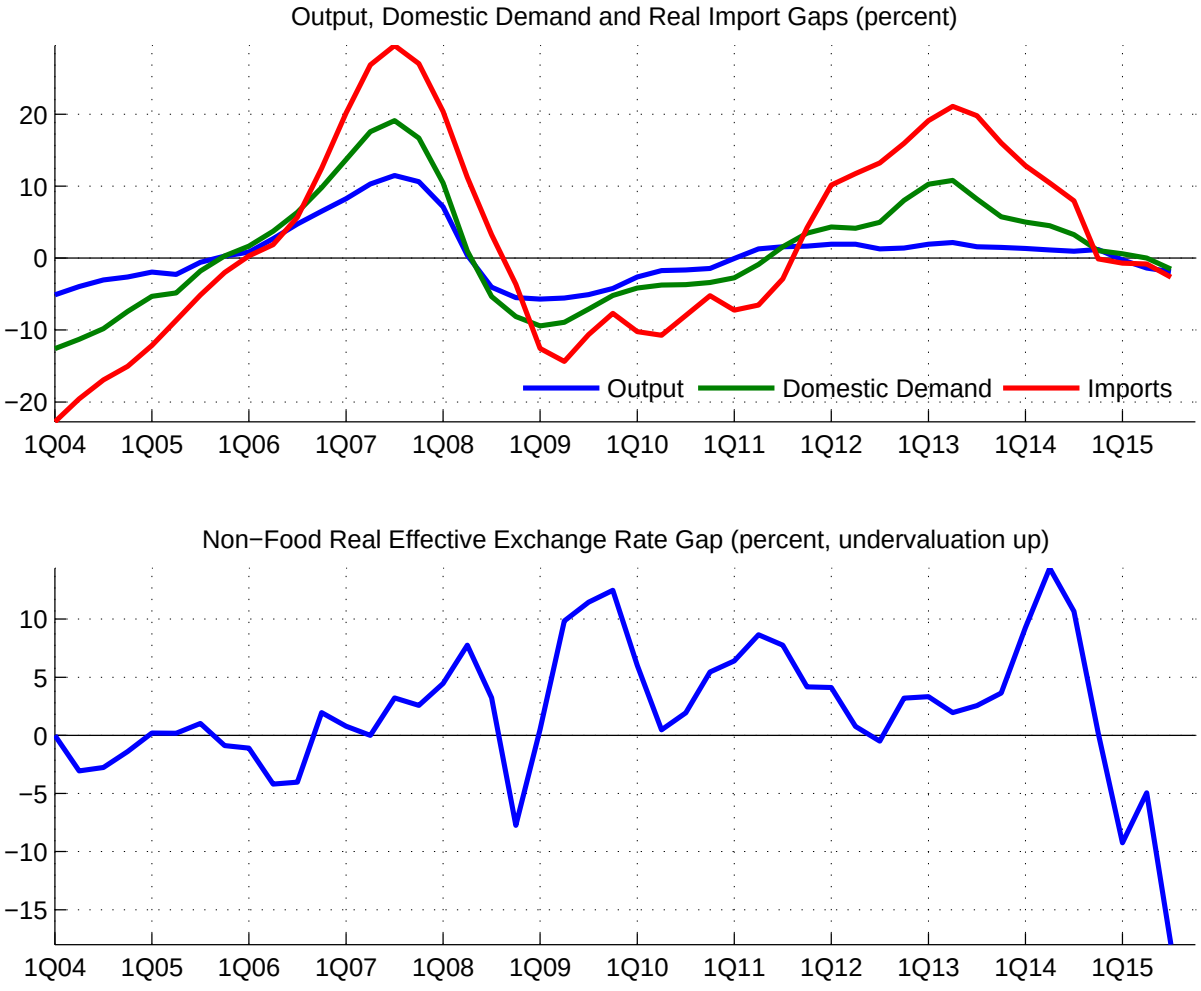
To summarize, the improvement in the long-term equilibria in the Kazakh economy between 2004 and 2006 was accompanied by rise in the oil price, strong real economic activity, and real exchange rate appreciation. However, this trend was disrupted by rising inflationary pressures from world prices (of both oil and food), leading to an overheating of the economy subsequently accompanied by the onset of the global financial crisis, which hit Kazakhstan hard.

[7] This trend of growing dependence on the oil sector in Kazakhstan continued in the subsequent period, causing an increasing problem for the economy.

4.2 The Overheating of the Economy prior to the Global Crisis

In contrast to the favorable evolution of the economy in the first half of the 2000s, which the model-based filter interprets as an improvement in country fundamentals, the country entered the global crisis year 2008 with several domestic disequilibria. The signs of an overheating economy and currency undervaluation are estimated to have reached more than 10 percent for the output gap and about 5 percent for the non-food real exchange rate gap in 2007/2008, as shown in Figure 4. Both gaps definitely indicated increasing imbalances in the economy before the global crisis.

Figure 4: The Output and Real Effective Exchange Rate Gaps



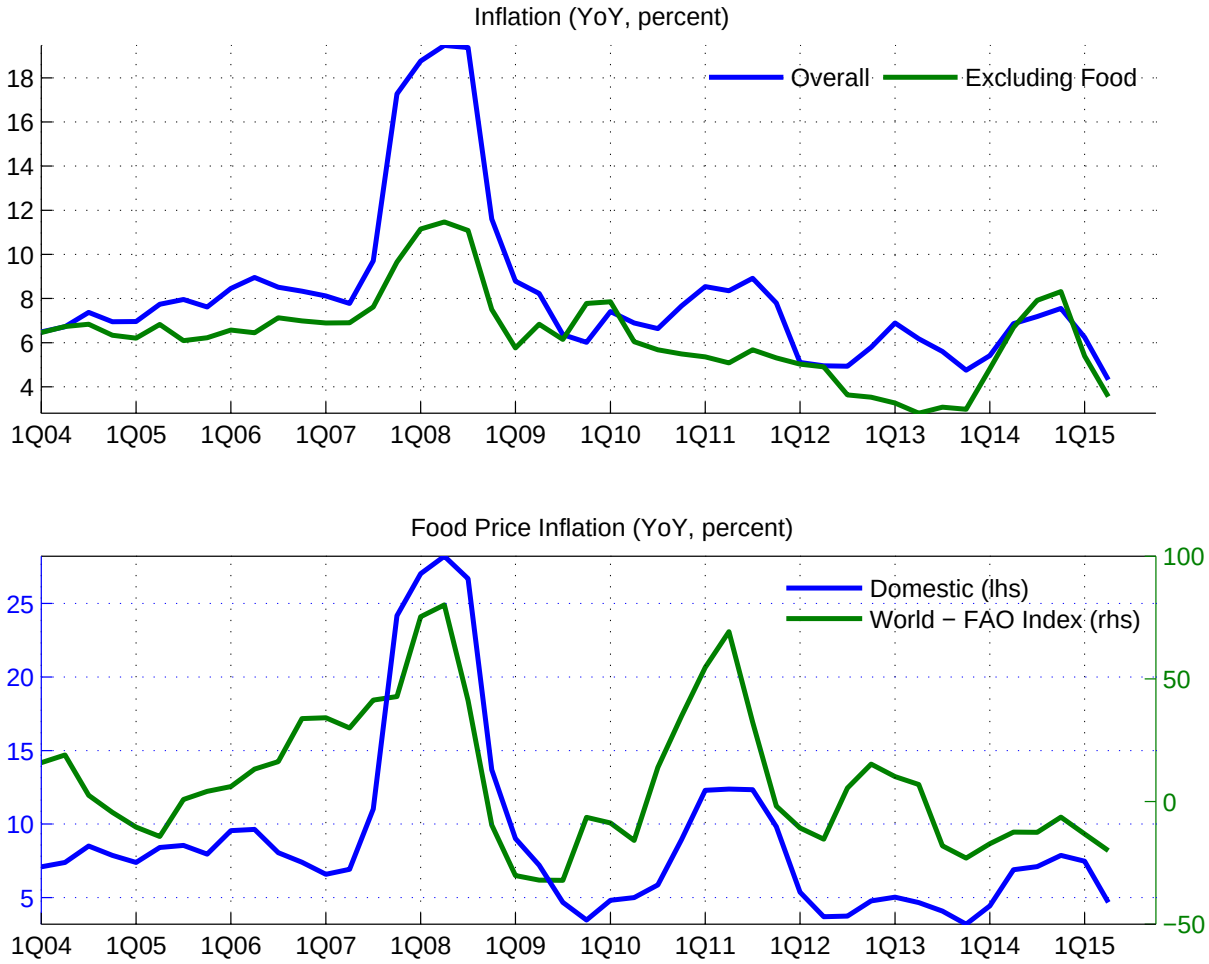
Source: QPM-based results.

The filtration clearly interprets the robust annual growth of the economy of more than 10 percent in 2007 as being partly attributable to the cyclical movement of output. Besides expansionary fiscal policy (on the back of oil revenues based on rising oil prices attacking the level of USD 100 per barrel at the beginning of 2008), the positive output gap was driven by domestic demand. Kazakh banks were borrowing heavily on the international market and providing cheap financing to over-optimistic households and firms. Rising wages further fueled private consumption, which (together with an appreciating nominal exchange rate) was the main driver of accelerating

imports. The overheated economy and overvalued currency (in line with the favorable but already imbalanced terms of trade) caused the current account deficit to rise sharply to around 10 percent by the end of 2007.

The overheating economy was reflected in rising CPI inflation. The positive domestic demand gap pushed the non-food component of overall inflation above 10 percent in early 2008. On top of that, the world food price shock that appeared at the end of 2007 caused imported prices to shoot up, and annual food inflation accelerated over 28 percent. Overall annual inflation reached almost 20 percent in 2008 (see Figure 5).

Figure 5: Overall CPI Inflation and its Components



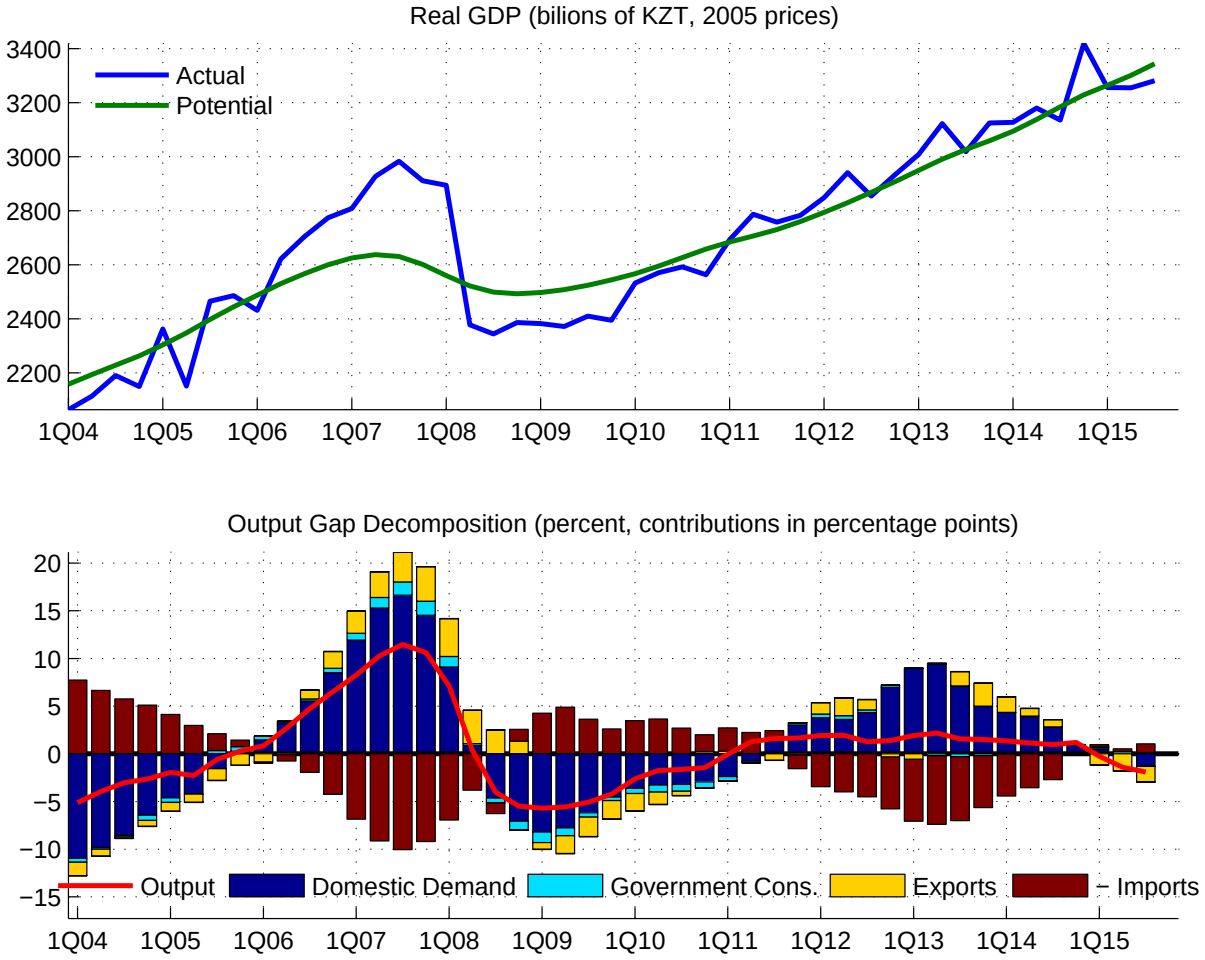
Source: QPM-based results.

4.3 The World Economic Crisis

The 2008 financial crisis hit the overheating Kazakh economy harder than the majority of other countries. As an oil exporting country, Kazakhstan additionally suffered a significant worsening of its terms of trade and problems on the domestic financial market. As a result, the economy contracted and the central bank devalued the tenge by almost 20 percent at the beginning of 2009.

The worldwide recession and frozen financial markets accompanied by the unfavorable terms-of-trade shock[8] hit the economy hard. GDP contracted by almost 14 percent that year and continued to record negative growth in 2009. The model-based filter interprets the situation as a decline in potential output accompanied by a deterioration in the cyclical position of the economy – the output gap turned significantly negative, as depicted in Figure 6. Weak global demand, subdued commodity prices, and regional spillovers (particularly from Russia) contributed to falling exports (see Figure 7). Imports also decreased on the back of contracting domestic demand and government consumption. Fiscal policy turned contractionary, reflecting both the falling oil prices and the worsening situation in the domestic economy, especially in the financial sector.

Figure 6: Filtration of Potential Output and the Output Gap

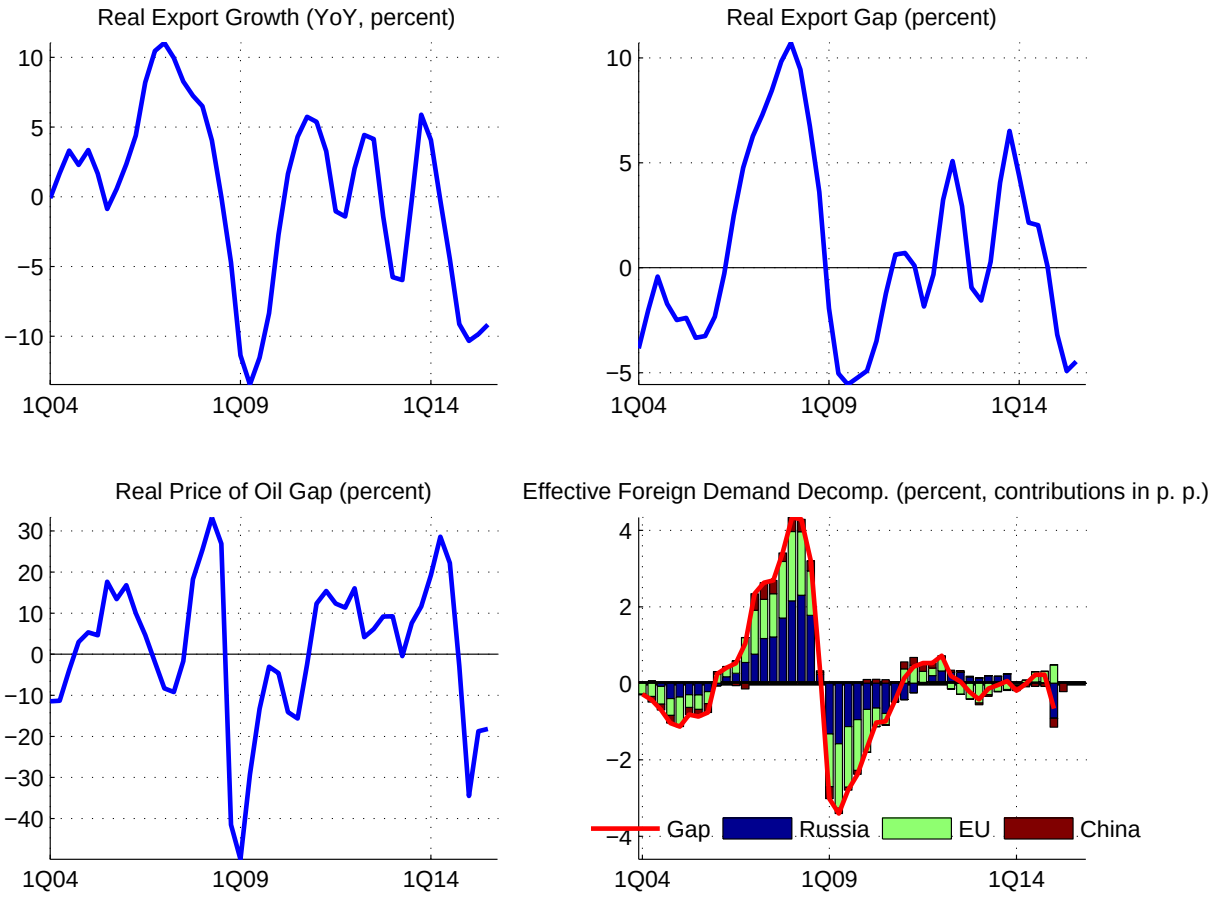


Source: QPM-based results.

The crisis also impacted on the Kazakh financial market and led to a nominal devaluation of the currency. The stress on the Kazakh banking system was a consequence of its high dependence on foreign capital and the halt in foreign funding in international financial markets, which ultimately resulted in lending to the economy coming to a complete stop. In general, investors began to withdraw capital and their risk tolerance dropped sharply. In terms of the model interpretation,

[8] The Brent oil price slumped by more than 60 percent during 2008, hitting a low of USD 45 per barrel in December (see Figure 1).

Figure 7: The Real Export, Oil Price, and Foreign Demand Gaps



Source: QPM-based results.

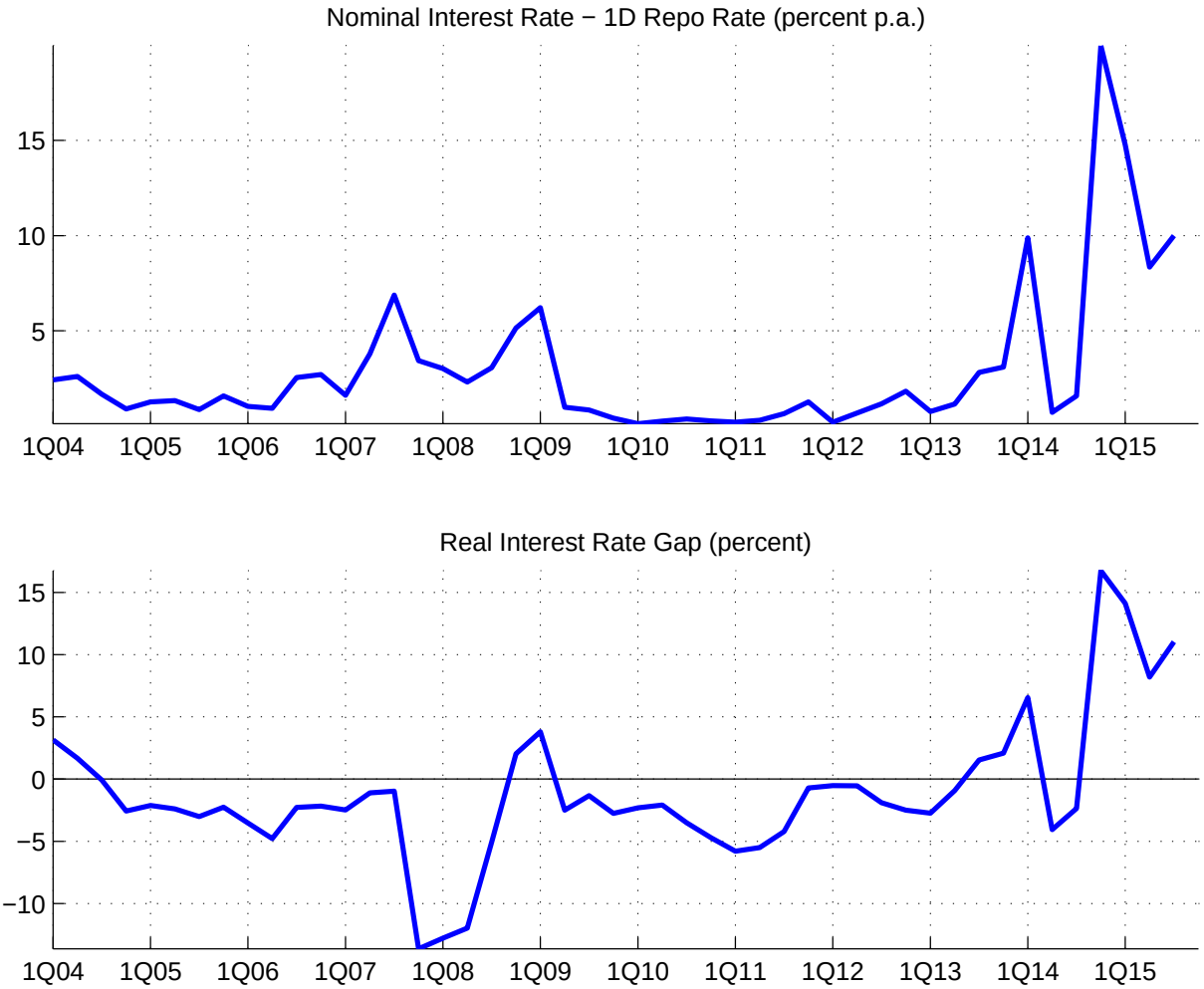
this translated to a shock to the country risk premium. The change in the perception of the riskiness of Kazakhstan, capital outflows, the depreciating Russian ruble, rising deposit dollarization, and declining oil prices, combined with current account deficits, a sharp fall in national oil fund (NFRK) foreign currency assets (as funds were disbursed under the government anti-crisis plan), and increasing reserve losses pushed the central bank to devalue the currency from 122 to 150 tenge per U.S. dollar in early February 2009.[9] Following the devaluation (with a +/-3 percent band established around the central parity of 150 KZT per USD), the model estimates that the real effective exchange rate returned to country fundamentals, allowing the exchange rate pressures to stabilize (see Figure 3). This step also created a solid real exchange rate buffer for the future.

In reaction to the developments in the economy after the devaluation, monetary policy remained accommodative. The one-day repo rate floated below 2 percent p.a. and, according to the model, the real interest rate gap remained negative until the end of 2013 (see Figure 8). Countercyclical policy thus helped limit the economic slowdown. Additionally, the central bank lowered the reserve requirements substantially and enhanced its liquidity facilities for the banking sector.

[9] The tenge was pegged to the dollar in late 2007, when the global financial turmoil first hit Kazakhstan. This currency regime was sustainable during 2008, but the pressure on the exchange rate began to increase toward the year-end.

On top of that, the Kazakh government launched a policy package drawing on the ample resources in the national oil fund (NRFK) to stabilize the banking system. The expansionary fiscal policy resulted in a non-oil budget deficit of about 12 percent of non-oil GDP.

Figure 8: Interest Rates



Source: QPM-based results.

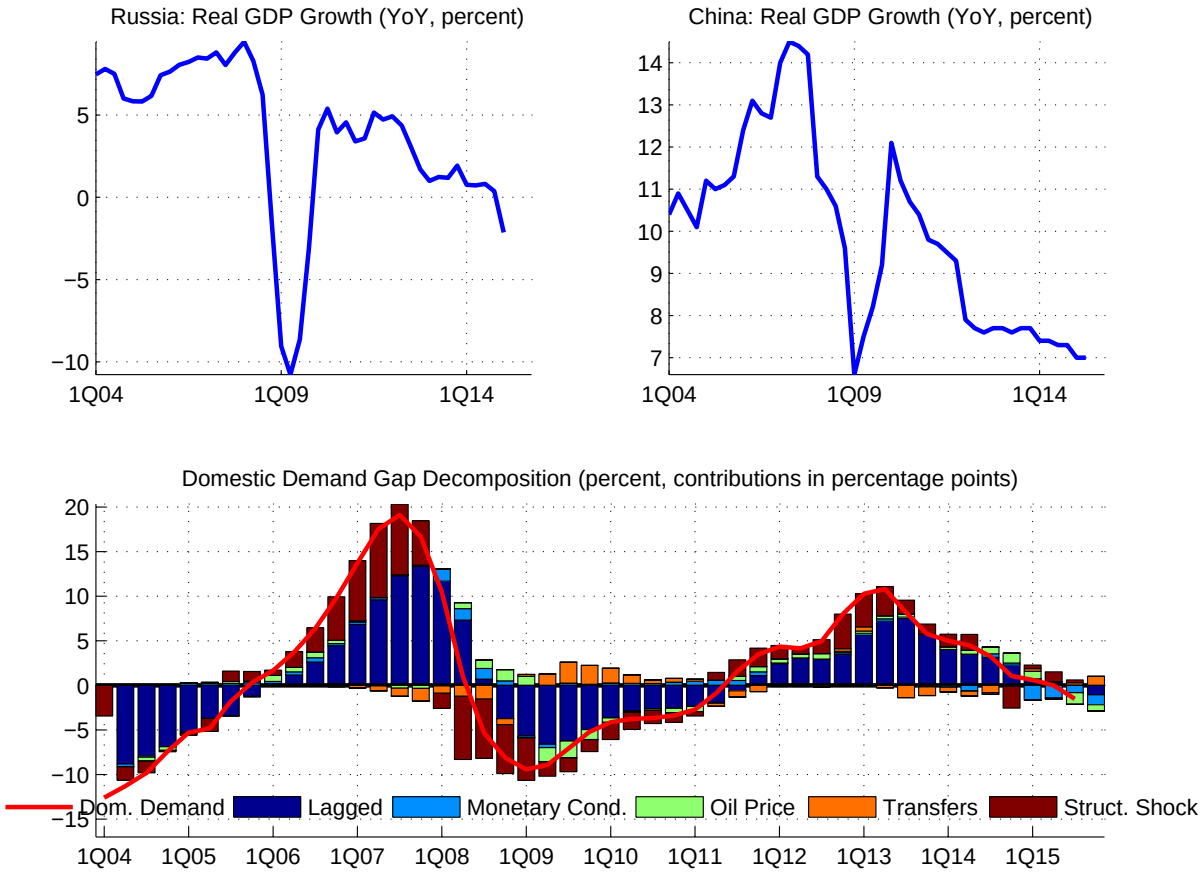
In line with recovering world oil prices and foreign direct investment (particularly in the energy sector), improving foreign demand, and accommodative macroeconomic policies, the Kazakh economy started to recover gradually. Growth was restored (averaging about 7 percent during 2010–2012) and the output gap closed in early 2011. Despite the devaluation, inflation was well-contained, benefiting from low foreign inflation, a stable exchange rate, and weak domestic demand. Despite the large-scale government support, however, the financial system remained highly dollarized and stressed and non-performing loans continued to rise.

4.4 Developments in Kazakhstan in 2014 and 2015

Similarly to other countries in the region, Kazakhstan was hit by large external shocks in 2014 and afterward. As a result, economic growth decelerated sharply, financial conditions tightened, and the central bank switched from a fixed rate to a floating rate in the second half of 2015.

The negatively affected oil sector decelerated economic growth. During 2012–2014, the Brent oil price had stabilized above UDS 100 per barrel, boosting Kazakh economic growth, but this tendency was reverted at the end of 2014, with entirely negative consequences for the country. The external position deteriorated significantly, with the current account balance turning negative as early as the second half of 2014. Real GDP growth slowed sharply to 2 percent in 2015, down from around 4 percent in 2014 and 6 percent in 2013. In addition to the oil price drop, the slower growth was due to continuing delays in the Kashagan oil field construction, lower income and profitability (resulting from lower oil prices), and confidence effects (reflecting tightening financial conditions, including a significant contraction in credit to the private sector, and unfavorable regional developments, especially weaker demand from Russia and China) on private consumption and domestic investment (see Figure 9).

Figure 9: GDP Growth in Kazakh Trading Partners and Domestic Demand Decomposition

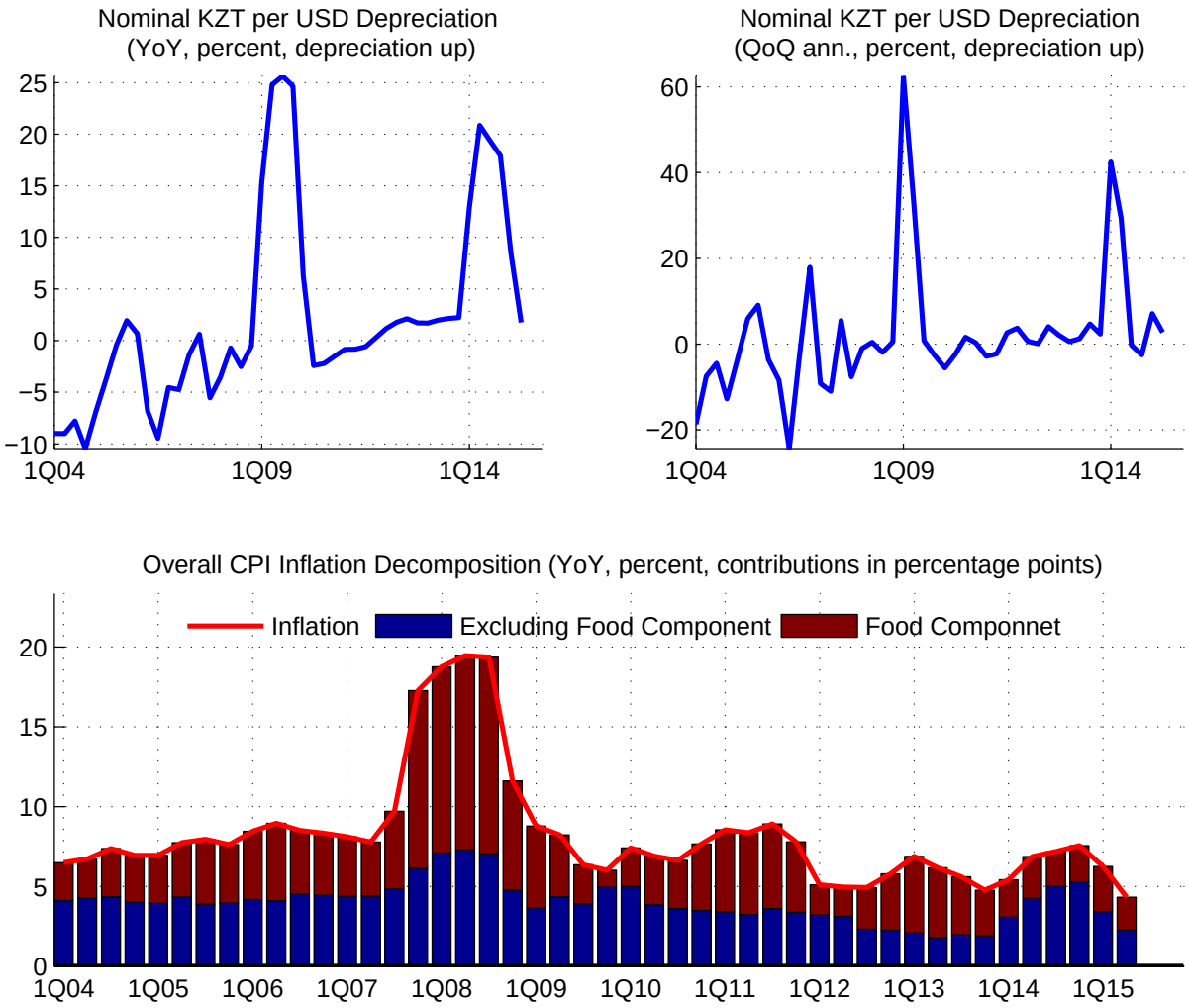


Source: QPM-based results.

The accumulated historical disequilibria induced the central bank to devalue the tenge by almost 20 percent against the dollar at the beginning of 2014. The NBK subsequently tried to hold the currency around the new level of 185 KZT per USD (with a band of 170–188 KZT per USD, which was widened to 170-198 KZT per USD in mid-July 2015) – see Figure 10.[10] Nevertheless, Kazakhstan's real effective exchange rate appreciated substantially, reflecting a sharp depreciation of the Russian ruble (see Figure 3).

[10] The mounting depreciation pressures were visible in an increasing interest rate already at the end of 2013; see Figure 8. This was a result of partly sterilized liquidity withdrawals by the NBK due to forex interventions.

Figure 10: Nominal Exchange Rate Depreciation and Inflation Dynamics



Source: QPM-based results.

The plunge in oil prices, continuing losses in the values of the currencies of Russia and China (Kazakhstan's two biggest neighboring trading partners), strengthening expectations of a forthcoming devaluation, and intensified interventions in the forex market led the central bank to devalue the tenge sharply against the dollar once again in August 2015 and subsequently switch to a managed float. However, the currency lost more than 100 percent in nominal terms in six months. The central bank also took extra measures to overhauling its monetary policy framework and operations. In particular, the decision to float the exchange rate in August was followed by the introduction of a new policy interest rate (base rate) as the new monetary policy anchor in September. The subsequent minimization of forex interventions by the central bank starting from November was meant to provide for better accommodation of shocks in the economy and reduce external imbalances, allowing the tenge to move more in line with fundamentals.

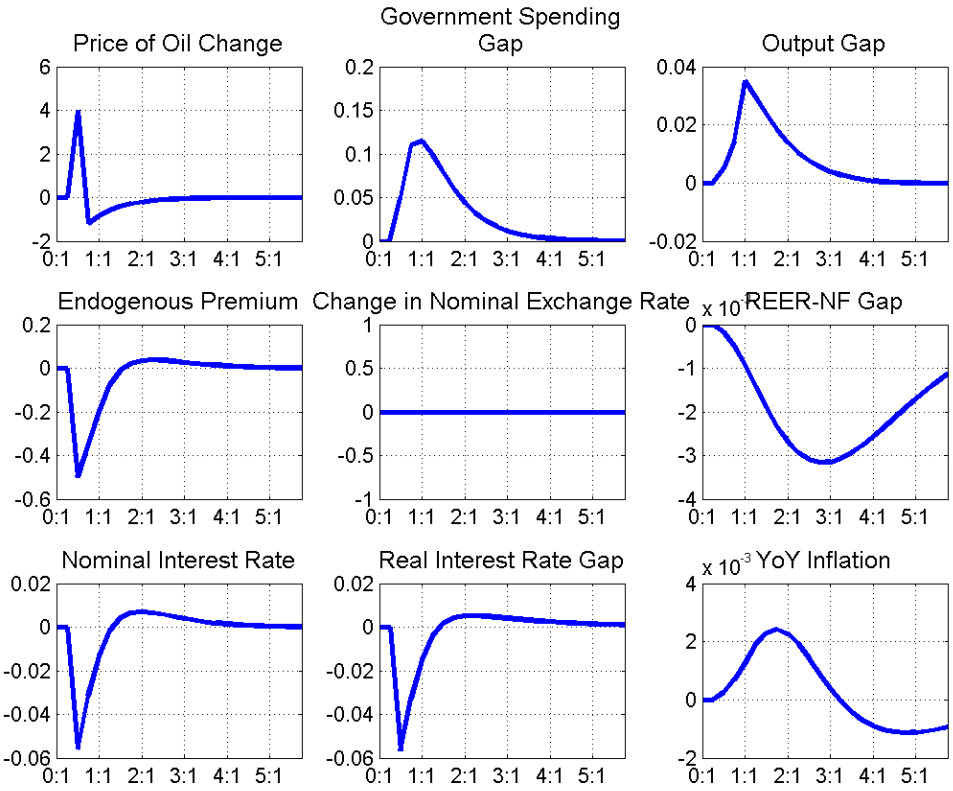
The two-step currency devaluation spilled over to prices. Before the devaluation, inflation had gradually decelerated to less than 4 percent in mid-2015 (with the exception of the early-2014 devaluation period) in the face of an economic slowdown, a stable exchange rate, and falling imported

prices (particularly from Russia), but the August devaluation and the move to a floating regime pushed inflation above 10 percent. This depreciation and the expected increase in inflation led to a tightening of monetary policy. In reaction, the one-day repo rate reached triple figures at the end of 2015 and adjusted only gradually afterward.

5. Model Properties: Impulse Responses

The Kazakh economy experienced several shocks that significantly influenced its development, as described in the previous section. To check the impact of these shocks on the economy and evaluate the model properties, in this section we describe and discuss the story behind the main macroeconomic structural shocks,[11] namely, the oil, domestic demand, and inflation shocks.

Figure 11: Oil Price Shock



Source: QPM-based results.

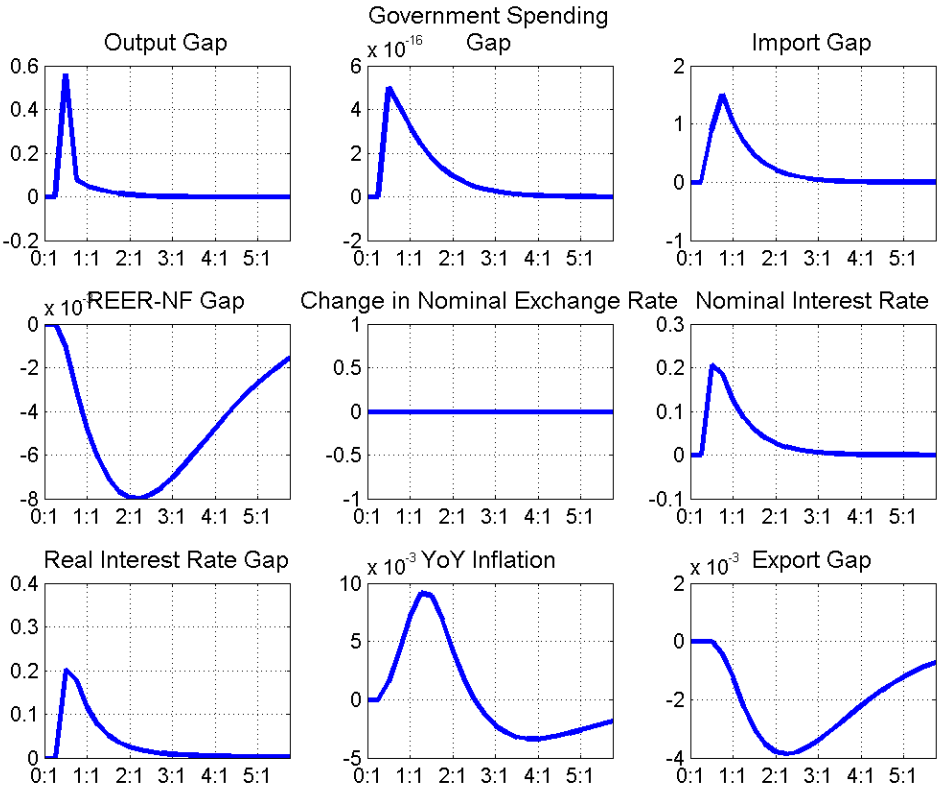
Kazakhstan is an oil-rich country, so it is extremely important to analyze the effects of changes in world oil prices on the economy, especially during significant swings in oil prices. Here, we focus on a 4 percent increase in oil prices which is unexpected and transient, i.e., the price suddenly rises in one quarter and then gradually returns to its original level. Since the model is linear, a slump in oil prices has the same quantitative effects but with opposite sign. The higher price of oil opens the positive government spending gap by 0.1 percentage point and the output gap by 0.04 percentage point. Higher nominal exports put pressure on the nominal exchange rate (the endogenous premium

[11] To deliver the overall story behind the shocks vividly, we present a slightly different set of pictures for each of them. The impulse responses to other shocks are available from the authors on request.

decreases), but the exchange rate appreciates only in real terms, since we assume a fixed exchange rate regime. The central bank keeps the nominal exchange rate fixed by intervening and lowering nominal interest rates by 0.06 percentage points.

As we can see from the shock decomposition of the output gap in Figure 6, demand shocks play an important role in the Kazakh economy, too. Figure 12 shows a typical demand shock – a domestic demand shock in this model framework. This shock is meant to capture a temporary increase in households' consumption or firms' investment. The 0.6 percent deviation of output from its potential level boosts the import gap by 1.5 percent, since most of the higher demand is saturated by imports. The negative trade balance increases the devaluation pressure on the nominal exchange rate. However, the NBK intervenes to mitigate the pressures on the nominal exchange rate and keep it fixed at the announced level and increases the nominal interest rate by 0.2 percentage points. A higher real interest rate and stronger real exchange rate (via higher inflation in the domestic economy) reduce the thirst for consumption and further contribute to the reduction of inflation pressures. Exports, which are import intensive, are suppressed by the appreciation of the real exchange rate and by higher demand for imports in the rest of the production sectors.

Figure 12: Domestic Demand Shock

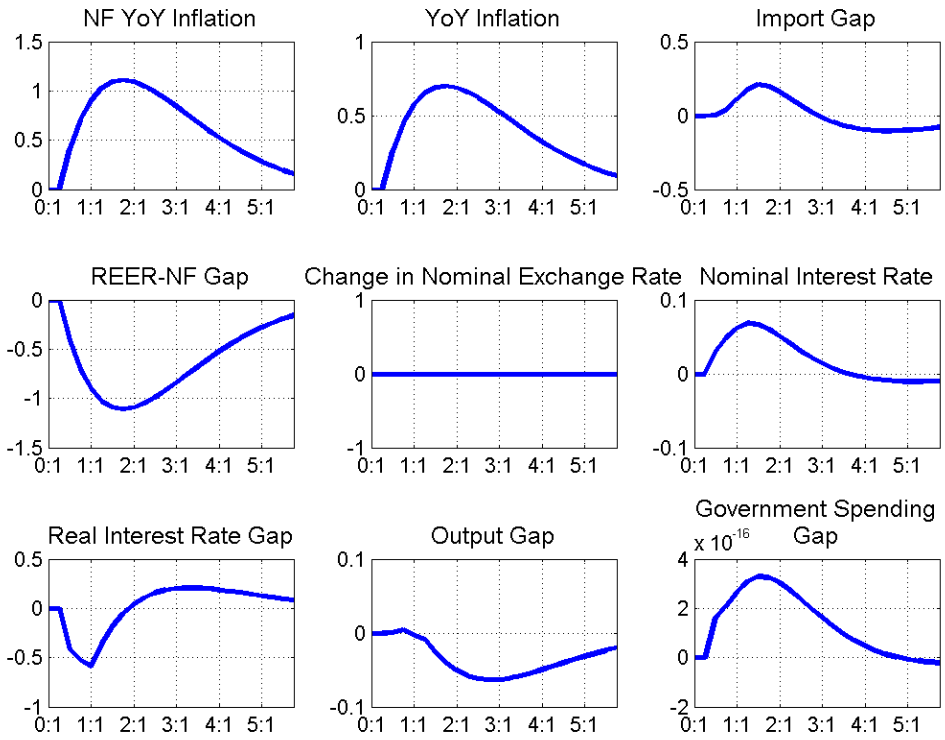


Source: QPM-based results.

Price-raising supply shocks are also quite common in the Kazakh economy and require appropriate policy measures. Unexpected temporary increases in inflation can originate in either its non-food or food component. Since food price shocks are considered to be import price shocks, we describe a non-food shock as a typical domestic price shock here. A one percentage point increase in non-food inflation results in partial substitution of domestic goods for imported ones. This puts

devaluation pressure on the nominal exchange rate due to a worsening trade balance. The central bank increases interest rates by almost 0.1 percentage point in order to mitigate the pressure on the currency and inflation. The higher imports and tightened monetary policy conditions reduce the output gap.

Figure 13: Domestic Inflation Shock



Source: QPM-based results.

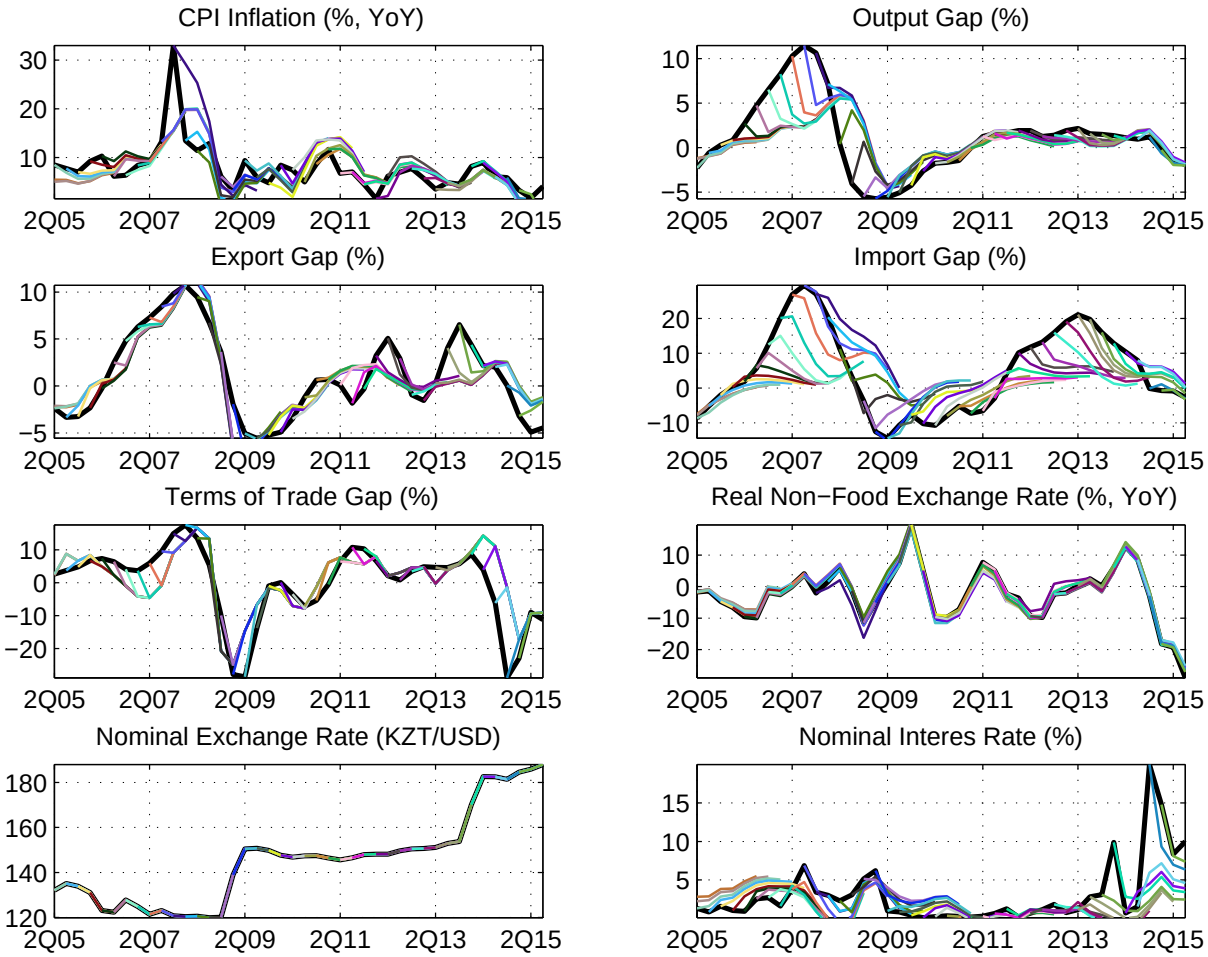
6. Model Properties: In-Sample Simulations

The predictive capabilities of the model can be tested using a series of in-sample simulations. There is a mechanistic forecast every quarter in the last ten years of the historical sample (i.e., 2005Q2–2015Q2) and these ex-post predictions are compared either with their observed data counterparts (known as of today), or with the most recent filtered estimates of such data (in the case of unobserved data, for example, the output gap). The quality of these mechanistic predictions can then be judged straightforwardly by looking at the differences between the model prediction and the data at a given point in time.

Such testing, however, is conditional on the design of the model simulations. The quality of such a predictive exercise depends in first place on the quality of the parameter calibration. Usually, one can generate forecasts conditional on the outlooks for the external environment, which are considered to be exogenous variables from the point of view of the model-based forecasting exercise. The strategy is employed by the authors of this paper as well, since the global economy is believed to have a significant impact on the Kazakh economy.

Figure 14 shows the ex-post mechanistic predictions for a selection of ten basic macroeconomic variables. Provided we have a perfect outlook for the external environment, the model is able to satisfactorily explain the fluctuations of those variables which are directly or indirectly linked to it (e.g., real exports, real exchange rates, and the terms of trade). A universal property of gap models is that model-based forecasts tend to close the gaps, so that eventually only the potential trends matter. While this property may prove useful in some cases (see the ex-post forecasts of the unemployment gap), it may fail in others (see the import gap).

Figure 14: In-Sample Simulations



Source: QPM-based results. The in-sample results are simulated from the Kalman-filter-identified initial position of the economy in the business cycle. The Kalman filter is applied to the data from the first observation through to the starting point of the simulation.

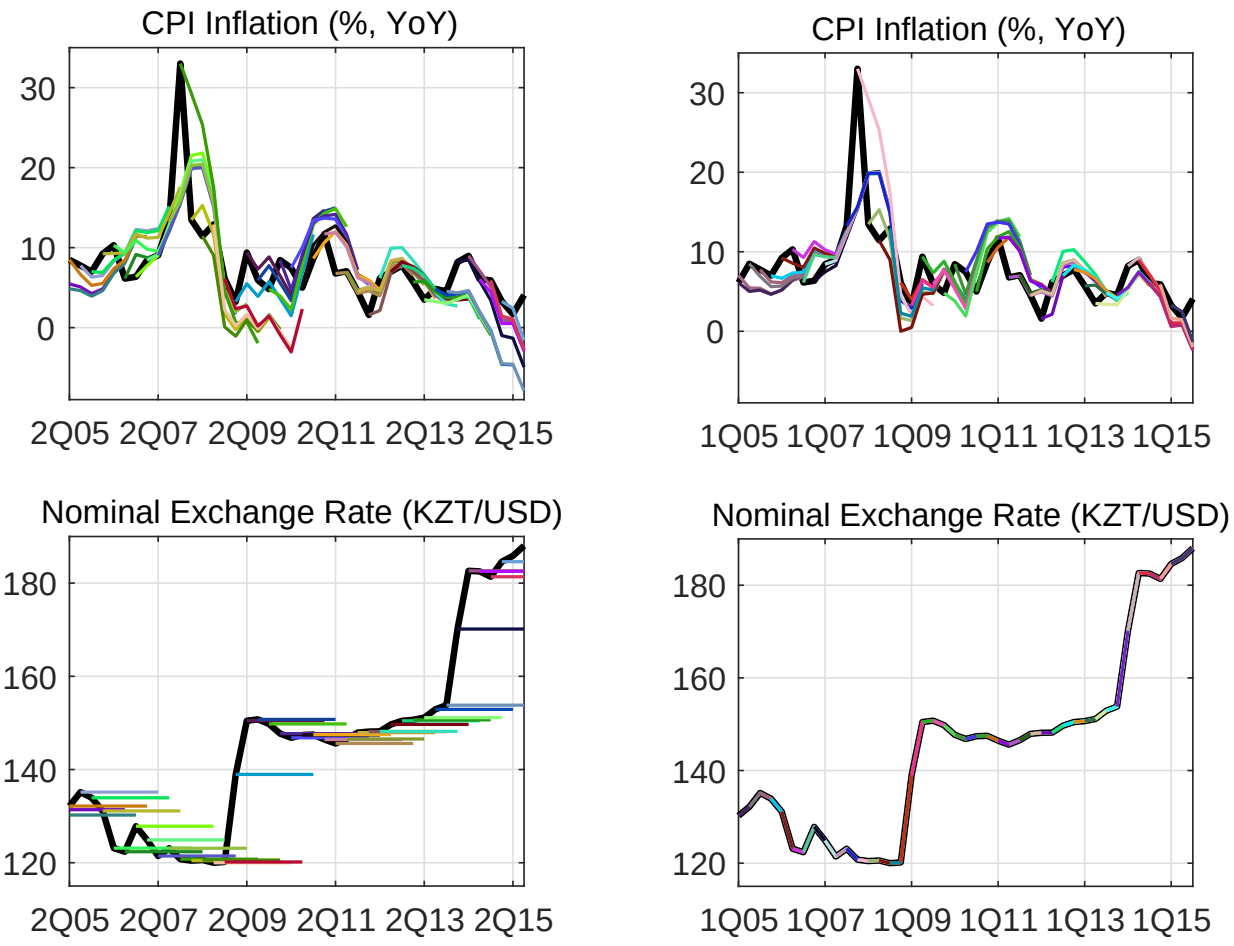
In general, the model has a satisfactory potential to replicate the historical data. The results exhibit appropriate data replication. This is true in the cases of the export gap and the terms of trade gap in particular.[12] Both variables are closely linked to the oil price (which is fixed as exogenous as

[12] The relative in-sample performance of the variables is obvious from Figure 14 and is confirmed by checking the root mean square prediction error.

a part of the external environment outlook) and indicate that the price is of high importance for the economy as a whole.

However, the in-sample simulations also reveal some possible weaknesses of the suggested model and some Kazakh-specific aspects which are not completely captured by the model. The expected regime switch from the fixed exchange rate to inflation targeting led to sharp increases in the newly established base interest rate to prevent further depreciation of the tenge in 2015, which (for obvious reasons) the model is not capable of explaining at all. In terms of forecasting inflation, the model exhibits overshooting behavior, especially during the crisis years. Such behavior usually emanates from the fact that some of the explanatory factors are driven by overly volatile data (in this specific case oil and food prices). Furthermore, the model shows quite weak forecasting strength in terms of the import gap, which itself is, by construction, a function of the lagged domestic demand gap. It turns out that in Kazakhstan, the import gap is driven by other factors as well. Not surprisingly, under a fixed exchange rate regime the predictions of the exchange rate always form a flat line stemming from the last observed value.

Figure 15: Comparison of the In-Sample Simulations of Inflation for the Fixed Exchange Rate (right column)



Source: QPM-based results.

To check the performance of the model and the impact of the currency devaluations, we also fixed the nominal exchange rate path and simulated its impact. This simulation reflects the fact that the central bank decides and sets the nominal exchange rate under a fixed exchange rate regime. The exchange rate trajectory is thus known (even during currency crises, at least roughly), improving the forecasting power of the model. This simulation is presented in Figure 15 and reveals that the improvement in the in-sample simulations for CPI inflation is about 15 percent as measured by the root mean square prediction error on average. Clearly, the most significant improvements are linked to the strong devaluations of the tenge during crises. The adjusted simulations for inflation consequently improve the in-sample nominal interest rate and the real exchange rate, including its impact on real economy variables.

7. Conclusion

We developed a semi-structural New Keynesian-style model of the Kazakh economy which takes into account country-specific features, especially the predominant oil-exporting character of the country. The model is suitable for analyzing and interpreting the recent historical developments and for medium term forecasting, and can also provide guidance on relevant monetary policy questions under the fixed exchange rate regime. The model was used for practical monetary policy forecasting and analysis at the National Bank of Kazakhstan (NBK) in 2014 and 2015 and was the first model used for this purpose at the NBK. In a general sense, it can be considered a quarterly projection model designed for oil-rich countries operating under a fixed exchange rate regime.

To capture the Kazakh specifics, the model expands the benchmark set-up in several respects. First, aggregate supply is modeled by a pair of Phillips curves in order to distinguish between food and non-food prices. This allows for computation of the real exchange rate gap on the basis of non-food prices, which helps better explain the evolution of the export gap due to the structure of the export sector. Next, aggregate demand is collapsed into the major components of the national accounts, each of which is modeled separately, with a different parameter calibration and lag structure. Finally, the model features a positive correlation between domestic demand and the world oil price, as is usual for oil-exporting countries.

The model seems to perform reasonably well and provides applicable results for the period of the fixed exchange rate regime in Kazakhstan. Given the suggested calibration, we demonstrate the behavior of the model in response to exogenous shocks and we assess the forecasting performance. The model also provides an intuitive trend/gap decomposition of the observed variables. It turns out that the period of stable growth in the early 2000s was characterized by a continuous improvement in equilibrium trends, whereas during the crisis years from 2007 onward, the economy was negatively influenced by accumulated domestic imbalances, with the output gap exceeding 10 percent, and, of course, by a global external shock. The developments immediately after the crisis years are interpreted by the model as a decline in potential output accompanied by a negative output gap. The devaluations of the tenge in early 2009 and early 2014 are believed to have pushed the real exchange rate back to its fundamentals according to the model filtration. Despite Kazakh strong dependence on global demand for oil, the model results suggest that the economy is significantly influenced by domestic demand factors as well.

Regarding future steps, the model of the Kazakh economy presented here could be modified into a framework compliant with the inflation targeting approach. This would be in line with the actual plans of the Kazakh monetary authority. Such model extension would not necessarily

be difficult; one could, for instance, introduce forward-looking inflation directly into the interest rate-setting rule and thus break the dependence on the foreign interest rate. Finally, the exchange rate equation could be transformed into an uncovered interest rate parity condition to allow drifting of the exchange rate under a free or managed floating framework in accordance with the interest rate differential.

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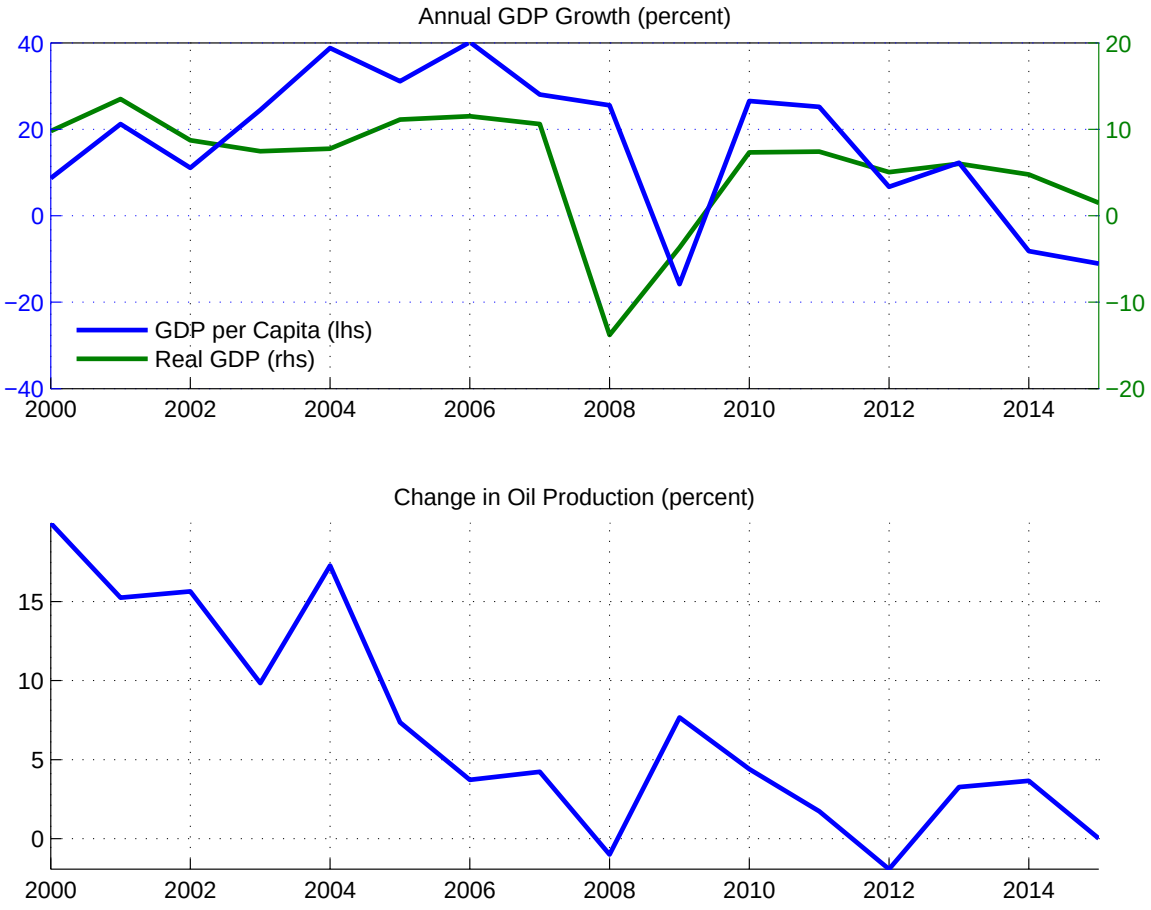
Appendix A: Key Kazakh Macroeconomic Characteristics

This appendix further develops the key features of the Kazakh economy which were briefly introduced in the second section. These are real macroeconomic developments, with a special focus on hydrocarbons, fiscal policy, the financial market, monetary policy, the tenge exchange rate, and inflation. These characteristics substantially affect the model specification and calibration and thus serve as a complementary part to section 3 about the Kazakh model.

A.1 Economic Growth

Although the Kazakh economy experienced solid economic growth averaging about 6 percent over the past 15 years, fluctuations in oil prices and global financial conditions generated a lot of excessive volatility (see Figure A1). Driven mainly by high world oil prices, large FDI inflows into the hydrocarbon industry, and massive fiscal spending, real GDP growth fluctuated around 10 percent from 2000 to 2007. After the outbreak of the global economic crisis in 2008 and the slump in oil prices in 2009, the Kazakh economy fell sharply into recession then returned to growth of between 5.0 and 7.5 percent during the 2010–2013 period. Afterward, the economy slowed further and stagnated in 2015. This pattern clearly shows the different periods and crises (with their consequences) experienced by Kazakhstan – the Russian crisis in 1998, the global financial crisis in the second half of the 2010s, and the slump in oil prices at the end of 2014.

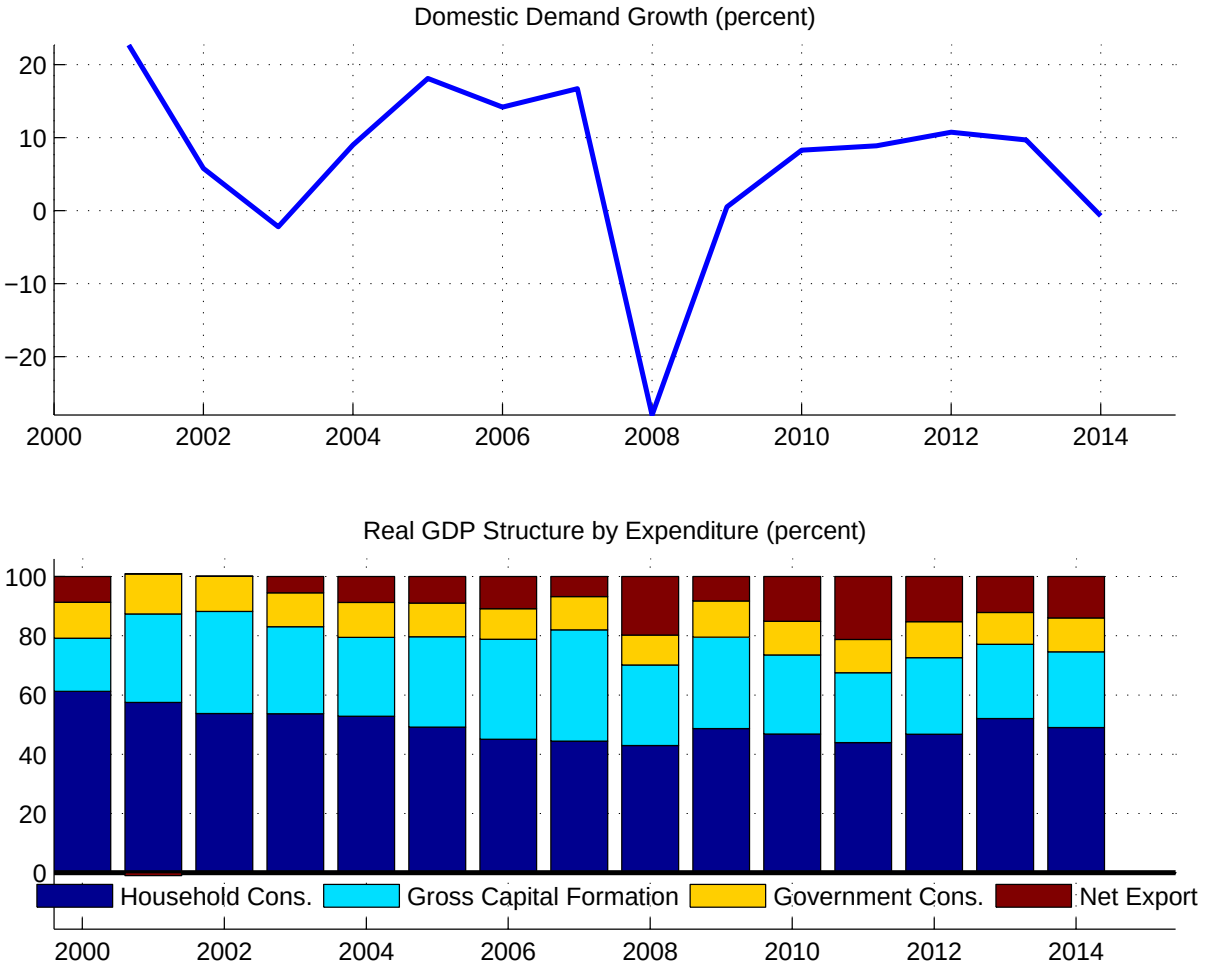
Figure A1: GDP Growth and Oil Production



Source: NBK and authors' calculations.

Overall, the economic growth after 2000 has been driven predominantly by domestic demand and exports, supported by high oil prices in some periods. Household consumption has grown steadily at around 10 percent, and FDI – flowing mainly into the oil sector – has boomed during the periods of high oil prices. Domestic demand expenditure has dominated GDP, forming a share of about three quarters on average during the past 15 years (see Figure A2). These shares are used to calibrate the parameters in equations (4) and (5).

Figure A2: Domestic Demand Growth and GDP Structure



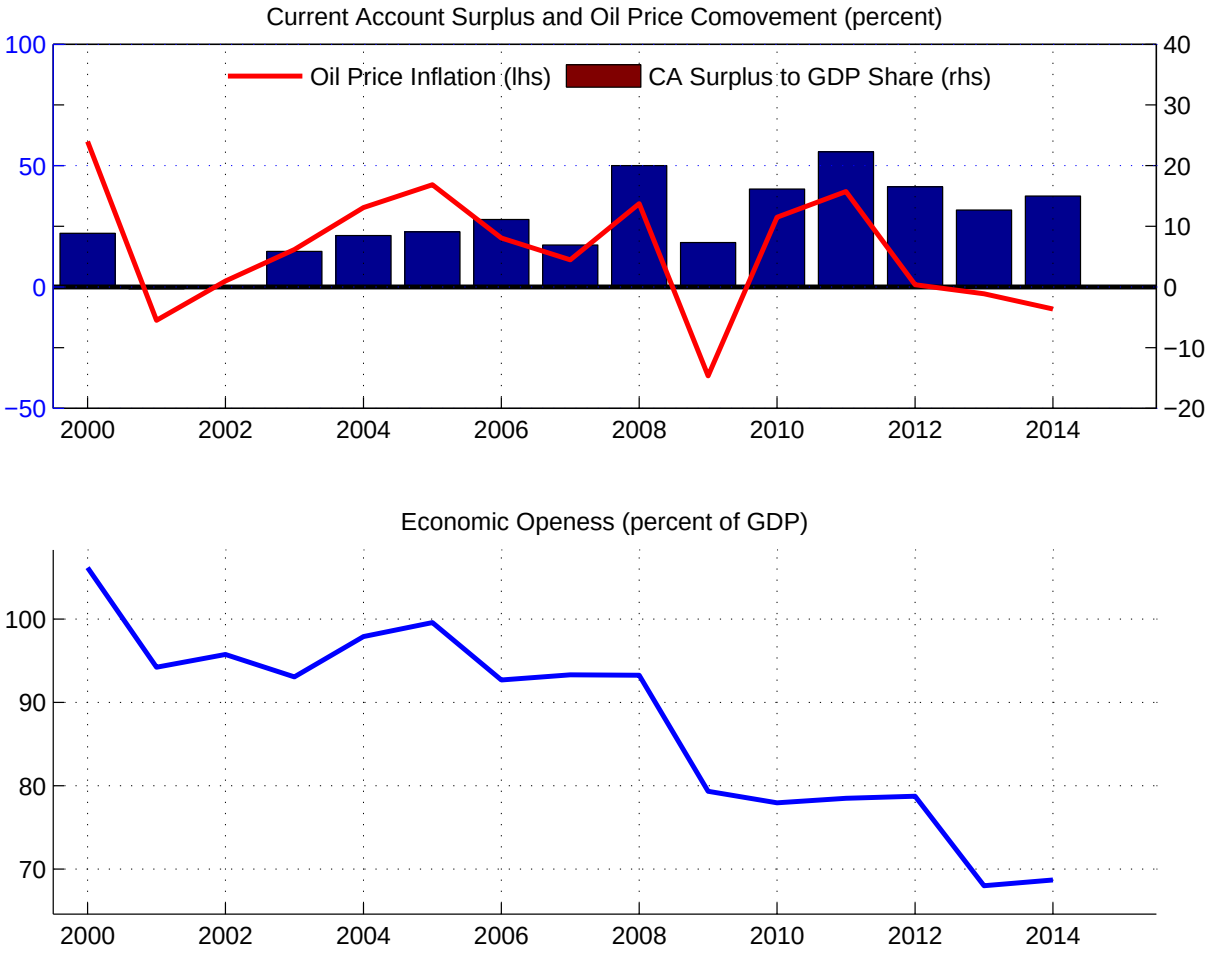
Source: NBK and authors' calculations.

Government consumption and the current account position of Kazakhstan heavily depend on the country's crude oil production and the world price of oil (see Figure A3). The increasing ratio of net exports to GDP reflects the continuing efforts of the Kazakh authorities to open the country to international trade and to liberalize trade in general.[13] Trade openness (measured as the ratio of total trade in goods and services to GDP) rebounded strongly after the 1998 Russian crisis and fluctuated between 90 and 100 percent afterward. However, this favorable development was interrupted by the global economic crisis and the sharp decline in oil prices in 2014, causing a contraction in Kazakh international trade – both imports and exports declined significantly (exports

[13] Kazakhstan entered a customs union with Russia and Belarus and joined the WTO in 2015.

decreased from 56 percent of GDP in 2008 to below 40 percent in seven years). Consequently, the oil linkages of the Kazakh economy are reflected in the model structure and design.

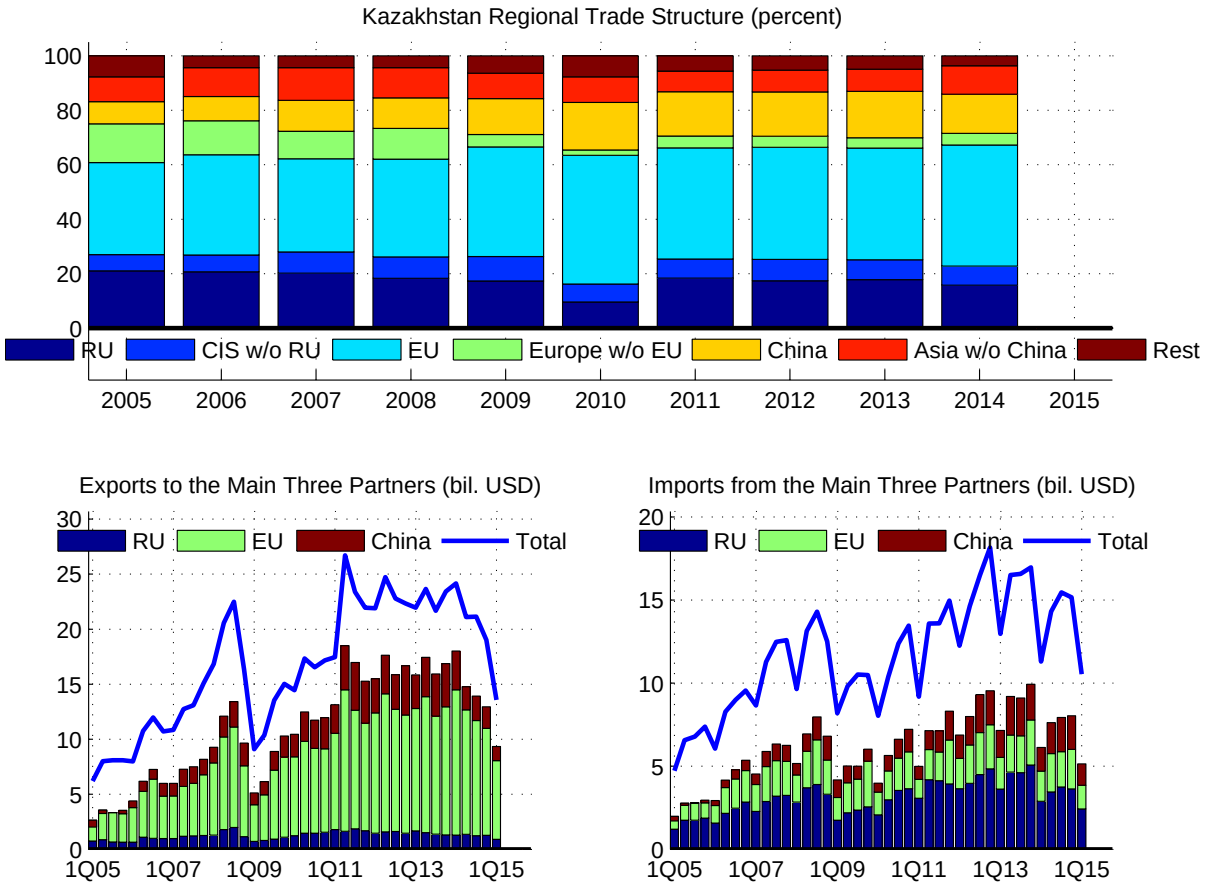
Figure A3: Kazakh External Position



Source: NBK and authors' calculations.

Regarding the regional structure of trade relations, China, Russia, and the EU are Kazakhstan's key trading partners, while trade with Central Asia remains low. The economic linkages between Kazakhstan and China have grown recently, with China becoming Kazakhstan's second biggest trading partner and fourth largest foreign investor. China is also a strategic lender to projects in key sectors such as oil refining and energy generation. The already significant trade and financial linkages between Kazakhstan and Russia and the euro area are expected to deepen further. The structure of Kazakhstan's main trading partners is shown in detail in Figure A4: roughly one third of Kazakh trade is with the former Soviet Union countries (labeled in the figure as RU and CIS w/o RU), about half is with Europe (the majority of that with EU members), and the rest is with China and the remaining Asian countries. The main three trading partners (Russia, the EU, and China) have accounted for almost 80 percent of total trade on average during the past ten years. These facts are used to approximate the foreign effective output gap in the total exports specification in equation (7).

Figure A4: Kazakh International Trade by Main Trading Partners



Source: NBK and authors' calculations.

Kazakhstan's oil sector plays a dominant role in the economy and is likely to remain the main driver of growth in the near future. The mining boom in the early 2000s, especially in the oil sector, continuously crowded out growth in the non-oil segment of the economy. Although Kazakh non-oil output increased by 8 percent a year on average during the 2000s, a big part of this growth reflected increased demand stemming from the hydrocarbon sector, such as the construction of extraction facilities and transport of petroleum. Additionally, the growth in non-oil exports (exceeding 15 percent every year in the first half of the 2000s) mainly involved metals and other raw materials, which are heavily dependent on global demand and world prices of commodities.

Kazakhstan shows clear signs of the Dutch disease, which was fully revealed recently when oil prices slumped. Moreover, the country has not developed a distinct positive productivity differential between tradable and non-tradable goods, while the rapid wage growth has not been accompanied by productivity growth.

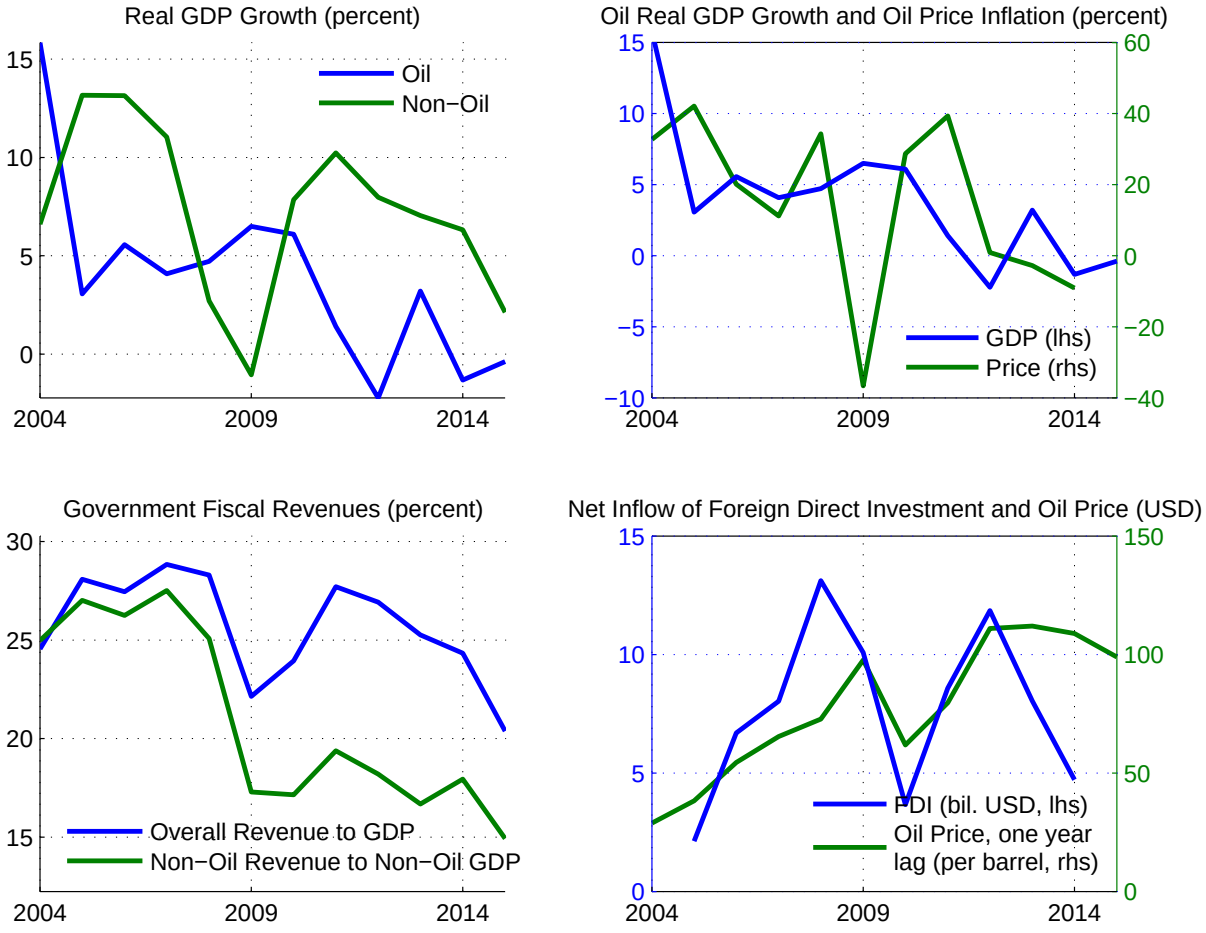
A.2 Hydrocarbons

Oil production started up in Kazakhstan in 2000 and has gradually been expanding, exceeding 200 million tons per year (about 4.5 million barrels a day) in 2015. Therefore, a big share of the increase in trade and overall economic growth has been driven by oil exports, as well as

rising exports of gas, metals, and several other commodities. This volume of oil production ranks Kazakhstan among the world's top 20 oil producers, and it is the largest producer in the region after Russia. Proven reserves are now estimated at 40 billion barrels (ensuring about a 2 percent share in global oil production) due to oil discoveries in the Kashagan field in the Caspian Sea.[14]

The oil sector dominates the economy, accounting for about one quarter of GDP, more than 60 percent of total exports, and 55 percent of total fiscal tax revenues (see Figure A5, which shows the reasoning behind some of the relations in the model specification). During the period of very high oil prices and before the global crisis, about three quarters of FDI inflows were directed into oil and gas-related activities. These ratios are expected to rise significantly with the launch of production at Kashagan, which was originally expected in 2015, but has been postponed several times now. Once the giant Kashagan field achieves its peak production, estimated to occur five years after it opens, Kazakh oil production is expected to double from its current levels.

Figure A5: Oil -Related Macroeconomic Development

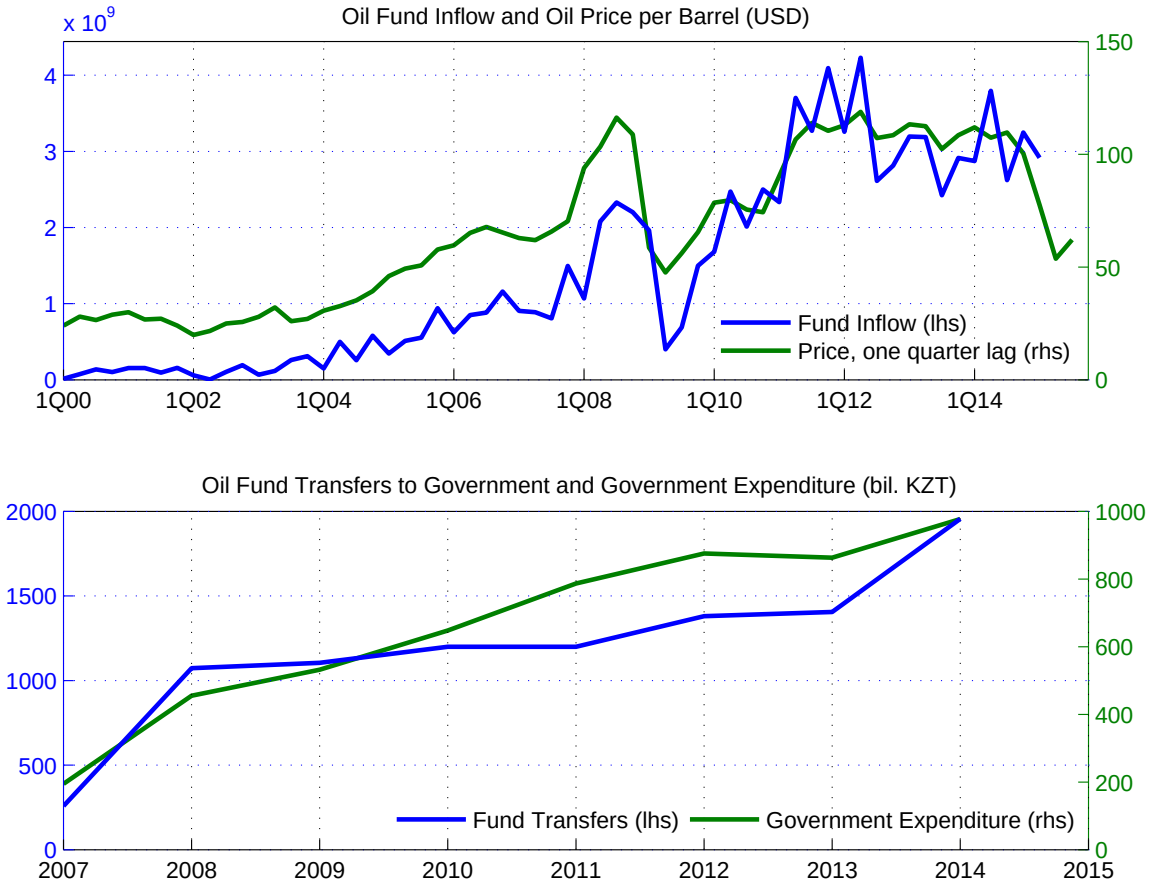


Source: NBK and authors' calculations.

[14] The Kashagan oil field was discovered in 2000 and is the largest new field to have been discovered anywhere in the world in the past 30 years. For more details, see `www.offshore-technology.com/projects/kashagan/`.

In order to manage its oil wealth, the government established an off-budget oil fund. The fund – the National Fund of the Republic of Kazakhstan (NFRK)[15] – collects oil revenues in the form of taxes and royalties from the oil-producing sector. The main goal (via channeling out these funds from the budget) was to ensure that volatility in oil revenues translates neither into excessive volatility in expenditures, nor into increased volatility of the nominal exchange rate.[16] The oil revenues are used primarily via government spending, as there are regular yearly transfers from the oil fund to the budget, and the economy thus benefits from the oil revenues mainly via budget spending and spillovers to oil-related services. The government budget is supported by a fixed transfer from the fund of USD 8 billion every year, with the caveat that the NFRK is not allowed to fall below 20 percent of GDP. The authorities have been disciplined in adhering to the set targets for transfers from the NFRK, and, as a result, the NFRK has steadily accumulated assets, naturally mainly during periods of high oil prices (see Figure A6).

Figure A6: Oil Fund Development



Source: NBK and authors' calculations.

[15] The NFRK is an off-budget fund that is managed by the NBK on behalf of the government. The transfers to the NFRK are in both domestic and foreign currency, but the proceeds are then invested in foreign assets. These assets are invested abroad (primarily in liquid instruments such as sovereign debt securities) and denominated mainly in U.S. dollars, euros, UK pounds, and Japanese yen.

[16] For instance, during the 2008–2009 crisis, oil fund savings were used to finance a large stimulus package that helped alleviate the economic downturn. After the crisis, the stimulus was phased out and the non-oil deficit declined, albeit at a slower pace than initially planned. At the same time, Kazakhstan accumulated a substantial buffer in the NFRK, reaching almost 30 percent of GDP as of the end of 2012.

The country's dependence on oil revenues, however, poses several challenges to its macroeconomic balance. The macroeconomic effects of highly volatile oil prices cannot be completely neutralized by domestic fiscal measures. Oil price changes are usually accompanied by increased exchange rate volatility and require corrective measures from the central bank. At the same time, the effectiveness of macroeconomic policy is hampered by the limited ability of the small non-oil sector to mitigate the impact of volatile oil prices on its activity in response to policy actions.[17]

Due to the high dependence of Kazakhstan on the performance of its oil production industry, which is strongly influenced by the level of oil prices, the key long-term policy priority of the authorities is to diversify Kazakhstan's production base. The main principles of this long-term strategy were laid down in a document called Strategy 2050, aimed at developing Kazakhstan into a developed economy through industrialization, closing the infrastructure gap, and making institutional improvements. However, while oil wealth is a significant asset that will no doubt help Kazakhstan achieve its diversification and development goals, the Dutch disease and the possible increasing role of the state in the economy seem to be the main challenges going forward.

A.3 Fiscal Policy

Kazakhstan, similarly to other commodity-producing countries, has historically faced significant terms-of-trade changes driving its growth and government revenues. Nevertheless, government spending remained under control and fairly stable relative to GDP on average until 2008. Kazakhstan's fiscal revenues, generated by high oil prices, increased from 4.5 to 12.5 percent of GDP. A significant part of those revenues were used to reduce government debt and build up a buffer in the NFRK. In fact, at the oil price peak in 2006–2007, about 60 percent of oil revenues were transferred into the NFRK. By contrast, falling oil revenues and anti-crisis and other measures resulted in a deterioration of the fiscal position during 2008–2009. Although the large-scale fiscal stimulus was stabilizing and helped curb the economic slowdown,[18] it resulted in a deterioration of the general government fiscal position. Consequently, the overall fiscal balance turned into a deficit in 2009, with the non-oil deficit exceeding 11 percent of non-oil GDP. Several years later, the government reacted to the overall worsening of Kazakhstan's economic situation by implementing another fiscal stimulus package (a five-year Economic Support Package, introduced in 2014) aimed at supporting the country's economic recovery. The measures resulted in the non-oil fiscal deficit significantly exceeding 10 percent of non-oil GDP.

A.4 Financial and Banking Sector

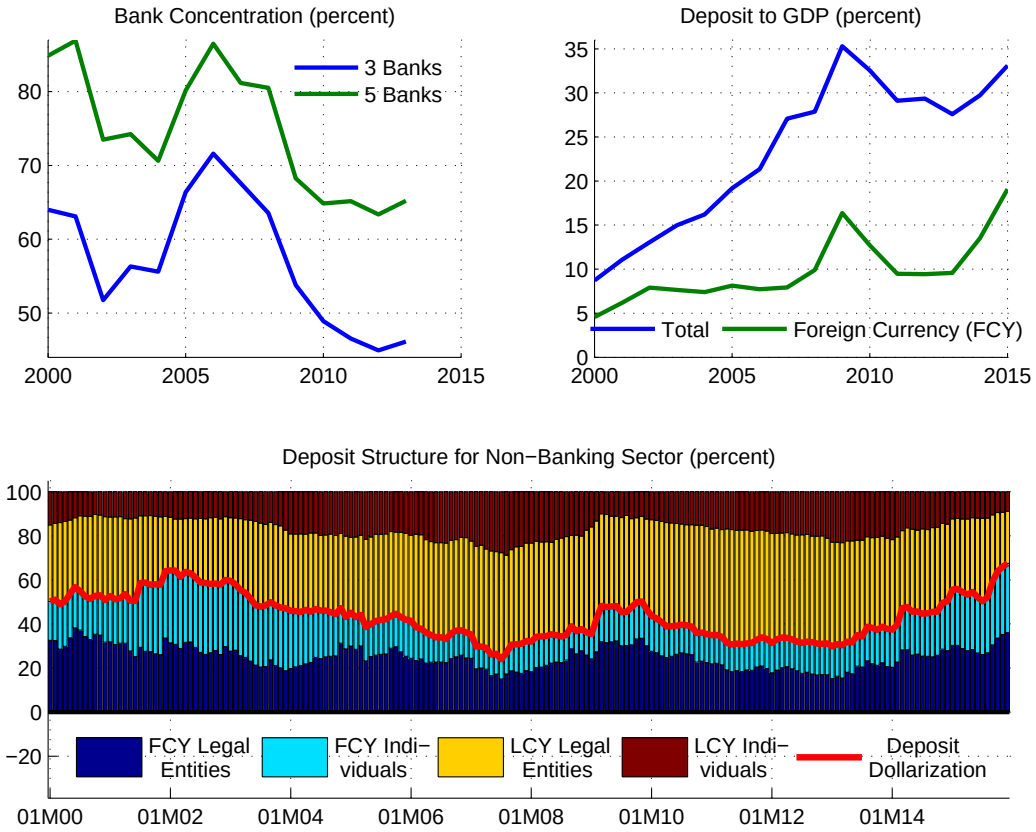
The banking sector, which dominates the financial system in Kazakhstan, consists of about 40 commercial banks and accounts for almost 80 percent of total financial system assets and half of GDP. Although the five largest banks accounted for more than half of banking assets in 2013 (see Figure A7, where bank concentration is calculated as the share of the assets of the three and five largest commercial banks in total commercial banking assets), bank concentration has gradually been declining as medium-sized banks have expanded their lending. The public funded pension

[17] The direct benefits of economic growth in the oil sector are shared by a few related sectors only, such as transportation and communications. Other key domestic sectors of the economy, such as manufacturing, construction, and real estate, benefit little from high activity in the oil sector. In particular, given the pattern of financing in the energy sector, where companies generally rely on funds for investment financed from abroad, there is a limited role for the domestic financial system to develop financial intermediation. See the discussion later.

[18] The IMF estimates the total fiscal impulse from the general government budget in 2008–2009 at about 4.5 percent of GDP. When off-budgetary spending is taken into account as well, the fiscal impulse rises to almost 7.5 percent of GDP.

system, formerly comprised of ten private pension funds, accounts for 18 percent of the financial system. At the beginning of 2013, the government began a process of nationalization of the ten private pension funds (owned by banks), with all assets to be consolidated in the Unified Accumulation Pension Fund in 2014.

Figure A7: Financial Sector Characteristics



Source: NBK and authors' calculations.

Although the global crisis had a positive impact on the structure and solvency of the banking system (the system has been streamlined and rendered less vulnerable to external developments, including the 2014 and 2015 devaluations), deep-seated vulnerabilities remain and non-performing loans are still high. Additionally, the financial sector can be characterized by:

- **A low deposit base.** The deposit base in Kazakhstan is lower than could be expected based on its level of economic development. Figure A7 shows that total and foreign currency deposits were about 30 and 15 percent of GDP, respectively, in the second half of the 2000s and have stayed around these levels recently.
- **High dollarization.** The low domestic deposit base is more pronounced when it is broken down by currency. The positive de-dollarization trend in the first half of the 2000s has been disrupted by the global crisis and devaluations of the tenge over the past several years. Foreign currency deposits dropped below 30 percent of total deposits as the crisis struck in 2007, but they had more than doubled by the end of 2015 (see Figure A7).
- **High reliance on foreign funding.** Before the global crisis, banks were able to sustain rapid expansion of their balance sheets via high levels of foreign borrowing. The banking sector's external debt grew from around 6 percent in 2002 to about 44 percent of GDP in 2007. The

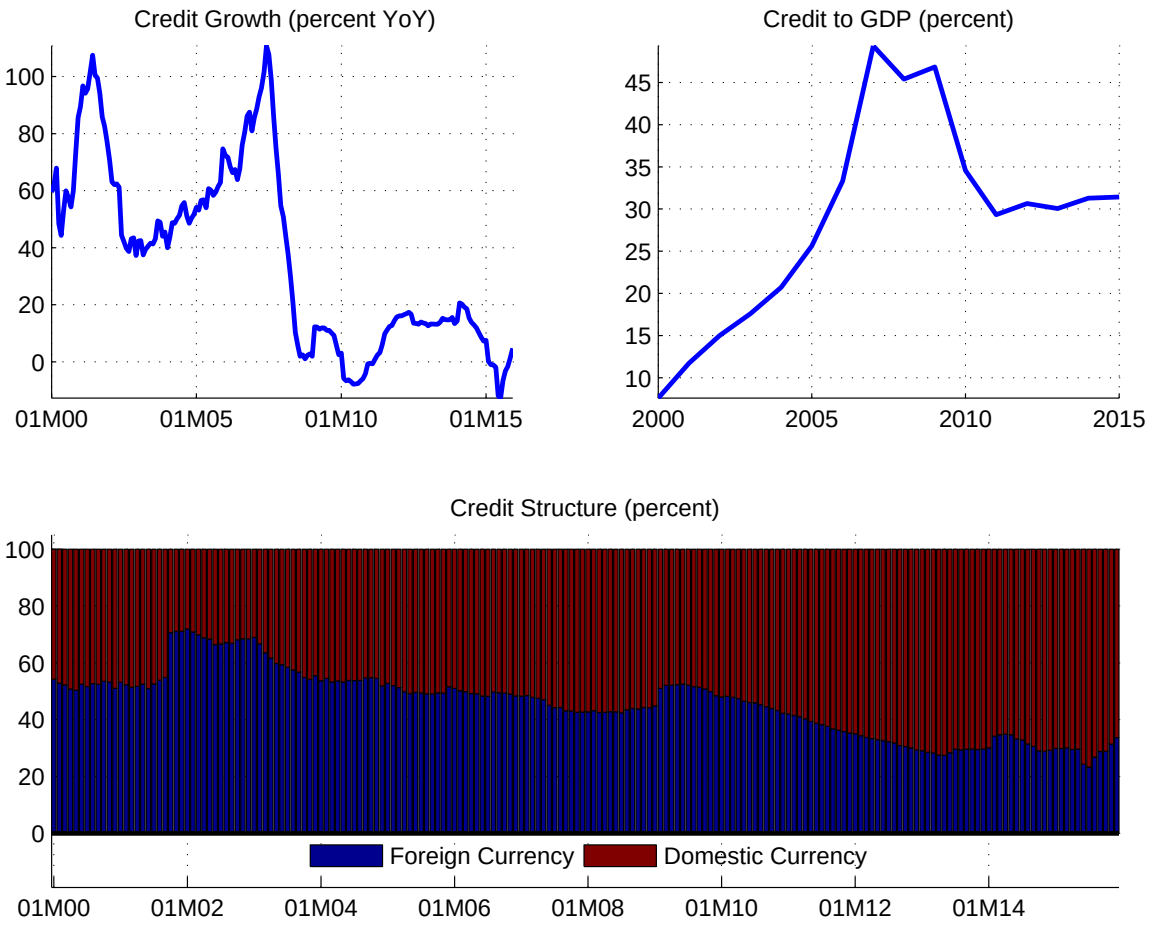
loan-to-deposit ratio nearly doubled during this period, peaking above 200 percent in 2007, and has remained one of the highest among countries of comparable economic size.

These features significantly affect the monetary policy transmission mechanism and are captured via the calibration of the structural model parameters.

Foreign currency risk continues to be high and dollarization keeps the economy vulnerable to exchange rate volatility and exchange rate-induced credit risk (see Figure A8). While the share of dollar-denominated loans has declined by nearly 20 percentage points since 2009, the share of foreign currency deposits has risen. The shares of USD-denominated loans and deposits are currently close to a relatively high 40 percent.

The credit market remains shallow. The NPL overhang at about 25 per cent, combined together with dollarization and tight monetary policy in 2014 and 2015, continues to restrict the banks' ability to extend credit. Given its limited depth and scope, the domestic credit market has had only a modest impact on economic activity. The shallow credit markets weaken the interest rate channel and naturally constraints the effectiveness of monetary policy.

Figure A8: Credit Market Characteristics



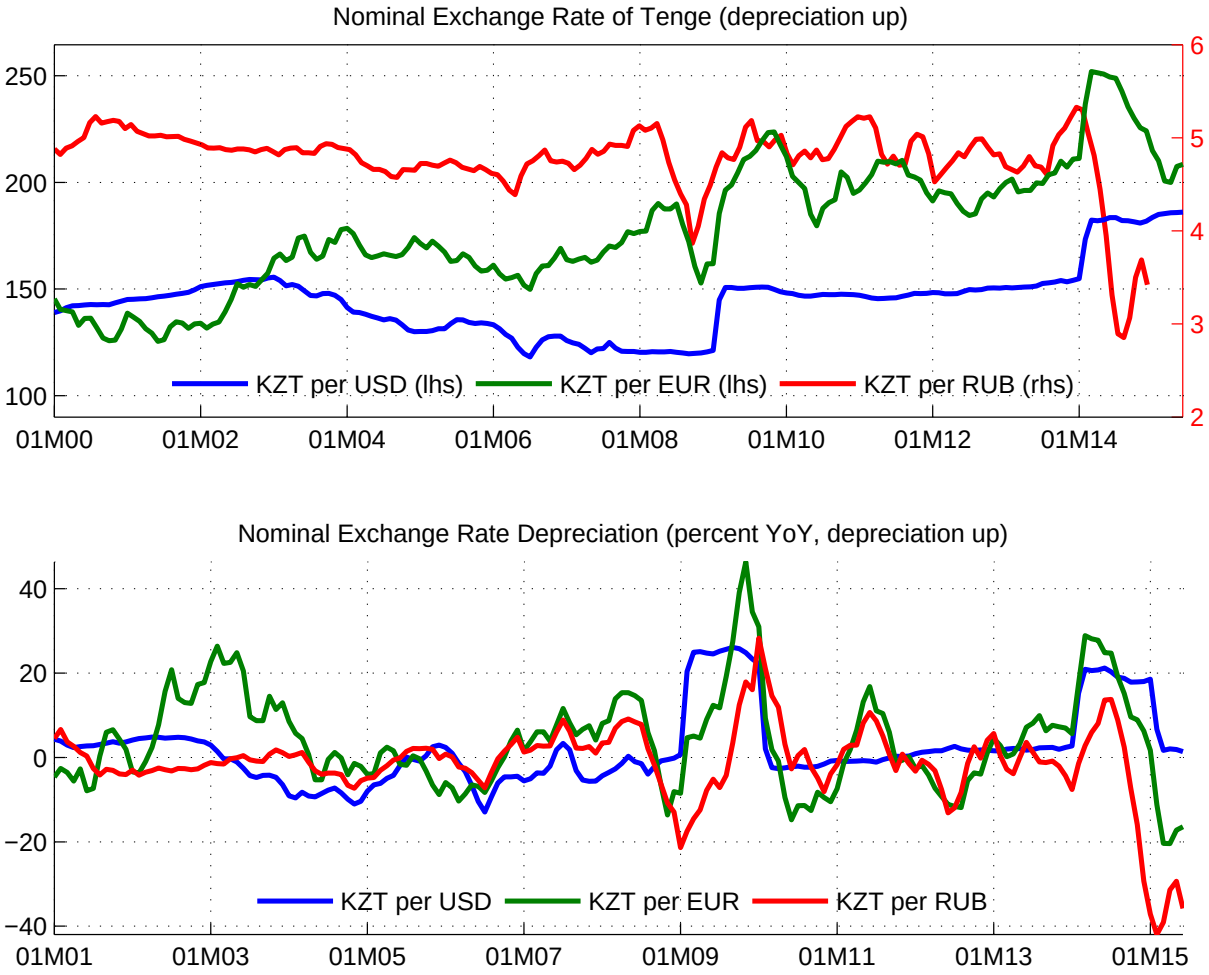
Source: NBK and authors' calculations.

A.5 Monetary Policy and the Exchange Rate

The specification of the model – the monetary and exchange rate block in particular – and the model calibration reflect the Kazakh monetary policy framework. This is mirrored mainly in the fixed exchange rate specification and the interest rate dynamics, including the risk premium (see equations (11), (12), and (13)) and monetary policy transmission. The following paragraphs describe the reasoning behind this.

The primary goal of NBK monetary policy is maintaining price stability and keeping inflation in a pre-announced corridor. At the same time, the National Bank of Kazakhstan (NBK) tightly managed the tenge exchange rate, requiring frequent interventions in the foreign exchange market. Interest rate policy was not very active, as money market rates were not actively managed by the central bank, liquidity management required further improvements, and open market operations were rather occasional. The main policy instrument of the NBK relied primarily on the regulation of minimum reserves and liquidity absorption facilities.

Figure A9: Nominal Exchange Rate of the Tenge against the Main Currencies

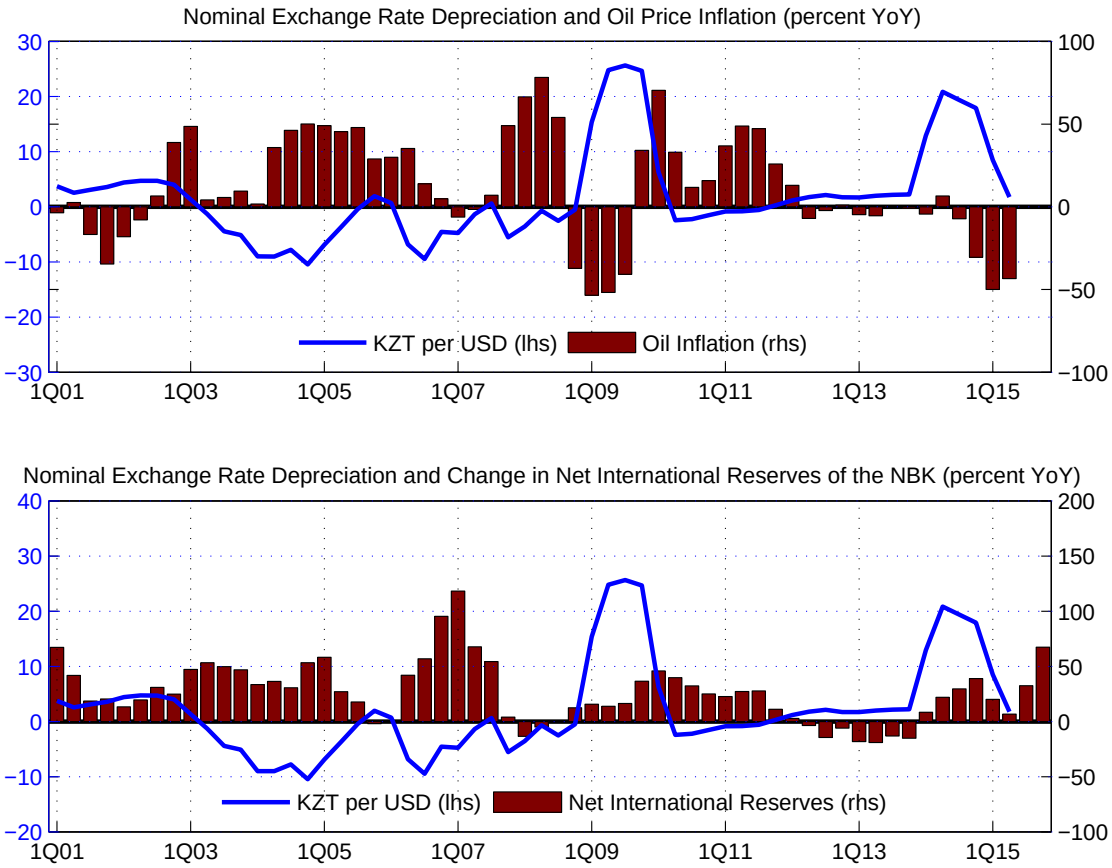


Source: NBK and authors' calculations.

The managed exchange rate regime was the basis for the NBK's policy – the tenge was kept stable against a basket of three currencies of the main trading partners (see Figure A9). The

multiple-currency basket consisted of the dollar, the euro, and the ruble (with weights of 70, 20, and 10 percent, respectively). Despite the clear dominance of the U.S. dollar in the basket, trade with Russia and international links with other countries were important and drove the Kazakh economy. The currency basket thus reflected major movements in the ruble-dollar exchange rate, the dynamics of the current account balance, reflecting oil price movements, FDI inflows and capital outflows, and the external competitiveness of the country's non-oil sectors.

Figure A10: Drivers of the Nominal Exchange Rate



Source: NBK and authors' calculations.

Being an open economy, Kazakhstan is exposed to external shocks and has periodically resorted to one-step exchange rate devaluations. In early 2009, as a result of the sharp drop in global oil prices during the second half of 2008 and following a significant depreciation of the Russian ruble, the NBK devalued the tenge by 20 percent against the dollar to 150 KZT per USD. During 2009–2013, the tenge was kept stable against the dollar. The NBK switched to the use of a multi-currency basket to smooth excessive forex fluctuations in September 2013. In February 2014, however, it unexpectedly devalued the tenge by almost 20 percent to 185 KZT per USD and reestablished a tight new corridor of +/- 3 tenge around the new devalued rate. Later on, the band was twice widened, to 170–188 and 170–198 KZT per USD. Unfavorable economic developments, primarily reflecting an oil price slump, and the subsequent need for intensified foreign exchange interventions by the NBK led to further depreciation of the tenge against the dollar in August 2015 (see Figure A10). This decision was accompanied by an overall change to the monetary policy framework, with the NBK introducing a floating exchange rate and creating a strategy for adopting inflation targeting. The new framework also included the introduction of a new policy interest rate (base rate) as a new monetary policy instrument of the NBK. The operational side of monetary policy was updated as well.

The central bank's benchmark interest rate, the official refinancing rate, played little part in liquidity management and did not provide a signal about the stance of monetary policy. As a consequence, interbank interest rates reflected movements in tenge liquidity. The official refinancing rate and the NBK's deposit rate constituted a sort of interest rate corridor: the deposit rate served as a hard floor, because it was tied to a standing facility, but the refinancing rate played only an indicative role, serving instead as a soft ceiling.

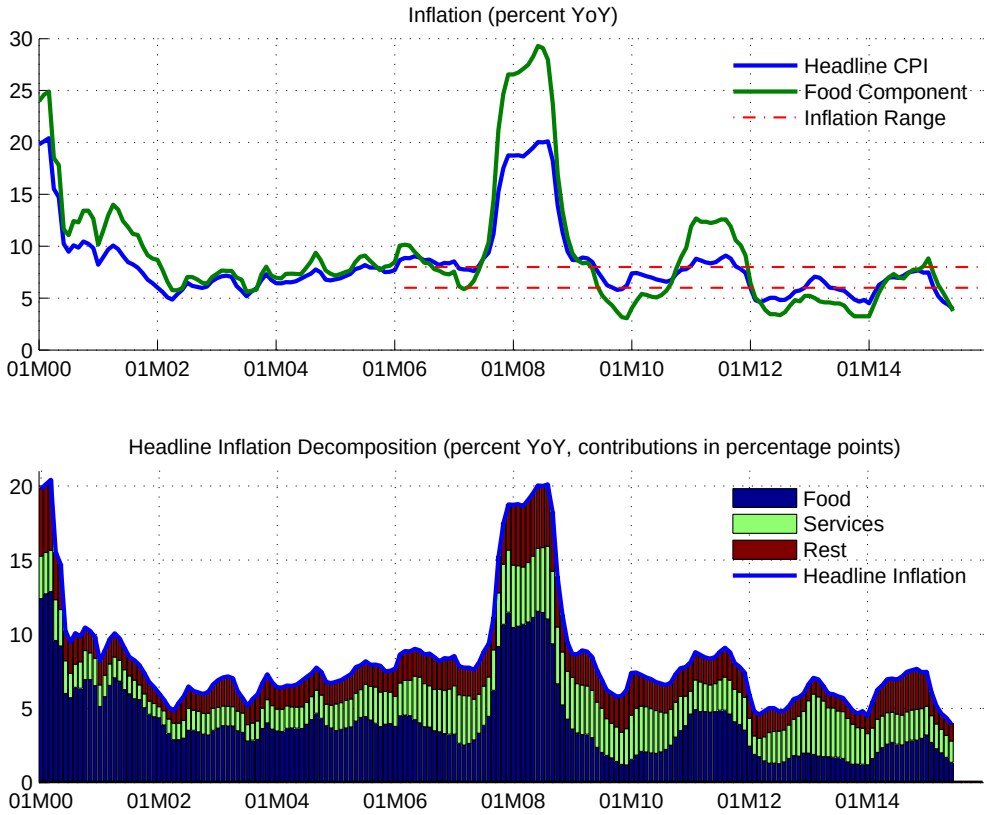
The update of the monetary policy framework in the second half of 2015 significantly improved the NBK's transparency in communicating its policy objectives, actions, and future plans. The NBK started to actively guide markets, strengthened its analytical capacity, and changed its medium-term orientation to inflation.

A.6 Inflation

The exchange rate strategy focused on a stable nominal exchange rate was able to deliver relatively stable inflation hovering within the 5–10 percent range most of the time. The NBK officially announced a narrower corridor of 6–8 percent for headline inflation in advance in 2005 (see Figure A11). The potential conflict in policy preferences with respect to inflation and the exchange rate revealed itself fully in mid-2015 and resulted in the introduction of a floating exchange rate and the adoption of inflation targeting at the end of 2015.

Jumps in headline inflation have often occurred due to soaring prices of food. Food accounts for a large share of the CPI consumption basket (about 50 percent on average historically), but its weight declined to 36 percent in 2014, which is the value of parameter a_1^1 in equation (1).

Figure A11: Inflation Dynamics



Source: NBK and authors' calculations.

Appendix B: Data Used in the Model

Here we describe the collection of the data that were used for the empirical work with the Kazakh model. Table B1 provides an overview of the time series used, including descriptions and sources. The data roughly span the time period from the late 1990s until 2015. The majority of the data are provided directly from internal NBK sources.

Special attention was paid to the model data relating to the external environment. While most of the data were used without any further processing, this is not true for the data representing the external environment. To reflect the diversity of the export and import structures of the Kazakh economy, we calculated effective indicators of the foreign output gap and foreign prices as a weighted average across the data of the main trading partners – Russia, China, and the EU. In this regard, we used time-varying weights derived from the trade statistics. The mapping of the data onto the model variables measured in levels followed the logarithmic transformation. The original time series were seasonally adjusted where appropriate.

Table B1: Data Sources

Indicator	Units	Source♣	Available from
Prices			
CPI inflation	%, QoQ p.a.	NBK	1995Q1
Non-food prices	100*log(level)	NBK	1995Q1
Food prices	100*log(level)	NBK	1995Q1
Equilibrium oil price	KZT	NBK	2000Q1
Terms of trade	Gap, %	NBK	2000Q1
National accounts (in real terms)			
Output	100*log(level)	NBK	2000Q1
Domestic demand	100*log(level)	NBK	2000Q1
Exports	100*log(level)	NBK	2000Q1
Imports	100*log(level)	NBK	2000Q1
Government consumption	100*log(level)	NBK	2000Q1
Transfers	Gap	NBK	2007Q1
External environment			
Foreign non-energy prices	100*log(level) [USD]	NBK	2001Q1
Foreign food prices	100*log(level) [USD]	NBK	1995Q1
Oil price (Brent)	USD	Bloomberg	1996Q1
Foreign output	Gap	EIU/Bloomberg	2001Q1
Money market & FOREX			
Kazakh 3M Interbank Rate	% p.a.	NBK	2002Q1
US Federal Funds Target Rate	% p.a.	FRED	1995Q1
Nominal exchange rate	KZT/USD	NBK	2000Q1

♣ EIU = Economist Intelligence Unit; FRED = Database of Federal Reserve Bank of St. Louis; NBK = courtesy of National Bank of Kazakhstan representatives

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