Mongolia Macro-Fiscal Model

Model Guide

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1. EXECUTIVE SUMMARY

Introduction

Mongolia holds enormous mineral wealth for a country with a population of 3 million. Beneath its vast territory are some of the largest untapped coking and thermal coal deposits on the planet, as well as the world's largest new copper and gold mine. At the beginning of the 2010s, when commodity prices were high, the prospects of potentially large future resource revenues led some watchers to say that Mongolia could become the Saudi Arabia or Kuwait of Central Asia.

But this vision seems elusive. Mongolia is, for now, a middle-income country, heavily dependent on the limited revenues it currently generates from the sector. While minerals and petroleum account for 90 percent of all exports, they only cover one third of budget expenditures. Instead of putting aside the revenues from exhaustible minerals for rainy days and for future generations, the government has accumulated new debt at a rate that far outpaces savings.

Mongolia has also experienced very strong economic booms and busts over the last decade. These were driven partly by commodity swings. They were also aggravated by excessive borrowing and consumption during boom times. Mongolia rebounded from a balance of payment crisis followed by an International Monetary Fund (IMF) bailout in 2009. Now it faces renewed short-term financial pressures amid growing public debt.

The opportunities and challenges created by the mining sector highlight the need for careful planning and a solid policy framework that promotes economic sustainability. The Mongolian government took multiple important steps in this direction. In 2010, the parliament adopted a set of fiscal rules as part of the Fiscal Stability Law setting ceilings on expenditure growth, structural budget deficits and on the stock of government debt. In 2017, the government is establishing a new sovereign wealth fund, the Future Heritage Fund, to accumulate a proportion of natural resource revenues for future generations.

But are these rules meeting their objectives? NRGI built a Mongolia macro-fiscal model in order to monitor progress and analyze challenges.

How the model works

The model provides an open, simple and user-friendly model of the Mongolian economy. It was developed to project a baseline scenario and describe how different shocks or policy changes would impact the trajectory of key macroeconomic and fiscal variables over a 30-year horizon.

The macro-fiscal model is comprised of three main sections: the macroeconomic model, the mineral sector block and the fiscal block. A small-scale, semi-structural macroeconomic model provides key calculations estimating the complex relationships among a variety of aggregate economic variables. These include consumption, investment, economic output, budget deficit, and national and international prices.

The model separates the economy into three economic sectors: mineral, agricultural and the core sector, which represents industrial and service sectors.

Due to its economic significance and distinct features, the mineral sector is modeled from the bottom up. It uses simplified project-level financial models of the country's five largest mines, which are then aggregated alongside a linear projection of the remainder of the mineral sector.

The fiscal block provides detailed projections across the main tax and expenditure categories, as well as most important fiscal aggregates, such as various measures of the deficit and debt.

Combining these sections allows for the capture of key linkages between the mineral sector, the budget and the overall economy. Users can test the impact of shocks in the mining sector or monitor how changes in fiscal policy might affect the country's debt sustainability outlook and Mongolia's compliance with its fiscal rules.

No model can do everything. This model is not designed to be a forecasting tool; it won't answer questions about what the country's optimal growth-enhancing strategy might be. Rather, it allows users to assess sustainability implications of various scenarios compared to a pre-defined baseline scenario. These estimates are based on a theoretically consistent framework and calibrated using observations of Mongolia's economy between 2000 and 2015. Chapters 2-6 of this document describes the detailed workings of the model.

Why is this novel?

Macro-fiscal models with similar aims have been regularly built by public agencies (Mongolia's central bank and ministry of finance), international organizations (IMF, the World Bank) and by the private sector (investment banks, think tanks). The Economic Research Institute of Mongolia evaluated the risk of "Dutch disease" (Tserendorj, 2012). The World Bank published short-term forecasting and long-term growth models (Dutu, 2012). The IMF in 2015 analyzed optimal public investment strategy for Mongolia (Gupta, 2015).

However, this model has a number of innovative features that make it distinct both within and outside Mongolia.

Macroeconomic models are used regularly in OECD economies; far fewer have been used in developing countries. Difficulties in obtaining reliable data, more limited resources to build and maintain such tools, and less experience in how they can be best used might all be potential contributing reasons for that. We hope this tool will support regular analysis of Mongolia's economic sustainability.

Most such models do not adequately address the significance and particularities of the natural resource sector. While many other sectors experience volatility, changes in expansion plans, tax terms, or the delays in mining mega-projects can have very large ramifications. By incorporating simplified financial models from the country's five largest mines, we are building a bridge between the growing repository of financial models of mines, such as the open model of the Oyu Tolgoi mine (OpenOil, 2016) and macroeconomic models.

Most such models are not public. While some include a description of the model, main equations employed, key results and some parameters describing the robustness of the results, in very few instances is the full model made public. By making our model public, we open it up to wider reuse, scrutiny and adaptation.

Most such models are made with proprietary and hard-to-access software. The computationally heavy nature of the undertaking led to a flourishing of dedicated tools for experts. These tools are both expensive and difficult to learn. This model, available in XLSX format and with a user-friendly interface, will reach new users inexperienced with macroeconomic models.

Using and improving the model

The model is available in XLSX format on www.resourcegovernance.org under CC-BY (open) license.

The model has a user-friendly interface, labeled the "control panel" tab, allowing users to test various scenarios and interpret results. The user can define a hypothetical scenario by inputting key parameters for commodity price and volume shocks (both one-off and permanent), as well as different tax and expenditure measures.

The user can choose one or multiple types of shocks from the list by setting a non-zero value (either positive or negative) for relevant measures. For example, an expenditure increase will be a positive figure, while an expenditure cut will be a negative figure. The user can also adjust the start year for the shock. Appropriate start years range between 2017 and 2030. Another possible shock is to set back the development of the gigantic underground mine of Oyu Tolgoi compared to currently planned production start in 2021.

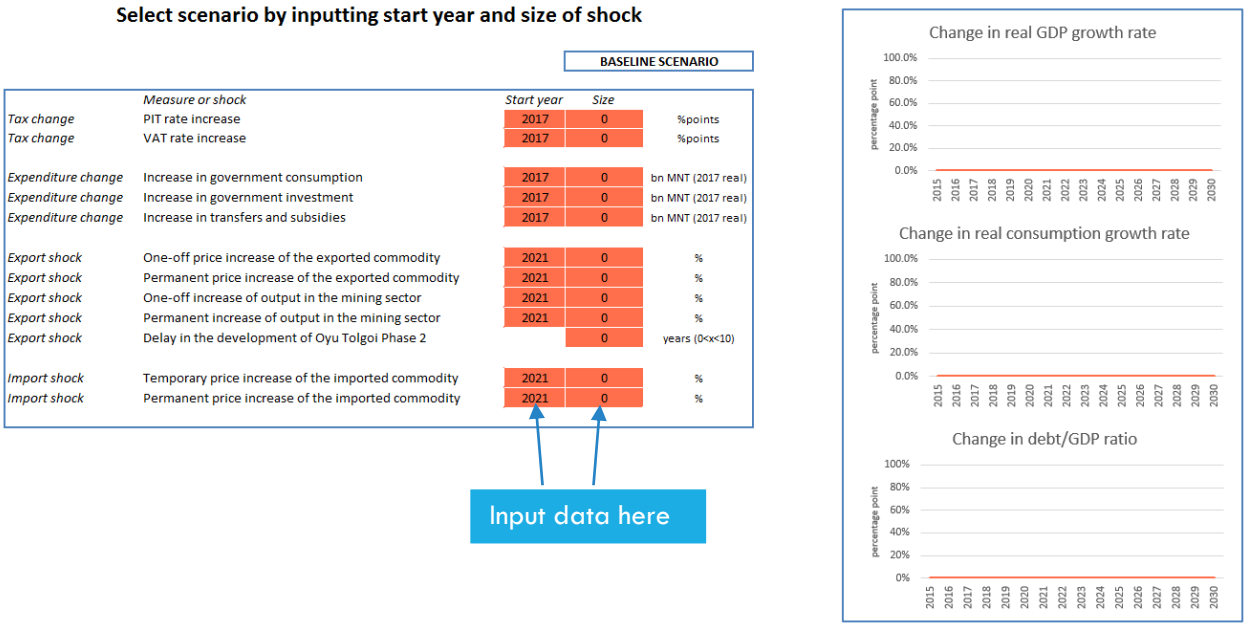

Figure 1. The Control Panel of the model

Once the data on the size and start year of shocks and policy changes are inputted, the graphs on the right will display metrics of the impact of this alternative scenario compared to our baseline. The "graphical results" and "numerical results" tabs provide further details on the trajectory of key economic and fiscal variables along both the baseline and the alternative scenario. Additional, more complex shocks

can be inputted through the “advanced control panel.” For further detail on the spreadsheet refer to chapter 9 of this document.

This model was built using data from a variety of government, company and international sources collected throughout 2016. All data used is presented in the spreadsheet. It also reflects a series of meetings with experts in Mongolia in November 2016 to refine calculations and clear up ambiguities. Nevertheless, some uncertainties and data gaps remain, most importantly regarding the financial details of the largest mines in the country as well as contingent liabilities of the state. The model is also subject to errors and overlooked information.

For questions or to provide feedback on this model:

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NRGI analysts will continue to work with stakeholders in Mongolia to refine and update the model.

Key findings

Mongolia's economy is in severe shock. Financial and economic indicators started deteriorating in 2015 and have plunged sharply in 2016. Immediate responses will be needed to address looming debt payments, but these responses need to be developed in tandem with finding adequate responses to medium- and long-term sustainability challenges. Using the model, we arrived at the following findings.

The baseline

In our baseline scenario, we assume a rapid recovery from the current shock propelled by easing of financial pressures and large expansion of the Oyu Tolgoi copper and gold mine. Growth rate accelerates gradually from near 0 to 8 percent by 2020 and remains this high until 2024. After this peak, growth stabilizes at 4 percent to 5 percent, occasionally interrupted by mine shut-downs. Our long-term growth outlook is built on the assumption that the mining and agricultural sectors will gradually decrease in significance compared to the industrial and service sector, which is driven by a 1.5 percent population growth, a 5 percent capital stock growth and a 3 percent productivity growth.

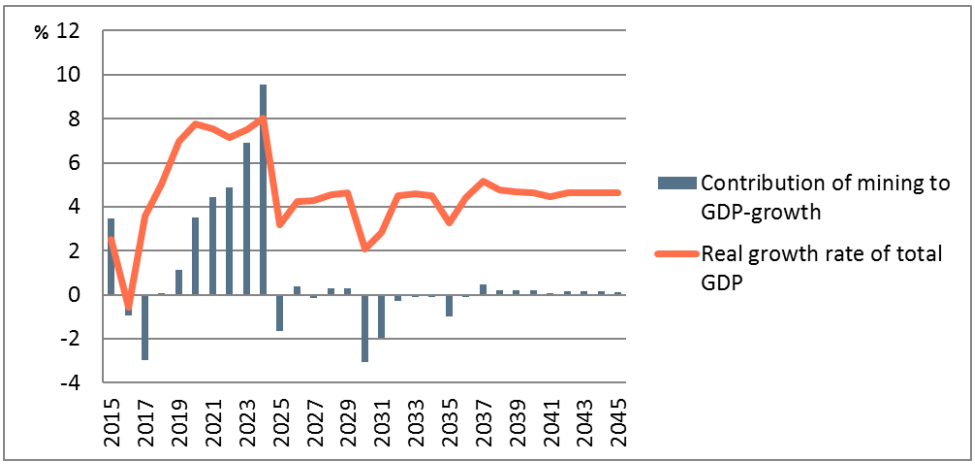

Figure 2. Real GDP growth (baseline scenario)

After pressing financing challenges are resolved along this brightened medium-term growth outlook, our model projects a considerable improvement in revenues collection fueled partly by mining sector expansion. Nevertheless, primary expenditures (which exclude interest payments) are permanently above overall revenues. Therefore, interest expenditure (the gap between primary expenditures and total expenditures) increases steadily.

Because of worsening deficit and accruing interests, the level of debt to GDP ratio (which includes government guarantees on private debts) is on an unsustainable trajectory, growing rapidly throughout the projection horizon, even during the period of rapid economic expansion until 2024. This baseline is further susceptible to negative shocks, such as mining project delays, or adverse commodity price shocks. The baseline scenario is presented in more detail in Chapter 7.

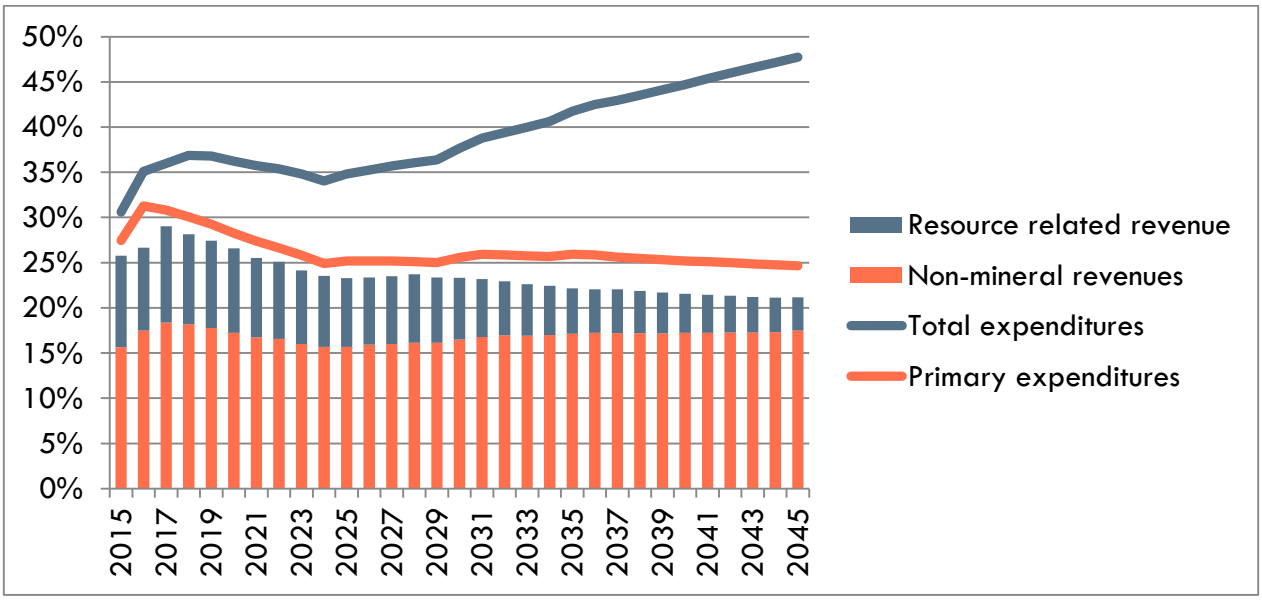

Figure 3. Fiscal variables (baseline scenario)

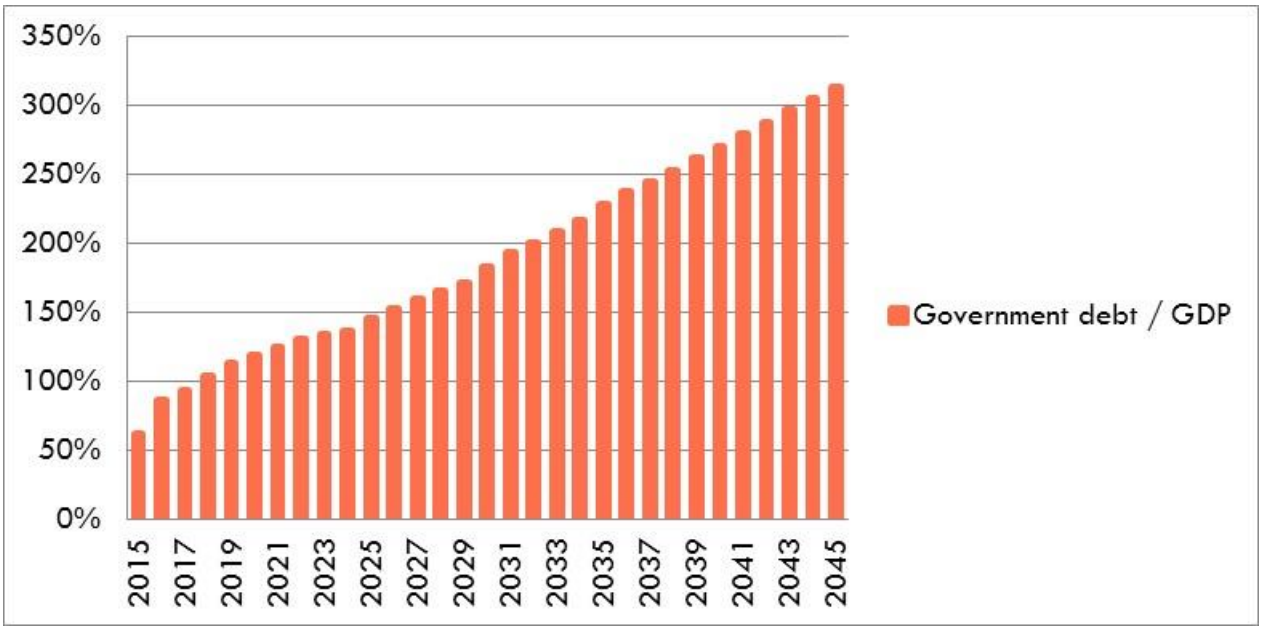

Figure 4. Government debt (baseline scenario)

Scenarios

There are important trade-offs between different fiscal measures the government can take to bring down the short-term fiscal deficit.

Increasing taxes on labor

Increasing the currently 10 percent personal income tax rate by 10 points would reduce the primary deficit by 1.8 percent. By substantially reducing the incentive to work, however, this would lead to slower GDP growth and a smaller reduction in the debt-to-GDP ratio. The positive snowball effect of reducing the interest expenditures would also contribute to a 30 percent decrease of the debt-to-GDP ratio by 2030, compared to the baseline.

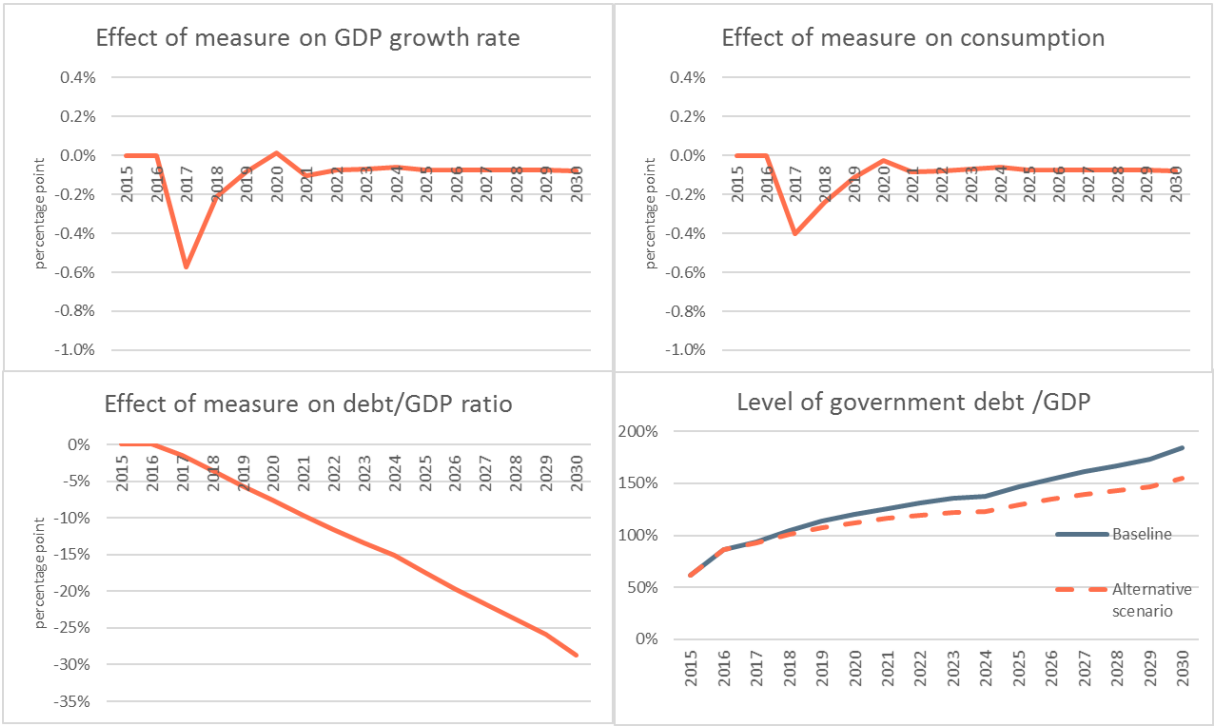

Figure 5. Effects of 10 percent increase in personal income tax

Increasing tax on consumption

A 5 percent increase of the current 10 percent VAT rate (excluding mines where VAT rates are fixed in long-term contracts) would lead to an approximately 2 percent amelioration in the primary deficit. The VAT hike is beneficial for private savings and investment, as it reduces the propensity to consume. Its negative short-term effects on GDP growth, therefore, are outweighed by its positive effects on the medium- to long-term period. The positive snowball effect of reducing the interest expenditures would also contribute to close to 40 percentage point decrease of the debt-to-GDP ratio by 2030, compared to the baseline.

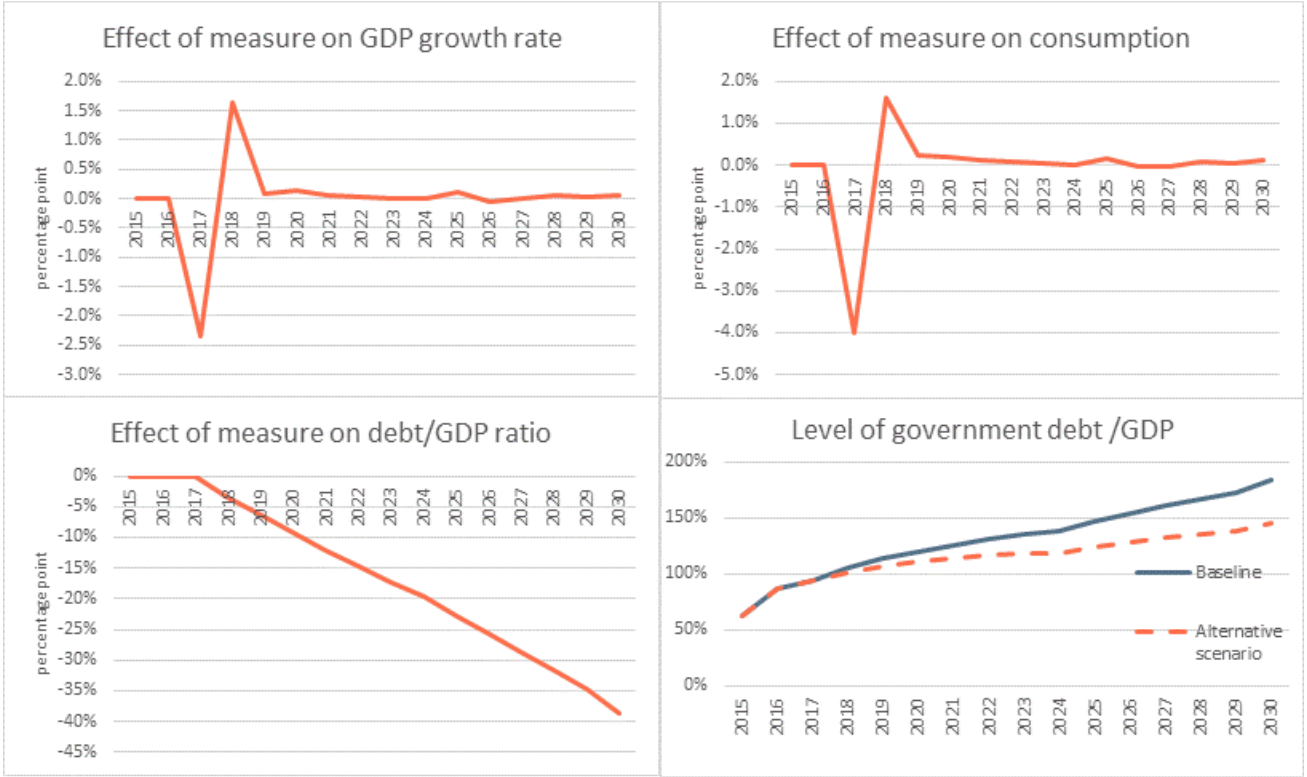

Figure 6. Effects of 5 percentage point increase in VAT

Different expenditure cuts

Government expenditures are classified in three categories: government consumption, government investment and social transfers. Cutting investment is usually the politically easiest fiscal adjustment: it has smaller negative effects on household consumption, but its long-term negative effect on growth substantially reduces its overall effect on fiscal sustainability. Cutting transfers helps the most to reduce the debt-to-GDP ratio, but it also reduces private consumption the most. A cut of 2 percent of GDP (MNT 500 billion) in government expenditures can reduce the debt-to-GDP ratio by 2030 compared to the baseline by 15 percent if it falls on government investments but by 21 percent if it decreases subsidies and transfers.

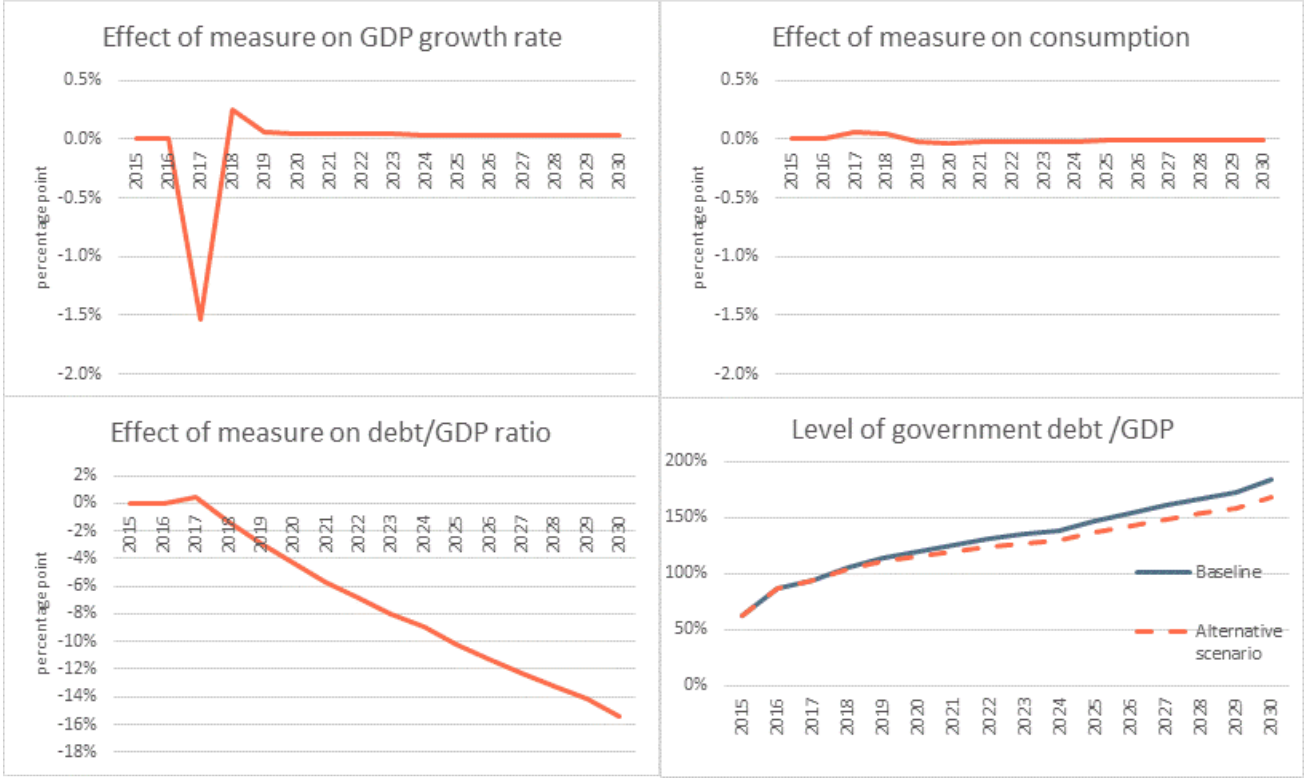

Figure 7. Effects of MNT 500 billion cut in government investments

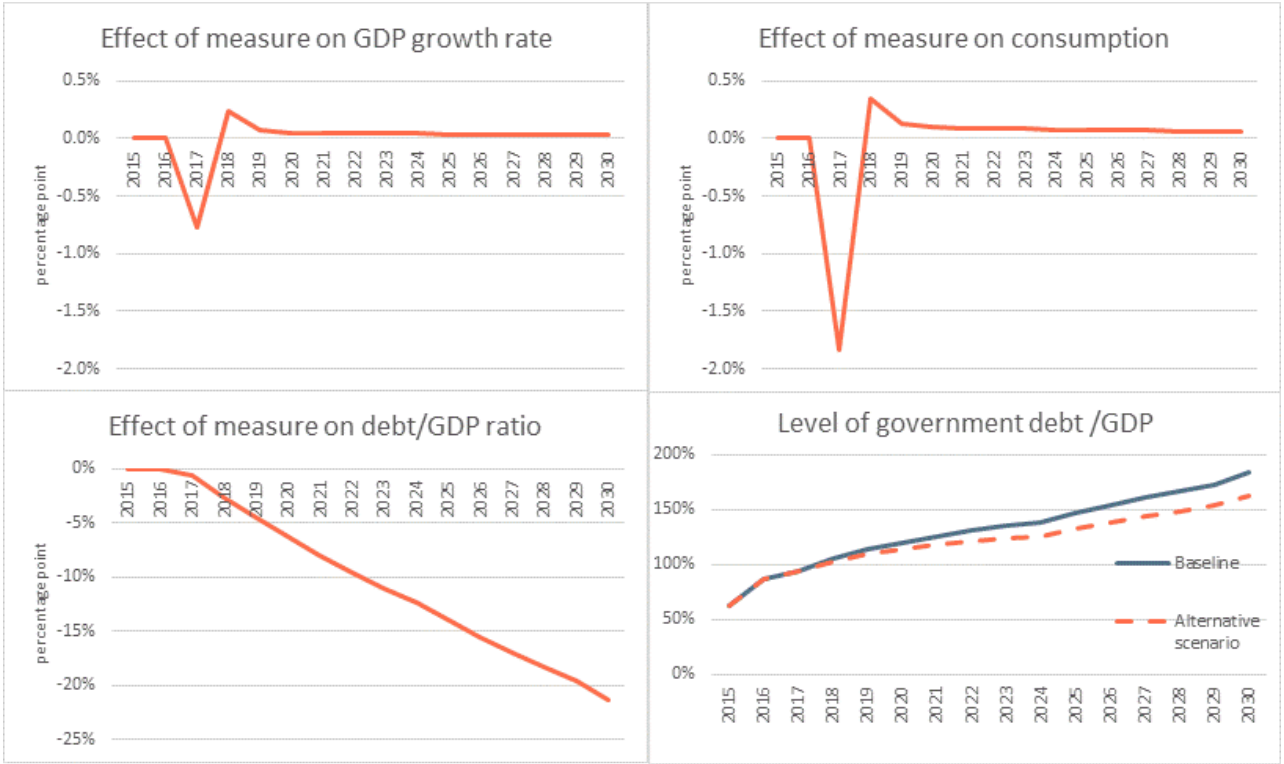

Figure 8. Effects of MNT 500 billion cut in subsidies and transfers

Major expenditure cuts or tax hikes to cut the deficit will hurt growth and household consumption, but are unlikely to restore debt to a sustainable path on their own. Detailed results of the model (presented in Chapter 8) provide some insight into how a combination of deficit reducing and growth enhancing measures can be more effective in helping to restore fiscal sustainability.

Among the various policy scenarios, reallocation of expenditures toward efficient government investment and to reduce the risk premium (e.g. improved access to credit, institutional changes or increased transparency) have a positive long-term effect on growth.

Fiscal rules

The Fiscal Stability Law adopted in 2010 was put in place "for the purpose of ensuring fiscal stability, creating renewable wealth, making investments that support economic development and generating financial savings with mineral revenues for the purpose of ensuring fiscal stability." It sets three clear targets designed to help achieve these goals. The model is able to inform policy decisions by evaluating the distance between the designated fiscal rules and the fiscal path under various scenarios.

The balanced budget rule sets a structural deficit target of 2 percent of GDP, while our baseline scenario shows a deteriorating deficit path. Similarly, the debt rule sets a target of 60 percent of GDP for government debt, while our baseline depicts a rapidly increasing trajectory. The model indicates that very drastic measures and/or positive shocks would be needed to turn these trends around. The expenditure growth rule is observed under the baseline scenario with considerable headroom.

On the whole the baseline (no policy change) scenario is not sustainable, however at least until 2024 the expenditure rule is obeyed; hence theoretically there would be some room for increasing growth enhancing expenditures, if the government decided to restore long term fiscal sustainability through a combination of other means.

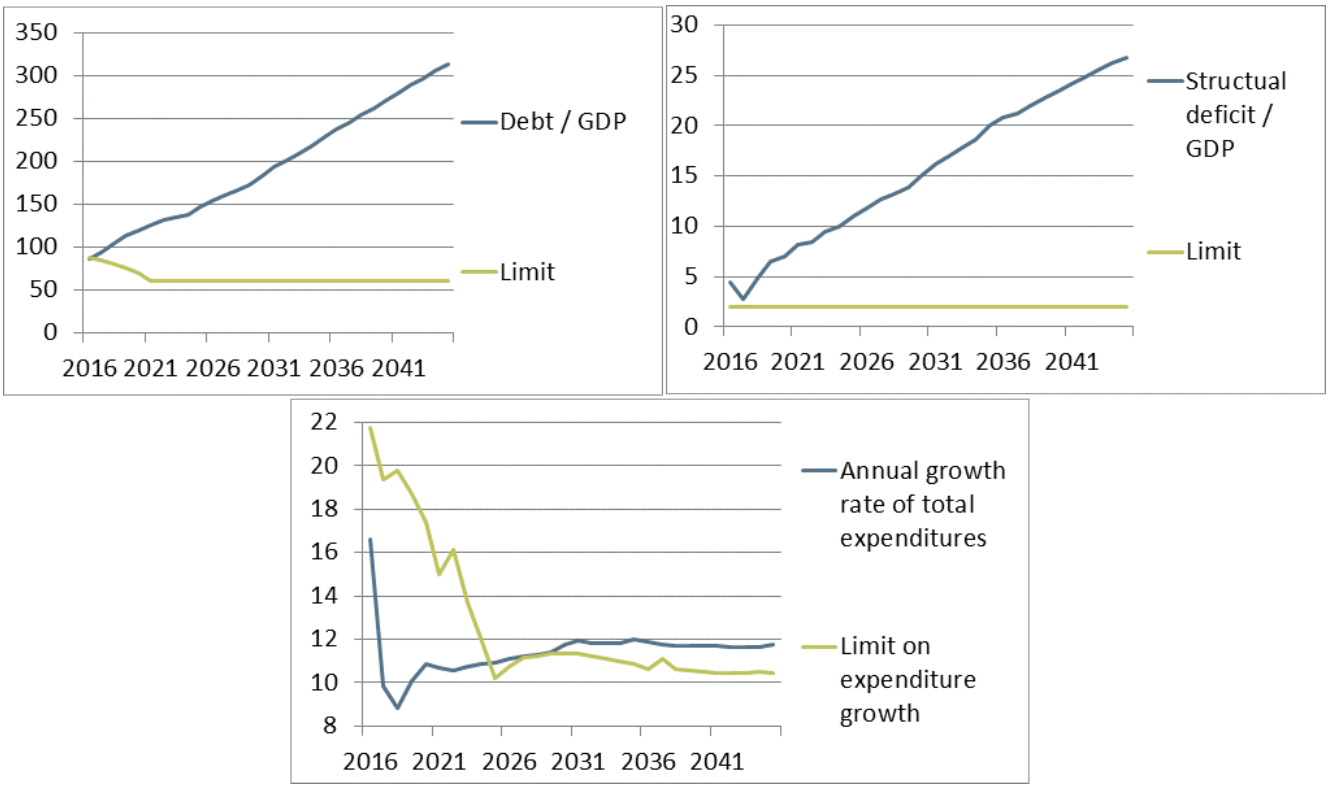

Figure 9. Observance of the fiscal rules (baseline scenario)

Overview of this document

In the following sections, we describe the workings of the model and further results from our analysis using the MMM. The model is described across four chapters: chapter 3 reviews the small scale semi-structural macroeconomic model at the heart of the MMM, chapter 4 reviews the fiscal block and how main revenue and expenditure categories are being projected chapter 5 describes the mineral sector block building on financial modelling of the six largest mines and chapter 6 presents additional auxiliary calculations used in the projections: demographic, labor market and capital stock accumulation trends. Our finding from using the model are presented in the following two chapters. Chapter 7 describes the baseline scenario, and Chapter 8 provides an overview of how key variables behave across a variety of potential scenarios. Chapter 9 describes how the model can be used, how it can updated, the underlying data and some its limitations. Further technical appendices are available in a stand-alone document providing the equations, variables and parameters used in the model, as well as further details on the dynamic properties and forecast performance of the model.

2. THE MACROECONOMIC MODEL

The macroeconomic model provides a projection of all relevant macroeconomic variables driving the debt sustainability outlook of Mongolia. These macroeconomic projections are used both to understand the core behavior of the economy and as the main inputs to the forecast of the key fiscal variables. In this section we summarize the main properties of this model for Mongolia. This description consists of four parts: 1) introduction and modelling approach 2) model structure, 3) dynamic properties, 4) calibration, estimation and in-sample forecast properties.

These descriptions concentrate on the main channels and mechanism of the model only, all other technical details (all equations, parameter names and values) and detailed results (non-listed charts, variance decomposition, equation decompositions, test-statistics) are available in a stand-alone technical appendix.

Introduction and modelling approach

Macroeconomic modelling faces several trade-offs in describing the broad structure of the economy. As the Fagan-diagram shows (see figure below) structural models might explain relatively few particular aspects of the economy and offer an intuitive interpretation of economic actors' behavior in line with economic theory, but they are never able to replicate all relevant macro features of the whole economy.

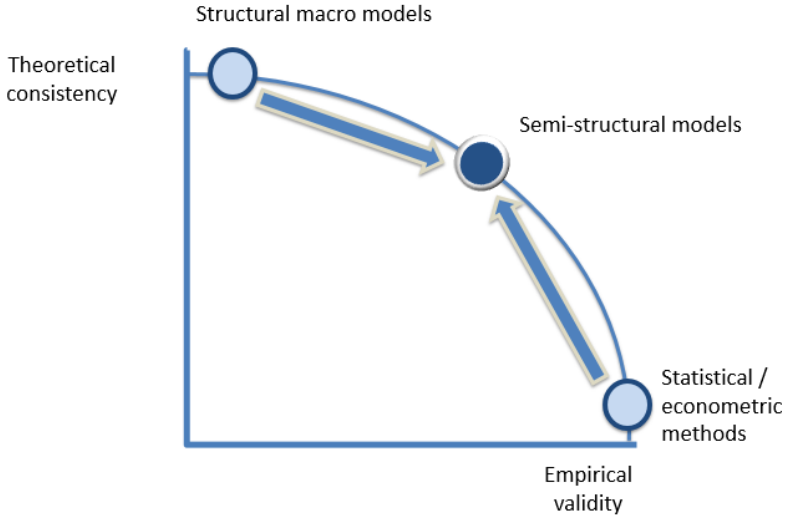

Figure 10. Fagan-diagram - Trade-offs in macroeconomic modelling

On the opposite end of the spectrum, purely statistical and econometric sets of equations might fit well to the empirical data, reproduce the stylized facts and give good short-term forecast for a limited set of macro variables, but they cannot capture the core and fundamental behavioral mechanism (Lucas critique): since these models estimate the short-run elasticities without regarding to core behavior, these methods are not sufficient to describe the transition of the economy after policy or other deep structural changes. Most

central banks and international institutions hence combine the structural models with econometric methods and publish parallel forecasts, or apply in-between so-called semi-structural models which balance a degree of theoretical consistency and good empirical fit. These models apply structural equations for the description of core behavior, however these equations are not directly derived from micro-based optimization problem as in structural models like Dynamic Stochastic General Equilibrium (DSGE) models. In the DSGE models the households' and firms' decisions are the results of a utility or profit maximization problem with strong assumptions about the objective function, and these mathematical assumptions need a relatively narrow interval of structural (deep) parameters. In semi-structural model we do not solve these kind of optimization problem, only assume relatively simple behavioral mechanism e.g.: the consumption is negative function of interest rate, or the inflation increases if the GDP exceeds its potential level, etc. And because we do not impose strong assumption on the structure of the economy (the parameters do not directly come from the utility or production function properties), they can be fitted more easily to the historical data but still explain their fluctuations from structural aspects. However, the calibration of these coefficients is less trivial, so it is the model developer's responsibility to set the parameters following economic intuition, and then confirm them through a variety of empirical validation tests.

The modelling dilemma is more pronounced in the case of emerging economies where the macroeconomic variables have significantly higher volatility and time series are more frequently stressed by structural breaks. Since the fundaments of these economies vary over time, it makes it very hard to fit a rigid structure imposed by a DSGE model. Standard DSGE models work much better in countries where economic development is stable, the potential growth and external economic environment is more or less unchanged. This is not the case for most developing countries and especially not in Mongolia with a history of economic booms and busts.

Semi-structural models perform better in such environments than DSGE-models but they also have some limitations. First, since in these models there are no optimizing agents, it is not clear what kind of optimization problem leads to the behavioral equations that describes the economy. Secondly, we work with linear equations, which by definition are not able to explain non-linearity, such as zero-level-bound. Thirdly we cannot simulate the effects of particular parameter changes, such as a jump in the household's propensity to consume.

Berg-Karam-Laxton (2007) provides an overview of how semi-structural models work and highlight forecast and policy relevant examples for Canada and Czech Republic where the prototype of this framework was introduced in the early 2000s. Over the last ten years this type of framework became widely used and adopted by several central banks and fiscal institutions across a variety of developed and emerging economies e.g.: Czech Republic - Czech National Bank (Coats et al, 2003), Hungary - Central Bank of Hungary (Szilagyi et al, 2013), Morocco - Bank Al-Maghrib (Horváth et al, 2016), IMF staff forecast based on Global Projection Model (Laxton et al, 2013), OECD - Simple Fiscal Stress Testing Model (Kamenik et al, 2013), Rwanda - Semi-structural Macroeconomic Model (Charry et al, 2014), UK - Office for Budget Responsibility (Murray 2012). All these models assume similar behavioral equations, but are calibrated to country specific environment.

In the following based on Berg-Karam-Laxton (2007) we give a general overview of our semi-structural model: listing the core structural assumptions, and specifying the Mongolian features. All endogenous variables are split into gap and trend components. The gap or cyclical movements capture the short run dynamics of the data; trends describe the medium-term (potential) growth. This separation is essential for

understanding the short run and medium term evolution of the macroeconomic variables. In the short run the prices are sticky (key properties of so-called New-Keynesian models), the demand side changes with the interaction of monetary or fiscal policy mostly determine the cyclical properties of the model economy. The medium-term properties (flexible price equilibrium) depend on the core endowments of a small open economy e.g.: in the case of Mongolia the speed of convergence is the function of improving terms-of-trade position.

The model assumptions can be categorized as aggregate demand, aggregate supply related and those on monetary policy. The aggregate demand and the output gap are function of the domestic and foreign monetary conditions (interest rate channel, market share position and expenditure switching channel) and the expectation channels. In short run the prices are sticky hence monetary policy is able to influence the real interest rate or real exchange rate. Any restriction in the monetary condition would shrink the domestic demand so it decreases the households' consumption and the private sector investment activity. The expectation has prominent role in modern macroeconomic models, it accounts for the dynamics of the system. These expectations are mix of the forward-looking expectation and past experience that are endogenously determined by the future or past monetary conditions.

The aggregate supply or Phillips-curve describes the evolution of domestic price (CPI) changes. The aggregate supply positively depends on aggregate demand, the imported foreign inflation and the expectations. Following an increase in aggregate demand (positive output gap) the inflation deviates from initial level and remains elevated until the central bank starts a restriction policy. In a small open economy framework part of the domestically consumed goods arrives from abroad, then the foreign prices could also affect the domestic prices. The strength of imported inflation depends on the actual position of nominal or real exchange rate, then it could happen that a high foreign inflation can be offset by the exchange rate appreciation.

The central bank through influencing the nominal interest rate or nominal exchange rate is able to stabilize the aggregate supply via aggregate demand reactions. Various monetary and exchange rate regimes can all be captured within this framework. We can model the chosen regime as a nominal anchor, a nominal variable that the central bank aims to drive back to its long-run steady-state level. If the monetary policy opts for a free floating exchange rate regime and concentrates on anti-inflationary policy, then explicit or implicit interest rate reaction guarantees the long-run stability of nominal variables. Because in short run the prices are sticky, the monetary policy is able to affect the real interest rate and in-turn domestic demand, which drives back inflation to the targeted level. If the central bank holds the nominal exchange rate fixed, then the real exchange rate become the main stabilizer of the domestic economy. Any real exchange rate appreciation makes the domestic economy less competitive which moves back the inflation to its long-term value. The model can also capture in-between cases such as Mongolian, where the monetary policy partly controls or smooths out the large fluctuation in the nominal exchange rate through interventions on the foreign exchange market. We model such managed floating regime assuming that the central bank relies on affecting both the nominal exchange rate and the short term nominal interest rates to stabilize domestic inflationary processes (Charry et al, 2014).

The expected upturn in mining production and related questions on fiscal sustainability motivated others to develop different models for Mongolia. Galindev et al (2015) built up a detailed, static CGE-model, where showing the long-run sectoral effects of terms-of-trade changes and sector specific intensified investment activities. The CGE-model depicts a highly detailed model of the economy describing future long-term equilibrium. However it is static in nature, hence it does not describe the dynamic transition

path in reaching that new equilibrium. The dynamics in our case are an essential part in order for example to monitor observance of fiscal rules over medium-term.

Gupta et al (2015) developed an RBC-style model with detailed production sector and fiscal block to examine the dynamic effect of mining sector expansion and the effects of public investment on government balance. This model does not include nominal variables (CPI, deflators, nominal exchange rate and monetary policy rate) but focuses only on the real variables. In our approach the short and medium term effects of the nominal variables are essential to drive our detailed forecast of fiscal variables. Nevertheless Gupta et al provides a solid reference point for medium-term development.

Dutu (2012) implemented a small open economy DSGE-model for Mongolia that ultimately follows Smets-Wouters model with the standard New-Keynesian features, IT-style monetary policy and several distortional taxes. A limitation to this approach is that the Bank of Mongolia does not follow a strictly inflation targeting regime. The model was estimated on Mongolian data between 2001 and 2011, but we observed that over the last 10 years the Bank of Mongolia had interventions to smooth out the fluctuations in the nominal exchange rate. This was an important feature to determine the path of other domestic nominal variables and the short-run competitiveness of the economy. Hence while the modelling approach was similar to Dutu (2012) we used a framework that we believe was more appropriate to reflect the nature of Mongolian monetary policy.

Description of the macroeconomic model

The main channels and mechanism of this model are summarized in the flowchart below.

1. We introduce detailed decomposition of domestic demand and production side of the economy: on the production side we differentiate the agricultural, mining and core production. The demand side are split into households' consumption, investment, government consumption and net-export.
2. The expectations are crucial in the determination of contemporaneous endogenous variables. The domestic demand components e.g.: households' consumption depends not only on current monetary conditions; it is a function of the next periods' conditions as well. Due to the interaction of other agents or the intervention of central bank the expectation term can change endogenously.
3. Short run the prices are sticky, hence the monetary policy is able to change the real interest rate and influence the real economy. In the price determination the expectations have a prominent role, the firms look ahead and change the prices according to the expected level of domestic demand or the foreign inflationary pressure.
4. In this small open economy framework, the fluctuations of nominal and real exchange rate affect the inflationary processes and directly change the net-export position.
5. The real economy and labor market performance - especially the mining production - determines the fiscal primary balance. The fiscal position affects the country risk premium that reverts back to the short and medium term economic growth.
6. The commodity prices influence directly the short run sector activity and permanent increase could improve the medium-term outlook of the country: it increases the yields on newly invested

capital, improves the households' income position, decreases the financing cost of the government and results in lower medium term interest rates.

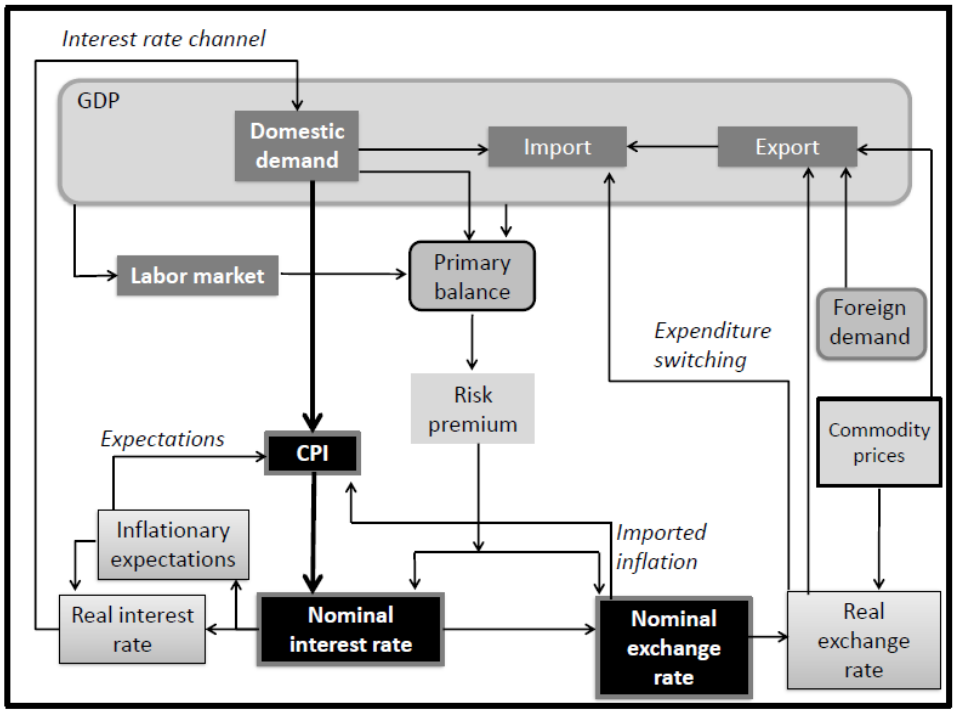

Figure 11. Flowchart of the model

In the detailed description we show the equations of aggregate supply, aggregate demand, fiscal and monetary policy. Because of the gap-trend decomposition all subsections have two parts where we describe the short run and medium-term behavioral equations separately.

Aggregate Supply

The model has separate decomposition for the production and expenditure side of the GDP. The production side GDP (gap ($\hat{y}$) and trend ($\overline{y}$) levels) can be divided into agricultural (y^{agr}), mining (y^{mine}), and core (y^{core}), components:

$$\hat{y}_t = w^{y,agr} \cdot \hat{y}_t^{agr} + w^{y,mine} \cdot \hat{y}_t^{mine} + \left(1 - w^{y,agr} - w^{y,mine}\right) \cdot \hat{y}_t^{core} + \sigma \cdot \varepsilon_t^{\hat{y}}$$

The questions this model seeks to answer focus on the mining sector of Mongolia, therefore we handle it separately. The cyclical component of the mining sector GDP can be written as:

$$\hat{y}_t^{mine} = \rho^{\hat{y}^{mine}} \cdot \hat{y}_{t-1}^{mine} + \left(1 - \rho^{\hat{y}^{mine}}\right) \cdot (\psi_1 \cdot \hat{y}_t^{FD} + \psi_2 \cdot \widehat{rp}_t^{Commodity}) + \sigma \cdot \varepsilon_t^{\hat{y}^{mine}}$$

where $\widehat{rp}_t^{Commodity}$ is the weighted real price gap of available commodities in the mining sector, $\hat{y}_t^{FD}$ is the effective foreign demand gap (weighted average of GDP gaps of the main trading partners). The trend has two parts: it follows an autoregressive process and also depends on the steady-state growth rate and medium-term mining export activity:

$$\Delta\bar{y}_t^{mine} = \rho^{\Delta\bar{y}^{mine}} \cdot \Delta\bar{y}_{t-1}^{mine} + \left(1 - \rho^{\Delta\bar{y}^{mine}}\right) \cdot (ss^{\Delta\bar{y}^{mine}} + \omega_{10} \cdot (\Delta\overline{ex}_t^{mine} - ss^{\Delta\overline{ex}^{mine}})) + \sigma \cdot \varepsilon_t^{\Delta\bar{y}^{mine}}$$

The agricultural production is an exogenous process, the short run and medium term variabilities are function of weather changes and the steady-state growth assumptions. The core GDP does not have explicit functional form on the production side, the evolution of core production is based on the two GDP identities (supply and expenditure side) and the behavioral equations of the expenditure side. Increasing mining sector activity intensifies domestic investments, increases mining related imports and has some small positive effect on mining sector employment.

Each GDP components on the production side determines its employment (emp^i), and real wage (w^i), gaps and medium term trend:

$$\widehat{emp}_t^i = \rho^{\widehat{emp}^i} \cdot \widehat{emp}_{t-1}^i + \left(1 - \rho^{\widehat{emp}^i}\right) \cdot \zeta \cdot \hat{y}_t^i + \sigma \cdot \varepsilon_t^{\widehat{emp}^i}$$

$$\widehat{w}_t^i = \rho^{\widehat{w}^i} \cdot \widehat{w}_{t-1}^i + \left(1 - \rho^{\widehat{w}^i}\right) \cdot \tau \cdot \hat{y}_t^i + \sigma \cdot \varepsilon_t^{\widehat{w}^i}$$

where i={agr,mine,core}. The weighted average of labor market variables gives the cyclical position of total employment and average real wage, and hence the short run income position of the households. The trends of the labor market are assumed to be simple autoregressive processes where the steady-states are function of potential growth rate.

Aggregate Demand

The aggregate demand side of the economy can be separated into domestic demand components and net-export component (Szilagyi et al, 2012). Households' consumption (c), gross capital formation (inv), government consumption (gov) constitute the domestic demand:

$$\hat{y}_t = w^{y,c} \cdot \hat{c}_t + w^{y,inv} \cdot \widehat{inv}_t + w^{y,gov} \cdot \widehat{gov}_t + w^{y,ex} \cdot \widehat{ex}_t - w^{y,im} \cdot \widehat{im}_t + \sigma \cdot \varepsilon_t^{\hat{y}^{core}}$$

Based on the New-Keynesian literature the private consumption is the function of hybrid (backward and forward looking) expectation, the effective real interest rate, income position of the households and agricultural production.

$$\hat{c}_t = \alpha_1 \cdot \hat{c}_{t-1} + (1 - \alpha_1) \cdot \hat{c}_{t+1} - \alpha_2 \cdot \hat{r}_t + \alpha_3 \cdot \widehat{inc}_t + \alpha_4 \cdot \hat{y}_t^{agr} + \sigma \cdot \varepsilon_t^{\hat{c}}$$

where $(\hat{r})$ is the real effective interest rate gap, $(\widehat{inc})$ is the cyclical position of labor income. The consumption trend is assumed to be the function of an autoregressive component, steady-state consumption growth, the medium term real interest rate, and the trend of income growth.

$$\Delta\bar{c}_t = \rho^{\Delta\bar{c}} \cdot \Delta\bar{c}_{t-1} + \left(1 - \rho^{\Delta\bar{c}}\right) \cdot (ss^{\Delta\bar{c}} - \omega_1 \cdot (\bar{r}_t - ss^{\bar{r}}) + \omega_2 \cdot (\Delta\overline{emp}_t^{total} + \Delta\overline{w}_t^{total} - ss^{\Delta\overline{emp}^{total}} - ss^{\Delta\overline{w}^{total}})) + \sigma \cdot \varepsilon_t^{\Delta\bar{c}}$$

The cyclical position of investment depends on the hybrid expectation, and the implicit value of the invested capital (Tobin-Q). The Tobin-Q shows the present value of payoffs from the current investment, which is proxied by the cyclical position of output and real price of commodities:

$$\widehat{inv}_t = \beta_1 \cdot \widehat{inv}_{t-1} + (1 - \beta_1) \cdot \widehat{inv}_{t+1} + \beta_2 \cdot Q_t + \sigma \cdot \varepsilon_t^{\widehat{inv}}$$

$$Q_t = \beta_3 \cdot Q_{t+1} + \beta_4 \cdot \hat{y}_t + \beta_5 \cdot \widehat{rp}_t^{Commodity} - \beta_6 \cdot \hat{r}_t$$

The investment trend growth also follows an autoregressive process, where the medium-term variability depends on the potential GDP growth and medium-term commodity prices:

$$\Delta\overline{inv}_t = \rho^{\Delta\overline{inv}} \cdot \Delta\overline{inv}_{t-1} + \left(1 - \rho^{\Delta\overline{inv}}\right) \cdot (ss^{\Delta\overline{inv}} - \omega_3 \cdot (\bar{r}_t - ss^{\bar{r}}) + \omega_4 \cdot (\Delta\bar{y}_t - ss^{\Delta\bar{y}})) + \sigma \cdot \varepsilon_t^{\Delta\overline{inv}}$$

In the case of Mongolia, the commodity export (from mining production) has a crucial role in the medium term growth prospect. The mining export gap is function of the available commodities, and weakly depends on the real exchange rate and foreign demand:

$$\widehat{ex}_t^{mine} = \rho^{\widehat{ex}^{mine}} \cdot \widehat{ex}_{t-1}^{mine} + \left(1 - \rho^{\widehat{ex}^{mine}}\right) \cdot (\gamma_7 \cdot \hat{z}_t + \gamma_8 \cdot \hat{y}_t^{mine} + \gamma_9 \cdot \widehat{rp}_t^{Commodity}) + \sigma \cdot \varepsilon_t^{\widehat{ex}^{mine}}$$

The short run non-mining activity fluctuates along with the international business cycles and the real exchange rate cyclical position:

$$\widehat{ex}_t^{non-mine} = \gamma_1 \cdot \widehat{ex}_{t-1}^{non-mine} + \gamma_2 \cdot \widehat{ex}_{t+1}^{non-mine} + \gamma_3 \cdot \hat{z}_t + \gamma_4 \cdot \hat{y}_{t-1}^{mine} + \gamma_5 \cdot \hat{y}_t^{FD} + \sigma \cdot \varepsilon_t^{\widehat{ex}^{non-mine}}$$

The non-mining export activity negatively depends on mining sector activity. These two branches of the traded sector are engaged in a strong competition therefore an intensifying mining sector activity crowds out the non-mining production and moves labor from core employment to mining employment. This phenomenon is described in the literature by the Dutch Disease (Corden and Neary, 1982),

These trends similarly to the previous subsections can be characterized by an autoregressive part, steady-state growth value, foreign demand trend growth and real exchange rate trend growth.

Imports can be given as the function of consumption, investment and re-exported import. In short run the cyclical position of real exchange rate could influence the import gap as well (expenditure switching): the depreciated real exchange rate gap increases the import prices which leads to substituting foreign products with domestic ones, therefore exchange rate depreciation boosts the GDP

$$\widehat{im}_t = w^{im,c} \cdot \widehat{im}_t^c + w^{im,inv} \cdot \widehat{im}_t^{inv} + \left(1 - w^{im,c} - w^{im,inv}\right) \cdot \widehat{im}_t^{ex} + \sigma \cdot \varepsilon_t^{\widehat{im}}$$

Fiscal policy

The macroeconomic variables listed above will all affect projections of different fiscal variables which we will present in more detail as part of the fiscal block. On the other hand, in order to avoid a complex set of simultaneous interactions between the fiscal block and the macroeconomic model, we simplify how fiscal policy affects other macroeconomic variables through the risk premium channel.

We assume that the cyclical position of primary balance ($\widehat{pby}$) is a function of the following macroeconomic variables: consumption gap, labor income gap, mining GDP gap, and government consumption gap. The trend component ($\overline{pby}$) expresses the cyclically adjusted budget balance position estimated from the observed data. The elasticities of the short term cyclical changes are consistently calibrated using detailed calculations in the fiscal block.

$$\widehat{pby}_t = \rho^{\widehat{pby}} \cdot \widehat{pby}_{t-1} + \left(1 - \rho^{\widehat{pby}}\right) \cdot (\mu_1 \cdot \hat{c}_t + \mu_2 \cdot \widehat{inc}_t + \mu_3 \cdot (\widehat{rp}_t^{Commodity} + \hat{y}_t^{mine}) - \mu_4 \cdot \widehat{gov}_t) + \sigma \cdot \varepsilon_t^{\widehat{pby}}$$

$$\overline{pby}_t = \rho^{\overline{pby}} \cdot \overline{pby}_{t-1} + \left(1 - \rho^{\overline{pby}}\right) \cdot (ss^{\overline{pby}} + \mu_5 \cdot \Delta\overline{rp}_t^{Commodity}) + \sigma \cdot \varepsilon_t^{\overline{pby}}$$

In the last 10 years we find a delayed, weak co-movement between the primary balance and nominal exchange rate yearly changes (see chart below). Therefore, we assumed that the primary balance position has some effect on the financial variables through the risk premium channel.

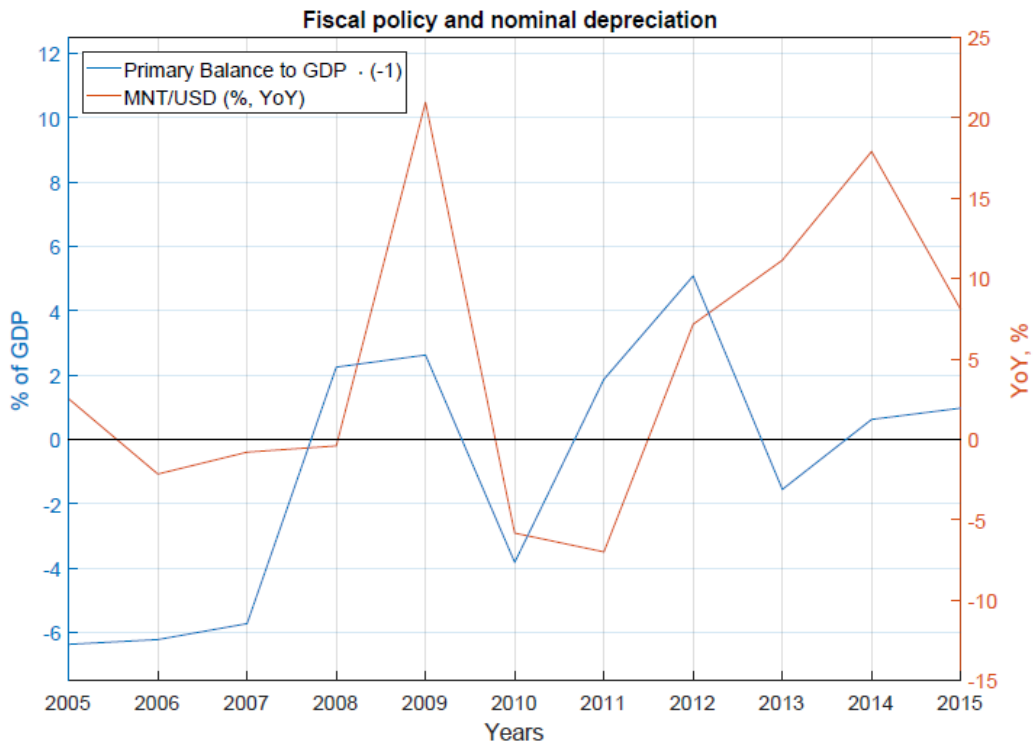

Figure 12. Primary balance to GDP and MNT/USD yearly changes

Thus the primary balance to GDP ratio can change the risk premium, and via the real interest rate the potential growth of the economy:

$$Prem_t = \rho^{Prem} \cdot Prem_{t-1} + (1-\rho^{Prem}) \cdot (ss^{Prem} - \theta_7 \cdot \left(pby_t - ss^{pby}\right) - \theta_8 \cdot (\Delta\bar{y}_t - ss^{\Delta\bar{y}})) + \sigma \cdot \varepsilon_t^{Prem}$$

This equation creates a relationship between primary balance and real economy development. A worsening fiscal deficit leads to higher risk premium and higher domestic interest rates. The increasing financing costs causes a decline in growth and can exert further challenges in debt sustainability.

Inflation

In the nominal block we apply the New-Keynesian Phillips curve to describe the domestic inflationary process. The percentage change in CPI is the function of hybrid expectation, consumption gap, real exchange rate gap, imported foreign inflation, oil and food real price gaps.

$$\Delta cpi_t = \nu_1 \cdot \Delta cpi_{t-1} + (1-\nu_1-\nu_2) \cdot \Delta cpi_{t+1} + \nu_2 \cdot \Delta cpi_t^F + \nu_3 \cdot (\nu_4 \cdot \hat{c}_t + (1-\nu_4) \cdot \hat{z}_t) + \nu_5 \cdot \widehat{rp}_t^{Food} + \nu_6 \cdot \widehat{rp}_t^{Fuel} + \sigma \cdot \varepsilon_t^{\Delta cpi}$$

where the imported foreign inflation is the weighted average of trading partners' inflation in MNT. In the model we observed USD denominated oil and food real prices. Deflating with the US CPI we get relative prices, that is decomposed into gap and trend components; the gap components measure the short term price effects on CPI dynamics.

In a small open economy model, the real exchange rate is another key variable that is responsible for inflationary dynamics. It can be calculated from the following:

$$\Delta z_t = \Delta s_t^{MNT/USD} + \Delta cpi_t^{F,USD} - \Delta cpi_t$$

where the real exchange rate has also a trend and gap part. The real exchange rate reflects the relative price differences between the foreign and domestic goods, since a small open economy imports most of their domestically consumed products then this relative price difference should have an effect on the domestic CPI as well.

Monetary policy

In Mongolia the monetary policy has dual mandate, it has some control over the nominal exchange rate depreciation, and via money supply sets the policy rate to achieve the price stability. The implicit annual inflation target is set to 5 %. Because the nominal exchange rate regime is not a fully free floating regime, the nominal exchange rate determination is assumed to be the weighted average of a pegged and a free floating exchange rate regime (Charry et al 2014).

$$\Delta s_t^{MNT/USD} = w^{FX} \cdot \tilde{\Delta} s_t^{\frac{MNT}{USD},fix} + (1 - w^{FX}) \cdot \tilde{\Delta} s_t^{\frac{MNT}{USD},float}$$

In the pegged regime the nominal exchange rate determination depends on the previous period exchange rate level and the devaluation components.

$$\tilde{\Delta} s_t^{\frac{MNT}{USD},fix} = \theta_4 \cdot \Delta s_{t-1}^{\frac{MNT}{USD}} + (1 - \theta_4) \cdot \Delta \bar{s}_t^{\frac{MNT}{USD}} - 4 \cdot \theta_5 \cdot \hat{z}_{t-1}$$

$$\tilde{\Delta} s_t^{\frac{MNT}{USD},fix} = 4 \cdot \left(s_t^{\frac{MNT}{USD},fix} - s_{t-1}^{\frac{MNT}{USD}} \right)$$

The devaluation is a weighted average of the previous depreciation and steady-state depreciation (that consist of inflationary differentials and real exchange rate trend), and also a function of the real exchange rate's cyclical component. If the real exchange rate gap turns to negative it means that the currency is overvalued, leading to intensifying current account deficit (see Figure below). In the case of huge changes in the real exchange rate the monetary authority decides by the devaluation of nominal exchange rate to eliminate the further depreciation pressure. This devaluation helps to stabilize the current account via expenditure switching channel: by depreciated nominal exchange rate households will substitute the foreign goods with domestic one, the exporters have an incentive to export more and the overall effects improve the trade balance. We use a linear model, so the central bank follows a symmetric rule and smooths out any changes in the nominal exchange rate, despite the fact that shocks in the past were not necessarily symmetric e.g.: in the case of excess current account deficit the real exchange rate appreciated much more and the central bank devaluated the currency more than in normal times. However, the model also identified some periods when the real exchange rate also depreciated, but the central bank decided not to intervene.

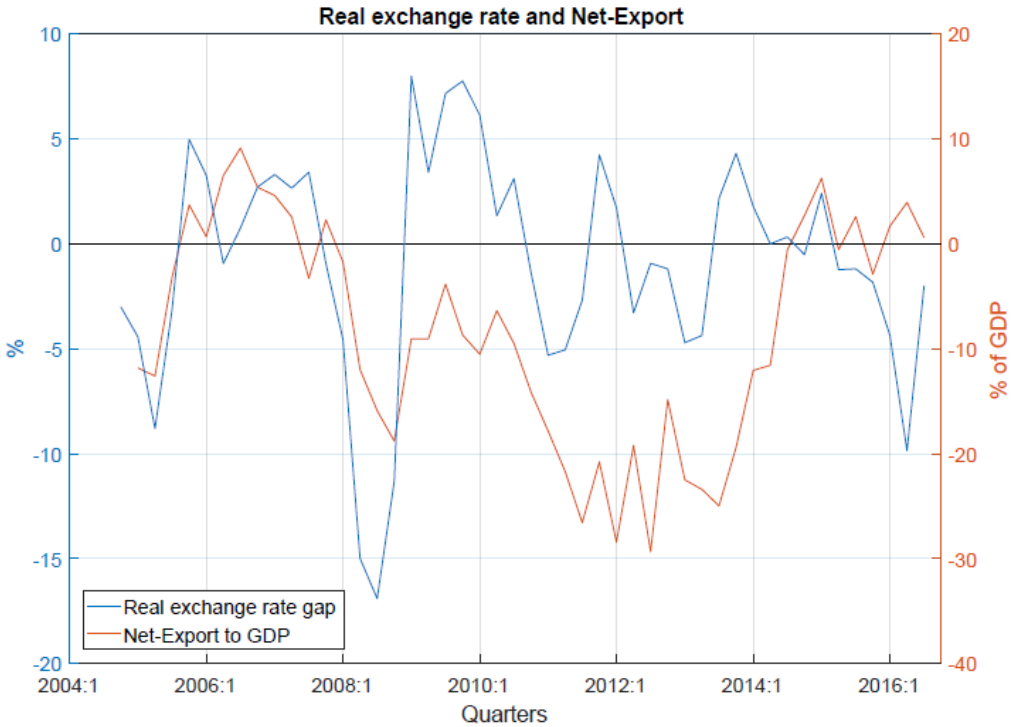

Figure 13. Real exchange rate and net export to GDP

The free floating part follows the standard uncovered interest rate parity (UIP) conditions: it is the function of the interest rate differentials, exchange rate expectation and the risk premium:

$$\tilde{\Delta} s_t^{\frac{MNT}{USD},float} = \theta_6 \cdot \left(\tilde{\Delta} s_{t+1}^{\frac{MNT}{USD},float} + \Delta s_{t+1}^{\frac{MNT}{USD}} \right) + (1-\theta_6) \cdot 2 \cdot \Delta \bar{s}_t^{\frac{MNT}{USD}} - i_t^{pol} + i_t^{US} + Prem_t + \sigma \cdot \varepsilon_t^{\Delta s^{MNT/USD}}$$

$$\tilde{\Delta} s_t^{\frac{MNT}{USD},float} = 4 \cdot \left(s_t^{\frac{MNT}{USD},float} - s_{t-1}^{\frac{MNT}{USD}} \right)$$

The Bank of Mongolia follows money supply rules, but by doing so it implicitly sets the money market rate. The Mongolbank rate can be described with a forward-looking Taylor-rule with interest rate smoothing:

$$i_t^{pol} = \rho^{i^{pol}} \cdot i_{t-1}^{pol} + \left(1 - \rho^{i^{pol}}\right) \cdot \left(\bar{r}_t + tar_t + \theta_1 \cdot (\Delta_4 cpi_{t+1} - tar_{t+1}) + \theta_2 \cdot \hat{y}_t^{core} + \theta_3 \cdot \left(\Delta s_{t+1}^{\frac{MNT}{USD}} - \Delta \bar{s}_{t+1}^{\frac{MNT}{USD}} \right) \right) + \sigma \cdot \varepsilon_t^{i^{pol}}$$

where $\Delta_4 cpi$ is the yearly changes of CPI, tar is the implied target, $\Delta \bar{s}^{MNT/USD}$ is the trend depreciation rate.

The Mongolbank does not follow a monetary policy regime of strictly inflation targeting, however every year it declares a desired band for the average inflation (Mongolbank, 2015). Because historically the actual inflation has rarely corresponded with the central bank's declared goal, we identified an implicit inflation target (see chart below). This implicit target is the medium term growth rate of the CPI that we estimate that all nominal variables are anchored to. The difference between expected year-on-year inflation and implied inflation target, called inflation gap, is essential to determine the short run inflationary reaction of the central bank. If the inflation exceeds this implicit target the Mongolbank tighten the monetary conditions to shrink the real economic performance and stabilize the short run nominal variables.

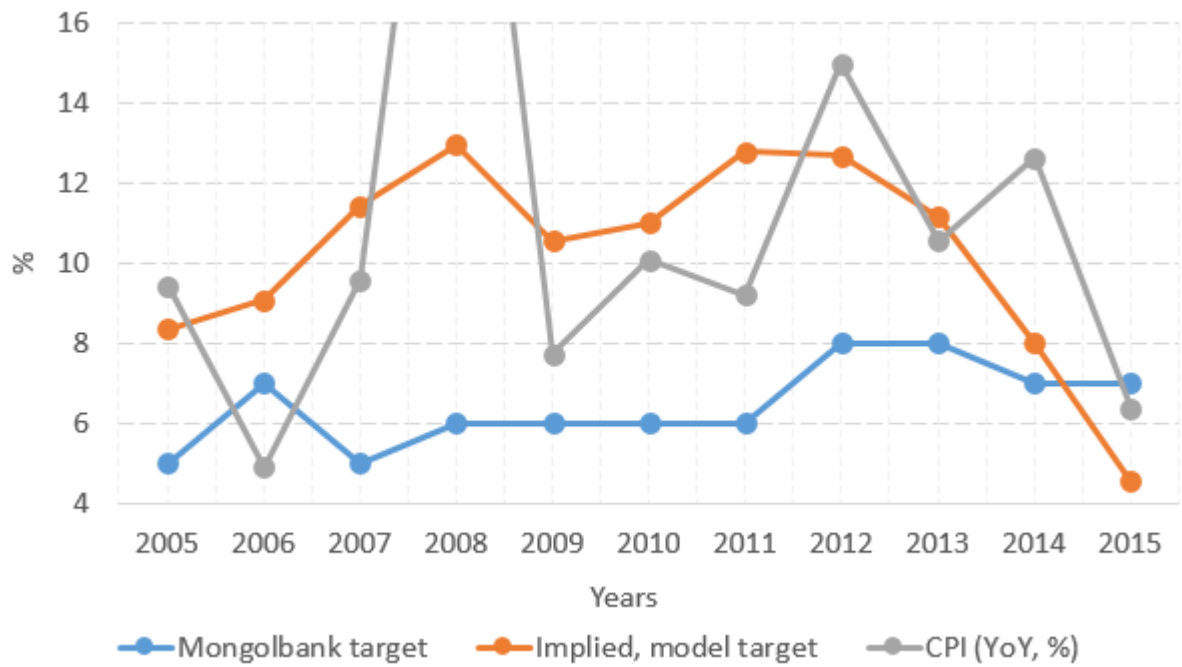

Figure 14. Inflation, Mongolbank target and implied target

Because of the hybrid nature of nominal exchange rate determination, the observed policy rate is not equivalent to the theoretical effective interest rate. We assume there is a gap between the two that reflects the opportunity cost of having hybrid exchange rate regime: it carries an implicit cost imposed on the private sector.

We calculate the effective but unobserved rate *called the UIP-based rate*, that is derived from the sum of the foreign interest rate, risk premium and expected depreciation of fixed nominal exchange rate regime. This implied rate reflects this shadow cost of the PEG-regime:

$$i_t^{uip} = \tilde{\Delta} s_{t+1}^{\frac{MNT}{USD},fix} + i_t^{US} + Prem_t$$

The weighted average of Mongolbank rate and UIP-based rate gives the effective interest rates that feeds back to the private sector activity in our model:

$$i_t^{eff} = (1 - w^{FX}) \cdot i_t^{pol} + w^{FX} \cdot i_t^{uip}$$

$$\hat{r}_t = i_t^{eff} - \pi_{t+1} - \bar{r}_t$$

where the short term real interest rate is the function of the effective nominal interest rate, the next period inflation and the medium term real interest rate.

In medium term we assume the classical dichotomy holds: nominal variables are independent from real variables. Therefore the real interest rate is also independent from monetary policy decision and driven by a mostly exogenous process that is described by the real-UIP conditions: it is the sum of the foreign interest rate trend, real exchange rate trend depreciation and country specific risk premium:

$$\bar{r}_t = \bar{r}_t^{US} + Prem_t + \Delta\bar{z}_t + w^{CN,CPI} \cdot \left(-ss^{\Delta s^{\frac{CNY}{USD}}} + ss^{\Delta cpi^{US}} - ss^{\Delta cpi^{CN}}\right) + w^{EU,CPI} \cdot \left(-ss^{\Delta s^{\frac{EUR}{USD}}} + ss^{\Delta cpi^{US}} - ss^{\Delta cpi^{EU}}\right)$$

Dynamic properties of the model

In this section we test the dynamic properties of the model. The simplest way to test the model is analyzing impulse response functions that show how the model reacts to a given shock (deviation from a baseline projection). This analysis is very useful for the calibration and scenario analysis, because we exam the strength of different channels in the model, and can also easily compare alternative model and shock specifications. In this documentation we depict 3 basic short term, temporary shocks most widely reported in macroeconomic modelling: aggregate demand shock, aggregate supply shock and nominal exchange rate shock; and 2 more permanent shocks that are most relevant in Mongolia: a commodity price shock, and a mining sector production shock. Each shock hits the economy in 2017 and we plot the percentage or percentage point difference between the baseline projection and alternative scenario.

Consumption shock

The consumption shock is a common aggregate demand shock (chart below), when the households decide to increase temporary their expenditures due to some exogenous changes e.g.: an income shock, a change in preferences. The increasing domestic demand results an increase in GDP and domestic production, the firms intensively use domestic labor and are willing to increase the workers' compensation. This temporary improvement in the households' income position elongates the positive effects on the consumption as well. Firms face increasing demand, and to improve their profitability they increase the domestic prices generating demand side inflationary pressure. The central bank following its mandate increases the policy rate to stabilize the domestic inflation and appreciates the nominal exchange to offset the inflationary pressure. Since the country does not follow fully free floating exchange rate regime, then the central bank smooths out the (nominal) exchange rate to its new equilibrium implied by the new price level differences.

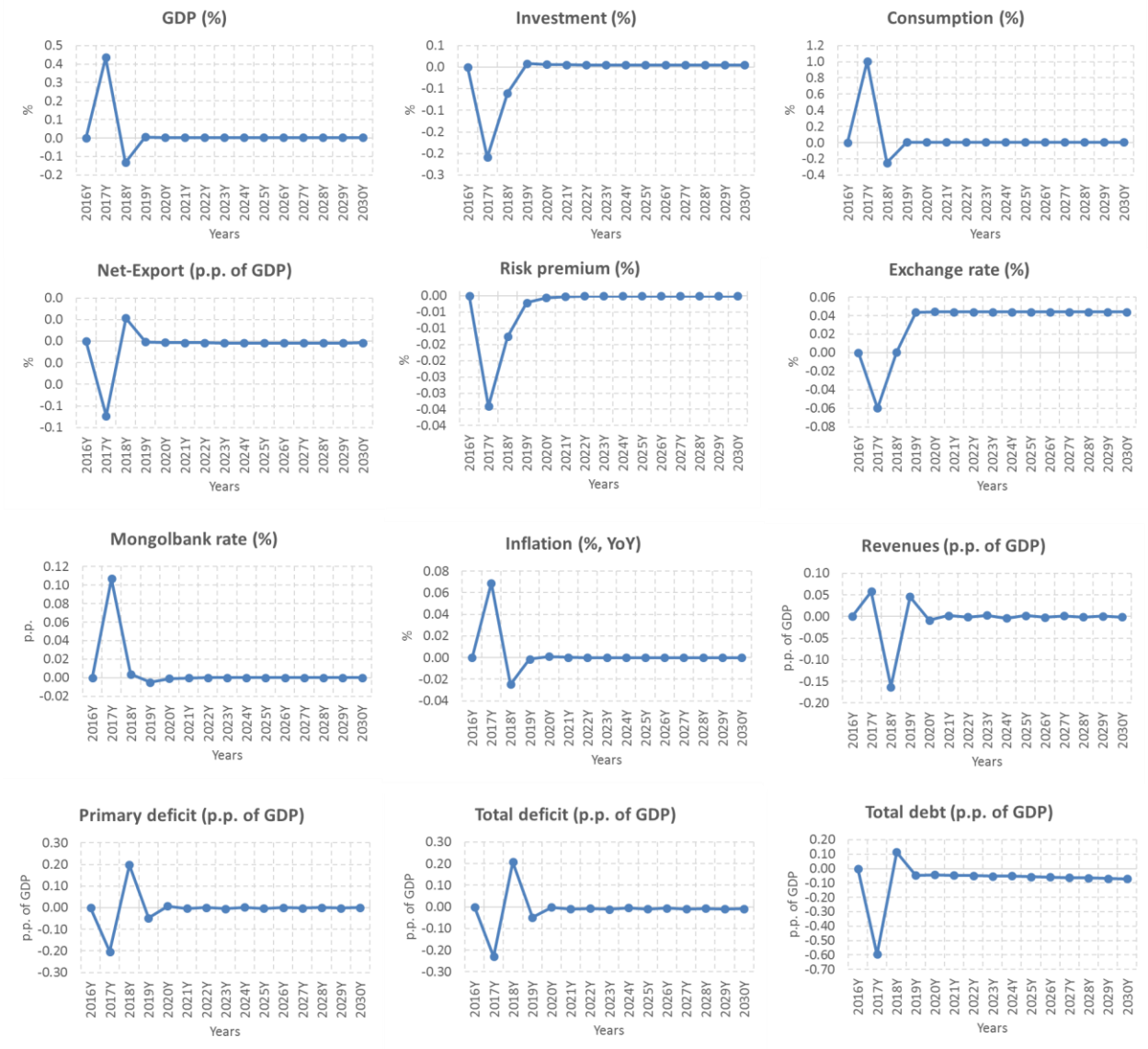

Figure 15. Consumption shock: 1 % temporary increase in consumption

Inflationary shock

Economies often face with supply side shocks that results domestic price changes (chart below). Whether this is caused by foreign and domestic price shocks, the monetary policy has the same reaction: it launches a tightening to offset the inflationary pressure. This tightening cycles results in a decline in real economy variables until the inflation goes back to the targeted level. Nevertheless, there could be asymmetry between domestic and foreign originated supply shocks. If the monetary policy faces domestic inflationary pressure, it increases the domestic interest rates and smooths the nominal exchange rate to shrink the domestic demand until the inflation stabilizes around the targeted level. In the case of foreign shock, the key policy instrument is the nominal exchange rate, so the central bank lets the nominal exchange rate to appreciate in real and nominal terms, and stabilizes the economy via the shrinking net-export position.

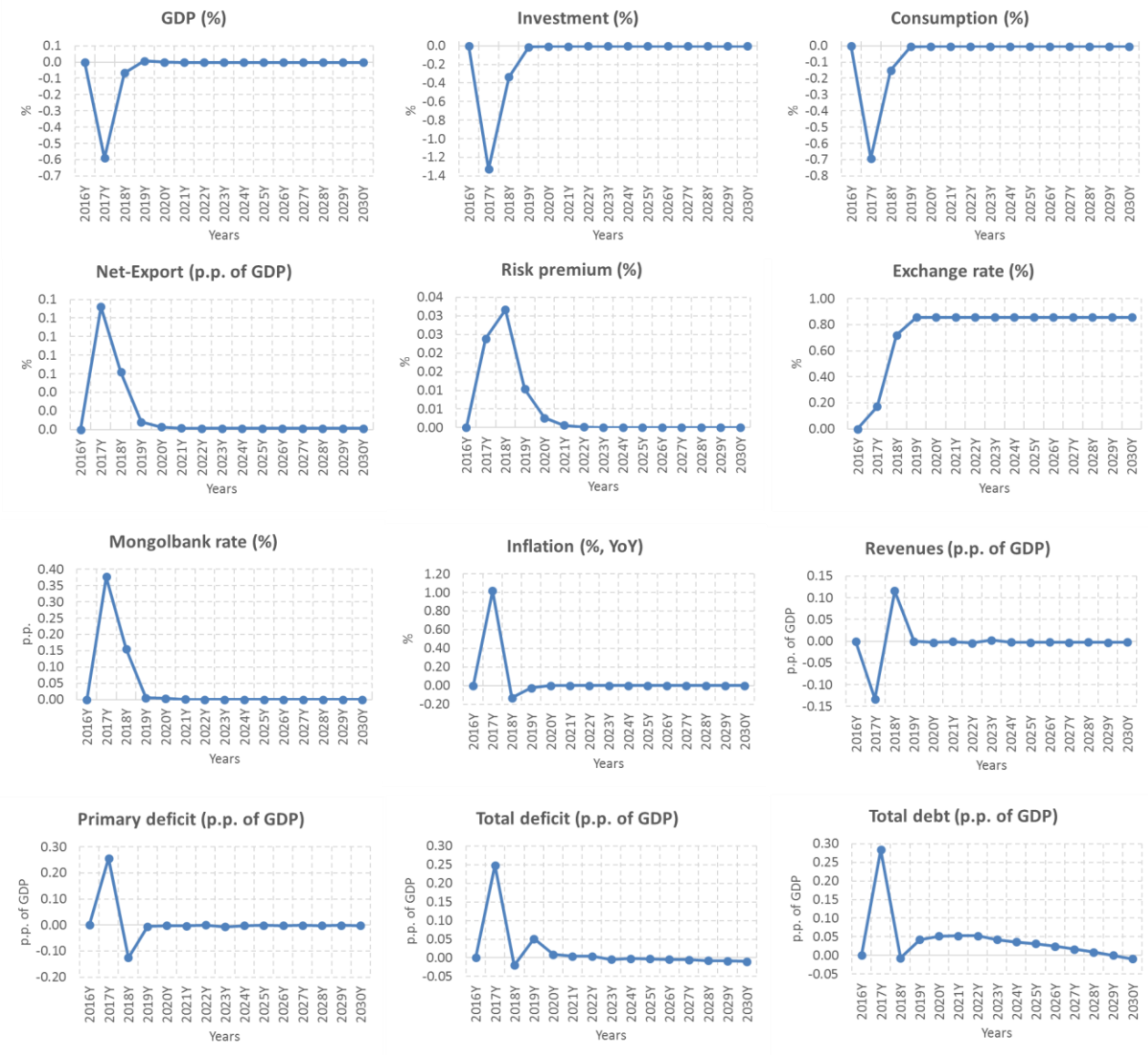

Figure 16. CPI shock: 1 % temporary increase in YoY CPI

Exchange rate shock

Small open economies are always hit by temporary and permanent exchange rate shocks (chart below). In the case of Mongolia these shocks are special since the monetary regime is mixed. If the policy decides on a temporary weaker exchange rate, implicitly it means that the monetary policy eases the financial conditions and the effective interest rate goes down. Decreasing effective interest rate stimulates the real economy, the increasing real exchange rate gap improves the financial position of the exporters. The nominal exchange rate increases the inflationary pressure on the economy, to which the central bank reacts with higher policy rate. This process last until the nominal exchange rate stabilize at the new equilibrium level.

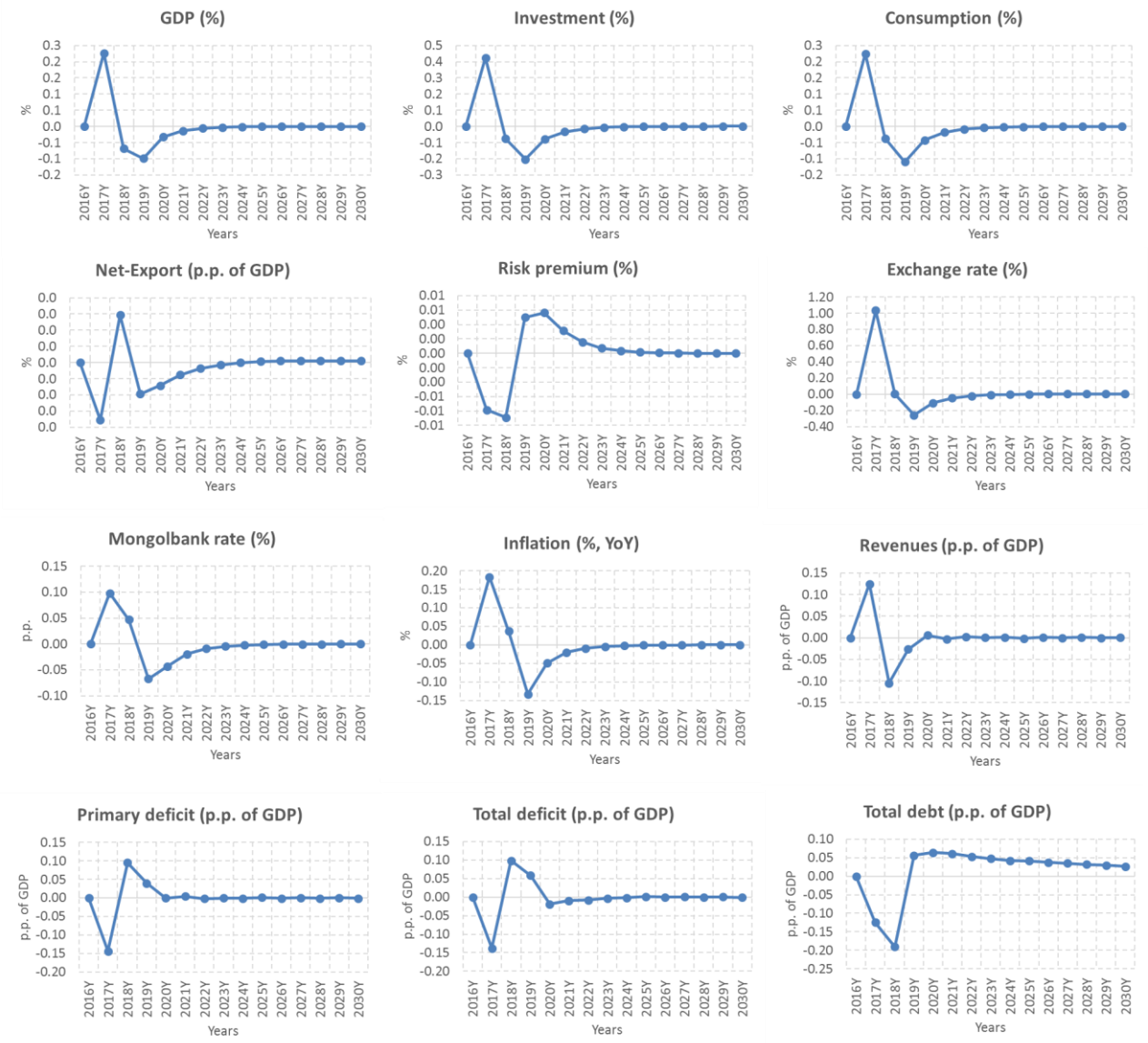

Figure 17. MNT/USD shock: 1 % temporary deprecation of MNT/USD

Copper price increase

In Mongolia the commodity price changes have a crucial role and could determine the medium term economic development (chart below). We look at the effects of a 10% increase in copper price assuming they remain elevated on the forecast horizon. This price increase improves the profitability of the firms in the mining sector, raises the labor income. The higher revenues and better fiscal position lead to lower country risk premium and appreciate the nominal exchange rate. This favorable terms-of-trade position and improving economic outlook intensify the investment activity and mining production as well. Most of the capital accumulation and elevated mining production are covered by increasing import. Although the hike in commodity price temporarily improves the households' income position so they increase their consumption, and the labor force flows to the mining sector. This reallocation in turn results in a shrinking of core GDP and a decline of the overall labor income. This is why some correction in the dynamics of GDP

appear after the peak, which shows how the model replicates the Dutch disease phenomenon following a terms-of-trade shock.

Figure 18. Copper price shocks: 10 % permanent increase in copper prices

Increased mining sector production

We now turn to analyzing how the economy responds to a decision by mining companies to increase their level of mining sector production while prices remain unchanged (chart below). Higher level of productions needs more imported goods and more labor force from the domestic labor market. The increasing labor demand temporary improve the income position of the households and exert excess demand for domestically produced good. However, in medium term the overall GDP effect becomes half the size of the initial change because of increasing import shrinks the domestic core production on a longer horizon. How model results differ between the volume and price shocks may be surprising. In the previous simulation the improvement in terms-of-trade has also negative impact on non-mining GDP but it was

smaller. The permanent commodity price hike increases the profitability of mining firms and induces more investment. In the current simulation the commodity prices do not change, hence the firm should cover the cost of intensified mining production caused by more demand for non-substitutable imported goods and more labor force from the non-mining sector. So the higher production decreases the relative demand for domestic goods and also reallocates labor force from another core domestic branches that start shrinking. This scenario is a good example of trade-offs between the intensive mining production and the possible negative effects on other economic sectors.

The model does not an anticipation channel: economic variables don`t respond ahead of future shocks to mineral sector output, a phenomenon described in Wills (2014).

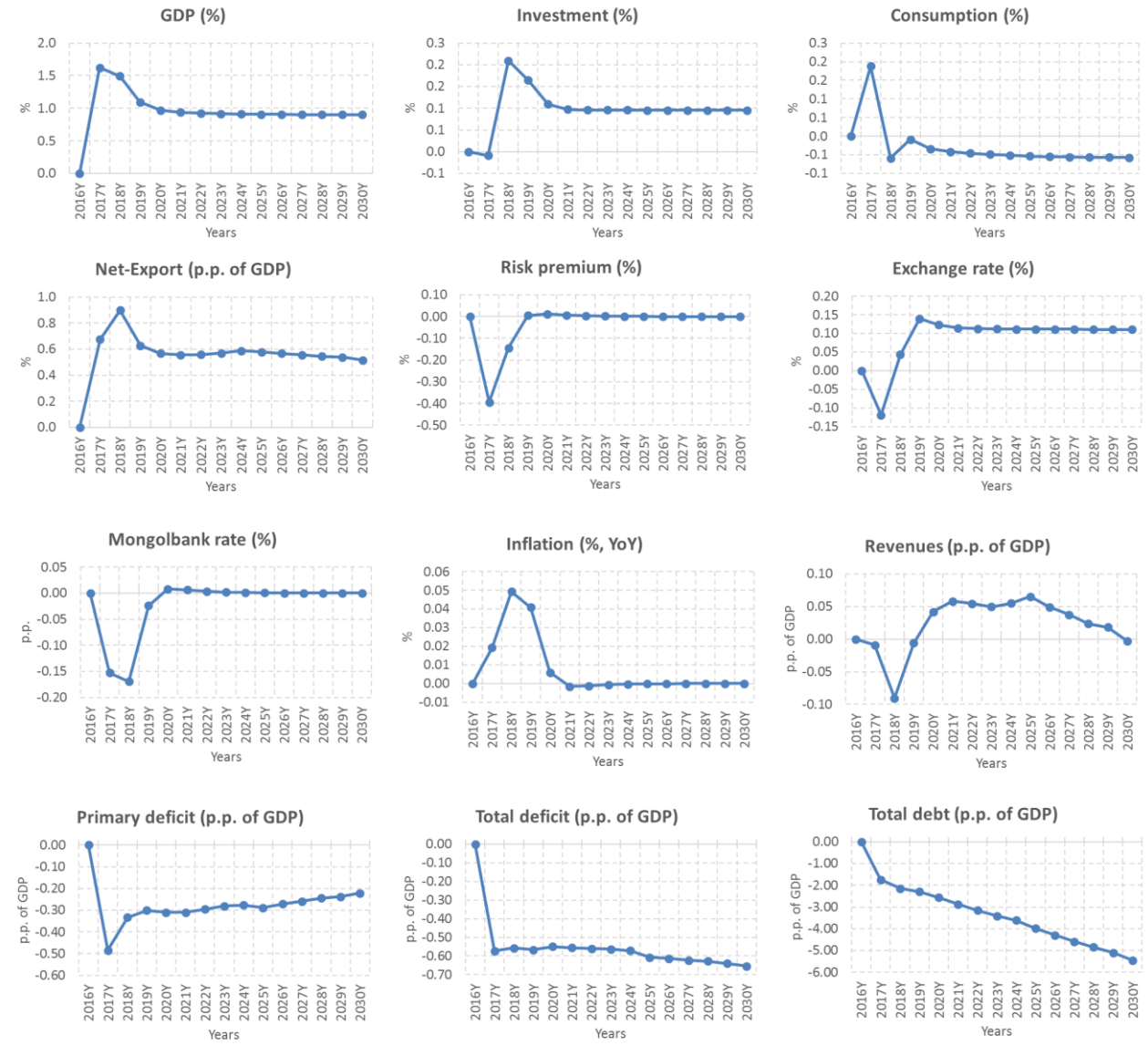

Figure 19. Mining sector shock: 10 % permanent increase in mining sector production

Calibration, estimation of the model and forecast performance

The calibration, estimation and validation of the model structure is an essential but demanding step in the model development. Because of the shortness and the large volatility of the data a mixed approach is required for this. First, we calibrated the model using a balanced approach between empirical fit, valid interpretation of historical data and reasonable theoretical explanations (impulse response functions). This was an iterative process where we use reduced form (VAR representation) of the model and Kalman filter for the empirical test. As a final step, we estimate the core parameters of the final model with Bayesian techniques.

Calibration of the core parameters

There are three main categories within the set of parameters: 1) lead-lag coefficients; 2) deep behavioral parameters; 3) steady-state values. The lead-lag coefficients give the dynamic to the system and are responsible for the gradual accommodation of endogenous variable. The deep behavioral parameters express the strength of the main channels and implicitly tell us how strongly related the endogenous variables are to each other. The steady-state values provide the long-run or trend values of the endogenous variables, while the gaps by definition are zero in their steady-state.

The lead-lag coefficients can be estimated directly from the observed time-series, these parameters should capture the degree of autocorrelation within the time-series. For example, the central bank changes the policy rate gradually in Mongolia, which means that the interest rate smoothing parameter (the autoregressive term in the Taylor-rule) should have a relatively large coefficient. Or another example: the CPI in Mongolia dominated by commodity and food components that makes the inflation volatile, a less persistent process than in developed economies. This means that the backward-looking term of the Phillips curve should be lower to avoid slow accommodation in inflation.

The calibration of deep behavioral parameters is less trivial. Some of them can be directly identified from forecast performance exercise which we describe later e.g.: domestic demand effect on inflation, interest rate elasticity in consumption equation, but some values reflect the developers' judgment. In the New-Keynesian models the interest rate elasticity of domestic demand, the domestic demand coefficient in the Phillips curve, and the weight of fixed and pegged exchange rate regime are the most important parameters determining the core properties of the model.

For these three coefficient we conduct two tests: first we compare the impulse-response functions of alternative calibration, secondly we test the model forecast performance.

Impulse response functions of alternative calibrations

The interest rate channel is a core component of the model. The strength of the interest rate channels show how effective the monetary policy is in the stabilization of domestic inflation. In this exercise we examine what are the differences among different parametrization for the interest rate channel (see chart below). We run a monetary policy shock (the interest rate temporary increases from its steady-state level) for three specifications: lower, actual and higher value for interest rate elasticity. With lower value the monetary policy could not exert a large effect on consumption gap and it is less effective to decrease the inflation. To the contrary with larger parameter values the households' consumption decreases more. The

overall effects on CPI are similar in each case. This result is consistent with our prior on the Mongolian inflation: that it is driven mostly by non-demand sensitive components such as imported inflation, commodity prices hence nominal exchange rate fluctuations have a larger effect on domestic inflation. In this exercise the coefficients of exchange rate are the same for all specification. This example shows that the reactions to monetary tightening are similar, and a temporary 100 basis point hike in interest rate results around 0.3% drop in short run inflation which then disappears after 2 years.

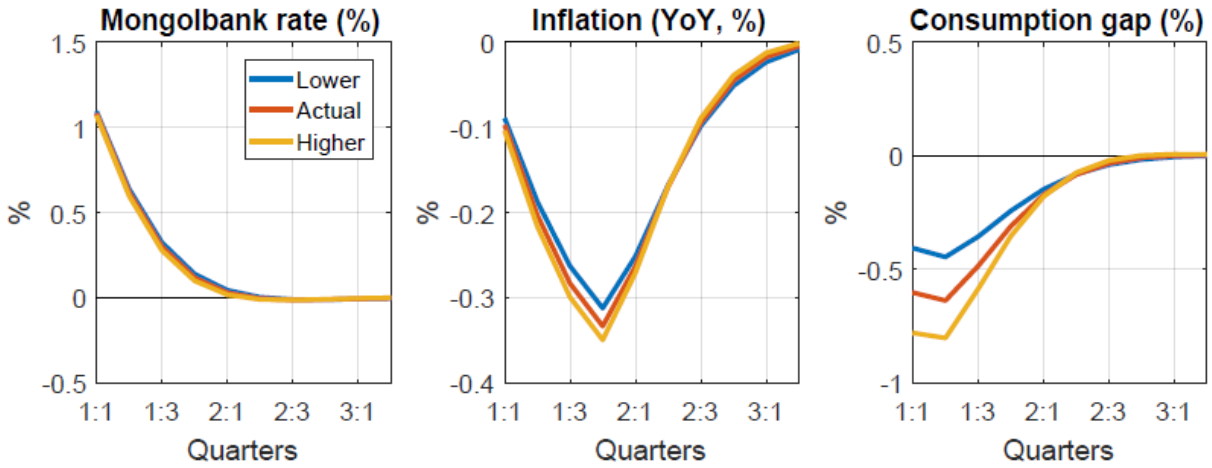

Figure 20. Monetary policy shock and different interest rate elasticities in consumption function

The demand side effect on CPI is another key channel of the model. Different demand side effect could completely change not only the CPI reaction, but also the central bank reaction on how to anchor the long-term inflation around the target. From the previous exercise we learnt that the Mongolian CPI is less sensitive to the demand side components, so we do not expect too strong reaction in CPI following a consumption shock (chart below). If we chose lower parameter values, than the monetary policy does not need to react to domestic inflation. This was not the case for Mongolia, looking at the active monetary policy reaction in the last decade by the central bank. For larger coefficients we need to check the model's historical performance and the size of estimated shocks to decide which parameter fits better. In the calibration exercise we found that 1 percent temporary increase in consumption contribute 0.05 % temporary increase in YoY inflation and results in a more than 5 basis-point increase in policy rate.

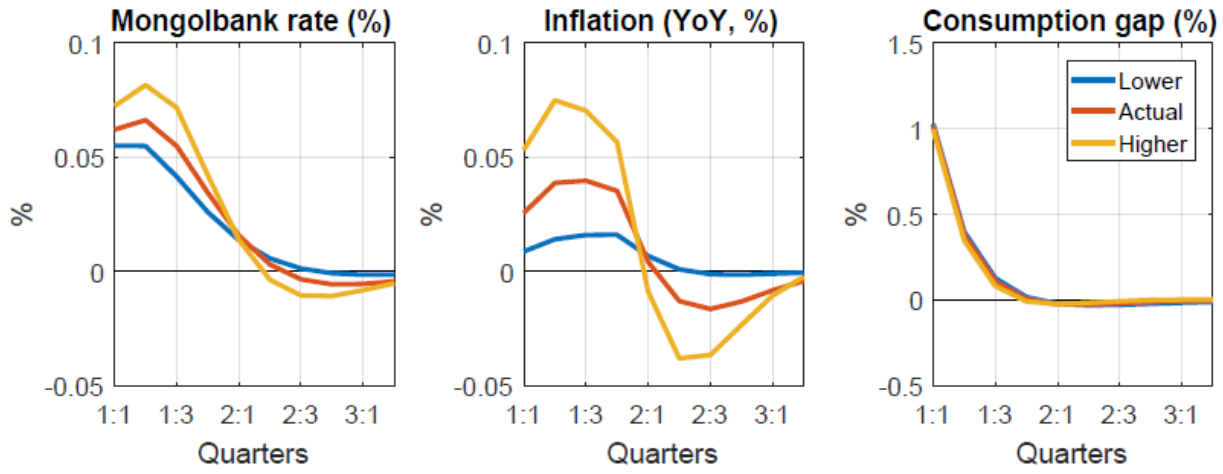

Figure 21. Consumption shock and inflationary reaction by different model specifications

How we model the exchange rate regime is the third key questions in the model. In Mongolia monetary authorities attempt to smooth out the exchange rate path with regular interventions, but don`t follow a strict pegged regime for interventions. In the model there is no explicit mechanism for capturing these interventions, instead we assume that the exchange rate determination arises from a mixture of a strictly flexible nominal exchange rate and a strictly pegged exchange rate regime. These two regimes are combined with a weight to explain the historical data. The weight of the two regime are not trivial. We hence test this value with several specifications to find out which could better describe the Mongolian case. To calibrate this parameter in the following exercise we assumed a temporary increase in foreign interest rate that gradually diminishes but exert effect on the Mongolian FX-market (figure 20). The question is how strong the exchange rate smoothing reaction of the central bank is. If the central bank decides to smooth more and intervene more on FX markets (higher) than the central bank does not need to increase the interest rate as much as it should do in totally flexible (lower) case. In the lower case the central bank needs to tolerate more fluctuation in nominal exchange rate, but offsetting the inflationary pressure it should increase the interest rate more aggressively. In our calibration we found that for Mongolia a 1 percentage point increase in foreign interest rate in the first two years would result in more than 0.6 % depreciation in nominal exchange rate on average, and the central bank would also increase the policy rate by 15 basis point temporarily to sustain the price stability.

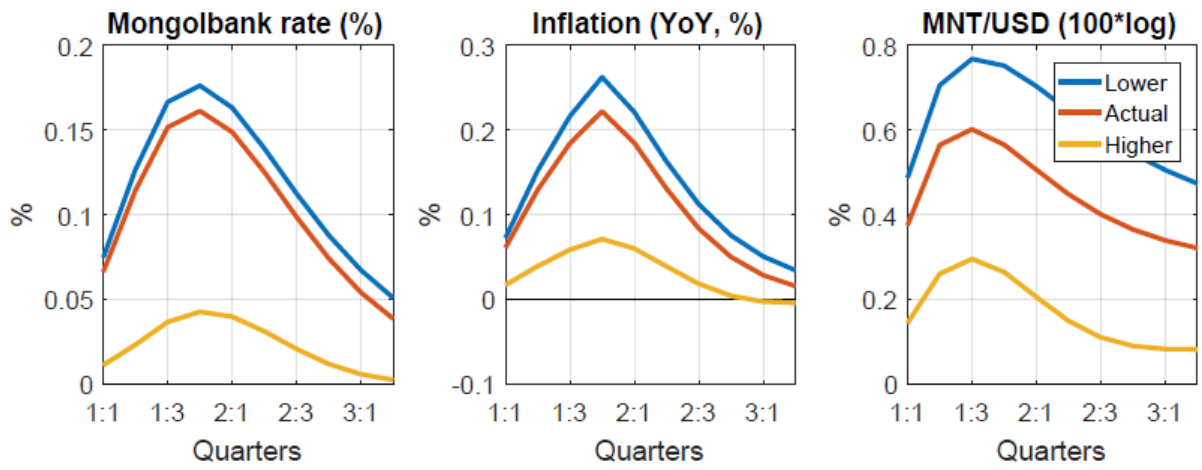

Figure 22. Foreign interest rate shock by different share of fixed nominal exchange rate

Testing forecast performance

In this section we test the robustness of our short-term forecasts. To do so we select different time periods in the sample from where we carry out within sample forecasts. We can then compare our own predictions to the actual data after that selected time period. Then we calculate test-statistics, such as the root-mean squared error (RMSE) between the predictions and the actual observations. These statistics are not very informative on their own, but they can be compared to other the results from other forecasts e.g.: different model calibrations or other forecast methods. Following standard practice, we compared the performance of our forecasts with a random-walk forecast, since macroeconomic variables generally follow near random walk processes.

In the case of the emerging economies due to the large volatility it is hard to capture precisely all movements of the data. We aim for two objectives when calibrating our model: 1) the model should be able to capture the main tendency and turning points of the time series; 2) additional information should improve the overall forecast performance.

We test forecasting performance under two cases: with or without additional external assumptions. For both cases we review how the figure captured main tendencies and turning points, then we compare the RMSE of our forecast with that of a random walk forecast.

In the first case we check what happened with the endogenous variables if we simply run 8 quarters long forecast without any additional exogenous information from the future (foreign or other exogenous variables). In the following figures the black solid lines show the hard observations, and the grey dashed lines shows the model own forecast from each quarter (figure below). In this case the model predicts well the main tendencies consistently with the actual data. Each grey dashed lines fluctuates around the actual observations and later crosses the black solid lines.

The calculated RMSE ratios (the RMSE of our in sample model forecast over the RMSE of a random walk forecast) gives similar results (see figure and table below). If this ratio is lower than one, it means that the model is able to generate better forecast than the random walk. In the first quarters it is often the case

that the model prediction is close to the random walk forecast, but later in time the differences become more significant and the model is able to give better projection than the random walk forecast.

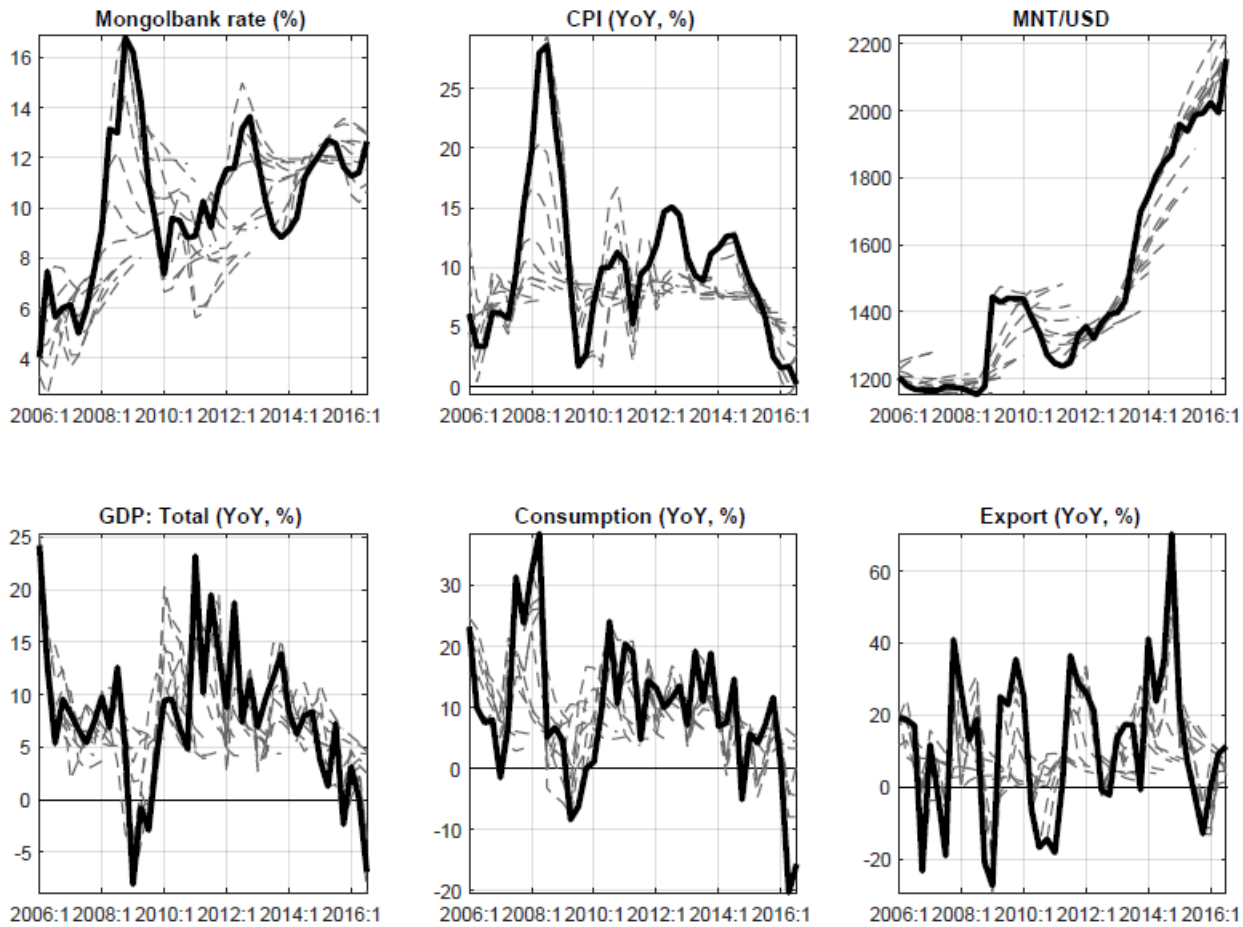

Figure 23. Forecast exercise without external assumptions

RMSE ratios: without exogenous assumptions in calibrated model								
Name	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
Mongolbank rate (%)	0.94	0.79	0.73	0.74	0.74	0.74	0.73	0.74
CPI (YoY, %)	0.70	0.68	0.64	0.64	0.63	0.65	0.69	0.72
MNT/USD (100*log)	0.79	0.64	0.51	0.49	0.49	0.52	0.56	0.60
GDP: Total (YoY, %)	0.63	0.57	0.49	0.48	0.71	0.72	0.76	0.72
Consumption (YoY, %)	0.67	0.57	0.51	0.41	0.61	0.74	0.70	0.73
Investment (YoY, %)	0.65	0.57	0.51	0.52	0.76	0.72	0.66	0.62
Export (YoY, %)	0.57	0.49	0.48	0.44	0.70	0.92	0.94	0.94
Import (YoY, %)	0.60	0.50	0.48	0.42	0.64	0.69	0.73	0.73

Table 1. RMSE ratios without external assumptions in calibrated model

In the second case we run these forecast for the same time periods, but additionally to what is done in the previous case, we assume that all exogenous variables (foreign GDP-s, foreign CPI-s, fiscal policy target, implicit inflation target, commodity prices, agricultural and mining sector trend) are known on the whole forecast horizon. Results using the same tests for this second case are displayed in figure and table below.

The figure below highlights that the model is able to capture not only the main tendencies, but also predicts well the huge changes in the Mongolian time-series. For example the interest rate and nominal exchange rate predictions (grey dashed lines) fit accurately to the observed actual data (black solid lines). In general, the model forecasts relatively well the path of the monetary variables. For the inflation and real economy variables we can predict the main tendencies of the data, however the forecast is less precise than for monetary variables due to the large volatility. Table 2 shows that the overall forecast performance of the model improved significantly with the additional information, which is reflected in the lower root-mean squared error ratios.

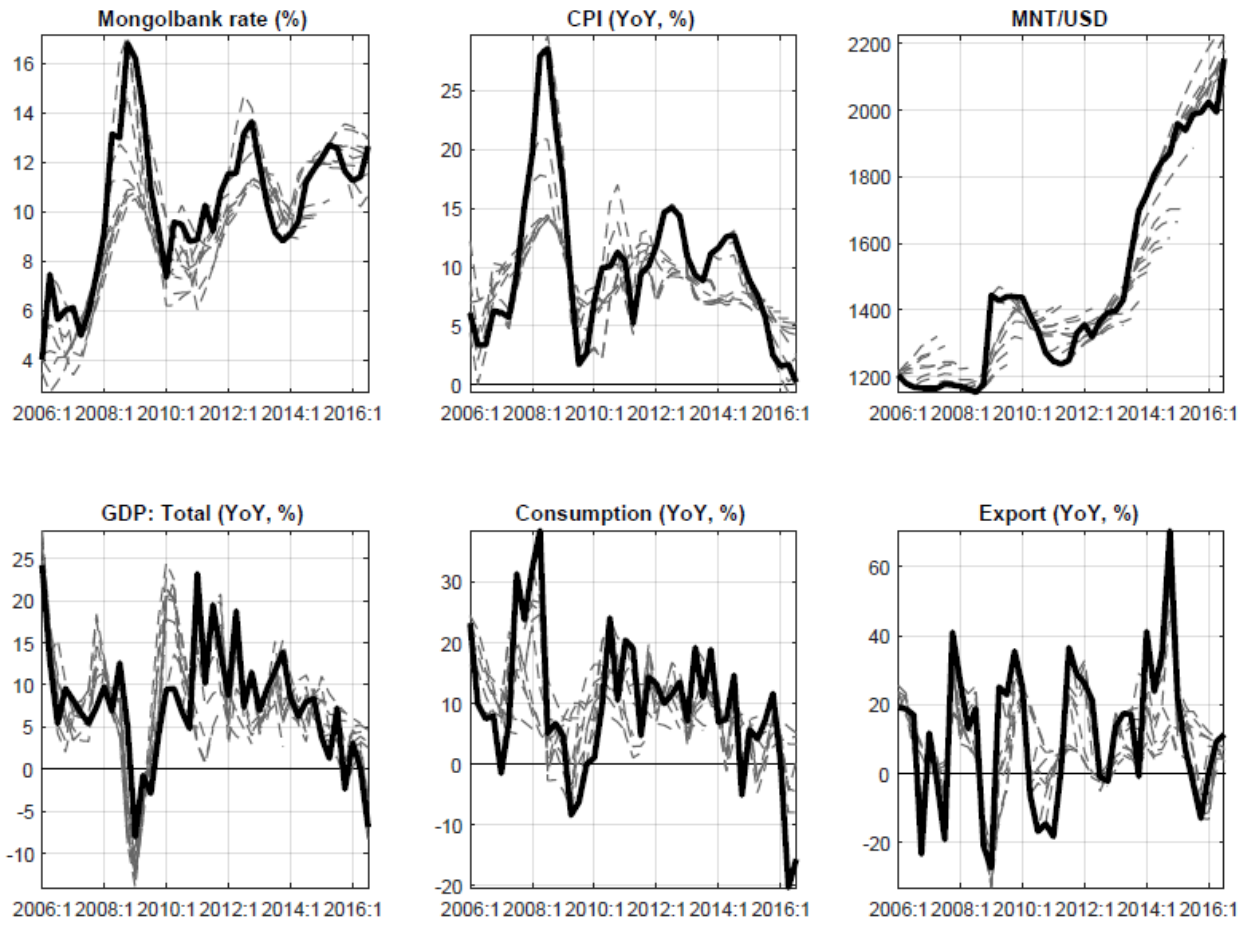

Figure 24. Forecast exercise with external assumptions

RMSE ratios: with exogenous assumptions in calibrated model								
Name	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
Mongolbank rate (%)	0.89	0.68	0.58	0.53	0.50	0.48	0.47	0.47
CPI (YoY, %)	0.67	0.63	0.56	0.53	0.50	0.50	0.52	0.53
MNT/USD (100*log)	0.76	0.61	0.51	0.46	0.46	0.48	0.52	0.57
GDP: Total (YoY, %)	0.66	0.69	0.62	0.54	0.86	0.83	0.86	0.77
Consumption (YoY, %)	0.66	0.57	0.52	0.42	0.60	0.73	0.70	0.74
Investment (YoY, %)	0.63	0.55	0.49	0.49	0.73	0.68	0.62	0.58
Export (YoY, %)	0.50	0.38	0.38	0.37	0.63	0.83	0.88	0.92
Import (YoY, %)	0.59	0.48	0.46	0.40	0.61	0.66	0.69	0.68

Table 2. RMSE ratios with external assumptions in calibrated model

Bayesian estimation of the model

As a final step we estimated the core parameters of the model using Bayesian estimation techniques. The Bayesian econometrics differ from classical estimation techniques in that it takes only limited information from the data. This procedure combines distributional prior assumptions and improving the model (likelihood) test-statistics in fitting the data (An & Schorfheide, 2007). The main advantage of this technique is that a model developer can control the possible range of parameter values to avoid meaningless parameter combinations and non-sense model reactions.

We use this Bayesian estimation as a final validation of the calibrated core model parameters. Therefore we took the calibrated parameter values as the mean of the prior distributions. Most of the prior coefficients were assumed to have so-called beta distributions, be positive and smaller than one, while for the monetary policy reaction we assumed a normal distribution.

Parameter	Prior mean	Posterior mean	90% interval		Prior distribution	standard error
$\rho^{y,agr}$	0.30	0.26	0.12	0.41	beta	0.10
$\rho^{y,mine}$	0.20	0.21	0.13	0.29	beta	0.05
ψ_1	0.20	0.19	0.12	0.27	beta	0.05
ψ_2	0.10	0.10	0.03	0.18	beta	0.05
α_1	0.30	0.13	0.05	0.20	beta	0.10
α_2	0.13	0.12	0.07	0.17	beta	0.05
α_3	0.05	0.05	0.04	0.07	beta	0.01
β_1	0.30	0.23	0.17	0.30	beta	0.05
ρ^{gov}	0.40	0.36	0.05	0.65	beta	0.20
γ_1	0.30	0.21	0.09	0.31	beta	0.10
γ_5	0.50	0.81	0.65	0.96	beta	0.20
$\rho^{ex,mine}$	0.10	0.10	0.03	0.18	beta	0.05
γ_8	0.70	0.64	0.31	0.98	beta	0.20
γ_9	0.10	0.10	0.02	0.18	beta	0.05
v_1	0.30	0.11	0.05	0.18	beta	0.10
v_2	0.03	0.02	0.01	0.04	beta	0.01
v_3	0.15	0.24	0.14	0.34	beta	0.05
v_5	0.08	0.08	0.03	0.12	beta	0.03
v_6	0.01	0.01	0.01	0.01	beta	0.00
$\rho^{i,pol}$	0.70	0.74	0.59	0.91	beta	0.20
θ_1	1.10	1.13	0.98	1.31	norm	0.10
w^{FX}	0.20	0.37	0.24	0.51	beta	0.05

Table 3. Prior assumptions and estimated parameter values

From the results we conclude that the estimated parameters are broadly in-line with the calibrated values. Most noteworthy differences are the estimated lag coefficients of inflation and aggregate demand are lower than the calibrated values. However we obtained slightly higher values for the interest rate smoothing, which confirms findings by Doojav (2016) who estimated a slow interest rate pass through, implying that any change in monetary conditions only occurs gradually in the real economy. The estimation also suggests higher values for the exchange rate smoothing - the role of interventions might have been more important in the past.

Turning to the forecast performance of the model we can find the estimates somewhat improve the RMSE-ratios and in short run the model fits the data better, while it does not change the overall power of the model significantly compared to calibrated values. We use these estimated parameters in our model to calculate impulse responses and the effects of various scenarios.

RMSE ratios: with exogenous assumptions in estimated model								
Name	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
Mongolbank rate (%)	0.83	0.64	0.58	0.53	0.49	0.46	0.44	0.44
CPI (YoY, %)	0.65	0.59	0.52	0.49	0.46	0.47	0.49	0.50
MNT/USD (100*log)	0.76	0.59	0.49	0.47	0.49	0.54	0.59	0.64
GDP: Total (YoY, %)	0.67	0.66	0.57	0.50	0.90	0.85	0.85	0.76
Consumption (YoY, %)	0.59	0.47	0.46	0.42	0.65	0.73	0.69	0.73
Investment (YoY, %)	0.59	0.51	0.47	0.47	0.72	0.67	0.62	0.59
Export (YoY, %)	0.48	0.35	0.36	0.35	0.62	0.80	0.84	0.89
Import (YoY, %)	0.58	0.47	0.45	0.40	0.61	0.66	0.69	0.69

Table 4. RMSE ratios with external assumptions in estimated model

The analysis presented in this chapter validates the model calibration and confirms that this semi-structural model is able to describe the short- and medium-term development of Mongolian economy.

3. THE FISCAL BLOCK

In this section we present how the different fiscal variables are projected. As part of the macro model, the primary balance is the only fiscal variable which interacts with other economic variables. But as part of the fiscal block presented below, each major revenue and expenditure item in the budget is projected separately using various variables as inputs. Most importantly these fiscal projections build on the variables estimated with the macroeconomic model (GDP, consumption, imports) presented in chapter 3, on the extractive revenue projections from the mineral sector block presented in chapter 5, additionally it uses demographic, labor market and capital stock projections presented in chapter 6 on auxiliary calculations. We project fiscal variables at a level of disaggregation consistent with the annual budget data published by the Mongolian Central Statistical Office. We present the projection methods of these variables in the order they appear in the budget, results are reported both in absolute term and as percentage of GDP. We conclude this section by presenting the definition of the main fiscal aggregates primary balance, overall balance and government debt referred to in this report.

Corporate income tax

The corporate income tax (CIT) revenue is usually the single most difficult tax to forecast. CIT paid by mineral companies are derived on a company basis for the largest mines, while the rest of the sector is projected as a linear function of commodity prices as part of the mineral sector block. CIT paid by the rest of the economy is projected as follows.

The national accounts category closest to the CIT tax base is the net operating surplus (NOS) of enterprises. By definition

Value added = Gross output – Intermediate consumption

Net operating surplus = Value added
– Compensation of employees
– Consumption of fixed capital
– Net taxes on production and import

The value added for the whole economy is the GDP at market prices. Compensation of employees is projected as part of the labor market section while consumption of fixed capital is projected as part of the capital stock calculation both presented in the auxiliary calculations section. We assume net taxes on production and import comprise of the VAT, the excise taxes, the Income of special purposes and the customs duties.

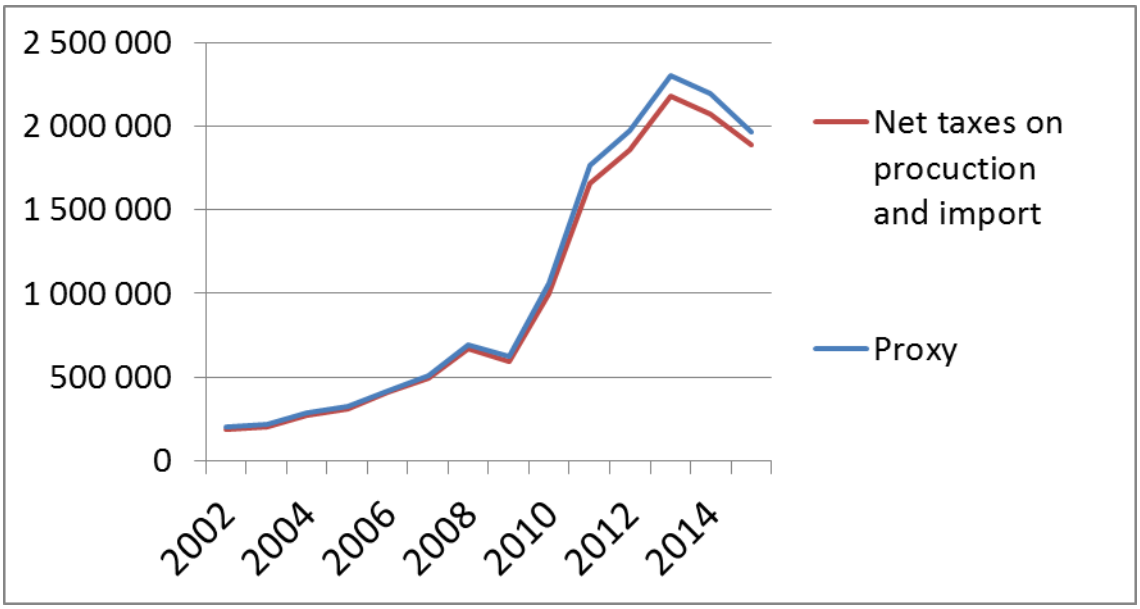

Figure 25. Net taxes on production and import

The Mongolian CSO publishes annual tables to derive the net operating surplus. Unfortunately, the "net taxes on production and import" category is not completely identical with the sum of the above mentioned five taxes, especially not in the 2008-2011 period.

The difficulties in forecasting corporate income tax revenues stem to a large extent from the dynamic (profits can be partly offset by previous years' losses) and nonlinear nature of the tax: there is always a kink at zero profit, but in Mongolia where even the rate is progressive, there may be multiple such kinks.

To handle these difficulties, we let the short term growth rate of the real tax revenue deviate from the short term real growth rate of the NOS, but include an error correction mechanism to ensure that on the long run the effective tax rate remains stable, as described in the following equation.

$$dlog\left(\frac{CIT_t}{P_t}\right) = \beta dlog\left(\frac{NOS_t}{P_t}\right) + \gamma\left[log\left(\frac{CIT_{t-1}}{\tau_{t-1}NOS_{t-1}}\right) - \alpha\right] + \epsilon_t$$

where τ is the average statutory tax rate. If the tax scheme is progressive and the tax brackets are not adjusted, then even a constant real tax base can result in increasing real tax revenue. The first term is the real growth rate of the tax base. If β is larger than one, then tax revenues "overreact" to changes in the tax base. This can be explained by the nonlinearity of the tax scheme. The second term is the error correction mechanism. If the tax revenue is higher than the value implied by the tax base and the tax rate, then in the next period the growth rate of the real tax revenue lags behind the real tax base. We also include a constant (α) in the error correction term allowing for an effectivity rate of the tax below 1.

The parameter estimates for the 2011-2015 period are

$$\alpha = -1{,}62$$
$$\beta = 1{,}3536$$
$$\gamma = -1{,}{,}8755$$

We only have factual data for CIT payment by the mining companies for 2011-2014 and in this period the net operating surplus in the core economy was around 60 percent of the core sector GDP. Nevertheless, for the projection period we have to handle the possibility of a very low or even negative aggregate amount of net operating surplus. As CIT is paid only by companies with a positive tax base, we have to estimate the positive part of the net operating surplus. In absence of micro level data, we assume the following rule:

$$\frac{NOS^{+}_{core}}{GDP_{core}} = \frac{1}{\theta} ln\left(1 + e^{\theta * z}\right)$$

Where

$$z = \frac{NOS_{core}}{GDP_{core}}$$

As the best estimate is

$$\theta = 35$$

practically the system behaves is if there was no negative net operating surplus at company level (at least in the 2011-2014 period). This is highly unlikely, but that's what available data show. Nevertheless we keep this transformation in order to avoid any mathematical problem in the projection period.

The following figure depicts how well the fitted values calculated with the above equations capture the dynamics of change in CIT revenues measured at constant price.

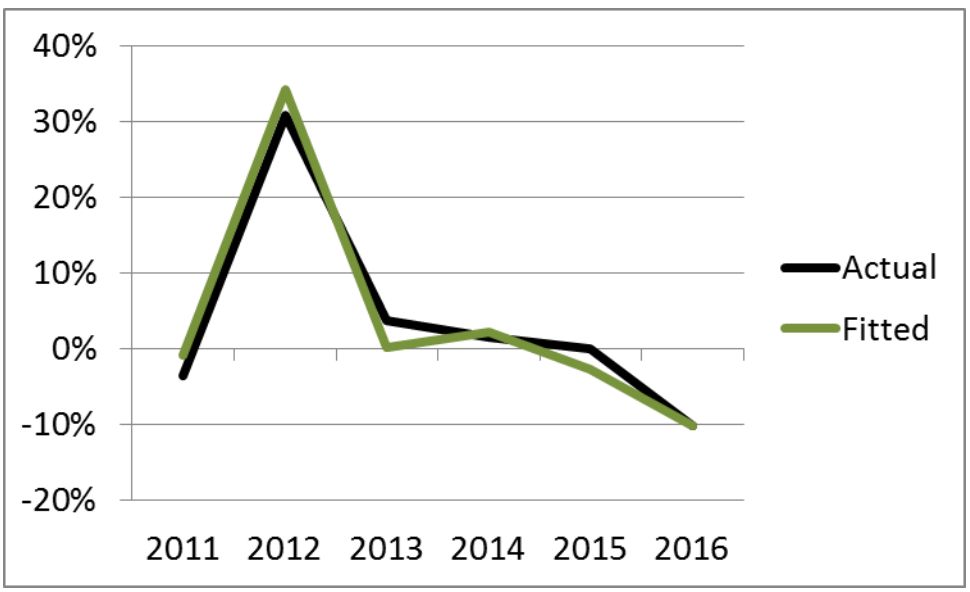

Figure 26. Growth rate of the corporate income tax revenue at constant prices

Personal income tax

The personal income tax rate has been held constant at 10 percent since 2009, before that it had multiple progressive rates. As the rate was kept flat for many years, tax revenues are generally assumed to be a linear function of the overall amount of wages and salaries in the economy with constant effectivity.

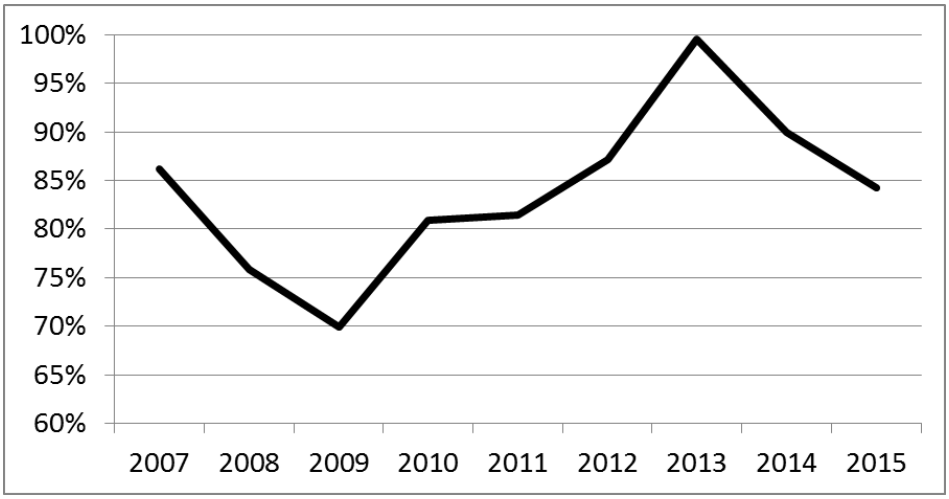

Figure 27. Effectivity rate of the personal income tax

In reality the variation of the effectivity rate is quite sizable over time (see Figure above). Hence we assume that the effectivity rate is a linear function of

- the real growth rate of average wages and salaries in the core economy
- the real growth rate of household consumption and
- a (negative) dummy for the years 2007-2011

The dummy increases the goodness of fit (MSE drops by 60%) especially in the second half of the period which is more important for the parameter estimates to be used in the projection period.

Value Added Tax

Value added taxes are projected in two parts: mining and core sector related. Mining companies pay VAT on their operating costs, capital costs and (Oyu Tolgoi) on the management fee paid to the foreign owners, i.e. based on items that are traditionally not part of the VAT tax base, this part of the revenue has to be separated and projected in the mineral sector block.

The core VAT revenue is the product of three factors: the tax base, the statutory tax rate and the effectivity rate

VAT revenue = Tax base X Statutory rate X Effectivity rate

As we don't have data for tax base adjustment (tax credits, refunds, etc.) we cannot differentiate between the theoretical tax base and the effective tax base. The tax base consists of three parts:

- Consumption expenditure of households
- Government purchase of goods and services
- Government investment

Each of these items are projected into the future using the macroeconomic model.

The statutory tax rate is exogenously given by the legislation. The rate was 15% until 2006, since then it has been 10 percent and there is no change envisaged.

The effectivity rate is calculated from past data. It shows some correlation with real GDP growth implying that in good times proportionately more tax revenue can be collected than in bad times.

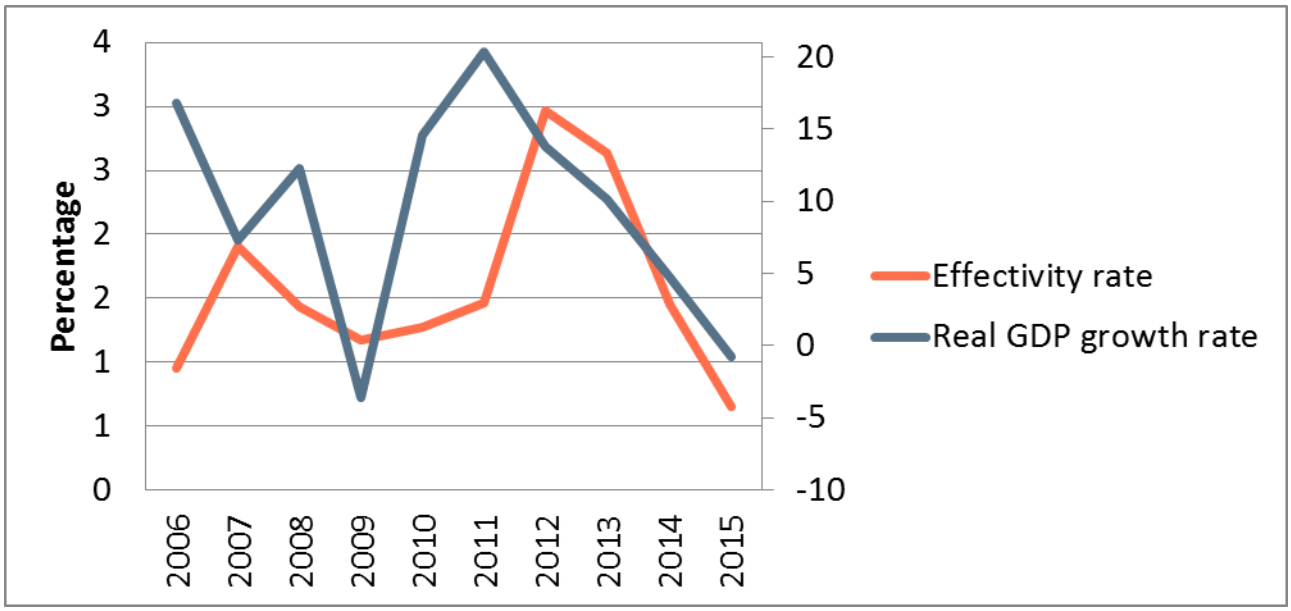

Figure 28. Effectivity rate of the Value Added Tax and the real growth rate of the core GDP over time

However the 2015 data cannot be used for establishing the relationship between the GDP growth and effectivity, because of the tax amnesty measure first adopted in autumn 2015, but later extended by the parliament into 2016.

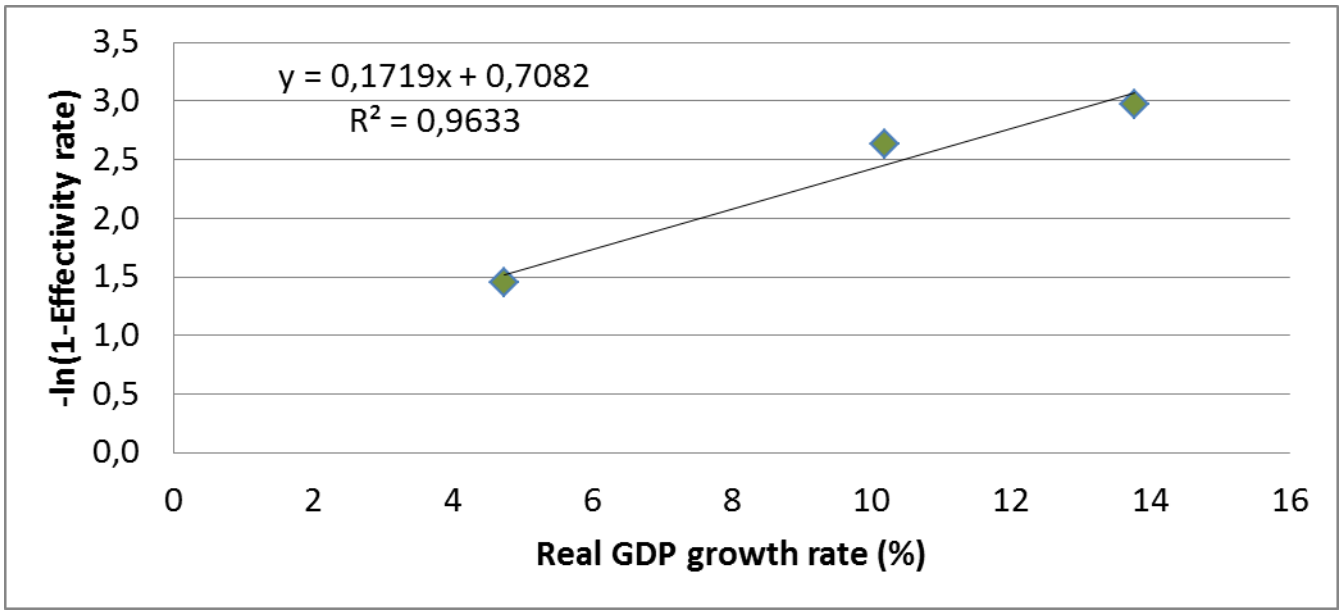

Figure 29. Effectivity rate of VAT and the real growth rate of GDP 2012-2014

Excise taxes

Excise taxes are assumed to be a simple linear function of household consumption expenditure

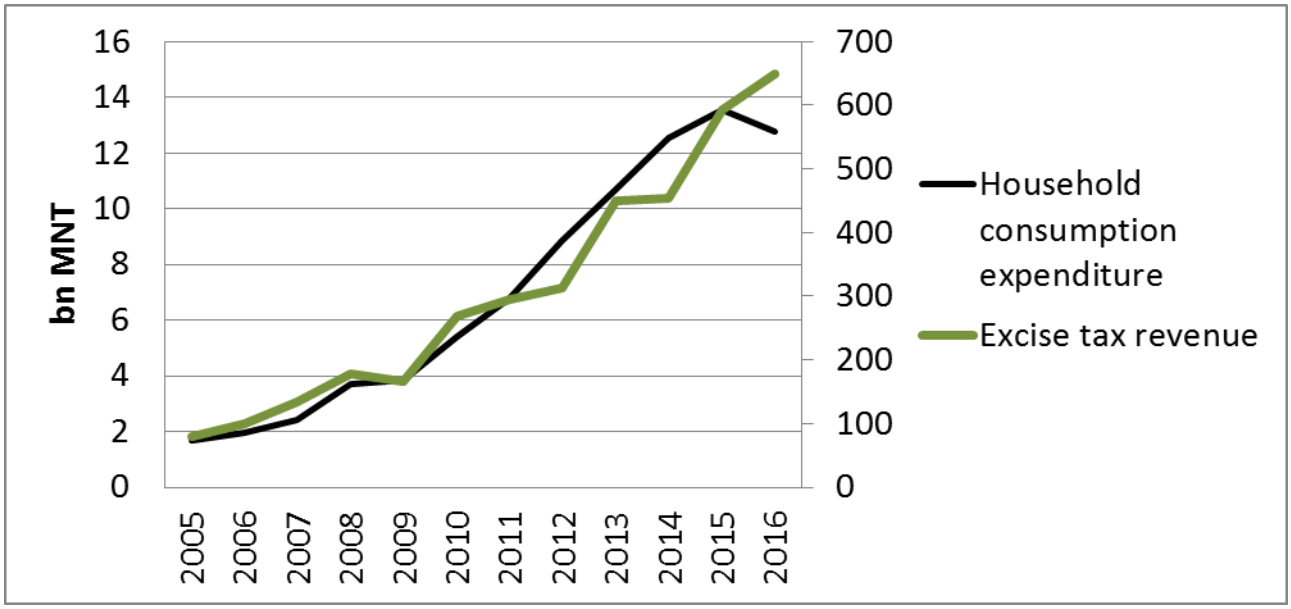

Figure 30. The co-movement of excise tax revenues with household consumption expenditure

The average ratio of excise tax revenue / consumption expenditure is 4,16% over the period 2012-2016.

Income of special purposes

The "income of special purposes" used to be correlated with household real consumption expenditure before 2011. In the period 2011-2013 the link was more uncertain. Since 2013 the coefficient seems to be stable again. We take the value for the last three years (0,13%) for the projection period.

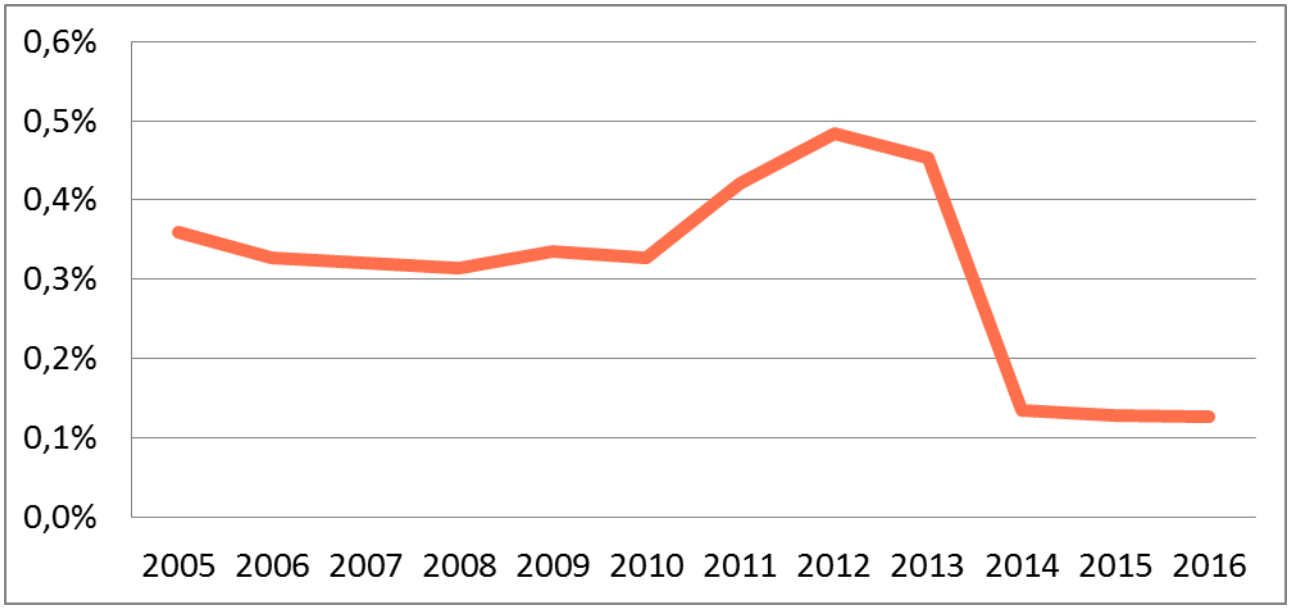

Figure 31. Income of special purposes as a percentage of household consumption at 2010 prices

Customs duties

Customs duties are – as expected - very strongly correlated with import of goods and services.

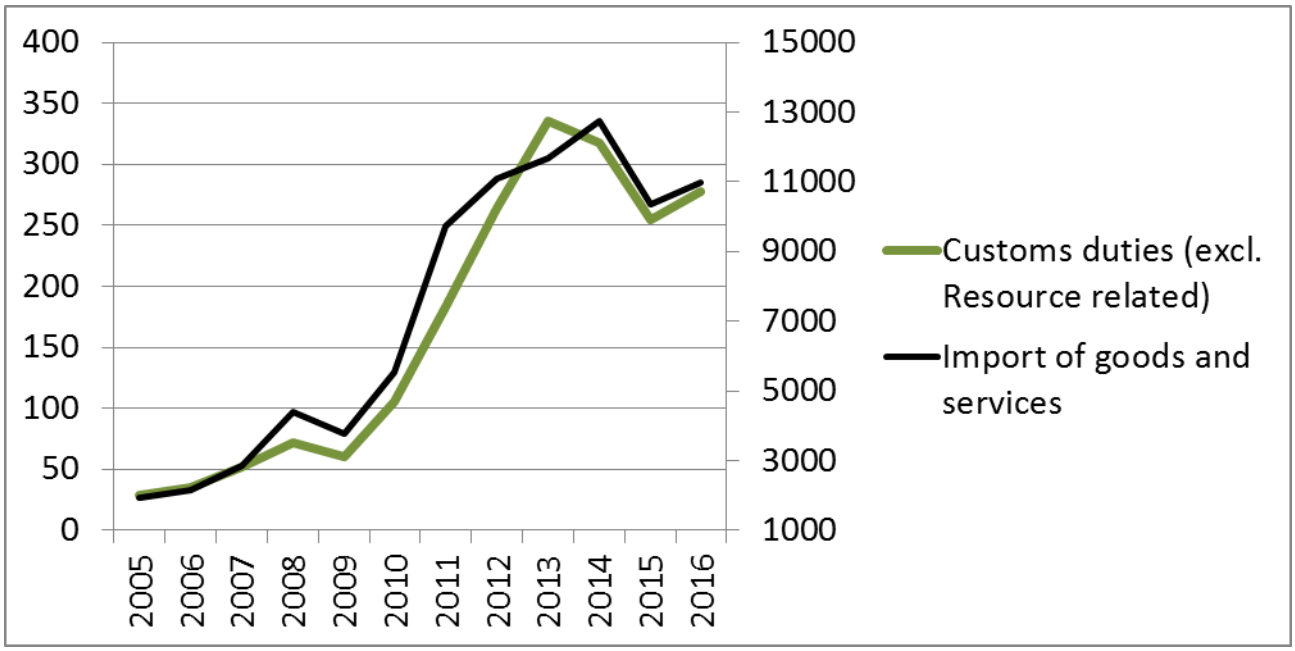

Figure 32. Revenue and tax base – customs duties (bn MNT)

Natural resource related customs duties revenues are projected in the mineral sector block. The core part of this item depends on the nominal value of import. The average ratio of customs duties and import of goods and services over the period 2014-2016 was 2,5%, which we hold constant for the projection period.

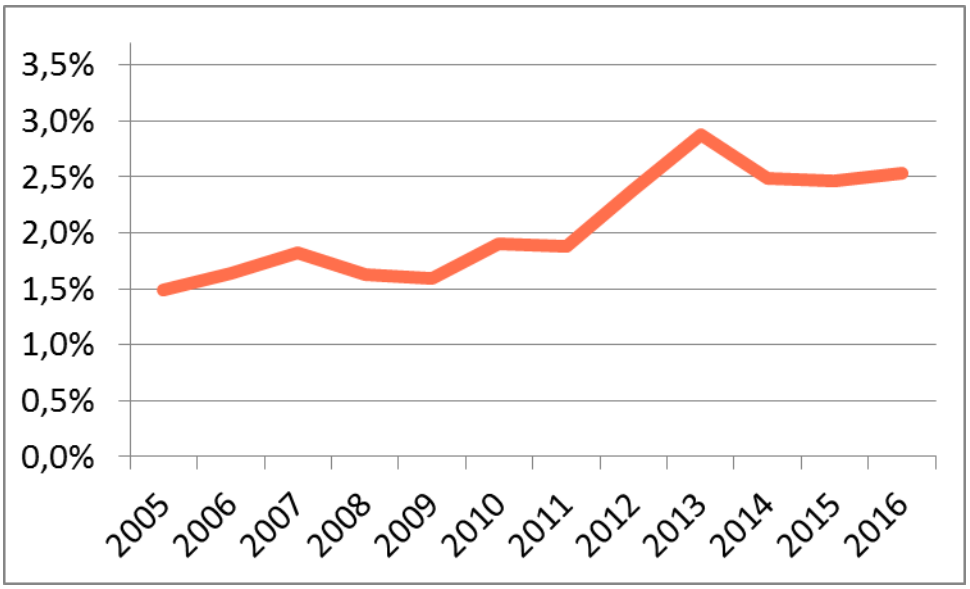

Figure 33. Non resource related customs duties revenue / Total import

Social security contributions (revenue)

Since 2009 social security contribution rates have been constant. The employers' rate of contribution is 13 percent[1], while employees pay 10 percent of the gross wage.

From the budget's revenue side, we have data on the total revenue, i.e. the sum of the employers' and employees' contributions from the total economy, while from the expenditure side of the budget we have data on the employers' contribution from the government sector. We assume that the effectivity rates differ across sectors, but for the employers' and the employee's contribution of the same sector are identical. From the expenditure side data, we can calculate the effectivity rate for the government sector. Applying the same effectivity rate for the government sector employee's contribution we can calculate the total contribution from the government sector. By subtracting it from the total SSC revenue we can get as a residual the total SSC of the private sector. From this we can calculate the effectivity rate for the private sector, and hence we can estimate the employers' and employee's SSC of the private sector separately.

[1] The base SSC rate for employers is only 11 percent, but the sectors with higher risk of industrial accidents and occupational illness pay higher. Heavy industry, mining, power plants etc. pay the higher rate, and this is that we used in our calculations.

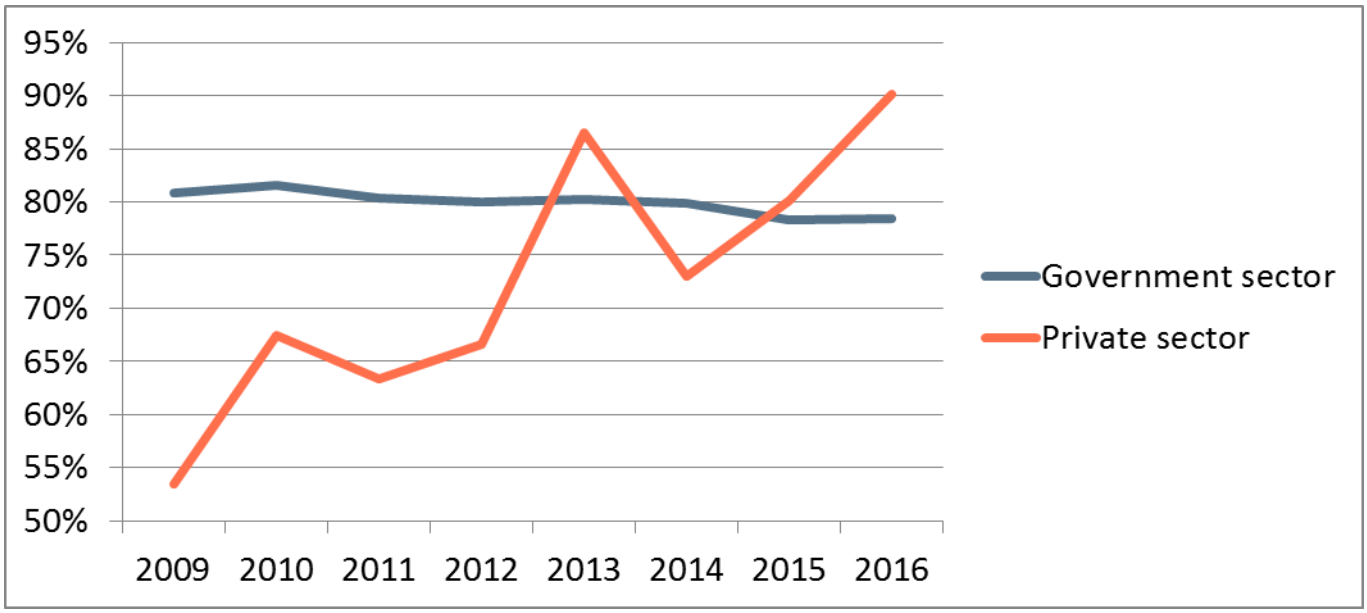

Figure 34. Effectivity rate of the social security contribution

For the projection period we use the average effectivity of the 2012-2016 period. For both the government sector and the private sector this happens to be equal to 79%.

Capital revenues

Capital revenues used to be somewhat more sizable in the 1990s, but over the last 15 years they did not account for more than 0,1 percent of the GDP. In 2015 a slightly bigger amount (0,25% of GDP) showed up, but it is still close to negligible.

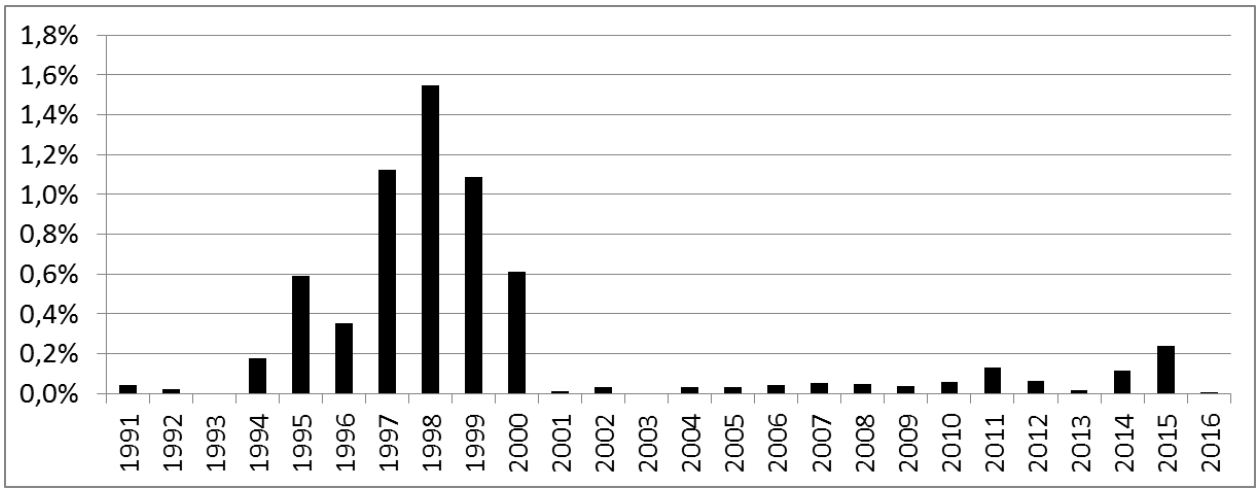

Figure 35. Capital revenues as a share of GDP

Over the projection period we assume that capital revenue will only contain the dividend revenue from the mining sector and will be estimated at a company level in the mineral sector block.

Grants and transfers

Fiscal revenues from grants and transfers were more than 1 percent of the GDP in the first years of the 1990s, but as Mongolia became wealthier they became smaller. Based on the Balassa-Samuelson theory we use the ratio of the nominal exchange rate and the PPP conversion rate as the measure of relative wealth. As the figure below shows, this index decreased between 1993 -1995, increased between 1995 - 1999 (meaning that in that period Mongolia was lagging behind), decreased again between 1999-2010 and it stabilized between 2010-2013. (In 1991-1993 international grants and transfers to the post-communist countries were much larger than afterwards.) The 2000-2001 global recession and from 2010 the global financial crises seem to have had a significant negative impact on the amount on grants and transfers. Simply speaking donor money is smaller if a country is doing relatively well and/or if there is an economic problem in the donor countries.

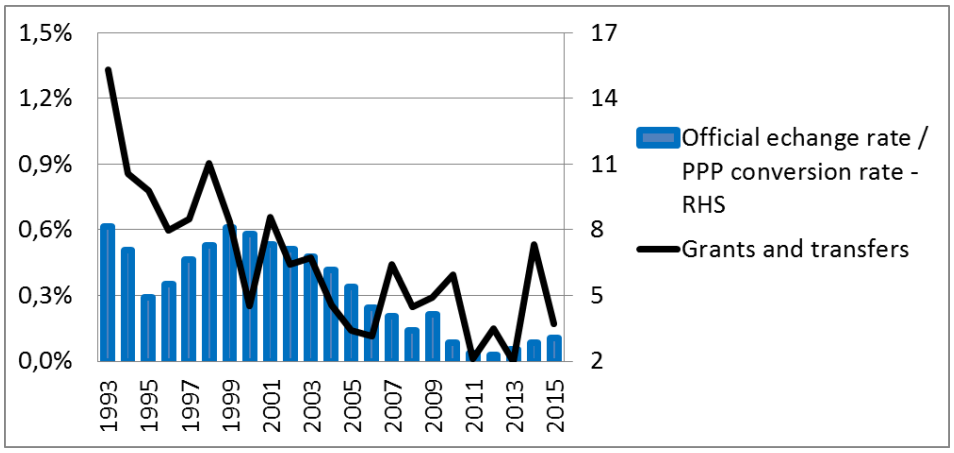

Figure 36. Grants and transfers are vanishing as Mongolia is catching up

For the projection period we assume that grants and transfers / GDP stabilizes if the Mongolian per capita GDP grows at the same rate as the US economy in terms of per capita GDP (1,2% per year). If the Mongolian economy is growing faster, grants and transfers / GDP decrease proportionately. In our baseline scenario the Mongolian per capita GDP grows at about 4 percent per year, and hence the grants and transfers revenue as a share of the GDP goes down from the current 0,37% value to 0,09%.

Other revenues

About 2/3 of other revenues are related to mining. The rest consists of several smaller items (e.g. property taxes, export duties).

For the projection period we assume the mining related part to contain the royalty and other revenues from the mining companies, while the rest follows the growth pattern of the non-mining GDP.

Wages and salaries

Government wages as a share of government consumption has been relatively stable over the last few years. The ratio in 2012-2015 was 54-55 percent, but (based on information available at the end of 2016) in 2016 it dropped to 45 percent.

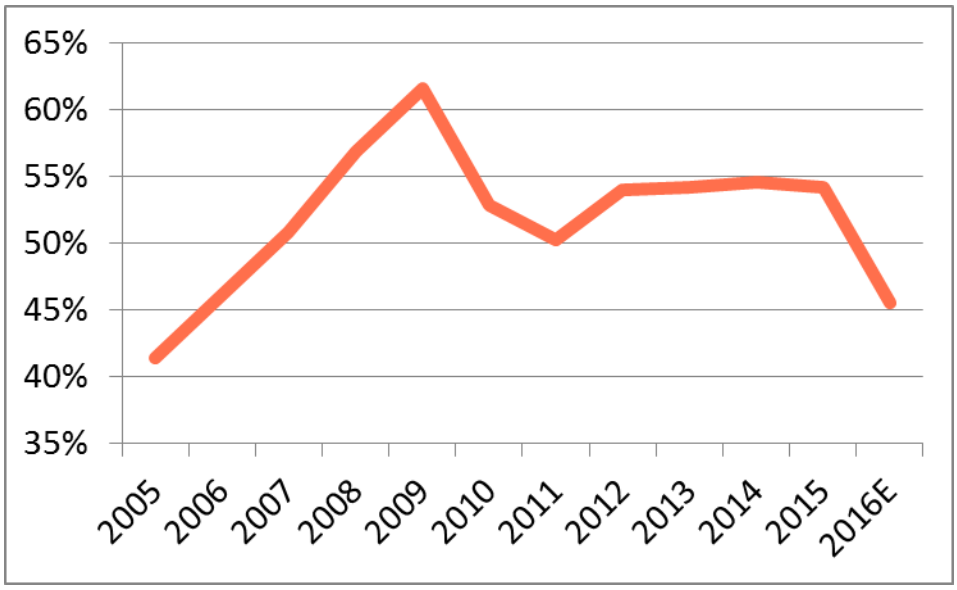

Figure 37. Government wages as a share of government consumption

The number of government employees is assumed to be proportionate to total employment which is kept constant at 17%.

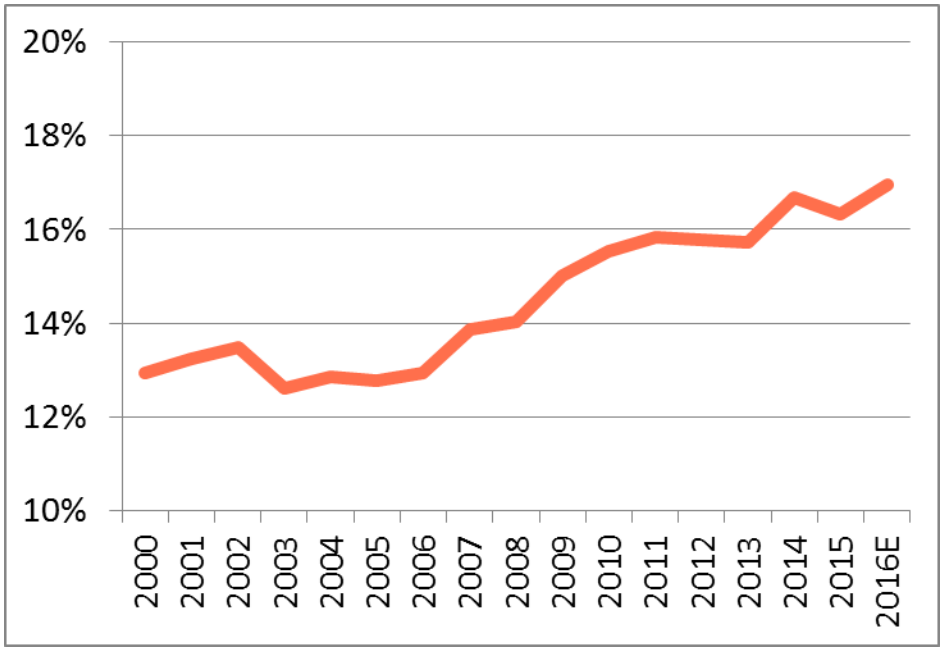

Figure 38. Share of government employment in total employment

Social security contributions (expenditure)

The employers' social security contribution in the government sector is assumed to grow proportionately with the total amount of wages and salaries in the government sector.

Purchase of goods and services

Our method to project the value of goods and services purchased by the government is based on the statistical identity:

Government consumption + Government market production =

Compensation of government employees + Purchase of goods and services + consumption of capital +net taxes on production paid by the government

In the above equation we have already projection for all items except for the market production and the purchase of goods and services. In line with past data we assume that in the projection period government market production compared to government consumption decreases along an exponential path.

Subsidies and transfers

In absence of more detailed data we assume that Subsidies and transfers are solely paid to households (expert opinion suggested it may be about 80%).

Subsidies and transfers are mainly related to persons not employed. Children, elderly, sick, disabled and unemployed get most of the social transfers in money. We assume that the per capita transfer to not-employed people is kept up with average wages in the economy (see figure below).

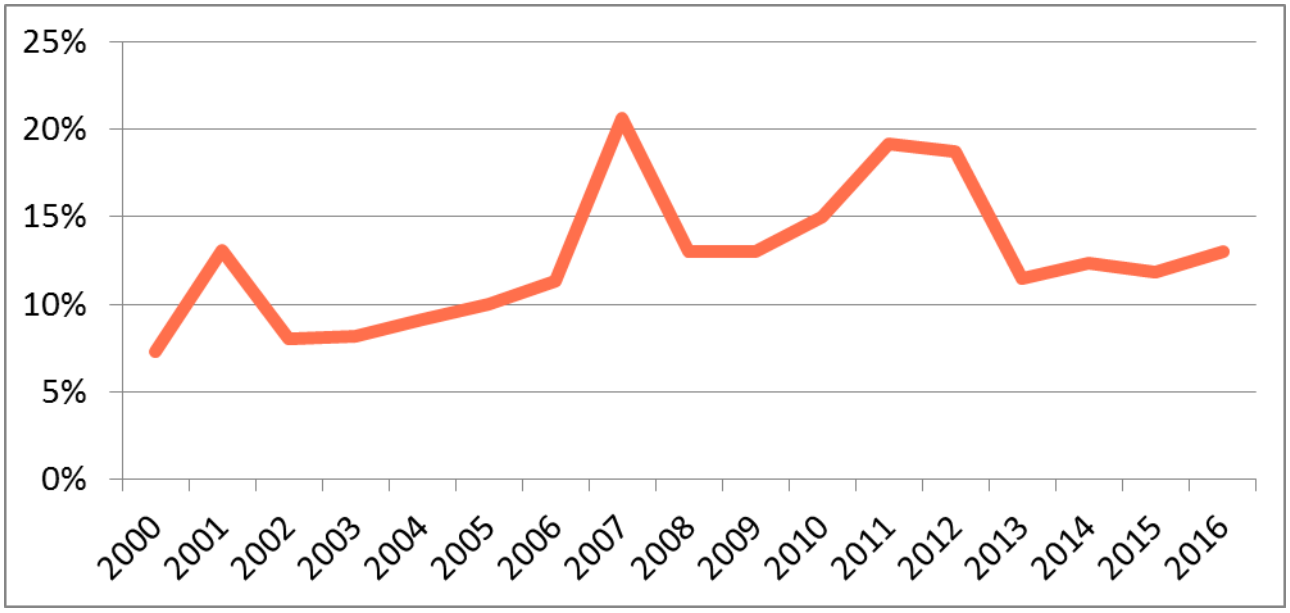

Figure 39. Subsidies and transfers as a percentage of gross wage per person

We assume that over the projection period the ratio of per capita grows wage and subsidy and transfer per people not employed remains stable at 13,04%.

Number of not employed people can be projected as the difference between the total population and the number of employed people as projected in the macro section

Capital expenditure

Capital expenditures consist of two main parts: "domestic investment" (government gross fixed capital formation) and other capital expenditures.

Domestic investment

Government investment is assumed to grow at the same rate as private sector investment, unless there is a government policy measure to increase or decrease investment expenditures. Implicitly this implies that there is a need for government (infrastructure) investment proportionate to the private investment along the development path (government investment is complementary to private investment). While we assume that government investment grows in tandem with private investment, this does not mean that their efficiency is the same. In fact, we assume that only half of public investment is as efficient as a private investment, while the other half has to be treated as public consumption from an economic point of view.

Other capital expenditure

Assumed to be zero. Unless there is a government decision to recapitalize partly state-owned mining companies due to their losses accumulated.

Interest payment and government debt

We model debt dynamics by approximating it with five different instruments:

- FX (USD) denominated debt at market interest rate (5Y maturity)
- FX (USD) denominated debt at concessional rate (10Y maturity)
- Short term (6M maturity) MNT denominated debt
- Medium term (3Y maturity) MNT denominated debt
- Government guaranteed debt of state owned enterprises

Interest payment is the product of the stock of debt and the implicit interest rate paid on the debt. For each instrument we calculate the relevant interest rate in the auxiliary table "Interest rates". The following summarizes our key assumptions.

We assume that state owned enterprises will be able to finance their debt without extra government subsidies, hence their value is only added to the government debt for statistical purposes, but their interest does not add further burden to the budget.

For the projection period we assume that the foreign exchange denominated part of the debt is renewed in USD and a fix share (which we set at 20 percent in the baseline scenario) of the annual deficit is financed by FX denominated instruments.

As part of the FX denominated debt, we assume that Mongolia will receive new concessional financing from international institutions to the tune of 2 percent of GDP each year.

The MNT denominated part of the new issuances is split between a short term (six months) and a medium term instrument (three years) in a fix proportion. The rate is 90% in short term security that implies an average maturity of the MNT denominated part of the government debt gradually increasing to 1,07 year from the current 0,92 year. Increasing the average maturity of the debt would imply a higher average interest rate and hence a more rapidly growing government debt. Shortening the debt helps to reduce annual interest expenditures, but it increases both the refinancing and the interest rate risk.

A new proposed law allows for the accumulation of a so called Heritage Fund (NRGI, 2015). The Fund would be fed by 5 percent of the government's royalty revenue paid by the mines. The Fund is assumed to invest its assets in liquid USD denominated securities with a yield equal to the prevailing FED funds rate (~US monetary policy rate). Accumulating assets into the Heritage Fund requires to increase gross government debt by same amount. The fund also generates lower interest revenues, then the corresponding debt financing expenditures, hence the overall effect is an increase in net interest expenditures and net debt stock. In our baseline calculations we do not assume that moneys are accumulated into the Heritage Fund, as priority is given to paying down current debt. But the Excel-based model (Advanced Control Panel) allows for the possibility to estimate the effects of accumulating savings in parallel to borrowing. If the Fund was annually receiving 5% of all royalty revenues, it would accumulate slightly above one billion USD in foreign assets by 2045, but this would also imply a one percent higher gross debt/GDP ratio compared to the baseline.

Aggregate fiscal indicators

The above budget items are aggregated into total revenue and total expenditure, while the difference between the two represents the overall government balance (also referred to as headline deficit). Additional indicators of the fiscal balance are also derived. The primary balance excludes interest expenditures; the primary non-resource balance also excludes net resource related revenues (calculated in the mineral block); the primary non-resource recurrent balance also excludes government capital expenditures providing insight into how permanent revenues compare with recurrent expenditures, in other words whether the non-renewable mineral revenues are being used to finance current consumption or rather saved and invested into domestic capital accumulation.

Debt dynamics are also derived based on our calculation of the primary and overall balance. The change in debt reflects accumulation of interest on debt from previous year, additional financing need arising from the given year`s primary balance and change in the valuation of the foreign currency denominated stock of debt due to exchange rate shocks.

4. THE MINERAL SECTOR BLOCK

The macroeconomic model and the fiscal block partially builds on projections about how the resource sector will develop and what revenues it will generate. The Mongolian resource sector is very complex, with 1391 mining production licenses for 57 types of minerals. 16 deposits across the country were designated of strategic importance (EITI 2014 Report). Out of these, the model provides individual mine level projection for the 5 largest deposits in terms of economic output and revenue generation potential: Oyu Tolgoi, Erdenet, Tsagaan Suvarga, Gatsuurt, and Tavan Tolgoi (split across the state owned mine and a privately owned mine).

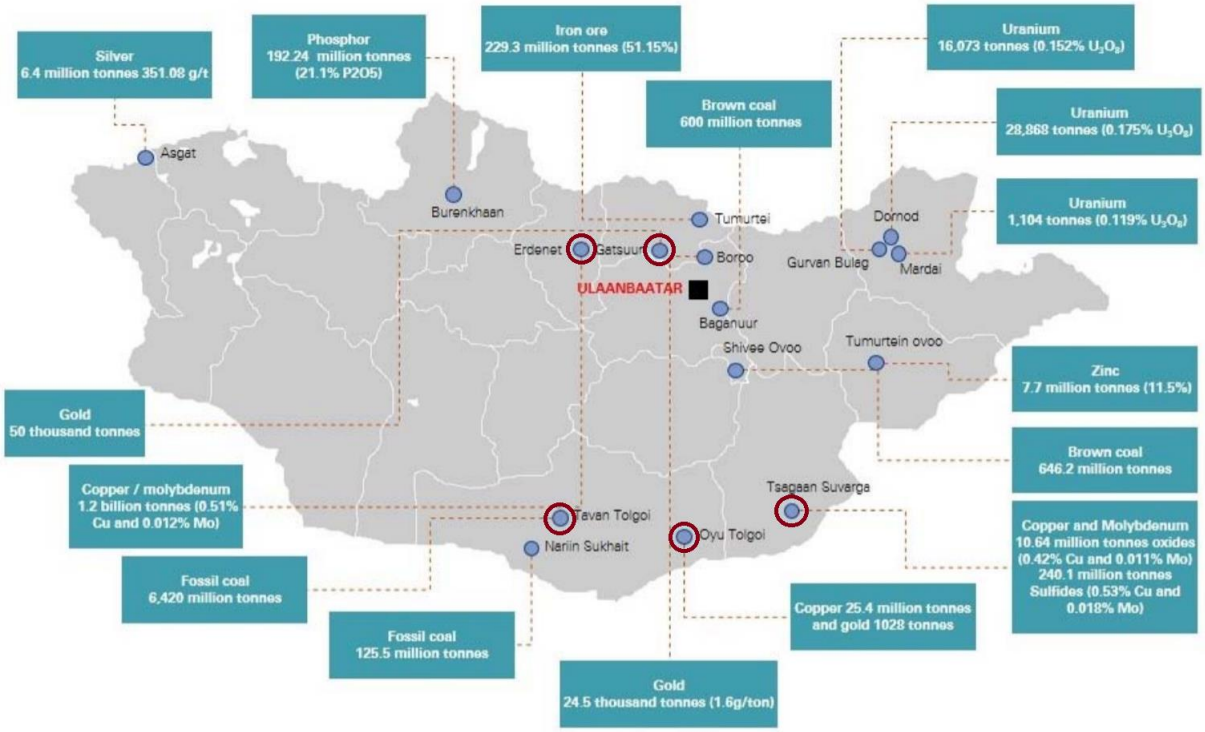

Figure 40. Strategic deposits in Mongolia and location of five mining projects modeled (Source: EITI 2014 Report)

For each of these mines a simplified project level financial model uses detailed production, operational cost, capital cost, tax burden and financing data to derive output and revenue projections for the following 30 years. The remainder of the sector is projected linearly as a function of average commodity prices.

The reason the economic and tax dynamics of these five largest mines are considered separately is three-fold: First, because these few projects dominate the resource sector and have the potential to generate a sizeable proportion of total government revenues and GDP in Mongolia. Secondly, the size and timing of revenues they will generate is unique and non-trivial for each project depending on project expansion timelines, individually negotiated fiscal terms and financing arrangements. Thirdly, this model has an important emphasis on understanding how changes in the commodity sector may impact the economic outlook, to which using simple linear approximations of the relationship between key variables would be overly simplistic. For example, certain thresholds should trigger the start of payment of corporate tax or the state to start earning dividends, resulting in non-linear relationship between commodity price and revenues.

In the following we present briefly the key assumptions we make about these five projects, followed by an overview of total mineral revenue under the baseline scenario.

Oyu Tolgoi

One of the world`s largest new copper-gold mining project. It combines an open pit and an underground mine that producing mineral concentrate which is then transported by rail to China for processing. Open pit operations started in 2012, while the development of the underground mine has only recently been approved in March 2016 with a two-year delay compared to original timeline. The underground mine is planned to more than double the mine's copper output and produce copper concentrate of higher grade, therefore expected generating much higher economic value. The mine is being developed as a joint-venture between Canadian-based Turquoise Hill Resources (66%) and the Government of Mongolia (34% ownership). Exploration and development costs up to date reached $10 billion (OpenOil model, 2016). The required investment of approximately $10 billion for the expansion of the mine into the underground is assumed to be financed through a combination of external loans from various financial institutions and export credit agencies (40%), shareholder loan from parent companies (35%) and equity (25%). Our calculations assume financing at an interest rate of LIBOR + 6.5 % and that investors take advantage of their investor tax credit. Our results show no corporate income tax or state dividend earnings being paid but still yield $7.8 billion (in 2016 real terms) in government earning primarily from royalties and VAT in the 30 years of modelled project lifetime. Calculations are primarily based on the 2009 Oyu Tolgoi Investment Agreement[2], the amended 2011 Shareholder Agreement[3], the 2014 technical report published by Turquoise Hill Resources[4], the 2015 development and financing plan[5], the open source financial model developed by OpenOil, discussions at the parliament of the project and investor presentations.

Large mining projects can be slow to develop particularly in countries where debt is high and with governance challenges (Khan, 2016). The average mine is also rarely on budget, capital cost overruns are typically between 20% and 60% (Haubrich, 2014). In this case, Oyu Tolgoi has already seen setbacks in in its own development timeline. Therefore the model allows to evaluate an exogenous shock, where the user can input the years of delay in phase 2. Such delays result in the start of copper production from phase 2 to be set back by this given number of year compared to currently planned production start in 2021, as well as increasing development costs associated with the expansion proportionately to the delay.

Erdenet

An open pit copper-molybdenum mining operation opened in 1974. It is the fourth largest copper mine in the world and has historically been an important contributor to Mongolia`s economy. Formerly a Soviet-Mongolian state-owned joint-venture, the Russian state stake (49%) was recently transferred into Mongolian private ownership. The remaining 51% is state-owned. In our analysis we assume the mine will continue to be a major contributor to total mining production, but with its large production costs and lower quality ore, operating margins will remain small, and the mine will accumulate growing losses over its lifetime. We calculate $100 million per year or $3.1 billion over life time in government revenues (in 2016 real terms) mainly from royalties and VAT, which is dwarfed by the financing needs of the company.

[2] http://www.resourcecontracts.org/contract/ocds-591adf-MN2079301876RC/view
[3] http://www.resourcecontracts.org/contract/ocds-591adf-MN2079301876RC-1658/view
[4] http://www.turquoisehill.com/i/pdf/2014-10-27_OyuTolgoiTechReport.pdf
[5] http://www.resourcecontracts.org/contract/ocds-591adf-MN2079301876RC-1656/view

Tsagaan Suvarga

A copper and molybdenum open pit mine currently in pre-production phase. The project needs an over $1.1 billion investment to start production according to documents circulated in the Mongolian press at the time of signing of the Investment Agreement between the license holder, Mongolia Gold Corporation (MAK), a local company, with the government. While the mine was set to start an intensive development from this year, due to financing issues the actual investments may not start in 2016. It is considerably smaller than the other two copper mines, and information about project production profile, costs and financing is more limited. Even without assuming historical debts accumulated by the mine through its history, we project that the current investment requirements make it unlikely to generate any taxable profits. We project VAT and royalties to be the main source of government revenues generating $0.7 billion (in 2016 real terms) over a 20-year horizon.

Gatsuurt

An open pit gold and silver mine currently under negotiation with Centerra Gold, a Canadian mining company. Centerra has previously operated Boroo gold mine in the vicinity of the project, and assuming government approvals would use processing facilities at Boroo for the production at Gatsuurt. The negotiations for the project have been dragging for years because of the uncertainty created by prohibition of mining activities in the forest and river basin areas and significant protests by some groups in Mongolia over the impact of the mine on historic archaeological sites (the mine is located in the vicinity of a historic burial place for Mongolian elites). The mine was designated a strategic asset in 2015, opening up the opportunity for government ownership, which is currently uncertain, and excepting the mine from the prohibition imposed for mining in forest areas (this prohibition does not apply to 'strategic deposits'). The new government (formed in July) made a priority to 'move large projects' including Gatsuurt, and currently is negotiating the investment and deposit development agreements. We project a small ramp up in gold production up to 175 koz followed by a gradual decline across the outstanding 10 years of life-of-mine assumed based on a technical report (where)[6]. Based on cost data[7] from the company we project considerable operating margins going forward, but financing needs and additional capital costs will decrease profits making the project only generating very limited corporate taxes. A combination of royalties, other smaller mining taxes and some CIT are projected to generate about $150 million in government revenues across the mines lifetime.

Tavan Tolgoi

One of the world's largest untapped coking and thermal coal deposits, with a total of estimated resource of 6.4 billion tonnes. The vast coal deposit divides into six sections, five of which are fully state owned via Erdenes Mongol LLC (except for one small part of Tavan Tolgoi which has long been exploited by Tavan Tolgoi LLC, a local government majority owned producer of unprocessed coal, but we ignore this for modelling purpose as the production at this mine is lower in quantity and expected to be dwindle), and one section (Ukhaa Khudag) which is privately owned by the Energy Resources (ER) a subsidiary of Mongolian Mining Corporation, a private company listed on the Hong Kong Stock Exchange. Erdenes production is of approximately 5,000 ktons of coking coal, in contrast with 7,200 kton of processed coal produced by ER. On top of producing larger volume, the coal mined at Ukhaa Khudag mined by ER is also almost four times as valuable per ton as a result of processing. Both mines are projected to continue produce steadily at current levels over next 30 years. While Erdenes mine is projected to generate a small negative cash flow, ER is projected to generate some positive cash flow, but not turn profitable during the projection horizon. State revenues will hence accrue from royalties and other small taxes only. The state

[6] http://renmarkfinancial.com/cg/gatsuurt_tech_report.pdf

[7] http://www.centerragold.com/operations/boroo/production-and-reserves

owned part may generate about $8 million / year, compared to $32 million /year from ER. Over the 30 years, this is equivalent to $249 million and $958 million in revenues in 2016 real terms. Projections for Erdenes are based on the company's financial reports posted on their website, presentations by the company and the government, and other information available online were used. Projections for the Energy Resources part of the project is based on the government report, interviews of officials and reports from the parent company Mongolian Mining Corporation[8] for the Hong Kong Stock Exchange. Recently, the government started negotiations with Chinese coal giant Shenhua and Mongolian MCS, a parent of Energy Resources, on developing the government part of Tavan Tolgoi more extensively, with the resolution of lowering costs by building a railway to China, but our assumptions do not include this scenario.

Additional assumptions

Financial modelling of the mines is based on investor prospectus, contracts where available, taxes paid from 2011-2014 from the EITI database. Projections are carried out for the period 2016-2045 in real USD terms. For the tax burden of the 6 major mines and the other mines together data in nominal MNT terms were also given for the period 2011-2014. To calculate value added in the mining sector we assumed that intermediate consumption is 70 percent of the operating cost of the mines (the remaining 30 percent is the compensation of employees). Lack of comprehensive data on financing and debt are a major cause of uncertainty regarding the projection. Whether certain taxes, such as withholding taxes on Oyu Tolgoi will be paid in light of double taxation agreements is another area of uncertainty.

In the baseline scenario for 2016-2045 natural resource prices grow by 3 percent per year in nominal USD terms (assuming a 2 percent steady state inflation in the US economy and a 1 percentage point permanent growth rate of the real price of commodities.

In alternative scenarios we can experiment with prices at the level of the previous 12 year's average, or prices at a fix percentage point below or above the baseline scenario over the full projection horizon.

Mineral sector revenue aggregates

[8] http://upload.mmc.mn/financial-report/ANNUAL%20REPORT%202015%20eng.pdf

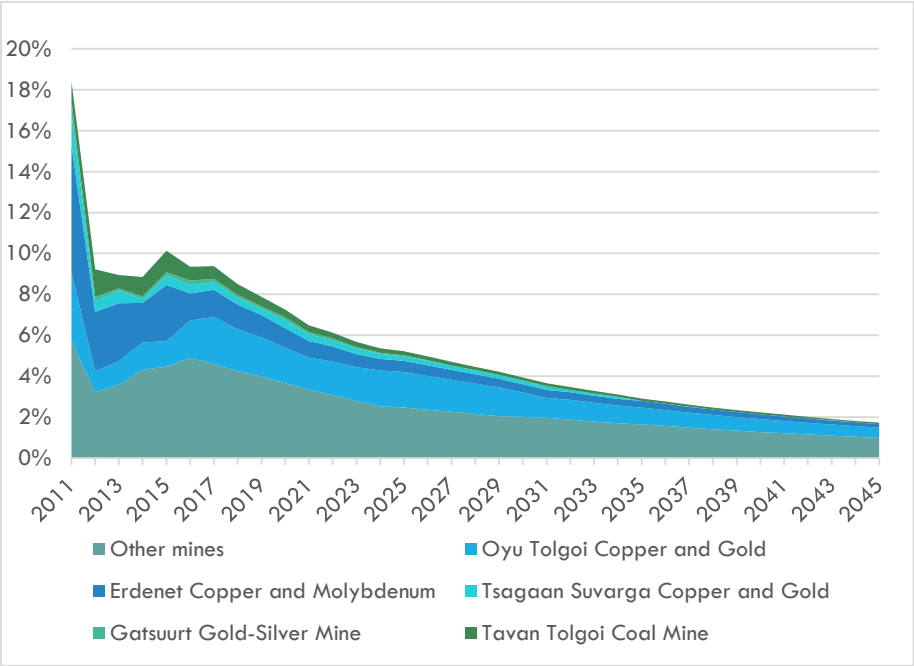

Figure 41. Government resource related revenues by mining project

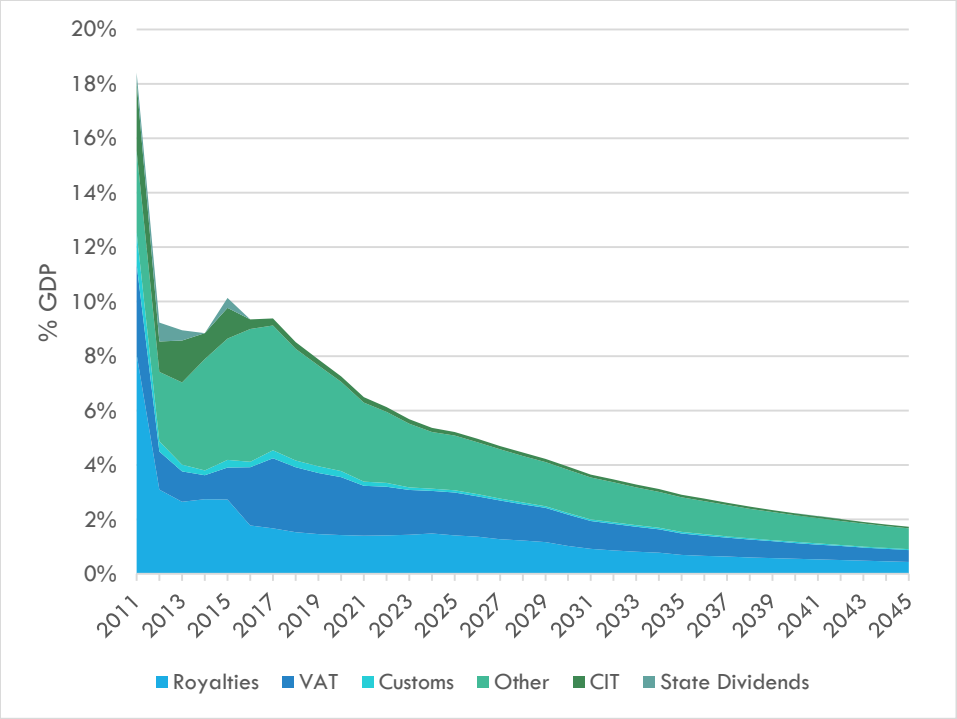

Figure 42. Government resource related revenues by revenue type

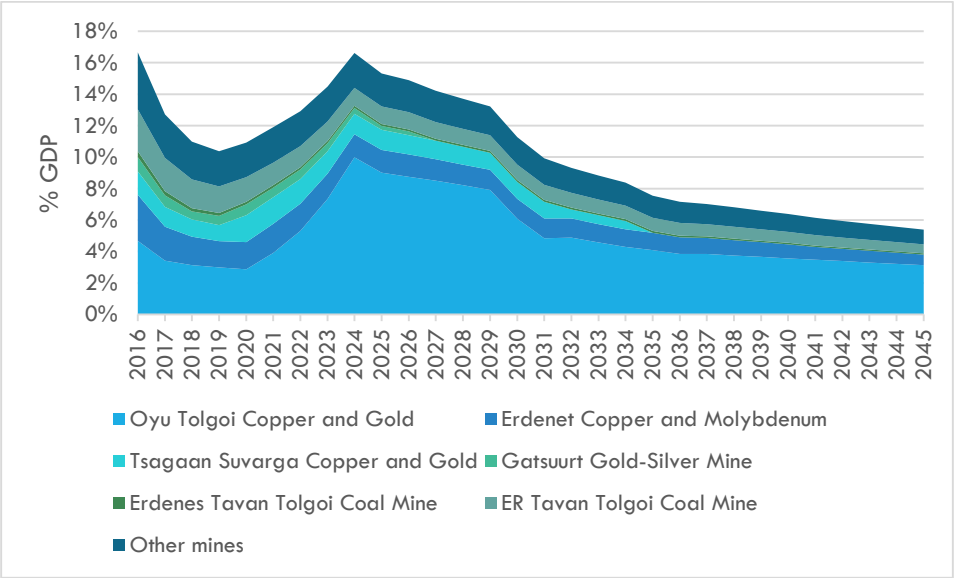

Figure 43, Contribution of mining projects to nominal gdp

5. AUXILIARY CALCULATIONS

Demographic projection

Historical population data is taken from the World Bank. The below figure shows various scenarios for the number of people living in Mongolia in the projection period. Eight scenarios were produced by the UN and another three by the Mongolian Statistical Office (MONSIS).

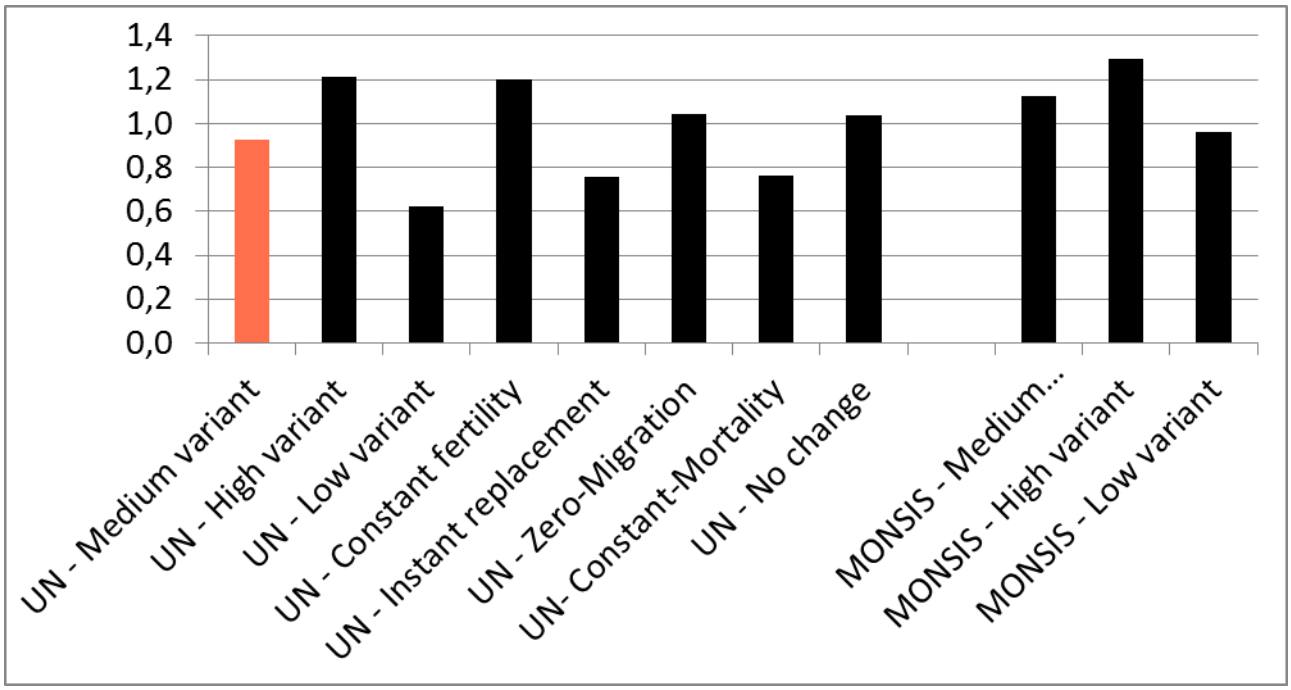

Figure 44. Average growth rate of total population for the period 2015-2045

For the baseline we took the Medium variant of the UN population projection for Mongolia.

Labor market

The labor market block's aim is to determine the total amount of wages and salaries for each of the following four categories:

1. Agriculture, fishing, hunting and forestry
2. Mining
3. Core economy
    a. Government sector
    b. Other private sector

The block uses employment figures and average wages and salaries by industries as published by MONSIS. By assumption government sector comprises " Public administration and defense; compulsory social insurance", "Education" and "Human health and social work activities".

Fixed capital stock projection

MONSIS publishes data on gross fixed capital formation at current and constant prices, as well as consumption of fixed capital at current prices. In real terms the law of motion for the stock of net capital is as follows:

$$K(t+1) = (1-a)*K(t) + I(t+1)$$

where K is the value of net capital stock, a is the rate of amortization and I is gross fixed capital formation. Both K and I are measured at constant prices. If K and I denote values at current price level, then:

$$K(t+1) = (1-a)*P(t+1)/P(t)*(K(t) + I(t+1)$$

where P denotes the price level of fixed capital that by assumption applies not only to fixed capital formation, but also to the whole stock of capital and the consumption of fixed capital.

This calculation can be performed for the total economy for the period 2005-2015 and for the main sectors for the period 2010-2014. (Sheets "Total capital stock" and "Sectoral capital stocks").

The net capital stock estimate is the value that minimizes the relative standard deviation of the rate of amortization implied by the data for the above mentioned periods.

As a simple reality check on the calculations we show the results of the standard growth accounting scheme for the baseline scenario:

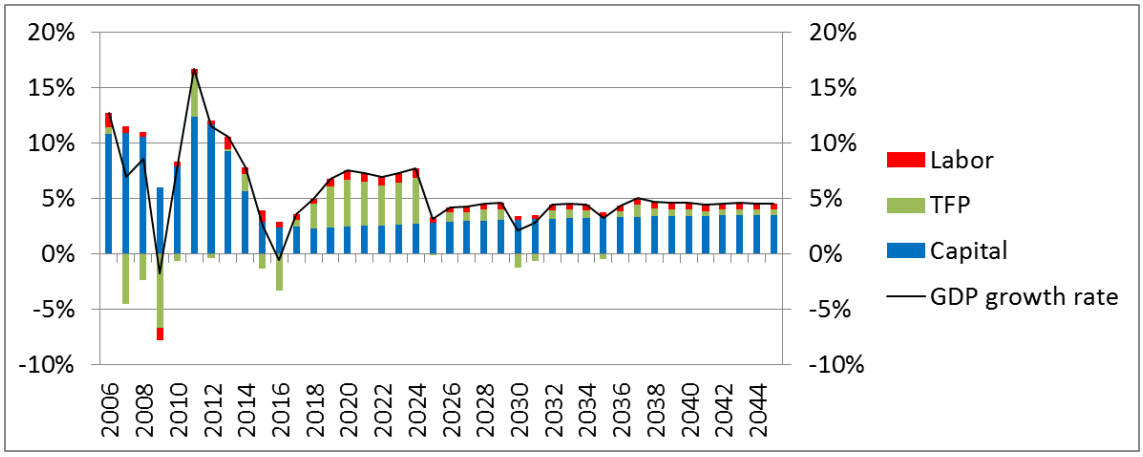

Figure 45. Growth accounting of the baseline scenario

Around 2025 and 2030 many of the largest mines are shutting down or ramping down according to the business plan of the relevant companies.

Interest rates

As described in the section on government debt, we model debt dynamics by approximating it with five different instruments:

- FX (USD) denominated debt at market interest rate (5Y maturity)
- FX (USD) denominated debt at concessional rate (10Y maturity)
- Short term (6M maturity) MNT denominated debt
- Medium term (3Y maturity) MNT denominated debt
- Government guaranteed debt of state owned enterprises

Interest rates for the above instruments are derived from the following components: the US central bank rate ("FED funds rate"), the policy rate of the Mongolian central bank ("Mongolbank rate"), the country

risk premium calculated in the macro model and a "liquidity premium". This latter depends on the quantity of FX denominated Mongolian government securities. The bigger the market, the smaller the premium.

- FX market rate = FED funds rate + risk premium + liquidity premium
- Concessional rate is 0,6 percent over the whole projection period
- Yield on the short term MNT denominated debt = Mongolbank rate
- Yield on the medium term MNT denominated debt = Mongolbank rate + 1,35%

6. THE BASELINE

Macroeconomic indicators

Based on 2016Q3 data from the Mongolian CSO we expect for 2016 a 0,6 percent decrease in real GDP.

In the baseline scenario GDP growth rate accelerates to 8 percent by 2020. The high growth (7-8 percent per year) period lasts until 2024, after that it stabilizes in the 4-5% range occasionally interrupted by episodes when some mines are closed down.

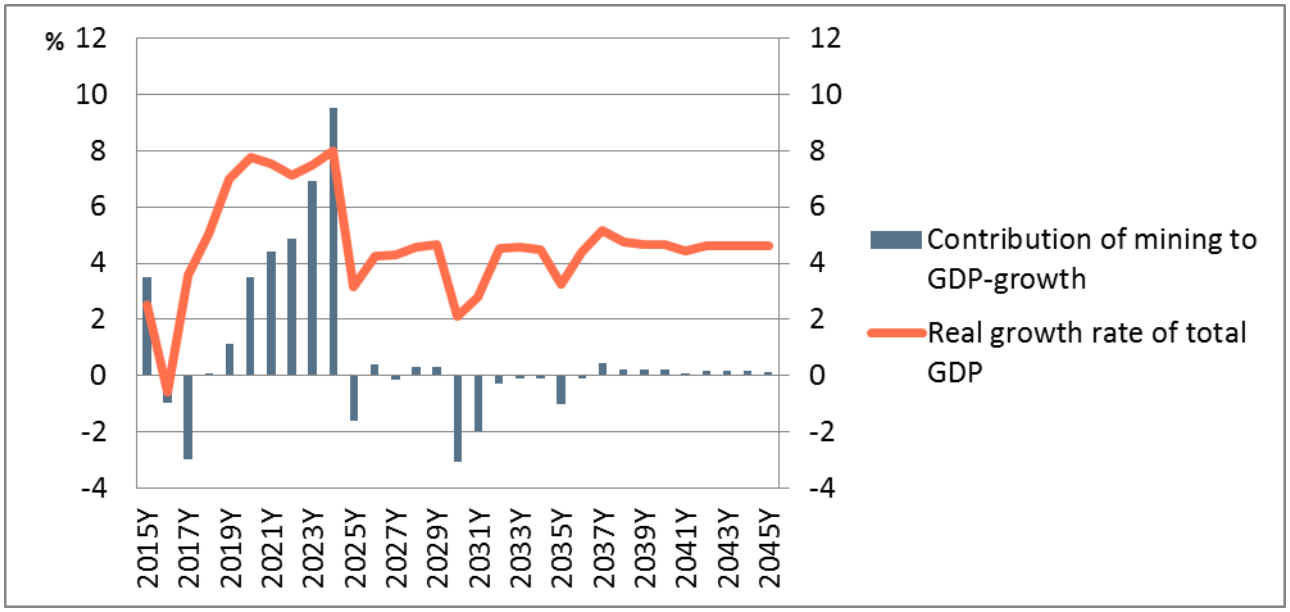

Figure 46. Real GDP growth in the baseline scenario

Employment in the agriculture accounted for about 40 percent of total employment in 2005. Nowadays it as about 30 percent and by 2045 we expect a further decrease of this ratio to 16 percent.

Agriculture's contribution to the GDP was close to 20 percent in 2005. In 2016 it is expected around 13 percent and we assume that by 2045 converges to the steady-state of 4 percent.

The annual productivity growth in the mining sector converges to 1.5 percent, in the agriculture sector to 1 percent and in the core economy to 3 percent.

Household consumption follows a smoothed version of the real GDP growth pattern, except for 2016, when consumption drops by 10 percent.

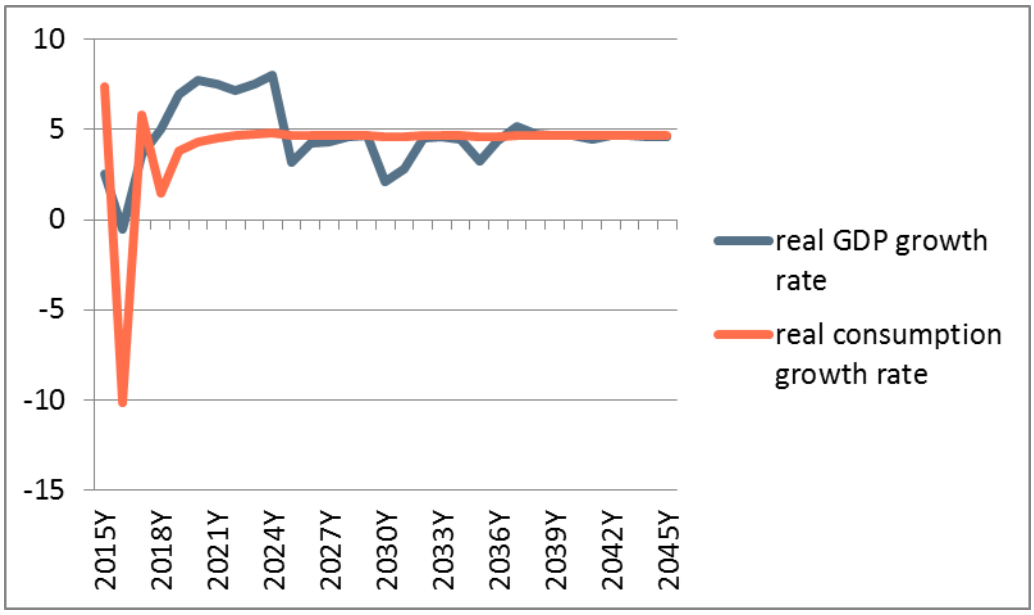

Figure 47. Real GDP and consumption growth in the baseline scenario

The currency devalues over the 2016-2017 period by a cumulative 28 percent, but in the steady state nominal depreciation is slightly below 2%/year. Inflation (GDP-deflator) starts at 8% in 2017 and then gradually decelerates to the 5-6% long term range value by 2022.

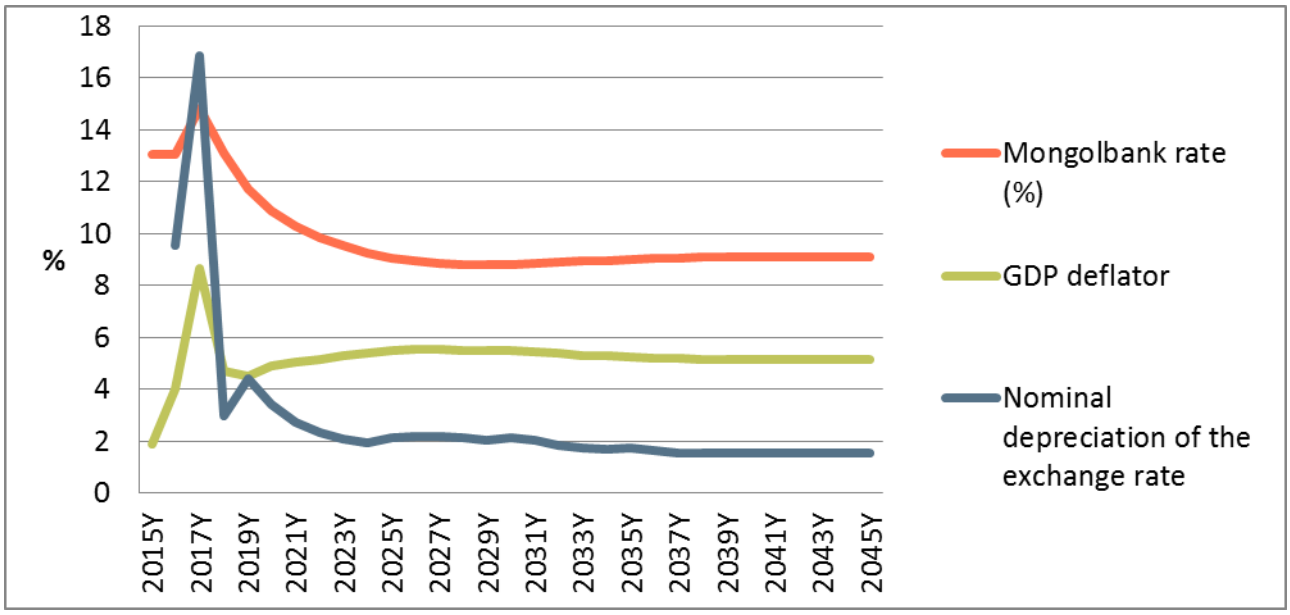

Figure 48. GDP-deflator, the interest rate and the exchange rate in the baseline scenario

The short term nominal interest rate (see above) on the contrary starts at 15% in 2017 and then gradually decreases to 9-10% by 2023. In consequence the real interest rate falls from 11% in 2017 down to 3-4% by 2022. The bulk of the change takes place over the next four years. After the dramatic 36% fall in its real value in 2015 investment activity over the next 4 years is expected to rebound gradually.

As inflation in Mongolia (measured by the GDP-deflator) stabilizes around 5 percent, inflation in its trading partner countries fluctuates around 2 percent, the 2 percent annual nominal devaluation of the MNT means that the currency revalues in real terms by about 1,5% every year. This reflects a modest Balassa-Samuelson effect implying the revaluation of currencies in emerging economies (in tandem with their catching up to developed countries).

The trade balance is expected to be positive on the forecast horizon and after 2021 with the intensified mining extraction it will remain strongly positive for more than a decade. Within total export mining sector revenues (assumed to come exclusively from export) starts from 70 percent in 2016 and then gradually decreases to about 20% by 2045.

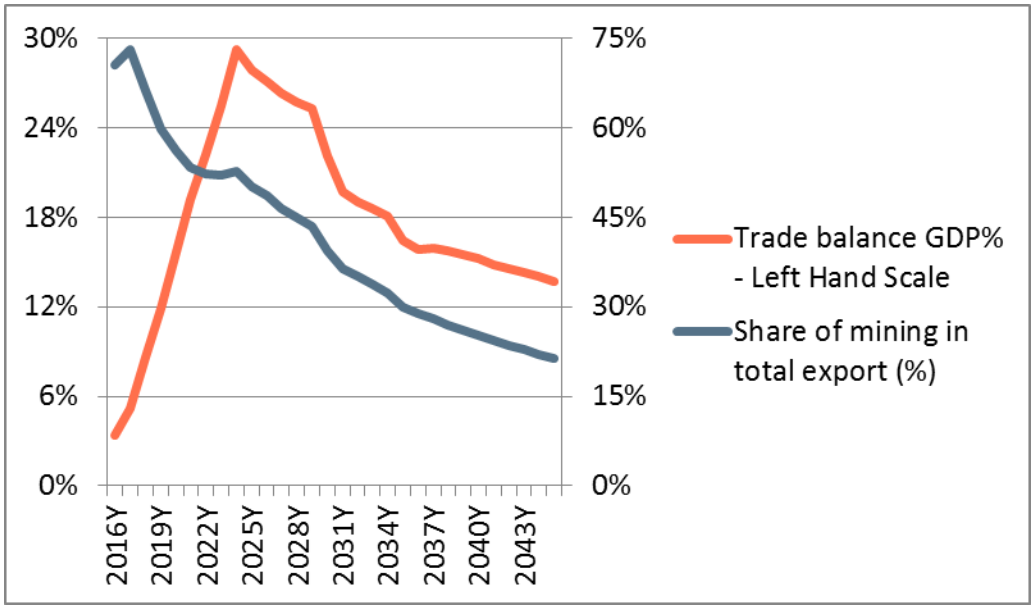

Figure 49. Trade balance and mining export

Fiscal indicators

Natural resource revenues exceed 10 percent of the GDP in 2017. By the end of the projection period this will shrink below 3,7 percent without significant deviations from the trend.

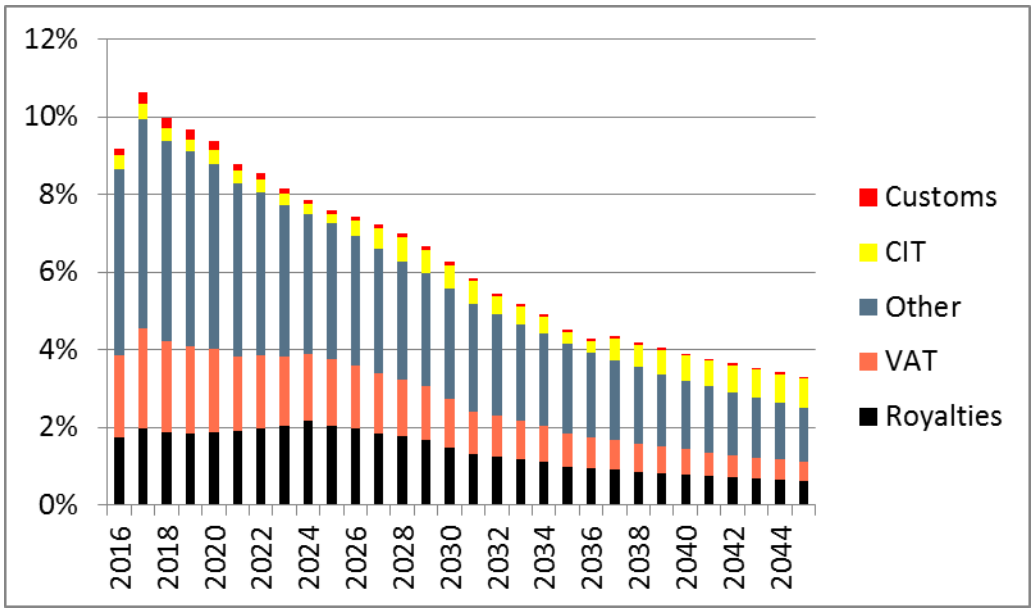

Figure 50. Trade balance and mining export

Natural resource related revenues are 20-30 percent of the gross revenue of the mining companies, 30-50 percent of the mining sector GDP (in 2016-2019 more) and a steadily declining share of total budget revenues (from the current 35% down below 20%).

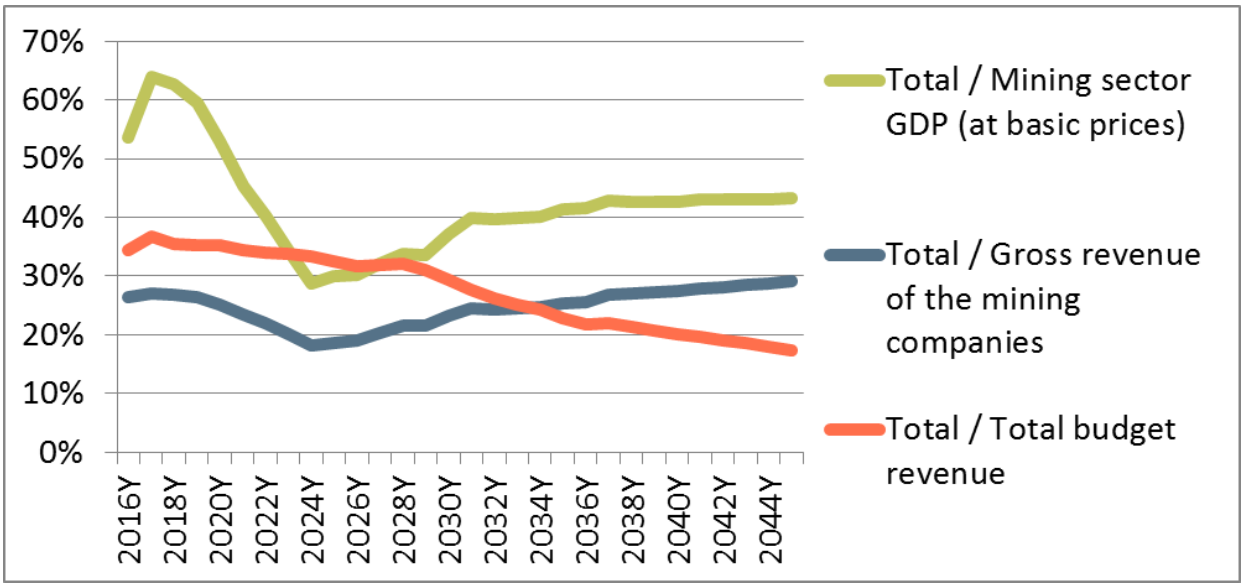

Figure 51. Weight of the total natural resource related revenues

Structural resource revenues (the hypothetical revenues based on the assumption of export mineral prices at the level of their 12-year average value) are higher than actual revenues by about 3-4 percent of GDP

over the coming 6 years. After 2023 the "cyclical component" gradually vanishes. Non-mineral revenues of the budget fluctuate in the 15.5-17.5 percent of GDP range.

Primary expenditures are permanently above the revenues (even the structural revenues), government debt and hence interest expenditure (the gap between primary expenditures and total expenditures) increases steadily. (Interest expenditures do not contain the interest accrued on the carried interest of the state in Oyu Tolgoi!)

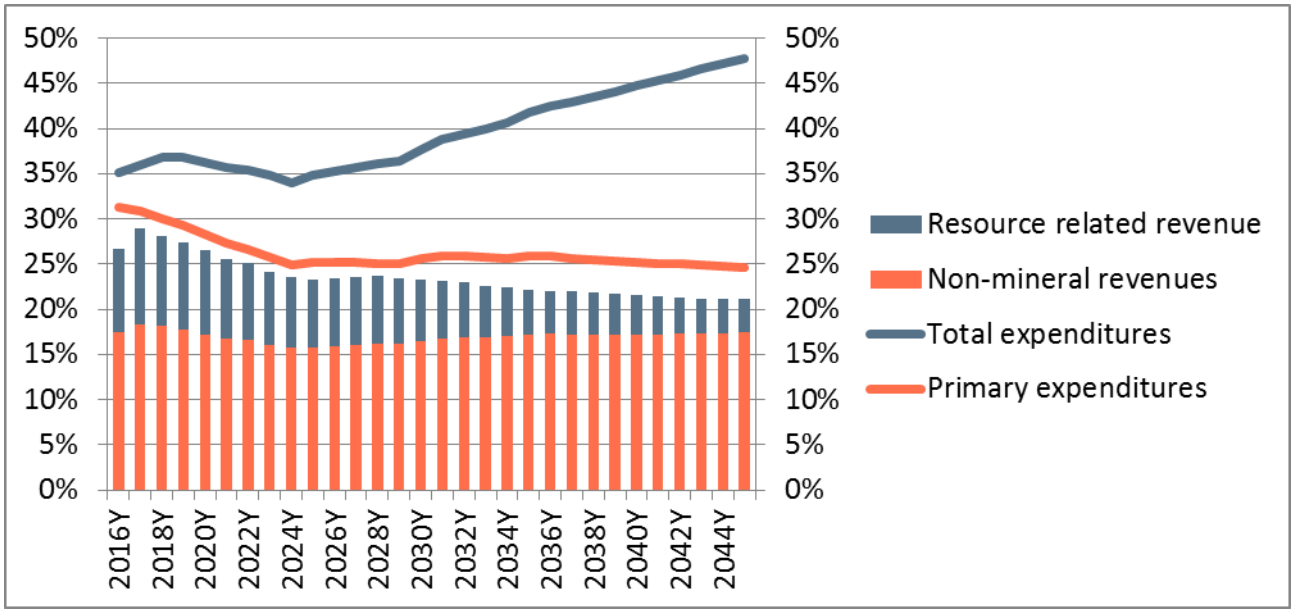

Figure 52. Main revenue and expenditure aggregates as a share of GDP

Headline deficit / GDP in 2016 jumps to almost 10 percent, but even the structural deficit / GDP ratio (adjusting deficit for the effect of mineral world prices being significantly below their 12-year average) exceeds the 2% limit. After 2017 both indicators start to increase quite rapidly on a clearly unsustainable path.

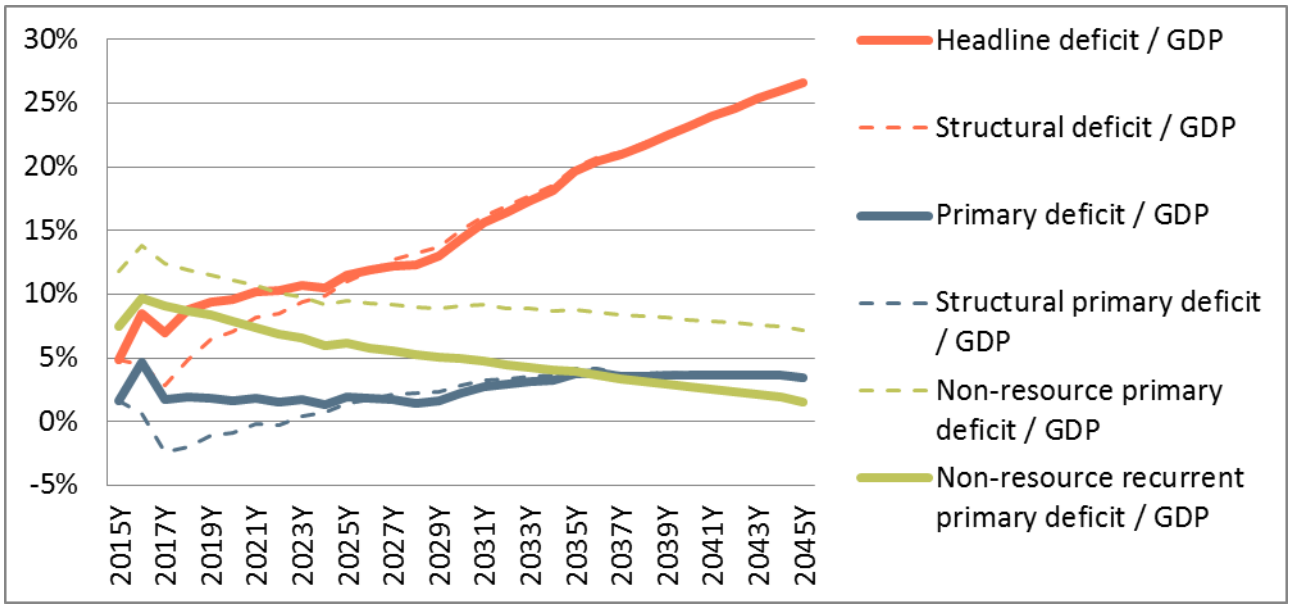

Figure 53. Deficit indicators in the baseline scenario

Non-resource primary deficit and non-resource recurrent primary deficit as a percentage of GDP are the highest in the years 2016-2018. After that they decrease steadily but slowly over the whole projection period, but never even come close to zero.

The debt to GDP ratio (excluding the carried interest in Oyu Tolgoi) increases over the whole projection period. On the long run annual increase in the debt ratio is close to 10 percentage points.

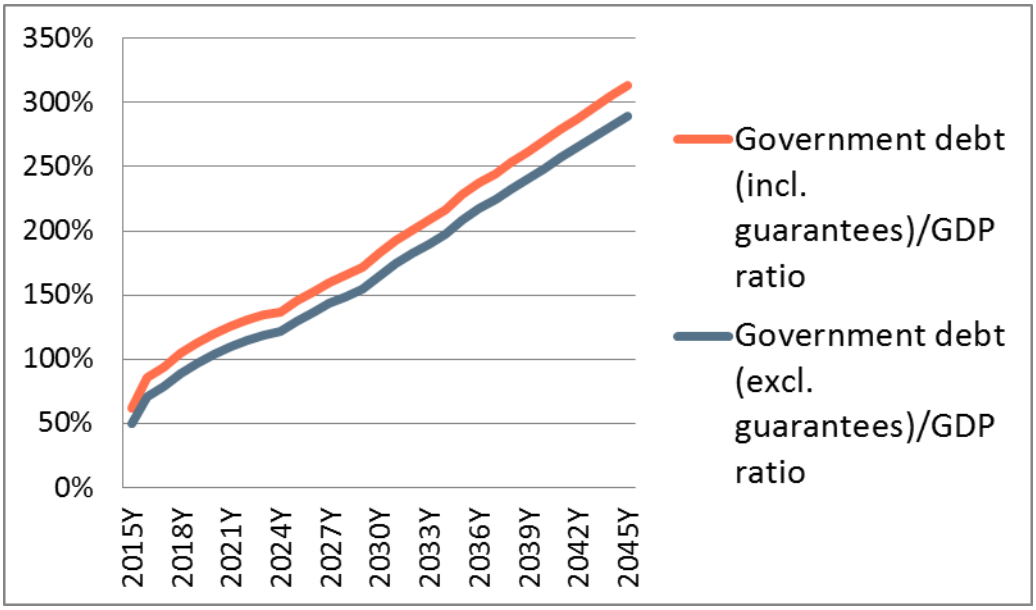

Figure 54. Government debt and carried interest as a percentage of GDP

Compliance with the fiscal rules

1. rule: the structural deficit / GDP ratio has to be below 2%

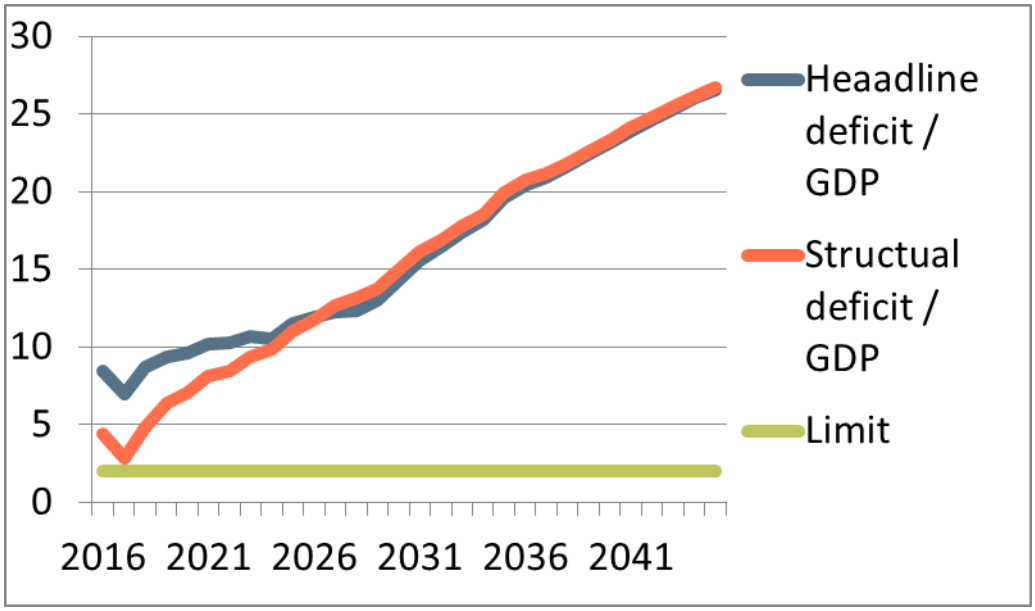

Figure 55. Compliance with structural deficit rule

The rule is permanently violated over the whole projection period leaving no headroom to increase the structural deficit.

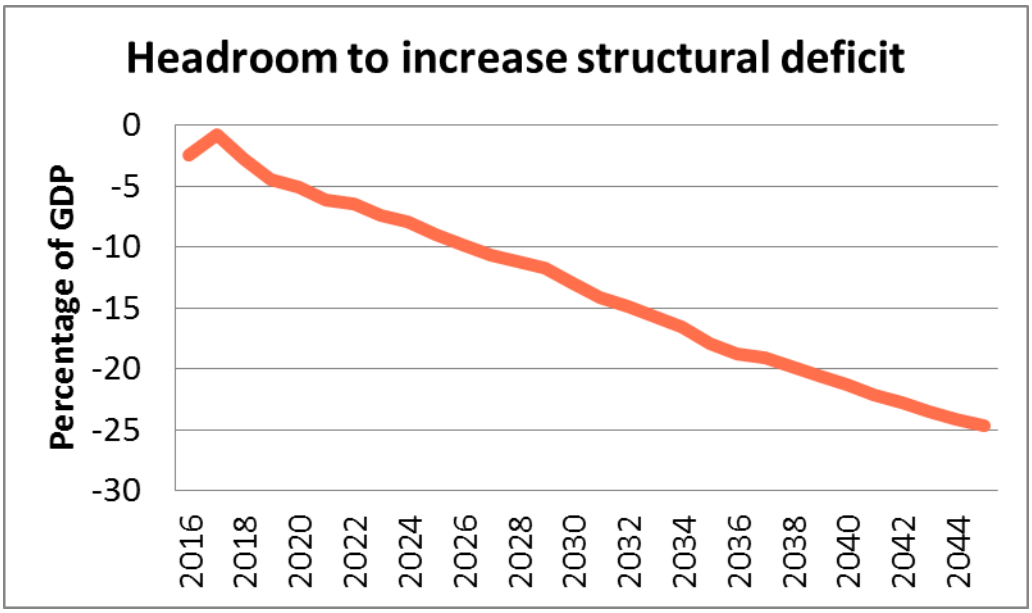

Figure 56. Headroom to increase structural deficit under deficit rule

2. rule: the debt / GDP ratio (including government guarantees) has to be below 60 percent from 2022 on (and could be somewhat higher before)

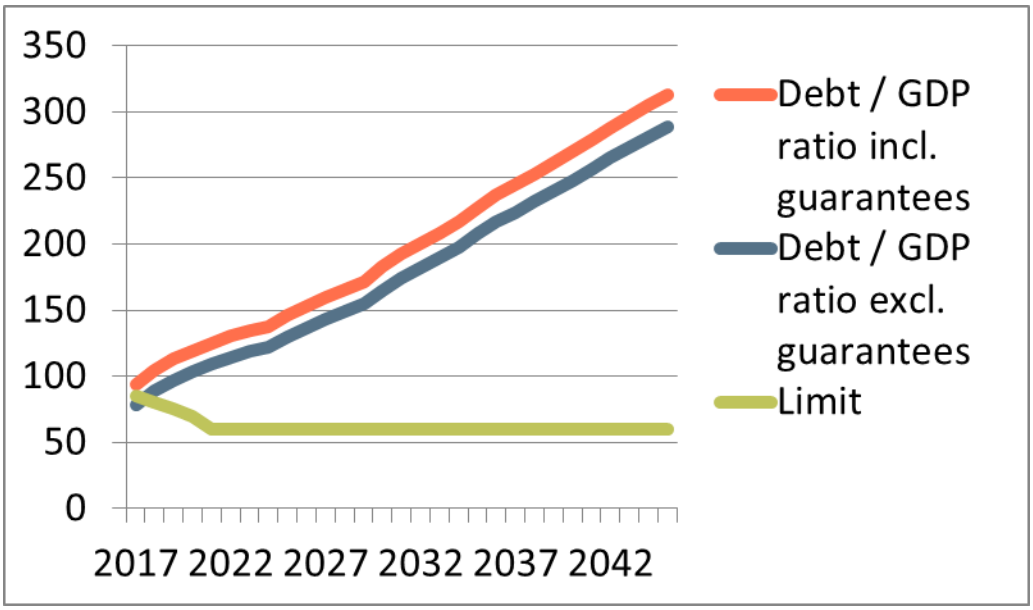

Figure 57. Compliance with debt rule

The rule is permanently violated over the whole projection period leaving no headroom to increase debt.

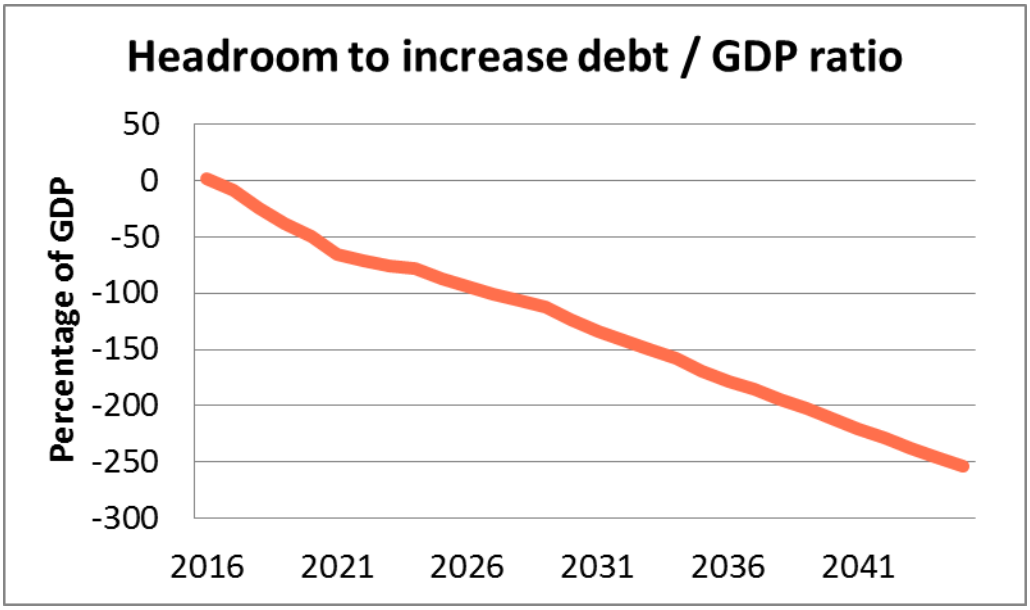

Figure 58. Headroom to increase debt under debt rule

3. rule: "Total budget expenditure growth of the particular year shall be not more than the greatest of the non-mineral GDP growth rate of the particular year and the average of non-mineral GDP for 12 consecutive years preceding the particular year"

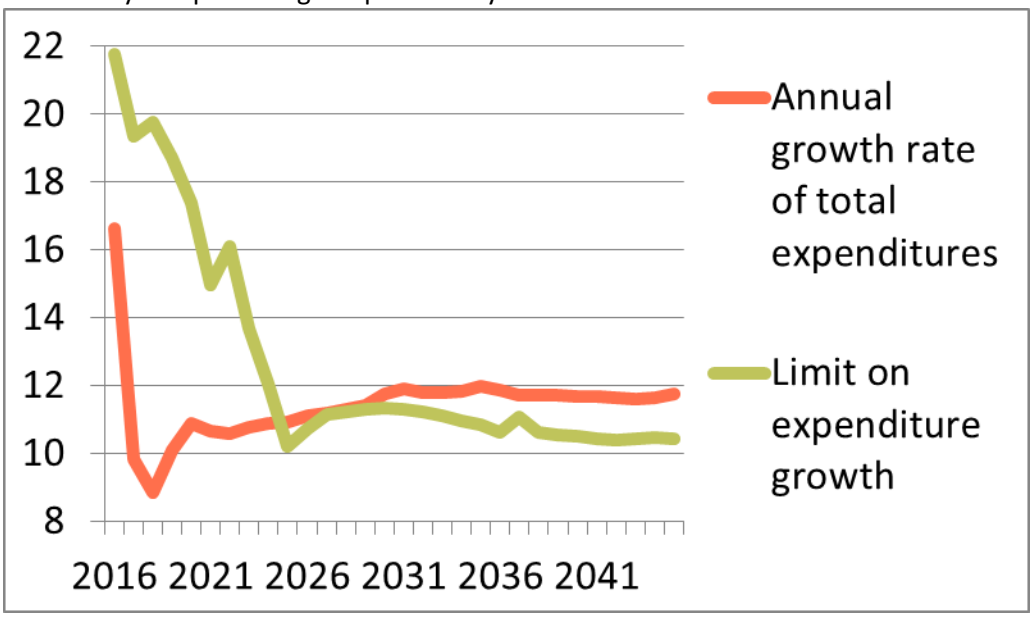

Figure 59. Compliance with expenditure rule

There is significant room for increasing expenditures over the medium run, hence this rule is currently not an effective constraint on government expenditures.

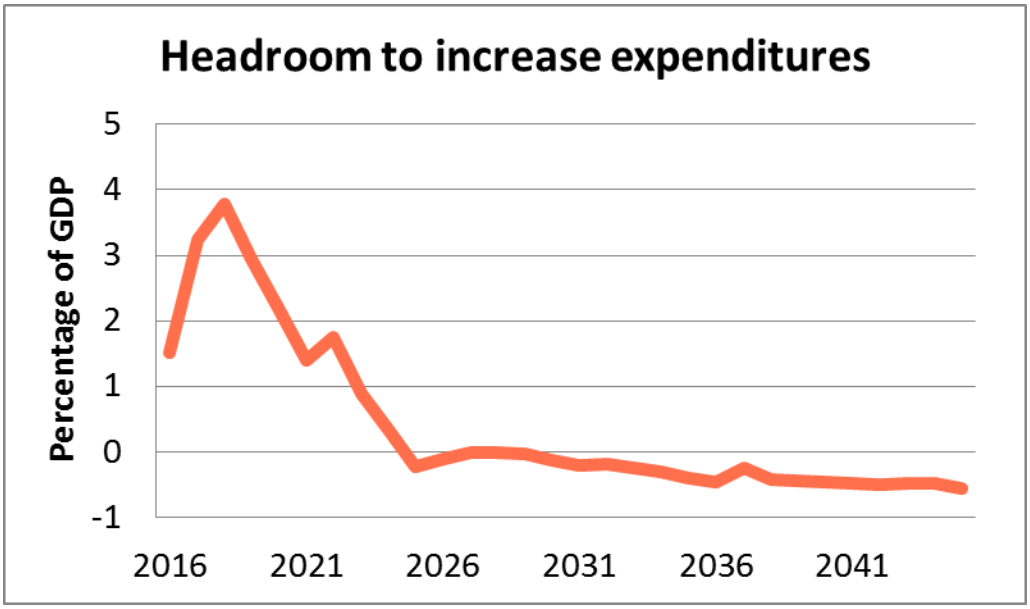

Figure 60. Headroom to increase expenditure under expenditure rule

On the whole the baseline (no policy change) scenario is not sustainable, however at least until 2024 the expenditure rule is obeyed; hence theoretically there would be some room for increasing growth enhancing expenditures, if the government decided to restore long term fiscal sustainability by tax hikes.

7. FISCAL EFFECTS OF SELECTED SHOCKS

Exogenous macroeconomic shocks

First we calculated 5 different exogenous shock scenarios affecting the mining sector and foreign trade. In the first scenario the Oyu Tolgoi Phase 2 investment project is finished one year later compared to the baseline. This delay also involves a proportionate cost overrun (appr. 15-20 percent) In the second scenario the price of exported commodities (incl. all minerals) increases by 5 percent from 2021 onward, while in the third scenario the same export prices increase by 20 percent, but only for one year (in 2021). The fourth shock hits import prices (e.g. food, and oil) and in the fifth case the the quantity of output in the overall mining sector increases from 2021 by 10 percent.

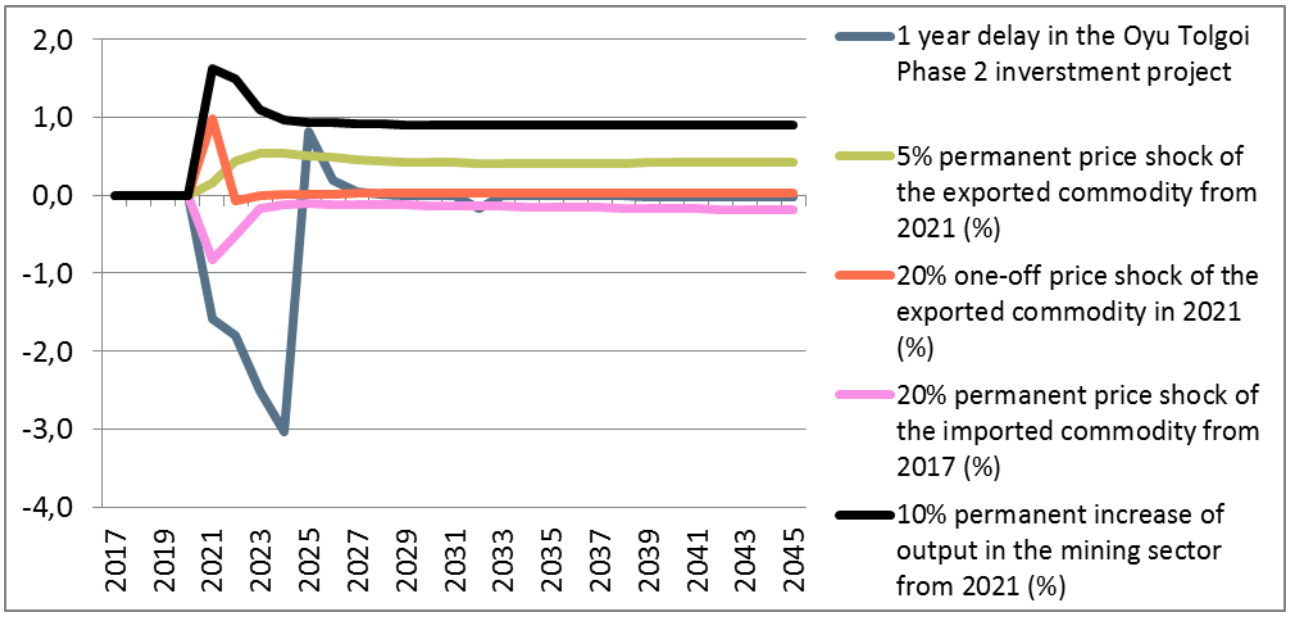

Figure 61. Effect of different exogenous shocks on the level of real GDP

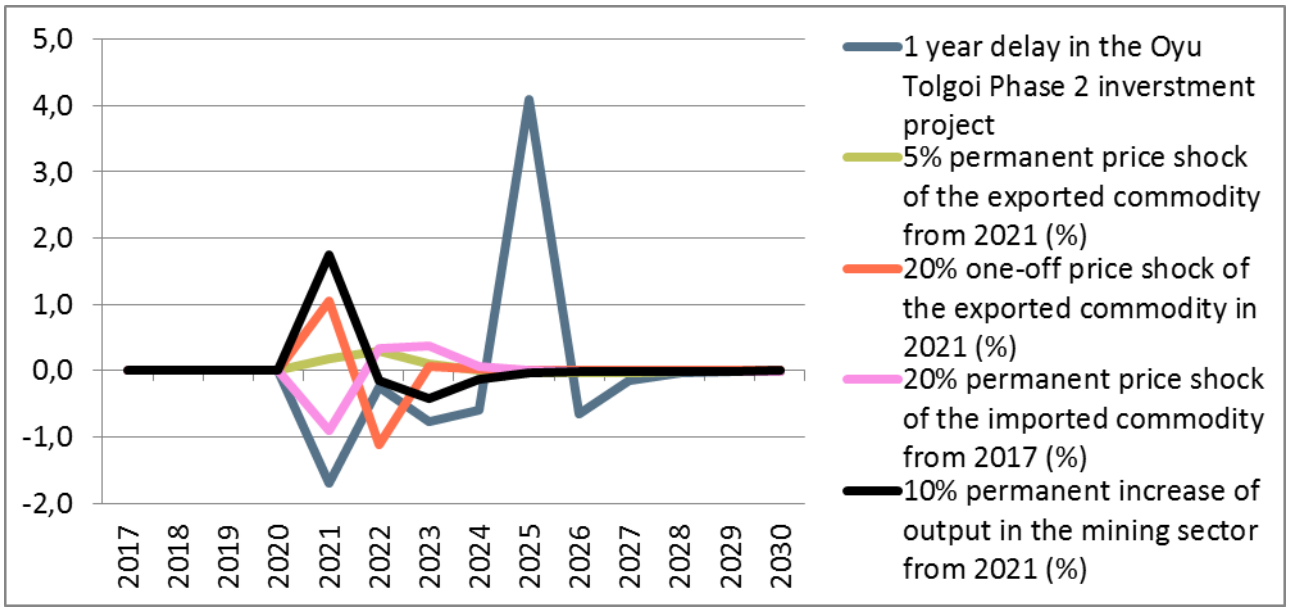

Figure 62. Effect of different exogenous shocks on the growth rate of real GDP

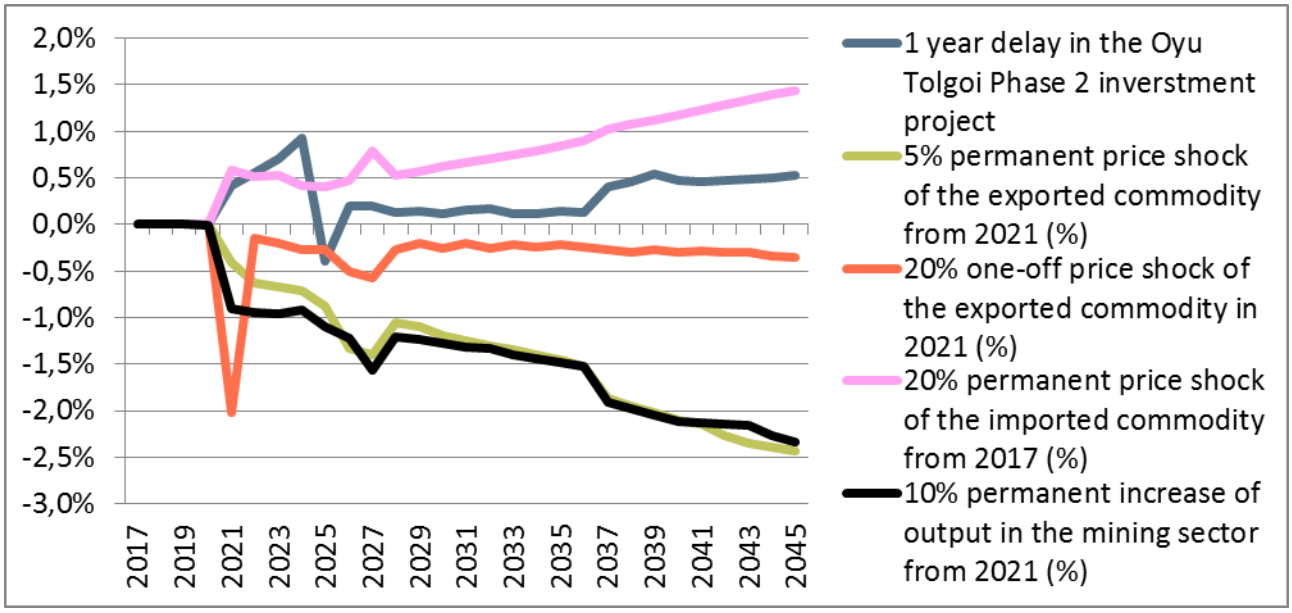

Figure 63. Effect of different exogenous shocks on the headline deficit / GDP ratio

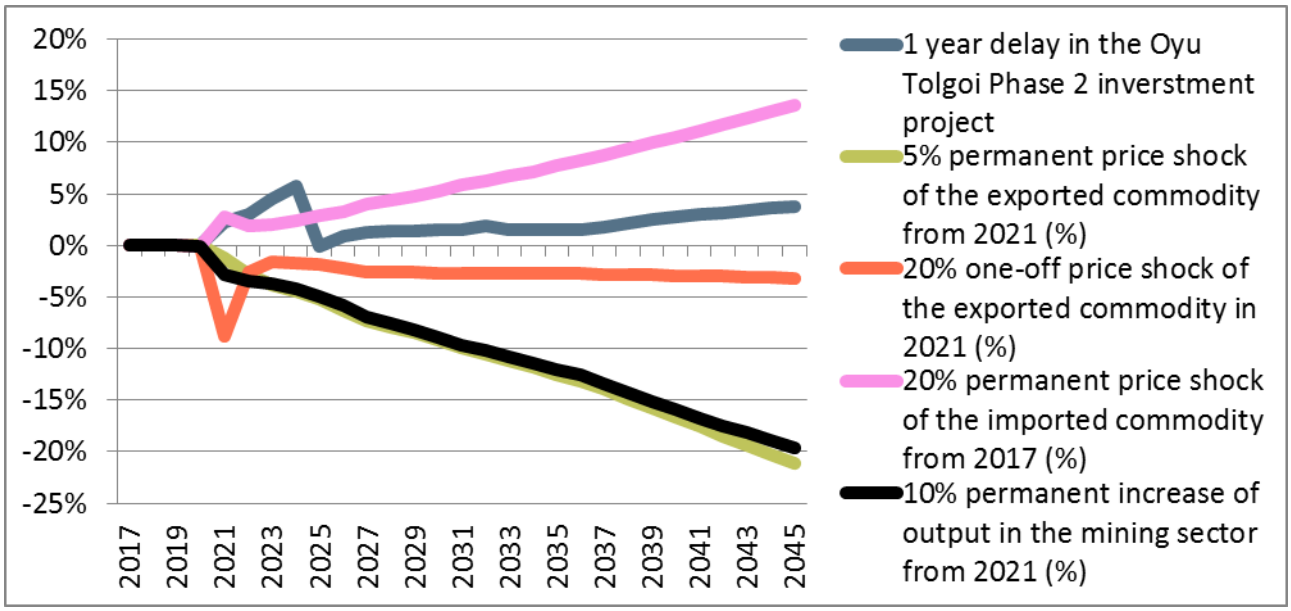

Figure 64. Effect of different exogenous shocks on the debt / GDP ratio (incl. carried interest)

As the above figures show, only the permanent shocks can have a lasting effect on real growth but if a temporary shock (e.g. the delay in the OT project) is big enough and, then it can have a lasting effect on fiscal sustainability. We took the 10 percent increase of the output in the mining sector as an exogenous shock. However, this can be achieved by high quality productive investment in the mining sector, hence this is also a matter of policy choice.

Macroeconomic and second round fiscal effects of selected fiscal policy measures

Tax measures

Below we show the effects of three different tax measures. As PIT revenue is only 55% of VAT revenue in the budget the 5 percentage points increase in the VAT rate is equivalent approximately to a 9 percentage points increase in the PIT rate in terms of instant revenue effect.

As the below Figures show all types of tax increases decrease the GDP level on the short run. However, VAT rate hike's negative effects turns into positive on the long run, while PIT hike's somewhat smaller original effect even deteriorates with time.

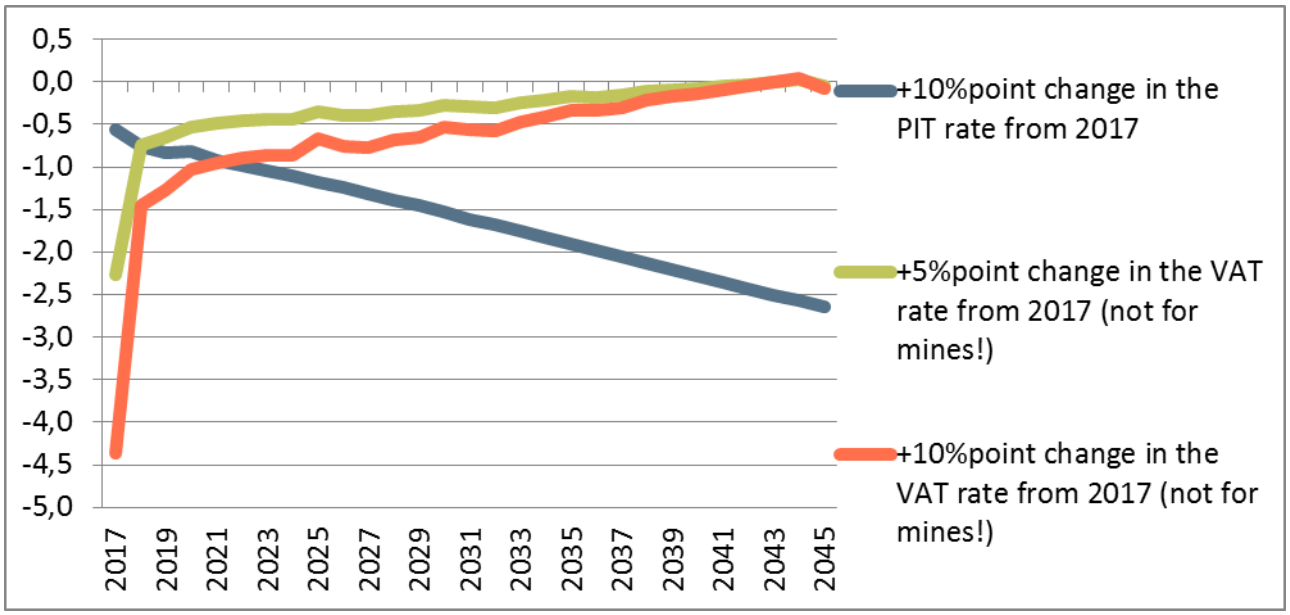

Figure 65. Effect of different tax measures on the level of real GDP

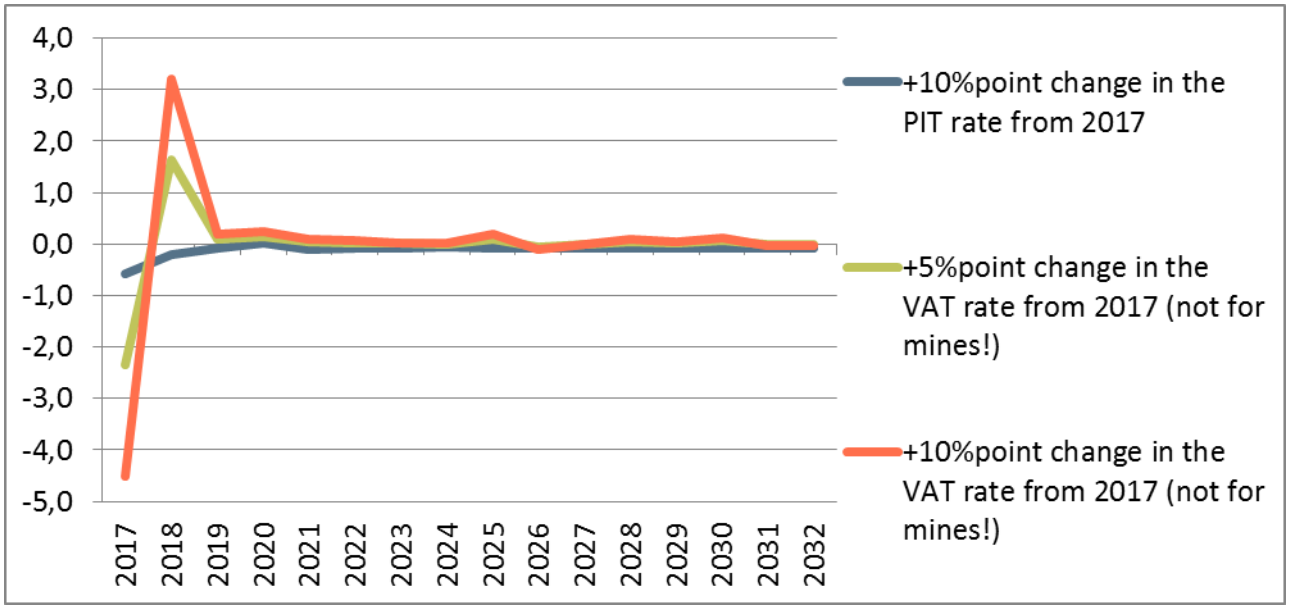

Figure 66. Effect of different tax measures on the growth rate of real GDP

In terms of fiscal effect all measures ameliorate the budget balance, but VAT hike is more efficient in restoring sustainability.

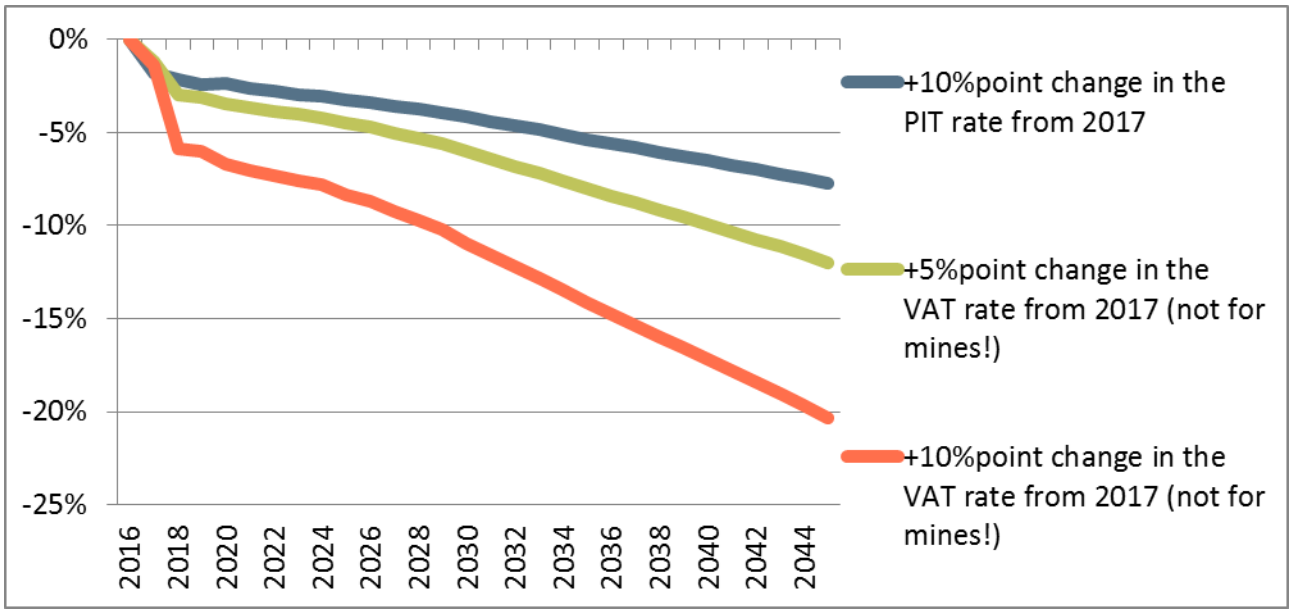

Figure 67. Effect of different tax measures on the headline deficit / GDP ratio

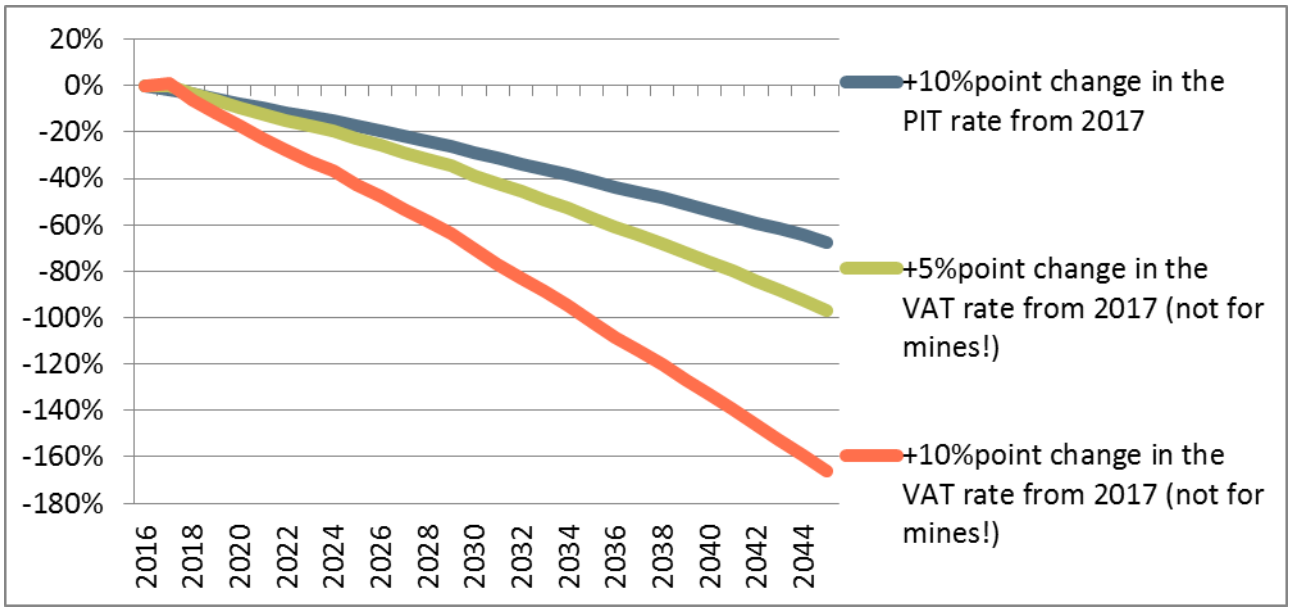

Figure 68. Effect of different tax measures on the debt / GDP ratio (incl. carried interest)

The main reason for VAT hike's higher efficiency is due to its more positive effect on the private sector's behavior. As the below figures show, VAT-hike implies an increasing, while a PIT hike implies a decreasing level of both real investment and employment.

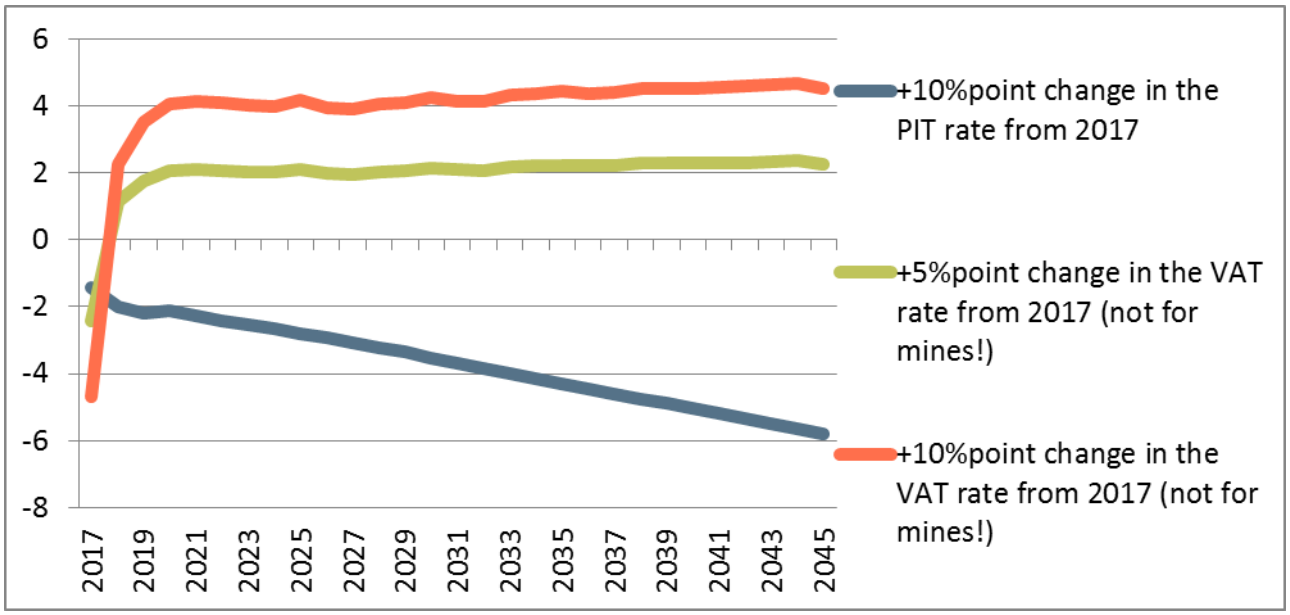

Figure 69. Effect of different tax measures on the level of real investment

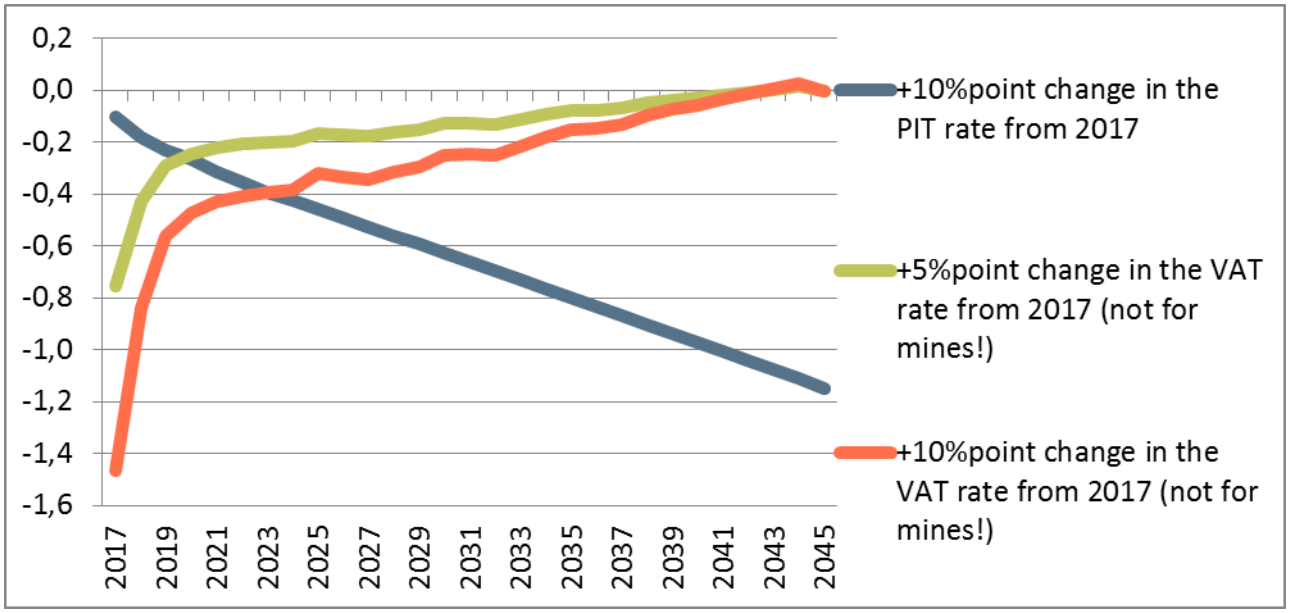

Figure 70. Effect of different tax measures on the level of employment

Expenditure measures

On the expenditure side we quantify the macro-fiscal effects of three different types of measure: cut in government consumption, government investment and transfers. As the figures below show, cutting government investment is far the most detrimental to output, while cutting transfers is somewhat less negative even on the medium run than cutting government consumption.

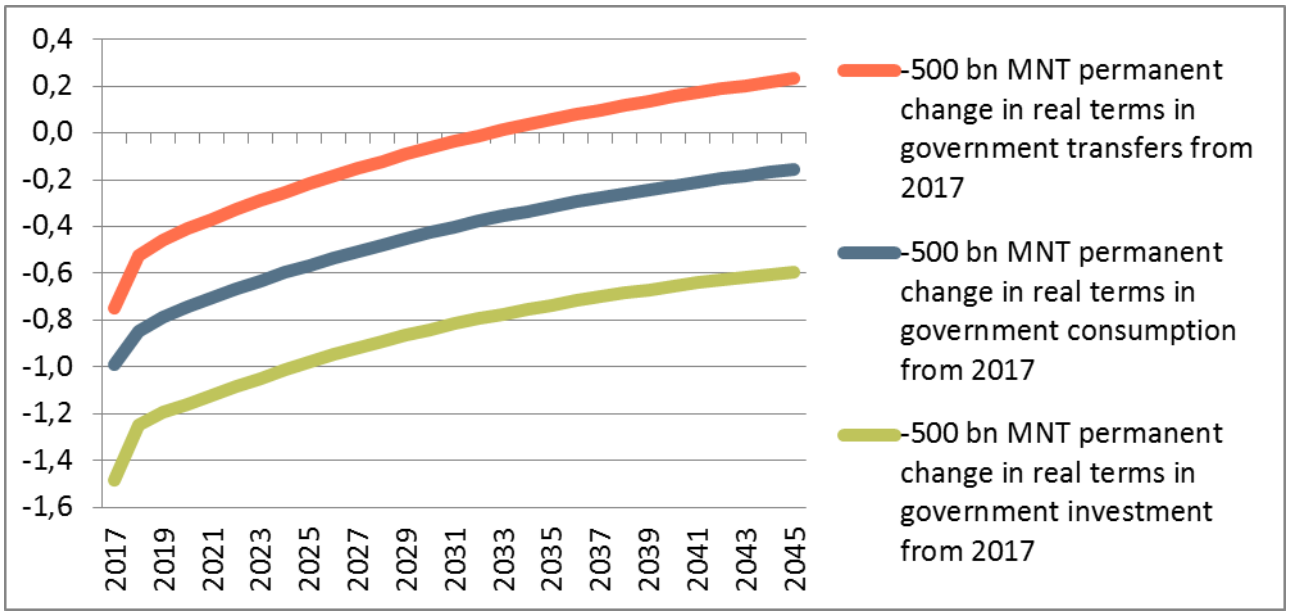

Figure 71. Effect of different expenditure measures on the level of real GDP

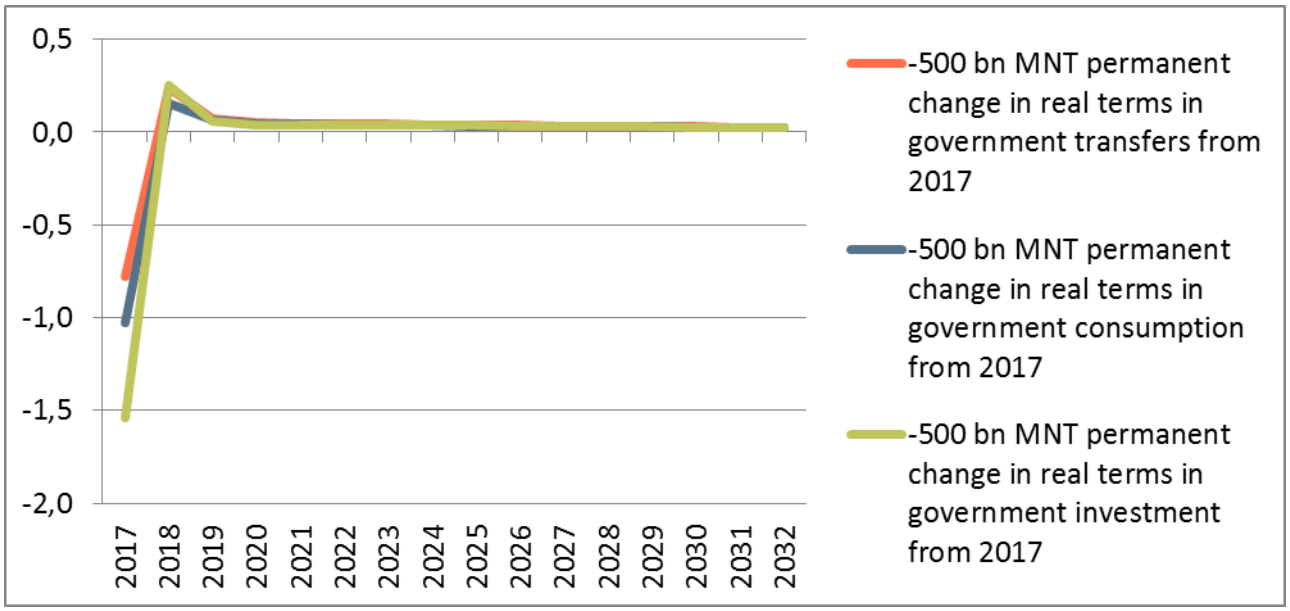

Figure 72. Effect of different expenditure measures on the growth rate of real GDP

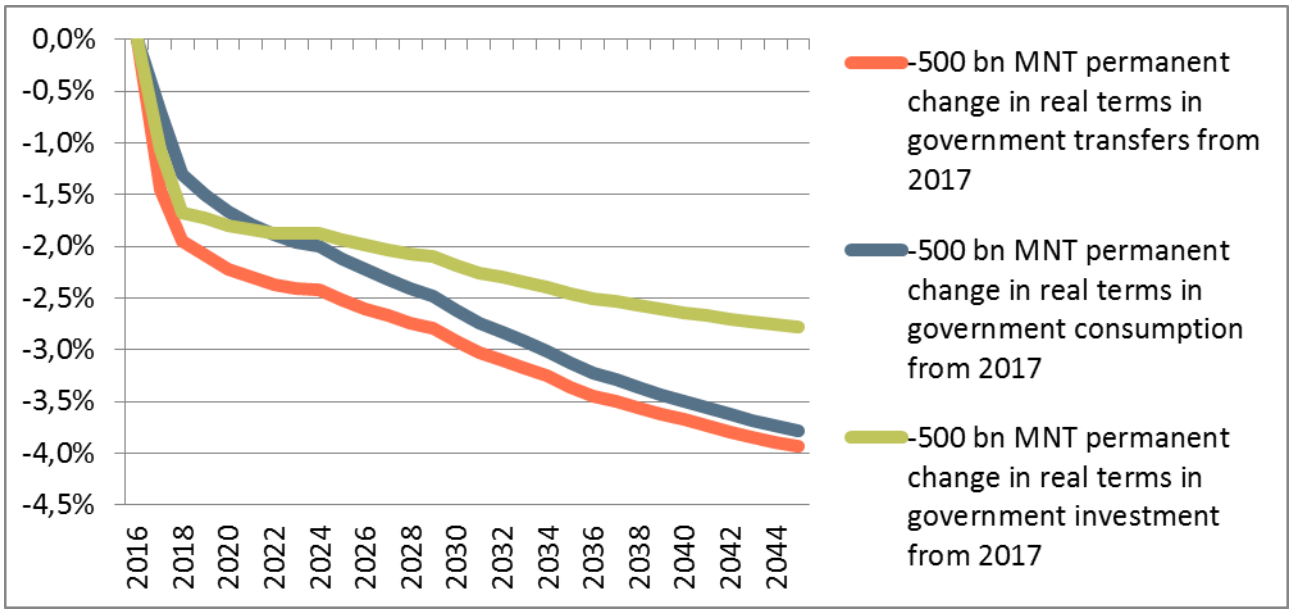

Figure 73. Effect of different expenditure measures on the headline deficit / GDP ratio

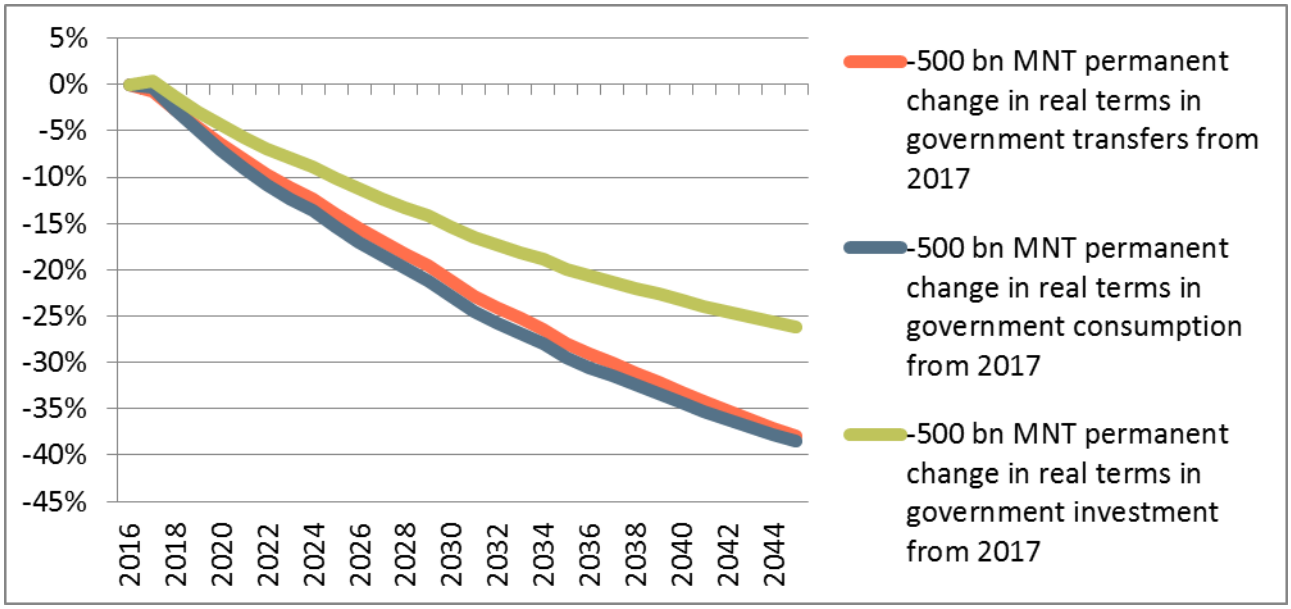

Figure 74. Effect of different expenditure measures on the debt / GDP ratio (incl. carried interest)

Here again, the main mechanisms implying the differences work through investment and employment.

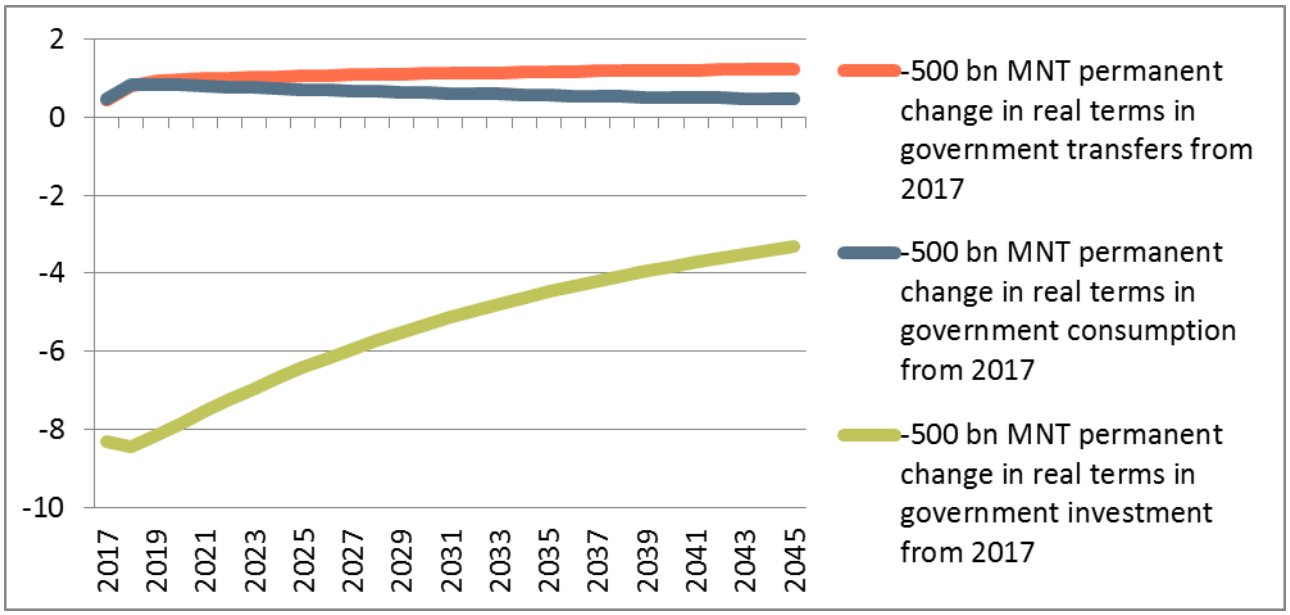

Figure 75. Effect of different expenditure measures on the level of real investment

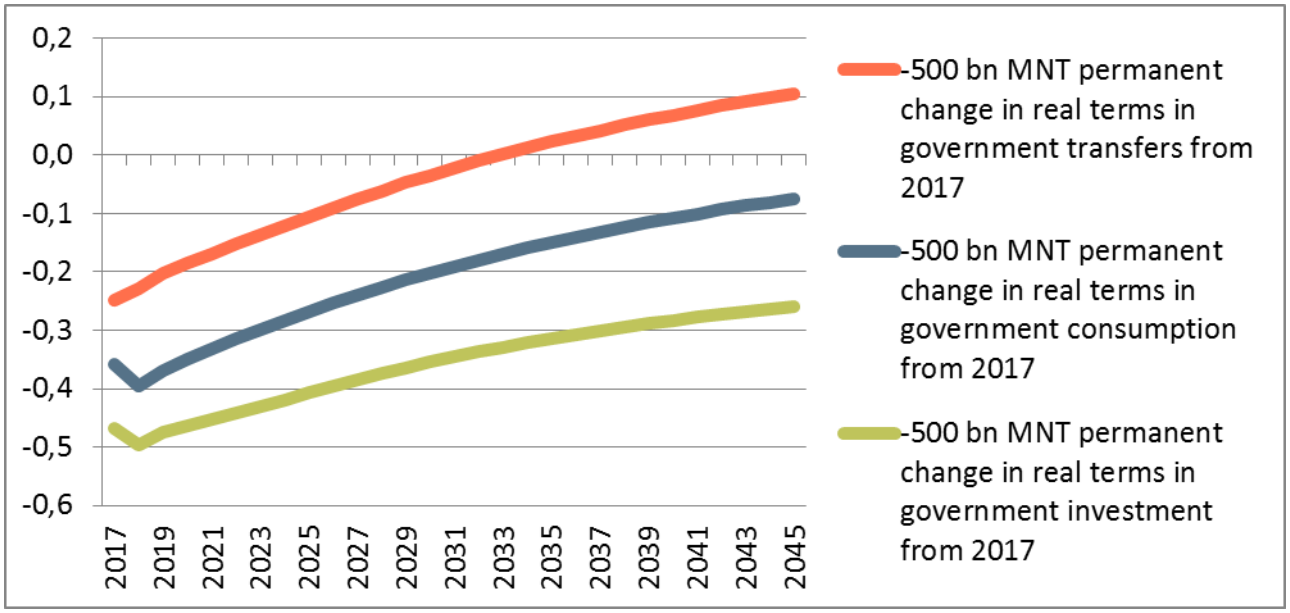

Figure 76. Effect of different expenditure measures on the level of employment

Growth enhancing measures

Below we selected two growth enhancing measures from the above options (permanent increase in mining productivity and VAT rate-hike) and contrasted them with two other scenarios. In the first case the risk premium drops in a triangular shape by 200 basis points between 2017 and 2023 compared to the baseline. Such a significant but temporary drop in the risk premium can be the result of an agreement with the IMF. The fourth scenario is a combination of measures: VAT-rate is increased permanently by 5%points, but the extra revenue (approximately 800 bn MNT per year) in the first four years (2017-2020)

is used for financing government investment (still half of which is productive) resulting in a 10 percent permanent increase in the mining productivity from 2021 (as investments are accomplished).

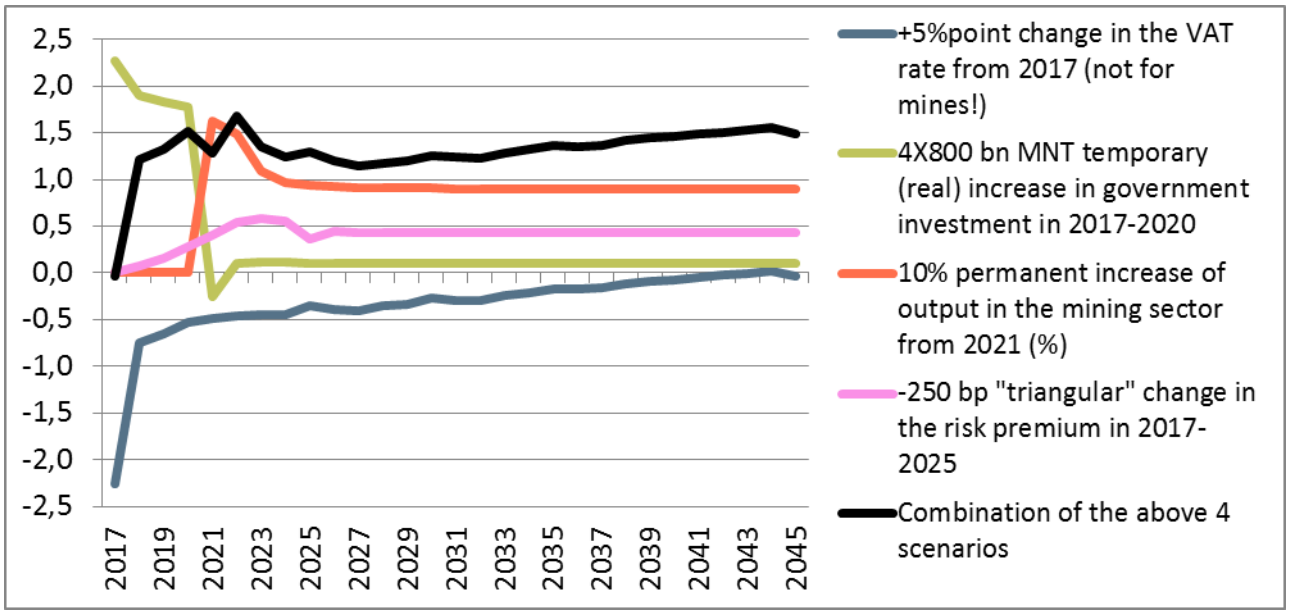

Figure 77. Effect of different growth enhancing measures on the level of real GDP

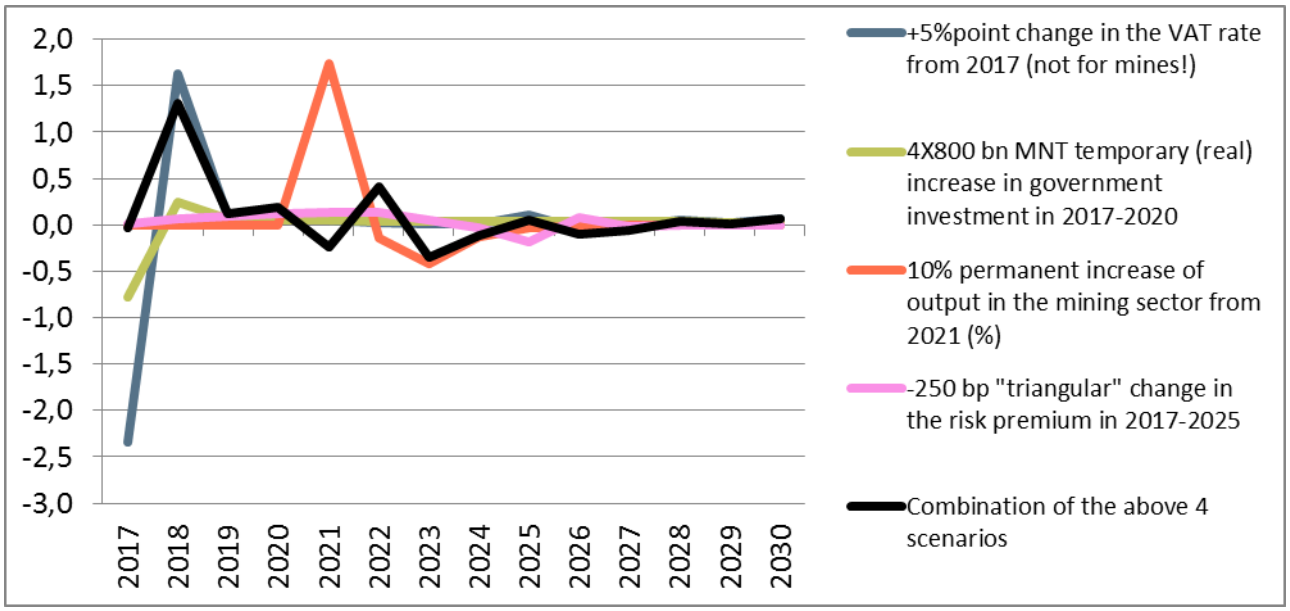

Figure 78. Effect of different growth enhancing measures on the growth rate of real GDP

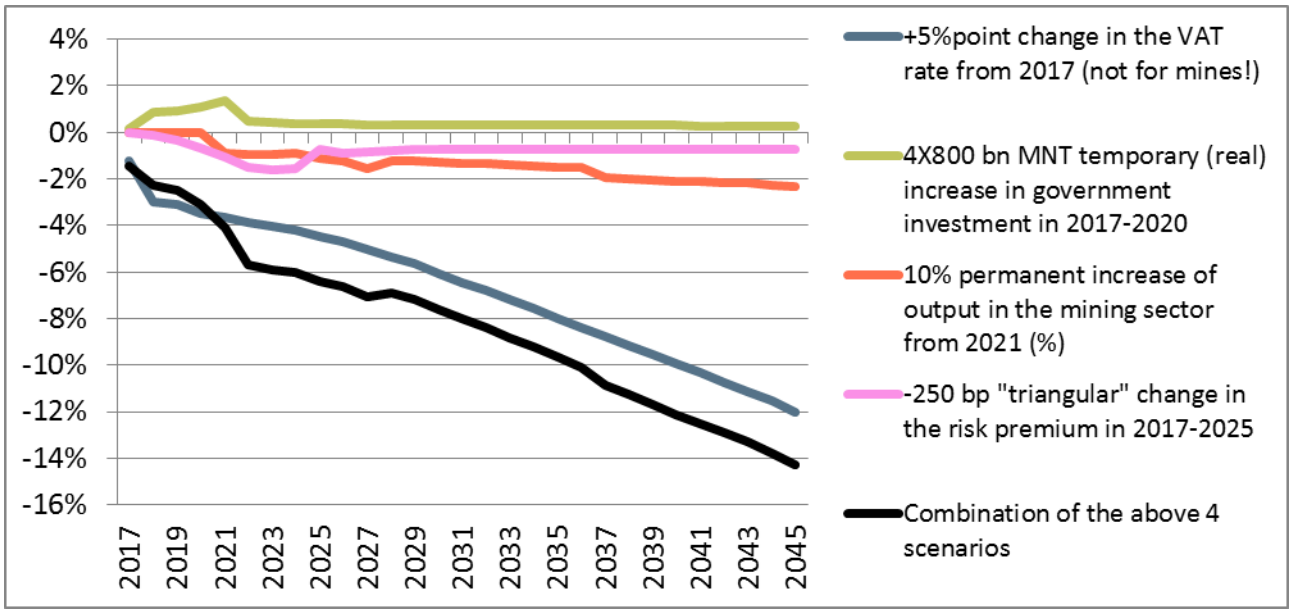

Figure 79. Effect of different growth enhancing measures on the headline deficit / GDP ratio

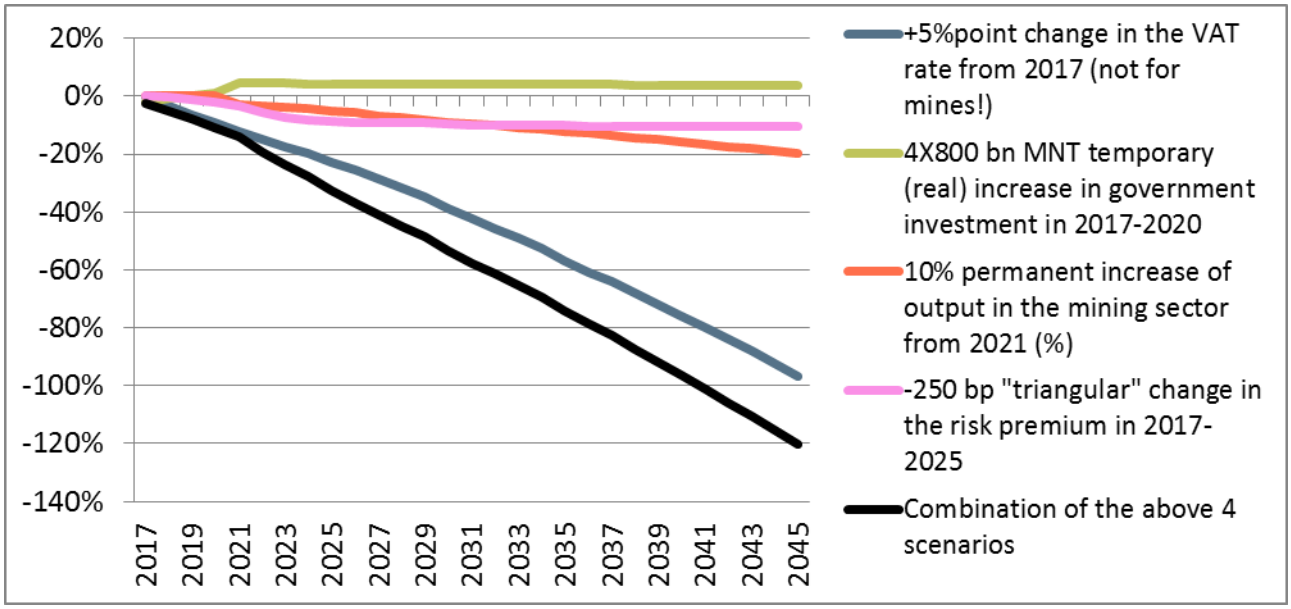

Figure 80. Effect of different growth enhancing measures on the debt / GDP ratio (incl. carried interest)

Comparing scenarios and policy options

The final goal of economic policy is to maximize social welfare within the limit of financial resources. As the simplest measure of social welfare we use the net present value of the real consumption stream throughout the whole projection period. A reduction in the NPV of real consumption compared to the baseline is a sacrifice of social welfare. Fiscal sustainability is measured by the change in the debt-to-GDP ratio compared to the baseline. A scenario or a policy option is better than another one if reduces the debt-to-GDP ratio by more with the same amount of sacrifice in terms of consumption, or it reduces the

debt-to-GDP ratio by the same amount, but at a lower price in terms of consumption sacrificed (Direction "South-East" in the below figure).

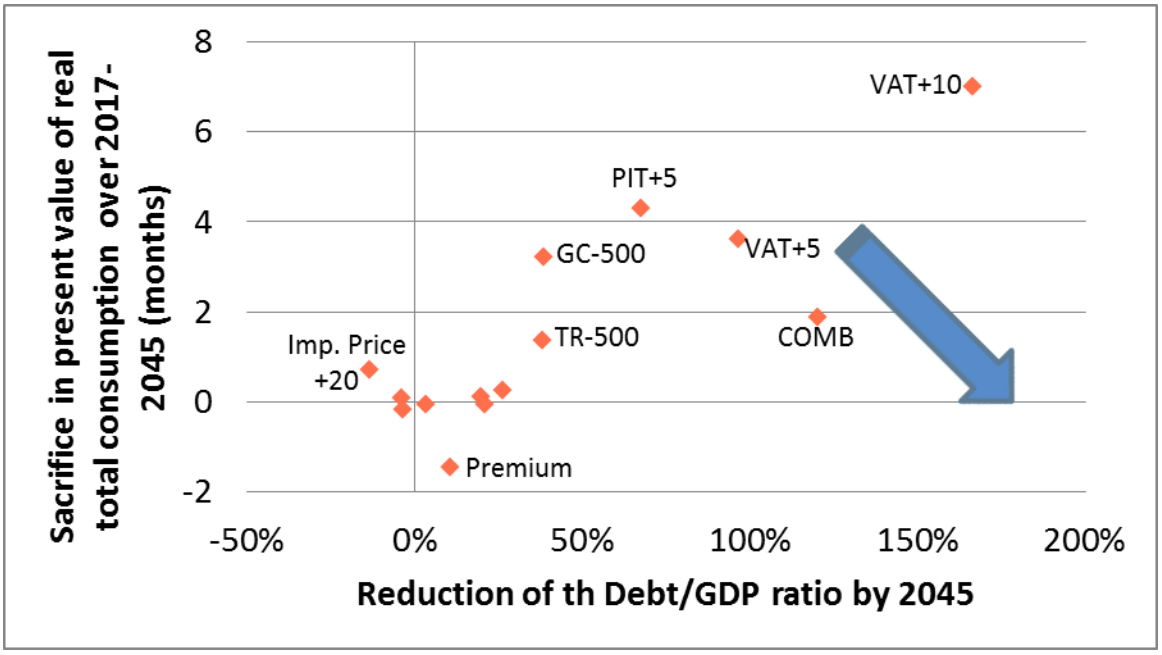

Figure 81. Comparison of scenarios and policy measures

As the above figures show a temporary drop in the risk premium ("an IMF safety network without content") can increase the level of GDP (negative sacrifice), but its effect on the long run sustainability is basically negligible. A pure VAT rate hike ("VAT+10") can be very efficient in curbing the debt ratio, but it comes with a very high cost in the level of real GDP (and consumption of course). Some combination of tax and growth enhancing expenditure measures (e.g. "COMB") can probably serve more efficiently the social welfare.

8. USING THE MODEL

User interface of the model

The MMM was developed with a user-friendly interface to allow users with no prior experience in using macroeconomic models to explore some of the key results.

The Excel file's opening tab is labelled 'Guide to Model` which provides a very brief overview to using the file. The following section provides some further detail.

The 'Control Panel` tab was designed to be the main interface in testing various scenarios and interpret numerical results. It allows to select a hypothetical scenario and define its parameters. In order to do this, the user can chose from a menu of possible external shocks and policy measures, such as commodity price and volume shocks (both one-off and permanent), delay in the development of Oyu Tolgoi's major underground mine (labelled phase II of the project), as well as various tax and expenditure measures.

The user can choose one or multiple types of shocks from the list by setting a non-zero size for relevant item. The size of the measure / shock can be any numerical value, but should be subject to sense check (is it a plausible figure?). The value can be both negative and positive. For example an expenditure increase will be a positive figure, while an expenditure cut will be a negative figure. The user can also adjust the start year for the shock. Appropriate start years range between 2017 and 2030. Another possible shock is to set back the development of the gigantic underground mine of Oyu Tolgoi compared to currently panned production start in 2021.

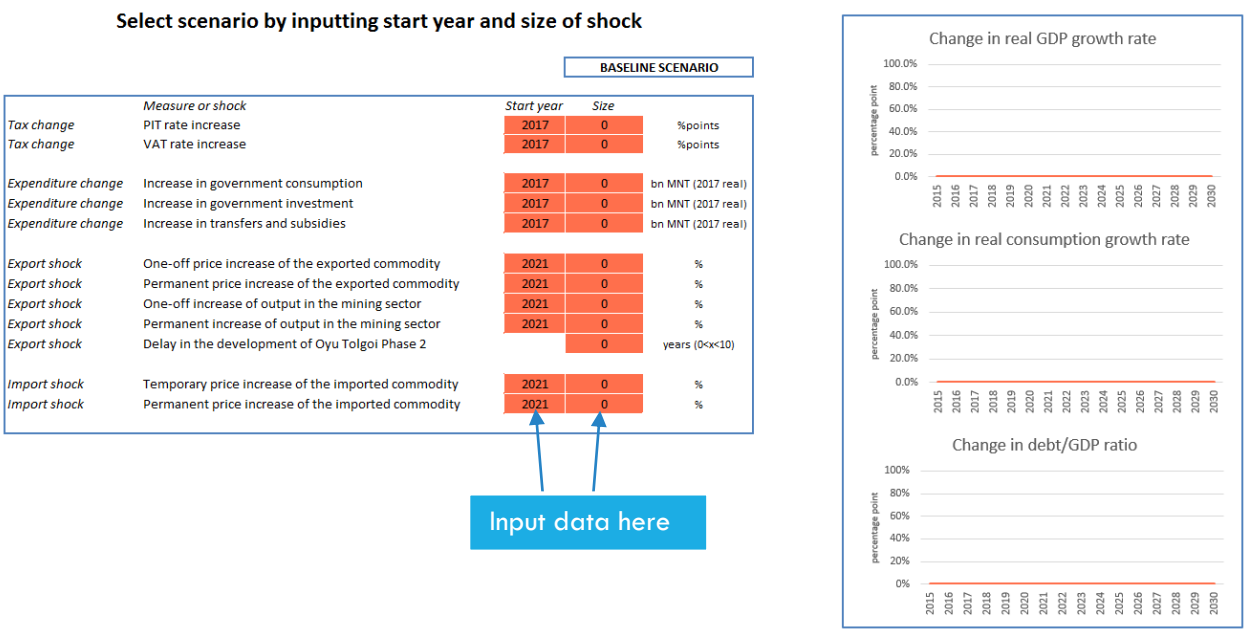

Figure 82. The Control Panel of the model

If the user sets a non-zero size for any of the items on the menu on the 'Control Panel', the file automatically calculates

- the new production, price and financial data of the mining companies
- the new macro scenario
- the deviations from the macro baseline
- all the budget items
- all the derivative fiscal indicators

The control panel will flag that this is now an alternative scenario as opposed to the baseline in the information box above the menu. The right hand side displays three graphs that show the deviation in real GDP growth, real consumption and government debt compared to the baseline (all measured in percentage point difference). These do not show the expected values of the variables in the future, instead they illustrate the size of the shock or policy change across time.

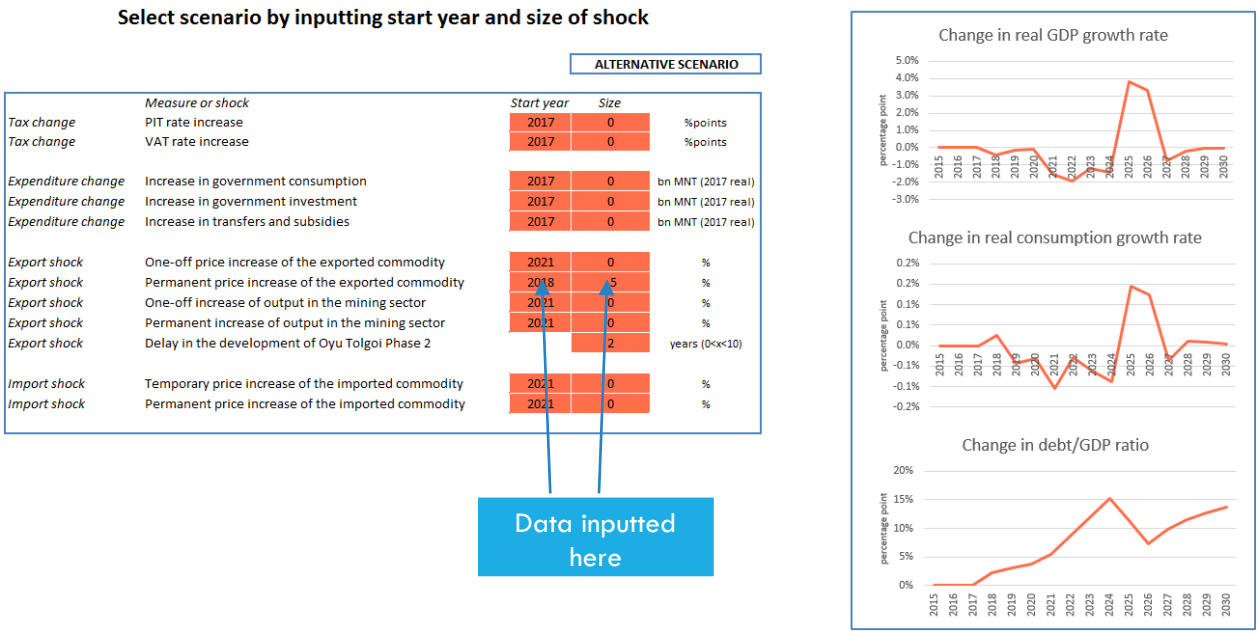

Figure 83. The Control Panel of the model after user inputs

After selecting a scenario, the user can review results on the 'Graphical results' tab and the 'Numerical results' tab.

The 'Graphical results' tab provides a review in graphs of key economic and fiscal variables for both the baseline and the selected scenario. The continuous blue line shows the trajectory of the variable under the baseline, while the dashed orange line shows the trajectory under the selected scenario. The difference between the two can be interpreted as the impact of the selected measure.

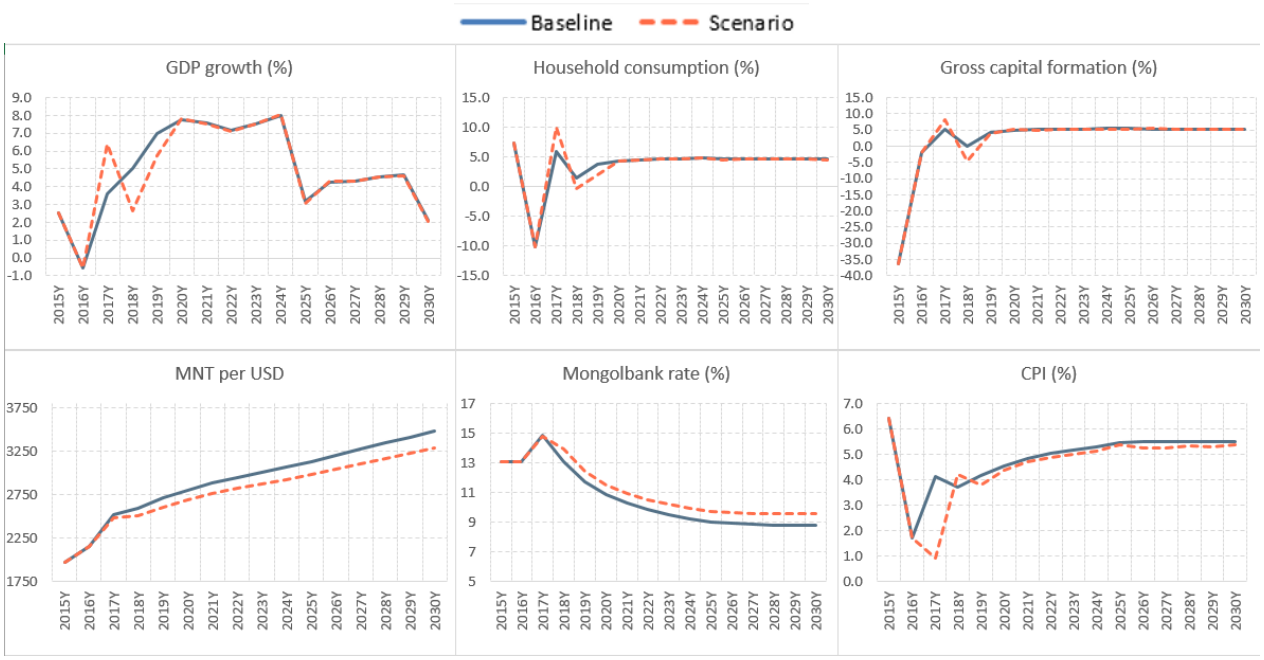

Figure 84. Selected graphical results from the model

The 'Numerical results' tab allows to review a more comprehensive list of economic and fiscal variables separately for the selected scenario and the baseline. These allow both to review a longer list of variable, look at smaller changes, which would go unobserved in the graphs, and to reuse the results for further calculations.

The 'Advanced Control Panel' allows users to input scenarios that are more complex. Instead of restricting these shocks or policy changes to a particular year as on the regular 'Control Panel', here they can be set to oscillate over time. It also covers a broader set of topics than the regular 'Control Panel' including consumption shocks, changes in perceived country risk or changes to the debt management strategy. For example, users can enable the accumulation of a proportion of royalties into a sovereign wealth fund, as proposed in the rules for the Heritage Fund (NRGI, 2014).

Users can enable the 'Advanced Control Panel' with a dropdown box on top of the sheet. After that, they can set a different yearly value for the size of each shock and policy change listed across the 2017 - 2045 period. Results of the advanced inputs can be reviewed on the Graphical Results and Numerical Results tab. When the Advanced Control Panel is enabled, the regular one gets disabled.

Advanced scenarios can be inputted here:

Enable advanced scenario input: NO (YES / NO)

Enable advanced inputs

Advanced inputs of shock scenario	Unit	2017					2022	2023	2024	2025
Domestic economy shocks (not fiscal)										
Consumption shock	*billion MNT*	0	0	0	0	0	0	0	0	0
Markup shock	*p.p. of inflation*	0	0	0	0	0	0	0	0	0
Premium	*p.p.*	0	0	0	0	0	0	0	0	0
Exchange rate shock	*%*	0	0	0	0	0	0	0	0	0
Monetary policy shock	*p.p.*	0	0	0	0	0	0	0	0	0
Agricultural GDP: improving productivity	*p.p. of agricultural GDP*	0	0	0					0	0
Commodity price and mining shocks										
Commodity price shock: export (copper, gold, etc.) transitory	*% level*	0	0	0					0	0
Commodity price shock: export (copper, gold, etc.) permanent	*% level*	0	0	0					0	0
Commodity price shock: import (food, oil) transitory	*% level*	0	0	0	0	0	0	0	0	0
Commodity price shock: import (food, oil) permanent	*% level*	0	0	0	0	0	0	0	0	0
Mining sector output shock: temporary	*% level*	0	0	0	0	0	0	0	0	0
Mining sector output shock: permanent	*YoY %*	0	0	0	0	0	0	0	0	0

Data inputted here

Figure 85. Using the Advanced Control Panel

Users requiring further detail may trace formulas from the 'Numerical results' tab onto the relevant background sheets (e.g. 'Concise annual budget', 'Fiscal rules' etc. sheets). The list of all sheets is described briefly in the next section.

Content of the Excel file

The Excel file contains the following sheets:

- The opening sheet with a short guide to using the model
- A table of contents, from where each sheet can be jumped to directly
- The user interface: The four sheets described in the previous section: the Control Panel, the Advanced Control Panel, the Graphical results and Numerical results.
- Macro sheets: Nine sheets, which calculate the key macroeconomic indicators, based on the equations presented and parameters estimated and calibrated. Having no shock inputted allows to review the baseline.
- Auxiliary calculations: Ten sheets to calculate population, capital stock, natural resource prices in nominal terms, etc.)
- Fiscal summary tables: Four sheets for aggregate fiscal data and scenario analysis
- Budget items: Fifteen sheets for individual projecting budget items and the government debt
- Resource sector: Eleven sheets for detailed data of the individual mining companies
- Preset scenarios: 20 sheets o/w 15 sheets contain the data of individual scenarios and five sheets help to compare them in numbers and in charts
- Raw data: 16 sheets for primary data from Government of Mongolia, from the World Bank, from the IMF and from the Mongolian Central Statistical Office

Only the "Control Panel" and "Advanced Control Panel" sheet (among the User interface sheets) can be modified by the user.

The "Macro baseline" sheet contains values only as opposed to formulas, as it shows the fixed macro baseline against which the effects of all scenarios are measured. It is identical to setting no scenarios.

Data used

The cut-off date for new data entering the model was December 31, 2016. This applies for both national statistics (e.g. national accounts), market data on commodities and international data on changes to the global economy. Annual budget data for 2016 were estimated from the first 11 months' data based on the previous year's seasonality patterns. The excel file provides the raw data with sources used for this model taken primarily from Mongolian government and international institutions.

Updating needs

The model should ideally be updated once a year, as one more year of macroeconomic, budget and mining sector data becomes available. The new fact data can be integrated into the calculations by inputting latest figures as values in appropriate sheets and changing the year from which the projections starts. Intra-year or partial updates should be avoided, as they expose only a partial economic picture thus can have substantial and misleading effects on projected trajectories.

The elasticities, dynamics of change and main external assumptions (e.g. long term growth rate of the trading partners) cannot be changed by the user. These would require re-estimating and recalibrating all the equations on which the model is built. This sort of major update would only be appropriate if there were major changes in our assumptions about the fundamental properties of the Mongolian economy.

We are aiming to establish protocol for a yearly update of the model subject to interest and availability of information.

Data problems

Macroeconomic data

- Available Mongolian macroeconomic data are very volatile and time series are relatively short that made modelling difficult. Time series across all necessary variables covered only 12 years and even this short period was interrupted by three crisis episodes adding significantly to volatility.
- The expenditure and production decomposition of GDP data is not always consistent, in some periods there is a significant gap between the two approaches.
- For the consumer price index we only could use the headline number, as the components necessary to calculate core CPI were not available for the full period. As a result we could not separate in our model underlying inflationary processes from short-term fluctuations caused by international commodity prices.

Mining sector data:

- Data on resource revenues are only available with a close to two-year lag. The latest mining revenue figures used were from 2014 (source: EITI report).

- Data on actual production costs for the country`s largest mines are generally not available. The data used are estimates taken from feasibility studies and development plans. There is a risk that these may prove overly optimistic (Haubrich, 2014).
- Other key information missing on mines include contracts (with the exception of Oyu Tolgoi), and data on how the projects are financed, including outstanding debt and interest costs.

Fiscal data

- Monthly and annual fiscal data available on the Monsis webpage contradict each other in several cases. In absence of the official annual figures from the final accounts for 2015 and the December figures for 2016 we estimated the full-year data for 2016 from the first 11 months from the seasonality of previous years. In our calculations (and raw data included in the excel-based model) we imposed consistency on monthly and annual data, hence may not be equivalent to the forthcoming final Monsis figures.
- Data on government debt are incomplete across sources. It was not possible to find a single date for which the total amount of outstanding debt was broken down by instruments in a consistent way that includes maturity, interest rates and valuation. Instead data was assembled from various sources from different periods.
- The Mongolian government announced during 2016 that the fiscal deficit that year would be far bigger than original plans, but there was no information about the sources of this deviation, namely how much is due to changes in statistical accounting methods concerning past events, how much is actual "new" transactions affecting "standard" budget items, and how much was based on transactions outside the central government but affecting the debt figures. In absence of such a decomposition we couldn't reconcile our estimates for 2016 (both stocks and flows) with publicly available news.
- The overall effect of the VAT tax amnesty introduced in 2015 is unknown. Our calculations assume that the drop in effectivity observed in 2015/2016 data is a one-off shock.

Other data

- Though it only has a limited effect on our key results, the approximately 10 percent deviation in the reported population of Mongolia according to Monsis and the World Bank increases vastly the uncertainty in projecting demographic trends.
- Data on government employment, average wages in the government sector and wage bill in the budget do not seem to be fully consistent.

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