124

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Can we predict the future?

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Tomas Miklosovic is thankful for support from the EU project 'Next Generation EU through the Recovery and Resilience Plan for Slovakia' No. 09I03-03-V04-00536.

Can we predict the future?

ABSTRACT

There is a need to improve various forecasting tools for various times of crisis, such as the COVID-19 pandemic, the war in Ukraine, and the energy crisis. The key forecasting tools used in various countries include macroeconomic forecasting models in the short to medium term. The applications and development of such models have been studied for a long time at the Institute of Economic Research of the Slovak Academy of Sciences (IER SAS). This paper is divided into two parts. The first part describes the improvements of the econometric error correction model designed at the IER SAS for the purpose of making macroeconomic forecasts. In this section, the basic econometric equations are also presented, as are the individual parametric estimates. The second section presents the validation of the model, which consists of introducing several fiscal shocks to the economy. This section presents the results for selected macroeconomic variables resulting from the introduction of specific shocks.

KEYWORDS: medium-term forecast, error correction model, endogenous, government block, exogenous shocks
JEL CLASSIFICATION: C51, C53, E17

Dokážeme predpovedať budúcnosť?

ABSTRAKT

V aktuálnej dobe je nevyhnutné zdokonaliť prognostické nástroje pre rôzne krízové situácie, ako je pandémia COVID-19, vojna na Ukrajine alebo energetická kríza. Kľúčové prognostické nástroje používané v rôznych krajinách zahŕňajú makroekonomické prognostické modely v krátkodobom až strednodobom horizonte. Aplikácie a vývoj takýchto modelov sa dlhodobo skúma na Ekonomickom ústave Slovenskej akadémie vied (EÚ SAV). Tento článok je rozdelený na dve časti. Prvá časť opisuje vylepšenia ekonometrického modelu korekcie chýb navrhnutého na EÚ SAV na účely makroekonomického prognózovania. V tejto časti sú tiež uvedené základné ekonometrické rovnice, ako aj jednotlivé parametrické odhady. Druhá časť predstavuje validáciu modelu, ktorá spočíva v zavedení niekoľkých fiškálnych šokov do ekonomiky. V tejto časti sú uvedené výsledky pre vybrané makroekonomické premenné vyplývajúce zo zavedenia konkrétnych šokov.

KĽÚČOVÉ SLOVÁ: strednodobá prognóza, medium-term forecast, model korekcie chýb, endogenita, vládny blok, exogénne šoky
JEL KLASIFIKÁCIA: C51, C53, E17

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Contents

Introduction

Econometric modelling has long been a fundamental tool for understanding economic systems, assessing policy impacts, and forecasting macroeconomic trends. By formalizing economic relationships into mathematical frameworks, these models enable analysts to simulate scenarios, evaluate the effects of fiscal policies, and anticipate economic fluctuations. As a key component of economic forecasting, econometric modelling provides a structured approach to analysing interactions between macroeconomic variables such as consumption, investment, and foreign trade, making it essential for policymakers and economic strategists.

Macroeconomic forecasting plays a significant role in economic planning and decision-making, offering insights that support a wide range of applications, such as decision-making on the basis of data, economic stabilization through government policies, fiscal planning, monitoring of economic targets and maintaining a supportive investment climate. Forecasts inform governments, businesses, and investors in planning resource allocation and setting economic priorities (Blanchard, 2020; Mankiw, 2020). By identifying potential changes in trends, inflationary pressures, or financial imbalances, forecasts contribute to timely policy interventions (Reinhart & Rogoff, 2009). Projections of economic growth and inflow of revenues help guide budgetary decisions on public investments, social support, and infrastructure construction (IMF, 2014). Forecasting models help track progress towards macroeconomic goals, such as reducing unemployment or maintaining price stability (OECD Economic Outlook, 2020). Finally, reliable macroeconomic predictions enhance investor confidence, fostering both domestic and foreign investment inflows (World Bank, 2017).

In Slovakia, econometric models have been widely applied in macroeconomic forecasting and policy evaluation. Institutions, such as the Ministry of Finance, the National Bank of Slovakia (NBS), and the Council for Budget Responsibility (CBR), employ sophisticated econometric frameworks to assess economic developments and simulate fiscal policy impacts (Priesol, 2021; Relovsky & Siroka, 2009; Klucik, 2015). These models rely on a neoclassical production function for long-term trend estimation and incorporate short-term dynamics using an error correction approach (ECM). In a different type of model representation, a DSGE is used for medium-term forecasting, and a microsimulation model is used for fiscal policy simulations in CBR (Mucka, 2016; Siebertova, Svarda, Valachyova, 2015). NBS employs a DSGE model for medium-term forecasting as well (Vyskrabka, Zeleznik, Tvrz, 2019). However, econometric models are more suitable for standard medium-term forecasts because of their ability to align with official macroeconomic time series used for policy decisions.

By refining econometric modelling techniques and incorporating recent macroeconomic developments, this paper contributes to the ongoing efforts to improve the accuracy and policy relevance of macroeconomic forecasts in Slovakia. This paper presents an updated ECM-based econometric model, building on the framework of Radvansky et al. (2010). The revised model introduces several enhancements:

- **Improved short-term forecasting** – Refining error correction mechanisms across economic sectors by expanding the dataset, a new parameter estimation.
- **Enhanced fiscal policy representation** – A newly integrated government block better captures fiscal policy effects on aggregate demand, reflecting recent economic policy shifts.
- **Refined investment modelling** – The investment demand block incorporates evolving trends in capital formation, including external shocks such as EU Recovery and Resilience Plan funds.
- **Upgraded trade modelling** – Foreign trade dynamics are adjusted to reflect shifting global demand conditions, incorporating a broader range of trade partners and their respective weights in external demand calculations.
- **Alignment with recent economic developments** – The demand-side components are recalibrated to account for business cycle variations, incorporating events such as the COVID-19 pandemic, the energy crisis, and inflationary shocks.

In terms of economic theory, the model is in line with the New Keynesian perspective, integrating short-run demand fluctuations with a neoclassical long-run equilibrium. In the long term, it assumes that firms optimize supply through profit-maximizing behaviour, which is consistent with neoclassical theory. However, in the short run, demand-side factors play a crucial role in shaping economic dynamics. The model ensures that key economic variables evolve in line with optimizing decisions made by agents operating under realistic budget constraints. This is achieved through detailed modelling of the financial constraints faced by governments, households, and private firms, which are essential for evaluating fiscal policy strategies effectively.

While long-term supply relationships are firmly based on economic theory, short-term demand dynamics rely on empirical data and estimated behavioural equations. The model assumes adaptive, backwards-looking expectation formation, reflecting real-world decision-making patterns. Short-term supply and demand interactions are influenced by nominal rigidities, with price adjustments serving as the primary mechanism to balance economic forces. Additionally, the model maintains a stable trajectory for government revenues and expenditures and does not incorporate endogenous fiscal rules. Thus, empirically, the model assumes no policy change over the projection horizon. Fiscal adjustments and alignment with targeted debt and deficit levels are allowed through the assignment of specific policies on either the revenue side or expenditure side of the public budget.

The introduction is followed by the model description. An overview of the model offers a more detailed description of the main blocks of the model—the external environment, GDP and its structure, the labour market, prices and the government block. Model evaluation is based on responses to demand, supply, and fiscal policy shocks followed by a review of fiscal multipliers.

1. Model description

The version of the econometric model SAS_B_IER_ECM_24q2 is based on quarterly nonseasonally adjusted data from 1995q1 to 2024q2; it includes the maximum of 118 observations and is roughly double the size of the former model[1]. The database includes National Accounts data from the Statistical Office of the Slovak Republic, financial data from the National Bank of Slovakia and accrual data of the public budget of the Ministry of Finance of the Slovak Republic. Additional data on foreign trade are gathered from the databases of Eurostat and the International Monetary Fund (IMF).

The model builds on five blocks: GDP and its components, the price block, the labour market block, the public budget block and the foreign trade block. Overall, the model contains 45 behavioural equations with 108 endogenous and 45 exogenous variables. Two unobserved variables—the output gap and unemployment gap—are based on the HP filter to capture the business cycle state of the economy and possible price and labour market pressures. Forecasts of potential GDP and employment are exogenous in forecasting exercises, converging towards the equilibrium zero output gap and the natural unemployment rate on the basis of European Commission estimates (AWG, 2024).

As mentioned above, stochastic equations have the form of an error-correction mechanism (ECM). First, a particular cointegrated long-term relationship is found for basic endogenous variables. Second, deviations based on a short-term correction mechanism are allowed to adjust towards long-term equilibrium. Note that it is based on a two-step Engel–Granger approach, and we do not report the test results (ADF) due to capacity limitations. For Johanson's approach, large samples are required for reliable results, i.e., much longer time series, which is why we chose Engel–Granger. The model allows both immediate impacts and gradual adjustments to be captured, making it useful for studying dynamic systems. In the next section, the basic blocks of the model are described in more detail.

1.1 External environment block

Exports are driven by foreign demand, and imports depend primarily on domestic demand. Their elasticities reflect the economy's openness and dependence on trade. The ECM adjusts trade flows on the basis of deviations from long-term equilibria, ensuring that exports and imports gradually align with stable income and demand levels.

Exports are highly elastic to foreign demand (Eq. 1) and are expected to align with trading partners' imports in the long run. At this point, the time openness of the economy becomes constant in relation to GDP. Export volumes can change in the short term due to a loss/win of competitiveness stemming from relative price changes and relative labour productivity. Currently, large deviations are observable in the development of export volume and foreign demand. This is due mainly to expanding/contracting domestic automotive production capacity,

[1] Radvansky et al. (2010) included 60 observations over the sample 1995q1 to 2009q4.

changes in price competitiveness, and the diminishing significance of the export capacity of steel products and electronics. The development since the pandemic crisis has manifested in a loss of foreign markets (Figure 1).

Figure 1
Lagging Slovak exports (real value), nsa, 2019=100)

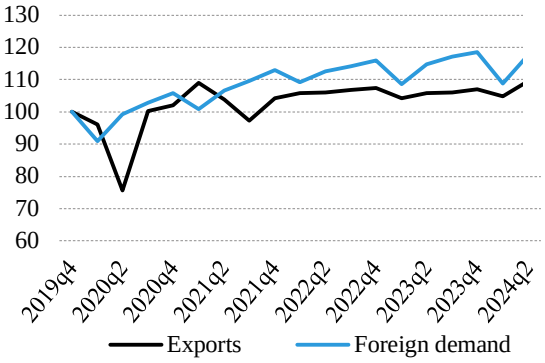
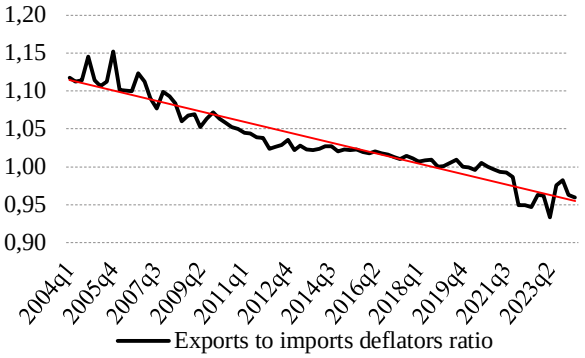


Figure 2
Increase in the price competitiveness of Slovak foreign trade (ratio, levels, linear trend line)



Source: SO SR, NBS, SAS

Exports are aligned with foreign demand (IIMP14Q). Gaining foreign markets is attained through advancements in labour productivity (LPROD) compared with our trading partners (FLPROD). Prices development abroad (FPMGSR) can cause fluctuations in real exports in the event of different development compared with domestic export prices (PEGSRs), thus affecting the price competitiveness of exporters.

The foreign demand indicator (IIMP14Q) includes 14 main trading partners. Unlike the original version of the model of Radvansky et al. (2010), this version includes countries outside the EU, such as the US, the UK and China. The former weighted demand indicator included only the core EU-15 countries. An addition to the old model is the linkage to the productivity difference between the domestic economy and foreign economies. Indicators of foreign labour productivity and foreign deflators are based on weights of 14 indicators on the import and export sides and data of nominal GDP and ESA employment.

Functional relationships in the external environment block:

EGSPR = f(IIMP14Q,PEGSR,FLPROD, LPROD)
PEGSR = f(exogenous)
DDP = f(HCP, DFKP, GP)
MGSPR = f(DDP,PMGSR,FPMGSR, EGSPR)
PMGSR = f(exogenous)

EGSPR – nominal exports of goods and services, national accounts
IIMP14Q – imports of goods and services of 14 main trading partners
PEGSR – deflator of exports of goods and services
FLPROD – real labour productivity of 14 main trading partners
LPROD – real domestic labour productivity (ESA employment)
MGSPR – nominal imports of goods and services, national accounts
PMGSR – deflator of imports of goods and services
FPMGSR – deflator of imports of goods and services – 14 main trading partners
DDP – nominal domestic demand
HCP – nominal private consumption of households
DFKP – nominal fixed investments
GP – nominal public consumption

Domestic trade volumes synchronize with foreign business cycles, emphasizing the high comovement with partners' economies due to high trade dependence. Foreign demand forecasts are exogenous in forecast exercises, taking the average growth rates of the most recent forecasts of international institutions, such as the IMF (IMF, 2024), OECD (OECD, 2024) and European Commission (EC, 2024b). The same applies for forecasts of export and import prices. This block reflects the open economy's reliance on foreign demand while accounting for short-run and long-run adjustments in trade flows relative to partner economies' growth.

Export and import nominal volumes do not respond strongly to relative price development; currency effects are minimized mostly because of the use of a common currency among many trade partners, which makes competitiveness largely a function of real factors, such as productivity. The terms of trade show increasing price competitiveness of Slovak exports due to slower selling price growth relative to increasing import prices (Figure 2).

Nominal exports of goods and services (EGSPR) [2]**:**

$$\begin{aligned}\mathbf{log(EGSPR_t)} = {} & \boldsymbol{c_{egspr_{l1}}} + \boldsymbol{c_{egspr_{l2}}} * \mathbf{log(IIMP14Q_t)} + \boldsymbol{c_{egspr_{l3}}} * \mathbf{D2020Q2} + \boldsymbol{c_{egspr_{l4}}} \\ & * \mathbf{log(PEGSR_t)} + \boldsymbol{c_{egspr_{l5}}} * \left(\frac{\mathbf{1}}{\mathbf{TREND}} > \mathbf{2021Q3}\right) + \boldsymbol{c_{egspr_{l6}}} \\ & * \mathbf{log(FLPROD_t/LPROD_{t-1})} + \boldsymbol{c_{egspr_{l7}}} * \mathbf{log(FPMGSR_t/PEGSR_t)}\end{aligned} \quad 1)$$

$$\begin{aligned}\mathbf{dlog(EGSPR_t)} = {} & \boldsymbol{c_{egspr_{s1}}} * \mathbf{resid_{egspr_{t-1}}} + \boldsymbol{c_{egspr_{s2}}} * \mathbf{dlog(IIMP14Q_t)} + \boldsymbol{c_{egspr_{s3}}} \\ & * \mathbf{D2020Q2} + \boldsymbol{c_{egspr_{s4}}} * \mathbf{dlog(PEGSR_t)}\end{aligned} \quad 2)$$

Coefficients (standard errors):

c_egspr_l1 = 8.435 (0.766)	*c_egspr_s1 = -0.323 (0.214), EC*
c_egspr_l2 = 1.00 (calibrated)	*c_egspr_s2 = 1.0 (calibrated)*
c_egspr_l3 = -0.216 (0.039)	*c_egspr_s3 = -0.236 (0.0523)*
c_egspr_l4 = 1.00 (calibrated)	*c_egspr_s4 = 1.0 (calibrated)*
c_egspr_l5 = -0.104 (0.020)	
c_egspr_l6 = -0. 556 (0.354)	*Sample: 2011Q2-2024Q2*
c_egspr_l7 = 0.865 (0.241)	*R^2 = 0.61*
	Durbin-Watson = 1.88

[2] Regression estimates for IMP14Q show elasticity of 1.11, but to ensure stability of model convergence in simulation it is calibrated to unit elasticity.

Nominal imports of goods and services (MGSPR):

$$\log(\mathbf{MGSPR_t}) = c_{mgspr_{l1}} + c_{mgspr_{l2}} * \log(\mathbf{DDP_t}) + c_{mgspr_{l3}} * \log(\mathbf{EGSPR_t}) + c_{mgspr_{l4}} * \log(\mathbf{PMGSR_t}/\mathbf{FPEGSR_t}) \quad 3)$$

$$\mathbf{dlog}(\mathbf{MGSPR_t}) = c_{egspr_{s1}} * \mathbf{resid}_{\mathbf{mgspr_{t-1}}} + c_{mgspr_{s2}} * \mathbf{dlog}(\mathbf{DDP_t}) + c_{mgspr_{s3}} * \mathbf{dlog}(\mathbf{EGSPR_t}) \quad 4)$$

Coefficients (standard errors)

c_mgspr_l1 = -1.004 (0.226)
c_mgspr_l2 = 0.501 (0.022)
c_mgspr_l3 = 0.6 (calibrated)
c_mgspr_l4 = -0.35 (0.247)

c_mgspr_s1 = -0.347 (0.093), EC
c_mgspr_s2 = 0.287 (0.042)
c_mgspr_s3 = 0.6 (calibrated)

Sample: 2004Q2-2024Q2
R^2 = 0.89
Durbin-Watson = 1.94

Changes in commodity prices impact import volume (FPEGSR), with terms-of-trade adjustments on the import side capturing real income effects on the domestic trade balance. Temporary demand or supply shocks cause short-term deviations in import volumes, which are gradually corrected through the error-correction mechanism. Imports reflect high elasticity to domestic demand (DDP, 0.5) and to exports (EGSPR, 0.6)3. Fluctuations around the path of aggregate demand are the result of different prices in domestic and foreign economies (PMGSR and FPMGSR, respectively). The trade balance feeds into the model, directly affecting domestic GDP. Second-round effects result in changes in household income and consumption via multiplier effects, reflecting the sensitivity of the open economy to trade flows.

1.2 GDP block

A standard consumption block captures the long-term relationship between consumption and disposable income (GDI) while allowing for short-term fluctuations around this equilibrium relationship. The Slovak data show near-unit elasticity, implying that consumption increases proportionally to income (Figure 3). Deviations from the long-run equilibrium are captured by short-run adjustments, where changes in disposable income influence consumption with lagged effects. The gap between the actual and desired levels of consumption (based on long-run income levels) is corrected in each period, pulling consumption towards equilibrium. As the graph shows, the relationship between consumption and income has been disrupted, mainly during the COVID-19 period, with a large increase in savings, whereas during the energy crisis, there has been a significant drop in savings due to high inflation.

[3] Calibrated according to regression estimates (nonsignificant results of econometric estimates in the full sample).

Disposable income directly affects consumption, adjusted for changes in taxes and transfers, reflecting changes in household purchasing power as a result of public policy action. Additional variables, such as wealth and interest rates, might influence consumption; however, we did not find any significant econometric relationship. This suggests that credit conditions or asset values do not significantly impact spending behaviour. We incorporate past consumption as a predictor, maintaining habit persistence to smooth out short-term fluctuations. Transitory shocks or consumption-specific uncertainties are factored in through trend dummies from 2018 and during the COVID-19 crisis from 2020 to 2021.

Nominal consumption of households (HCP):

$$\mathbf{log(HCP_t)} = c_{hcpl_1} * \mathbf{log(GDI_t)} + c_{hcpl_2} * \left(\frac{\mathbf{1}}{\mathbf{TREND}} > \mathbf{2018Q1}\right) + c_{hcpl_3} * (\mathbf{TREND} > \mathbf{2020Q2})(\mathbf{TREND} < \mathbf{2021Q4}) \quad 5)$$

$$\mathbf{dlog(HCP_t)} = c_{hcprs_1} * \mathbf{resid_{hcps_{t-1}}} + c_{hcps_2} * \mathbf{dlog(GDI_t)} + c_{hcps_3} * (\boldsymbol{TREND} > \mathbf{2020Q2}) \quad 6)$$

Coefficients (standard errors)

c_hcp_l1 = 0.996 (0.001)
c_hcp_l2 = -0.026 (0.006)
c_hcp_l3 = 0.053 (0.008)

c_hcp_s1 = -0.351 (0.125), EC
c_hcp_s2 = 0.237 (0.034)
c_hcp_s3 = 0.014 (0.006)

Sample: 2009Q2-2024Q2
R^2 = 0.67
Durbin-Watson = 2.11

Figure 3
Disposable income, consumption and savings rate of households (mill. euro, nominal, savings rate in % of disposable income, RHS)

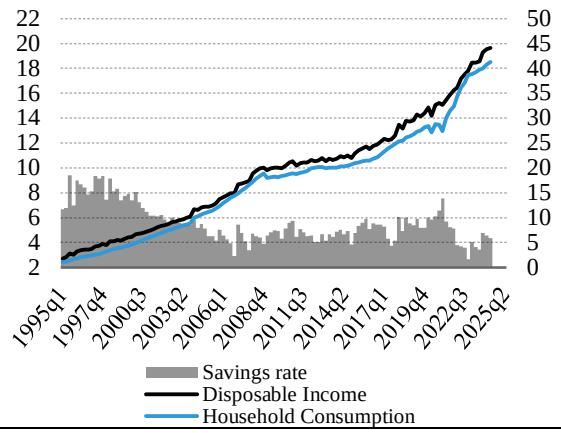
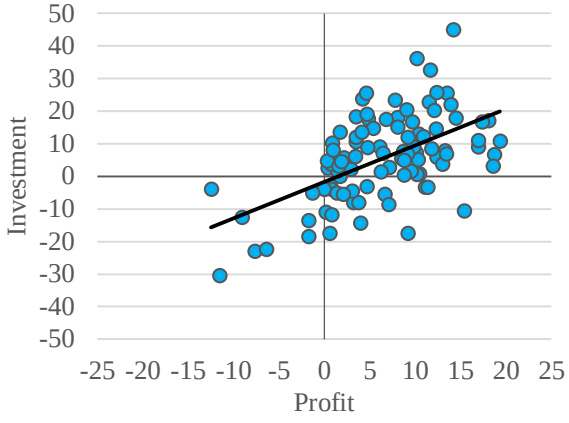


Figure 4
Profit as a central driver of investment (nominal, yoy growth in %)



Source: SO SR, SAS

In the investment block, firms' profits and exogenous investments (e.g., EU structural funds, EU Recovery and Resilience Plan funds, RRP) are key inputs in representing possible changes in investment trends. Firm profits are defined as gross operating surplus from national accounts and are closely related to investment (Figure 4), capturing the relationship between profitability and firms' willingness to invest in productive capital. The elasticity of investment to profits reflects how responsive firms' capital expenditures are to changes in profitability, with higher profits generally encouraging more investment.

Deviations from the long-term investment level trigger adjustments of the error correction mechanism and gradually bring investment back to its equilibrium path through long-term profit and public investment, both of which are net of EU funds. The advantage over the original model is that investments from EU structural funds and the new RRP funds are treated as exogenous inputs, directly boosting aggregate investment without responding to cyclical economic fluctuations. Exogenous structural funds can provide stability during downturns in the business cycle and represent additional sources of investment within the economy.

The remaining components of GDP are changes in inventories and government consumption. Changes in inventories are set exogenously and reflect stable growth of inventory stock in line with GDP, which comove together during subsequent stages of the business cycle. Government consumption is described in more detail in the government block section.

Functional relationships in GDP block:

HCP = f(GDI)	NX = EGSR – MGSR
DFKP = f (PBCE,EUF_I_TOT,EUF_IG, YP,COMP,TYZ)	EGSPR = EGSR * PEGSR
DKP = DFKP + DJP	MGSPR = MGSR * PMGSR
YP = HCP + GP + DKP + NXP	NXP = EGSPR – MGSPR
HC = HCP/PC	DJ = DJP/PDFK
G = GP/PG	Y = YP/PY
DFK = DFKP/PDFK	

HC and HCP – private consumption in constant and current prices
GDI – gross disposable income (of households)
DFKP and DKP – nominal fixed investments and gross investments
DFK and DK – real fixed investments and gross investments
DJ and DJP – change in inventories in constant and current prices
NX and NXP – net exports in constant and current prices
PC and PG – deflator of final consumption of households (PC) and government (PG)
YP and Y – nominal GDP (YP) and GDP in constant prices (Y)
PY – deflator of GDP
PEGSR and PMGSR – deflators of foreign trade (export and import of goods and services)
EGSPR and MGSPR – nominal foreign trade (export and import of goods and services)
EGSR and MGSR – real foreign trade (export and import of goods and services)
PBCE – public budget capital expenditures
GP and G– government consumption in current prices and constant prices
COMP – nominal compensations of employees, National Accounts definition
TYZ – corporate income tax
EUF_I_TOT – total investment from EU funds – structural funds and RRP
EUF_IG – EU funds in government sector – structural funds and RRP
PDFK – deflator of the formation of gross fixed capital (investments)

Nominal fixed investment (DFKP):

$$\log(\mathbf{DFKP_t} - \mathbf{EUF\_I\_TOT_t}) = \mathbf{c_{dfkpl_1}} + \mathbf{c_{dfkpl_2}} * \log(\mathbf{PBCE_t} - \mathbf{EUF\_IG_t}) + \mathbf{c_{dfkpl_3}} * \log(\mathbf{Y_t} - \boldsymbol{COMP_t} - \mathbf{TYZ_t}) + \mathbf{c_{dfkpl_4}} * (\mathbf{TREND} > \mathbf{2009Q2}) \quad 7)$$

$$\mathbf{dlog}\left(\mathbf{DFKP_t} - \mathbf{EUF_{I_{TOT_t}}}\right) = \mathbf{c_{dfkps_1}} + \mathbf{c_{dfkps_2}} * \mathbf{resid_{dfkps_{t-1}}} + \mathbf{c_{dfkps_3}} * \mathbf{dlog}(\mathbf{PBCE_t} - \mathbf{EUF\_IG_t}) + \left(\mathbf{1} - \mathbf{c_{dfkps_3}}\right) * \mathbf{dlog}(\mathbf{Y_t} - \mathbf{COMP_t} - \mathbf{TYZ_t}) \quad 8)$$

Coefficients (standard errors)

c_dfkp_l$_1$ = *-1.201 (0.499)*
c_dfkp_l$_2$ = *0.058 (0.016)*
c_dfkp_l$_3$ = *0.980 (0.052)*
c_dfkp_l$_4$ = *0.189 (0.033)*

c_dfkp_s$_1$ = *-0.916 (0.016)*
c_dfkp_s$_2$ = *-0.881 (0.156), EC*
c_dfkp_s$_3$ = *0.047 (0.015)*

Sample: 2000Q2-2024Q2
R^2 = 0.88
Durbin-Watson = 1.99

1.3 Labour market block

The labour market block contains exogenously forecasted demographic variables (e.g., population, participation rate, and long-term unemployment rate). We rely on short-term population projections of Eurostat, medium-term forecasts of the Macroeconomic Forecast Committee under the Ministry of Finance (MF SR, 2024) and long-term projections of the Ageing Working Group (EC, 2024a). Labour supply is the main variable affecting employment[4]. Exogenous demographic forecasts of the population and the participation rate drive the potential labour supply, influencing overall employment capacity.

The long-term relationship between labour supply and demand is linked by real GDP growth and potential labour employment. Both indicators determine the development of employment in the long run and allow short-term fluctuations due to changes in domestic and foreign aggregate demand (DD) and the economically active population (EAO) on the supply side. The inclusion of EAO enables the capture of migration effects.

Nominal wages are determined in the long run by nominal productivity. In the short run, wages adjust to the given long-term path by means of labour market slack (unemployment) and the bargaining power of households, which is the difference between GDP and private consumption deflator growth. Inflationary pressures in the labour market are captured by a Phillips curve relationship, where wage growth responds to deviations in the unemployment rate from its long-term (natural) rate. Labour productivity impacts both wages and employment levels, adjusting for how efficiently labour is used in production and influencing wage setting.

[4] Acoording to Labour Force Survey (LFS) statistics.

Functional relationships in the labour market block:

L_ESA = f(L)	W = f(LPROD, UR_POT, CPI15, PC-PY)
L = f(L_POT, Y, EAO, DD, EGSR)	YW = f(L, W)
GMI = f(YP-YW, PC-PY)	GDI = f(COMP, GMI, ST, SOC)

L_ESA – employment according to ESA methodology
L – employment according to the Labour Force Survey (LFS)
L_POT – potential employment (HP filter)
DD – real domestic demand
Y – real GDP
EAO – economically active population according to the LFS
YP/L-W – labour demand given the current level of nominal productivity and nominal wages
W – average nominal quarterly wage
LPROD – real labour productivity
UR – unemployment rate according to the LFS
UR_POT – potential unemployment rate
UR_GAP – difference between actual unemployment rate (UR) and potential/natural unemployment rate (UR_POT)
CPI15 – consumer price index with the base year 2015
GMI – gross mixed income
COMP – nominal compensations
YP-YW – gross operating surplus
PC-PY – difference between selling prices (PC) and production prices (PY), wage bargaining, selling price setting
YW – nominal gross wages volume
ST – social transfers of government to households
SOC – social contributions of households

Employment (L):

$$\mathbf{log(L_t)} = \boldsymbol{c_{l_1}} + \boldsymbol{c_{l_2}} * \mathbf{log\left(L_{POT_t}\right)} + (\mathbf{1} - \boldsymbol{c_{l_2}}) * \mathbf{log(Y_t)} + \boldsymbol{c_{l_3}} * (\mathbf{TREND} > \mathbf{2016Q1}) \, (\mathbf{TREND} < \mathbf{2019Q4}) \quad 9)$$

$$\mathbf{dlog(L_t)} = \boldsymbol{c_{l_s1}} * \mathbf{resid_{ls_{t-1}}} + \boldsymbol{c_{l_s2}} * \mathbf{dlog(EAO_t)} + \boldsymbol{c_{l_s3}} * \mathbf{D2011Q4} + \boldsymbol{c_{l_s4}} * \mathbf{dlog(DD_t + EGSR_t)} \quad 10)$$

Coefficients (standard errors)

c_l_l1 = -0.145 (0.026)
c_l_l2 = 0.937 (0.012)
c_l_l3 = 0.012 (0.002)

c_l_s1 = -0.240 (0.091), EC
c_l_s2 = 0.929 (0.072)
c_l_s3 = -0.009 (0.002)
c_l_s4 = 0.011 (0.009)

Sample: 2010Q2-2024Q2
R^2 = 0.89
Durbin-Watson = 1.11

Nominal wages (W):

$$\mathbf{log(W_t)} = c_{wl_1} + c_{wl_2} * \mathbf{log}(\boldsymbol{LPROD_t}) + c_{wl_3} * \mathbf{log(CPI15_t)} + c_{wl_4} * (\mathbf{TREND} > \mathbf{2012Q1}) \quad 11)$$

$$\mathbf{dlog(W_t)} = c_{ws_1} * \mathbf{resid_{ws_{t-1}}} + c_{ws_2} * \mathbf{dlog}\left(\frac{\mathbf{YP_t}}{\boldsymbol{L_t}}\right) + c_{ws_3} * \mathbf{dlog(UR\_GAP_t)} + c_{ws_4} * \mathbf{log(PC_t/PY_t)} \quad 12)$$

Coefficients (standard errors)

c_w_l1 = 1.589 (0.128)
c_w_l2 = 1.00 (calibrated)
c_w_l3 = 0.542 (0.031)
c_w_l4 = 0.006 (0.001)

c_w_s1 = -0.371 (0.123), EC
c_w_s2 = 0.863 (0.027)
c_w_s3 = -0.002 (0.000)
c_w_s4 = -0.257 (0.070)

Sample: 2000Q2-2024Q2
R^2 = 0.95
Durbin-Watson = 1.44

Gross mixed income (GMI):

$$\mathbf{log(GMI_t)} = c_{hzd_{l1}} + c_{hzd_{l2}} * \mathbf{log(YP_t - YW_t)} + c_{hzd_{l3}} * \left(\frac{\mathbf{1}}{\mathbf{TREND}} > \mathbf{2021Q4}\right) + c_{hzd_{l4}} * (\mathbf{TREND} > \mathbf{2009Q1})(\mathbf{TREND} < \mathbf{2017Q4}) \quad 13)$$

Coefficients (standard errors)

c_GMI_l1 = 3.868 (0.797)
c_GMI_l2 = 0.451 (0.084)
c_GMI_l3 = 0.203 (0.031)
c_GMI_l4 = 0.119 (0.025)

Sample: 2009Q1-2024Q2
R^2 = 0.92
Durbin-Watson = 1.78

Gross disposable income (GDI):

$$\log(\mathbf{GDI_t}) = c_{hdd_{l_1}} + c_{hdd_{l_2}} * \log(\mathbf{COMP_t} + \mathbf{GMI_t} + \mathbf{ST_t} - \mathbf{SOC_t} - \mathbf{TC_t} - \mathbf{TYX_t} - \mathbf{TVAT_t}) + c_{hdd_{l_3}} * (\boldsymbol{TREND} > \mathbf{2021Q3}) \quad 14)$$

$$\mathbf{dlog}(\mathbf{GDI_t}) = c_{hdd_{s_1}} * \mathbf{resid}_{\mathbf{hdds_{t-1}}} + c_{hdd_{s_2}} * \mathbf{dlog}(\mathbf{COMP_t} + \mathbf{GMI_t} + \mathbf{ST_t} - \mathbf{SOC_t} - \mathbf{TC_t} - \mathbf{TYX_t} - \mathbf{TVAT_t}) \quad 15)$$

Coefficients (standard errors)

c_GDI_l1 = 0.007 (0.002)
c_GDI_l2 = 1.00 (calibrated)
c_GDI_l3 = -0.024 (0.004)

c_GDI_s1 = -0.437 (0.112), EC
c_GDI_s2 = 0.927 (0.014)

Sample: 2008Q2-2024Q2
R^2 = 0.99
Durbin-Watson = 2.21

1.4 Price block

The price block contains exogenous energy prices and endogenous core inflation. Core inflation is modelled as a function of domestic price pressures represented by producer prices (PY – deflator of GDP) and input costs, including regulated energy inflation (REG and PMGS – import prices). Owing to the high degree of economic openness (180% - the average over the last 5 years), import prices have a significant effect on domestic prices. On the other hand, the pass-through may be limited because the currency is stable relative to that of major trade partners (except the US).

Regulated prices, which directly affect headline inflation, are treated separately to isolate core inflation dynamics. The GDP deflator is set endogenously as the weighted growth of individual GDP component deflators. High domestic demand (i.e., PC, PG and PDFK) can lead to price increases, especially because of the high import intensity of consumption (50%, on the basis of econometric estimation). The government consumption deflator is influenced by the development of public wages and is directly affected by inflation due to inflation indexation of some government expenditures. Most of the investment goods are imported, and the investment deflator reflects this and domestic investment goods prices as well. This price block allows us to capture core inflation dynamics within an open economy, adjusting for demand-side effects, exogenous price influences, and gradual correction mechanisms.

Functional relationships in the labour market block:

CPI15 = f(REG, PY, PMGSR)	PY = f(PC, PG, PDFK, PMGSR, PEGSR)
PC = f (CPI15)	PDFK = f (PY, PMGSR)
PG = f (CPI15,W,PY)	

REG – index of regulated prices with the base year 2000

Consumer prices (CPI15):

$$\mathbf{log(CPI_t)} = \boldsymbol{c_{cpi_{l_1}}} + \boldsymbol{c_{cpi_{l_2}}} * \mathbf{log(PMGSR_t)} + \left(\mathbf{1} - \boldsymbol{c_{cpi_{l_2}}}\right) * \mathbf{log(PY_t)} + \boldsymbol{c_{cpi_{l_3}}} * (\boldsymbol{D2022Q4}) + \boldsymbol{c_{cpi_{l_4}}} * (\mathbf{TREND > 2018Q1}) + \boldsymbol{c_{cpi_{l_5}}} * (\mathbf{TREND > 2023Q1}) + \boldsymbol{c_{cpi_{l_6}}} * \mathbf{log(REG_t)} \quad 16)$$

$$\mathbf{dlog(CPI_t)} = \boldsymbol{c_{cpi_{s_1}}} * \mathbf{resid_{cpis_{t-1}}} + \boldsymbol{c_{cpi_{s_2}}} * \mathbf{dlog(REG_t)} + \boldsymbol{c_{cpi_{s_3}}} * \mathbf{dlog(}\boldsymbol{PY}_\mathbf{t}\mathbf{)} \quad 17)$$

Coefficients (standard errors)

c_cpi_l$_1$ = *3.977 (0.119)*
c_cpi_l$_2$ = *0.150 (0.026)*
c_cpi_l$_3$ = *0.040 (0.006)*
c_cpi_l$_4$ = *0.006 (0.002)*
c_cpi_l$_5$ = *0.019 (0.005)*
c_cpi_l$_6$ = *0.126 (0.022)*

c_cpi_s$_1$ = *-0.363 (0.262), EC*
c_cpi_s$_2$ = *0.143 (0.089)*
c_cpi_s$_3$ = *0.632 (0.120)*

Sample: 2014Q2-2024Q2
R^2 = *0.61*
Durbin-Watson = 1.63

Deflator of GDP (PY):

$$\mathbf{log(PY_t)} = \boldsymbol{c_{py_{l_1}}} + \boldsymbol{c_{py_{l_2}}} * \mathbf{log(PC_t)} + \boldsymbol{c_{py_{l_3}}} * \mathbf{log(PMGSR_t)} + \boldsymbol{c_{py_{l_4}}} * \mathbf{log(PEGSR_t)} + \boldsymbol{c_{py_{l_5}}} * \mathbf{log(PG_t)} + \boldsymbol{c_{py_{l_6}}} * \mathbf{log(PDFK_t)} + \boldsymbol{c_{py_{l_7}}} * \mathbf{D2023Q1} \quad 18)$$

$$\mathbf{dlog(PY_t)} = \boldsymbol{c_{py_{s_1}}} * \mathbf{resid_{pys_{t-1}}} + \boldsymbol{c_{py_{s_2}}} * \mathbf{dlog(}\boldsymbol{PC}_\mathbf{t}\mathbf{)} + \boldsymbol{c_{py_{s_3}}} * \mathbf{dlog(}\boldsymbol{PMGSR}_\mathbf{t}\mathbf{)} + \boldsymbol{c_{py_{s_4}}} * \mathbf{dlog(}\boldsymbol{PEGSR}_\mathbf{t}\mathbf{)} + \boldsymbol{c_{py_{s_5}}} * \mathbf{dlog(}\boldsymbol{PG}_\mathbf{t}\mathbf{)} + \boldsymbol{c_{py_{s_6}}} * \mathbf{dlog(PDFK_t)} + \boldsymbol{c_{py_{s_7}}} * \mathbf{D2023Q1} \quad 19)$$

Coefficients (standard errors)

c_py_l$_1$ = *-0.002 (0.001)*
c_py_l$_2$ = *0.608 (0.021)*
c_py_l$_3$ = *-0.682 (0.040)*
c_py_l$_4$ = *0.614 (0.038)*
c_py_l$_5$ = *0.080 (0.017)*
c_py_l$_6$ = *0.402 (0.025)*
c_py_l$_7$ = *-0.046 (0.008)*

c_py_s$_1$ = *-0.789 (0.106), EC*
c_py_s$_2$ = *0.537 (0.052)*
c_py_s$_3$ = *-0.676 (0.045)*
c_py_s$_4$ = *0.632 (0.049)*
c_py_s$_5$ = *0.198 (0.044)*
c_py_s$_6$ = *0.332 (0.032)*
c_py_s$_7$ = *-0.047 (0.009)*

Sample: 1995Q2-2024Q2
R^2 = *0.89*
Durbin-Watson = 1.93

Deflator of fixed capital formation (PDFK):

$$\log(\mathrm{PDFK_t}) = c_{pdfk_{l1}} + c_{pdfk_{l2}} * \log(\mathrm{PY_t}) + (1 - c_{pdfk_{l2}}) * \log(\mathrm{PMGSR_t}) + c_{pdfk_{l3}} * (\mathrm{TREND} > 2009Q2) \quad 20)$$

$$\mathrm{dlog}(\mathrm{PDFK_t}) = c_{pdfk_{s1}} * \mathrm{resid}_{\mathrm{pdfks_{t-1}}} + c_{pdfk_{s2}} * \mathrm{dlog}(PY_t) + (1 - c_{pdfk_{s2}}) * \mathrm{dlog}(PMGSR_t) \quad 21)$$

Coefficients (standard errors)

c_pdfk_l$_1$ = *-0.002 (0.002)*
c_pdfk_l$_2$ = *0.807 (0.043)*
c_pdfk_l$_3$ = *0.041 (0.014)*

c_pdfk_s$_1$ = *-0.375 (0.109), EC*
c_pdfk_s$_2$ = *0.658 (0.101)*

Sample: 2009Q2-2024Q2
R^2 = 0.78
Durbin-Watson = 1.71

Deflator of government consumption (PG):

$$\log(\mathrm{PG_t}) = c_{pg_{l1}} + c_{pg_{l2}} * \log(\mathrm{PY_t}) + c_{pg_{l3}} * \log(\mathrm{W_t}) + (1 - c_{pg_{l2}} - c_{pg_{l3}}) * \log(\mathrm{CPI15_t}) + c_{pg_{l4}} * (\mathrm{TREND} > 2017Q1) \quad 22)$$

$$\mathrm{dlog}(\mathrm{PG_t}) = c_{pg_{s1}} * \mathrm{resid}_{\mathrm{pgs_{t-1}}} + c_{pg_{s2}} * \mathrm{dlog}(PY_t) + (1 - c_{pg_{s2}}) * \mathrm{dlog}(CPI15_t) + c_{pg_{s3}} * (\mathrm{TREND} > 2012Q1) \quad 23)$$

Coefficients (standard errors)

c_pg_l$_1$ = *-2.405 (0.219)*
c_pg_l$_2$ = *0.637 (0.057)*
c_pg_l$_3$ = *0.271 (0.037)*
c_pg_l$_4$ = *0.023 (0.006)*

c_pg_s$_1$ = *-0.320 (0.086), EC*
c_pg_s$_2$ = *0.391 (0.089)*
c_pg_s$_3$ = *0.015 (0.002)*

Sample: 2007Q2-2024Q2
R^2 = 0.81
Durbin-Watson = 1.99

1.5 Government block

The government block includes both revenues and expenditures (some endogenous to GDP, others exogenous) and is structured as follows. Public revenues are divided into tax components (e.g., personal income taxes, corporate taxes, VATs and consumption taxes) and social contributions. Revenues are endogenously linked to their macroeconomic bases, whereas some revenues (e.g., investments from RRP or EU funds) are exogenously determined. Tax revenues are modelled to respond to their macroeconomic bases according to their effective rates, capturing the sensitivity of tax receipts to economic growth and cyclical changes in the

economy. The main innovation of the model is the representation of the government block by accrual national account definitions of public expenditures and revenues rather than the state budget and cash data, as in the former model of Radvansky et al. (2010).

Government spending includes categories such as public wages, social benefits, and public investments. The core investment without RRP and structural funds is set endogenously. Social benefits are endogenous to economic conditions, whereas others are driven by nominal GDP development through effective rates. Certain government expenditures, such as unemployment benefits, act as automatic stabilizers and are increasing in downturns and decreasing in upturns, which helps smooth business cycles. Interests on public debt are calculated as a function of the existing debt stock and 10-year government yields (effective interest rates), which impacts overall expenditures and the budget balance.

Figure 5
Public budget balance (mill. euro, nominal, deficit in % of GDP, RHS)

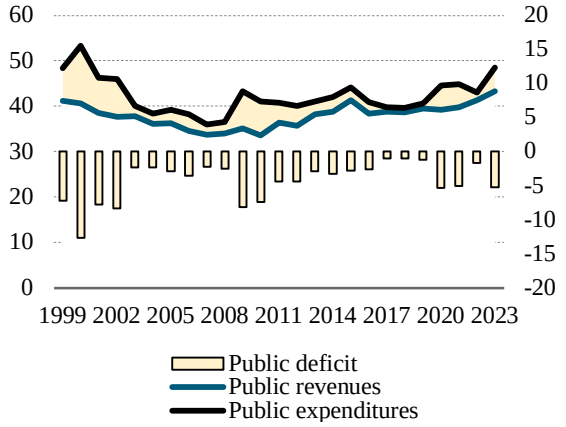
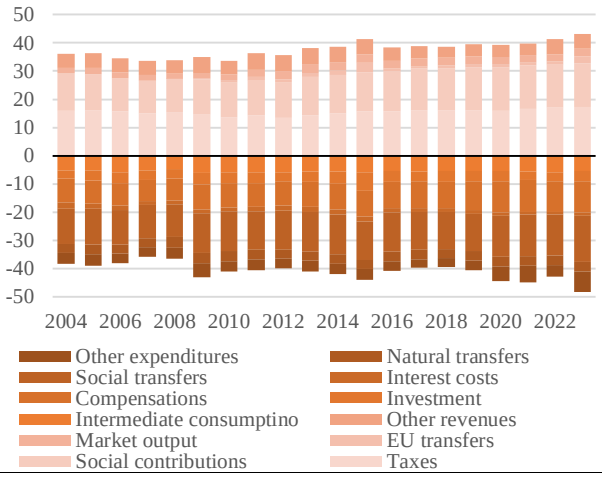


Figure 6
Largest contributors to public revenues and expenditures (nominal, in % of GDP)



Source: SO SR, SAS

The model does not include fiscal rules (e.g., debt or deficit targets). However, it is possible to set government policy shocks on both the revenue and expenditure sides, according to government announced consolidation or expansion plans. Policy changes (e.g., tax cuts, stimulus spending) can be modelled as exogenous shocks, with short-term impacts on the budget balance and a gradual return to equilibrium guided by the ECM. The value of these measures is either own estimate or taken from the Macroeconomic Forecasting Committee under the Ministry of Finance of the Slovak Republic. Government spending and tax policies feed back into GDP through multiplier effects, influencing private consumption and investment.

Figure 7
Change in public deficit – revenue side (% of GDP)

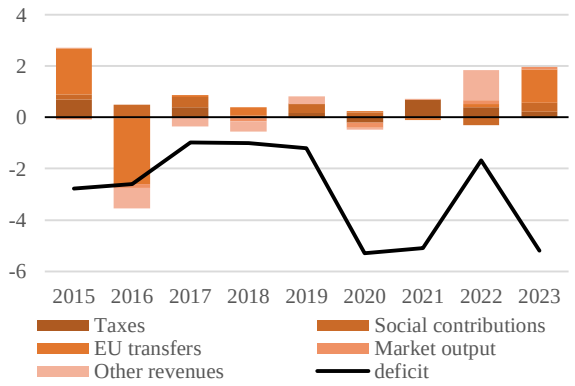
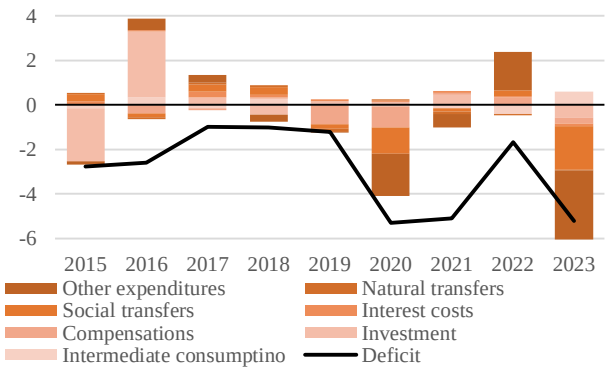
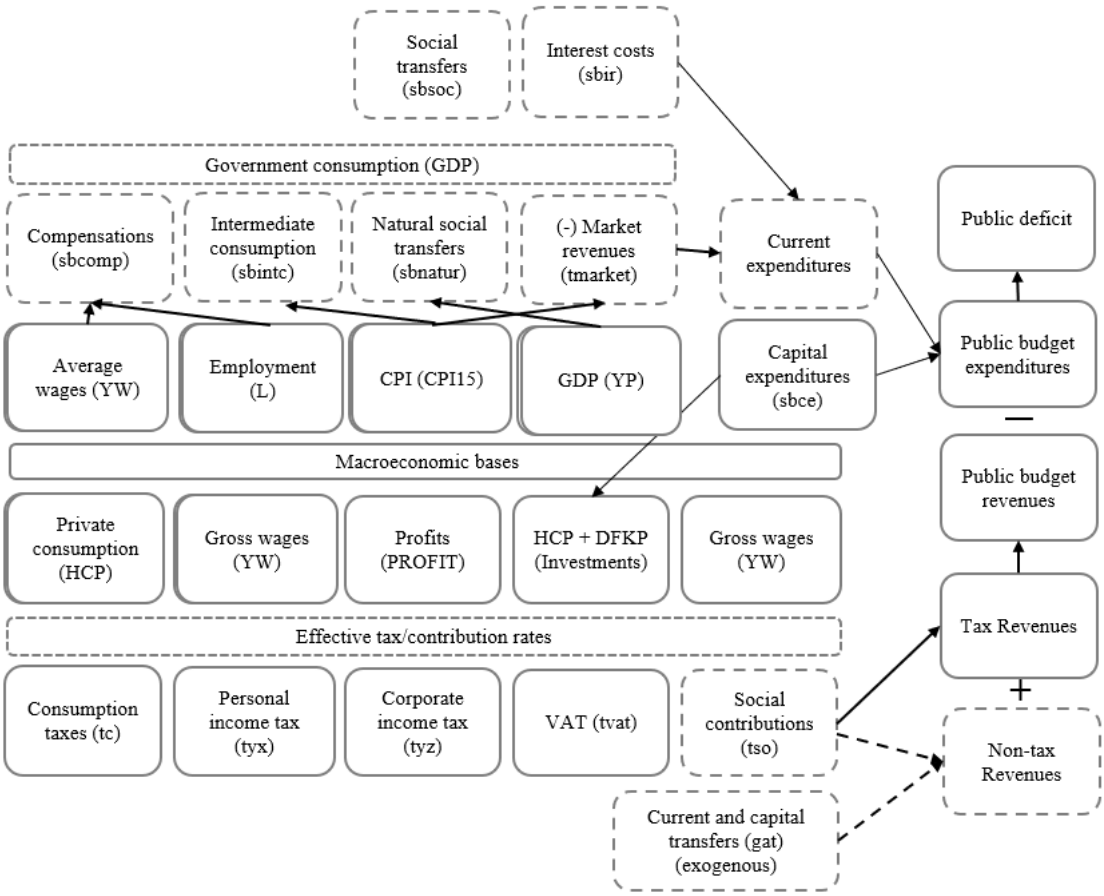


Figure 8
Change in public deficit – expenditure side (% of GDP)



Source: SO SR, SAS

Scheme 1



Functional relationships in the government block:

PBCOMP = f(W, L)	PBCE = f(YP-COMP-GMI, RRP_I, EUF_I)
PBINTC = f (CPI15, YP)	TMARKET = f (CPI15)
PBNATUR = f (CPI15, W)	

PBCOMP – compensations of public employees
PBINTC – public intermediate consumption
PBNATUR – natural social transfers
TMARKET – public market revenues

COMP – compensation of employees
RRP_I – investment of RRP EU funds
EUF_I – investment of EU structural funds
GMI – gross mixed income of households
GAT_CAPIEU – government capital transfers from EU (received)
GAT_CURREU – government current transfers from EU (received)

Public budget capital expenditures (PBCE):

$$\mathbf{log(PBCE_t)} = \boldsymbol{c_{pbce_{l\,1}}} + \boldsymbol{c_{pbce_{l\,2}}} * \mathbf{log(YP_t - COMP_t - GMI_t)} + \boldsymbol{c_{pbce_{l\,3}}} * \mathbf{log\left(EUF_{I_t} + RRP_{I_t}\right)} + \boldsymbol{c_{pbce_{l\,4}}} * \mathbf{D2023Q1} \quad 24)$$

$$\mathbf{dlog(PBCE_t)} = \boldsymbol{c_{pbce_{s\,1}}} * \mathbf{resid_{pbces_{t-1}}} + \boldsymbol{c_{pbce_{s\,2}}} * \mathbf{dlog}\left(\boldsymbol{GAT_{CAPIEU_t}}\right) + \boldsymbol{c_{pbce_{s\,3}}} * \mathbf{D2022Q2} \quad 25)$$

Coefficients (standard errors)

c_pbce_l$_1$ = *-1.090 (2.030)*
c_pbce_l$_2$ = *0.716 (0.236)*
c_pbce_l$_3$ = *0.162 (0.055)*
c_pbce_l$_4$ = *-1.571 (0.235)*

c_pbce_s$_1$ = *-0.773 (0.193), EC*
c_pbce_s$_2$ = *0.087 (0.011)*
c_pbce_s$_3$ = *-0.759 (0.306)*

Sample: 2010Q2-2024Q2
R^2 = 0.85
Durbin-Watson = 2.42

Public budget intermediate consumption (PBINTC):

$$\mathbf{log(PBINTC_t)} = \boldsymbol{c_{pbintc_{l\,1}}} + \boldsymbol{c_{pbintc_{l\,2}}} * \mathbf{log(CPI15_t)} + (\mathbf{1} - \boldsymbol{c_{pbintc_{l\,2}}}) * \mathbf{log}(\boldsymbol{YP_t}) \quad 26)$$

$$\mathbf{dlog(PBINTC_t)} = \boldsymbol{c_{pbintc_{s\,1}}} * \mathbf{resid_{pbintcs_{t-1}}} + \boldsymbol{c_{pbintc_{s\,2}}} * \mathbf{dlog}(\boldsymbol{CPI15_t}) + (\mathbf{1} - \boldsymbol{c_{pbintc_{s\,2}}}) * \mathbf{dlog}(\boldsymbol{YP_t}) + \boldsymbol{c_{pbintc_{s\,3}}} * \mathbf{dlog}\left(\boldsymbol{GAT_{CURREU_t}}\right) \quad 27)$$

Coefficients (standard errors)

c_pbintc_l$_1$ = *-1.011 (0.405)*
c_pbintc_l$_2$ = *0.305 (0.076)*

c_pbintc_s$_1$ = *-0.867 (0.137), EC*
c_pbintc_s$_2$ = *0.646 (0.116)*
c_pbintc_s$_3$ = *0.010 (0.041)*

Sample: 2010Q2-2024Q2
R^2 = 0.97
Durbin-Watson = 1.95

2. Model validation

The evaluation of the model is based on impulse response functions and implied fiscal multipliers, with a focus on key macroeconomic and fiscal shocks in the Slovak economy. These

include shocks to external demand, labour productivity, taxes and public expenditures. The shocks are defined as permanent and are expressed as percentage deviations from baseline growth rates. Fiscal multipliers are derived using the method of Uhlig (2010) to assess the short- and medium-term effects of different fiscal consolidation scenarios. The model assumes no fiscal rules, i.e., a nonpolicy scenario with default settings. A high starting deficit could lead to fiscal instability in the medium term.

Simulations show fiscal tightening scenarios equivalent to 1% of GDP and track their effects on key economic variables over 6 years. The model's complex lag structure induces more volatile fluctuations in the short term but becomes stable along a new equilibrium in the long term. The long-term effects of shocks on variable levels should be interpreted cautiously, as the model's steady state is defined by growth rates rather than absolute levels.

2.1 World demand shock

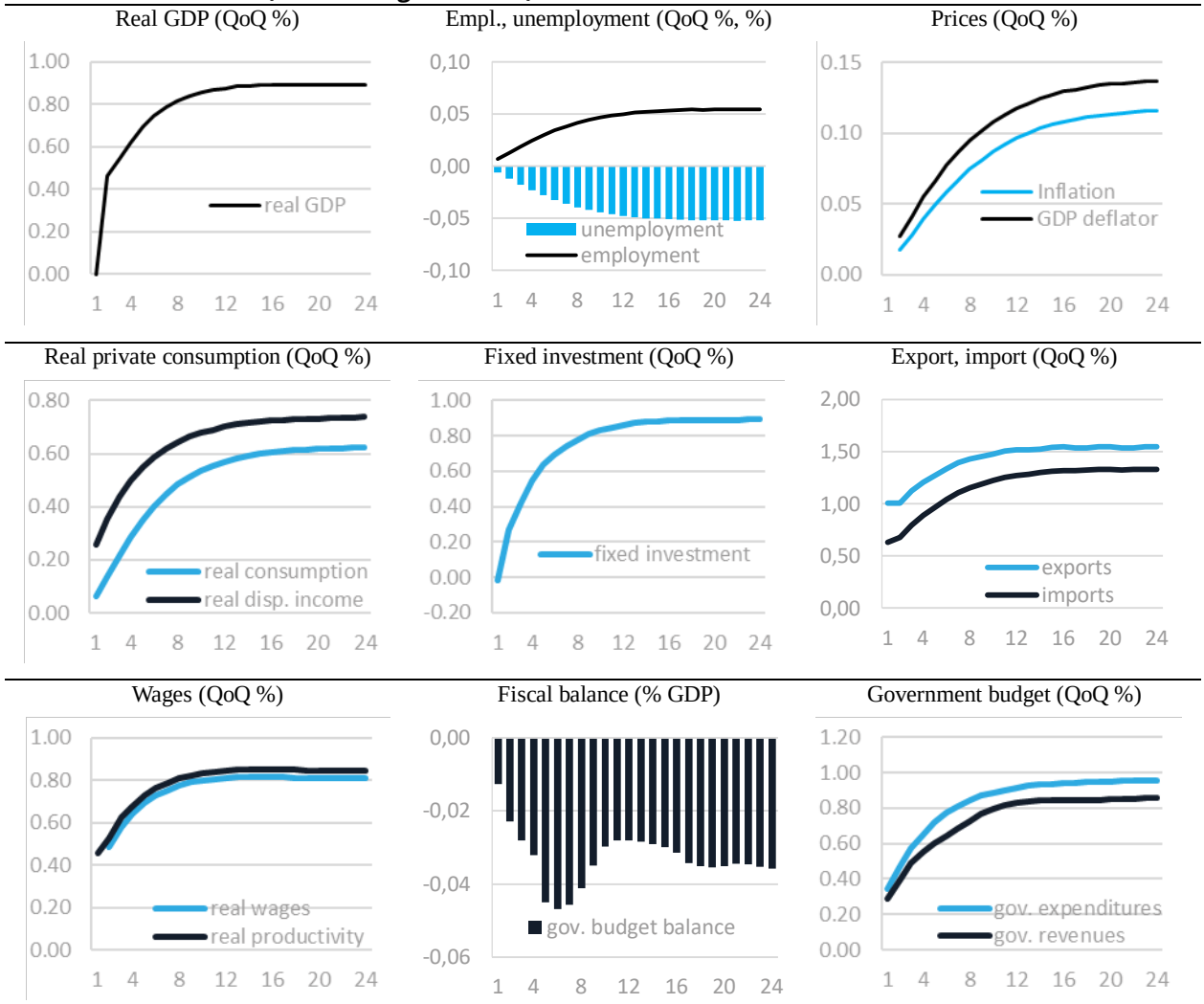
A positive world demand shock of 1%, such as an increase in foreign demand for a country's exports, leads to a higher GDP of 0.8%. A stronger external demand boosts exports more than imports, whereas net exports remain 0.2 p.p. over the baseline in the long term. Although the response of exports coincides with the impact of external demand, the expansion of economic activity increases export growth over the baseline by a factor of 1.4. This high multiplier is a result of increased domestic production and sales, including investment.

Labour market conditions improve following a positive world demand shock, as firms hire more workers to meet increased production needs. However, this effect is not strong. An increase in employment of 0.1% over the baseline shows only a limited effect on employment. Increased production is rather the result of stronger productivity and indicates the presence of labour hoarding, which is a tendency to keep employment stable despite cyclical fluctuations, with anticipation of future return of economic activity to its equilibrium. Econometric estimates show a rather weak relationship between GDP and employment in various samples since the global financial crisis. The latest transitive shocks, such as COVID-19 and the energy crisis, confirmed the labour hoarding effect.

A tight labour market leads to higher wages and stronger household income. Higher domestic demand leads to slightly increased inflationary pressures, with inflation above 0.2 p.p. over the baseline. The government balance remains roughly untouched by the foreign demand shock. The quasineutral impact with slightly higher government expenditures after the demand shock shows the low elasticity of government tax revenues to the foreign trade activities of domestic firms. In no-policy settings, revenues and government expenditures develop roughly according to general economic activity represented by nominal GDP.

Figure 9

World demand shock (1% of foreign demand)



2.2 Supply shock – labour productivity

A positive labour productivity shock, such as technological advancements or improved worker efficiency, leads to a GDP increase of 0.6% in the long term. Higher productivity increases firms' profitability and competitiveness, consequently boosting exports by approximately 1%. Higher productivity means sustainable GDP growth without generating additional inflationary pressures. Additional inflation below 0.1% over the baseline is a result of a higher deficit of government producing permanently higher demand in the no-policy setting.

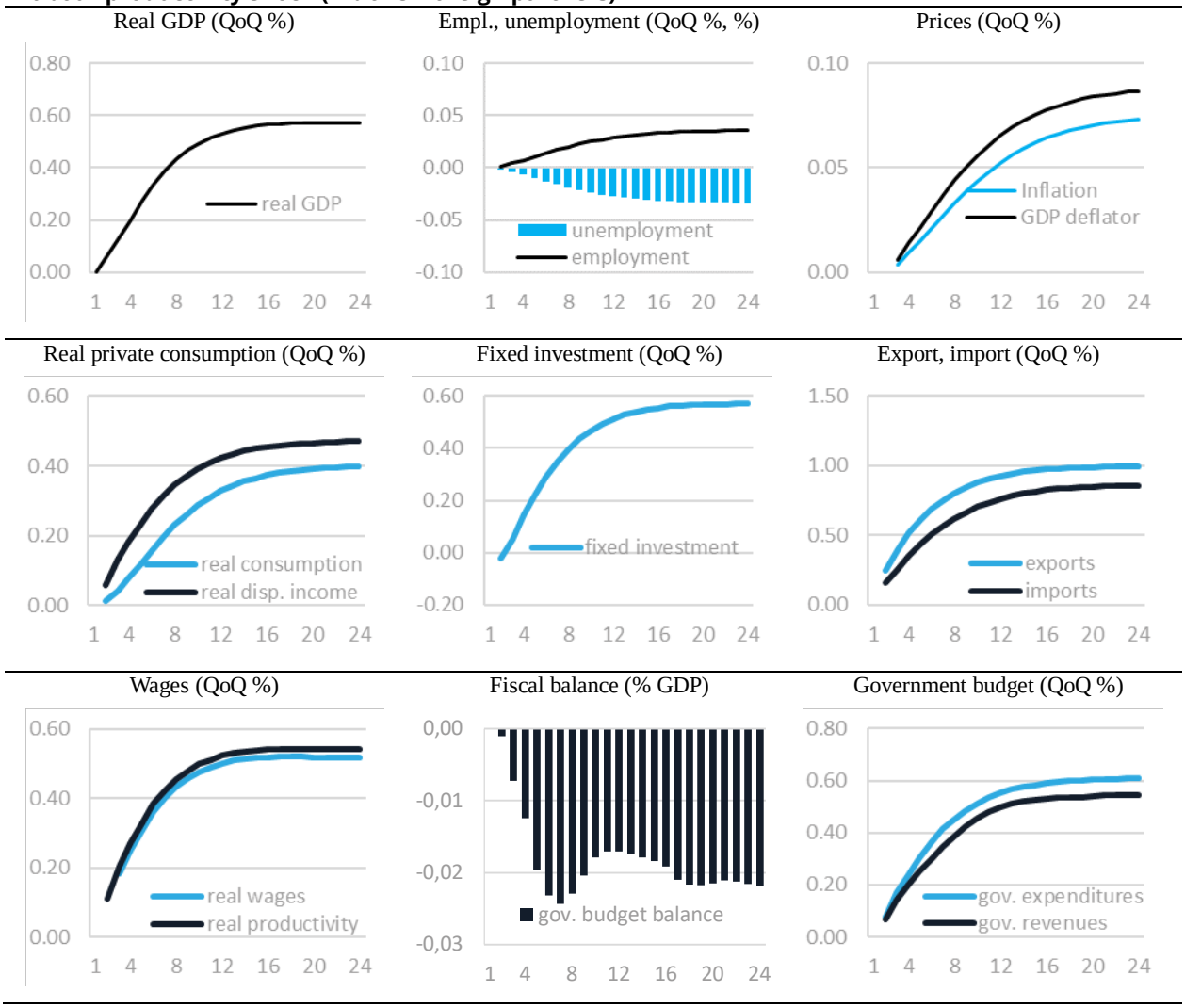
A productivity shock stimulates capital accumulation, as firms have higher profits. Moreover, lower costs create space for wage bargaining, consequently leading to increased real disposable income and higher consumption.

In the labour market, the output increases faster than the need for additional workers, and employment growth is slow but slightly greater than that in the baseline. However, rising productivity leads to higher wages, as firms share efficiency gains. Profitability may also enable firms to expand in the long run, creating new job opportunities. As we can see from the

simulations, a flexible labour market allows for both higher wages and stable employment levels over time.

Figure 10

Labour productivity shock (1% over foreign partners)



2.3 Fiscal consolidation shock – VAT tax

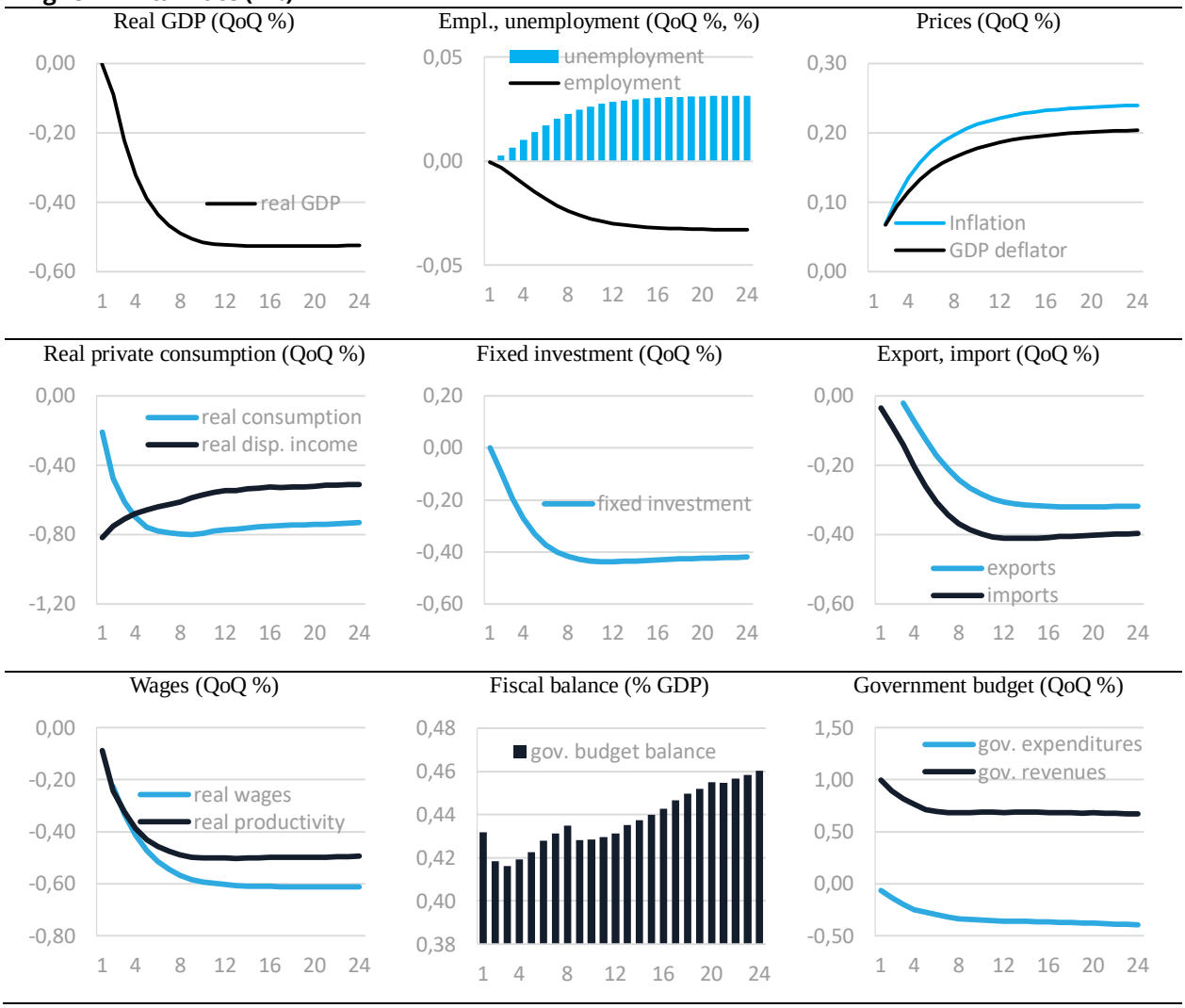
A fiscal consolidation shock through a higher value-added tax (VAT) of 1 p.p. leads to a decline in GDP of 0.5%. It directly reduces household purchasing power by 0.8%. Private consumption needs to be adjusted to reduce the inflow of income. The consumption decreases by 0.2% at impact, but consequently, it gradually decreases by 0.8% and allows households to adjust their savings accordingly. The second important effect of higher VAT is higher prices. Firms reflect higher VAT into end products despite their risk of losing competitiveness to importers. One percentage point of the VAT effective rate leads to an increase in the CPI of 0.2%.

Overall, a higher VAT leads to lower real disposable income for consumers, which dampens aggregate demand. On the other hand, net exports improve as domestic demand weakens, reducing imports more than exports do. Profit cuts lead to lower investment activity; additionally, firms must reduce employment and wages. Owing to higher prices, lower real wages copy lower productivity and fall significantly by 0.6% over the long run.

Government revenues rise from the higher VAT, which helps reduce budget deficits; however, the increased tax burden discourages investment, and long-term growth is hampered by lower capital accumulation. However, in the long run, successful fiscal consolidation stabilizes public finances and reduces borrowing costs.

Figure 11

Higher VAT tax rate (1%)



2.4 Fiscal consolidation shock – Corporate income tax

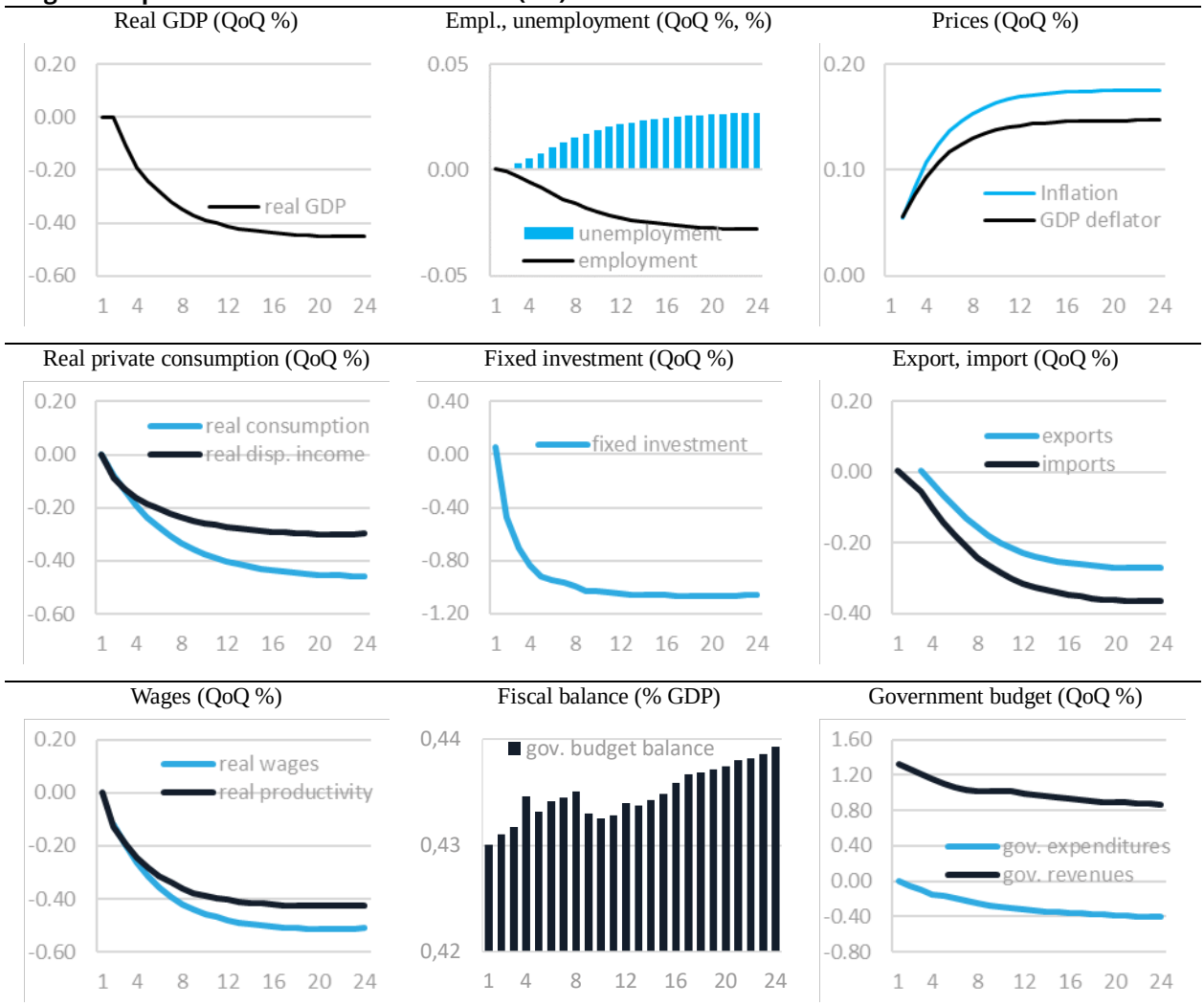
A fiscal consolidation shock through a higher corporate income tax rate leads to a decline in GDP of 0.4%. Higher taxes reduce firms' profits, discourage investment, hire workers, or increase wages. In the long run, it hampers potential growth. Rising input costs not only limit investments but also prevent companies from meeting former production plans; exports decrease by 0.4%.

Firms reflect higher costs into end prices for consumers, which in turn lead to lower real consumption by households. In the labour market, higher corporate taxes lead to lower employment growth and rising unemployment. Wage growth is slower not only because of weaker firms' profits but also because households are not able to fully bargain for higher inflation into nominal wages.

The fiscal balance improves by 0.5% of GDP on average over the simulation horizon. Revenues from taxes improve by 1% of GDP. Slower nominal GDP growth is reflected in lower macroeconomic bases for some of the public expenditures. These lead to lower expenditures by 0.4% against the baseline. The government benefits from fiscal consolidation with a permanently positive fiscal balance; on the other hand, the economy faces higher price levels and slower real GDP growth with an overall worse labour market.

Figure 12

Higher Corporate effective income tax rate (1%)



2.5 Fiscal consolidation shock – Personal income tax

A personal income tax rate of 1% leads to a decline in GDP of almost 0.4%. Primarily, it reduces households' disposable income and weakens consumer demand. With a higher tax burden, households have less money to spend, leading to lower consumption. Additionally, higher personal income taxes reduce incentives to work, leading to lower labour force participation and productivity in the long run.

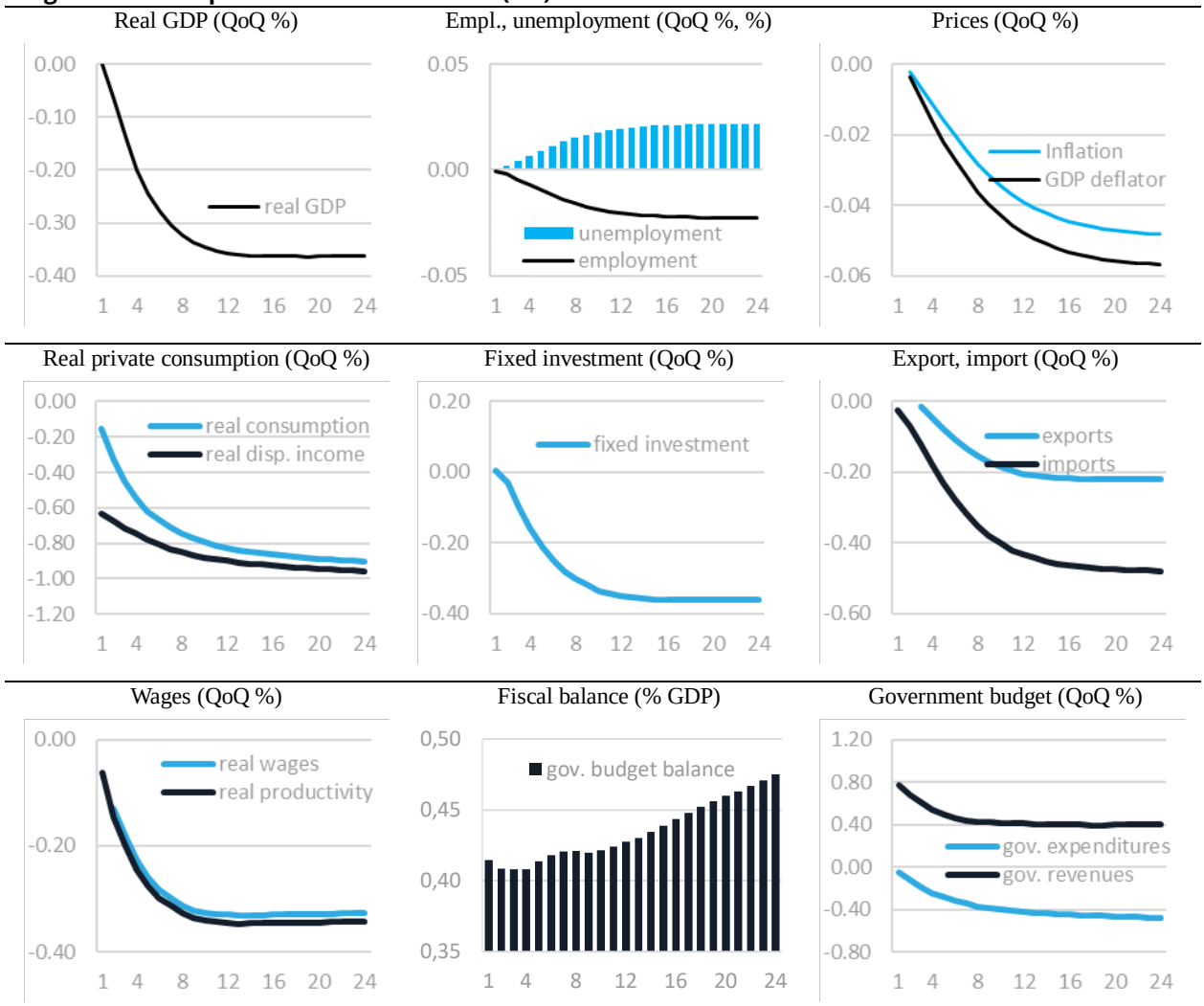
In the GDP structure, the most significant contraction is in household spending, and real private consumption is weaker by 1% in the long run than in the baseline. Business investment also declines, but in comparison with direct taxes on firms, such as the corporate income tax, the

effect is much smaller. Weaker domestic demand reduces imports, but with declining sales, exports and investment are also slower, further dampening GDP growth.

In the labour market, higher personal income taxes lead to lower wage growth and higher unemployment. Higher marginal tax rates discourage labour supply. On the other hand, government revenues increase, which helps reduce fiscal deficits by 0.4% of GDP. Government expenditures decline like their bases and positively contribute to the fiscal balance.

Figure 13

Higher effective personal income tax rate (1%)



2.6 Fiscal consolidation shock – Compensation of employees

A fiscal consolidation shock by means of lower public compensation expenditures, such as reductions in public sector wages or public employees, leads to a decline in GDP of almost 1%. A large multiplier indicates a relatively large public sector. Lower government expenditures on compensation directly reduce household incomes, leading to weaker consumer demand and slower economic growth.

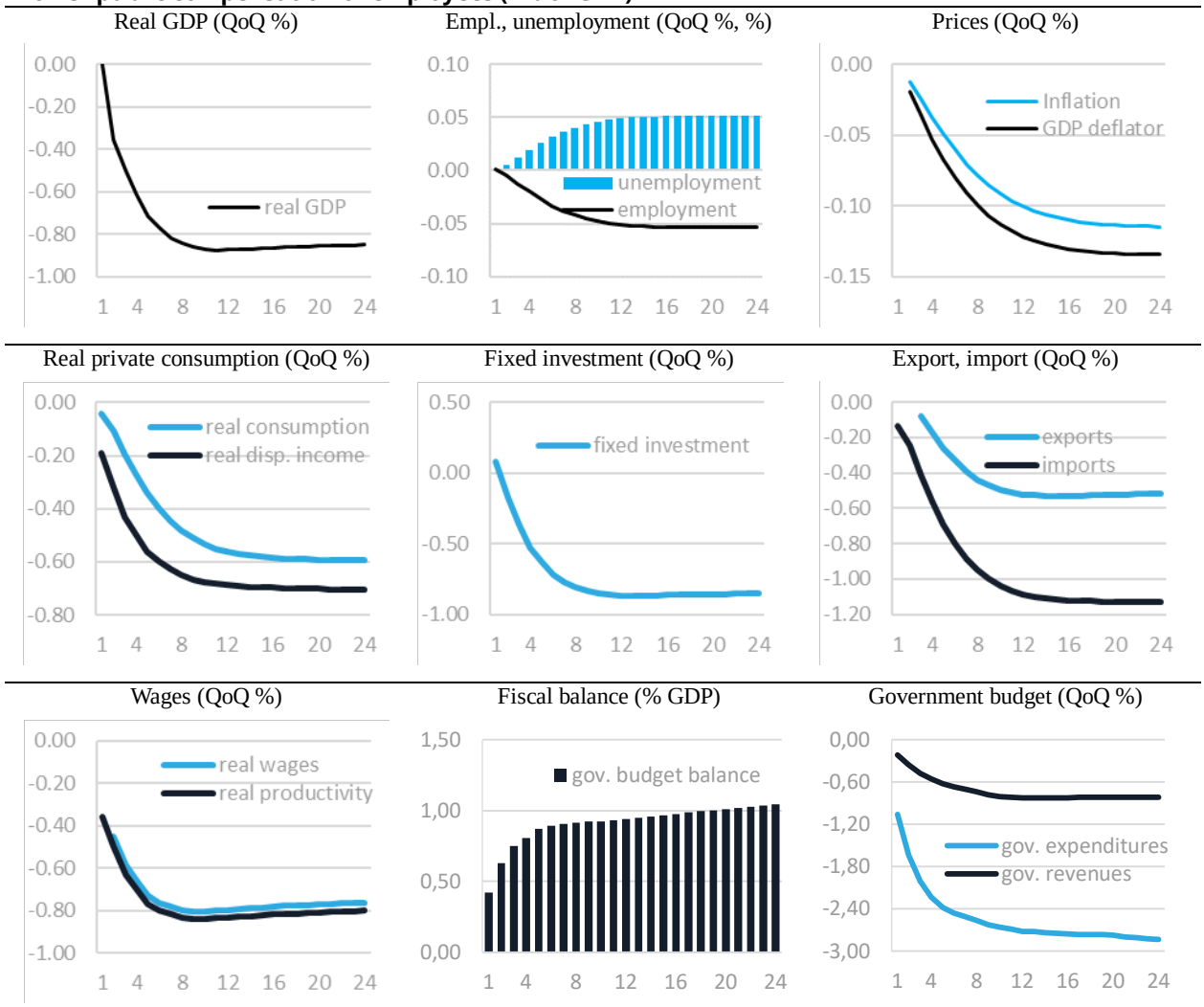
The structure of GDP shifts towards higher contributions of net exports, as imports suffer from weaker domestic demand. Weaker domestic demand leads to lower sales in the private sector because of reduced government spending and consumer spending. Investment activity also contracts, further amplifying the GDP decline.

In the labour market, lower public compensation leads to rising unemployment and slower wage growth. The private sector absorbs some displaced public workers; however, it is not able to fully compensate for the reduction in employment. Wage cuts in the public sector put downwards pressure on private sector wages; overall, real wage growth is 0.8% weaker in the consolidation scenario than in the baseline scenario.

The government deficits improve by 1% of GDP. The negative effects of consolidation can be mostly felt in terms of public sector quality and the labour market. Lower public debt leads to reduced borrowing costs, which can produce a more stable environment and can encourage job creation in the long term.

Figure 14

Lower public compensation of employees (1% of GDP)



2.7 Fiscal consolidation shock – Intermediate consumption

Compared with public compensation, a reduction in public expenditures for goods and services, i.e., intermediate consumption, is less harmful to the economy. A decline in expenditures by 1% of GDP leads to slower growth of the economy by 0.4%. The demand effects associated with reducing government purchases are mostly indirect. Firms adjust faster to lower demand, while employees have hard times finding jobs in the private sector.

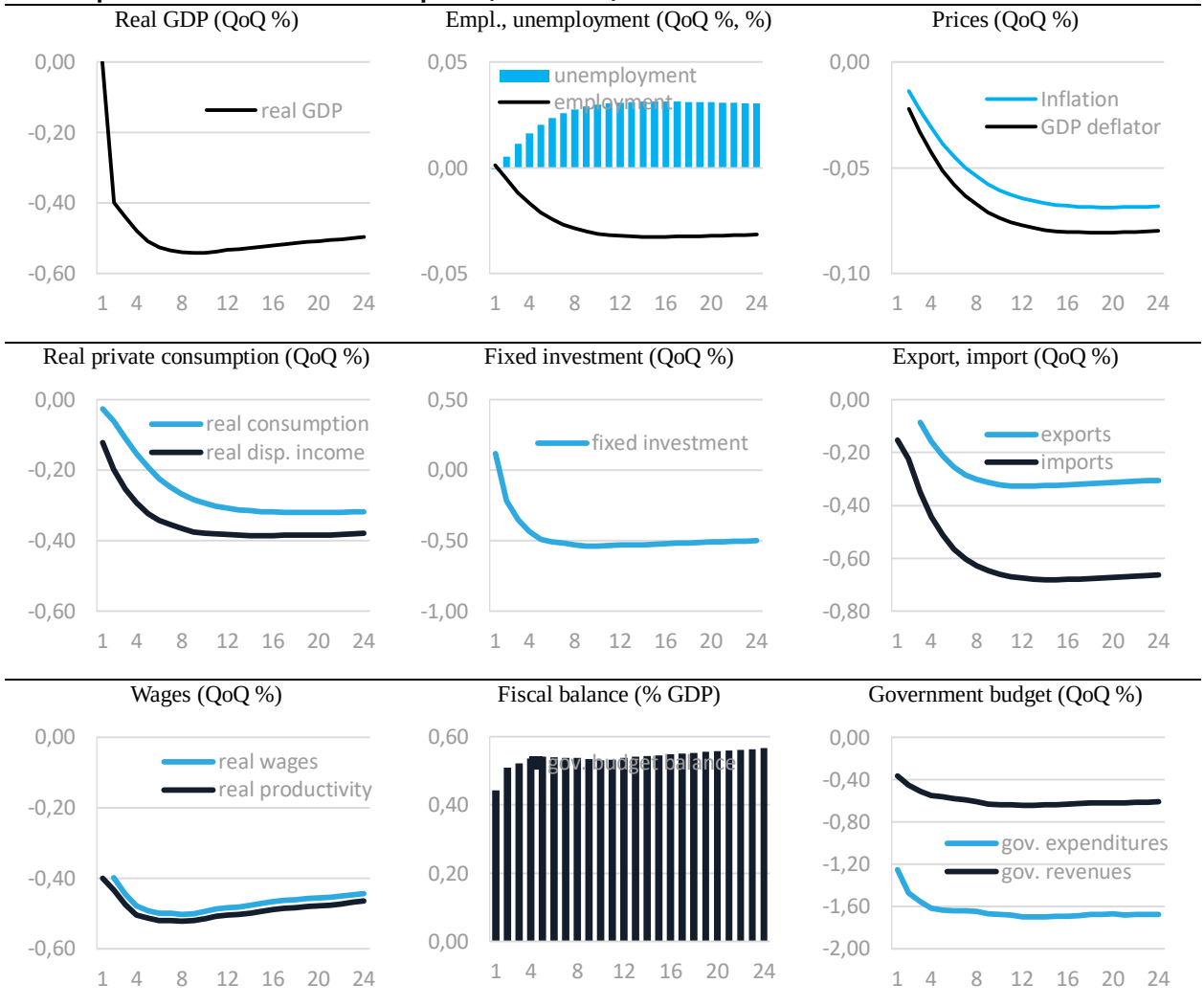
The demand effect shows its power in reducing imports, but it is only half of that of the reduced compensation of domestic households. The second-round effects show a decline in domestic investment and consumption, resulting in moderate employment and real wages. One can observe a slight negative demand effect on prices in the economy.

The decrease in real productivity is a result of maintaining employment at a stable level, which, however, happens precisely at the expense of productivity. A decrease in GDP of 0.4% is accompanied by 0.05% employment, which results in a decrease in productivity of almost 0.4%. The real wages follow the decline in productivity very closely in the model.

An improvement in the government budget balance of 0.4% is driven by a significant decrease in government expenditures. Compared with the baseline without shock, total government expenditures decline by almost 2%. A slowdown in government revenue inflow dampens the positive effects of lower government expenditures.

Figure 15

Lower public intermediate consumption (1% of GDP)



2.8 Fiscal consolidation shock – PUBLIC INVESTMENT

Among the listed consolidation measures, reducing public capital expenditures has the most severe impact on the economy. A reduction in public investment results in a 1% decline in

GDP. The effect involves only core public investment, as expenditures from EU resources are treated in the econometric relationship separately.

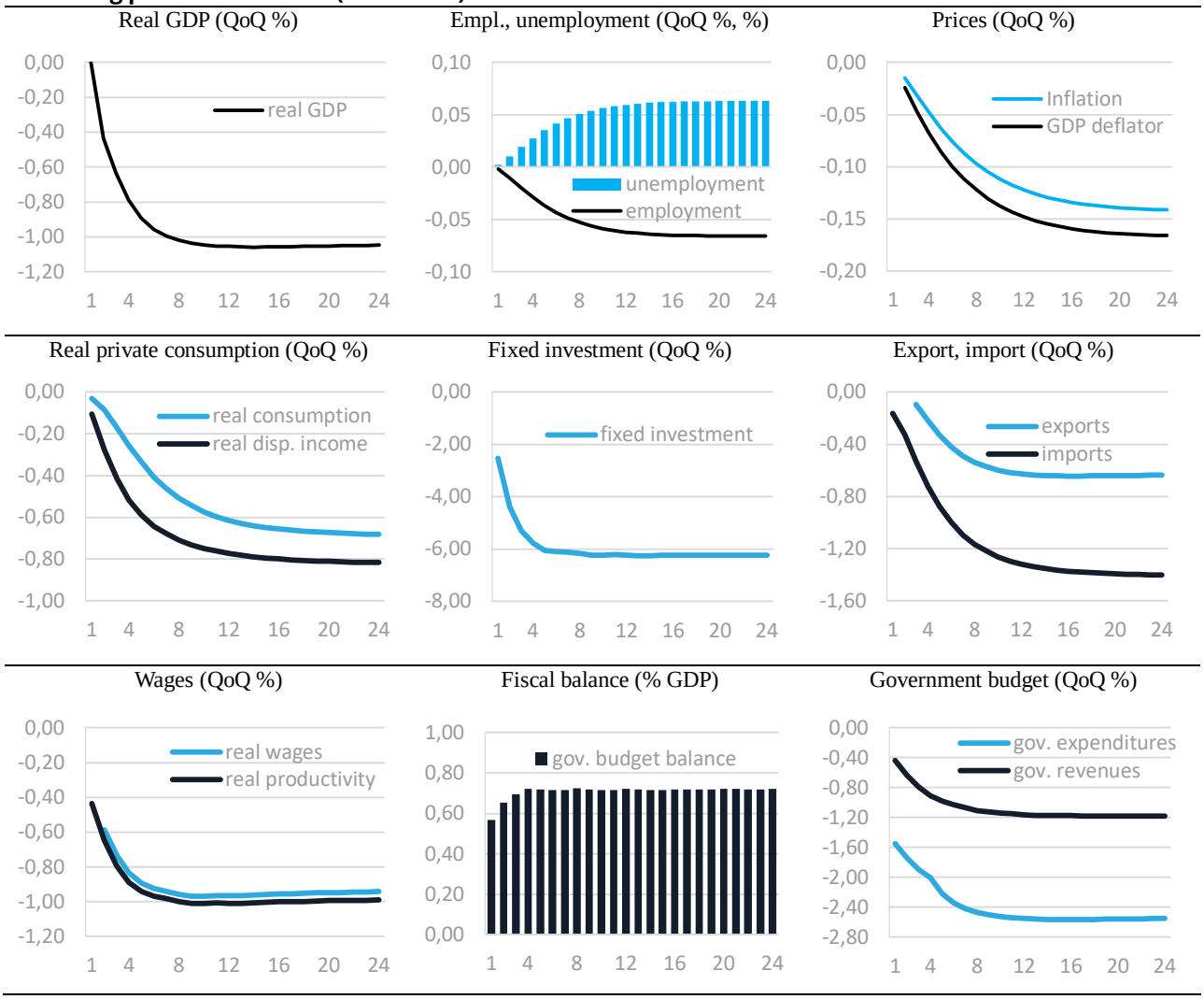
The outflow of investment from the economy has a strong demand effect, reducing private consumption and related imports. Some of the reduced imports are directly from investment, with a relatively strong import intensity of 50%. Lower demand is missing in domestic sales, leading to lower wages and employment. This also has a limited impact on reduced inflation rates.

The key reason for the higher multiplier of public investment lies in positive private sector spillovers. The crowd-in of private investment originates from the lower production costs of firms due to better infrastructure, either in transport or telecommunications. This contrasts with public intermediate consumption, which is not related to broader economic activity and has very limited crowding-in effects. Another related issue to more effective growth stimuli involves a possible greater propensity for the consumption of workers in firms involved in public construction.

Cuts in public investment lead to an increased budget balance of 0.7%, meaning that the worse budget is in part due to the fall of government revenues from taxes and contributions. Total government expenditures decline by 2.5% and are the main driver of better fiscal performance.

Figure 16

Lowering public investment (1% of GDP)



3. Fiscal multipliers

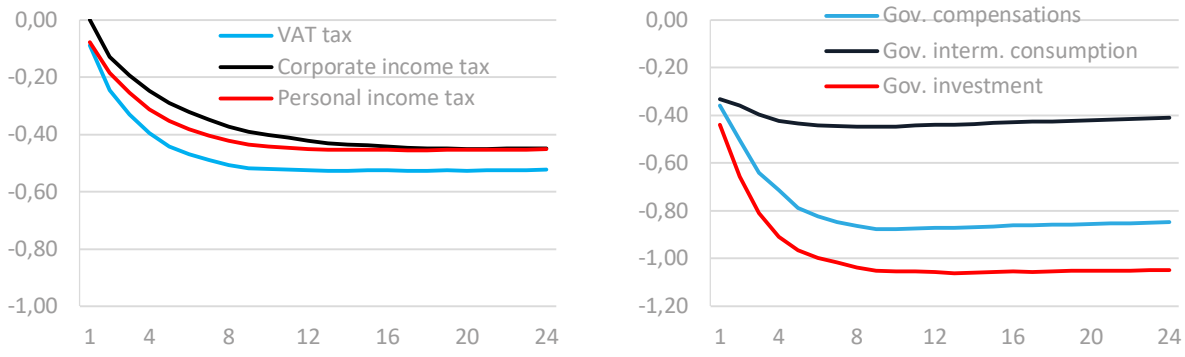
The study evaluates the effects of fiscal consolidation through different revenue and spending adjustments by analysing fiscal multipliers. The model considers a fiscal tightening of 1% of GDP and examines its medium-term impact on GDP growth. Fiscal multipliers are calculated as the ratio of changes in GDP relative to changes in government revenue or expenditures. The approach follows Uhlig (2010), computing cumulative fiscal multipliers to assess the empirical impact of various fiscal consolidation scenarios on the domestic economy.

On the revenue side, the most adverse fiscal consolidation scenario involves higher VAT taxation due to its negative effects on both consumer prices and disposable income. Corporate tax increases lead to a short-term decline in private investment, higher production costs, and reduced economic activity, making them the lowest short-term fiscal multiplier. Employee tax hikes, however, have a more significant medium-term impact by limiting the disposable income of households.

On the expenditure side, a permanent reduction in government spending on investment of 1% of GDP leads to the largest drop in GDP. This immediate negative impact is amplified by a decline in private investment through the accelerator effect. In the long run, lower public spending on investment also results in weaker potential. Similarly, the reduced compensation of employees leads to a similar drop in GDP because of the strong impact on household income and domestic demand. Intermediate consumption leads to declining public consumption directly through the link to GDP but has small effects in the medium-term horizon compared with investment and compensation multipliers.

This study emphasized that while fiscal consolidation can stabilize public finances, its economic impact depends on the specific revenue or spending measures implemented, with some strategies being less detrimental to growth and employment than others are.

Figure 17
Revenue and expenditure fiscal multipliers (1% of GDP)



Conclusions

The updated IER SAS macroeconometric model demonstrates some improvements in forecast flexibility and offers valuable insights for Slovakia's medium-term economic planning. Improvements to the model include expanded datasets, revised structural blocks, and better alignment with current economic challenges such as the COVID-19 recovery, the energy crisis, and evolving global trade dynamics.

Key innovations include the integration of a new government block that accurately captures the effects of fiscal policy on aggregate demand. Similarly, updates to the investment block, which incorporates corporate profits and exogenous factors such as EU structural funds, support more realistic projections of capital formation. In addition, improvements to the external trade block and the error correction mechanism ensure that the model reflects Slovakia's high dependence on external demand while addressing deviations from long-run equilibria. The labour market block of the model provides a robust framework for understanding employment dynamics, capturing short-term changes driven by domestic demand while considering long-term demographic trends. Similarly, the price block appropriately balances endogenous inflationary pressures and exogenous factors such as energy prices. Together, these updates allow for a more subtle depiction of the sensitivity of the Slovak economy to internal and external shocks.

A verification of the macroeconomic model was subsequently developed, which presents the effects of individual exogenous shocks. Demand and supply shocks were presented in turn. Next, the impacts of several tax rate changes are described, and their multiplier effects are described.

Scenario analyses highlight the key role of economic policymaking in shaping Slovakia's economic trajectory. The model also highlights the risks associated with fiscal consolidation, export competitiveness and demographic challenges and offers actionable insights for policy makers to maintain economic stability. In conclusion, the revised model is an important tool for guiding Slovakia's economic future, combining empirical rigor with practical applicability to support informed decision-making in an increasingly uncertain environment.

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