Technical Paper: Macroeconomic Model for Bosnia and Herzegovina

Macroeconomic model is used for short- and medium-term forecasting of key macroeconomic variables in the Central Bank of Bosnia and Herzegovina. It was developed in 2020, through technical assistance to the CBBH, provided by Rafael Ravnik, an external consultant, financed by the USAID FINRA. The following CBBH staff participated in development of the model, and drafting of this technical paper: Belma Čolaković, Elma Hasanović, Antonio Musa, Dragan Jović, Belma Hadžihalilović-Kasumović and Dragana Stanišić[1].

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Summary

The Paper documents and describes the first macro-econometric model of Bosnia and Herzegovina (the Model) developed in the Central Bank of Bosnia and Herzegovina (CBBH). The Model consists of the following blocks: national accounts, the labor market, prices, the fiscal sector, the external sector, and selected monetary and financial sector variables. The Model is a semi-structural model that combines equations, estimated within the standard error correction framework, and identities. It should be emphasized that development of the Model posed a major challenge, due to relatively short time series, with numerous structural breaks and changes in methodologies. An additional challenge in the process of Model development was the COVID-19 pandemic.

The Paper presents two types of simulations from the Model: impulse response analysis and forecasts. Furthermore, the Model may also be used for scenario analysis with a broad range of applications, such as the fiscal and banking stress tests, policy implementation analysis, tax policy changes, and the simulations of foreign alternative scenarios and transmissions to BH economy. In this paper, we present the original version of the model from May 2020. By the time this papers is published, we already upgraded the model by enhancing the interlinkages between real and financial sectors. As with any other model used for projections, the Model is subject to constant evolution. By publishing this technical paper, and fully disclosing the original structure of the model and the results, we aim to contribute to better exchange of information and empirical research between the interested parties. Also, we hope to elevate the interaction between the CBBH and the users of our forecasts.

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1 Introduction

This technical paper presents Macroeconomic Model of Bosnia and Herzegovina (the Model) developed in the Central Bank of Bosnia and Herzegovina (CBBH) in the first half of 2020. The Model was constructed to capture the key relations amongst macroeconomic segments, analyze the implications of alternative risks and scenarios, and produce reliable forecasts of economic activity.

The Model may be classified as the semi-structural macro-econometric model for medium-term forecast based on error-correction equations. This type of model is used by large number of central banks, primarily, but not limited to, those in small open economies, with short time-series and large variability in macroeconomic series. Examples of such models are Budnik et al. (2009) for Poland, Danielsson et al. (2006) for Island, but also Baumgartner et al. (2004) for Austria, Baghli et al. (2004) for France, or Burns et al. (2019) for modelling the global economy. Such type of model seeks to strike the optimum balance between theoretical consistency and actual empirical relations of modelled economy.

The Model is comprised of estimated behavioral equations and a large number of identities. Its role is primarily for forecasting, but it can also be used for scenario analysis. The key mechanisms in the Model describe various links among agents significant for economic activity in Bosnia and Herzegovina (BH). The aim is to generate forecasts of selected, most relevant, easily explained by the economic theory, and underpinned by the structure of the BH economy, macroeconomic and financial sector variables. The Model encompasses detailed structure of: the block for aggregate demand, supply (prices), the financial sector, the fiscal sector and the labor market. The framework of the Model does not replicate the equations of other countries, but rather include specific elements of BH economy. In that respect, an assumption of fixed exchange rate against the euro was also included (given the currency board arrangement in place). A particular attention was devoted to modelling the links with the external sector given its relevance for BH. The examples of such equations are workers remittances, export reliance on the GDP of the EU, or reliance of domestic prices on the global oil prices and other foreign prices. Currently, the forecasts are produced semi-annually, with a three-year horizon (the current year, t, and the subsequent two years, t+1 and t+2). The forecasting process in the Model provides an insight on the trajectory of the short-term conjuncture over the medium run, with a straight and consistent economic interpretation.

As stated by Burns et al. (2019), such models can capture the most significant inter-linkages within and amongst sectors of observed economy in a theoretical, relatively consistent manner, in line with the main identities of national accounts, the labor market, the relations with the external sector, the financial sector, and, occasionally, the fiscal sector. The main difference, when compared to the models based on financial programming, is that most relevant relations are estimated econometrically, i.e., a large number of behavioral equations is included. Although academics with an expertise in macroeconomists often criticize such models for the lack of microeconomic foundations and rational expectations, and the fact that the estimates are done equation by equation, they still represent one of the most important forecasting tools of macroeconomic variables for the central banks, ministries of finance and other professional forecasters. Their advantages include: flexibility in modifications of the model; a possibility of calibration based on expert judgements; intuitive story telling behind the forecasts, and; richness in transmission channels with a large number of variables.

The structure of the Paper is as follows. Data section of the Model is presented in the second chapter. Chapter three is a detailed description of the model structure. A simulation of selected shocks (the IRF analysis) and forecasts is given in the fourth chapter. The final chapter concludes.

2 Data and Seasonal Adjustment

The starting point in constructing the Model are the variables, a list of which, with detailed description, provided in Appendix 1. The frequency of the dataset is quarterly, covering the period 2008 through 2019. The modelling approach allows us to use different samples for the estimation of individual equations. The ARIMA X12 software was used for seasonal adjustment of the original data. Over the observed period, there are structural breaks in several time series, caused by changes in methodology and data collection and processing. These shocks were addressed by various techniques, including synthetic and dummy variables, in the modelling process. Coding and programming was done in Eviews.

In order to properly ground an economic model in relevant theory, a large set of macroeconomic, financial, and fiscal data is required. Some data is not publically available, in which case one must construct proxies in order to obtain model estimates. In our case, investments of household were extracted from total investments published in annual reports on private investment. As the final result, the model observed separately investments of firms from those of households and public sector. The perpetual inventory concept, accumulated past investment, and 5% assumed rate of depreciation was used to estimate capital stock. Housing capital was estimated based on the average housing real estate prices in major cities in BH and the latest population census that contains data on total area of housing purpose real estates in BH. The depreciation rate of 3% was used, as slower depreciation of residential property was assumed when compared to total capital stock. Total household financial wealth was estimated to 150% of total savings, as a part of households' financial wealth is held in the form of cash, shares, ownership in micro and small firms, investment funds and other forms of financial assets. Disposable income is constructed as a sum of wages, workers' remittances and the estimates of property income and grey economy. This will be addressed in the following chapter. The reference short-term interest rate is derived from the corresponding interest rates in neighboring countries. It is important to emphasize the assumption that components of national accounts add up exactly to seasonally adjusted real GDP. The unemployment rate is linked to the number of employed persons in a similar fashion. Namely, the constructed unemployment rate is implicit, as we assumed to fully observe the number of employed persons and labor force. The tax rates are also implicit, obtained by dividing the revenue from a particular type of tax with the tax base. For example, the VAT rate is equal to total revenue from the VAT divided by personal consumption.

The process of seasonal adjustment and construction of non-observed variables is entirely automated and harmonized with the identities of the Model.

3 Model structure

This chapter presents the structure of the Model, followed by detailed description of the blocks, and chosen specification of the estimated equations. A separate review and description of exogenous variables included into the Model is provided.

3.1. Main features of the Model

The Model is a semi-structural model that could generally be split into six blocks: i) national accounts (demand side); ii) the labor market, including the accounts of households; iii) the financial and monetary sector; iv) prices (supply side); v) the fiscal sector, and; vi) the external sector. Blocks iii), v) and vi) are incomplete and are not in a closed form, while other sectors are consistent and fully integrated into the system. By modelling domestic variables, links with foreign variables are explicitly considered, as explained below. Three types of economic agents are modelled: i) households, ii) firms and iii) policy makers.

The Model is a combination of estimated equations and identities. Endogenous real variables are modelled in two step procedure to obtain both short and long run estimates. The long run equation, modeled in line with economic theory, enters the short run equation via the error correction factor. This enables modelling the theoretically coherent structure, with long-term features of the Model, while preserving flexibility of short-term empirical relations observed in the data. On the other side, endogenous nominal variables are modelled exclusively through short run equations. For example, the Phillips curve is used to model core inflation. Most of parameters are estimated econometrically, while some of them are calibrated if, due to high volatility or insufficient length of series, estimates did not provide meaningful outcomes. Calibration also ensured that the signs of parameters are consistent with presumed economic theory. To incorporate all equations into a single system, numerous identities were included in the model. Some of those identities are standard macroeconomic, such as the national accounts identity; some of them are used as deflators, linking nominal and real variables; while some of them link various variables in the block in order to ensure consistency. The examples of the latter are the link between the employment, labor force and unemployment rate, but they were also used for construction of new variables that cannot be directly observed, such as total wealth of households. The employed modelling approach is extremely flexible and enables simple adding and exclusion of variables and equations. This characteristic is of great importance as every model requires frequent adjustments and upgrades, including introductions of the new blocks, in order to enhance preciseness and ensure consistency of forecasts.

The Model produces out of sample dynamic forecasts for all endogenous variables from the last observation through the end of the projection horizon, conditional on exogenous variables. Being backward looking, solving the Model is simple and not time consuming, unburdened by complicated computational procedures that are necessary in forward looking models. However, it is of crucial importance to ensure mutually consistent exogenous variables, in order to obtain consistent projections of endogenous variables.

The forecasts for the period 2020–2022, based on data through 2019, are presented in the appendix. This first round of forecasts was generated in extremely challenging times of the COVID-19 pandemic. The presented forecasts are indicative and do not necessarily correspond to the current official CBBH forecasts, as they strongly rely on the assumptions regarding changes in exogenous variables making the forecast error of domestic variables conditional on the forecast errors od exogenous variables. It was not possible to test the predictive powers of the Model by calculating the forecast error for the subsample given extremely short data series.

Dynamic models allow the use of the impulse response function (IRF) to estimate the effects of an initial unit change in variable x (an impulse) to variable y over time (the responses). Changes in variable y gradually fade with time relapse and converge to zero if shocks are transitory, or converge to a non-zero constant if shocks are permanent. The Model also allows the IRF analysis, which we constructed as generalized functions (see chapter 4).

3.2. Summary of the main equations

The Model consists of 84 equations and endogenous variables (28 of which are estimated equations, while 56 are identities), and 36 are exogenous variables. Most equations are estimated by the two-stage least squares estimation procedure: first the long-run equation is estimated in line with the assumed theory, after which this equation is fitted into the short-run equation via the error correction term. This approach is applied on real variables, while for most of nominal variables only the short-run equations are estimated. Most parameters are estimated via the ordinary least squares (OLS) method, while some of the parameters are calibrated. The rest of this section describes the estimated equations of the Model.

The IS Curve (Personal consumption in the IS curve-PCR) (1)

$$
\begin{aligned}
& DLOG(PCR) \\
& = -0.001 - 0.26 * (LOG(PCR(-1)) - (-0.14 + 0.9 * LOG(PYR(-1)) @ + (1 - 0.9) \\
& * LOG(WLR(-2)) - 0.05 * TRH(-1) - 4.73 * (T(-1))\hat{}2))@ - 0.07 * DLOG(PCR(-1)) \\
& + 0.57 * DLOG(PYR) + @ 0.05 * DUM2012Q1 + 0.04 * DUM2013Q2
\end{aligned}
$$

The equation (1) above[2] represents personal consumption in the Model. The term in the parentheses, next to the second coefficient, represents the long-run equation, while the part outside the parentheses represents the short-run relations. All other error-correction equations will be presented in the same fashion. Personal consumption (PCR) is modelled so that, in long run, it depends on real disposable household income (PYR) at time t, previously accumulated real total household wealth (WLR), and real interest rate on loans to households (TRH).[3] The equation also has a constant term and the square of trend. The current disposable income is comprised of the wage bill (number of employees multiplied by the average wage), remittances and other unobservable income. The latter, amongst other, include estimated return on investments in residential real estate, income from ownership in enterprises, grey economy, and other unobservable income, as a part of real disposable household income (PYR) identity in Appendix 2. Real interest rate on loans to households was not found to be statistically significant for the level of private consumption in BH. However, estimated parameter is of the expected sign, which indicates that households shall, to a certain extent, adjust their consumption over time depending on the interest rate level. Net wealth includes financial wealth (deposits minus outstanding loans) and housing wealth (stock of housing real estate multiplied by the average real estate prices). The coefficient next to disposable income represents marginal propensity to consume, i.e., the percentage of current disposable income that households, on average, consume at time t. The sum of coefficients next to PYR and WLR equals unity, as consumption exceeding current disposable income is financed from wealth. Marginal propensity to consume is calibrated to 90 percent, based on historical data of countries with longer time series and comparable levels of development.

The short-run estimation equation for PCR has all coefficients statistically significant at 5% level. A statistically significant coefficient next to the error correction term of -0.26, indicates that in BH personal consumption converges to the long-run equilibrium in, approximately, 4 quarters. This factor of correction represents, for all following equations, the short run divergence from the equilibrium, and must be of a negative sign, in line with theory, if the gap is correcting. A positive

[2] Numeric values represent the parameters (estimated or calibrated). The variables in are represented by the alphabet codes, the list of which is provided in Appendix 1. Differentials, lags and logs are in the standard coding format.

[3] As a result of fitting the long-run equation into the short-run one, all long-run variables are a lagged.

sign of this coefficient would indicate that the gap is, actually, widening, and that the mechanism is not error correcting.

Investments (ITR) **(2)**

$$DLOG(ITR) = 0.021 - 0.25 * \left(LOG\big(ITR(-1)\big) - \left(3.821 * T(-1)^2 - 0.13 * LOG\big(UCC(-1)\big) + 0.89 * LOG\left(\big(YER(-1) - ITR(-1)\big)\right) - 0.005 * \left(\frac{KSR(-2)}{ITR(-2)}\right)\right)\right) - 0.057 * DLOG(UCC) - 0.11 * DLOG\big(ITR(-1)\big) - 0.26 * DUM2012Q1(-2) - 0.30 * DUM2012Q1 - 0.37 * DUM2013Q2$$

The equation (2) illustrates private investments (investments by firms) i.e., total investments excluding investments in residential real estate and public investments. Private investments (ITR) are modelled in a way that they depend on unit cost of capital (UCC, conditional on real interest rate and the taxes paid by enterprises), intensity of domestic economic activity from other expenditure categories, represented by the difference between GDP and private investments (YER - ITR), and a ratio of total capital to private investments (KSR / ITR) in the previous quarter.

An increase in KSR / ITR, when statistically significantly, indicates diminishing real investments, which is consistent with underlying theory. Namely, if capital accumulation was relatively strong in the past, in line with standard production function, an increase in investments will begin to decline. Conversely, if capital was not sufficiently accumulated in the past, there is space for faster increase in investments in the current quarter. The series of capital itself follows standard accumulation equation (capital law-of-motion), with assumed depreciation rate of 5% annually, as presented in identities in Appendix 2. Intuitively, an increase in unit costs of capital also leads to a decline in investments, as companies would delay their investment activity in periods in which cost of capital (the interest rate or taxes) is relatively high, or increase it if capital is relatively cheap. Apart from the trend component that approximates a pattern in a fraction of investments, an increase in real GDP (YER), net of private investments, as expected, has the strongest effect on investment activity. This is in line with the investment accelerator theory, whereby investment expenditure increases when either demand or income increases.

Most parameters in both short- and in long-run are significant, as well as dummy variables, included to account for major breaks. In estimated equation of real investments, the coefficient next to error correction term was calibrated in a way that long-run equilibrium is achieved in 4 quarters.

Real investment in residential real estate (IHR) **(3)**

$$DLOG(IHR) = -0.053 - 0.068 * LOG\big(IHR(-1)\big) - 1 * LOG(ITR(-1))) + 0.075 * DLOG(ITR) + 0.138 * DUM2014Q1 - 0.097 * DUM2014Q1(-1) + 0.158DUM2014Q1(-4)$$

Real investment in residential real estate (IHR) represent investments of household sector, and it is modelled separately from investments of firms. However, they closely follow investment of firms, which is the only explanatory variable in equation (3), apart for several dummy variables. Separate modelling of IHR allows for different dynamics in the short run, but the long term correlation between the two variables is set to unity. The stock of residential real estate follows the standard law-of-motion, with a depreciation rate set to 3%, which is slightly below one used for investment of firms. All coefficients are statistically significant, including the one next to the error correction term. The estimated equation also includes the autoregressive component and three dummy variables.

Residential real estate prices (IHX) ***(4)***

$$DLOG(IHX) = -0.003 - 0.408 * \left(LOG\big(IHX(-1)\big) - \left(-8.555 - 0.530 * TRH(-1) + 0.580 * LOG\big(PRY(-1)\big) - 0.095 * \left(\frac{HHA(-2)}{PCN(-2)}\right)\right)\right) + 0.078 * DLOG\big(IHX(-1)\big) + 0.419 * DLOG(YER)$$

In the residential real estate prices equation (5), the average real estate price for the regional centers in BH was used as an endogenous variable (IHX). The equation reflects demand for residential real estate. A statistically robust long run relationship was established between IHX on one side, and real interest rates on loans to households (TRH), disposable income (PYR) and wealth from residential real estate (HHA), adjusted for nominal personal consumption (PCN), on the other side.

As expected, the sign of the coefficient next to real interest rate is negative, as it represents a cost of financing for investment in residential real estate. If raised, this cost reduces demand, and consequently the price as well. Disposable income, similar to personal consumption equation, represents income available to households to spend as investments to residential real estate. The positive sign is expected, as higher disposable income is expected to increase housing demand, exerting an upward pressure on price. Wealth from residential real estate (stock of residential area multiplied by the average residential real estate prices), expressed as a fraction of personal consumption, is expected to have a negative impact on the price of residential real estates. Economic interpretation of the coefficient is also intuitive, as one expects decrease in demand, once a certain level of residential real estates is reached. Vice versa holds as well.

All coefficients are of the expected signs. The coefficient next to the error correction term in the short run equation is negative (0.4), so the long-run equilibrium is achieved after 2.5 quarters.

General Government Interest Expenses (INP) **(5)**

$$INP = 48{,}232.283 - 31{,}0552.416 * STN - 0.002 * @CUMSUM(DEF)$$

General government interest expenses on public debt (INP) is the only endogenous component of government expenditure, thus it will impact government sector balance (deficit). The interest on the public debt of general government is affected by domestic short-term interest rate (STN), which is defined as a sum of the risk premium and domestic risk free interest rate. Interest rates increase with rising cumulative deficit, as deficit is an accumulated public payables. The higher the public debt, ceteris paribus, the higher the interest expenses.

Export (XTR) **(6)**

$$DLOG(XTR) = 0.008 - 0.1 * \Big(LOG\big(XTR(-1)\big) - \Big(-35.842 + 3.326 * LOG\big(FOD(-1)\big) - 0.442 * \Big(LOG\big(XTD(-1)\big) - LOG\big(CPX(-1)\big)\Big) + 0.028 * T(-1) - 0.001 * T(-1)^2\Big)\Big) + 3.416 * DLOG(FOD) - 0.488 * DLOG\big(XTR(-1)\big) + 0.079 * DUM2013Q2$$

Demand for BH exports (equation 6) establishes relationship between total export of goods and services (XTR) on one side, and foreign demand (FOD), and a ratio of domestic export prices to foreign export prices (LOG(XTD) - LOG(CPX)). Trend and a square of trend are also included. An exogenous variable, the EU GDP, is used as a proxy for foreign demand. The forecast of the EU GDP is available for the forecast horizon of the Model. A relatively high coefficient exceeding 3, clearly indicates a strong impact of foreign demand (FOD) on BH export of goods and services. A ratio of export deflator to export prices of our main trading partners represents an impact of price competitiveness on export, i.e., relatively cheaper domestic products should increase BH export.

In the short-run export equation, the coefficient next to the error correction term is negative (-0.1). It indicates a slow convergence, of around 10 quarters, of export towards the long-run equilibrium, once the series diverges from the equilibrium levels.

Import (MTR) **(7)**

$$DLOG(MTR) = -0.001 - 0.517 * \Big(LOG\big(MTR(-1)\big) - \Big(-0.0151 + 1.315 * LOG\big(DDR(-1)\big) - 0.2 * \Big(LOG\big(MTD(-1)\big) - LOG\big(YED(-1)\big)\Big) + 0.213 * LOG\big(XTR(-1)\big)\Big)\Big) + 0.172 * DLOG(XTR) + 1.300 * DLOG(DDR)$$

Equation (7) estimates the impact of real domestic demand (DDR), import deflator (MTD), GDP deflator (YED) and real export (XTR) on import. Similarly to export, import prices above domestic prices diminish import and vice versa. Real export is included in the equation as there is, traditionally, a non-negligible value of export after inward processing in the case of BH. The sign of the coefficient is, as expected, positive. The coefficient next to domestic demand is highly significant, and positive.

All parameters in both short- and long-run equations are significant, their direction of impact is consistent with economic theory, and the long-run equilibrium is restored very fast, within two quarters.

Remittances (REM) **(8)**

$$LOG(REM) = 5.132 + 0.974 * DLOG(FOD, 0{,}4) - 0.239 * LOG(LAN) + 0.879 * LOG(REM(-1))$$

In the estimated remittances equation (8), the impact of both GDP of our trading partners and working population is assessed. Due to intensive and persistent emigration, as well as still strong relationship of our migrants with BH, remittances are one of the three key determinants of disposable income of households (PYN). Rising GDP of our trading partners (in which population originating from BH predominantly lives), as expected, positively and very strongly affects remittances. An increase in working age population (which is an equivalent for net decrease of emigration), leads to decreasing remittances, is found statistically insignificant. Autoregressive component is found to have a significant impact on the current values of remittances.

The Phillips curve (HEF) **(9)**

$$DLOG(HEF) = -0.001 + 0.075 * DLOG(PCR) + 0.371 * DLOG\big(HIC(-1)\big) + 0.1 * DLOG\big((TPDV + TTIR)\big) - 0.010 * DUM2017Q1(-1)$$

Consumer Price Index (CPI) is comprised of five components in the Model. Prices of food and beverages, transport prices, prices of clothes and footwear, administratively regulated prices and core inflation are modelled separately, then aggregated by using weights of each of the component, in line with the identity for HIC (total CPI) in Appendix 2.

Changes in core inflation (HEF), are affected by demand, or more specifically, consumption (PCR), the previous level of headline inflation (HIC(-1)), as a substitute for forward-looking expectations, and changes in indirect tax rates (the implicit rate of the VAT, TPDV, and; the implicit rate of other indirect taxes, TTIR). For the indirect tax rates see chapter on exogenous variables. Expectedly, change in real personal consumption has a positive and significant effect on core inflation, as higher demand pushes the prices. The effect of the overall price level from the previous period is particularly significant, as 1 percent increase in headline inflation in the previous period rises core inflation by 0.37 percentage points. The effect of indirect taxes was calibrated to 0.1. The forecast of domestic inflation will be determined also by other factors, not only by core inflation, in order to simulate Phillips curve for open economy. Some of these external factors are the global oil prices, the EU inflation and foreign exchange rate against the U.S. dollar.

Transport prices (HEG) **(10)**

$$DLOG(HEG) = -7.840 + 0.070 * D\big(LOG(POU) - LOG(MUS)\big) + 0.502 * DLOG(MTD) + 0.028 * (DUM2018Q1 + DUM2018Q1(-1) + DUM2018Q1(-2))$$

Transport prices (HEG) are determined by the global oil prices (POU), nominal exchange rate of KM against the USD (MUS), being the main world currency in oil trade, and import prices deflator (MTD). The coefficients are statistically significant at the level of 1 percent. Transmission of the effects of foreign to domestic variables is crucial for forecasting, which implicates that domestic inflation is under strong influence of the global oil prices.

Food prices (HIF) **(11)**

$$DLOG(HIF) = 0.001 + 0.018 * D\big(LOG(PFU) - LOG(MUS)\big) + 0.123 * DLOG(MTD) + 0.531 * DLOG(HIF(-1))$$

Food prices (HIF) are determined by the global oil prices (PFU), the nominal exchange rate of KM to USD (MUS), USD being the main world currency in oil trade, and especially by the import prices deflator (MTD) and food prices from previous period. The coefficients are statistically significant at the level of 1 percent. By including the import prices deflator, the chain of transfer of foreign prices onto domestic prices is modelled. As later presented, the deflator is strongly influenced by foreign prices, which will additionally feed into domestic food prices, apart from already modelled direct impact of food prices from the previous period, and the exchange rate against the dollar. The exchange rate represents the pass-through effect of foreign prices onto domestic prices. Another currency significant for BH economy, the euro, is not included because of the CBBH currency board arrangement.

Clothing and footwear prices (HCL) **(12)**

$$LOG(HCL) = 0.223 + 0.963 * LOG\big(HCL(-1)\big) - 0.001 * T + 0.1 * LOG(TPDV + TTIR)$$

Clothing and footwear prices are separately modelled because of their strong impact on the consumer price index, regardless of the weight that is far below those for food and transport prices. Over the horizon of several years, the series exhibits persistently declining trend, with only several episodes of short lived deviations, thus constantly diminishing inflation. This is the reason why a trend is included in (12) above. At almost unit elasticity, the price effect from the previous periods verifies sluggishness of the series. However, it is necessary to emphasize that the equation is modelled in logs, and not in growth rates. The effect of the VAT implicit rate and other indirect taxes is calibrated to 0.1, similar to the core inflation.

Personal Consumption Deflator (PCD) **(13)**

$$DLOG(PCD) = 0.001 + 0.581 * DLOG(HIC) + 0.018 * (DUM2019Q3 + DUM2019Q3(-1))$$

Given that expenditure based statistical data on deflator are still very volatile, the consumer price index is used for real personal consumption. In theory, the index should also be the basis for the deflator.

Investment deflator (ITD) **(14)**

$$DLOG(ITD) = -0.001 + 0.058 * DLOG(ITR) + 0.424 * DLOG(HIC)$$

Investment deflator was modelled as a function of real investment (ITR), representing demand component, and consumer prices (HIC), representing total prices.

Export Prices (XTD) **(15)**

$$DLOG(XTD) = -0.005 - 0.1 * DLOG(EEN) - 0.241 * \Big(LOG\big(XTD(-1)\big) - 1 * +LOG\big(FCP(-1)\big)\Big) + 3.877 * DLOG(FCP)$$

The equation of export prices, or the export deflator (XTD), estimates the impact of the nominal effective exchange rate (EEN), past values of export deflator (XTD), and consumer prices of trading partners (FCP). A decrease in EEN represents depreciation, just as a decrease in EER also signals depreciation, since EER = EEN * FCP / HIC. In other words, if foreign prices are rising slower than domestic, the real effective exchange rate depreciates. This depreciation in the nominal effective exchange rate is passed on a fraction of domestic prices, making a fraction of export more expensive. Additionally, the long run equation, with an assumption that domestic prices fully mirror those of the trading partners, is included. The adjustment coefficient implicates convergence within four quarters.

Import Deflator (MTD) **(16)**

$$DLOG(MTD) = 0.001 + 0.121 * DLOG\big(MTD(-1)\big) + 0.868 * D\big(LOG(FCP) - LOG(EEN)\big) + 0.033 * D\big(LOG(POU) - LOG(MUS)\big) + 0.047 * DUM2018Q4$$

The equation of import deflator (MTD) affects all the components of domestic inflation. It was estimated only for the short run by using the autoregressive component, the growth rate of prices of trading partners converted into domestic currency (log(FCP) - log(EEN)), the growth rates of global oil price converted into domestic currency (log(POU) - log(MUS)). As expected, all variables positively affect the export deflator, all the coefficients are significant, but low persistency of import deflator is noticed, as the estimated coefficient is not particularly large. This equation, together with the equations of transport price (10) and food (11), makes a chain though which foreign prices transfer to domestic consumer prices, which also includes the effect of change of the exchange rate against the US dollar (the pass-through effect). The impact of foreign prices cannot be interpreted through single equation, but through this chain of transfers, as well as all other equations in the model.

Labor Market Supply (ULA) **(17)**

$$DLOG(ULA) = -0.121 - 0.277 * \Big(LOG\big(ULA(-1)\big) - \Big(-0.819 - 0.344 * LOG\big(URX(-1)\big) + 0.823 * LOG\big(YED(-1)\big)\Big)\Big) - 0.166 * DLOG\big(ULA(-1)\big) - 0.846 * (D(URX))$$

The estimated equation of the unit cost of labor (ULA) is interpreted as labor supply (by employees), or the so-called, wage-setting equation. For that reason, the unit cost of labor is assumed to depend on the unemployment rate (it has a negative impact on the unit cost of labor), and the overall price level, measured by the GDP deflator (positive effect). The coefficient next to the error correction term is statistically significant at the level of 5 percent, with the parameter of short-term disequilibrium of -0.28. In the long run, higher unemployment (lower employment) results in diminishing wages, as the bargaining power of the employees and trade union reduces due to lower labor market tightness. As in other countries, the unemployment rate has very slow changing trends, which may reverse, so it is an unreliable predictor of wages or the unit labor cost. Apart from the unemployment rate, the overall price level is also included for the ULA, expressed in nominal terms.

The unit labor cost is derived as a product of the average gross wage and the implicit contribution rate, divided by labor productivity. The links between the number of employees, labor force, labor participation rate, working age population, the unemployment rate, and the number of unemployed persons are described by the identities in Appendix 2.

Demand for labor (URX) **(18)**

$$D(URX) = -0.001 - 0.05 * \Big(LOG\big(URX(-1)\big) - \Big(4.25 - 0.344 * LOG\left(\frac{YER(-1)+YER(-2)+YER(-3)+YER(-4)}{4}\right) + 0.3 * LOG\big(ULA(-1)\big) + 1 * LOG\big(URT(-1)\big) + 0.639 * LOG\big(PRO(-1)\big)\Big)\Big) + 0.797 * D\big(URX(-1)\big) + 0.024 * DLOG\big(ULA(-1)\big) - 0.008 * DUM2017Q1$$

In equation (18), the labor demand by enterprises is linked to the unemployment rate (URX), the unit labor cost (ULA; of the opposite sign from the equation 17), productivity (PRO), total economic activity (YER), and a trend of the rate of unemployment (URT). The latter is exogenous, and it is anchoring labor demand. An exogenous increase in productivity (PRO) rises unemployment (URX), as a smaller number of employees will be needed for the existing production capacity. In the long run equation, the coefficient next to productivity is significant at the level of 1 percent, implying that 1 percent increase will raise unemployment rate by 0.64 percentage points. The average annual rate of real GDP is smoothened to better match a cycle in pronouncedly even series of the unemployment rate. The coefficient next to the cost of labor (ULA) is calibrated, as the official data did not verify an inverse relationship between the cost of labor and demand. The calibration of the ULC ensured an economic interpretation of the demand curve. The equation also includes the trend of the unemployment rate (URT), as it should not significantly deviate in the long run. The unemployment rate during one quarter corrects 5 percent of total deviation from the long-run equilibrium. A very slow adjustment towards the equilibrium is in line with generally perceived sluggishness of labor market across countries.

Labor force activity rate (LAX) **(19)**

$$LOG(LAX) = -0.206 + 0.768 * LOG\big(LAX(-1)\big) + 0.001 * T + 0.025 * DUM2016Q1 + 0.049 * DUM2017Q1$$

The labor force activity rate (LAX) is necessary to derive a number of employed persons from the above-described unemployment rate. To model it, a simple autoregressive model with trend was used. Dummy variables were included to account for the methodological changes in calculation of the number of employed persons from early 2017.

Money supply (M2) **(20)**

$$DLOG(MM2) = 0.008 + 0.005 * \Big(LOG\big(MM2(-1)\big) - \Big(-29.028 + 1.232 * LOG\big(YER(-1)\big) + 1.165 * LOG\big(LHH(-1)\big) + 0.017 * \big(STN(-1) - FST(-1)\big)\Big)\Big) + 0.150 * DLOG\big(MM2(-1)\big) + 0.149 * DLOG(YER)$$

Apart from the real gross domestic product (YER), loans to non-financial firms (LNF), and loans to households (LHH), the right hand side of the long-run equation of money supply (MM2) also includes the difference between short-term domestic (STN) and foreign interest rate (FST). It is clear that higher GDP leads to larger money supply. Loans, through the process of multiplication, will lead to larger M2. The difference between domestic and foreign interest rate reflects an open economy setting, where capital shifts from abroad if domestic interest rate is relatively higher, or flows out if foreign interest rate is higher.

All long run coefficients are statistically significant at the level below 1%, but not the short-term ones. The coefficient next to the error correction term is extremely low, and even positive, which indicates a non-correcting mechanism. In the absence of feedback from money supply to the real sector variables, this equation was kept in the original Model. The future work on the Model will be specifically related to improving financial and monetary sector links.

Loans to households (LHH) **(21)**

$$DLOG(LHH) = 0.002 - 0.303 * (LOG(LHH(-1)) - (9.730 + 0.394 * ((LOG(PCR(-1)@ + IHR(-1)) + (LOG(PCR(-2) + IHR(-2)) @ + (LOG(PCR(-3) + IHR(-3)) + (LOG(PCR(-4)@ + IHR(-4)))/4 - 3.602 * (TNH(-1) + TNH(-2) + TNH(-3) + TNH(-4))/4 + @5.709 * T(-1)\hat{}2 + 0.126 * (LOG(IHX(-1)) + LOG(IHX(-2)) + LOG(IHX(-3)) + @ LOG(IHX(-4)))/4)) + 0.638 * DLOG(LHH(-1)) @ + 0.059 * DLOG(IHR) - 1.114 * D(TNH))$$

In the long run, loans to households (LHH) are assumed to depend on total real expenditures of population, which include personal consumption (PCR) and investment to housing real estate (IHR), the interest rates on loans to households (TNH), and the prices of residential real estate. All explanatory variables are smoothed in order to eliminate the variations of variables within a quarter, since the loans series is rater even. The signs of the coefficients are intuitive, as higher personal consumption and investments will require more new sources of financing, thus increasing demand for loans. Also, higher interest rates will discourage demand for loans, while higher prices of the residential real estates will lead to higher demand for loans.

Restoring the long-run equilibrium in the case of loans to households is rapid (in about three quarters). All key variables are statistically significant, and of expected sign.

Loans to non-financial enterprises (LNF) **(22)**

$$DLOG(LNF) = 0.004 - 0.155 * \left(LOG\big(LNF(-1)\big) - \left(-0.128 + 1.017 * LOG\big(YET(-1)\big) - 0.715 * \frac{UCC(-1)+UCC(-2)+UCC(-3)+UCC(-4)}{4}\right)\right) + 0.388 * DLOG(LNF(-1))$$

The equation of loans to non-financial enterprises (LNF) is structurally identical to that of loans to households. In line with economic theory, loans to enterprises depend on demand for loans, represented by the economic activity (YET), the price of loans, i.e. the unit cost of capital (UCC). Both series are smoothed. An increase in the unit cost of capital, expectedly, has a strong negative effect on loans to enterprises, implying a high price elasticity of loans. Rising economic potential clearly spurs firms' demand for loans. The coefficient next to the convergence parameter is statistically significant and half the size that of loans to households. Therefore, the convergence towards equilibrium in this sector will be slower.

The ratio of non-performing loans (NPL) (23)

$$LOG(NPL) = -1.468 + 0.613 * \left(\frac{LHH}{PCN+IHN}\right) + 0.287 * \left(\frac{LNF}{ITN}\right) + 2.313 * (TNH + TNB) + 0.909 * LOG\big(NPL(-1)\big) - 0.117 * DUM2014Q1(-3)$$

The BH financial system is bank-centered. Consequently, the non-performing loans (NPL) have a prominent role in the equations of financial sector. In the Model, the NPL depends on relative indebtedness of households (LHH / (PCN+IHN)) and enterprises (LNF / ITN), and the interest rates on loans to households (TNH) and enterprises (TNB), as well as the autoregressive component. In the original version of the Model, the NPL equation does not take into account all changes in the regulatory treatment of non-performing loans, but still makes a rather good estimate of the NPL. Further improvements of the Model should encompass the moratoria introduced during the pandemics, and the effects of the write off of fully provisioned NPL. Expectedly, the estimated impact of all variables on the non-performing loans is statistically significant, and of a positive sign. A relative over-indebtedness of either the households or enterprises raises the NPL, and the same applies to the interest rates. The coefficient next to the autoregressive term of around 0.9 indicates a strong persistence of NPL.

The households' deposits (HAA) (24)

$$DLOG(HAA) = -0.798 - 0.027 * \Bigg(LOG\big(HAA(-1)\big) - \bigg(-10.179 + 1.886 * LOG\Big(PYN(-1) - LOG\big(PCN(-1) + IHN(-1)\big)\Big) + 0.5 * \big(SNH(-1)\big) + 1.684 * LOG\big(YEN(-1)\big)\bigg)\Bigg) - 0.179 * DLOG\big(HAA(-1)\big) + 0.858 * SNH + 0.283 * DLOG(YER)$$

The equation of household financial wealth (HAA), i.e. the households' deposits, assumes a relationship between the deposits and the unspent income of households (estimated as the difference between the disposable income, PYN, and total households' expenditure, PCN and IHN), the interest rates on deposits, and the nominal GDP. All coefficients are statistically significant, and of the expected signs. The unspent disposable income of households at time t increases savings, similar to the nominal GDP. Higher saving interest rates incentivize households' savings. The coefficient next to the error correction term is statistically significant and negative, but extremely low. The average speed of adjustment towards the long-run equilibrium is only 2.7% per quarter.

Nominal interest rate on loans to households (TNH) (25)

$$TNH = 0.003 + 0.055 * STN + 0.921 * TNH(-1)$$

Given that there is currently a lack of domestic research on determinants of the interest rate on loans to households (TNH), we used domestic short-term interest rate and the autoregressive component. Both coefficients are statistically significant at the level below 5%. The size of the coefficient next to the auto regressive term suggest that the interest rates on loans to enterprises exhibit high persistence. Further improvements of the Model will be in modelling nominal interest rates used, assessing the impact of other variables, rather than relying strongly on the autoregressive term.

Nominal interest rate on loans to non-financial enterprises (TNB) (26)

$$TNB = 0.001 + 0.046 * STN + 0.952 * TNB(-1)$$

The interest rate to non-financial enterprises (TNB) is modelled similarly to the interest rate on loans to households. The estimated relationship is also statistically robust, and the estimated coefficients are, approximately, at the same levels as in the TNH equation.

Nominal interest rate on households' deposits (SNH) (27)

$$SNH = -0.002 + 0.059 * TNH + 0.910 * SNH(-1)$$

The nominal interest rate on deposits of households (SNH), apart from its value from the previous period, is set to be determined by the interest rate on loans to households. These two interest rates tend to change in the same direction.

Domestic short-term interest rate (STN) **(28)**

$STN = 0.004 + 0.833 * STN(-1) + 0.001 * FST$

Domestic short-term interest rate (STN) is constructed as a sum of the risk premium and domestic risk free interest rate. It was modelled by assessing the influence of the autoregressive component and foreign interest rate, the EURIBOR (FST). The Euribor is used as BH partially imports monetary impulses from country of the reserve currency, i.e., from the Eurozone. The impact of foreign interest rate is not too strong (an increase in FST by one percentage point increases domestic interest rate by 0.0017 percentage points), but it is statistically significant.

STN impacts the cost of borrowing, i.e. the interest rates of households, enterprises, and the government, affecting budget expenditures, and budget deficit which accumulates into public debt.

3.3. Exogenous variables

BH is a small open economy, and international economic trends have a significant repercussions on economic activities in BH. The variables related to developments abroad are treated as the exogenous in the Model. Their forecasts were taken over from the relevant external sources4. Some of the domestic variables are also set as exogenous in the Model in order to close the system, but also to model the fiscal policy. Exogenous variables are described in Table 1 below.

Table 1: Exogenous variables

CPX	Export prices of trading partners	CPX is a variable in the export equation. We used the harmonized index of consumer prices for the Euro area to determine the price level, a proxy for the export price level of our trading partners. The operating assumption is that, ceteris paribus, BH export prices above the export prices of our foreign partners would diminish BH export.

[4] Source: The European Central Bank (ECB), The European Commission (EC), The International Monetary Fund (IMF), Index Mundi: available at www.indexmundi.com, CMEGroup: available at https://www.cmegroup.com).

EEN	Nominal effective exchange rate	It was used in the import deflator equation (MTD) and for Real effective exchange rate (EER), in line with the identity EER = EEN * FCP / HIP, FCP is foreign prices, i.e. the consumer of trading partners, and HIC represents the CPI based domestic prices.
FCP	Consumer prices of trading partners	Foreign prices are used in the equations for export (XTD) and import (MTD) deflators, and in the real effective exchange rate (EER) identity. We used seasonally adjusted series of the harmonized index of consumer prices for the Euro area, published by EC as a proxy for the CPI of our trading partners.
FOD	GDP of trading partners- foreign demand	Foreign demand is used in the equations for real export (XTR) and remittances (REM). We used EU GDP data available at Eurostat and forecasts from EC as a proxy for the real GDP of our main trading partners. Higher GDP of the main trading partners raises BH exports and an inflow of the remittances to BH.
FST	Euribor	BH commercial banks commonly use the 6 month Euribor rate as the variable part when setting variable interest rates on loans.
GCN	Nominal government expenditure	This variable is taken from the budget. This variable is taken from the budget. We used data for forecast horizon from the latest available BH Global Fiscal Framework.
GCR	Real government expenditure	This variable is taken from the budget. This variable is taken from the budget. We used data for forecast horizon from the latest available BH Global Fiscal Framework.
HAT	The administrative prices sub-component of the CPI	This variable is used as a component of the consumer prices. We used data available at BHAS as a proxy for the administered prices that are a sub-component of the CPI in BH.
LAN	Working age population	It includes both active and inactive population. This variable is used to construct an indicator of emigration, and it is the only demographic variable in the Model. It is used in the equation for remittances from abroad. We used information from BHAS Labor Force Survey to construct working age population.

MUS	Nominal exchange rate KM/USD	It is used in the import deflator equation (MTD), and for the energy sub-component of domestic CPI (HEG) and the food sub-component of the CPI (HIF) via the global oil price (POU) and global food price (PFU). We used exchange rate of EUR/USD from the EC official forecasts to construct the nominal exchange rate for the forecast horizon.
PFU	World food prices	Small, open economies, like BH, economy cannot significantly affect the global economy. PFU is approximated by the IMF food index, and it is used for assessment of domestic CPI food equation (HIF).
POU	World oil prices in USD	This variable is used in the equations for the energy sub-component of the BH CPI, and in the import deflator equation. We used oil prices (POU) from Index Mundi and projections over the forecast horizon from CMEGroup.
TCUS	Implicit customs rate	Forecast of the variable based on autoregressive model
TDTH	Implicit income tax rate	Forecast of the variable based on autoregressive model.
TFT	TFP trend	Total factor productivity is based on the estimate of YER = ((KSR^0.35)*(LEN^0.65)) Capital (KSR) and employees (LEN) are defined as identities in Appendix 1.
TOOR	Implicit rate of other budget revenue	Forecast of variable based on autoregressive model
TOTX	Implicit rate of other taxes	Forecast of variable based on autoregressive model
TPDV	Implicit VAT rate	This variable was used in the core inflation equation (HEF), and also in the clothing and footwear sub-component of the prices (HCL).
TSCE	Implicit contribution rate	The variable is constructed by dividing total contributions with total net wage bill and total contributions. Forecast of the variable is generated by the autoregressive model.

TTIR	Implicit rate of other indirect taxes	It represents a ratio of the revenues from other taxes to nominal personal consumption. Forecast of the variable is generated by the autoregressive model.
UMO	Total expenses excluding interest	The domestic variable defined in the model and its forecast is generated by the autoregressive model.
URT	Unemployment rate trend (NAIRU)	The Hodrick-Prescott filter is used to generate the trend of the unemployment rate. We used administrative unemployment rate from BHAS.
w_HAT	Weight of the administered prices in the CPI	The weight for the administered prices is the sum of the latest available weights for the following sub-indices: Housing, water, electricity, gas and other fuels; Alcoholic beverages and tobacco; Communication; Healthcare, and; Education.
w_HCL	Weight of clothing prices in the CPI	The latest available weight used is that for the footwear and clothing sub-index of the CPI.
w_HEF	The weight of all remaining sub-indices of the CPI	The latest available weight for all remaining prices is the sum of the weights for the following sub-indices: Furnishing, Recreation and art, Restaurants and hotels, and Other prices.
w_HEG	Weight of energy prices in the CPI	The latest available weight used is that for the transport sub-index of the CPI.
w_HIF	Weight of food prices in the CPI	The latest available weight used is that for the food and non-alcoholic beverages sub-index of the CPI.
DUM2012q1	Dummy variable	Used in the IS curve equation.
DUM2013q2	Dummy variable	Used in the IS curve equation.
DUM2014q1	Dummy variable	Used in the NPL equation.
DUM2016q1	Dummy variable	Used in the Labor force participation equation.
DUM2017q1	Dummy variable	Used to account for a break following the introduction of the new methodology for the number of employed persons.
DUM2018q1	Dummy variable	Used with the transport prices,
DUM2018q4	Dummy variable	Used with the import deflator equation.

DUM2019q3	Dummy variable	Used with the personal consumption deflator.
T	Trend	Time trend.

4 Simulations and results

4.1 Simulation of shocks

The primary purpose of this Model is consistent forecasting of the macroeconomic variables, while the economic interpretation of shocks is of the secondary importance. Nevertheless, the selected shocks to the variables are presented in this section, aiming to explain the Model in more detail, and the assumed linkages amongst the variables. If a structural or semi-structural model is used for forecasting, it is of the crucial importance to clearly understand the dynamics and the interplay among the variables. That is why we devoted this chapter to the analysis of the Impulse Response Functions (IRF). The selected IRFs will illustrate the linkages among the endogenous variables, between endogenous and exogenous variables, but the sensitivity of variables to changes in other variables in the process of forecasting and simulations of alternative scenarios. Only the IRF analysis will enable conclusions regarding direction and the intensity of dependence of a variable. Individual equations indicate only a partial insight, while we are interested in, so called, the general equilibrium effect, i.e. the overall outcome of individual reactions, both direct and indirect. A rigorous economic analysis of such functions is possible exclusively for the genuine structural models (for example, the DSGE), that have clearly identified structural shocks. The shocks in our model are less structural, which has to be kept in mind when interpreting the results. However, a certain structural interpretation might be attributed *ex-post* to most shocks, as explained further in this Paper.

The estimated Model enables generalization of the IRF in the following manner. The first step is to forward solve dynamical system of equations, for H periods, conditional on the set of the assumed exogenous variables. That simulation is the baseline forecast. The next step is to assume a certain shock, i.e., we either increase or decrease a variable / equation by x%, and simulate again the same model, over the same sample H, with the same exogenous variables, differing only for the mentioned shock. Such a simulation is the alternative scenario. By comparing the alternative scenario to *baseline* scenario outcome for chosen endogenous variables, the IRF is estimated for every moment of h as a simple percentage difference of the observed endogenous variable under different scenarios. Such dynamic IRF is then estimated for each h = 1,...,H for the chosen group of endogenous variables, which will illustrate graphically. The simulation in the Model allows for, at least, three types of shocks.

- The first type is the simplest and assumes a shock to the exogenous variable. It assumes an x% increase/decrease of the exogenous variable, over the simulation horizon (in the first quarter of the horizon, several quarters, or across the horizon). As the variable is exogenous, such shock is a true isolated exogenous shock, but its economic interpretation is not necessarily structural.

- The second type of shock represents an exogenisation of an endogenous variable. In this case, the equation that is subject to a shock in the alternative scenario is excluded from the system, and the endogenous variable from this equation is exogenised. The exogenisation means that the variable values from the baseline scenario are shocked, i.e. increased or reduced by x% in one or several quarters over the simulation horizon H. In that case, the path of the shocked variable will be entirely presumed by the forecaster, and such variable cannot dynamically on its own values, as the corresponding equation is excluded. Such type of shock is rarely used in the IRF analysis, but is often used in construction of the alternative scenarios, for example for the stress tests of banking or fiscal sector.

- The third type of shock is represented by an equation add-on. Such shock is the most similar to the shock in the VAR model. It represents an increase/decrease of the residual in an endogenous variable equation by x%, without exclusion of the equation from the system, which means that the endogenous variable from that equation also reacts to the shock. In this case, the forecaster only decides on the magnitude of the shock, and not on the trajectory of the shocked endogenous variable. It is also possible here to shock the system in one quarter through the simulation horizon.

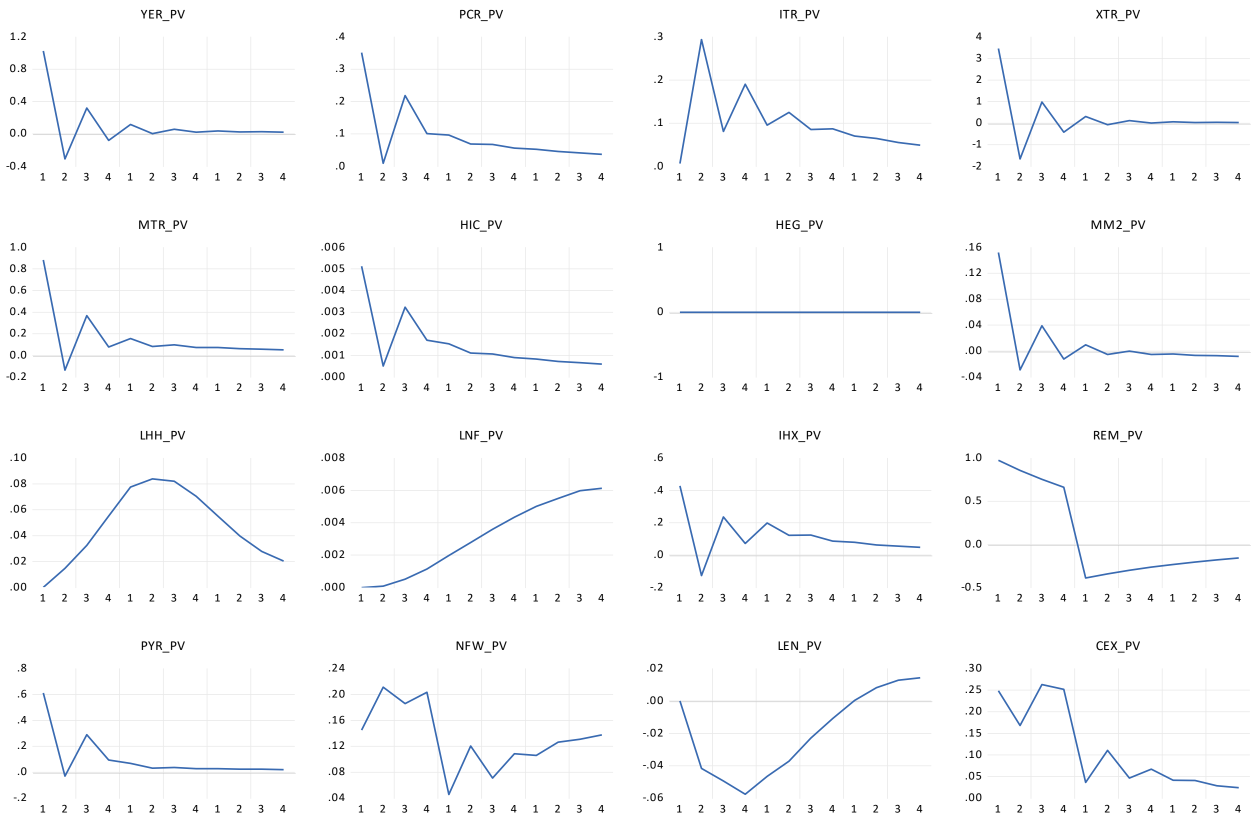
In this chapter we present the IRFs for 5 different shocks, three being of the above described first type of shock, and two of the third type. The second type of shock will not be presented as the interpretation is rather complicated. Presented is the reaction of a selected group of the most relevant endogenous variables, for the simulation horizon of 12 quarters. All shocks are assumed to be temporary, lasting one quarter, standardized to 1%, or 1 percentage point, or 1% of GDP for easier interpretation and comparison.

4.1.1 Foreign demand shock

The response function on the impulse of foreign demand (the EU GDP shock), illustrated in Figure 1, indicates that the assumed shock to the exogenous variable primarily affects export and remittances. Indirectly, it affects almost all other endogenous variables in the Model. The reactions of variables to the shock are generally of the expected direction. A positive shock will rise total economic activity, and increase growth of the key macroeconomic indicators as a consequence of demand for BH export.

If different channels of the shock propagation are compared, one can conclude that an external stimulus, apart via export, also has an effect via income from the remittances, which directly influences the disposable income of household, and, indirectly, the GDP. It is estimated that a positive shock of foreign demand, in the first instance, increases export by just over 3%, but due to rising prices, it partly diminishes in the following quarter. The responses through the rest of the horizon are not straight forward, but reflect a series of adjustments. The same dynamics can be observed in the case of GDP, and ever more pronounced in the cases of private consumption, import and investments. At the end of the forecast horizon, changes in the real variables will be reverting to zero, but for some variables it may take 4 to 5 years (the entire horizon is not shown on the Figure 1 below) to return to the pre-shock levels. Such adjustment is expected if the model is stationary, as a transitory single shock should not have long-lasting consequences to the Model.

Figure 1: The IRF on temporary positive shock of foreign demand (EU GDP) by 1%



Source: Author's calculation.

Inflation reacts positively to the shock, with similar dynamics as personal consumption, implying that foreign demand shock affects the prices mainly through demand side, that is, through the Phillips curve. It is important to emphasize that the external sector itself was not explicitly modelled, but the emphasis is placed on the transfers of foreign onto domestic variables. The foreign demand shock is perceived as an isolated increase in foreign GDP, without indirect effects on foreign prices and foreign interest rates. In reality, foreign prices and interest rates would also adjust and additionally influence domestic prices and interest rates. For that reason, some variables, such as transport prices, will not react as they depend on foreign prices that are exogenous in this shock.

Labor market variables also react to the foreign demand shock, as increased economic activity of BH companies will require more employees, but with a substantial lag. As illustrated in figure above, that number of employed persons (LEN) initially declines, and does not start to rise for two years, which is caused by the short-term increase of productivity (higher GDP for the same input), deferring the positive effect on employment. The equilibrium is restored after several years. The response of nominal salaries (CEX) is slightly different, as in this model employees seek higher wages immediately due to improved economic conditions, increased productivity, but also because of rising the overall price level.

Financial variables also react positively. Monetary aggregate M2 and the residential real estate prices, unlike loans, closely follow the dynamics of GDP. As a rule, loans require longer period for repayment. A rise in lending activity in the initial period, which is a consequence of perceived improvement of creditworthiness of banks' clients, should require far longer period to revert to the equilibrium. In the case of households, the adjustment lasts about 4 years, and in the case of enterprises, even longer.

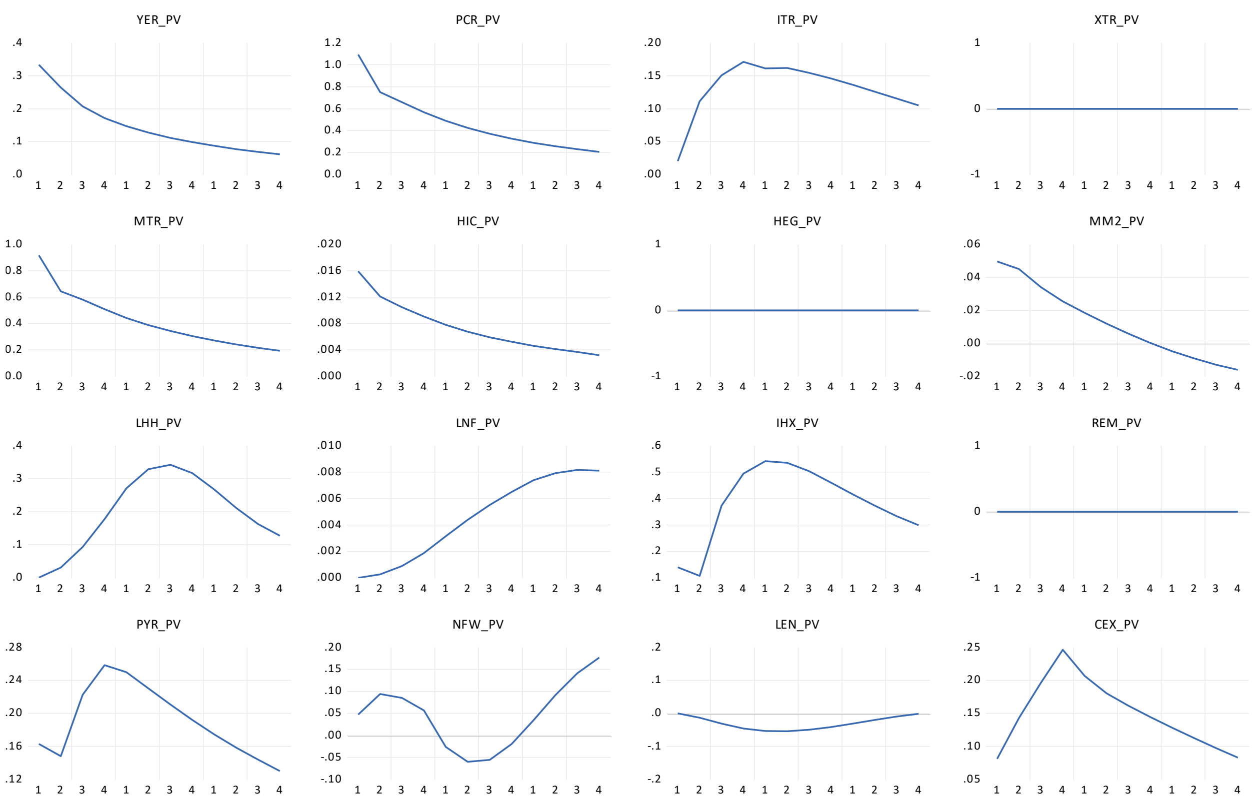
4.1.2 Government Expenditure Shock

The government expenditure shock may be especially interesting to the professional and academic community, as it indicates potential positive and negative consequences of the expansionary fiscal policy. The COVID-19 pandemic is expected to significantly increase government expenditures, thus widening the budget deficit, and rising the public debt. Consequently, the expected slowdown of economic activity should be, to a certain extent, muted. This Model is an adequate tool for quantifying the effect of the assumed scenario. We illustrate here the responses on the rising general expenditure impulse in one quarter, standardized to the magnitude of one percent of GDP. The shock can easily be rescaled (linear model) to any desired positive or negative value.

The IRF clearly indicates that an expansionary fiscal shock will affect most of the endogenous domestic variables, except for those which are dependent exclusively on foreign variables. In other words, this is a purely domestic shock. It is important to note that the government expenditure is exogenous in the model, so this is the type one shock, as described above. This shock propagates through the economy directly via two channels: the GDP via the national accounts identity, and; via budget deficit identity. The effect of the shock on all other variables is indirect. Higher GDP results in rising investments, via the accelerator effect, and also stimulates import, as domestic demand intensifies.

On the other side, personal consumption is expected to drop mildly, as a result of two forces. The first one is a drop in wages and employment in private sector, as a consequence of crowding out effect which diminishes disposable income in the current structure of the model. However, the effect on wages and employment is expected to flip in later periods, once the positive effect begins to prevail. The second force behind the initial drop in personal consumption is an increase in interest rates due to rising risk premium risk (higher government expenditure widens deficit, exerting an upward pressure on the interest rate). Consequently, consumption in the current period is deferred, borrowing falls, and saving increases. The interest rate effect is expected in the case of investment as well, but demand effect is expected to prevail due to stronger elasticity of investment on the economic cycle (GDP), increasing investments in the short run.

Figure 2: The IRF on temporary positive shock of government expenditure of 1% in GDP



Source: Author's calculation.

The difference between enterprises and households is also noticeable in the case of loans. Intensified investments increase demand for loans by the enterprises, while the households decrease demand for loans. This behavior of households is also evident from the pattern in the average price of the residential real estates. Following the initial speculative spike, the response of the average price falls below zero, and very slowly returns to the equilibrium. The consumer prices were not found to have a significant reaction to reduced personal consumption.

4.1.3 Consumer confidence shock

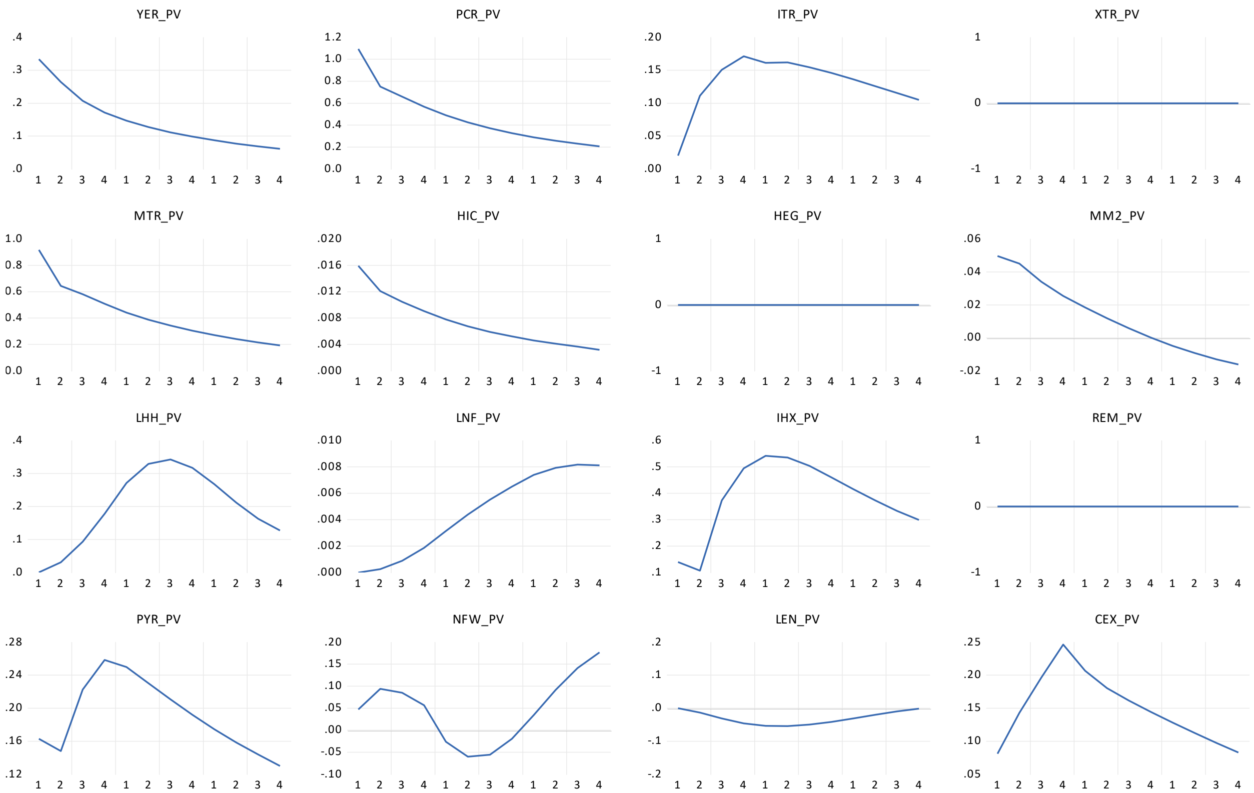
The consumer confidence shock is often analyzed in macroeconomic models. This is an exogenous, temporary increase in consumption, unfounded in macroeconomic fundamentals. We also calibrate it as a one percent positive shock that affects the personal consumption equation. It was implemented as the type 3 shock, as described above, that is, as a temporary consumption equation add-on. Again, we emphasize that this is not entirely a structural shock, given the type of model used.

The shock propagates through the economy via the national accounts identity by increasing the GDP which then has an effect on other endogenous variables. Other channels of propagation are via the Phillips curve triggering the price increase, and via the loans to households equation and higher indebtedness of households.

Higher GDP, through the accelerators, attracts larger investments, and higher import, which deteriorates the trade balance. Stronger lending activity, on the other hand, leads to an increase in M2, but also additionally supports growth of investments in the residential real estate, pushing their prices as well. Total increase in the economic activity and consumer prices will lead to an increase in nominal wages, and two quarters later, the real wages as well. On the other hand, the employment drops mildly since the increase in the personal consumption is completely exogenous, and is not a result of an improvement in the economic fundamentals. Consequently, the enterprises will not immediately recruit more employees. But, as said earlier, this reduction in employment is negligible. The economic growth and higher private investments will also lead to an increase in lending to enterprises.

The difference in the speed of the convergence towards the equilibrium is noticeable between real and financial variables. The real variable converge relatively fast, within the forecasted horizon or after a few quarters, while the financial variables converge much slower. The trajectory of the convergence is also very interesting, especially if compared to that following the foreign demand shock. In the case of foreign demand shock, the trajectory was everything but straight forward because of dynamics in exports. Here, the convergence is even and more gradual as a consequence of the consumption smoothing.

Figure 3: The IRF on temporary shock (add-on) of personal consumption of 1%



Source: Author’s calculation.

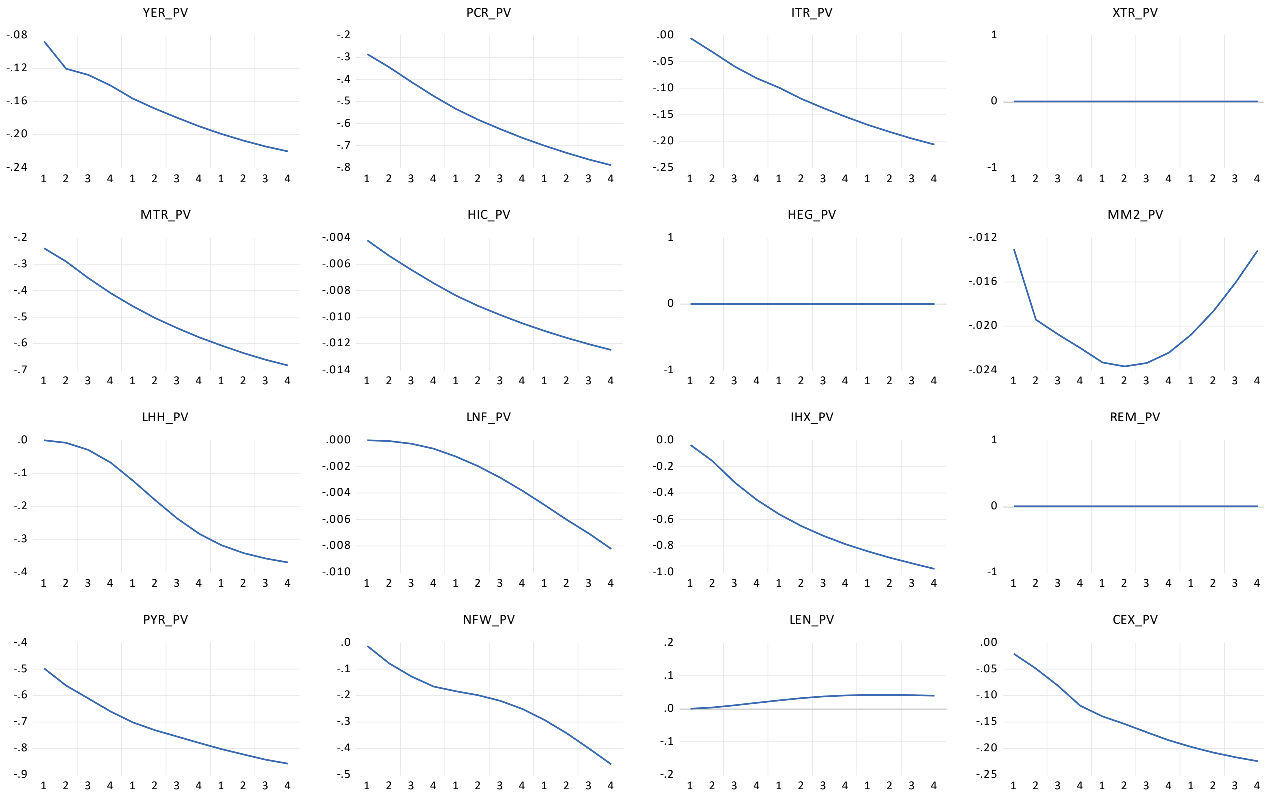
4.1.4 Shock of the implicit income tax rate

We chose to present the effects of another fiscal shock, this time on the budget revenue side. The shock on income tax rate was calibrated to 1 percentage point. Although the used tax rate does not correspond to the official income tax rate, it can be approximately interpreted as a parallel increase in the income tax rate, in all tax classes, and in both geo-political entities by 1 percentage point[5]. It is also important to note that, unlike the previous shocks, the shift in tax rate is permanent, and not

[5] The implicit tax rate was generated by dividing the tax revenues by the tax base. In the case of income tax, we divided total revenues from income tax by the nominal wage bill.

temporary. For that reason we expect the convergence of the IRFs towards a certain value, and not towards zero as it was previously the case.

Figure 4: The IRF on shock of permanent increase of income tax implicit tax rate of 1 percentage point



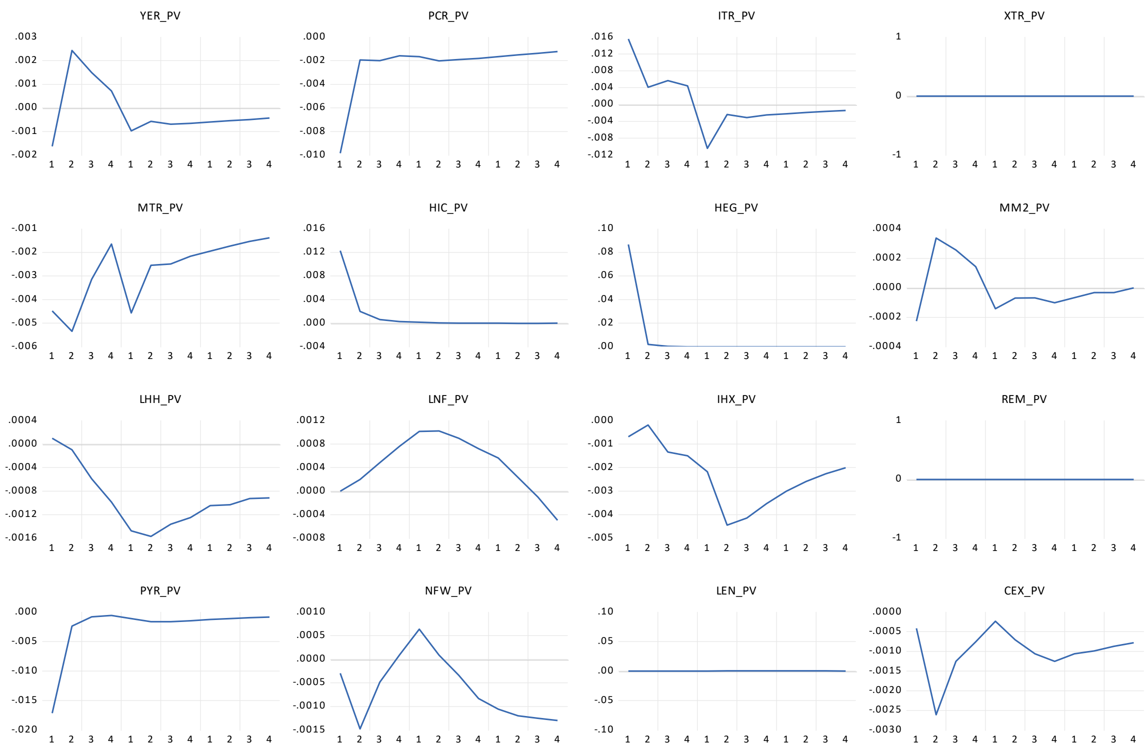
Source: Author's calculation.

The shock propagates through the economy via the decrease in disposable income, i.e., via the decrease in net wages, while the gross wages remain intact. Figure 4 below indicates a decline in disposable income (PYR), which causes a decline in personal consumption of the same dynamics, but somewhat smaller percentage (as the marginal propensity to consume is less than 1). Consequently, a decline in personal consumption reduces the GDP, investment and import, and then almost all other variables in the Model. Again, the financial variables decline with a certain lag compared to the real variables. The prices (consumer and residential real estate) also decline as a consequence of reduced aggregate demand. An aggregate decline in the GDP over the period of three years following the shock is expected to be around 0.22%.

4.1.5 The global oil prices shock

The last shock illustrated in this paper is an oil shock, that is, an increase in the global crude oil prices by 1%.[6] In this case, the shock is temporary, to an exogenous variable, which does not affect other exogenous variables.

Figure 5: The IRF on temporary shock of increase in global oil prices by 1%



Source: Author's calculation.

Unlike all other presented shocks, this shock can be regarded as the supply side shock. The shock propagates through the Model via the equation of transport prices, and affects the aggregated level of the consumer prices in the same quarter. All other reactions stem from these changes. Initially, there is a drop in personal consumption, as a result of a drop in disposable income. A decline in personal consumption is transferred to the decline in GDP. However, GDP initially that becomes positive, albeit briefly, as a consequence of the reactions of investments and import. Investments grow in the

[6] This is an illustrative example, with a relatively small shift in oil prices. If there is a need to estimate the effects of a stronger oil price shock, it is possible to rescale the IRFs as the model is linear.

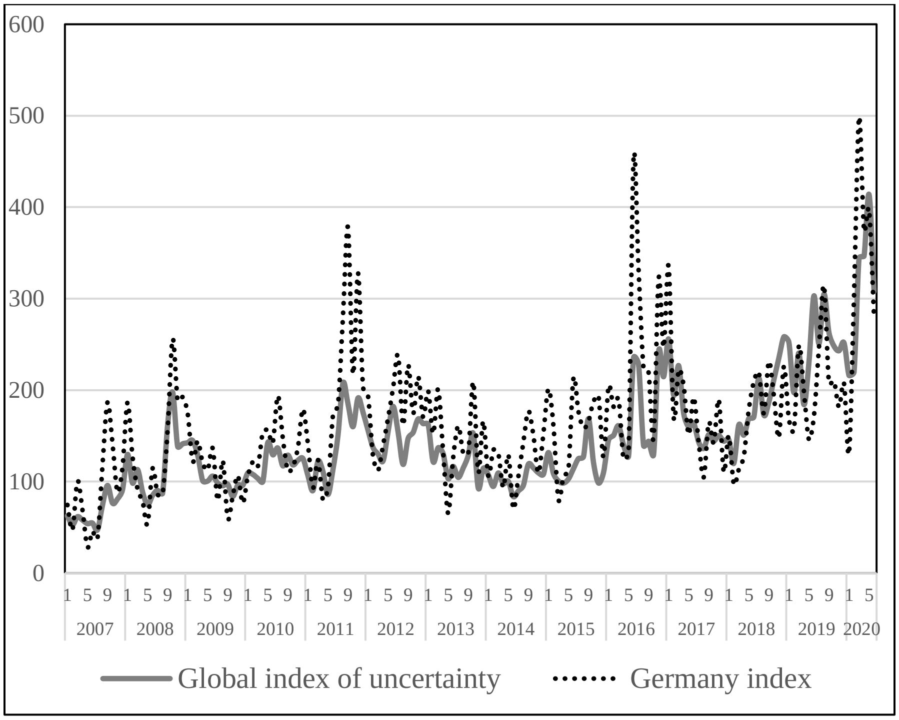
short run since the real interest rate declines (higher prices, with unchanged nominal interest rate). This is a shortcoming of the models that lack rational forward-looking expectations, and does not have the monetary policy that that sets the interest rates, bearing in mind the inflation (the Taylor rule). As a result of the increase in investment, lending to enterprises will also rise over a certain period of time. Consequently, the money supply will rise as well. However, the trends will revert soon, and the IRF will go into negative territory. Lending to households, demand for the residential real estate, and the average prices of the real estate also gradually decline.

4.2 Model forecasting in times of uncertainty

The role of uncertainty in the business cycle is getting more prominent in recent time. Along with standard uncertainty at the firms' level and financial uncertainty, Baker et al. (2015) suggest the possible role for the policy uncertainty. According to the same source, one must distinguish between uncertainties as an endogenous mechanism, from that as an independent source of macroeconomic shocks. Besides the American Trade Policy Uncertainty Index, an American Global Reliability Index was created several years ago, , as well as the country indices that monitor uncertainty with respect to a certain category such as trade, monetary policy, healthcare or national security. Both the American Global Reliability Index and German Reliability Index suggest the extraordinary rise if uncertainty during the pandemic (Figure 6).

COVID-19 pandemic caused an enormous uncertainty shock, exceeding the one during the financial crisis. Baker et al. (2020) report sharp increase in uncertainty, almost in real time, by measuring the stock market volatility, economic uncertainty based on the newspaper articles, and by aggregating the survey responses analysis on indicated uncertainty at the business level. According to this research, COVID-19 pandemic is expected to cause a major contraction, where more than a half of it is a consequence of the economic uncertainty. An estimate of the economic impact of the pandemic is of crucial importance for the policy makers, which is a challenging task, as the crisis unfolds remarkably fast. Furthermore, the estimates of all economic trends, including those from our model, assume a relative improvement of the healthcare crisis. Any further deterioration in the healthcare shall further deepen the economic crisis and dispute the forecasts.

Figure 6: The Reliability indices



Source: www.PolicyUncertainty.com

For the aforementioned reasons, we present the forecasts of the macroeconomic variables that, in addition to baseline forecast, also include expert judgements in a form of add-on shocks. It is also important to emphasize that presented forecasts are produced based on the available data and exogenous forecasts from May 2020. By the time this working paper was published, some assumptions changed, while the uncertainty did not reduce significantly. For those reasons, the presented results are solely for the illustrative purpose.

The final forecasts of the selected variables are presented in Table 4.2. As already emphasized, the forecasts are the result of the model, assumptions, and minor expert judgements in a form of add-on shocks, which are common in similar models. The Model was estimated for the period through 2019Q4, while the forecast is for the period 2020 through 2022. One must emphasize that the forecasts were made under the extraordinary circumstances, at the dawn of COVID-19 pandemic, when most countries, BH included, special measures aiming to contain the spread of the virus, were enforced, and when economic activities was confined globally. Therefore, such model of a small, open economy is guided by the assumed global recession and the fiscal policy intervention. In that respect, the forecast errors in these assumptions are directly transmitted to domestic variables, given the model setting of an open economy. The forecasts of world economies were changing significantly over a very short period of time, making the forecasting process challenging. On one hand, various assumptions were being imposed, but one also had to understand how these changes in the assumptions could affect the final forecasts. Taking into consideration the aforementioned, presented forecasts should be taken with higher uncertainty than the forecasts from the more tranquil periods (Appendix 3 and Appendix 4).

Table 2: Projections of the selected macroeconomic variables

	2017	2018	2019	2020	2021	2022
		(annual growth rate)				
Real GDP	3,3	3,4	2,6	-5,0	3,8	2,1
CPI	1,2	1,4	0,6	0,2	0,8	0,8
Loans to households	6,7	7,3	7,9	1,8	1,8	4,2
Loans to enterprises	8,0	3,7	5,4	0,5	2,2	2,2
		(in % of GDP)				
Personal consumption	76,1	75,3	75,2	76,3	72,8	71,7
Government consumption	20,2	19,7	19,6	23,1	23,1	23,1
Investments	20,6	20,9	21,6	22,4	22,8	23,7
Net export	-16,8	-15,9	-16,4	-21,8	-18,8	-18,5
		(annual growth rate)				
Average net wages	1,5	3,3	4,8	-0,9	3,2	4,2
Employees	3,2	2,5	2,6	-1,6	0,1	2,2
M2	9,8	9,5	8,7	5,8	6,8	6,7
Real estate prices	-1,2	5,6	7,1	-4,2	-2,7	1,0
Unemployment rate (implicit)	38,4	36,0	33,3	33,9	33,7	31,9
NPL (end of period)	10,0	8,8	7,4	7,2	7,2	7,1

5 Conclusion

This paper is a technical description of the semi-structural macroeconomic model of a small, open economy with BH country specifics included. It is the first attempt of a comprehensive and consistent modelling of BH economy. To our knowledge, this is the first all encompassing, consistent, domestically developed model of the BH economy. The primary purpose of the model is production of the consistent medium-term forecasts. The paper provides a detailed description of the model structure, including all estimated behavior equations, identities, exogenous and endogenous variables, and simulations in a form of the impulse response functions and three year forecasts.

Development of the Model proved possible to build a consistent model, capable of providing forecasts of the selected macroeconomic variables, despite the environment of fairly short time series, significant volatility of the series, structural breaks and changes in methodology, and, occasionally, missing data for which the unobservable data series had to be created. Under the circumstances of major changes, such are those caused by the COVID-19 pandemic since early 2020, the forecasting was increasingly more difficult. As the role of the business cycle uncertainty is getting more prominent recently, it is something that should be factored in the forecasts, to the extent possible. For that reason, we described some of the possibilities to include expert judgements in a form of exogenous variables or add-ons.

The secondary purpose of the Model is for the scenario analysis and the impulse response function analysis. The scenario analyses can be very useful for the construction of the stress tests scenarios, but also for the estimates of the impacts that various policies have on the economy. The impulse response functions, despite the fact that they do not show reactions to real structural shocks, can graphically illustrate dynamic features of the Model, and the interlinkages amongst variables from which one can get a better grasp of the BH country specifics. These information can be useful for the professional and academic community. The paper briefly comments on the reactions of the chosen variables to five standard shocks, but a reader can identify, from the illustrated responses, other peculiarities worth investigating in more detail. Therefore, the Model is not exclusively a forecasting tool, but also a learning tool on the BH shaped in a relatively consistent and clearly structured manner, within the integral model.

The model presented in this paper is of a very flexible structure, and very convenient for the further upgrades. Apart for the listed by the estimated equations, the future improvements of the Model could focused on the mechanisms for the adjustments towards the equilibrium, and the cointegration analysis. The first step forward will be further improvement of the financial block of the Model, with stronger interlinkages between the real economy and financial sector.

6 Literature

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7 The Appendices

Appendix 1: The list of variables

Abbreviation	Variable	Category	Source
CAN	Current account balance (national account)	I	CBBH
CER	Real average gross wages	I	CBBH
CEX	Nominal average gross wages	I	CBBH
COE	Cost of employees	I	BHAS
CPE	Product of unit labor cost and productivity	I	BHAS
CUS	Customs receipts	I	UINO
DDR	Real domestic demand	I	CBBH
DEF	Deficit	I	CBBH
DTH	Income tax revenue	I	CBBH
EER	Real effective exchange rate	I	CBBH
GCD	Government expenditure deflator	I	BHAS
HAA	Financial wealth (deposits) of households	E	CBBH
HCL	Clothing and footwear prices	E	CBBH
HEF	CPI without food, energy and administrative prices	E	CBBH
HEG	CPI energy	E	BHAS
HHA	Housing capital	I	CBBH
HIC	CPI total	I	BHAS
HIF	CPI food	E	BHAS
IHN	Nominal investment in housing	I	CBBH
IHR	Real investment in housing	E	CBBH
IHX	Housing prices	E	CBBH
INP	Interest expenses	E	CBBH
ITD	Investment deflator	E	BHAS
ITN	Nominal investment	I	BHAS
ITR	Real investment	E	BHAS
KSR	Capital	I	CBBH
LAX	Activity rate	E	BHAS
LEN	Employees	I	BHAS
LFN	Workforce	I	BHAS
LHH	Loans to households	E	CBBH
LNF	Loans to non-financials firms	E	CBBH
LNT	Labor supply trend (input of work in potential GDP)	I	CBBH
LPT	Activity rate trend	I	CBBH
MM2	Monetary aggregate	E	CBBH
MTD	Import deflator	E	BHAS

MTN	Nominal import	I	BHAS
MTR	Real import	E	BHAS
NFW	Net financial wealth	I	CBBH
NPL	NonF-preforming loans	E	CBBH
OOR	Other budget revenue	I	CBBH
OPN	Other income	I	CBBH
OTX	Other tax revenue	I	CBBH
PCD	Personal consumption deflator	E	BHAS
PCN	Nominal personal consumption	I	BHAS
PCR	Real personal consumption	E	BHAS
PDF	Primary deficit	I	CBBH
PDV	Value added tax revenue (VAT)	I	UINO
PRO	Productivity	I	CBBH
PYN	Disposable household income (nominal)	I	CBBH
PYR	Disposable household income (real)	I	CBBH
REM	Remittances	E	CBBH
SCE	Contribution income	I	CBBH
SNH	Nominal deposit interest rate to households	E	CBBH
STN	Short term interest rate	E	CBBH
SVR	Households savings	I	CBBH
TAX	Tax revenues	I	CBBH
TIN	Indirect tax revenues	I	UINO
TIR	Other indirect tax revenues	I	UINO
TNB	Nominal loan interest rate to non-financials firms	E	CBBH
TNH	Nominal loan interest rate to households	E	CBBH
TOOR	Implicit rate of other budget revenues	I	CBBH
TRB	Real loan interest rate to non-financials firms	I	CBBH
TRH	Real loan interest rate to households	I	CBBH
UCC	Unit cost of capital	I	CBBH
ULA	Unit cost of labor	E	CBBH
UNX	Number of unemployed persons	I	BHAS
URT	Unemployment trend (NAIRU)	I	BHAS
URX	Unemployment rate	E	BHAS
WIN	Gross wage bill (nominal)	I	BHAS
WIR	Gross wage bill (real)	I	BHAS
WLN	Total household wealth (nominal)	I	CBBH
WLR	Total household wealth (real)	I	CBBH
WON	Net wage bill (nominal)	I	BHAS
WOR	Net wage bill (real)	I	BHAS
WRN	Average net wages (nominal)	I	BHAS
WRR	Average net wages (real)	I	BHAS

XTD	Export deflator	E	BHAS
XTN	Nominal export	I	BHAS
XTR	Real export	E	BHAS
YED	GDP deflator	I	BHAS
YEN	Nominal GDP	I	BHAS
YER	Real GDP	I	BHAS
YET	Potential GDP	I	CBBH
YGA	Output gap	I	CBBH
	Total variables	84	
	Of which:		
	Identities (I)	56	
	Estimated equations (E)	28	

Abbreviation sources: BHAS – Statistics Agency of BH; CBBH – Central Bank of BH; UINO – Indirect Taxation Authority; ECB – European Central Bank; EC – European Commission; IMF – International Monetary Fund; CMEGROUP - https://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html; CBOE - http://www.cboe.com/vix; EURIBOR - https://www.euribor-rates.eu/.

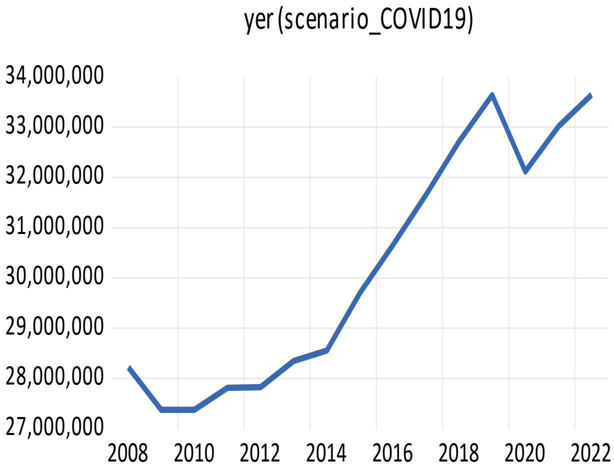
Appendix 2: The list of identities

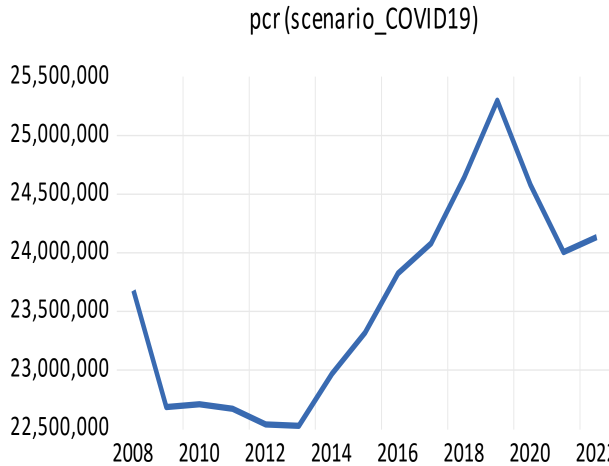
Abbreviation		
CAN	=	XTN-MTN
CER	=	CEX/HIC
dlog(CEX)	=	dlog(CPE)-dlog(1+TSCE)
COE	=	CPE*LEN
CPE	=	ULA* ((PRO+PRO(-1) +PRO(-2) +PRO(-3))/4)
CUS	=	TCUS*MTN
DDR	=	PCR+ITR+GCR
DEF	=	UMT-TOR
DTH	=	TDTH*WIN
EER	=	EEN*FCP/HIC
GCD	=	GCN/GCR
HHA	=	(1-deltaH)*HHA(-1) + IHR
HIC	=	dlog(HAT)*w_HAT + dlog(HEG)*w_HEG + dlog(HEF)*w_HEF + dlog(HIF)*w_HIF + dlog(HCL)*w_HCL
IHN	=	IHR*ITD
ITN	=	ITR*ITD
KSR	=	KSR(-1)*(1-delta)+ITR
LEN	=	(1-URX)*LFN
LFN	=	LAN*LAX
LNT	=	(1-URT)*LAN*LPT
LPT	=	(LAX+LAX(-1)+LAX(-2)+LAX(-3)+LAX(-4)+LAX(-5)+LAX(-6)+LAX(-7))/8
MTN	=	MTR*MTD
NFW	=	HAA-LHH
OOR	=	TOOR*YEN
OPN	=	HHA*IHX*0.05 +0.3*yen
OTX	=	TOTX*YEN

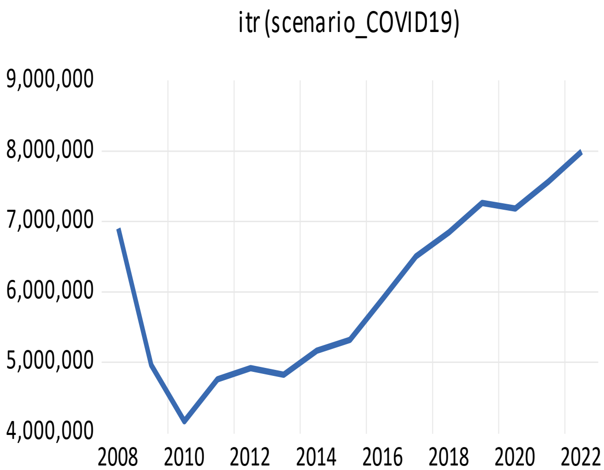
PCD	=	PCN/PCR
PDF	=	UMO-TOR
PDV	=	TPDV*PCN
PRO	=	YER/LEN
PYN	=	WON+REM+OPN
PYR	=	PYN/HIC
SCE	=	(COE*TSCE)/(0.65*0.105/0.415)
SVR	=	(PYN-PCN)/PCN
TAX	=	TIN+OTX
TIN	=	PDV+CUS+TIR
TIR	=	TTIR*PCN
TOOR	=	TAX+SCE+OOR'+DTH
TRB	=	TNB-(HIC-HIC(-4))
TRH	=	TNH-(HIC-HIC(-4))
UCC	=	(TRB+0.02)*(1+TOOR +TSCE)'0.5*TRB + 0.25*TOOR + 0.25*TSCE
UNX	=	URX*LFN
URT	=	urxf.hpf
dlog(WIN)	=	dlog(CEX)+dlog(LEN)
dlog(WIR)	=	dlog(CER)+dlog(LEN)
WLN	=	NFW+HHA*IHX
WLR	=	WLN/HIC
WON	=	WIN-DTH
WOR	=	WON/HIC
WRN	=	WON/LEN
WRR	=	WOR/LEN
XTN	=	XTR*XTD
YED	=	YEN/YER
YEN	=	PCN+ITN+GCN+XTN-MTN

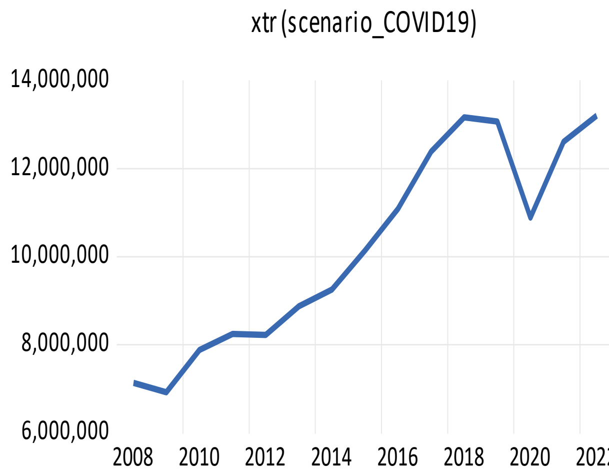
YER	=	PCR+ITR+GCR+XTR-MTR
YET	=	KSR^0.35*LNT^0.65*TFT
YGA	=	YGA=YER/YET-1

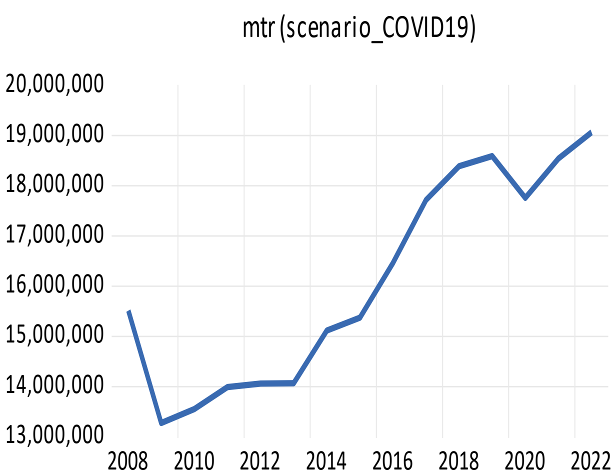
Appendix 3: Forecast of National Account and Income from Remittances

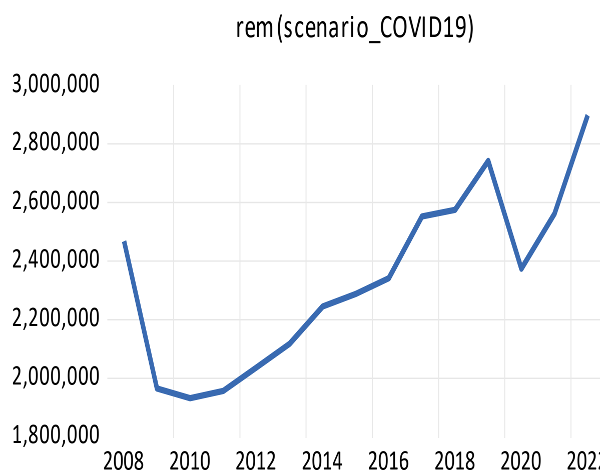












Appendix 4: Forecast of other variables