inštitút finančnej politiky

Ministerstvo financií SR / www.finance.gov.sk/ifp

Structural Macroeconomic Model of Slovakia

November 2021

Economic analysis 56

Abstract

We estimate a structural econometric model of the Slovak economy that is suitable for both macroeconomic forecasts and simulations. Furthermore, we enrich the model by a fiscal block and make it applicable also for a policy analysis. We thus aim to find a trade-off between simplicity and accuracy for forecasting purposes and a detailed structure for a policy analysis. The model is then based on error correction equations to incorporate both long-run development of model variables that are consistent with a macroeconomic theory and short-run dynamics of model variables that are estimated from historical data. Furthermore, we present impulse response functions for a set of macroeconomic and fiscal shocks as well as implied fiscal multipliers to evaluate different consolidation scenarios. The most negative outcome results from an increase in taxation of corporates and employees that suppress not only actual but also potential output in the domestic economy. On the other hand, the most favourable outcome results from an increase in taxation of consumption in a short horizon and a decline in consumption of government in a medium horizon.

Acknowledgement

The author would like to thank Lucia Šrámková (IFP), Daniel Dujava (IFP), Miroslav Kľúčik (RRZ), Martin Feješ (NBS) and František Brázdik (ČNB) for their helpful advices and comments.

Authors:

Richard Priesol richard.priesol@mfsr.sk

Table of contents

1 Introduction

Forecasting of macroeconomic development is a crucial process for a smooth operation of world economies. First, development of production and financial sectors is closely related to actual and future macroeconomic prospects. Second, a reasonable identification of future macroeconomic shocks is necessary for monetary and fiscal authorities to pursue effective countercyclical policies. Finally, development of budgetary plans is based on macroeconomic bases for revenue and expenditure components of a public budget. While an application of expert judgement is an important tool for macroeconomic forecasts that should be included in macroeconomic models, especially in a short horizon, we argue that a model-based approach that incorporates structural relationships in an economy is crucial for consistency and credibility of a forecasting process in a medium horizon. In fact, a forecasting process of many domestic and international institutions is based on a combination of expert judgement and structural macroeconomic models to produce the most accurate macroeconomic forecasts.

There is a number of different model classes that are applied for macroeconomic forecasts and simulations from simple vector autoregressive (VAR) models to complex dynamic stochastic general equilibrium (DSGE) models. Despite a plausible forecasting performance of the VAR models, in general, they do not pass the Lucas critique and could be thus not applicable for a policy analysis. Specifically, since these models are based on a historical projection of macroeconomic variables, they do not capture structural relationships in an economy given by a theory of general equilibrium and rational expectations of macroeconomic agents.[1] On the other hand, the DSGE models are derived from microeconomic foundations of representative agents and their rational expectations and thus pass the Lucas critique for a policy evaluation. However, since these models rely on a set of structural assumptions about rational behaviour of representative agents, they could be too rigid for practical forecasting in small open economies. Therefore, to find a trade-off between a macroeconomic theory, a historical projection and proper impulse response functions, we propose a general equilibrium model based on error correction equations that is plausible for forecasting purposes as well as a policy analysis.

Error correction models (ECM) are based on pairs of structural equations that incorporate both long-run stochastic trends and short-run empirical dynamics of model variables to handle cointegration of macroeconomic time series. This approach thus eliminates non-stationary components in model variables that could result in a spurious identification of model equations in the short runs and also captures a convergence process of model variables that is implied by stochastic trends in the long runs. While the long-run equations are mostly derived from a microeconomic theory, i.e. production and utility functions under a perfect or imperfect competition, the short-run equations are mostly estimated on a historical dataset to obtain the maximal fit of historical data. ECM models thus produce impulse response functions in line with a macroeconomic theory and also capture empirical dynamics of model variables. Furthermore, they meet a demand for structure in contrast to the VAR models and relax too rigid assumptions of the DSGE models. They are thus suitable for both macroeconomic forecasts and simulations. For more information about cointegration of time series variables and introduction to error correction models see Engle and Granger (1987).

Core structure of our model is based on an area wide model (AWM) of the euro area that was proposed by Fagan et al. (2001). The model is adapted for the Slovak economy and further extended for comprehensive budgetary restrictions of firms and households. Furthermore, we enrich the original model by a fiscal block and thus make it suitable for a policy analysis.[2] Structure of the model is based on a theory of production function and a set of empirical equations that are estimated from historical data with econometric methods. Even though there

[1] For more information see Lucas (1976).

[2] Enrichment by a fiscal block is an important extension of the model to produce more accurate macroeconomic forecasts with a respect to fiscal variables and simulate an impact of fiscal policies on the domestic economy for the Stability Programme (SP) and the Draft Budgetary Plan (DBP).

are different versions of error correction models for the Slovak economy that were developed by the National Bank of Slovakia (NBS) and the Council for Budget Responsibility (CBR), we propose an important extension of the original research with a detailed structure of the domestic economy and a focus on macro-fiscal interactions.

First, since the model contains comprehensive budgetary restrictions of firms, households and government, we can separately model these budgetary components and thus obtain endogenous estimates of financial flows in the Slovak economy. Second, since we provide a sectoral disaggregation of the domestic economy where we further distinguish between firms, households and government, we obtain a set of sectoral equations for (i) the domestic labour market, i.e. sectoral employment and wages and (ii) the domestic capital market, i.e. sectoral investment and depreciation, in line with the budgetary restrictions. The model is thus consistent with the construction of national accounts and allows for a correct identification of historical variables as well as a simple tractability of macroeconomic and fiscal shocks.

Finally, we can simulate an impact of a fiscal policy on the domestic economy with a respect to both revenue and expenditure components of a public budget. While the expenditure components, i.e. public consumption and investment, have a direct impact on the domestic output, the revenue components, i.e. domestic taxes and contributions, influence private consumption and investment through budgetary restrictions of firms and households. Selected instruments of a fiscal policy are further affected by a deviation of a fiscal balance and a public debt from their target paths to ensure stabilization of the fiscal variables.[3] The fiscal rules are based on the expenditure components of a public budget, in line with the latest research, see for example Claeys et al. (2016), Darvas et al. (2018) or Feld et al. (2018).

We structure the paper as follows. First, we provide a literature review with a focus on error correction models and fiscal multipliers. Second, we describe a structure of model equations with a detailed view of individual model blocks. Third, we provide an overview of a historical dataset and describe technical aspects of the model. Fourth, we discuss parametrization of the model that consists of estimation of the macroeconomic parameters and calibration of the fiscal parameters. Finally, we evaluate the model with impulse response functions for a set of macroeconomic and fiscal shocks and provide implied fiscal multipliers for alternative consolidation strategies on both revenue and expenditure sides of a public budget.

[3] For a comparison of alternative fiscal rules see Cordes et al. (2015) and Eyraud et al. (2018).

2 Related literature

An area wide model proposed by Fagan et al. (2001) is one of the most popular tools for macroeconomic forecasts of the European Central Bank (ECB). The model is based on error correction equations with an endogenous monetary policy and an exogenous fiscal block. While a supply side of the economy is based on a Cobb-Douglas production function that pins down the potential output by labour and capital production factors, a demand side of the economy defines a national income identity and thus calculates a domestic output as a sum of private consumption, public consumption, domestic investment and trade balance. Wages and prices are pinned down by first order conditions in a long run and empirical equations in a short run.

Furthermore, the area wide model operates with an endogenous financial block that is based on a monetary demand and a term structure of interest rates. A monetary policy is pinned down by a standard Taylor rule that sets a policy rate with a respect to a deviation of an inflation rate and an output gap from their target values. On the other hand, a fiscal block is rather simplified with a fiscal balance determined by a share of taxes and contributions on a gross domestic product and exogenous public consumption and investment. The model is mostly backward looking and thus based on adaptive expectations, with the exception of financial variables that are defined under a model-consistent approach. Specifically, an exchange rate between domestic and external economies is pinned down by an uncovered interest rate parity (UIP) and an effective interest rate is based on future expectations of the policy rate.

These types of structural econometric models are further a popular tool for macroeconomic forecasts and simulations (i) within the euro area, see for example the models of Ireland by Bergin et al. (2017) or Netherlands by Berben et al. (2018), (ii) outside the euro area, see for example the models of Poland by Budnik et al. (2009) or Norway by Bardsen and Nymoen (2015) and also (iii) across the world, see for example the models of Canada by Gervais and Gosselin (2014) or Australia by Balantine et al. (2019).

First econometric model of the Slovak economy was proposed by Livermore (2004). The model is based on a theory of general equilibrium and error correction equations with endogenous monetary and fiscal blocks. The model thus incorporates structural relationships in the domestic economy and also active policies of monetary and fiscal authorities. However, since the model operates with an endogenous monetary policy and is mostly calibrated from pre-crisis data and related literature, it does not reflect a current structure of the Slovak economy.

Macroeconomic forecasts and simulations of the National Bank of Slovakia (NBS) are based on a structural econometric model of Reľovský and Široká (2009). The model is based on the original work of Fagan et al. (2001) and adapted for the Slovak economy.[4] Since entering the monetary union of the euro area, a monetary policy is set exogenous to the model and implied by nominal interest rates and exchange rates of the ECB. Finally, we need to mention a macroeconomic model of the Council for Budget Responsibility (CBR) that was proposed by Kľúčik (2015) and extends the original work of Reľovský and Široká (2009) with a fiscal block. This model could be thus applied for macroeconomic forecasts and simulations as well as a quantification of alternative consolidation scenarios.

While a core structure of our model is in line with the model of Reľovský and Široká (2009), we provide important extensions of the original work. First, the sectoral disaggregation of the domestic economy leads to a more detailed estimation of both labour and capital markets. Second, the decomposition of budgetary restrictions of firms and households allows for a more detailed definition of private consumption and investment. Finally, the inclusion of a fiscal block allows for (i) a decomposition of a public budget into revenue and expenditure components, (ii) a definition of a fiscal balance and a public debt, (iii) a direct impact of fiscal variables on

[4] It is important to note that macroeconomic forecasts and simulation of the National Bank of Slovakia are based on an updated version of the model by Reľovský and Široká (2009).

the domestic economy, (iv) a definition of fiscal rules with a respect to public expenditures and (v) an evaluation of alternative consolidation strategies. On the other hand, we extend the model of Kľúčik (2015) with (i) a sectoral disaggregation of the domestic economy to obtain a more detailed structure of public revenues, (ii) a separate set of error correction equations to provide a more detailed definition of public expenditures and (iii) market expectations about a fiscal policy to reflect their impact on a confidence of investors.

Next, to evaluate and compare alternative consolidation scenarios, we should be interested in an identification of fiscal multipliers. Literature on fiscal multipliers consists of a number of different models and methods. We could mention a summary of existing literature published by Spilimbergo et al. (2009) and a more recent overview by Gechert and Will (2012). Both dynamic stochastic models (DSGE) and structural econometric models (ECM) produce higher multipliers on an expenditure side than on a revenue side of a public budget. For example, we remark dynamic stochastic models by Baksa et al. (2010) or Ambrisko et al. (2012) and error correction models by Dalsgaard et al. (2001) or Henry et al. (2004). Finally, we summarize domestic literature on fiscal multipliers that is based on vector autoregressive models (SVAR), see for example papers by Benčík (2009) or Čolláková et al. (2014), and dynamic stochastic models (DSGE), see for example papers by Múčka (2016) or Zeman (2016). However, since a number of macroeconomic models do not incorporate market expectations about a fiscal policy and can be further biased by short data samples and a small number of consolidation episodes, we need to be careful with their estimation of fiscal multipliers.[5]

On the other hand, some recent works based on the narrative approach analyse particular consolidation episodes and their impact on an economic performance and thus avoid model issues with market expectations and short data samples. These papers argue that the revenue multipliers are empirically higher than the expenditure ones not only in a medium term but also in a short term, see for example Guajardo et al. (2014) or Alesina et al. (2018). The authors assume that while a decline in public expenditures has a positive impact on private investment, in line with a stronger confidence of investors, an increase in taxes and contributions distorts the potential output and thus limits an economic performance.[6] Furthermore, some papers argue that a fiscal consolidation based on public expenditures could be even expansionary, see for example Giavazzi and Pagano (1990) or Alesina and Perotti (1996). However, the most recent studies suggest that the expansionary contraction is restricted only to particular consolidation scenarios and could be also explained by additional factors.[7]

[5] For more details about the market expectations and their impact on the estimation of fiscal multipliers see Alesina et al. (2018).

[6] For further information and more studies based on the narrative approach see Batini et al. (2014).

[7] For more information see Guajardo et al. (2014).

3 Model specification

We proceed with a specification of a macroeconomic model that consists of a set of behavioural equations and macroeconomic identities and can be further decomposed into six model blocks, i.e. a supply side block that pins down the potential output, a demand side block that defines a domestic output, a block of wages and prices that pins down domestic wages and prices, an interest rate block that defines a domestic risk premium, a block of firms and households that defines a disposable income and a corporate surplus and a fiscal policy block that pins down a fiscal balance and a public debt. Variables are denoted by letters from the Latin alphabet and parameters by letters from the Greek alphabet. Log() corresponds to a logarithm of variables, sqrt() to a square root of variables, tfp() to a surplus of variables over productivity, diff() to a time differential of rates, dlog() to a time differential of logarithms and dtfp() to a time differential of surpluses over productivity. Furthermore, to capture an asymmetric impact of effective tax rates on domestic prices, we label a time differential with a positive sign by up() and a time differential with a negative sign by down(). Finally, gap() corresponds to a deviation from potential values, dev() corresponds to a deviation from target values and cor() denotes an error correction term. Variables are further labelled by a time index *t*.

3.1 Supply side block

We start with a supply side of the economy that pins down the potential output and corresponding production factors in line with a microeconomic theory of production function and profit maximization. The potential output ($\mathbf{yt_t^*}$) is defined by a Cobb-Douglas production function in line with Fagan et al. (2001) and thus based on a labour production factor ($\mathbf{lt_t^*}$), a capital production factor ($\mathbf{kt_t}$) and a total factor productivity ($\mathbf{at_t}$) as stated in the Eq.1.

$$\mathbf{log(yt_t^*) = log(at_t) + \beta * log(kt_t) + (1 - \beta) * log(lt_t^*)} \tag{1}$$

We calibrate the elasticity of labour ($\mathbf{1 - \beta}$) from a historical ratio between compensations of employees and gross domestic product and then complement with the elasticity of capital ($\boldsymbol{\beta}$), in line with Reľovský and Široká (2009). This parametrization thus results from a first order condition with a respect to the labour component.[8] Maximization of profit ($\mathbf{\Pi_t}$) under flexible prices ($\mathbf{pt_t^*}$) and flexible wages ($\mathbf{wt_t^*}$) then leads to an optimization problem of domestic producers that is given by the Eq.2. The optimization function is based on revenues from domestic production and expenditures on labour and capital production factors.

$$\mathbf{Max\ \Pi_t = yt_t^* * pt_t^* - lt_t^* * wt_t^* - kt_t * pk_t * (1/4 * lr_t + \delta t_t + \lambda t_t)} \tag{2}$$

While the labour costs are implied by a price of labour ($\mathbf{wt_t^*}$), the capital costs are implied by a price of capital that further consists of a real interest rate ($\mathbf{lr_t}$), a depreciation rate ($\mathbf{\delta t_t}$) and a correction term ($\mathbf{\lambda t_t}$). The real interest rate includes also a domestic risk premium and thus incorporates an impact of a fiscal policy on the potential output. We further exogenize the correction term to maintain a historical ratio between domestic investment and gross domestic product in a steady state.[9] It is important to note that we distinguish between potential output prices ($\mathbf{pt_t^*}$) and capital stock prices ($\mathbf{pk_t}$) and thus restrict nominal variables in a short run and real variables in a long run. Solution of the optimization problem results in first order conditions that are further included in the model. Specifically, the first order condition with a respect to the labour component (Eq.3) pins down the potential labour costs ($\mathbf{wt_t^*}$) and the potential output prices ($\mathbf{pt_t^*}$), while the first order condition with a respect to the capital component (Eq.4) corrects the evolution of domestic investment ($\mathbf{it_t}$).

$$\mathbf{lt_t^* * wt_t^* = (1 - \beta) * yt_t^* * pt_t^*} \tag{3}$$

[8] Compensations of employees are equal to domestic employment that is multiplied by average labour costs of domestic employees.

[9] The correction term captures additional capital costs, for example capital taxes and capital dividends.

$$\mathbf{kt_t * pk_t * (1/4 * lr_t + \delta t_t + \lambda t_t) = \beta * yt_t^* * pt_t^*} \tag{4}$$

We proceed with a supply of labour and thus with a domestic labour force ($\mathbf{ls_t}$) that is driven by an evolution of productive population ($\mathbf{np_t}$) and domestic employment ($\mathbf{lt_t}$) as stated in the Eq.5. While the first term captures a population projection for the domestic economy, the second term incorporates transition effects between labour demand and supply. We further extend the equation with a net labour income ($\mathbf{rn_t}$) and labour taxes and contributions ($\boldsymbol{\tau}_t^{tc}$) to approximate an optimization of households between work and leisure. Finally, the potential labour force ($\mathbf{ls_t^*}$) is implied by the potential participation in the domestic economy.

$$\begin{gathered}\mathbf{dlog(ls_t) = ls_1 * dlog(np_t) + ls_2 * dlog(lt_t) + ls_3 * dlog(ls_{t-1}) + ls_4 * dtfp(rn_t) -} \\ \mathbf{ls_5 * diff(\tau_t^{tc}) - ls_6 * log(ls_{t-1}/ls_{t-1}^*)}\end{gathered} \tag{5}$$

A demand for labour then materializes in domestic employment and frictions on the labour market are displayed in domestic unemployment. We further decompose the domestic employment ($\mathbf{lt_t}$) into its private, personal and public components. The private component ($\mathbf{lf_t}$) is then driven by the potential employment ($\mathbf{lt_t^*}$) with a positive impact of a domestic demand ($\mathbf{yt_t}$) and a negative impact of private labour costs ($\mathbf{rf_t}$) as stated in the Eq.6. Furthermore, we extend the equation for a crowding out of public employment ($\mathbf{lg_t}$) to capture a substitutability between private and public labour markets.

$$\begin{gathered}\mathbf{dlog(lf_t) = lf_1 * dlog(lt_t^*) - lf_2 * dlog(lg_t) + lf_3 * dlog(lf_{t-1}) + lf_4 * dtfp(yt_t) -} \\ \mathbf{lf_5 * dtfp(rf_t) + lf_6 * cor(lt_{t-1})}\end{gathered} \tag{6}$$

The personal component ($\mathbf{lh_t}$) is also driven by the potential employment ($\mathbf{lt_t^*}$) with a positive impact of a domestic demand ($\mathbf{yt_t}$) and a negative impact of domestic labour costs ($\mathbf{rt_t}$) as stated in the Eq.7. Again, we extend the equation for a crowding out of public employment ($\mathbf{lg_t}$) to capture a substitutability between personal and public labour markets.

$$\begin{gathered}\mathbf{dlog(lh_t) = lh_1 * dlog(lt_t^*) - lh_2 * dlog(lg_t) + lh_3 * dlog(lf_{t-1}) + lh_4 * dtfp(yt_t) -} \\ \mathbf{lh_5 * dtfp(rt_t) + lh_6 * cor(lt_{t-1})}\end{gathered} \tag{7}$$

On the other hand, we assume that the public employment ($\mathbf{lg_t}$) is not crowded out by the private ($\mathbf{lf_t}$) nor the personal ($\mathbf{lh_t}$) components and is driven only by the potential employment ($\mathbf{lt_t^*}$) with a positive impact of a domestic demand ($\mathbf{yt_t}$) and a negative impact of public labour costs ($\mathbf{rg_t}$) as stated in the Eq.8. This assumption is consistent with a historical evidence. The error correction term is implied by an inverted production function of the domestic output (Eq.1).

$$\mathbf{dlog(lg_t) = lg_1 * dlog(lt_t^*) + lg_2 * dtfp(yt_t) - lg_3 * dtfp(rg_t) + lg_7 * cor(lt_{t-1})} \tag{8}$$

The potential employment ($\mathbf{lt_t^*}$) is then based on productive population ($\mathbf{np_t}$) and potential rates of participation ($\boldsymbol{\eta}_t^*$) and unemployment ($\boldsymbol{\mu}_t^*$) as stated in the Eq.9. Furthermore, we extend the equation with labour taxes and contributions ($\boldsymbol{\gamma}_t^{tc}$) to model their impact on the potential labour force and thus on the potential output in the domestic economy.[10]

$$\mathbf{dlog(lt_t^*) = dlog(np_t) + dlog(\eta_t^*) - diff(\gamma_t^{tc}) + dlog(1 - \mu_t^*)} \tag{9}$$

We continue with a domestic capital stock ($\mathbf{kt_t}$) that is pinned down by a capital accumulation method and thus based on a depreciation rate ($\boldsymbol{\delta}\mathbf{t_t}$) and domestic investment ($\mathbf{it_t}$) as stated in the Eq.10. It is important to note that we include a net capital stock at the beginning of a corresponding period to capture an evolution of the productive capital that is relevant for the potential output. The domestic depreciation rate ($\boldsymbol{\delta}\mathbf{t_t}$) then results from the decomposition of the domestic capital stock ($\mathbf{kt_t}$) into its private, personal and public components. Sectoral depreciation rates are set exogenous to the model.

[10] While the contemporaneous changes in the effective tax rates influence the domestic labour force, the smooth changes in the effective tax rates influence the potential labour force.

$$\mathbf{kt_{t+1} = (1 - \delta t_t) * kt_t + it_t} \tag{10}$$

Next, we need to decompose the domestic investment $(\mathbf{it_t})$ into its private, personal and public components. The private component $(\mathbf{if_t})$ is then based on a combination of a domestic demand $(\mathbf{yt_t})$ and a corporate surplus $(\mathbf{rs_t})$ with a negative impact of interest rate costs $(\mathbf{lr_t})$ and corporate income taxes $(\boldsymbol{\tau_t^{ci}})$ as stated in the Eq.11. Furthermore, we extend the equation for a crowding out of public investment $(\mathbf{ig_t})$, to capture a substitutability between private and public capital markets, and incorporate also market expectations about a fiscal policy with a respect to components of public employment $(\mathbf{lg_t})$ and labour costs $(\mathbf{rg_t})$, intermediate consumption $(\mathbf{ic_t})$ and public social transfers $(\mathbf{st_t})$, to reflect their impact on a confidence of investors. Specifically, we assume that an increase in the public expenditures has a negative impact on the confidence of investors and thus results in a decline in the private investment. This assumption is further consistent with the presence of Ricardian households that base their economic decisions on future expectations about a fiscal policy.[11]

$$\begin{gathered}\mathbf{dlog(if_t) = if_1 * dlog(yt_t) - if_2 * dlog(ig_t) + if_3 * dlog(rs_{t-1}) - if_4 * dlog(lg_t) -} \\ \mathbf{if_4 * dlog(rg_t) - if_5 * dlog(ic_t) - if_6 * dlog(st_t) - if_7 * diff(\boldsymbol{\tau_t^{ci}}) -} \\ \mathbf{if_8 * diff(lr_{t-1}) + if_9 * cor(it_{t-1})}\end{gathered} \tag{11}$$

The personal component $(\mathbf{ih_t})$ is then based on a disposable income $(\mathbf{hi_t})$ with a negative impact of interest rate costs $(\mathbf{lr_t})$ and corporate income taxes $(\boldsymbol{\tau_t^{ci}})$ as stated in the Eq.12. Furthermore, we extend the equation for a crowding out of public investment $(\mathbf{ig_t})$, to capture a substitutability between personal and public capital markets, and incorporate also market expectations about a fiscal policy with a respect to components of public employment $(\mathbf{lg_t})$ and labour costs $(\mathbf{rg_t})$, intermediate consumption $(\mathbf{ic_t})$ and public social transfers $(\mathbf{st_t})$.

$$\begin{gathered}\mathbf{dlog(ih_t) = ih_1 * dlog(hi_t) - ih_2 * dlog(ig_t) + ih_3 * dlog(hi_{t-1}) - ih_4 * dlog(lg_t) -} \\ \mathbf{ih_4 * dlog(rg_t) - ih_5 * dlog(ic_t) - ih_6 * dlog(st_t) - ih_7 * diff(\boldsymbol{\tau_t^{ci}}) -} \\ \mathbf{ih_8 * diff(lr_{t-1}) + ih_9 * cor(it_{t-1})}\end{gathered} \tag{12}$$

On the other hand, we assume that the public investment $(\mathbf{ig_t})$ is not crowded out by the private $(\mathbf{if_t})$ nor the personal $(\mathbf{ih_t})$ components and is based only on a combination of actual $(\mathbf{yt_t})$ and potential $(\mathbf{yt_t^*})$ output in the domestic economy as stated in the Eq.13. This assumption is consistent with a historical evidence. The error correction term is based on a first order condition with a respect to the capital component (Eq.4).

$$\mathbf{dlog(ig_t) = ig_1 * dlog(yt_t^*) + ig_2 * dlog(yt_t) + ig_6 * cor(it_{t-1})} \tag{13}$$

Finally, it is important to note that while a decline in public expenditures has a positive impact on private investment, an increase in taxes and contributions distorts the potential output and thus limits an economic performance.[12] We thus incorporate a Non-Keynesian framework into the model to capture spillovers from a fiscal policy.

3.2 Demand side block

We continue with a demand side of the economy that describes a decomposition of a gross domestic product into a set of income and expenditure components. We thus assume that the gross domestic product $(\mathbf{yt_t})$ is equal to a sum of private consumption $(\mathbf{ct_t})$, public consumption $(\mathbf{gt_t})$, domestic investment $(\mathbf{it_t})$, inventories and valuables $(\mathbf{dt_t})$ and a difference between domestic exports $(\mathbf{xt_t})$ and domestic imports $(\mathbf{mt_t})$ as stated in the Eq.14. Inventories and valuables $(\mathbf{dt_t})$ are set exogenous to the model.

[11] Even though we assume a negative impact of public expenditures on private investment, we abstract from a negative impact of public expenditures on private consumption, in line with the estimation results of Afonso and Sousa (2009).

[12] For more information see Alesina et al. (2018).

$$\mathbf{yt_t = ct_t + gt_t + it_t + dt_t + xt_t - mt_t} \tag{14}$$

We proceed with a definition of potential consumption $(\mathbf{ct_t^*})$ that is pinned down by a disposable income $(\mathbf{hc_t})$ as stated in the Eq.15. We abstract from an impact of domestic assets on the potential consumption for two reasons. First, since a gross public debt and net foreign assets are mostly owned by foreign investors, we assume that the households are not the owners of these assets that are thus not relevant for consumption of households. Second, even though a private capital stock is an important component of a domestic wealth that is relevant also for an intertemporal decision of households between consumption and leisure, we do not find any historical evidence of this relationship for the Slovak economy.[13]

$$\mathbf{\log(ct_t^*) = ct_1 - ct_2/sqrt(t) + ct_3 * \log(hc_t)} \tag{15}$$

On the other hand, we enrich the equation by constant $(\mathbf{ct_1})$ and trend $(\mathbf{ct_2})$ components to capture a historical decline in a savings rate of households, in line with a convergence process of the Slovak economy (Fig.1). This is driven by a fact that while higher savings contribute to domestic productivity in poor countries, a positive impact of a capital formation is much smaller in rich countries, see for example Aghion et al. (2006).

Fig.1: Savings of Households

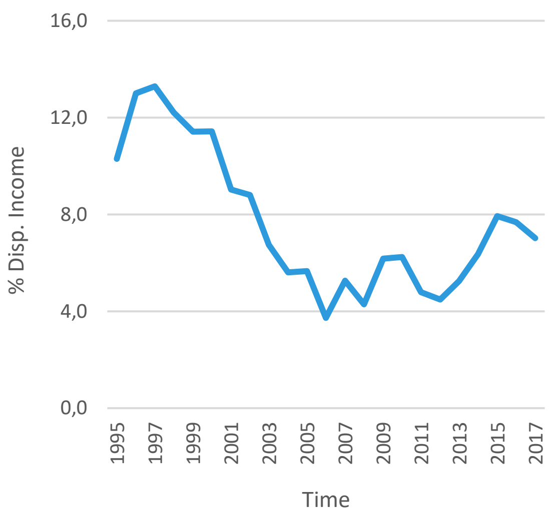
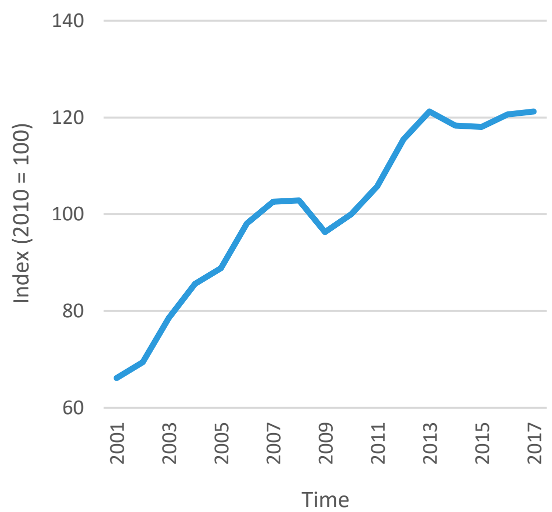


Fig.2: Domestic Market Shares



Private consumption $(\mathbf{ct_t})$ is then based on a disposable income $(\mathbf{hc_t})$ and interest rate costs $(\mathbf{sr_t})$ as stated in the Eq.16. While the first term reflects an empirical degree of a Non-Ricardian behaviour of households in the domestic economy, the latter term is consistent with the Euler equation of a dynamic allocation problem of households. We thus incorporate both Ricardian and Non-Ricardian types of households into the model.

$$\begin{gathered}\mathbf{dlog(ct_t) = ct_4 * dlog(hc_t) + ct_5 * dlog(ct_{t-1}) + ct_6 * dlog(hc_{t-1}) -} \\ \mathbf{ct_7 * diff(sr_{t-1}) - ct_8 * \log(ct_{t-1}/ct_{t-1}^*)}\end{gathered} \tag{16}$$

Public consumption $(\mathbf{gt_t})$ in nominal terms consists of public compensations $(\mathbf{lwg_t})$ and public depreciation $(\mathbf{\delta kg_t})$ and intermediate consumption $(\mathbf{ic_t})$, taxes of government $(\mathbf{ot_t})$, natural transfers $(\mathbf{nt_t})$ and market production $(\mathbf{mp_t})$ in nominal terms as stated in the Eq.17. The public compensations further consist of employment $(\mathbf{lg_t})$ and labour cost $(\mathbf{wg_t})$ components and the public depreciation is implied by a public capital stock $(\mathbf{kg_t})$ under a public depreciation rate $(\mathbf{\delta g_t})$ and capital stock prices $(\mathbf{pk_t})$. The equation is adjusted for price components, i.e. domestic public prices $(\mathbf{pg_t})$ and domestic output prices $(\mathbf{pt_t})$.

[13] For an alternative definition of the potential consumption with an additional impact of the domestic assets see Reľovský and Široká (2015).

$$\mathbf{gt_t * pg_t = lg_t * wg_t + \delta g_t * kg_t * pk_t + ic_t * pt_t + ot_t * pt_t + nt_t * pt_t - mp_t * pt_t} \tag{17}$$

We continue with a definition of export of goods and services ($\mathbf{xt_t}$) that is driven by an external demand ($\mathbf{dx_t}$) and thus based on weighted imports of our most important trading partners as stated in the Eq.18. The imports of our trading partners are obtained in chain linked volumes in domestic currencies to exclude historical variations in inflation rates and exchange rates. The equation is further enriched by a degree of price and real competitiveness and thus by (i) a real exchange rate ($\mathbf{zx_t}$) that is equal to a nominal exchange rate ($\mathbf{er_t}$) plus external prices ($\mathbf{ip_t}$) minus domestic prices ($\mathbf{px_t}$) and (ii) a productivity differential ($\mathbf{da_t}$) between domestic ($\mathbf{at_t}$) and external ($\boldsymbol{\psi_t}$) factor productivity to approximate historical development of domestic market shares. Specifically, the domestic export grows faster than the external demand (Fig.2), in line with a structural trend in domestic market shares.[14] The potential component ($\mathbf{xt_t^*}$) is based on a logarithmic version of the Eq.18.

$$\mathbf{dlog(xt_t) = xt_6 * dlog(dx_t) + xt_7 * dlog(zx_t) + xt_8 * dlog(da_t) - xt_9 * log(xt_{t-1}/xt_{t-1}^*)} \tag{18}$$

Import of goods and services ($\mathbf{mt_t}$) is then driven by a domestic demand ($\mathbf{dm_t}$) and thus based on import intensities of private consumption, public consumption, domestic investment and domestic exports as stated in the Eq.19. It is important to note that we distinguish between the import intensity of private investment, which consists mostly of technical and transport equipment, and the import intensities of personal and public investment, which consist mostly of acquisitions of buildings and dwellings.[15] The equation is further enriched by two types of cost items to reflect a slope of an import demand curve and thus by (i) a real exchange rate ($\mathbf{zm_t}$) that is equal to a nominal exchange rate ($\mathbf{er_t}$) plus external prices ($\mathbf{ep_t}$) minus domestic prices ($\mathbf{pm_t}$) and (ii) an oil price differential ($\mathbf{do_t}$) that is defined as crude oil prices ($\mathbf{oil_t}$) minus domestic prices ($\mathbf{pm_t}$) plus a dollar exchange rate ($\mathbf{us_t}$). The potential component ($\mathbf{mt_t^*}$) is based on a logarithmic version of the Eq.19.

$$\mathbf{dlog(mt_t) = mt_6 * dlog(dm_t) - mt_7 * dlog(zm_t) - mt_8 * dlog(do_t) - mt_9 * log(mt_{t-1}/mt_{t-1}^*)} \tag{19}$$

Next, we define a gross value added ($\mathbf{va_t}$) in nominal terms as a gross domestic product ($\mathbf{yt_t}$) in nominal terms minus value added taxes ($\mathbf{vat_t}$), net consumption taxes ($\mathbf{cnt_t}$) and net production taxes ($\mathbf{ynt_t}$). Furthermore, we obtain a net domestic surplus ($\mathbf{ds_t}$) in nominal terms as a gross value added ($\mathbf{va_t}$) in nominal terms minus compensations of employees ($\mathbf{lwt_t}$) and depreciation of capital ($\boldsymbol{\delta}\mathbf{kt_t}$) as stated in the Eq.20. The compensations of employees further consist of employment ($\mathbf{lt_t}$) and labour cost ($\mathbf{wt_t}$) components and the depreciation of capital is implied by a domestic capital stock ($\mathbf{kt_t}$) under a domestic depreciation rate ($\boldsymbol{\delta}\mathbf{t_t}$) and capital stock prices ($\mathbf{pk_t}$). The equation needs to be adjusted for domestic output prices ($\mathbf{pt_t}$) to account for the variables in nominal terms.

$$\mathbf{va_t * pt_t = lt_t * wt_t + \delta t_t * kt_t * pk_t + ms_t * pt_t + os_t * pt_t} \tag{20}$$

The domestic surplus ($\mathbf{ds_t}$) further consists of a private mixed surplus ($\mathbf{ms_t}$) and a net operating surplus ($\mathbf{os_t}$). These variables are important components of the model, since the mixed surplus contributes to a disposable income of households and the operating surplus contributes to a corporate surplus of firms. The mixed surplus ($\mathbf{ms_t}$) is based on a combination of the potential output ($\mathbf{yt_t^*}$) and the domestic surplus ($\mathbf{ds_t}$) and the operating surplus ($\mathbf{os_t}$) results from the decomposition of a gross domestic product (Eq.20).

[14] It is important to note that the market shares are flat in a steady state.

[15] We calibrate the domestic demand from import intensities of private consumption, public consumption, domestic investment and domestic exports that are obtained from national input-output tables in 5-year intervals.

3.3 Interest rate block

We distinguish between two types of interest rates in the model to incorporate relationships on financial markets and approximate a term structure of interest rates (Fig.3). First, we define the nominal market rates that are set exogenous to the model and correspond to the 3-month Euribor rate ($\mathbf{eu_t}$). This is driven by an absence of an independent monetary policy and is thus in contrast to macroeconomic models with endogenous policy rules. Second, we define the government bond yields that are an endogenous component of the model and correspond to the 10-year Slovak bonds ($\mathbf{sk_t}$) that further consist of the 10-year German bonds ($\mathbf{de_t}$) and a domestic risk premium ($\mathbf{pr_t}$). While the short-term interest rates ($\mathbf{eu_t}$) approximate consumer loans and thus influence the private consumption (Eq.16), the long-term interest rates ($\mathbf{sk_t}$) approximate corporate and mortgage loans and thus influence private (Eq.11) and personal (Eq.12) investment. We further assume that the risk premium ($\mathbf{pr_t}$) is based on an evolution of a public debt ($\mathbf{dp_t^*}$) and a current account ($\mathbf{ca_t^*}$) as stated in the Eq.21. The risk premium is thus an important component of the model that captures an impact of a fiscal policy on the potential output as a capital cost item (Eq.4).

$$\mathbf{pr_t} = \boldsymbol{\Phi_1} + \boldsymbol{\Phi_2} * \mathbf{pr_{t-1}} + \boldsymbol{\Phi_3} * \mathbf{dp_t^*} - \boldsymbol{\Phi_4} * \mathbf{ca_t^*} \qquad (21)$$

Calibration of the equation is based on a two-step approach. First, we assume that an impact of a public debt ($\boldsymbol{\Phi_3}$) and a current account ($\boldsymbol{\Phi_4}$) on the risk premium should be equal before and after the adoption of Euro. We thus compute average values of these variables before and after the adoption of Euro and calibrate the parameters from a system of linear equations. We further assume that the adoption of Euro reduces the risk premium by a half percentage point, in line with a higher confidence of investors. It is important to note that this assumption results from a historical development of risk premiums in the Visegrad countries, i.e. historical differences between the 10-year Visegrad bonds and the 10-year German bonds. Specifically, we need to compute a difference between the Visegrad premium and the Slovak premium to approximate a relative confidence of investors to the Slovak economy with a respect to the Visegrad countries (Fig.4) and then compare its average values before and after the adoption of Euro.[16] Second, we estimate both constant ($\boldsymbol{\Phi_1}$) and persistence ($\boldsymbol{\Phi_2}$) parameters by the Ordinary Least Squares (OLS) under linear restrictions. Finally, we abstract from nonlinear effects of a fiscal policy on a confidence of investors, due to an absence of a historical evidence. This is driven by a short data sample and a small variance of fiscal variables.

Fig.3: Model Interest Rates

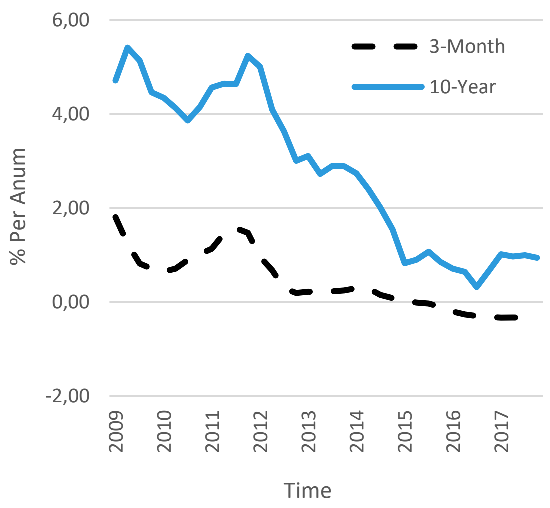
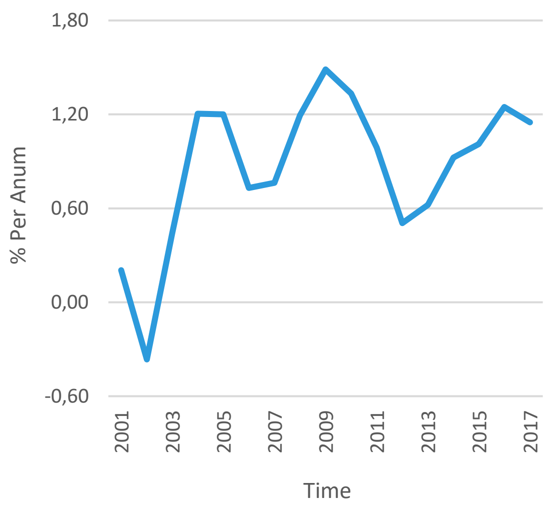


Fig.4: Confidence of Investors



[16] We construct the Visegrad premium as an average risk premium of the Visegrad countries, i.e. Czechia, Hungary, Poland and Slovakia.

An alternative method to approximate these nonlinear effects is based on a panel estimation of the Visegrad countries.[17] However, we abstract from this approach for two reasons. First, a monetary policy shift implied by the adoption of Euro results in a different structure of the domestic premium with a respect to other Visegrad countries. Before the adoption of Euro, the domestic premium was equal to a sum of a term premium, which was based on a domestic monetary policy, and a country premium, which consists of credit and liquidity components. On the other hand, an absence of an independent monetary policy after the adoption of Euro implies a trivial term premium for the domestic economy. For more information about a structure of the domestic premium see Ódor and Povala (2016). Second, an unconventional monetary policy of the European Central Bank (ECB) in the recent years that is driven mostly by the Quantitative Easing (QE) creates another form of heterogeneity between the Slovak economy and other Visegrad countries that is not captured by estimation methods.

3.4 Wages and prices

We start with the potential labour costs ($\mathbf{wt_t^*}$) that are based on a first order condition with a respect to the labour component (Eq.3) and thus on the potential productivity ($\mathbf{lp_t^*}$). On the other hand, we need to decompose the domestic labour costs ($\mathbf{wt_t}$) into private and public components. The private labour costs ($\mathbf{wf_t}$) are then driven by a labour productivity ($\mathbf{lp_t}$) and intersectoral spillovers from public labour costs ($\mathbf{wg_t}$) as stated in the Eq.22. The equation is further extended with contributions of employers to a private sector ($\boldsymbol{\tau_t^{fc}}$) and to a public sector ($\boldsymbol{\tau_t^{gc}}$) to divide a labour tax burden between both employees and employers. On the other hand, we assume that contributions of employees ($\boldsymbol{\tau_t^{lc}}$) and labour income taxes ($\boldsymbol{\tau_t^{li}}$) are born only by the employees and not the employers, due to a rigidity of gross wages and salaries. These assumptions are consistent with the estimation results of Kľúčik (2015). We further enrich the equation by (i) an unemployment gap ($\boldsymbol{\mu_t}$) to approximate a bargaining power of workers and firms in wage negotiations and (ii) corporate income taxes ($\boldsymbol{\tau_t^{ci}}$) to model a contemporaneous impact of a capital tax burden on gross wages and salaries. Finally, we determine a price component of the private labour costs by a combination of consumer ($\mathbf{cp_t}$) and output ($\mathbf{pt_t}$) prices to capture a mark-up between employees and employers.

$$\begin{gathered}\mathbf{dlog(wf_t) = wf_1 * dlog(lp_t) + wf_2 * dlog(wg_{t-1}) + wf_3 * dlog(lp_{t-1}) + wf_4 * dlog(cp_t) +} \\ \mathbf{wf_5 * dlog(pt_t) + wf_6 * diff(\boldsymbol{\tau_t^{gc}}) + wf_7 * diff(\boldsymbol{\tau_t^{fc}}) - wf_8 * gap(\boldsymbol{\mu_t}) - wf_9 * diff(\boldsymbol{\tau_t^{ci}}) -} \\ \mathbf{wf_{10} * log(wt_{t-1}/wt_{t-1}^*)}\end{gathered} \tag{22}$$

The public labour costs ($\mathbf{wg_t}$) are based on an identical behavioural equation but with a zero impact of an unemployment gap ($\boldsymbol{\mu_t}$) and corporate income taxes ($\boldsymbol{\tau_t^{ci}}$). The public labour costs ($\mathbf{wg_t}$) are thus driven by a labour productivity ($\mathbf{lp_t}$) and intersectoral spillovers from private labour costs ($\mathbf{wf_t}$) as stated in the Eq.23. This equation is also extended with contributions of employers to a private sector ($\boldsymbol{\tau_t^{fc}}$) and to a public sector ($\boldsymbol{\tau_t^{gc}}$) to divide a labour tax burden between both employees and employers. Again, we determine a price component of the public labour costs by a combination of consumer ($\mathbf{cp_t}$) and output ($\mathbf{pt_t}$) prices to capture a mark-up between employees and employers.

$$\begin{gathered}\mathbf{dlog(wg_t) = wg_1 * dlog(lp_t) + wg_2 * dlog(wf_{t-1}) + wg_3 * dlog(lp_{t-1}) + wg_4 * dlog(cp_t) +} \\ \mathbf{wg_5 * dlog(pt_t) + wg_6 * diff(\boldsymbol{\tau_t^{gc}}) + wg_7 * diff(\boldsymbol{\tau_t^{fc}}) - wg_8 * log(wt_{t-1}/wt_{t-1}^*)}\end{gathered} \tag{23}$$

We continue with the potential output prices ($\mathbf{pt_t^*}$) that are implied by unit labour costs ($\mathbf{ulc_t}$) under a flexible price setting of domestic producers. On the other hand, we define the domestic output prices ($\mathbf{pt_t}$) as a ratio between the domestic output in nominal terms ($\mathbf{yn_t}$) and in real terms ($\mathbf{yt_t}$). Production prices ($\mathbf{pp_t}$) are then driven by a combination of unit labour costs ($\mathbf{ulc_t}$) and inflation expectations ($\mathbf{pl_t}$) as stated in the Eq.24. We need to point out that the inflation

[17] For more information about the estimation process see Kľúčik (2015).

expectations are obtained as a discounted moving average of a monthly consumer inflation rate on a 5-year horizon, in line with Cieslak and Povala (2015), and are thus not defined in a model consistent manner as in rational expectations models. Forecast of the inflation expectations is set exogenous to the model.

$$\mathbf{dlog(pp_t) = pp_1 * dlog(ulc_t) + pp_2 * dlog(pl_t) + pp_3 * dlog(ulc_{t-1}) + pp_4 * up(\tau_t^{ci}) +} \atop \mathbf{pp_5 * down(\tau_t^{ci}) - pp_6 * \ log(pt_{t-1}/pt_{t-1}^*)} \quad (24)$$

Furthermore, we enrich the equation by an asymmetric impact of corporate income taxes ($\boldsymbol{\tau_t^{ci}}$) to capture a decision making of domestic producers under an imperfect competition in the domestic economy. This definition of production prices thus implies different impulse response functions for an increase and a decline in corporate income taxes. Finally, the error correction term is implied by a flexible price indicator (Fig.5) and thus by a ratio between domestic ($\mathbf{pt_t}$) and potential ($\mathbf{pt_t^*}$) prices in the Slovak economy.

Fig.5: Flexible Price Indicator

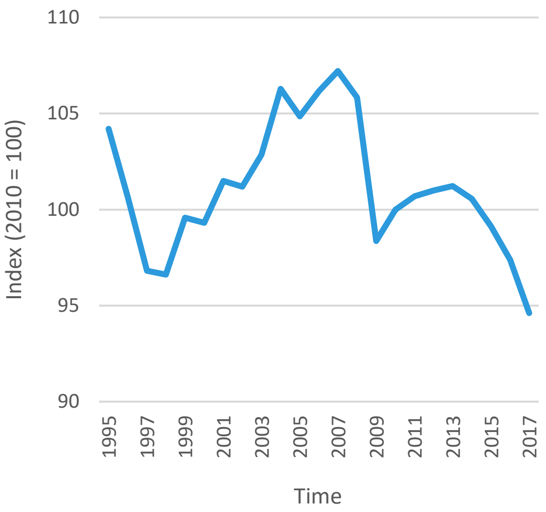
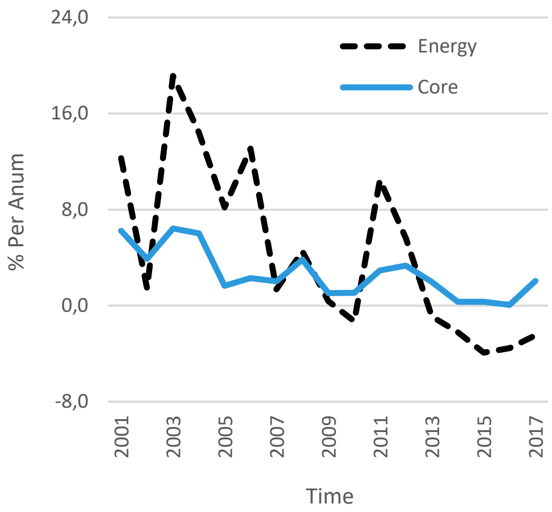


Fig.6: Model Inflation Rates



Next, we need to decompose consumer prices ($\mathbf{cp_t}$) into core and energy components (Fig.6), in line with their historical shares in the consumption basket.[18] The core component ($\mathbf{pn_t}$) is then driven by production ($\mathbf{pp_t}$) and import ($\mathbf{pm_t}$) prices and a combination of backward-looking and forward-looking expectations as stated in the Eq.25. Furthermore, we enrich the equation by (i) a domestic output gap ($\mathbf{yt_t}$) to capture a degree of economic slack and (ii) a productivity differential ($\mathbf{bs_t}$) between domestic ($\mathbf{lp_t}$) and external ($\boldsymbol{\varphi_t}$) labour productivity to approximate the Balassa-Samuelson effect. The equation is further extended with an asymmetric impact of value added taxes ($\boldsymbol{\tau_t^{va}}$) and net consumption taxes ($\boldsymbol{\tau_t^{cn}}$) to approximate a contemporaneous impact of an indirect tax burden on core consumer prices. Finally, the potential component ($\mathbf{pn_t^*}$) is based on a combination of output ($\mathbf{pt_t}$) and import ($\mathbf{pm_t}$) prices.

$$\begin{gathered}\mathbf{dlog(pn_t) = pn_6 * dlog(pp_t) + pn_7 * dlog(pl_t) + pn_8 * dlog(pm_t) + pn_9 * dlog(pn_{t-1}) +} \\ \mathbf{pn_{10} * dlog(bs_t) + pn_{11} * gap(yt_t) + pn_{12} * up(\tau_t^{va}) + pn_{13} * down(\tau_t^{va}) + pn_{14} * up(\tau_t^{cn}) +} \\ \mathbf{pn_{15} * down(\tau_t^{cn}) - pn_{16} * log(pn_{t-1}/pn_{t-1}^*)}\end{gathered} \quad (25)$$

On the other hand, the energy component ($\mathbf{pe_t}$) is pinned down by inflation expectations ($\mathbf{pl_t}$) and a combination of production ($\mathbf{pp_t}$) and crude oil ($\mathbf{oil_t}$) prices as stated in the Eq.26. It is important to note that we need to adjust the crude oil prices ($\mathbf{oil_t}$) for a dollar exchange rate ($\mathbf{us_t}$) to transform them into the domestic currency. This equation is also extended with an asymmetric impact of value added taxes ($\boldsymbol{\tau_t^{va}}$) and net consumption taxes ($\boldsymbol{\tau_t^{cn}}$) to approximate

[18] The decomposition of consumer prices is based on a harmonized index of consumer prices (HICP).

a contemporaneous impact of an indirect tax burden on energy consumer prices. We need to mention that the asymmetric impact of indirect taxes on consumer prices is in line with the literature on tax elasticities.[19] Finally, the potential component ($\mathbf{pe_t^*}$) is based on a combination of output ($\mathbf{pt_t}$) and crude oil ($\mathbf{oil_t}$) prices. Again, we need to adjust the crude oil prices ($\mathbf{oil_t}$) for a dollar exchange rate ($\mathbf{us_t}$) to transform them into the domestic currency.

$$\begin{gathered}\mathbf{dlog(pe_t) = pe_5 * dlog(pp_t) + pe_6 * dlog(pl_t) + pe_7 * dlog(oil_t) + pe_7 * dlog(us_t) +} \\ \mathbf{pe_8 * up(\tau_t^{va}) + pe_9 * down(\tau_t^{va}) + pe_{10} * up(\tau_t^{cn}) + pe_{11} * down(\tau_t^{cn}) -} \\ \mathbf{pe_{12} * log(pe_{t-1}/pe_{t-1}^*)}\end{gathered} \tag{26}$$

We proceed with a deflator of investment ($\mathbf{pi_t}$) that is driven by a combination of production ($\mathbf{pp_t}$) and import ($\mathbf{pm_t}$) prices and a deflator of capital stock ($\mathbf{pk_t}$) that is implied by the production prices ($\mathbf{pp_t}$). We abstract from the decomposition of aggregate deflators into sectors of firms, households and government, due to a lack of available historical data. Furthermore, we assume that a deflator of government ($\mathbf{pg_t}$) is driven by a combination of production ($\mathbf{pp_t}$) and consumer ($\mathbf{cp_t}$) prices and that a deflator of households ($\mathbf{pc_t}$) is implied by the consumer prices ($\mathbf{cp_t}$). Finally, we assume that (i) an export deflator ($\mathbf{px_t}$) is based on a combination of domestic prices ($\mathbf{pp_t}$) and external prices ($\mathbf{ip_t}$) that are adjusted for a nominal exchange rate ($\mathbf{er_t}$) and (ii) an import deflator ($\mathbf{pm_t}$) is based on a combination of domestic prices ($\mathbf{pp_t}$), external prices ($\mathbf{ep_t}$) that are adjusted for a nominal exchange rate ($\mathbf{er_t}$) and crude oil prices ($\mathbf{oil_t}$) that are adjusted for a dollar exchange rate ($\mathbf{us_t}$).[20]

3.5 Firms and households

We start with budgetary restrictions of firms that define a corporate surplus ($\mathbf{cs_t}$) in nominal terms under (i) private revenues that come from private depreciation ($\mathbf{\delta kf_t}$) and net operating surplus ($\mathbf{os_t}$) in nominal terms and (ii) private expenditures that are spent on corporate income taxes ($\mathbf{cit_t}$) as results from the Eq.27. The private depreciation is then implied by a private capital stock ($\mathbf{kf_t}$) under a private depreciation rate ($\mathbf{\delta f_t}$) and capital stock prices ($\mathbf{pk_t}$). Finally, we adjust the equation for domestic output prices ($\mathbf{pt_t}$).

$$\mathbf{cs_t = \delta f_t * kf_t * pk_t + os_t * pt_t - cit_t} \tag{27}$$

On the other hand, budgetary restrictions of households define a disposable income ($\mathbf{hn_t}$) in nominal terms under (i) personal revenues that come from personal depreciation ($\mathbf{\delta kh_t}$) and domestic ($\mathbf{lwt_t}$) and external ($\mathbf{lwe_t}$) compensations and public social transfers ($\mathbf{st_t}$) and private mixed surplus ($\mathbf{ms_t}$) in nominal terms and (ii) personal expenditures that are spent on both taxes ($\mathbf{toh_t}$) and contributions ($\mathbf{coh_t}$) of households as results from the Eq.28. The personal depreciation is then implied by a personal capital stock ($\mathbf{kh_t}$) under a personal depreciation rate ($\mathbf{\delta h_t}$) and capital stock prices ($\mathbf{pk_t}$). On the other hand, the domestic compensations consist of employment ($\mathbf{lt_t}$) and labour cost ($\mathbf{wt_t}$) components and also the external compensations consist of employment ($\mathbf{le_t}$) and labour cost ($\mathbf{we_t}$) components. We further extend the equation for net property transfers ($\mathbf{hpt_t}$) and net current transfers ($\mathbf{hot_t}$) that are based on the domestic output in nominal terms. Finally, we adjust the equation for domestic output prices ($\mathbf{pt_t}$).

$$\begin{gathered}\mathbf{hn_t = \delta h_t * kh_t * pk_t + lt_t * wt_t + le_t * we_t + st_t * pt_t + ms_t * pt_t -} \\ \mathbf{toh_t - coh_t + hpt_t + hot_t}\end{gathered} \tag{28}$$

The taxes of households ($\mathbf{toh_t}$) consist of labour income taxes ($\mathbf{lit_t}$) that are based on gross wages and salaries and property income taxes ($\mathbf{pit_t}$) that are based on a disposable income. On the other hand, the contributions of households ($\mathbf{coh_t}$) consist of contributions of employers to a private sector ($\mathbf{fsc_t}$) and a public sector ($\mathbf{gsc_t}$) that are based on gross wages and salaries,

[19] For further information and potential explanations see Melioris (2015).

[20] Specifically, we assume that the external import prices pin down the domestic export deflator and that the external export prices pin down the domestic import deflator.

contributions of employees ($\mathbf{lsc_t}$) that are based on gross wages and salaries, contributions of investors ($\mathbf{psc_t}$) that are based on a disposable income and personal ($\mathbf{ssc_t}$) and external ($\mathbf{esc_t}$) contributions that are based on personal and external compensations. Finally, the external employment ($\mathbf{le_t}$) is based on the productive population ($\mathbf{np_t}$) and the external labour costs ($\mathbf{we_t}$) are based on the domestic labour costs ($\mathbf{wt_t}$).

3.6 Fiscal policy block

We start with budgetary restrictions of government that define a fiscal balance ($\mathbf{bp_t}$) in nominal terms under (i) public revenues that are given by public depreciation ($\boldsymbol{\delta}\mathbf{kg_t}$), direct taxes ($\mathbf{dit_t}$), indirect taxes ($\mathbf{int_t}$) and social contributions ($\mathbf{soc_t}$) and (ii) public expenditures that are spent on interest rate costs ($\mathbf{irc_t}$) and other capital costs ($\mathbf{okc_t}$) and public consumption ($\mathbf{gt_t}$), public investment ($\mathbf{ig_t}$) and public social transfers ($\mathbf{st_t}$) in nominal terms as results from the Eq.29. The public depreciation is then implied by a public capital stock ($\mathbf{kg_t}$) under a public depreciation rate ($\boldsymbol{\delta}\mathbf{g_t}$) and capital stock prices ($\mathbf{pk_t}$). Furthermore, we extend the equation for net property transfers ($\mathbf{gpt_t}$), net current transfers ($\mathbf{got_t}$), net external transfers ($\mathbf{get_t}$) and net capital transfers ($\mathbf{gct_t}$) that are based on a number of external factors and thus set exogenous to the model.[21] Finally, the equation is adjusted for price components, i.e. domestic output prices ($\mathbf{pt_t}$), domestic public prices ($\mathbf{pg_t}$) and domestic capital prices ($\mathbf{pi_t}$).

$$\mathbf{bp_t} = \boldsymbol{\delta}\mathbf{g_t} * \mathbf{kg_t} * \mathbf{pk_t} + \mathbf{dit_t} + \mathbf{int_t} + \mathbf{soc_t} - \mathbf{gt_t} * \mathbf{pg_t} - \mathbf{ig_t} * \mathbf{pi_t} - \mathbf{st_t} * \mathbf{pt_t} - \mathbf{irc_t} - \mathbf{okc_t} + \mathbf{gpt_t} + \mathbf{got_t} + \mathbf{get_t} + \mathbf{gct_t} \tag{29}$$

The interest rate costs ($\mathbf{irc_t}$) are based on a cumulative value of a public debt ($\mathbf{dp_t}$) and an effective interest rate ($\mathbf{ir_t}$) to capture the price of outstanding and new debt portfolios. We need to mention that the interest rate costs ($\mathbf{irc_t}$) include also a domestic risk premium ($\mathbf{pr_t}$) that is further influenced by a fiscal policy and thus produce the fiscal loop for the public debt. On the other hand, the other capital costs ($\mathbf{okc_t}$) are set exogenous to the model. We then determine a public debt ($\mathbf{dp_t}$) with an outstanding debt from a previous period and a fiscal balance ($\mathbf{bp_t}$) as stated in the Eq.30. We thus abstract from an impact of a stock flow adjustment on the public debt and do not distinguish between net and gross public debt.[22]

$$\mathbf{dp_t} = \mathbf{dp_{t-1}} - \mathbf{bp_t} \tag{30}$$

We continue with the public consumption ($\mathbf{gt_t}$) that is defined as a sum of individual expenditure components (Eq.17). The natural transfers ($\mathbf{nt_t}$) and the market production ($\mathbf{mp_t}$) are based on compensations of employees ($\mathbf{lwt_t}$) and gross value added ($\mathbf{va_t}$) in the domestic economy. On the other hand, the taxes of government ($\mathbf{ot_t}$) are based on the public consumption ($\mathbf{gt_t}$). Finally, the intermediate consumption ($\mathbf{ic_t}$) is driven by a combination of actual ($\mathbf{yt_t}$) and potential ($\mathbf{yt_t^*}$) output as stated in the Eq.31. The error correction term is then based on a steady-state ratio between the intermediate consumption ($\mathbf{ic_t}$) and the potential output ($\mathbf{yt_t^*}$).

$$\mathbf{dlog(ic_t)} = \mathbf{ic_2} * \mathbf{dlog(yt_t^*)} + \mathbf{ic_3} * \mathbf{dlog(yt_t)} + \mathbf{ic_7} * \mathbf{cor(ic_{t-1})} \tag{31}$$

The public social transfers ($\mathbf{st_t}$) are then driven by a combination of the potential output ($\mathbf{yt_t^*}$) and domestic employment ($\mathbf{lt_t}$) and labour costs ($\mathbf{rt_t}$) to approximate different types of pension transfers as stated in the Eq.32. Furthermore, we extend the equation with an unemployment rate ($\boldsymbol{\mu}_\mathbf{t}$) and a participation rate ($\boldsymbol{\eta}_\mathbf{t}$) to approximate different types of labour market transfers. The error correction term is then based on a steady-state ratio between the public social transfers ($\mathbf{st_t}$) and the potential output ($\mathbf{yt_t^*}$).

$$\mathbf{dlog(st_t)} = \mathbf{st_2} * \mathbf{dlog(yt_t^*)} + \mathbf{st_3} * \mathbf{dlog(lt_t)} + \mathbf{st_3} * \mathbf{dlog(rt_t)} + \mathbf{st_4} * \mathbf{dlog}(\boldsymbol{\eta}_\mathbf{t}) + \mathbf{st_4} * \mathbf{dlog}(\boldsymbol{\mu}_\mathbf{t}) + \mathbf{st_8} * \mathbf{cor(st_{t-1})} \tag{32}$$

[21] For example a real time spending of the current EU funds and the capital EU funds.

[22] The stock flow adjustment includes some additional drivers of a public debt, for example a cash reserve formation or privatisation effects.

The direct taxes ($\mathbf{dit_t}$) consist of labour income taxes ($\mathbf{lit_t}$) that are based on gross wages and salaries, property income taxes ($\mathbf{pit_t}$) that are based on a disposable income, corporate income taxes ($\mathbf{cit_t}$) that are based on a net operating surplus and other income taxes ($\mathbf{git_t}$) that are set exogenous to the model. On the other hand, the indirect taxes ($\mathbf{int_t}$) consist of value added taxes ($\mathbf{vat_t}$) that are based on taxable parts of private consumption, public investment and intermediate consumption, net consumption taxes ($\mathbf{cnt_t}$) that are based on relevant shares of private consumption and domestic output and net production taxes ($\mathbf{ynt_t}$) that are set exogenous to the model.[23] Finally, the social contributions ($\mathbf{soc_t}$) consist of contributions of employers ($\mathbf{gsc_t}$), contributions of employees ($\mathbf{lsc_t}$), contributions of investors ($\mathbf{psc_t}$) and personal contributions ($\mathbf{ssc_t}$). The effective rates of domestic taxes and social contributions are set exogenous to the model.

Endogenous fiscal rules are based on public expenditures, in line with Claeys et al. (2016), Darvas et al. (2018) and Feld et al. (2018). Specifically, we assume that government corrects the public expenditures in line with a deviation of a fiscal balance ($\mathbf{bp_t^*}$) and a public debt ($\mathbf{dp_t^*}$) from their target paths. While the fiscal balance is pinned down by the public debt in a steady state, we allow for separate target paths for both fiscal variables in a medium horizon. Finally, we enrich the fiscal rules by a domestic output gap ($\mathbf{yt_t}$), to model a counter-cyclical policy of the government. It is important to note, that we need to calibrate the fiscal rules due to a short data sample and a lack of historical evidence.

A default fiscal strategy is then based on the expenditures on public compensations, public investment, intermediate consumption and public social transfers. We prefer expenditure over revenue components of a public budget, due to a simple practical implementation and plausible stabilization properties of the model. Furthermore, the expenditure components produce more convenient fiscal multipliers with a respect to the revenue components. Finally, a fiscal policy based on the expenditure components is more consistent with a policy focus on expenditure ceilings as proposed by Šuchta et al. (2018). An alternative approach to a fiscal policy could be based on a combination of both revenue and expenditure components of a public budget as proposed by Kľúčik (2015). For a comparison of different consolidation strategies in the European Union see Cournede et al. (2013) and Beetsma et al. (2018).

[23] Net consumption taxes consist of net excise taxes that are based on private consumption and net product taxes that are based on domestic output with a respect to their historical shares.

4 Methodology and data

We propose a structural econometric model of the Slovak economy that is built on the model of Fagan et al. (2001) and further adapted for domestic circumstances. The model is then extended for a sectoral decomposition of labour and capital markets and comprehensive budgetary restrictions of firms and households. Finally, the model is enriched by a fiscal block and is thus made suitable for a policy analysis. Since the Slovak Republic is characterized as a small open economy without an independent monetary policy, we build a single country model and exogenize external variables, i.e. total external demand ($\mathbf{dx_t}$), effective external prices ($\mathbf{pw_t}$), crude oil prices ($\mathbf{oil_t}$), effective exchange rate ($\mathbf{er_t}$), dollar exchange rate ($\mathbf{us_t}$), 3-month Euribor rate ($\mathbf{eu_t}$) and 10-year German bonds ($\mathbf{de_t}$), in line with macroeconomic forecasts of international institutions. Furthermore, we define stochastic paths for total factor productivity ($\mathbf{at_t}$), productive population ($\mathbf{np_t}$), world factor productivity ($\boldsymbol{\psi}_\mathbf{t}$), world labour productivity ($\boldsymbol{\varphi}_\mathbf{t}$) and potential rates of participation ($\boldsymbol{\eta}_\mathbf{t}^*$) and unemployment ($\boldsymbol{\mu}_\mathbf{t}^*$) and thus close the model.

The model consists of a set of behavioural equations and macroeconomic identities and can be further decomposed into six model blocks: a supply side block, a demand side block, a block of wages and prices, an interest rate block, a block of firms and households and a fiscal policy block. The error correction equations are then estimated by the Ordinary Least Squares (OLS) on a time period from the first quarter of 1995 to the last quarter of 2017. Quarterly data are seasonally adjusted and further benchmarked to their annual values.[24] Finally, the model is solved by a trust region algorithm that is derived from the Newton method. The estimation of model parameters is implemented in the R software and the solution of model equations is implemented in the Matlab software. The model is based on quarterly data and is designed for macroeconomic forecasts and simulations on a medium horizon.

4.1 Potential production

To apply the model for macroeconomic projections, it is necessary to identify the potential output ($\mathbf{yt_t^*}$) from a historical dataset. First, we identify the capital component ($\mathbf{kt_t}$) with the Perpetual inventory method that includes information about domestic investment, domestic depreciation and net capital assets in reproductive prices.[25] This method thus allows us to decompose a nominal capital stock into real and price components under the existence of a time variant depreciation rate and different price deflators for outstanding and new capital assets. This capital decomposition then results in (i) a higher inflation rate of a domestic capital stock with a respect to domestic investment, in line with a changing composition of domestic investment from buildings and dwellings to a technical equipment and (ii) a higher depreciation rate with a respect to the models of Reľovský and Široká (2009) and Kľúčik (2015) that results from differences between net and gross capital stock.

Second, we estimate the labour component ($\mathbf{lt_t^*}$) from a dataset of productive population ($\mathbf{np_t}$), potential participation ($\boldsymbol{\eta}_\mathbf{t}^*$) and potential unemployment ($\boldsymbol{\mu}_\mathbf{t}^*$). We incorporate the national population from 15 to 64 years and eliminate structural breaks in the time series that are driven by a low frequency of the population census. The participation rate ($\boldsymbol{\eta}_\mathbf{t}$) is then decomposed into its potential and cyclical components by the Hodrick-Prescott filter. On the other hand, the decomposition of the unemployment rate ($\boldsymbol{\mu}_\mathbf{t}$) is based on the Kalman filter that further incorporates the Phillips curve to exploit a functional relationship between an inflation rate and an unemployment gap. We thus obtain a non-accelerating inflation rate of unemployment, a popular approximation for the natural rate of unemployment.[26]

[24] Data are seasonally adjusted by the X13-Arima-Seats method and then benchmarked to their annual values by the Denton-Cholette method. Sectoral data are further aggregated by the Multivariate Denton method.

[25] We prefer the net capital stock over the gross capital stock, due to a changing composition of domestic investment.

[26] For more information about the estimation process see Habrman and Rybák (2016).

Finally, to decompose the domestic output ($\mathbf{yt_t}$) into its potential and cyclical components, we combine benefits of a production function approach, to obtain information about labour ($\mathbf{lt_t^*}$) and capital ($\mathbf{kt_t}$) production factors, with benefits of a multivariate filter approach, to exploit additional information from a real economy. We thus construct a model of unobserved components with the potential output ($\mathbf{yt_t^*}$) defined by a production function and thus in fact implied by a stochastic process for a total factor productivity ($\mathbf{at_t}$) and the domestic output gap pinned down by a set of behavioural equations.[27] Specifically, we exploit functional relationships between the output gap and an inflation rate (Phillips curve), an unemployment gap (Okun's law) and a trade balance (Current account). The model is then estimated by the Kalman filter with the Bayesian interface.

We thus propose one of the most robust and complex views of the potential output that is estimated from both potential and cyclical sides of an economy. See for example Havik et al. (2014) for the production function approach applied by the ECB and Blagrave et al. (2015) for the multivariate filter approach applied by the IMF. Finally, we need to mention the model of Darvas and Simon (2015) that extends the multivariate filters for a current account and thus incorporates open economy considerations into the estimation of the potential output. We assume that this extension of standard equations that are applied by the multivariate filters, i.e. the Phillips curve and the Okun's law, is crucial for a reasonable identification of the potential output in small open economies.

4.2 Macroeconomic data

Next, we construct an indicator of external demand ($\mathbf{dx_t}$) from weighted imports of our most important trading partners that are obtained from the Eurostat. The import shares are further based on individual exports of Slovakia to particular countries. A similar aggregation method is then applied for effective external prices ($\mathbf{pw_t}$) and effective exchange rate ($\mathbf{er_t}$) and also for factor ($\boldsymbol{\psi}_\mathbf{t}$) and labour ($\boldsymbol{\varphi}_\mathbf{t}$) productivity of the external world. We need to mention that the construction of these variables is based on the economies of the Euro Area and the economies of the Visegrad Group.[28] We prefer this specification over the one that would be based only on the economies of the Euro Area, due to a significant contribution of the Visegrad Group to both domestic exports and domestic imports.[29] Time series of crude oil prices ($\mathbf{oil_t}$), dollar exchange rate ($\mathbf{us_t}$) and nominal market rate ($\mathbf{eu_t}$) are received from the Bloomberg. Yields on government bonds are obtained from a term structure of interest rates that is provided by the Bundesbank of Germany ($\mathbf{de_t}$) and the National bank of Slovakia ($\mathbf{sk_t}$).

Data about the gross domestic product and the domestic labour market are then obtained from the ESA national accounts with a reference year 2010. On the other hand, a sectoral decomposition of the domestic economy is based on the ESA sectoral accounts of firms, households and government. Both national and sectoral accounts are obtained from the Statistical Office of the Slovak Republic. Taxes and contributions are also constructed under the ESA methodology and obtained from the Institute for Financial Policy.

4.3 Fiscal consolidation

Finally, we might be interested in a decomposition of a fiscal balance into its structural and cyclical components. The cyclical component could be then derived from a domestic output gap and the structural component further implied by the model. It is important to note that the structural balance would be thus an endogenous part of the model but would not influence

[27] It is important to note that we estimate the potential factor productivity from a Cobb-Douglas production function and abstract from an actual factor productivity that is obtained as the Solow residual. Labour and capital components are set exogenous to this model.

[28] Total external demand is based on individual imports of Germany, Czechia, France, Poland, Austria, Hungary, Italy and Spain. External prices and exchange rates are constructed for economies of Euro area, Czechia, Poland and Hungary.

[29] Approximately 35% and 65% of domestic exports and 40% and 60% of domestic imports are based on the Visegrad Group and the Euro Area.

a fiscal policy. On the other hand, a practical implementation of a fiscal policy in the Slovak economy should be based on a structural balance that is consistent with official fiscal rules of the European Commission. Consolidation strategy should be further driven by a budgetary plan to maintain macroeconomic forecasts consistent with the fiscal projections. We thus need to construct a consolidation mix in line with the budgetary plan that stabilizes the structural balance. However, this is problematic for three main reasons. First, a construction of a fiscal block in the model is not identical to a decomposition applied by the budgetary plan. Second, revisions of national accounts create inconsistences between an actual state of the economy and the budgetary plan. Third, formation of the budgetary plan on an annual basis is not consistent with more frequent macroeconomic forecasts.

To overcome issues with the budgetary plan and provide macroeconomic forecasts that are consistent with the fiscal projections, we implement a two-step forecasting process that is based on a proportional consolidation. In the first step, we turn off the fiscal rules and forecast model variables with no fiscal restrictions to obtain a baseline forecast of the domestic economy. In the second step, we target a structural balance from the budgetary plan under a proportional consolidation that is distributed between public revenues (50%) and public expenditures (50%), in line with historical shares of the budgetary components. Even though we prefer fiscal rules that are based on public expenditures for an evaluation of a model performance, we tend to apply a neutral consolidation mix for macroeconomic forecasts, due to a lack of relevant information about a fiscal policy.

Furthermore, the consolidation mix that is applied for macroeconomic forecasts is different from the fiscal rules that are proposed in the model, since (i) we need to target a structural balance in contrast to a fiscal balance and a public debt in the fiscal rules and (ii) we need to obtain a target value of the structural balance in each simulation period what is not consistent with a reaction function of the fiscal rules. However, this approach to a fiscal consolidation does not stabilize the model in a steady state, due to an unconstrained public debt, and is thus not applicable for the evaluation of a model performance.

5 Model parametrization

Parametrisation of the model is based on a combination of calibration and estimation and we distinguish between four basic groups of model parameters. First, equilibrium parameters that pin down a convergence process of the model and are calibrated in line with related literature and structural assumptions about the domestic economy. Second, structural parameters that capture macroeconomic ratios and are based on a historical development of model variables. Third, behavioural parameters that define empirical properties of the model and are mostly estimated with econometric methods, and finally, fiscal parameters that capture a structure and a magnitude of a fiscal policy and its impact on the domestic economy. These parameters are calibrated in line with impulse response functions. The estimation process then consists of one-by-one estimation of individual empirical equations. Specifically, the error correction equations are restricted by homogeneity conditions and calibration of individual parameters and estimated by the Ordinary Least Squares (OLS).

5.1 Steady state calibration

Steady state of the model is implied by a set of equilibrium parameters that includes output, population and price dynamics, depreciation, unemployment and participation rates and interest and exchange rates. Specifically, we set an equilibrium value for an output growth to 2.5% and for a population growth to 0.0%, in line with our assumptions on a long horizon.[30] Furthermore, we assume that the domestic inflation converges to an inflation target of the European Central Bank under a law of one price and thus set an equilibrium value for an inflation rate to 2.0%. However, it is important to note that a convergence process of the domestic economy implies higher domestic prices with a respect to the external ones in a medium horizon. This assumption is in line with a price convergence under the Balassa-Samuelson effect.[31]

Next, we set a steady state for a depreciation rate (Fig.7) equal to 4.0%, for an unemployment rate (Fig.8) equal to 5.0% and for a participation rate (Fig.9) equal to 75.0%, in line with structural trends in historical time series. We further assume that a real interest rate in the euro area is equal to 1.0% on a short horizon, i.e. for the market rates, and 1.5% on a long horizon, i.e. for the government bonds. This assumption is consistent with an estimation of the natural rate of interest over the last 15 years, for more information see Holston et al. (2016). On the other hand, a real exchange rate is set as constant in a steady state (Fig.10), in line with a constant value of a nominal exchange rate and a law of one price.

Furthermore, we calibrate a set of structural parameters from a historical dataset and thus fix a share of capital on production ($\boldsymbol{\beta}$) equal to 56.0% and a share of labour on production ($\mathbf{1}-\boldsymbol{\beta}$) equal to 44.0%, in line with a historical ratio between compensations of employees and gross domestic product (Fig.11). We can then obtain an equilibrium growth of a domestic productivity ($\mathbf{at_t}$) from the definition of the production function (Eq.1). Next, we fix a share of investment on output equal to 24.0%, in line with a historical ratio between domestic investment and gross domestic product (Fig.12), and thus calibrate an equilibrium value for the correction term ($\boldsymbol{\lambda}\mathbf{t_t}$) from the first order condition (Eq.4). An equilibrium value of a public debt with a respect to a domestic output ($\mathbf{dp_t^*}$) is set to 40.0%, in line with a target level of a debt brake proposed by the Council for Budget Responsibility.[32] It is important to note that a stricter debt rule with a respect to the Maastricht criteria is needed, due to an impact of the population ageing on the Slovak economy. An equilibrium value of a public balance with a respect to a domestic output ($\mathbf{bp_t^*}$) is then implied by the fiscal identity (Eq.30).

[30] These assumptions are consistent with Kľúčik (2015).

[31] Absence of a domestic currency after the adoption of Euro leads to a zero convergence by a nominal exchange rate what results in a convergence process by a domestic inflation rate. Domestic prices should be thus higher than the external ones throughout the convergence process.

[32] See for example a macroeconomic model by Múčka (2016). The target value of the debt brake should be reached at the end of 2028.

Fig.7: Depreciation of Capital

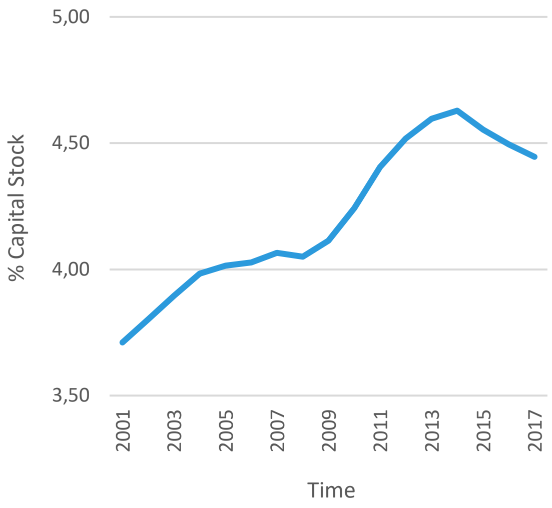


Fig.8: Domestic Unemployment

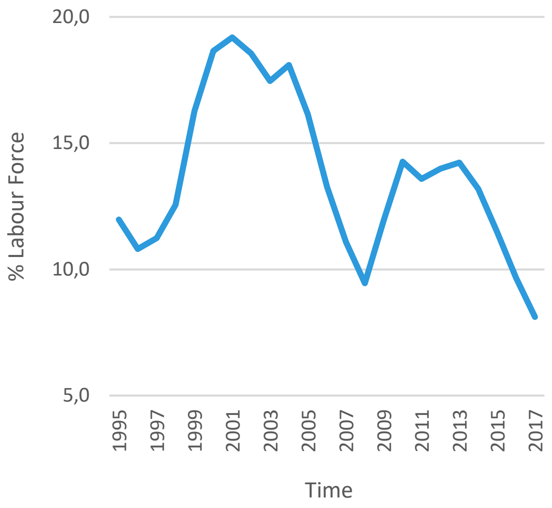


Fig.9: Domestic Participation

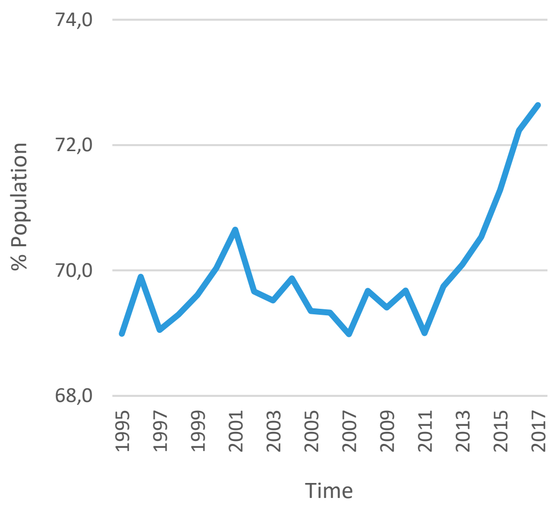


Fig.10: Effective Exchange Rate

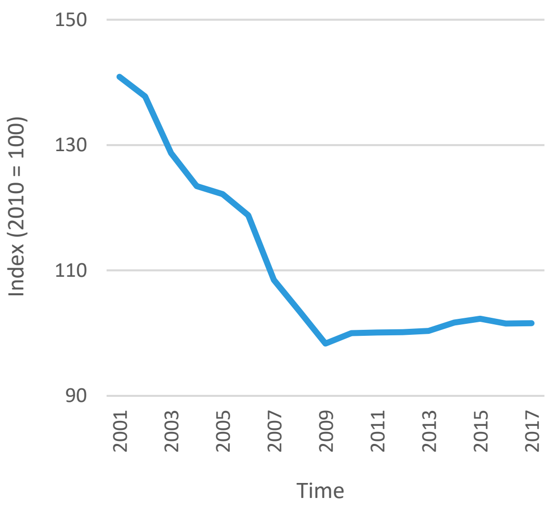


Fig.11: Elasticity of Labour

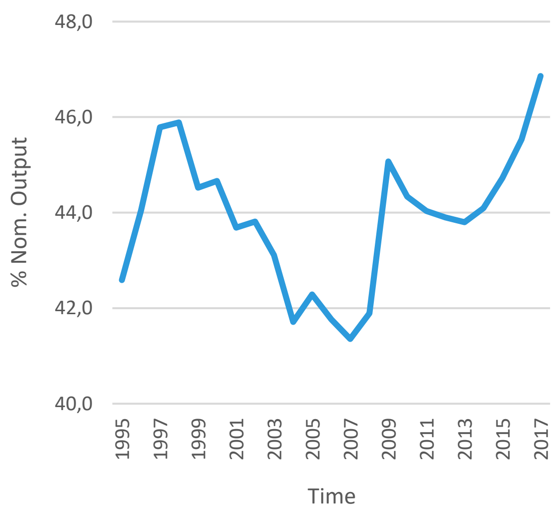
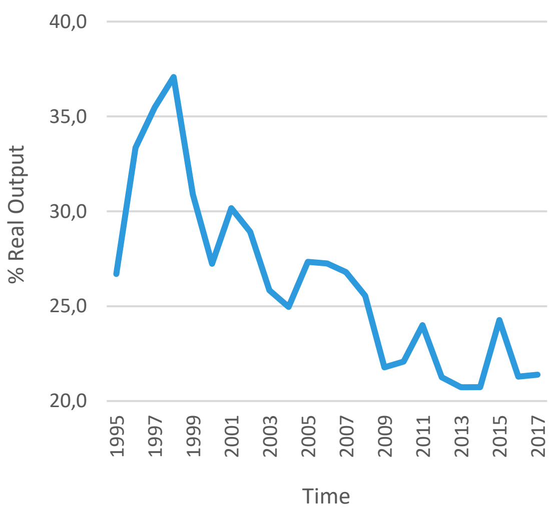


Fig.12: Share of Investment



5.2 Econometric estimation

We start with the estimation of private consumption (Eq.D2) that implies a significant impact of both actual $\mathbf{ct_4}$ and previous $\mathbf{ct_6}$ disposable income. We further estimate a high degree of consumption persistence $\mathbf{ct_5}$ and also a significant impact of interest rate costs $\mathbf{ct_7}$ on the private consumption. Next, we estimate the equation for private investment (Eq.S1) that is driven by a domestic demand $\mathbf{if_1}$ and a corporate surplus $\mathbf{if_3}$ and the equation for personal investment (Eq.S2) that is driven by both actual $\mathbf{ih_1}$ and previous $\mathbf{ih_3}$ disposable income.[33] On the other hand, we calibrate an empirical impact of interest rate costs on both private $\mathbf{if_8}$ and personal $\mathbf{ih_8}$ investment from the macroeconomic model of Kľúčik (2015). We further expect a stronger impact of the interest rate costs on the sector of firms $\mathbf{if_8}$ than on the sector of households $\mathbf{ih_8}$, due to a higher flexibility of corporate loans with a respect to mortgage loans. Furtermore, we need to calibrate a crowding out of public investment $\mathbf{if_2}$ and $\mathbf{ih_2}$ and market expectations about a fiscal policy with a respect to components of public compensations $\mathbf{if_4}$ and $\mathbf{ih_4}$, intermediate consumption $\mathbf{if_5}$ and $\mathbf{ih_5}$ and public social transfers $\mathbf{if_6}$ and $\mathbf{ih_6}$ from an impulse response analysis.[34] The estimation of public investment (Eq.S3) is then based on a combination of potential $\mathbf{ig_1}$ and domestic $\mathbf{ig_2}$ components.

Next, we need to calibrate the parameter for external demand $\mathbf{xt_6}$ in the export equation (Eq.D4) and the parameter for domestic demand $\mathbf{mt_6}$ in the import equation (Eq.D6) to unity to maintain the homogeneity conditions. We further estimate a significant impact of a real exchange rate $\mathbf{xt_7}$ on the domestic export (Eq.D4) from historical data and calibrate an empirical impact of a real exchange rate $\mathbf{mt_7}$ on the domestic import (Eq.D6) from the estimation results of Kľúčik (2015). We need to mention that the sum of exchange rate components in the export and import equations is less than one and thus violates the Marshall-Lerner conditions. However, since only a part of the export deflator (Eq.П6) is driven by domestic prices and only a part of the import deflator (Eq.П8) is driven by external prices, in contrast to the original assumptions, the Marshall-Lerner conditions do not need to hold to obtain plausible simulation results. On the other hand, we might overestimate an empirical impact of a productivity differential $\mathbf{xt_8}$ on the domestic export, since a strong impact of domestic market shares on the export performance leads to a counterintuitive response of model variables to a domestic productivity shock. We thus need to calibrate this parameter to unity to obtain plausible simulation results. Finally, we set an empirical impact of an oil price differential $\mathbf{mt_8}$ on the domestic import to zero. The estimation of a private mixed surplus (Eq.D7) is then based on the potential output $\mathbf{ms_2}$ and a net domestic surplus $\mathbf{ms_3}$.

We proceed with the estimation of domestic labour force (Eq.S4) that implies a significant impact of productive population $\mathbf{ls_1}$ and domestic employment $\mathbf{ls_2}$. We further estimate a high degree of labour persistence $\mathbf{ls_3}$ and calibrate the spillovers from a net labour income $\mathbf{ls_4}$, in line with a historical evidence from the domestic labour market.[35] Next, we calibrate the spillovers from labour taxes and contributions in line with their empirical impact on the net labour income (Eq.S4). Contributions of employees $\mathbf{ls_7}$ and labour income taxes $\mathbf{ls_9}$ have thus a stronger impact on the domestic labour force than contributions of employers to public $\mathbf{ls_8}$ and private $\mathbf{ls_{10}}$ sectors. This calibration aims to find a compromise between the estimation results of Fiorito and Zanella (2008) that are based on microeconomic and macroeconomic Frisch elasticities and the estimation results of Siebertová et al. (2014) that are based on a microeconomic simulation model. We further distinguish between contributions of employers

[33] The approximation of a domestic demand with a gross domestic product provides a better fit of historical data than the approximation with a gross value added for both domestic investment and domestic employment.

[34] A one percent increase of a public investment to output ratio in a steady state leads to a decline of a private investment to output ratio by 0.3%. On the other hand, a one percent increase of a public expenditures to output ratio in a steady state leads to a decline of a private investment to output ratio by 0.5%. These numbers are consistent with the estimation results of Cavallo and Daude (2011) and Furceri and Sousa (2011).

[35] In the first step, we estimate a coefficient between a domestic labour force and a previous labour income to obtain a significant estimate of a labour to income elasticity. In the second step, we take the estimate from the previous step and calibrate a coefficient between a domestic labour force and an actual labour income to exclude lags from the equation.

that are paid to a public sector $\mathbf{ls_8}$ and to a private sector $\mathbf{ls_{10}}$. We assume that the first ones should have a limited impact on the domestic labour force, in line with a share of contributions paid by employers and a form of income reduction of employees.[36] On the other hand, the latter ones should have a zero impact on the domestic labour force, under an assumption that while the contributions to a public sector result in a decline in disposable income, the contributions to a private sector result in an increase in savings of households.

We continue with the estimation of private employment (Eq.S5) and personal employment (Eq.S6) that are based on a combination of potential components $\mathbf{lf_1}$ and $\mathbf{lh_1}$ and persistent components $\mathbf{lf_3}$ and $\mathbf{lh_3}$. We further estimate a stronger impact of domestic demand on the private $\mathbf{lf_4}$ than the personal $\mathbf{lh_4}$ employment and a stronger impact of domestic labour costs on the personal $\mathbf{lh_5}$ than the private $\mathbf{lf_5}$ employment. Furtermore, we calibrate a crowding out of public employment $\mathbf{lf_2}$ and $\mathbf{lh_2}$ from an impulse response analysis.[37] The estimation of public employment (Eq.S7) is then based on the potential component $\mathbf{lg_1}$ with a significant impact of domestic demand $\mathbf{lg_2}$ and domestic labour costs $\mathbf{lg_3}$.

Next, we estimate a significant impact of an actual productivity $\mathbf{wf_1}$ and $\mathbf{wg_1}$ and a previous productivity $\mathbf{wf_3}$ and $\mathbf{wg_3}$ on private labour costs (Eq.W1) and public labour costs (Eq.W2) together with an empirical impact of both consumer prices $\mathbf{wf_4}$ and $\mathbf{wg_4}$ and output prices $\mathbf{wf_5}$ and $\mathbf{wg_5}$ on price components of domestic labour costs.[38] On the other hand, we calibrate an empirical impact of an unemployment gap $\mathbf{wf_8}$ on a bargaining power of workers and firms from the macroeconomic model of Kľúčik (2015). We further calibrate the spillovers from labour taxes and contributions from the estimation results of Kľúčik (2015) and thus assume that the contributions of employers to a public sector $\mathbf{wf_6}$ and $\mathbf{wg_6}$ and to a private sector $\mathbf{wf_7}$ and $\mathbf{wg_7}$ are paid by both employees and employers on the domestic labour market. On the other hand, we assume that the contributions of employees and the labour income taxes are born only by households and thus do not affect the domestic labour costs. These assumptions are further consistent with findings of Symons and Robertson (1990) that a fiscal neutral shift from a direct taxation of employees to a direct taxation of employers leads to an increase in domestic labour costs and thus rejects the Invariance of Incidence Proposition (IIP). Finally, we calibrate a degree of intersectoral spillovers between private labour costs $\mathbf{wf_2}$ and public labour costs $\mathbf{wg_2}$ from an impulse response analysis.[39]

We proceed with the estimation of production prices (Eq.P1) that are based on both actual $\mathbf{pp_1}$ and previous $\mathbf{pp_3}$ unit labour costs and inflation expectations $\mathbf{pp_2}$ of domestic producers. We need to mention that we approximate the production prices with domestic output prices for the purpose of model estimation. The estimation of core consumer prices (Eq.P3) then implies a significant impact of both production $\mathbf{pn_6}$ and import $\mathbf{pn_8}$ components and more backward-looking $\mathbf{pn_9}$ than forward-looking $\mathbf{pn_7}$ behaviour of domestic consumers. We further obtain a historical evidence of the Balassa-Samuelson effect $\mathbf{pn_{10}}$ in the domestic economy and estimate a significant impact of a domestic output gap $\mathbf{pn_{11}}$ on a consumer inflation rate. The estimation of energy consumer prices (Eq.P5) then implies a significant impact of both production $\mathbf{pe_5}$ and crude oil $\mathbf{pe_7}$ components and inflation expectations $\mathbf{pe_6}$ of domestic consumers. A deflator of investment (Eq.П2) is based on a combination of production $\mathbf{pi_4}$ and import $\mathbf{pi_5}$ prices and a deflator of government (Eq.П4) is based on a combination of production $\mathbf{pg_5}$ and consumer $\mathbf{pg_6}$ prices. Finally, an export deflator (Eq.П6) is driven by domestic $\mathbf{px_4}$ and external $\mathbf{px_5}$ prices and an import deflator (Eq.П8) is driven by domestic $\mathbf{pm_5}$ and external $\mathbf{pm_6}$ and crude oil $\mathbf{pm_7}$ prices.

[36] A reduction in the premium component implied by the contributions of employers should have a smaller behavioural impact on an intertemporal decision of households than a reduction in the wage component implied by the contributions of employees.

[37] A one percent increase of a public employment rate in a steady state leads to a decline of a private employment rate by 0.6% and a decline of an unemployment rate by 0.4%. These numbers provide a compromise between the estimation results of Behar and Mok (2013) and Lamo et al. (2014).

[38] The specification with a labour productivity of the domestic economy, e.g. a domestic output over domestic employment, provides a better fit of historical data than the specification with a labour productivity of the private sector, e.g. a domestic output over private and personal employment.

[39] The calibration of intersectoral spillovers between private and public labour costs is consistent with Afonso and Gomes (2008).

We continue with the estimation of public social transfers (Eq.F1) that are based on the potential output $\mathbf{st_2}$ and compensations of employees $\mathbf{st_3}$. On the other hand, we need to calibrate the spillovers from labour market rigidities $\mathbf{st_4}$ to identify different types of labour market transfers in the domestic economy.[40] The estimation of intermediate consumption (Eq.F2) is then based on a combination of potential $\mathbf{ic_2}$ and domestic $\mathbf{ic_3}$ components.

Next, we need to calibrate a contemporaneous impact of corporate income taxes on private investment (Eq.S1), personal investment (Eq.S2), private labour costs (Eq.W1) and production prices (Eq.P1) from the literature on tax elasticities. The spillovers to production prices are set in line with Baker et al. (2020) but in an asymmetric manner for an increase $\mathbf{pp_4}$ and a decline $\mathbf{pp_5}$ in the effective tax rate. On the other hand, the distribution of corporate income taxes between net domestic surplus, which should then manifest in private $\mathbf{if_7}$ and personal $\mathbf{ih_7}$ investment, and compensations of employees, which should then manifest in private labour costs $\mathbf{wf_9}$, is set in line with Dwenger et al. (2011) and Fuest et al. (2015). We further assume that the corporate income taxes affect only the private investment $\mathbf{if_7}$ and not the personal investment $\mathbf{ih_7}$. The spillovers from value added taxes then affect both core prices (Eq.P3) and energy prices (Eq.P5) in an asymmetric manner for an increase in the effective tax rate $\mathbf{pn_{12}}$ and $\mathbf{pe_8}$ and a decline in the effective tax rate $\mathbf{pn_{13}}$ and $\mathbf{pe_9}$. Furthermore, we need to distribute the spillovers from net consumption taxes between core prices (Eq.P3) and energy prices (Eq.P5) with a respect to relative magnitudes of excise taxes on alcohol, tobacco and fuels and relative shares of core and energy components in the consumption basket. Again, it is necessary to distinguish between an increase in the effective tax rate $\mathbf{pn_{14}}$ and $\mathbf{pe_{10}}$ and a decline in the effective tax rate $\mathbf{pn_{15}}$ and $\mathbf{pe_{11}}$.

Finally, we discuss a parametrization of a domestic risk premium (Eq.R1). We need to mention that our calibration of an empirical impact of a public debt $\boldsymbol{\phi_3}$ on the domestic premium (0.05) is consistent with the assumptions of the European Commission (0.03) and the International Monetary Fund (0.04) as outlined in Alcidi and Gros (2019). On the other hand, our calibration of an empirical impact of a current account $\boldsymbol{\phi_4}$ on the domestic premium (0.05) is milder than the estimate of the Council for Budget Responsibility (0.10) that is outlined in Kľúčik (2015). We further estimate a significant impact of both constant $\boldsymbol{\phi_1}$ and persistence $\boldsymbol{\phi_2}$ parameters on the domestic premium from historical data.

[40] We calibrate the parameter as a share of unemployment and social benefits on the public social transfers.

6 Solving the model

While a parametrization of the model consists of a one-by-one estimation of each behavioural equation, a solution of the model is based on a theory of general equilibrium. Specifically, we put the model equations together and then solve this system of equations in an iterative manner for each time period to obtain macroeconomic forecasts and simulations.[41] We need to mention that the model is characterized as backward looking and we are thus able to obtain the iterative solution without solving the rational expectations.[42] Even though both production and consumer prices are based on a combination of backward-looking and forward-looking expectations, it is important to note that the inflation expectations are not defined in a model consistent manner and thus do not violate the iterative solution. Model convergence is then ensured by error correction terms that correct macroeconomic variables and fiscal policy rules that correct fiscal variables. We further need to ensure the validity of homogeneity conditions, i.e. an equality between steady-state dynamics of an explained variable and a weighted sum of steady-state dynamics of explanatory variables. The homogeneity conditions thus imply linear restrictions on the model equations.

6.1 Convergence properties

Existence and speed of model convergence into its steady state is implied by a definition of persistence parameters, error correction terms and fiscal policy rules. We need to mention that even though a detailed structure of the model slows down the convergence process, we are able to achieve equilibrium values of model variables in a long horizon. We further present the convergence properties of actual and potential components of gross domestic product (Fig.13) and domestic employment (Fig.14), actual and flexible components of domestic output prices (Fig.15) and domestic labour costs (Fig.16) and actual and target components of public sector debt (Fig.17) and public sector balance (Fig.18). The model variables thus converge to their potential counterparts in a steady state, closing model gaps and meeting target values of a fiscal policy.[43]

We further analyse a sensitivity of model convergence to a calibration of error correction terms and fiscal policy rules. We find out that a variation of the error correction terms for private $\mathbf{if_9}$ and personal $\mathbf{ih_9}$ investment leads only to mild differences in terms of model convergence (Fig.C1). Furthermore, even though a variation of the error correction terms for private $\mathbf{wf_{10}}$ and public $\mathbf{wg_8}$ labour costs has a significant impact on convergence properties of domestic prices and wages, we observe only a marginal effect of these parameters on a pace of model convergence (Fig.C2). Contrary to this, a calibration of the reaction function to a public sector balance $\mathbf{ig_4}$ and $\mathbf{ic_5}$ is crucial for the process of model convergence, since a decline of the public balance response (Fig.C3) could slow down the convergence process and even destabilize the model, due to an inability of government to stabilize fiscal variables. On the other hand, a calibration of the reaction function to a public sector debt $\mathbf{ig_5}$ and $\mathbf{ic_6}$ and to a domestic output gap $\mathbf{ig_3}$ and $\mathbf{ic_4}$ should be further based on a policy response to a public sector balance, since a simple increase of the public debt response (Fig.C4) or the output gap response (Fig.C5) could destabilize the public sector balance. These results thus imply that while the calibration of error correction terms is not so important for convergence properties of the model, the calibration of fiscal policy rules is crucial to achieve equilibrium values of model variables in a long horizon.

[41] The model is solved by a trust region algorithm, solving n equations about n variables. We need to mention that a detailed structure of the model does not complicate the solution algorithm.

[42] This approach would be not applicable if some components of the model are defined in a model-consistent manner under rational expectations.

[43] We analyse the convergence properties of the model for an unconditional forecast of model variables.

Fig.13: Domestic Output

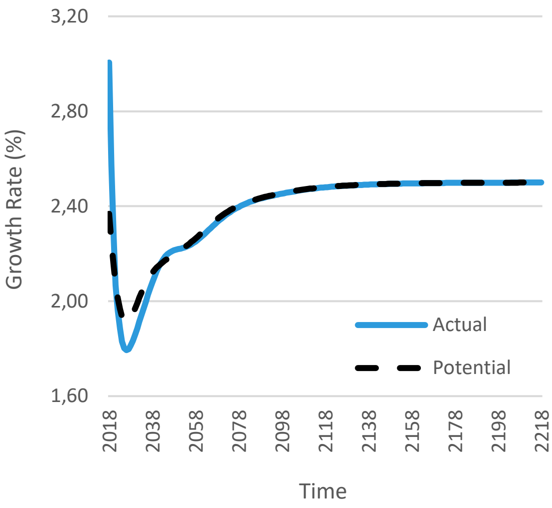


Fig.14: Total Employment

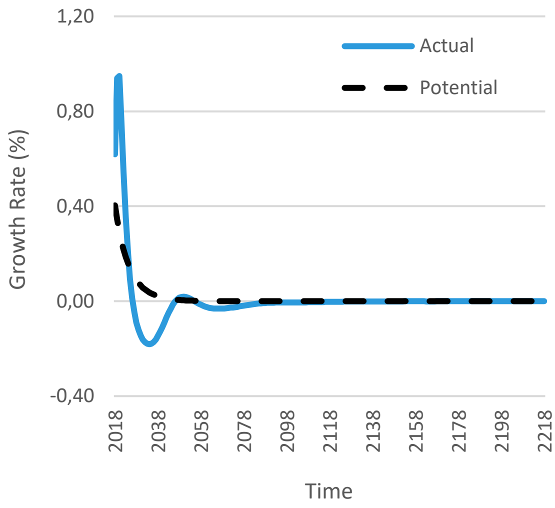


Fig.15: Output Prices

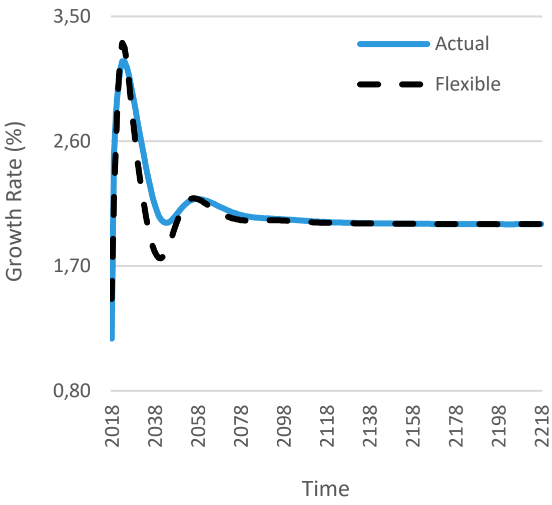


Fig.16: Labour Costs

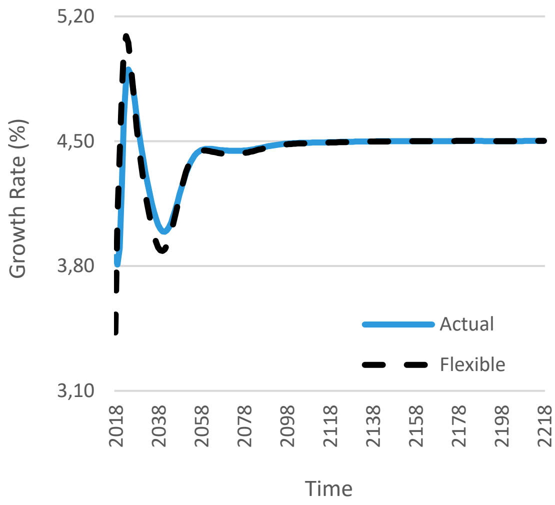


Fig.17: Public Debt

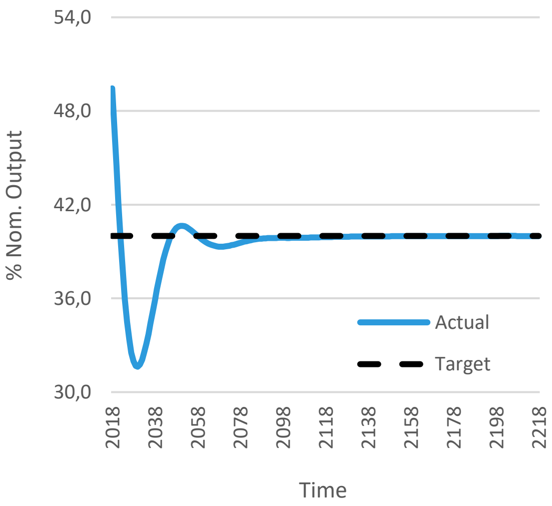
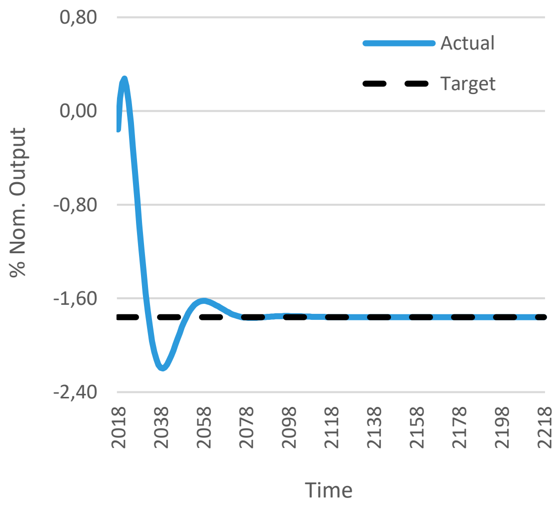


Fig.18: Public Balance



6.2 Steady state variables

An equilibrium share of domestic investment on a gross domestic product is equal to 24%, as implied by the calibration of the model (Fig.12). Furthermore, the convergence process implies that private consumption (Fig.19) explains 48% and public consumption (Fig.20) explains 16% of a gross domestic product in a steady state. On the other hand, an export to output ratio (Fig.21) is equal to 122% and an import to output ratio (Fig.22) is equal to 110% in a steady state, in line with the structural trends in historical time series. An equilibrium value of a trade to output ratio is thus equal to 12%. Furthermore, we discuss convergence properties of a domestic risk premium. It results from the definition of the domestic premium (Eq.21) that unconstrained values of a public debt and a current account would imply an unconstrained value of the domestic premium. On the other hand, the equilibrium values of the public debt and the current account imply an equilibrium value of the domestic premium that is equal to a half percentage point.

Fig.19: Private Consumption

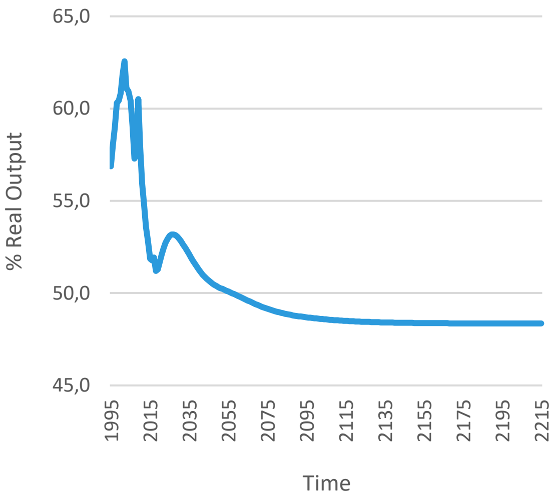


Fig.20: Public Consumption

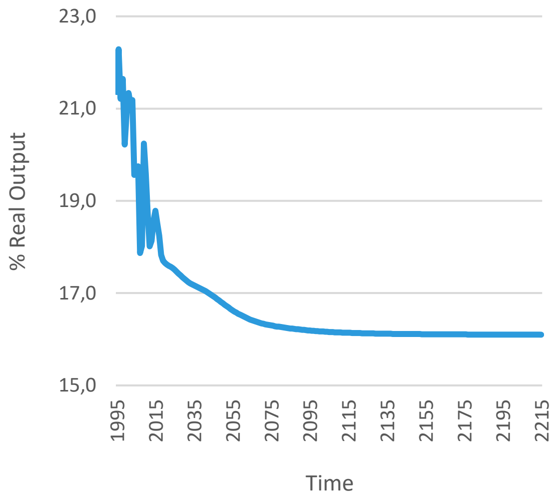


Fig.21: Domestic Export

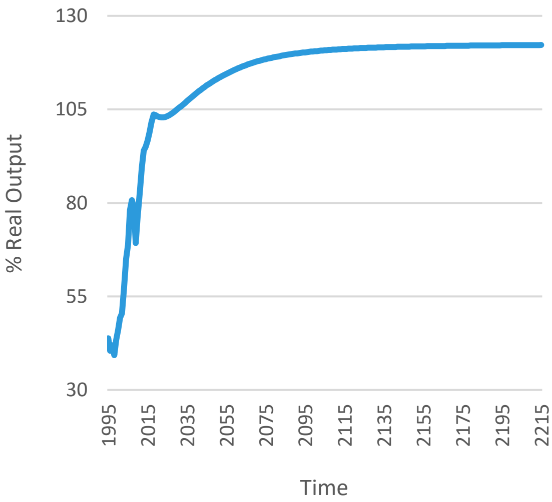
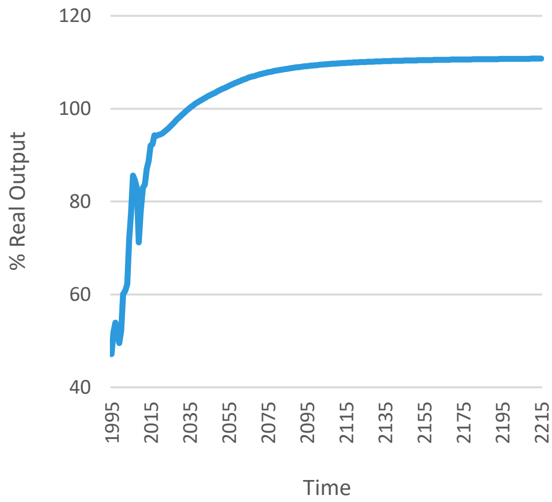


Fig.22: Domestic Import



7 Model evaluation

Evaluation of model performance is based on impulse response functions and implied fiscal multipliers. We compute impulse response functions for the most important macroeconomic and fiscal shocks in the Slovak economy, i.e. shocks to domestic productivity, external demand, interest rates and crude oil prices and shocks to domestic taxes, social contributions and public expenditures. The shocks to domestic productivity and to external demand correspond to an increase of the growth rate by 1.00 p.p. in the first quarter, the shocks to crude oil prices and to public expenditures correspond to an increase of the growth rate by 10.0 p.p. in the first quarter and the shocks to interest rates, to domestic taxes and to social contributions correspond to an increase of the effective rate by 1.00 p.p. in the first quarter. All of these shocks are set as permanent in the model and the impulse response functions are presented as percentage deviations from baseline growth rates.[44] The implied fiscal multipliers are then based on the method of Uhlig (2010) to evaluate both short-term and medium-term impact of alternative consolidation scenarios on the domestic economy.

It is important to note that we let the fiscal rules switched on and thus follow an endogenous response of a fiscal policy in both the impulse response analysis and the estimation of fiscal multipliers. Our results should be thus viewed as an empirical rather than an undisturbed impact of macroeconomic and fiscal shocks on the domestic economy. On the other hand, we assume a relatively mild response of a fiscal policy to limit its impact on the impulse response functions and the implied fiscal multipliers. This is in contrast to models of Fagan and Morgan (2005) without active fiscal rules. However, we argue that this approach could destabilize fiscal variables in a medium horizon. On the other hand, Klyuev and Snudden (2011) discuss an activation of fiscal rules for both an impulse response analysis and an estimation of fiscal multipliers. Kľúčik (2015) proposes a combination of these methods and turns off fiscal rules for two years after the shock and turns them on afterwards.

7.1 Macroeconomic shocks

We start with a demand side of the model and evaluate an impact of a positive shock to external demand (Fig.M1) on the domestic economy. A positive trade balance materializes in a positive output gap and puts an upward pressure on domestic wages and prices. Rising domestic output helps to create new jobs on the labour market what results in a decline in an unemployment rate and an increase in a participation rate. Compensations of employees then put an upward pressure on private consumption and stronger domestic demand further boosts private investment. Finally, a positive demand shock leads to an increase in a fiscal balance and a decline in a public debt.

We continue with a supply side of the model and evaluate an impact of a positive shock to domestic productivity (Fig.M2) on the domestic economy. Higher productivity puts an upward pressure on both actual and potential output in line with a theory of production function and market share spillovers. The potential output further exceeds the actual one what results in a negative output gap. Higher productivity will also cause workers and firms to produce more efficiently and thus leads to an increase in domestic wages and a decline in domestic employment. Lower labour costs have a dampening effect on domestic prices right after the shock that is further multiplied by a negative output gap. Afterwards, a labour productivity puts an upward pressure on domestic prices, in line with the Balassa-Samuelson effect.[45] Domestic market shares should boost the export performance and thus result in a positive trade balance. Later on, an exogenous character of external prices implies an appreciation of a real exchange rate with a negative impact on a domestic trade balance.

[44] The baseline scenario is set under an absence of macroeconomic and fiscal shocks.

[45] For an evaluation of a productivity shock in a small open economy see Ambrisko (2015).

Next, we simulate a positive shock to crude oil prices (Fig.M4) that materializes in consumer and investment inflation with further negative implications for private consumption and private investment. Furthermore, an increase in import prices overcomes a decline in real imports what results in a negative trade balance in nominal terms, in contrast to a positive trade balance in real terms. The decline in domestic demand further results in a negative output gap in the domestic economy. We conclude with a positive shock to interest rates (Fig.M3) that leads to a decline in private consumption and investment with negative implications for domestic output and employment.[46] Lower domestic wages and prices then materialize in a depreciation of a real exchange rate and thus result in a positive trade balance. The interest rate costs have a negative impact on a fiscal balance and a public debt.

Finally, we analyse a sensitivity of impulse response functions to a calibration of core model parameters, i.e. a productivity differential ($\mathbf{xt_8}$) in the export equation (Eq.D4), an oil price differential ($\mathbf{mt_8}$) in the import equation (Eq.D6) and spillovers from both public debt ($\boldsymbol{\phi_3}$) and current account ($\boldsymbol{\phi_4}$) in the premium equation (Eq.R1). We find out that a variation of the premium parameters leads only to mild differences in impulse response functions after both domestic and external shocks. On the other hand, a stronger impact of the productivity differential on the domestic export implies a stronger trade surplus and a positive output gap after the shock to a domestic productivity (Fig.S1) and a positive impact of the oil price differential on the domestic import implies an increase in domestic output and employment after the shock to crude oil prices (Fig.S2). Reasonable calibration of these parameters is thus crucial to obtain plausible impulse response functions.[47]

7.2 Fiscal policy shocks

We start with an increase in taxation of corporates (Fig.R1) that puts a downward pressure on a corporate surplus and thus crowds out private investment. On the other hand, production prices should increase and private wages should decline to compensate the impact of corporate income taxes on the profits of domestic firms. This implies a decline in a disposable income that further manifests in private consumption. The decline in domestic output then puts a downward pressure on domestic employment and results in a positive trade balance. Next, we simulate an increase in value added taxes (Fig.R5) and an increase in net consumption taxes (Fig.R6) that both manifest in consumer prices and domestic wages and thus result in a reduction in private consumption. The decline in private consumption then puts a downward pressure on domestic output and employment with a negative impact on private investment.

We proceed with an increase in taxation of employees (Fig.R2) that puts a downward pressure on both actual and potential labour force with further negative implications for domestic employment.[48] However, the decline in domestic labour force still results in a wedge between labour demand and supply and thus puts an upward pressure on domestic labour costs. A domestic output declines in both actual and potential components with a negative impact on private consumption and investment. On the other hand, an increase in taxation of employers (Fig.R4) materializes in domestic wages and prices and results in a milder decline in domestic output and employment. Finally, an increase in taxation of properties (Fig.R3) creates a wedge between labour supply and demand and thus puts a downward pressure on domestic wages and prices with a limited impact on the potential variables.[49]

---

[46] A one percentage point increase in nominal interest rates corresponds to a one percentage point increase in short-term interest rates and a one percentage point increase in long-term interest rates.

[47] We increase a direct impact of a productivity differential on the domestic export from 1.00 to 2.00 and increase a direct impact of an oil price differential on the domestic import from 0.00 to 0.02.

[48] A one percentage point increase in taxation of employees corresponds to a half percentage point increase in labour income taxes and a half percentage point increase in contributions of employees.

[49] A one percentage point increase in taxation of properties corresponds to a half percentage point increase in property income taxes and a half percentage point increase in contributions of investors.

We continue with a positive shock to public compensations (Fig.E1) that puts an upward pressure on private consumption and thus improves the domestic output.[50] On the other hand, the decline in a confidence of investors limits the formation of private investment. We further simulate a positive shock to government investment (Fig.E2) that puts an upward pressure on both actual and potential output. Stronger domestic demand helps to create new jobs on the labour market and results in an increase in domestic wages and prices. This further leads to an increase in private consumption but also to a crowding out of private investment. Finally, we simulate a positive shock to intermediate consumption (Fig.E4) that manifests in the consumption of government and a positive shock to public social transfers (Fig.E3) that boosts the consumption of households. However, since these shocks have a negative impact on a confidence of investors, they limit the potential output in the domestic economy.

7.3 Implied fiscal multipliers

Evaluation of alternative consolidation scenarios is based on implied fiscal multipliers in line with Uhlig (2010). We thus calculate an actual fiscal multiplier for a particular consolidation scenario as a ratio between (i) a logarithm of domestic output in constant prices and (ii) public revenues or expenditures in a percentage of gross domestic product. Specifically, the numerator is equal to a logarithm of domestic output in constant prices $(\mathbf{yt_t^s})$ relative to its baseline value $(\mathbf{yt_t^b})$ under an absence of fiscal consolidation and the denominator is equal to a ratio between public revenues or expenditures and gross domestic product $(\mathbf{bt_t^s})$ relative to its baseline value $(\mathbf{bt_t^b})$. Next, we compute a cumulative fiscal multiplier in an actual period *p* as a ratio between a sum of numerators and denominators in previous periods *t* as stated in the Eq.33. We need to mention that we present fiscal multipliers for the fiscal restriction to evaluate an empirical impact of alternative consolidation scenarios on the domestic economy. It is then important to note that some fiscal multipliers would be different for the fiscal expansion, in line with an asymmetric impact of effective tax rates on domestic prices.

$$\sum_{\mathbf{t=1}}^{\mathbf{p}} (\mathbf{yt_t^s} - \mathbf{yt_t^b}) \,/ \sum_{\mathbf{t=1}}^{\mathbf{p}} (\mathbf{bt_t^s} - \mathbf{bt_t^b}) \tag{33}$$

On a revenue side of a public budget, the most unfavourable consolidation scenarios in terms of cumulative fiscal multipliers are implied by an increase in taxation of corporates and employees, since the direct taxes have a negative impact not only on the actual but also on the potential output in the domestic economy. The highest fiscal multiplier in a short horizon is then implied by an increase in taxation of corporates (Fig.23) that crowds out private investment, reduces private labour costs and boosts production prices. On the other hand, the highest fiscal multiplier in a medium horizon is implied by an increase in taxation of employees (Fig.24) that puts a downward pressure on the potential labour force and thus limits the potential output in the domestic economy.[51] We need to mention that taxations of properties (Fig.25) and employers (Fig.26) produce milder cumulative multipliers, in line with their limited impact on a domestic labour force. Finally, value added taxes (Fig.27) produce higher cumulative multipliers than net consumption taxes (Fig.28), due to different dynamics of core and energy components of consumer prices. However, since the indirect taxes influence mostly cyclical components of model variables, they have a limited impact on the potential output in the domestic economy. The most favourable consolidation scenario on a revenue side of a public budget is then based on an increase in net consumption taxes. The second best option is based on an increase in value added taxes in a short horizon and an increase in taxation of properties in a medium horizon.

[50] A ten percentage point increase in public compensations corresponds to a five percentage point increase in public employment and a five percentage point increase in public labour costs.

[51] The short-term multiplier corresponds to a cumulative fiscal multiplier one year after the shock and the medium-term multiplier corresponds to a cumulative fiscal multiplier four years after the shock.

Fig.23: Taxation of Corporates

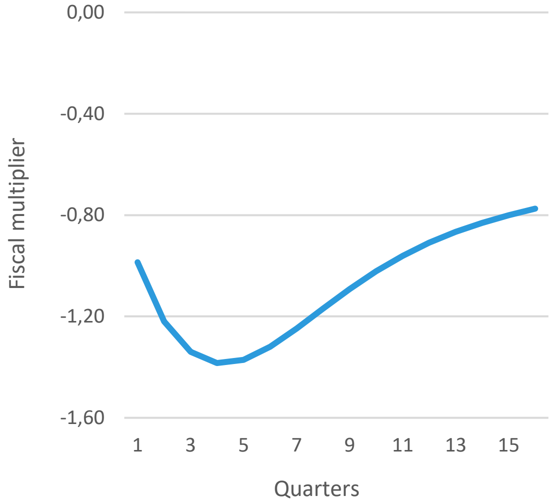


Fig.24: Taxation of Employees

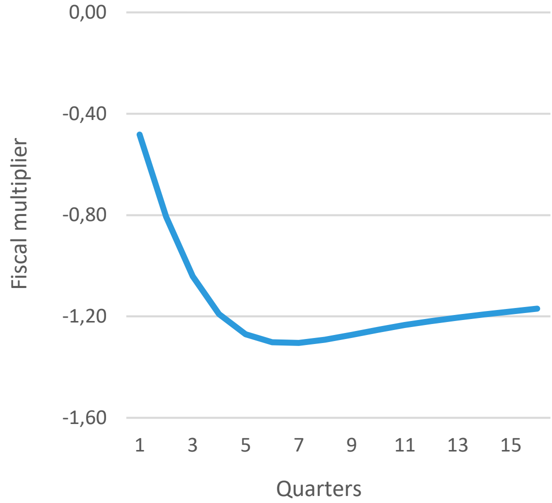


Fig.25: Taxation of Properties

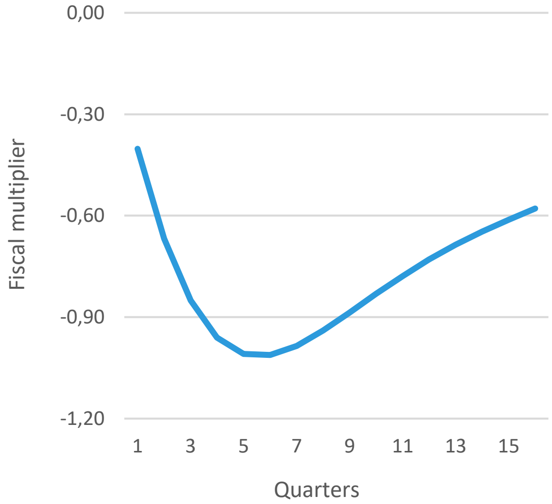


Fig.26: Taxation of Employers

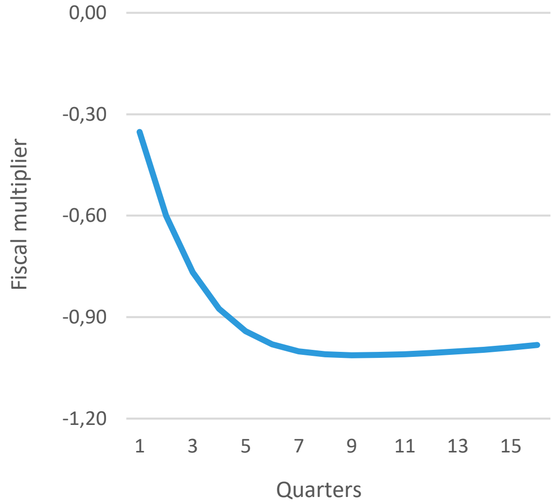


Fig.27: Value Added Taxes

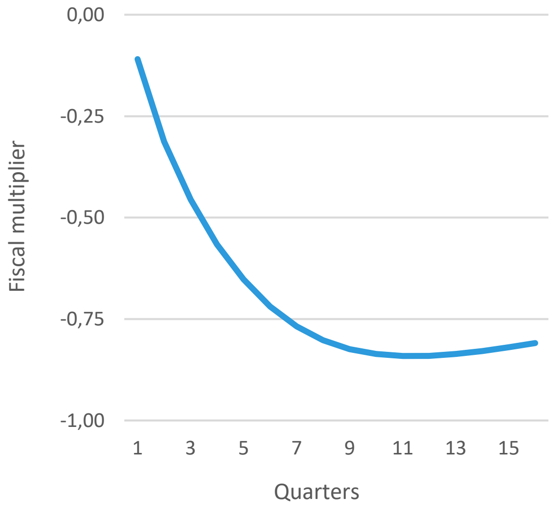
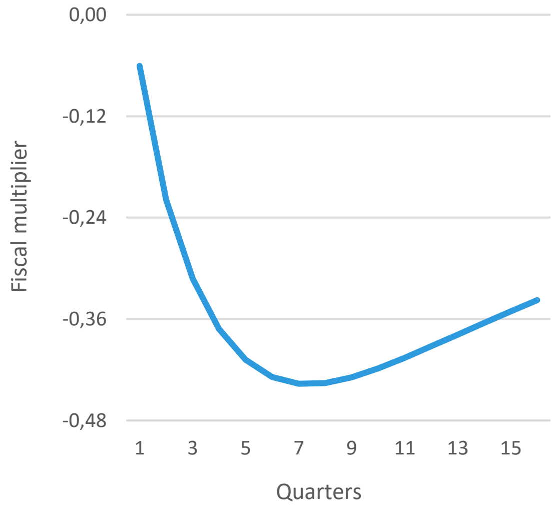


Fig.28: Net Consumption Taxes



On an expenditure side of a public budget, the most unfavourable consolidation scenarios in terms of cumulative fiscal multipliers are implied by a decline in public compensations in a short horizon (Fig.29) and a decline in government investment in a medium horizon (Fig.30). Intermediate consumption (Fig.32) then implies a similar cumulative multiplier as government investment (Fig.30) in a short horizon but provides much better results in a medium horizon, in line with its positive impact on a confidence of investors. Finally, public compensations (Fig.29) produce a higher cumulative multiplier than public social transfers (Fig.31) in a short horizon, due to sectoral spillovers to private labour costs, but a milder cumulative multiplier in a medium horizon, due to a crowding out of private employment. The most favourable consolidation scenario on an expenditure side of a public budget is then based on a decline in public social transfers in a short horizon and a decline in public compensations in a medium horizon. Even though the consolidation based on public expenditures could produce higher fiscal multipliers in a short horizon, the consolidation based on public revenues distorts potential variables and thus results in more negative implications in a medium horizon.

Fig.29: Public Compensations

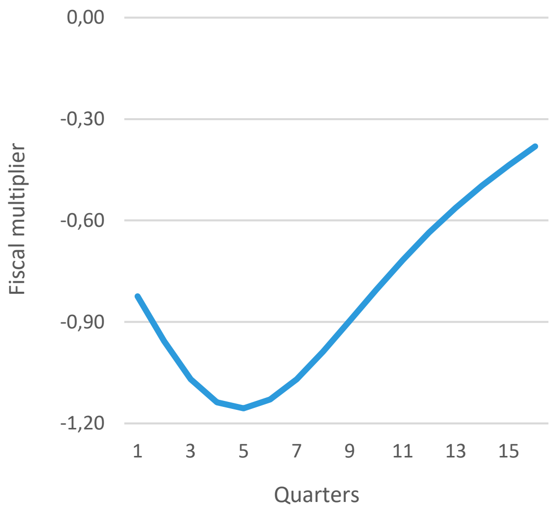


Fig.30: Government Investment

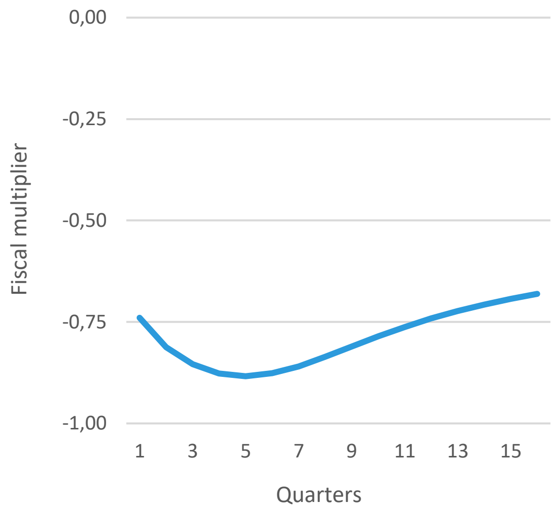


Fig.31: Public Social Transfers

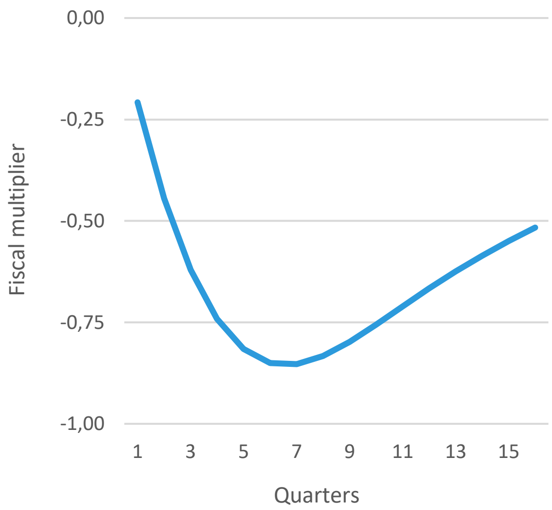
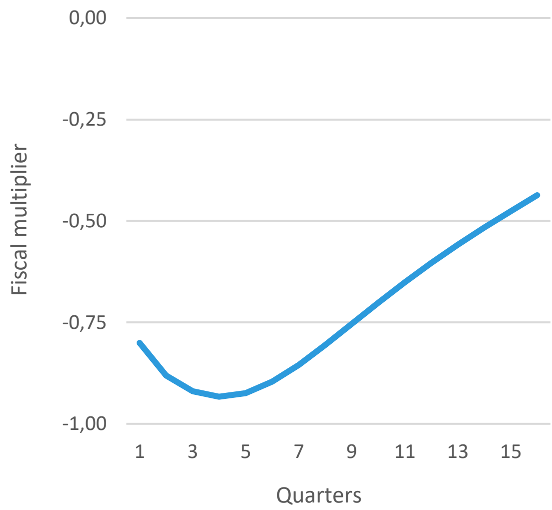


Fig.32: Intermediate Consumption



Next, we compare implied fiscal multipliers from the model with other related studies of the Slovak economy on both one-year (Tab.1) and four-year (Tab.2) horizons. We can thus see that the fiscal multipliers for taxation of labour are in the middle of an estimation range of Múčka (2016) and Zeman (2016). On the other hand, the fiscal multipliers for taxation of consumption are on the bottom of an estimation range of Múčka (2016) and Zeman (2016). Furthermore, we estimate higher fiscal multipliers for public expenditures on the short horizon and milder fiscal multipliers for taxation of capital on the medium horizon. The rest of fiscal multipliers are consistent with the estimation results of Múčka (2016) and Zeman (2016).

Tab.1: Short-term fiscal multipliers

	Múčka (2016)	Zeman (2016)	IFP Model
Taxation of Employees	1.5	0.2	1.2
Taxation of Corporates	1.5	---	1.4
Taxation of Employers	1.5	0.3	0.9
Taxation of Properties	1.5	---	1.0
Value Added Taxes	1.2	0.5	0.6
Net Consumption Taxes	1.2	0.5	0.4
Public Compensations	0.7	0.6	1.1
Government Investment	0.4	0.7	0.9
Public Social Transfers	0.6	0.7	0.7
Intermediate Consumption	0.5	0.6	0.9

Tab.2: Medium-term fiscal multipliers

	Múčka (2016)	Zeman (2016)	IFP Model
Taxation of Employees	2.0	0.1	1.2
Taxation of Corporates	1.9	---	0.8
Taxation of Employers	2.0	1.1	1.0
Taxation of Properties	1.9	---	0.6
Value Added Taxes	1.4	0.8	0.8
Net Consumption Taxes	1.4	0.8	0.3
Public Compensations	0.6	0.6	0.4
Government Investment	0.8	0.7	0.7
Public Social Transfers	0.6	0.5	0.5
Intermediate Consumption	0.4	0.6	0.4

Finally, we compare our simulation results with the fiscal multipliers of Kľúčik (2015) that are based on a structural econometric model of the Slovak economy (Tab.3). Specifically, we take a look at maximal cumulative multipliers of individual fiscal components to evaluate the maximal impact of alternative consolidation scenarios on the domestic economy. In general, we estimate higher fiscal multipliers on a revenue side of a public budget and milder fiscal multipliers on an expenditure side of a public budget with a respect to Kľúčik (2015), due to a different approach to market expectations about a fiscal policy. If we exclude the market expectations, a decline in public expenditures fully projects to a domestic output with additional spillovers to a private sector what results in the fiscal multipliers above one. Furthermore, an increase in taxes and contributions has a limited impact on the behaviour of households and firms, due to an absence of rational expectations about potential variables. On the other hand, if we include the market expectations, both households and firms adjust their investment strategies after a decline in public expenditures what results in the fiscal multipliers below one. Furthermore, an increase in taxes and contributions distorts the potential variables and thus results in more negative implications for the domestic economy.

Tab.3: Maximal cumulative multipliers

	Kľúčik (2015)	IFP Model
Taxation of Employees	0.7	1.3
Taxation of Corporates	0.7	1.4
Taxation of Employers	0.2	1.0
Taxation of Properties	0.5	1.0
Value Added Taxes	0.5	0.8
Net Consumption Taxes	0.3	0.4
Public Compensations	1.8	1.2
Government Investment	2.0	0.9
Public Social Transfers	0.2	0.8
Intermediate Consumption	1.4	0.9

8 Concluding remarks

We outlined a structural econometric model of the Slovak economy that is suitable for both macroeconomic forecasts and simulations. The model was built on the work of Fagan et al. (2001) and further adapted for domestic circumstances. It was also extended for a sectoral decomposition of labour and capital markets and comprehensive budgetary restrictions of firms and households. Finally, we enriched the model by a fiscal block and proposed simple fiscal rules in line with Claeys et al. (2016). The model then produces macroeconomic forecasts and simulations with fiscal implications for the Stability Programme (SP) and the Draft Budgetary Plan (DBP) and is thus an important part of a policy analysis.

The estimation of model parameters was based on standard econometric methods with linear restrictions. On the other hand, the calibration of model parameters was based on impulse response functions and related literature. Solution of the model was then implied by a theory of general equilibrium. Finally, the evaluation of model performance was based on convergence properties of the model and impulse response functions. Even though a detailed structure of the model slows down the convergence process, we are able to achieve equilibrium values of model variables in a long horizon. On the other hand, both macroeconomic and fiscal shocks produce impulse response functions that are consistent with related literature.

Furthermore, we evaluate alternative consolidation scenarios with implied fiscal multipliers on both short and medium horizons. Even though a decline in public expenditures could produce higher fiscal multipliers in a short horizon, market expectations about a fiscal policy have a significant impact on a confidence of investors and result in a Non-Keynesian reaction of macroeconomic variables in a medium horizon. On the other hand, an increase in taxes and contributions puts a downward pressure on potential variables and limits the economic performance in both short and medium horizons. The most negative outcome then results from an increase in taxation of corporates in a short horizon and an increase in taxation of employees in a medium horizon. On the other hand, the most favourable outcome results from an increase in taxation of consumption in a short horizon and a decline in consumption of government in a medium horizon. These results are further consistent with related literature.

Bibliography

Afonso, A., Gomes, P. (2008): *Interactions Between Private and Public Sector Wages,* Working paper, European Central Bank

Afonso, A., Sousa, R. M. (2009): *The Macroeconomic Effects of Fiscal Policy,* Working paper, European Central Bank

Aghion, P., Comin, D., Howitt, P. (2006): *When Does Domestic Saving Matter for Economic Growth?,* Working paper, National Bureau of Economic Research

Alcidi, C., Gros, D. (2019): *Public Debt and the Risk Premium: A Dangerous Doom Loop,* Policy paper, Centre for European Policy Studies

Alesina, A., Perotti, R. (1996): *Fiscal Adjustments in OECD Countries: Composition and Macroeconomic Effects,* Working paper, National Bureau of Economic Research

Alesina, A., Favero, C. A., Giavazzi, F. (2018): *Climbing Out of Debt,* Policy paper, International Monetary Fund

Ambrisko, R., Babecky, J., Rysanek, J., Valenta, V. (2012): *Assessing the Impact of Fiscal Measures on the Czech Economy,* Working paper, Czech National Bank

Ambrisko, R. (2015): *A Small Open Economy with the Balassa-Samuelson Effect,* Working paper, Center for Economic Research and Graduate Education

Baker, S. R., Teng Sun, S., Yannelis, C. (2020): *Corporate Taxes and Retail Prices,* Working paper, National Bureau of Economic Research

Baksa, D., Benk, S., Jakab, Z. M. (2010): *Does the Fiscal Multiplier Exist? Fiscal and Monetary Reactions, Credibility and Fiscal Multipliers in Hungary,* Working paper, Office of the Fiscal Council

Ballantyne, A., Cusbert, T., Evans, R., Guttmann, R., Hambur, J., Hamilton, A., Kendall, E., McCririck, R., Nodari, G., Rees, D. (2019): *MARTIN Has Its Place: A Macroeconometric Model of the Australian Economy,* Discussion paper, Reserve Bank of Australia

Bardsen, G., Nymoen, R. (2015): *NAM: Norwegian Aggregate Model,* Technical report, University of Oslo, Department of Economics

Batini, N., Eyraud, L., Forni, L., Weber, A. (2014): *Fiscal Multipliers: Size, Determinants and Use in Macroeconomic Projections,* Technical note, International Monetary Fund

Beetsma, R., Furtuna, O., Giuliodori, M. (2018): *Revenue versus Spending Based Consolidation Plans: The Role of Follow-Up,* Working paper, European Central Bank

Behar, A., Mok, J. (2013): *Does Public Sector Employment Fully Crowd Out Private Sector Employment?,* Working paper, International Monetary Fund

Benčík, M. (2009): *Analýza Vplyvu Fiškálnej Politiky na Hospodársky Cyklus: Aplikácia Štruktúrneho VAR Modelu [The Analysis of Effects of Fiscal Policy on Business Cycle: The Application of Structural VAR Model],* Working paper, National Bank of Slovakia

Berben, R. P., Kearney, I., Vermeulen, R. (2018): *DELFI 2.0: DNB Macroeconomic Policy Model of the Netherlands,* Working paper, De Nederlandsche Bank

Bergin, A., Conroy, N., Garcia Rodriguez, A., Holland, D., McInerney, N., Morgenroth, E., Smith, D. (2017): *COSMO: A New Core Structural Model for Ireland,* Working paper, The Economic and Social Research Institute

Blagrave, P., Garcia-Saltos, R., Laxton, D., Zhang, F. (2015): *A Simple Multivariate Filter for Estimating Potential Output,* Working paper, International Monetary Fund

Budnik, K., Greszta, M., Hulej M., Kolasa, M., Murawski, K., Rot, M., Rybaczyk B., Tarnicka, M. (2009): *The New Macroeconometric Model of the Polish Economy,* Working paper, National Bank of Poland

Cavallo, E., Daude, C. (2011): *Public Investment in Developing Countries: A Blessing or a Curse?,* Journal of Comparative Economics, Vol. 39 (1), 65-81

Cieslak, A., Povala, P. (2015): *Expected Returns in Treasury Bonds,* The Review of Financial Studies, Vol. 28 (10), 2859-2901

Claeys, G., Darvas, Z., Leandro, A. (2016): *A Proposal to Revive the European Fiscal Framework,* Working paper, Bruegel Institute

Cordes, T., Kinda, T., Muthoora, P., Weber, A. (2015): *Expenditure Rules: Effective Tools for Sound Fiscal Policy?,* Working paper, International Monetary Fund

Cournede, B., Goujard, A., Pina, A. (2013): *Reconciling Fiscal Consolidation with Growth and Equity,* Working paper, Organisation for Economic Cooperation and Development

Čolláková, V., Machlica, G., Melioris, L., Pécsyová, M., Šrámková, L. (2014): *Ako Veľmi Bolí Konsolidácia: Analýza Vplyvu Fiškálnej Konsolidácie na Rast HDP na Slovensku [How Much Consolidation Hurts: The Analysis of Effects of Fiscal Consolidation on GDP Growth in Slovakia],* Working paper, Institute for Financial Policy

Dalsgaard, T., Andre, C., Richardson, P. (2001): *Standard Shocks in the OECD Interlink Model,* Working paper, Organisation for Economic Cooperation and Development

Darvas, Z., Simon, A. (2015): *Filling the Gap: Open Economy Considerations for More Reliable Potential Output Estimates,* Working paper, Bruegel Institute

Darvas, Z., Martin, P., Ragot, X. (2018): *The Economic Case for an Expenditure Rule in Europe,* Policy paper, VoxEu.org

Dwenger, N., Rattenhuber, P., Steiner, V. (2011): *Sharing the Burden: Empirical Evidence on Corporate Tax Incidence,* Discussion paper, School of Business and Economics

Engle, R. F., Granger, C. W. (1987): *Co-Integration and Error Correction: Representation, Estimation and Testing,* Econometrica, Vol. 55 (2), 251-276

Eyraud, L., Debrun, X., Hodge, A., Duarte Lledo, V., Pattillo, C. A. (2018): *Second-Generation Fiscal Rules: Balancing Simplicity, Flexibility and Enforceability,* Discussion paper, International Monetary Fund

Fagan, G., Henry, J., Mestre, R. (2001): *An Area-Wide Model (AWM) for the Euro Area,* Working paper, European Central Bank

Fagan, G., Morgan, J. (2005): *Econometric Models of the Euro Area Central Banks,* ISBN: 978-18-4542-486-2

Feld, L., Schmidt, C., Schnabel, I., Wieland, V. (2018): *Refocusing the European Fiscal Framework,* Policy paper, VoxEu.org

Fiorito, R., Zanella, G. (2008): *Labour Supply Elasticities: Can Micro Be Misleading for Macro?,* Working paper, University of Siena, Department of Economics

Fuest, C., Peichl, A., Siegloch, S. (2015): *Do Higher Corporate Taxes Reduce Wages?,* Discussion paper, Institute for Labour Economics

Furceri, D., Sousa, R. M. (2011): *The Impact of Government Spending on the Private Sector, Crowding-Out versus Crowding-In Effects,* Kyklos International Review for Social Sciences, Vol. 64 (4), 516-533

Gechert, S., Will, H. (2012): *Fiscal Multipliers: Meta Regression Analysis,* Working paper, Macroeconomic Policy Institute

Gervais, O., Gosselin, M. A. (2014): *Analyzing and Forecasting the Canadian Economy Through the LENS Model,* Technical report, Bank of Canada

Giavazzi, F., Pagano, M. (1990): *Can Severe Fiscal Contractions Be Expansionary? Tales of Two Small European Countries,* Working paper, National Bureau for Economic Research

Guajardo, J., Leigh, D., Pescatori, A. (2014): *Expansionary Austerity? International Evidence,* Journal of the European Economic Association, Vol. 12 (4), 949-968

Habrman, M., Rybák, J. (2016): *Institutional Drivers of NAIRU,* Working paper, Institute for the Financial Policy

Havik, K., Mc Morrow, K., Orlandi, F., Planas, C., Raciborski, R., Roger, W., Rossi, A., Thum-Tyssen, A., Vandermeulen, V. (2014): *The Production Function Methodology for Calculating Potential Growth Rates and Output Gaps,* Working paper, European Commission

Henry, J., Hernandez, P. C., Momigliano, S. (2004): *The Short-Term Impact of Government Budgets on Prices: Evidence from Macroeconomic Models,* Working paper, European Central Bank

Holston, K., Laubach, T., Williams, J. C. (2016): *Measuring the Natural Rate of Interest: International Trends and Determinants,* Working paper, Federal Reserve Bank of San Francisco

Klyuev, V., Snudden, S. (2011): *Effects of Fiscal Consolidation in the Czech Republic,* Working paper, International Monetary Fund

Kľúčik, M. (2015): *Fiscal Adjustment in Slovakia: Findings from a Medium-Scale Econometric Model,* Working paper, Council for Budget Responsibility

Lamo, A., Moral-Benito, E., Perez, J. J. (2014): *Austerity Through Public Employment in Bad Times: Exploiting the Crowding-Out and the Competitivness Channels?,* Working paper, Banco de Espana

Livermore, S. (2004): *An Econometric Model of the Slovak Republic,* Working paper, Institute for the Financial Policy

Melioris, L. (2015): *Much Ado About Nothing? Yes and No: Value Added Tax Pass-Through to Consumer Prices,* Working paper, Institute for the Financial Policy

Múčka, Z. (2016): *Fiscal Policy Matters: A New DSGE Model for Slovakia,* Discussion paper, Council for Budget Responsibility

Ódor, Ľ., Povala, P. (2016): *Risk Premiums in Slovak Government Bonds,* Discussion paper, Council for Budget Responsibility

Reľovský, B., Široká, J. (2009): *A Structural Model of the Slovak Economy,* Banking Journal Biatec, Vol. 17 (7), 8-12

Siebertová, Z., Senaj, M., Švarda, N., Valachyová, J. (2014): *To Work or Not to Work? Estimates of Labour Supply Elasticities,* Working paper, Council for Budget Responsibility

Spilimbergo, A., Symansky, S., Schindler, M. (2009): *Fiscal Multipliers,* Working paper, International Monetary Fund

Symons, J., Robertson, D. (1990): *Employer versus Employee Taxation: The Impact on Employment,* Employment outlook, Organization for Economic Cooperation and Development

Šuchta, J., Jakub, P., Kubala, J., Šrámková, L. (2018): *Screwdriver of the Value for Money Project,* Discussion paper, Institute for the Financial Policy

Uhlig, H. (2010): *Some Fiscal Calculus,* American Economic Review, Vol. 100 (2), 30-34

Zeman, J. (2016): *Fiscal Multipliers in Slovak Economy: DSGE Simulation,* Banking Journal Biatec, Vol. 24 (4), 22-26

List of model variables

Supply side block

yt_t^* – Gross potential product (Real, Endogenous)

yn_t^* – Gross potential product (Nominal, Endogenous)

at_t – Total factor productivity (Real, Exogenous)

kt_t – Domestic capital stock (Real, Endogenous)

kn_t – Domestic capital stock (Nominal, Endogenous)

λt_t – Capital correction term (Rate, Exogenous)

it_t – Domestic investment (Real, Endogenous)

in_t – Domestic investment (Nominal, Endogenous)

δt_t – Domestic depreciation (Rate, Endogenous)

δkt_t – Domestic depreciation (Nominal, Endogenous)

if_t – Private investment (Real, Endogenous)

kf_t – Private capital stock (Real, Endogenous)

δf_t – Private depreciation (Rate, Exogenous)

δkf_t – Private depreciation (Nominal, Endogenous)

ih_t – Personal investment (Real, Endogenous)

kh_t – Personal capital stock (Real, Endogenous)

δh_t – Personal depreciation (Rate, Exogenous)

δkh_t – Personal depreciation (Nominal, Endogenous)

ig_t – Public investment (Real, Endogenous)

kg_t – Public capital stock (Real, Endogenous)

δg_t – Public depreciation (Rate, Exogenous)

δkg_t – Public depreciation (Nominal, Endogenous)

np_t – Domestic population (Persons, Exogenous)

ls_t^* – Potential labour force (Persons, Endogenous)

η_t^* – Potential participation (Rate, Exogenous)

γ_t^{tc} – Taxes and contributions (Rate, Endogenous)

lt_t^* – Potential employment (Persons, Endogenous)

μ_t^* – Potential unemployment (Rate, Exogenous)

ls_t – Domestic labour force (Persons, Endogenous)

η_t – Domestic participation (Rate, Endogenous)

τ_t^{tc} – Taxes and contributions (Rate, Endogenous)

lt_t – Domestic employment (Persons, Endogenous)

μ_t – Domestic unemployment (Rate, Endogenous)

le_t – External employment (Persons, Endogenous)

ω_t – External employment (Rate, Exogenous)

lf_t – Private employment (Persons, Endogenous)

lh_t – Personal employment (Persons, Endogenous)

lg_t – Public employment (Persons, Endogenous)

Demand side block

yt_t – Gross domestic product (Real, Endogenous)

yn_t – Gross domestic product (Nominal, Endogenous)

dt_t – Statistical discrepancy (Real, Exogenous)

dn_t – Statistical discrepancy (Nominal, Endogenous)

va_t – Gross value added (Real, Endogenous)

ds_t – Net domestic surplus (Real, Endogenous)

os_t – Net operating surplus (Real, Endogenous)

ms_t – Private mixed surplus (Real, Endogenous)

ct_t^* – Potential consumption (Real, Endogenous)

ct_t – Private consumption (Real, Endogenous)

cn_t – Private consumption (Nominal, Endogenous)

gt_t – Public consumption (Real, Endogenous)

gn_t – Public consumption (Nominal, Endogenous)

xt_t^* – Total potential export (Real, Endogenous)

xt_t – Total domestic export (Real, Endogenous)

xn_t – Total domestic export (Nominal, Endogenous)

dx_t – Total external demand (Real, Exogenous)

zx_t – Export exchange rate (Real, Endogenous)

ip_t – World import prices (Index, Exogenous)

da_t – Productivity differential (Real, Endogenous)

ψ_t – World factor productivity (Real, Exogenous)

mt_t^* – Total potential import (Real, Endogenous)

mt_t – Total domestic import (Real, Endogenous)

mn_t – Total domestic import (Nominal, Endogenous)

dm_t – Total domestic demand (Real, Endogenous)

zm_t – Import exchange rate (Real, Endogenous)

ep_t – World export prices (Index, Exogenous)

do_t – Oil price differential (Real, Endogenous)

us_t – Dollar exchange rate (Nominal, Exogenous)

oil_t – World crude oil prices (Index, Exogenous)

ca_t – Total current account (Nominal, Endogenous)

ca_t^* – Total current account (Rate, Endogenous)

er_t – Effective exchange rate (Nominal, Exogenous)

Interest rate block

sr_t – Short-term interest rate (Real, Endogenous)

eu_t – 3-month Euribor rate (Nominal, Exogenous)

$\pi\mathrm{s}_t$ – Short-term inflation rate (Rate, Endogenous)

ps_t – Short-term domestic price (Index, Endogenous)

lr_t – Long-term interest rate (Real, Endogenous)

sk_t – 10-year Slovak bonds (Nominal, Endogenous)

$\pi\mathrm{l}_t$ – Long-term inflation rate (Rate, Endogenous)

pl_t – Long-term domestic price (Index, Endogenous)

de_t – 10-year German bonds (Nominal, Exogenous)

pr_t – Domestic risk premium (Nominal, Endogenous)

ir_t – Effective interest rate (Nominal, Endogenous)

Wages and prices

lp_t^*– Potential productivity (Real, Endogenous)

wt_t^*– Potential labour costs (Nominal, Endogenous)

rt_t^*– Potential labour costs (Real, Endogenous)

lp_t – Domestic productivity (Real, Endogenous)

wt_t – Domestic labour costs (Nominal, Endogenous)

rt_t – Domestic labour costs (Real, Endogenous)

lwt_t – Gross domestic wages (Nominal, Endogenous)

wn_t – Total labour income (Nominal, Endogenous)

rn_t – Total labour income (Real, Endogenous)

lwn_t – Net domestic wages (Nominal, Endogenous)

wf_t – Private labour costs (Nominal, Endogenous)

rf_t – Private labour costs (Real, Endogenous)

lwf_t – Gross private wages (Nominal, Endogenous)

wg_t – Public labour costs (Nominal, Endogenous)

rg_t – Public labour costs (Real, Endogenous)

lwg_t – Gross public wages (Nominal, Endogenous)

we_t – External labour costs (Nominal, Endogenous)

σ_t – External labour costs (Rate, Exogenous)

lwe_t – Gross external wages (Nominal, Endogenous)

cp_t – Total consumer prices (Index, Endogenous)

pn_t^* – Core potential prices (Index, Endogenous)

pn_t – Core consumer prices (Index, Endogenous)

bs_t – Productivity differential (Real, Endogenous)

φ_t – World labour productivity (Real, Exogenous)

pe_t^* – Energy potential prices (Index, Endogenous)

pe_t – Energy consumer prices (Index, Endogenous)

pt_t^* – Potential output prices (Index, Endogenous)

ulc_t – Unit labour costs (Nominal, Endogenous)

pt_t – Domestic output prices (Index, Endogenous)

pp_t – Total production prices (Index, Endogenous)

pi_t^* – Potential capital prices (Index, Endogenous)

pi_t – Domestic capital prices (Index, Endogenous)

pk_t – Capital stock prices (Index, Endogenous)

pg_t^* – Potential public prices (Index, Endogenous)

pg_t – Domestic public prices (Index, Endogenous)

pc_t – Private sector prices (Index, Endogenous)

px_t^* – Potential export prices (Index, Endogenous)

px_t – Domestic export prices (Index, Endogenous)

pm_t^* – Potential import prices (Index, Endogenous)

pm_t – Domestic import prices (Index, Endogenous)

Firms and households

cs_t – Corporate surplus (Nominal, Endogenous)

rs_t – Corporate surplus (Real, Endogenous)

hn_t – Disposable income (Nominal, Endogenous)

hc_t – Consumption income (Real, Endogenous)

hpt_t – Property transfers (Nominal, Endogenous)

ν_t – Property transfers (Rate, Exogenous)

toh_t – Total income taxes (Nominal, Endogenous)

hi_t – Investment income (Real, Endogenous)

hot_t – Current transfers (Nominal, Endogenous)

υ_t – Current transfers (Rate, Exogenous)

coh_t – Total contributions (Nominal, Endogenous)

hr_t – Private revenues (Nominal, Endogenous)

pa_t – Pension adjustment (Nominal, Endogenous)

χ_t – Pension adjustment (Rate, Exogenous)

he_t – Private expenditures (Nominal, Endogenous)

ni_t – Non-profit institutions (Nominal, Endogenous)

κ_t – Non-profit institutions (Rate, Exogenous)

hs_t – Savings of households (Rate, Endogenous)

gsc_t – Public contributions (Nominal, Endogenous)

τ_t^{gc} – Public contributions (Rate, Exogenous)

γ_t^{gc} – Public contributions (Rate, Endogenous)

ssc_t – Personal contributions (Nominal, Endogenous)

τ_t^{sc} – Personal contributions (Rate, Exogenous)

γ_t^{sc} – Personal contributions (Rate, Endogenous)

fsc_t – Private contributions (Nominal, Endogenous)

τ_t^{fc} – Private contributions (Rate, Exogenous)

γ_t^{fc} – Private contributions (Rate, Endogenous)

esc_t – External contributions (Nominal, Endogenous)

τ_t^{ec} – External contributions (Rate, Exogenous)

γ_t^{ec} – External contributions (Rate, Endogenous)

lsc_t – Labour contributions (Nominal, Endogenous)

τ_t^{lc} – Labour contributions (Rate, Exogenous)

γ_t^{lc} – Labour contributions (Rate, Endogenous)

psc_t – Property contributions (Nominal, Endogenous)

τ_t^{pc} – Property contributions (Rate, Exogenous)

γ_t^{pc} – Property contributions (Rate, Endogenous)

Fiscal policy block

gr_t – Public revenues (Nominal, Endogenous)

gpt_t – Net property transfers (Nominal, Exogenous)

got_t – Net current transfers (Nominal, Exogenous)

ge_t – Public expenditures (Nominal, Endogenous)

get_t – Net external transfers (Nominal, Exogenous)

gct_t – Net capital transfers (Nominal, Exogenous)

bp_t – Total fiscal balance (Nominal, Endogenous)

bp_t^* – Total fiscal balance (Rate, Endogenous)

dp_t – Gross public debt (Nominal, Endogenous)

dp_t^* – Gross public debt (Rate, Endogenous)

dit_t – Total direct taxes (Nominal, Endogenous)

lit_t – Labour income taxes (Nominal, Endogenous)

τ_t^{li} – Labour income taxes (Rate, Exogenous)

γ_t^{li} – Labour income taxes (Rate, Endogenous)

pit_t – Property income taxes (Nominal, Endogenous)

τ_t^{pi} – Property income taxes (Rate, Exogenous)

γ_t^{pi} – Property income taxes (Rate, Endogenous)

cit_t – Corporate income taxes (Nominal, Endogenous)

τ_t^{ci} – Corporate income taxes (Rate, Exogenous)

γ_t^{ci} – Corporate income taxes (Rate, Endogenous)

git_t – Other income taxes (Nominal, Exogenous)

int_t – Total indirect taxes (Nominal, Endogenous)

vat_t – Value added taxes (Nominal, Endogenous)

τ_t^{va} – Value added taxes (Rate, Exogenous)

γ_t^{va} – Value added taxes (Rate, Endogenous)

cnt_t – Consumption taxes (Nominal, Endogenous)

τ_t^{cn} – Consumption taxes (Rate, Exogenous)

γ_t^{cn} – Consumption taxes (Rate, Endogenous)

ynt_t – Production taxes (Nominal, Exogenous)

soc_t – Social contributions (Nominal, Endogenous)

st_t – Public social transfers (Real, Endogenous)

nt_t – Public natural transfers (Real, Endogenous)

ξ_t – Public natural transfers (Rate, Exogenous)

ic_t – Intermediate consumption (Real, Endogenous)

mp_t – Public market production (Real, Endogenous)

ζ_t – Public market production (Rate, Exogenous)

ot_t – Taxes of government (Real, Endogenous)

θ_t – Taxes of government (Rate, Exogenous)

irc_t – Interest rate costs (Nominal, Endogenous)

okc_t – Other capital costs (Nominal, Exogenous)

List of model equations

Supply side block

$$\log(yt_t^*) = \log(at_t) + \beta * \log(kt_t) + (1-\beta) * \log(lt_t^*)$$

$$gap(yt_t) = yt_t / yt_t^* - 1$$

$$\log(yn_t^*) = \log(yt_t^*) + \log(pt_t)$$

$$kt_t = kf_t + kh_t + kg_t$$

$$\log(kn_t) = \log(kt_t) + \log(pk_t)$$

$$it_t = if_t + ih_t + ig_t$$

$$cor(it_t) = \beta * yn_t / kn_t - \delta t_t - 1/4 * lr_t - \lambda t_t$$

$$\log(in_t) = \log(it_t) + \log(pi_t)$$

$$\delta t_t * kt_t = \delta f_t * kf_t + \delta h_t * kh_t + \delta g_t * kg_t$$

$$\delta kt_t = \delta t_t * kt_t * pk_t$$

$$dlog(if_t) = if_1 * dlog(yt_t) - if_2 * dlog(ig_t) + if_3 * dlog(rs_{t-1}) - if_4 * dlog(lg_t) - if_4 * dlog(rg_t) - if_5 * dlog(ic_t) - if_6 * dlog(st_t) - if_7 * diff\left(\tau_t^{ci}\right) - if_8 * diff(lr_{t-1}) + if_9 * cor(it_{t-1})$$

$$kf_{t+1} = (1 - \delta f_t) * kf_t + if_t$$

$$\delta kf_t = \delta f_t * kf_t * pk_t$$

$$dlog(ih_t) = ih_1 * dlog(hi_t) - ih_2 * dlog(ig_t) + ih_3 * dlog(hi_{t-1}) - ih_4 * dlog(lg_t) - ih_4 * dlog(rg_t) - ih_5 * dlog(ic_t) - ih_6 * dlog(st_t) - ih_7 * diff\left(\tau_t^{ci}\right) - ih_8 * diff(lr_{t-1}) + ih_9 * cor(it_{t-1})$$

$$kh_{t+1} = (1 - \delta h_t) * kh_t + ih_t$$

$$\delta kh_t = \delta h_t * kh_t * pk_t$$

$$dlog(ig_t) = ig_1 * dlog(yt_t^*) + ig_2 * dlog(yt_t) - ig_3 * gap(yt_{t-1}) + ig_4 * dev(bp_{t-1}^*) - ig_5 * dev(dp_{t-1}^*) + ig_6 * cor(it_{t-1})$$

$$kg_{t+1} = (1 - \delta g_t) * kg_t + ig_t$$

$$\delta kg_t = \delta g_t * kg_t * pk_t$$

$$dlog(ls_t^*) = dlog(np_t) + dlog(\eta_t^*) - diff(\gamma_t^{tc})$$

$$gap(\eta_t) = \eta_t - \eta_t^*$$

$$diff(\gamma_t^{tc}) = ls_7 * diff\left(\gamma_t^{lc}\right) + ls_8 * diff\left(\gamma_t^{gc}\right) + ls_9 * diff\left(\gamma_t^{li}\right) + ls_{10} * diff\left(\gamma_t^{fc}\right)$$

$$dlog(lt_t^*) = dlog(ls_t^*) + dlog(1 - \mu_t^*)$$

$$gap(\mu_t) = \mu_t - \mu_t^*$$

$$dlog(ls_t) = ls_1 * dlog(np_t) + ls_2 * dlog(lt_t) + ls_3 * dlog(ls_{t-1}) + ls_4 * dtfp(rn_t) - ls_5 * diff(\tau_t^{tc}) - ls_6 * log(ls_{t-1}/ls_{t-1}^*)$$

$$log(\eta_t) = log(ls_t/np_t)$$

$$diff(\tau_t^{tc}) = ls_7 * diff\left(\tau_t^{lc}\right) + ls_8 * diff\left(\tau_t^{gc}\right) + ls_9 * diff\left(\tau_t^{li}\right) + ls_{10} * diff\left(\tau_t^{fc}\right)$$

$$lt_t = lf_t + lh_t + lg_t$$

$$cor(lt_t) = log(yt_t) - log(at_t) - \beta * log(kt_t) - (1 - \beta) * log(lt_t)$$

$$log(\mu_t) = log(1 - lt_t/ls_t)$$

$$log(le_t) = log(\omega_t) + log(np_t)$$

$$dlog(lf_t) = lf_1 * dlog(lt_t^*) - lf_2 * dlog(lg_t) + lf_3 * dlog(lf_{t-1}) + lf_4 * dtfp(yt_t) - lf_5 * dtfp(rf_t) + lf_6 * cor(lt_{t-1})$$

$$dlog(lh_t) = lh_1 * dlog(lt_t^*) - lh_2 * dlog(lg_t) + lh_3 * dlog(lh_{t-1}) + lh_4 * dtfp(yt_t) - lh_5 * dtfp(rt_t) + lh_6 * cor(lt_{t-1})$$

$$dlog(lg_t) = lg_1 * dlog(lt_t^*) + lg_2 * dtfp(yt_t) - lg_3 * dtfp(rg_t) - lg_4 * gap(yt_{t-1}) + lg_5 * dev(bp_{t-1}^*) - lg_6 * dev(dp_{t-1}^*) + lg_7 * cor(lt_{t-1})$$

Demand side block

$$yt_t = ct_t + gt_t + it_t + dt_t + xt_t - mt_t$$

$$tfp(yt_t) = \log(yt_t) - \log(at_t)/(1-\beta)$$

$$yn_t = cn_t + gn_t + in_t + dn_t + xn_t - mn_t$$

$$\log(dn_t) = \log(dt_t) + \log(pt_t)$$

$$va_t * pt_t = yt_t * pt_t - vat_t - cnt_t - ynt_t$$

$$ds_t * pt_t = va_t * pt_t - lt_t * wt_t - \delta t_t * kt_t * pk_t$$

$$os_t * pt_t = ds_t * pt_t - ms_t * pt_t$$

$$cor(ms_t) = \log(ms_1) + \log(yt_t^*) - \log(ms_t)$$

$$dlog(ms_t) = ms_2 * dlog(yt_t^*) + ms_3 * dlog(ds_t) + ms_4 * cor(ms_{t-1})$$

$$\log(ct_t^*) = ct_1 - ct_2/sqrt(t) + ct_3 * \log(hc_t)$$

$$dlog(ct_t) = ct_4 * dlog(hc_t) + ct_5 * dlog(ct_{t-1}) + ct_6 * dlog(hc_{t-1}) - ct_7 * diff(sr_{t-1}) - ct_8 * \log(ct_{t-1}/ct_{t-1}^*)$$

$$\log(cn_t) = \log(ct_t) + \log(pc_t)$$

$$gt_t * pg_t = lg_t * wg_t + \delta g_t * kg_t * pk_t + ic_t * pt_t + ot_t * pt_t + nt_t * pt_t - mp_t * pt_t$$

$$\log(gn_t) = \log(gt_t) + \log(pg_t)$$

$$\log(xt_t^*) = xt_1 - xt_2/sqrt(t) + xt_3 * \log(dx_t) + xt_4 * \log(zx_t) + xt_5 * \log(da_t)$$

$$dlog(xt_t) = xt_6 * dlog(dx_t) + xt_7 * dlog(zx_t) + xt_8 * dlog(da_t) - xt_9 * \log(xt_{t-1}/xt_{t-1}^*)$$

$$\log(xn_t) = \log(xt_t) + \log(px_t)$$

$$\log(zx_t) = \log(ip_t) + \log(er_t) - \log(px_t)$$

$$\log(da_t) = \log(at_t) - \log(\psi_t)$$

$$\log(mt_t^*) = mt_1 - mt_2/\mathrm{sqrt}(t) + mt_3 * \log(dm_t) - mt_4 * \log(zm_t) - mt_5 * \log(do_t)$$

$$\mathrm{dlog}(mt_t) = mt_6 * \mathrm{dlog}(dm_t) - mt_7 * \mathrm{dlog}(zm_t) - mt_8 * \mathrm{dlog}(do_t) - mt_9 * \log(mt_{t-1}/mt_{t-1}^*)$$

$$\log(mn_t) = \log(mt_t) + \log(pm_t)$$

$$dm_t = 0.15 * gt_t + 0.25 * ig_t + 0.35 * ct_t + 0.25 * ih_t + 0.55 * if_t + 0.65 * xt_t$$

$$\log(zm_t) = \log(ep_t) + \log(er_t) - \log(pm_t)$$

$$\log(do_t) = \log(oil_t) + \log(us_t) - \log(pm_t)$$

$$ca_t = xt_t * px_t - mt_t * pm_t$$

$$ca_t^* = (ca_t + ca_{t-1} + ca_{t-2} + ca_{t-3})/(yn_t + yn_{t-1} + yn_{t-2} + yn_{t-3})$$

Interest rate block

$$(1 + sr_t) = (1 + eu_t)/(1 + 4 * \pi s_t)$$

$$\pi s_t = ps_t/ps_{t-1} - 1$$

$$dlog(ps_t) = 0.75 * dlog(ps_{t-1}) + 0.25 * dlog(pp_t)$$

$$(1 + lr_t) = (1 + sk_t)/(1 + 4 * \pi l_t)$$

$$\pi l_t = pl_t/pl_{t-1} - 1$$

$$dlog(pl_t) = 0.95 * dlog(pl_{t-1}) + 0.05 * dlog(pp_t)$$

$$sk_t = de_t + pr_t$$

$$pr_t = \phi_1 + \phi_2 * pr_{t-1} + \phi_3 * dp_t^* - \phi_4 * ca_t^*$$

$$ir_t = 0.95 * ir_{t-1} + 0.05 * sk_t$$

Wages and prices

$$\log(lp_t^*) = \log(yt_t^*) - \log(lt_t^*)$$

$$\log(wt_t^*) = \log(rt_t^*) + \log(pt_t)$$

$$\log(rt_t^*) = \log(lp_t^*) + \log(1 - \beta)$$

$$\log(lp_t) = \log(yt_t) - \log(lt_t)$$

$$lf_t * wt_t + lg_t * wt_t = lf_t * wf_t + lg_t * wg_t$$

$$\log(rt_t) = \log(wt_t) - \log(pt_t)$$

$$lwt_t = lt_t * wt_t$$

$$tfp(rt_t) = \log(rt_t) - \log(at_t)/(1 - \beta)$$

$$lt_t * wn_t = lt_t * wt_t - lit_t - pit_t - lsc_t - psc_t - gsc_t - fsc_t$$

$$\log(rn_t) = \log(wn_t) - \log(cp_t)$$

$$lwn_t = lt_t * wn_t$$

$$tfp(rn_t) = \log(rn_t) - \log(at_t)/(1 - \beta)$$

$$\mathrm{dlog}(wf_t) = wf_1 * \mathrm{dlog}(lp_t) + wf_2 * \mathrm{dlog}(wg_{t-1}) + wf_3 * \mathrm{dlog}(lp_{t-1}) + wf_4 * \mathrm{dlog}(cp_t) + wf_5 * \mathrm{dlog}(pt_t) + wf_6 * \mathrm{diff}(\tau_t^{gc}) + wf_7 * \mathrm{diff}(\tau_t^{fc}) - wf_8 * \mathrm{gap}(\mu_t) - wf_9 * \mathrm{diff}(\tau_t^{ci}) - wf_{10} * \log(wt_{t-1}/wt_{t-1}^*)$$

$$\log(rf_t) = \log(wf_t) - \log(pt_t)$$

$$lwf_t = lf_t * wf_t$$

$$tfp(rf_t) = \log(rf_t) - \log(at_t)/(1 - \beta)$$

$$\mathrm{dlog}(wg_t) = wg_1 * \mathrm{dlog}(lp_t) + wg_2 * \mathrm{dlog}(wf_{t-1}) + wg_3 * \mathrm{dlog}(lp_{t-1}) + wg_4 * \mathrm{dlog}(cp_t) + wg_5 * \mathrm{dlog}(pt_t) + wg_6 * \mathrm{diff}(\tau_t^{gc}) + wg_7 * \mathrm{diff}(\tau_t^{fc}) - wg_8 * \log(wt_{t-1}/wt_{t-1}^*)$$

$$\log(rg_t) = \log(wg_t) - \log(pt_t)$$

$$\mathrm{lwg}_t = \mathrm{lg}_t * \mathrm{wg}_t$$

$$\mathrm{tfp}(\mathrm{rg}_t) = \log(\mathrm{rg}_t) - \log(\mathrm{at}_t)/(1-\beta)$$

$$\log(\mathrm{we}_t) = \log(\sigma_t) + \log(\mathrm{wt}_t)$$

$$\mathrm{lwe}_t = \mathrm{le}_t * \mathrm{we}_t$$

$$\mathrm{cp}_t = 0.85 * \mathrm{pn}_t + 0.15 * \mathrm{pe}_t$$

$$\log(\mathrm{pn}_t^*) = \mathrm{pn}_1 - \mathrm{pn}_2/\mathrm{sqrt}(t) + \mathrm{pn}_3 * \log(\mathrm{pt}_t) + \mathrm{pn}_4 * \log(\mathrm{pm}_t) + \mathrm{pn}_5 * \log(\mathrm{bs}_t)$$

$$\mathrm{dlog}(\mathrm{pn}_t) = \mathrm{pn}_6 * \mathrm{dlog}(\mathrm{pp}_t) + \mathrm{pn}_7 * \mathrm{dlog}(\mathrm{pl}_t) + \mathrm{pn}_8 * \mathrm{dlog}(\mathrm{pm}_t) + \mathrm{pn}_9 * \mathrm{dlog}(\mathrm{pn}_{t-1}) +$$
$$\mathrm{pn}_{10} * \mathrm{dlog}(\mathrm{bs}_t) + \mathrm{pn}_{11} * \mathrm{gap}(\mathrm{yt}_t) + \mathrm{pn}_{12} * \mathrm{up}(\tau_t^{\mathrm{va}}) + \mathrm{pn}_{13} * \mathrm{down}(\tau_t^{\mathrm{va}}) + \mathrm{pn}_{14} * \mathrm{up}(\tau_t^{\mathrm{cn}}) +$$
$$\mathrm{pn}_{15} * \mathrm{down}(\tau_t^{\mathrm{cn}}) - \mathrm{pn}_{16} * \log(\mathrm{pn}_{t-1}/\mathrm{pn}_{t-1}^*)$$

$$\log(\mathrm{bs}_t) = \log(\mathrm{lp}_t) - \log(\varphi_t)$$

$$\log(\mathrm{pe}_t^*) = \mathrm{pe}_1 - \mathrm{pe}_2/\mathrm{sqrt}(t) + \mathrm{pe}_3 * \log(\mathrm{pt}_t) + \mathrm{pe}_4 * \log(\mathrm{oil}_t) + \mathrm{pe}_4 * \log(\mathrm{us}_t)$$

$$\mathrm{dlog}(\mathrm{pe}_t) = \mathrm{pe}_5 * \mathrm{dlog}(\mathrm{pp}_t) + \mathrm{pe}_6 * \mathrm{dlog}(\mathrm{pl}_t) + \mathrm{pe}_7 * \mathrm{dlog}(\mathrm{oil}_t) + \mathrm{pe}_7 * \mathrm{dlog}(\mathrm{us}_t) +$$
$$\mathrm{pe}_8 * \mathrm{up}(\tau_t^{\mathrm{va}}) + \mathrm{pe}_9 * \mathrm{down}(\tau_t^{\mathrm{va}}) + \mathrm{pe}_{10} * \mathrm{up}(\tau_t^{\mathrm{cn}}) + \mathrm{pe}_{11} * \mathrm{down}(\tau_t^{\mathrm{cn}}) -$$
$$\mathrm{pe}_{12} * \log(\mathrm{pe}_{t-1}/\mathrm{pe}_{t-1}^*)$$

$$\log(\mathrm{pt}_t^*) = \log(\mathrm{ulc}_t) - \log(1-\beta)$$

$$\log(\mathrm{ulc}_t) = \log(\mathrm{lt}_t) + \log(\mathrm{wt}_t) - \log(\mathrm{yt}_t)$$

$$\log(\mathrm{pt}_t) = \log(\mathrm{yn}_t) - \log(\mathrm{yt}_t)$$

$$\mathrm{dlog}(\mathrm{pp}_t) = \mathrm{pp}_1 * \mathrm{dlog}(\mathrm{ulc}_t) + \mathrm{pp}_2 * \mathrm{dlog}(\mathrm{pl}_t) + \mathrm{pp}_3 * \mathrm{dlog}(\mathrm{ulc}_{t-1}) + \mathrm{pp}_4 * \mathrm{up}\left(\tau_t^{\mathrm{ci}}\right) +$$
$$\mathrm{pp}_5 * \mathrm{down}\left(\tau_t^{\mathrm{ci}}\right) - \mathrm{pp}_6 * \log(\mathrm{pt}_{t-1}/\mathrm{pt}_{t-1}^*)$$

$$\log(\mathrm{pi}_t^*) = \mathrm{pi}_1 + \mathrm{pi}_2 * \log(\mathrm{pt}_t) + \mathrm{pi}_3 * \log(\mathrm{pm}_t)$$

$$\mathrm{dlog}(\mathrm{pi}_t) = \mathrm{pi}_4 * \mathrm{dlog}(\mathrm{pp}_t) + \mathrm{pi}_5 * \mathrm{dlog}(\mathrm{pm}_t) - \mathrm{pi}_6 * \log(\mathrm{pi}_{t-1}/\mathrm{pi}_{t-1}^*)$$

$$\mathrm{dlog}(\mathrm{pk}_t) = \mathrm{dlog}(\mathrm{pp}_t)$$

$$\log(\mathrm{pg}_t^*) = \mathrm{pg}_1 - \mathrm{pg}_2/\mathrm{sqrt}(t) + \mathrm{pg}_3 * \log(\mathrm{pt}_t) + \mathrm{pg}_4 * \log(\mathrm{cp}_t)$$

$$\mathrm{dlog}(\mathrm{pg}_t) = \mathrm{pg}_5 * \mathrm{dlog}(\mathrm{pp}_t) + \mathrm{pg}_6 * \mathrm{dlog}(\mathrm{cp}_t) - \mathrm{pg}_7 * \log(\mathrm{pg}_{t-1}/\mathrm{pg}_{t-1}^*)$$

$$\mathrm{dlog}(\mathrm{pc}_t) = \mathrm{dlog}(\mathrm{cp}_t)$$

$$\log(\mathrm{px}_t^*) = \mathrm{px}_1 + \mathrm{px}_2 * \log(\mathrm{pt}_t) + \mathrm{px}_3 * \log(\mathrm{ip}_t) + \mathrm{px}_3 * \log(\mathrm{er}_t)$$

$$\mathrm{dlog}(\mathrm{px}_t) = \mathrm{px}_4 * \mathrm{dlog}(\mathrm{pp}_t) + \mathrm{px}_5 * \mathrm{dlog}(\mathrm{ip}_t) + \mathrm{px}_5 * \mathrm{dlog}(\mathrm{er}_t) - \mathrm{px}_6 * \log(\mathrm{px}_{t-1}/\mathrm{px}_{t-1}^*)$$

$$\log(\mathrm{pm}_t^*) = \mathrm{pm}_1 + \mathrm{pm}_2 * \log(\mathrm{pt}_t) + \mathrm{pm}_3 * \log(\mathrm{ep}_t) + \mathrm{pm}_3 * \log(\mathrm{er}_t) +$$
$$\mathrm{pm}_4 * \log(\mathrm{oil}_t) + \mathrm{pm}_4 * \log(\mathrm{us}_t)$$

$$\mathrm{dlog}(\mathrm{pm}_t) = \mathrm{pm}_5 * \mathrm{dlog}(\mathrm{pp}_t) + \mathrm{pm}_6 * \mathrm{dlog}(\mathrm{ep}_t) + \mathrm{pm}_6 * \mathrm{dlog}(\mathrm{er}_t) + \mathrm{pm}_7 * \mathrm{dlog}(\mathrm{oil}_t) +$$
$$\mathrm{pm}_7 * \mathrm{dlog}(\mathrm{us}_t) - \mathrm{pm}_8 * \log(\mathrm{pm}_{t-1}/\mathrm{pm}_{t-1}^*)$$

Firms and households

$$cs_t = \delta f_t * kf_t * pk_t + os_t * pt_t - cit_t$$

$$\log(rs_t) = \log(cs_t) - \log(pi_t)$$

$$hn_t = \delta h_t * kh_t * pk_t + lt_t * wt_t + le_t * we_t + st_t * pt_t + ms_t * pt_t - toh_t - coh_t + hpt_t + hot_t$$

$$\log(hc_t) = \log(hn_t) - \log(pc_t)$$

$$\log(hpt_t) = \log(\nu_t) + \log(yt_t) + \log(pt_t)$$

$$toh_t = lit_t + pit_t$$

$$\log(hi_t) = \log(hn_t) - \log(pi_t)$$

$$\log(hot_t) = \log(\upsilon_t) + \log(yt_t) + \log(pt_t)$$

$$coh_t = gsc_t + fsc_t + lsc_t + psc_t + ssc_t + esc_t$$

$$hr_t = hn_t + pa_t$$

$$\log(pa_t) = \log(\chi_t) + \log(lt_t) + \log(wt_t)$$

$$he_t = cn_t - ni_t$$

$$\log(ni_t) = \log(\kappa_t) + \log(ct_t) + \log(pc_t)$$

$$\log(hs_t) = \log(1 - he_t/hr_t)$$

$$gsc_t = lf_t * wf_t * \frac{\tau_t^{gc}}{1 + \tau_t^{gc} + \tau_t^{fc}} + lg_t * wg_t * \frac{\tau_t^{gc}}{1 + \tau_t^{gc} + \tau_t^{fc}}$$

$$\gamma_t^{gc} = 0.75 * \gamma_{t-1}^{gc} + 0.25 * \tau_t^{gc}$$

$$ssc_t = lh_t * wt_t * \tau_t^{sc}$$

$$\gamma_t^{sc} = 0.75 * \gamma_{t-1}^{sc} + 0.25 * \tau_t^{sc}$$

$$\mathrm{fsc}_t = \mathrm{lf}_t * \mathrm{wf}_t * \frac{\tau_t^{fc}}{1 + \tau_t^{gc} + \tau_t^{fc}} + \mathrm{lg}_t * \mathrm{wg}_t * \frac{\tau_t^{fc}}{1 + \tau_t^{gc} + \tau_t^{fc}}$$

$$\gamma_t^{fc} = 0.75 * \gamma_{t-1}^{fc} + 0.25 * \tau_t^{fc}$$

$$\mathrm{esc}_t = \mathrm{le}_t * \mathrm{we}_t * \tau_t^{ec}$$

$$\gamma_t^{ec} = 0.75 * \gamma_{t-1}^{ec} + 0.25 * \tau_t^{ec}$$

$$\mathrm{lsc}_t = \mathrm{lf}_t * \mathrm{wf}_t * \frac{\tau_t^{lc}}{1 + \tau_t^{gc} + \tau_t^{fc}} + \mathrm{lg}_t * \mathrm{wg}_t * \frac{\tau_t^{lc}}{1 + \tau_t^{gc} + \tau_t^{fc}}$$

$$\gamma_t^{lc} = 0.75 * \gamma_{t-1}^{lc} + 0.25 * \tau_t^{lc}$$

$$\mathrm{psc}_t = \mathrm{hn}_t * \tau_t^{pc}$$

$$\gamma_t^{pc} = 0.75 * \gamma_{t-1}^{pc} + 0.25 * \tau_t^{pc}$$

Fiscal policy block

$$gr_t = \delta g_t * kg_t * pk_t + dit_t + int_t + soc_t + gpt_t + got_t + get_t + gct_t$$

$$ge_t = gt_t * pg_t + ig_t * pi_t + st_t * pt_t + irc_t + okc_t$$

$$bp_t = gr_t - ge_t$$

$$bp_t^* = (bp_t + bp_{t-1} + bp_{t-2} + bp_{t-3})/(yn_t + yn_{t-1} + yn_{t-2} + yn_{t-3})$$

$$dp_t = dp_{t-1} - bp_t$$

$$dp_t^* = dp_t/(yn_t + yn_{t-1} + yn_{t-2} + yn_{t-3})$$

$$dit_t = lit_t + pit_t + cit_t + git_t$$

$$lit_t = lf_t * wf_t * \frac{\tau_t^{li}}{1 + \tau_t^{gc} + \tau_t^{fc}} + lg_t * wg_t * \frac{\tau_t^{li}}{1 + \tau_t^{gc} + \tau_t^{fc}}$$

$$\gamma_t^{li} = 0.75 * \gamma_{t-1}^{li} + 0.25 * \tau_t^{li}$$

$$pit_t = hn_t * \tau_t^{pi}$$

$$\gamma_t^{pi} = 0.75 * \gamma_{t-1}^{pi} + 0.25 * \tau_t^{pi}$$

$$cit_t = os_t * pt_t * \tau_t^{ci}$$

$$\gamma_t^{ci} = 0.75 * \gamma_{t-1}^{ci} + 0.25 * \tau_t^{ci}$$

$$int_t = vat_t + cnt_t + ynt_t$$

$$vat_t = 0.76 * ct_t * pc_t * \frac{\tau_t^{va}}{1 + \tau_t^{va}} + 0.82 * ic_t * pt_t * \frac{\tau_t^{va}}{1 + \tau_t^{va}} + 0.93 * ig_t * pi_t * \frac{\tau_t^{va}}{1 + \tau_t^{va}}$$

$$\gamma_t^{va} = 0.75 * \gamma_{t-1}^{va} + 0.25 * \tau_t^{va}$$

$$cnt_t = 0.88 * ct_t * pc_t * \frac{\tau_t^{cn}}{1 + \tau_t^{va}} + 0.12 * yt_t * pt_t * \frac{\tau_t^{cn}}{1 + \tau_t^{va}}$$

$$\gamma_t^{cn} = 0.75 * \gamma_{t-1}^{cn} + 0.25 * \tau_t^{cn}$$

$$soc_t = lsc_t + psc_t + gsc_t + ssc_t$$

$$cor(st_t) = \log(st_1) + \log(yt_t^*) - \log(st_t)$$

$$dlog(st_t) = st_2 * dlog(yt_t^*) + st_3 * dlog(lt_t) + st_3 * dlog(rt_t) + st_4 * dlog(\eta_t) + st_4 * dlog(\mu_t) - st_5 * gap(yt_{t-1}) + st_6 * dev(bp_{t-1}^*) - st_7 * dev(dp_{t-1}^*) + st_8 * cor(st_{t-1})$$

$$\log(nt_t) = \log(\xi_t) + \log(lt_t) + \log(wt_t)$$

$$cor(ic_t) = \log(ic_1) + \log(yt_t^*) - \log(ic_t)$$

$$dlog(ic_t) = ic_2 * dlog(yt_t^*) + ic_3 * dlog(yt_t) - ic_4 * gap(yt_{t-1}) + ic_5 * dev(bp_{t-1}^*) - ic_6 * dev(dp_{t-1}^*) + ic_7 * cor(ic_{t-1})$$

$$\log(mp_t) = \log(\zeta_t) + \log(va_t) + \log(pt_t)$$

$$\log(ot_t) = \log(\theta_t) + \log(gt_t) + \log(pg_t)$$

$$irc_t = 1/4 * ir_t * dp_{t-1}$$

Convergence properties

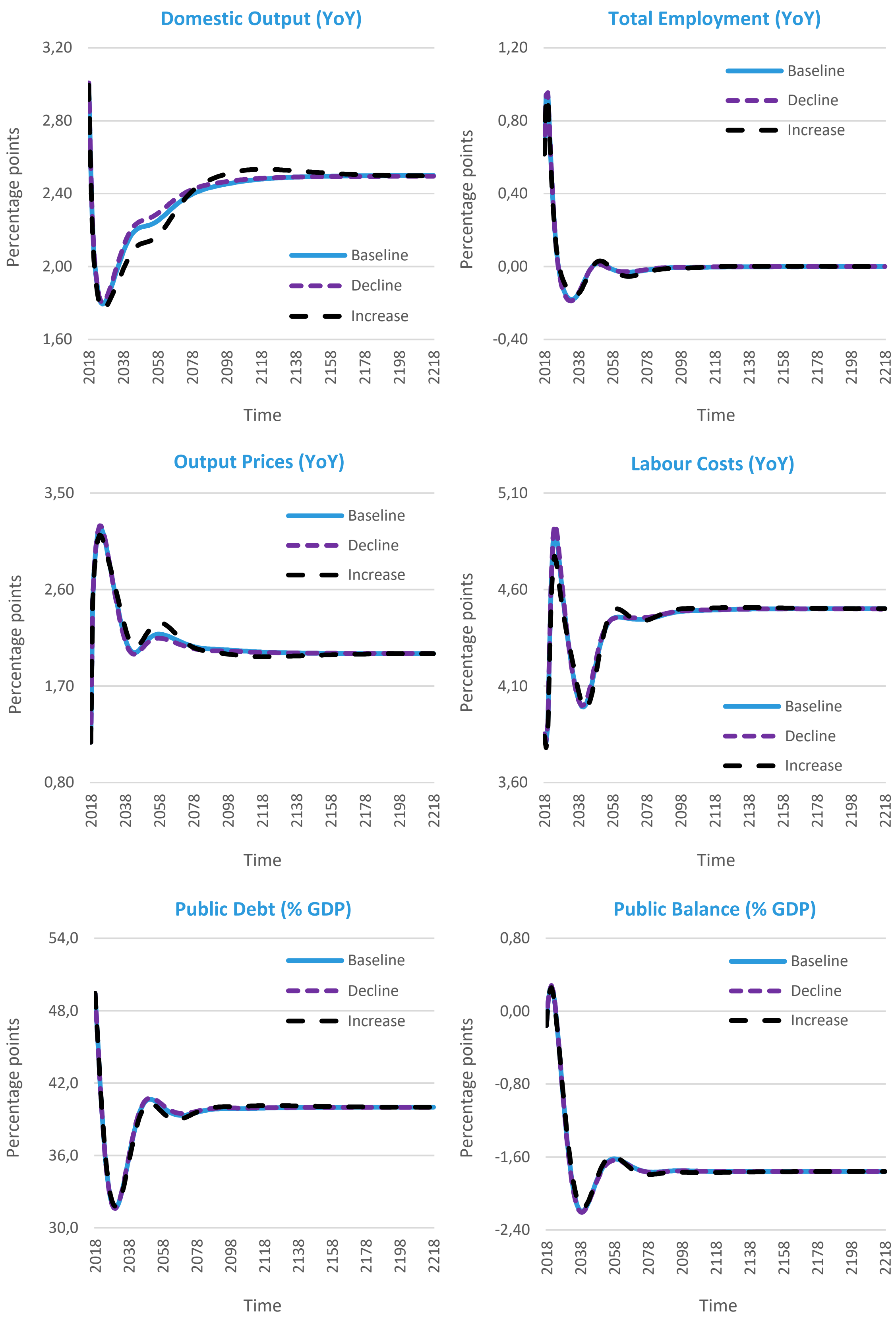


Fig.C1: Convergence properties of model variables under (i) a baseline scenario with the calibration of $\mathrm{if}_9 = 0.10$ and $\mathrm{ih}_9 = 0.05$, (ii) a decline scenario with the calibration of $\mathrm{if}_9 = 0.02$ and $\mathrm{ih}_9 = 0.01$ and (iii) an increase scenario with the calibration of $\mathrm{if}_9 = 0.40$ and $\mathrm{ih}_9 = 0.20$.

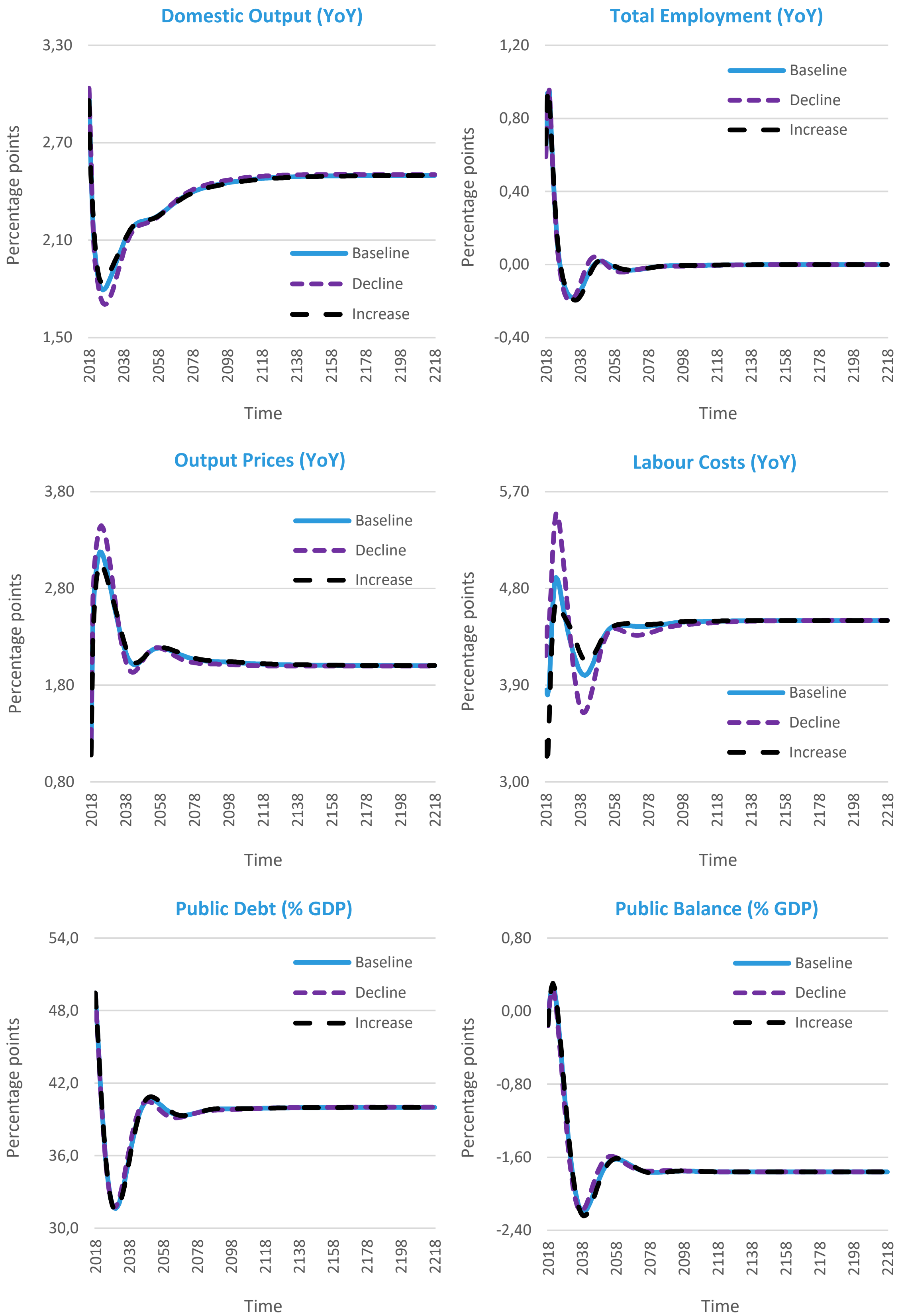


Fig.C2: Convergence properties of model variables under (i) a baseline scenario with the calibration of $\mathrm{wf}_{10} = 0.10$ and $\mathrm{wg}_8 = 0.05$, (ii) a decline scenario with the calibration of $\mathrm{wf}_{10} = 0.04$ and $\mathrm{wg}_8 = 0.02$ and (iii) an increase scenario with the calibration of $\mathrm{wf}_{10} = 0.20$ and $\mathrm{wg}_8 = 0.10$.

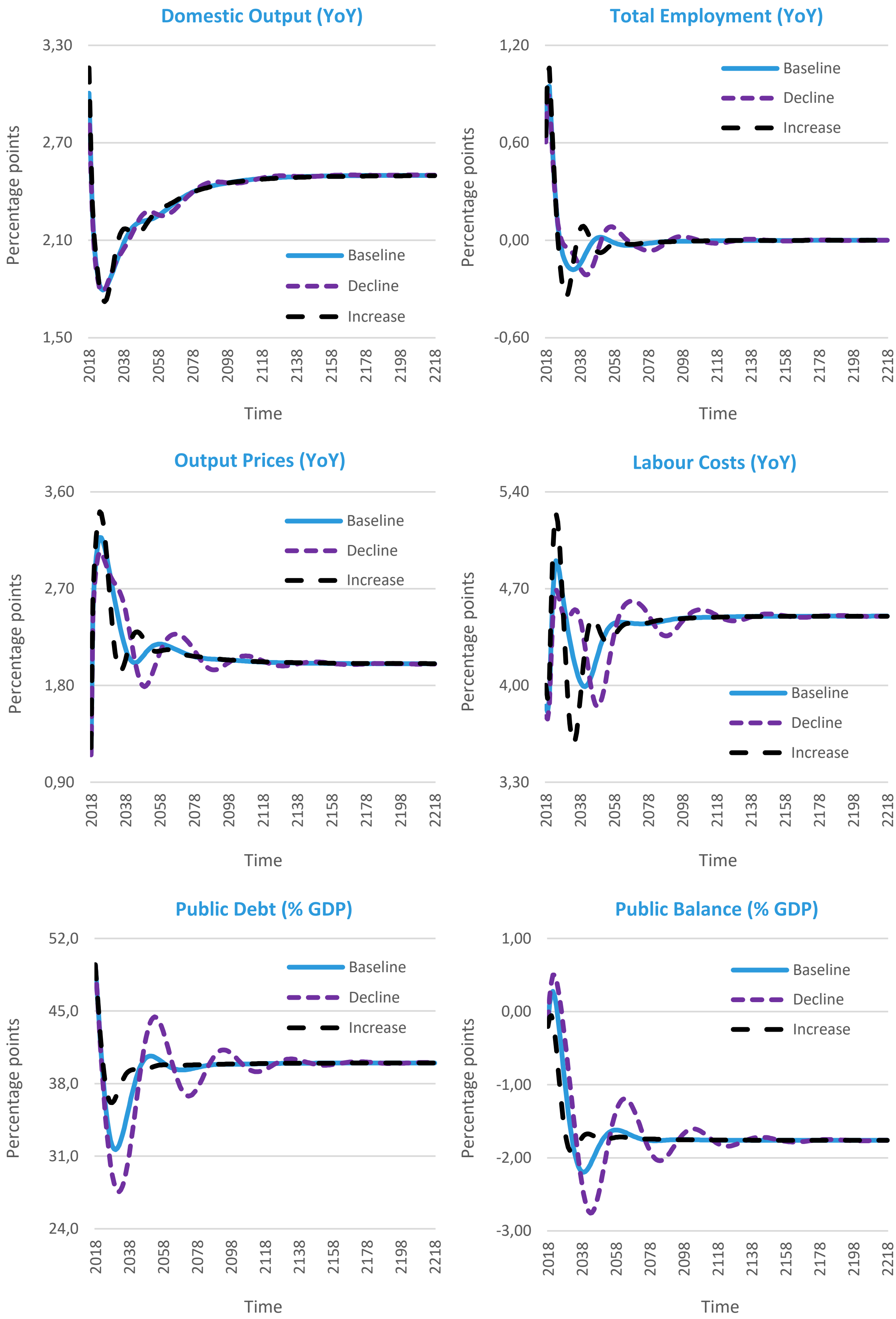


Fig.C3: Convergence properties of model variables under (i) a baseline scenario with the calibration of $\mathrm{ig}_4 = 0.80$ and $\mathrm{ic}_5 = 0.40$, (ii) a decline scenario with the calibration of $\mathrm{ig}_4 = 0.40$ and $\mathrm{ic}_5 = 0.20$ and (iii) an increase scenario with the calibration of $\mathrm{ig}_4 = 1.60$ and $\mathrm{ic}_5 = 0.80$.

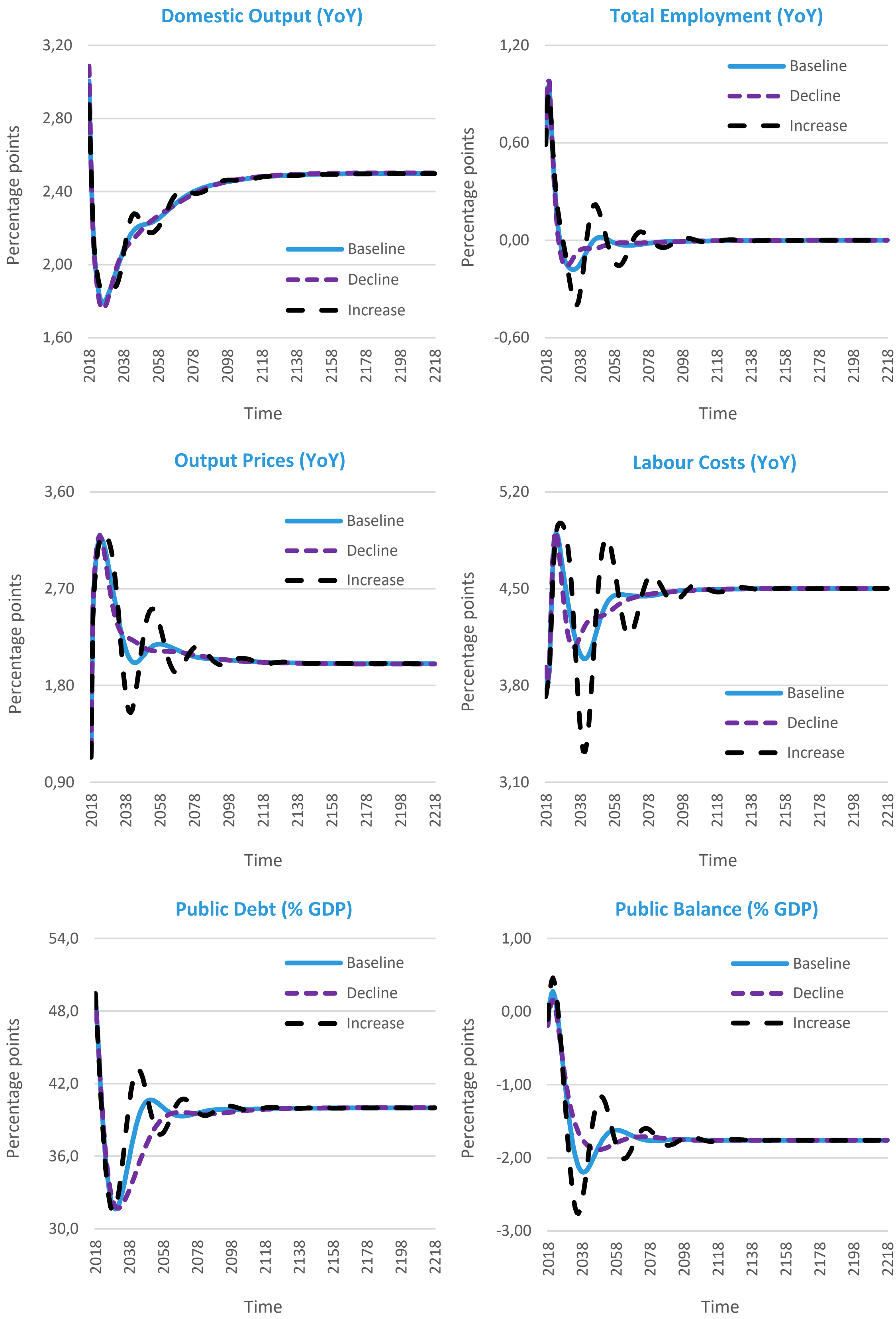


Fig.C4: Convergence properties of model variables under (i) a baseline scenario with the calibration of $ig_5 = 0.10$ and $ic_6 = 0.05$, (ii) a decline scenario with the calibration of $ig_5 = 0.04$ and $ic_6 = 0.02$ and (iii) an increase scenario with the calibration of $ig_5 = 0.20$ and $ic_6 = 0.10$.

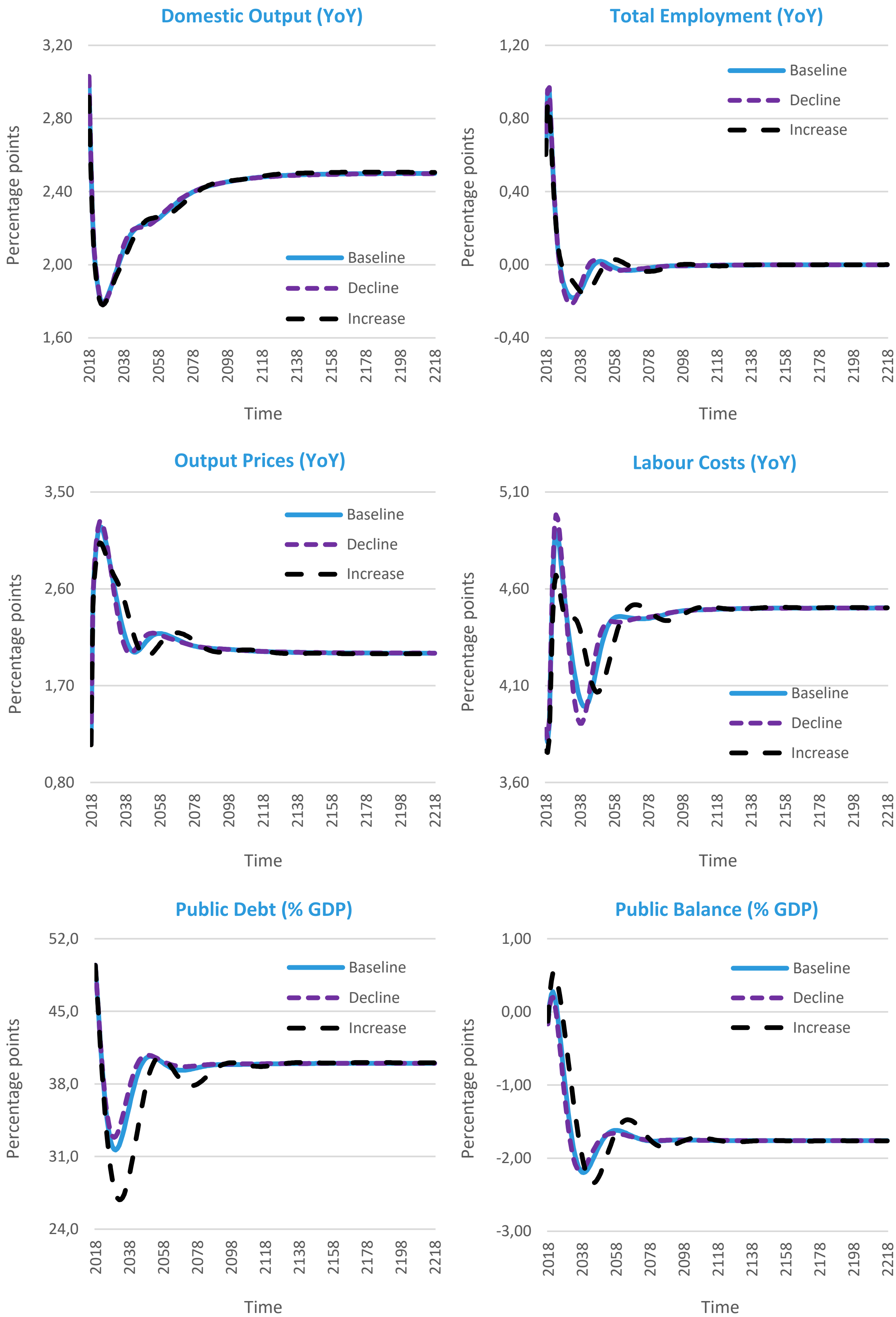


Fig.C5: Convergence properties of model variables under (i) a baseline scenario with the calibration of $ig_3 = 0.20$ and $ic_4 = 0.10$, (ii) a decline scenario with the calibration of $ig_3 = 0.04$ and $ic_4 = 0.02$ and (iii) an increase scenario with the calibration of $ig_3 = 0.80$ and $ic_4 = 0.40$.

Macroeconomic shocks

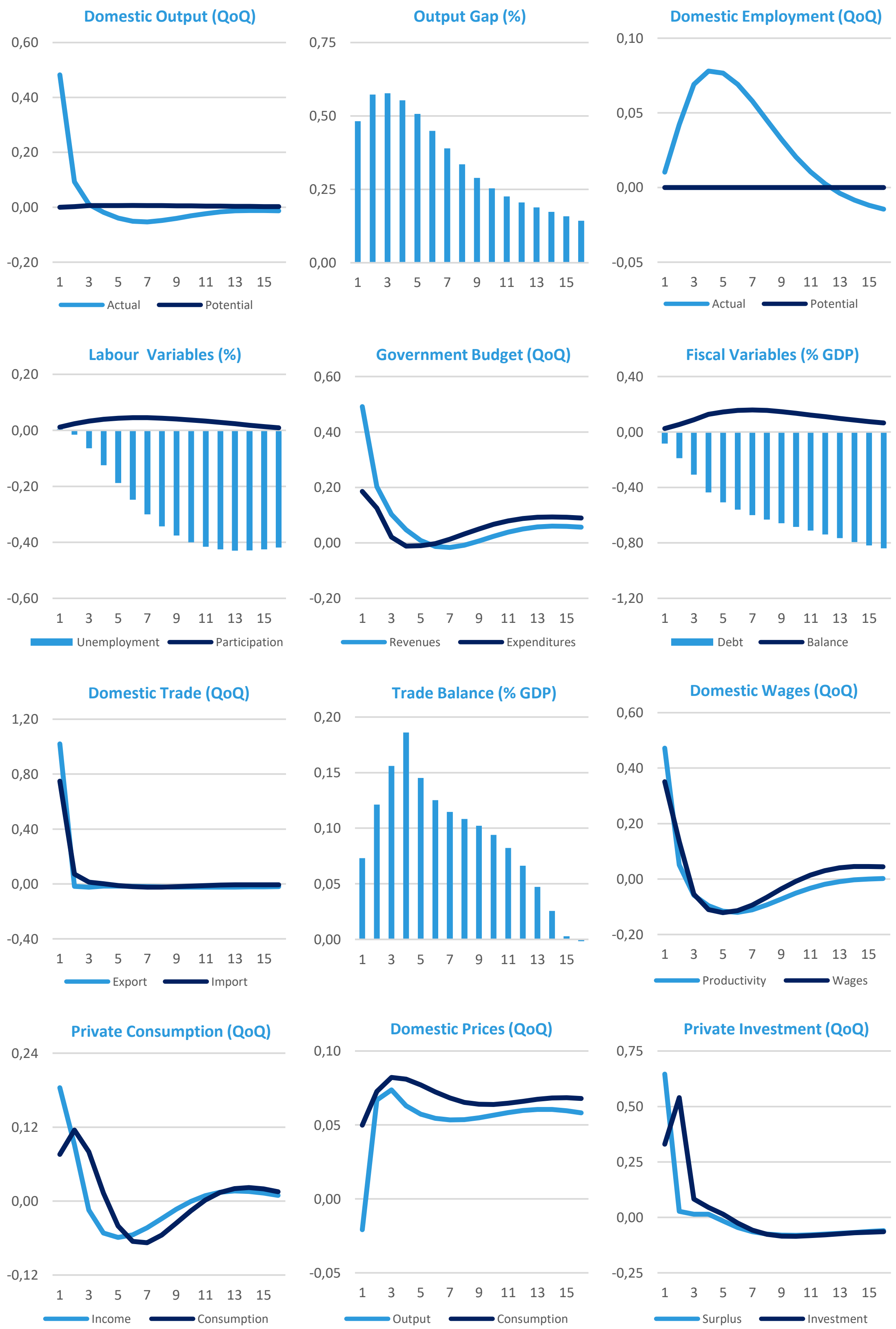


Fig.M1: A permanent shock to a total external demand that corresponds to an increase of a growth rate by 1.00 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

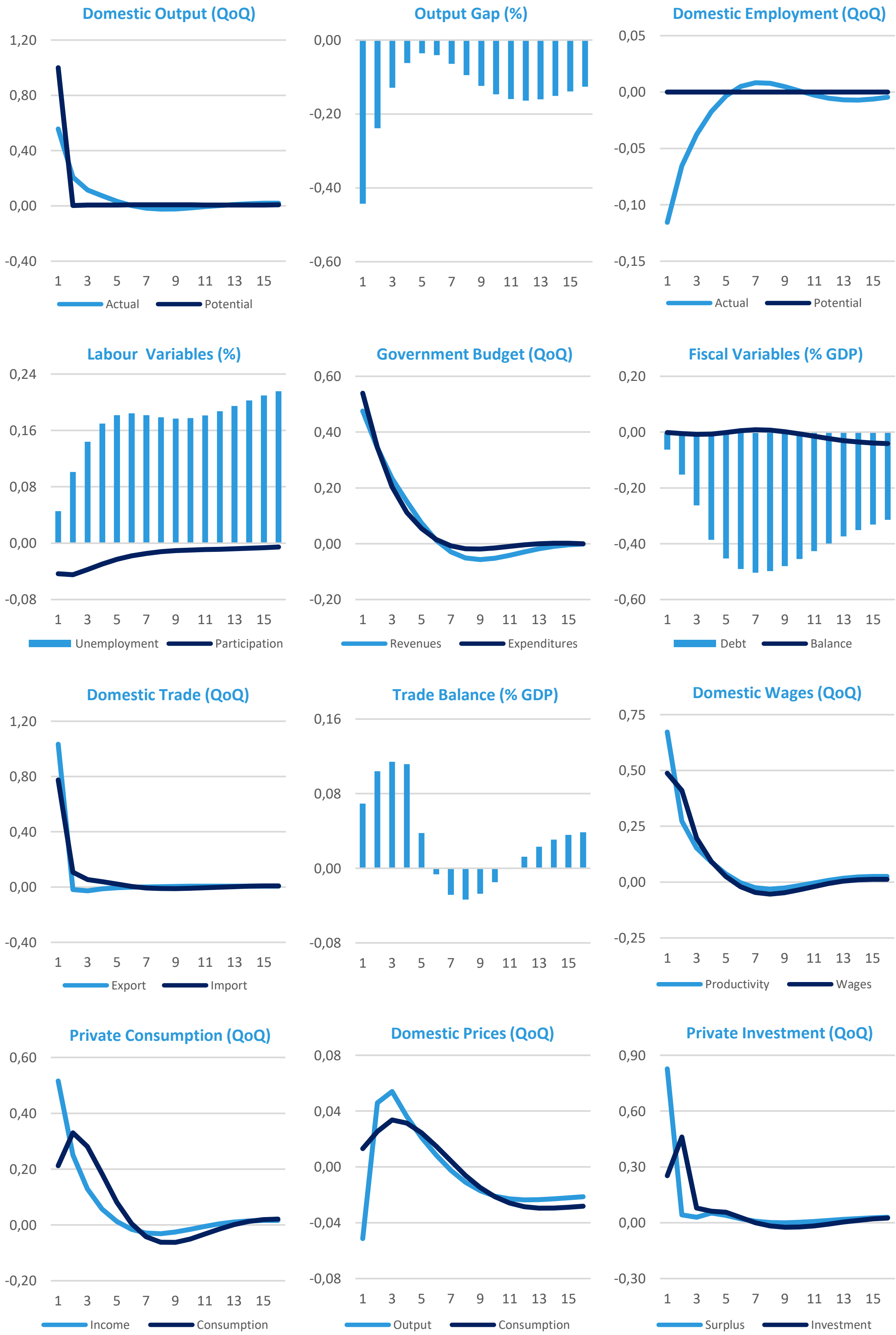


Fig.M2: A permanent shock to a total factor productivity that corresponds to an increase of a growth rate by 1.00 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

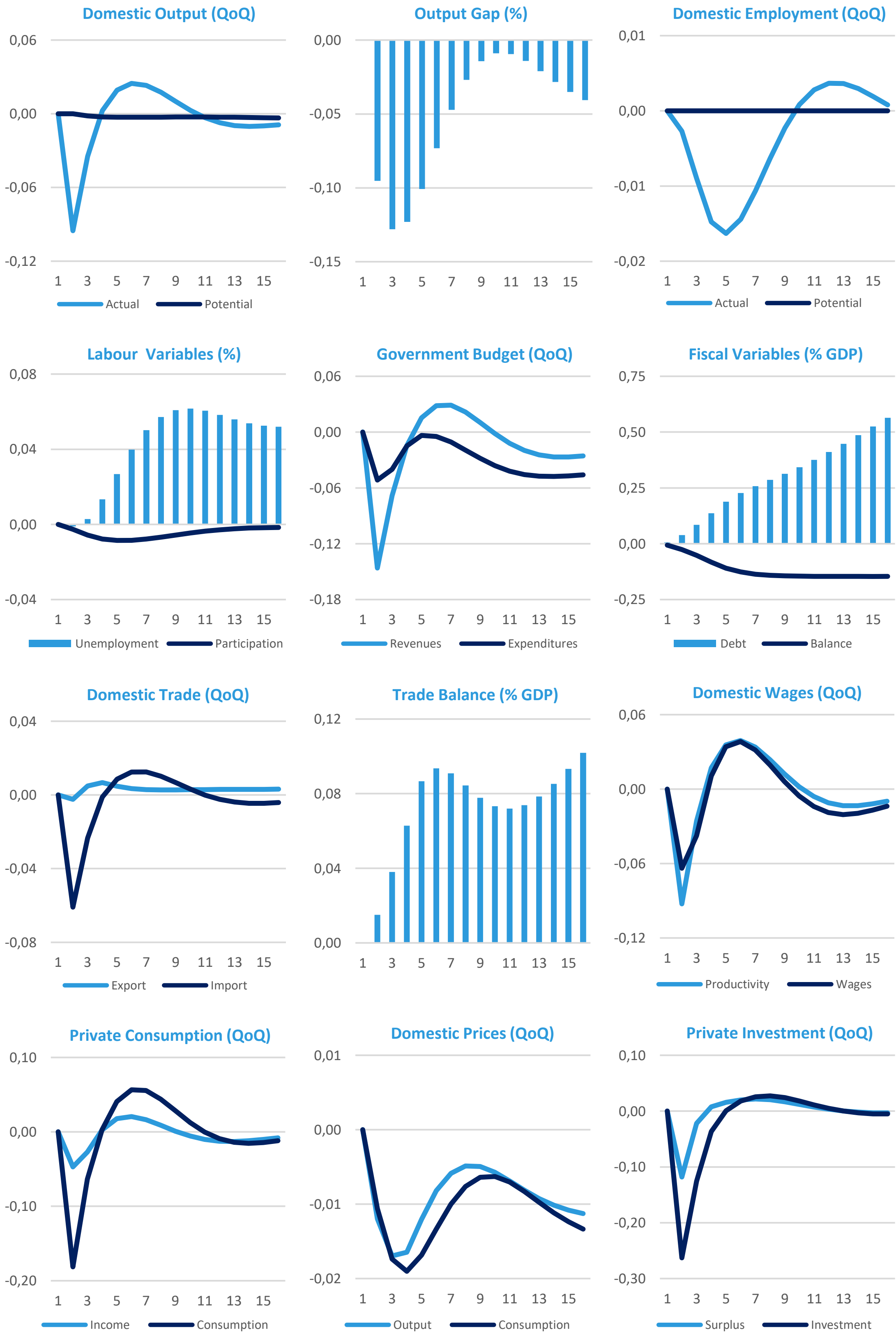


Fig.M3: A permanent shock to nominal interest rates that corresponds to an increase of an effective rate by 1.00 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

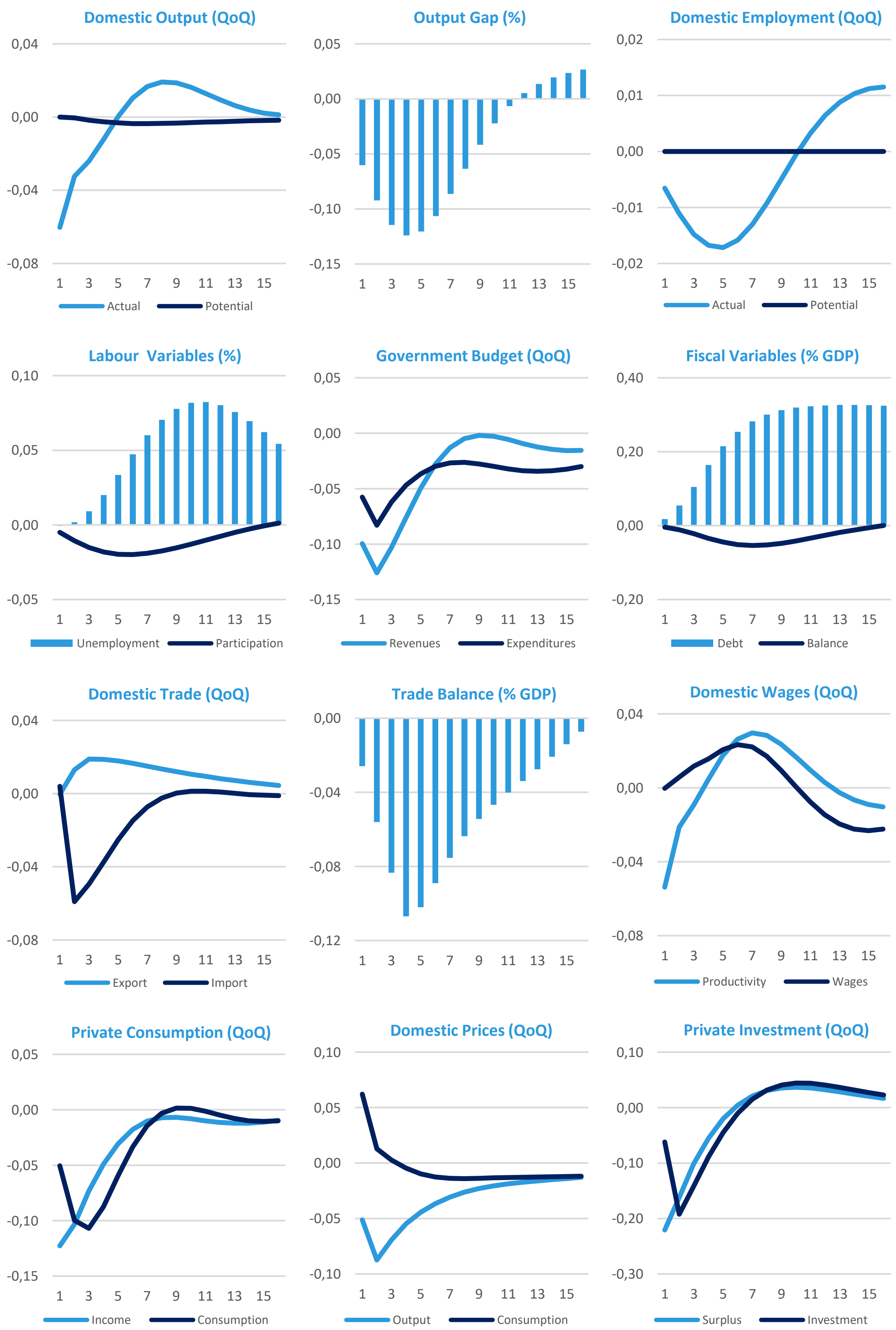


Fig.M4: A permanent shock to world crude oil prices that corresponds to an increase of a growth rate by 10.0 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

Sensitivity of calibration

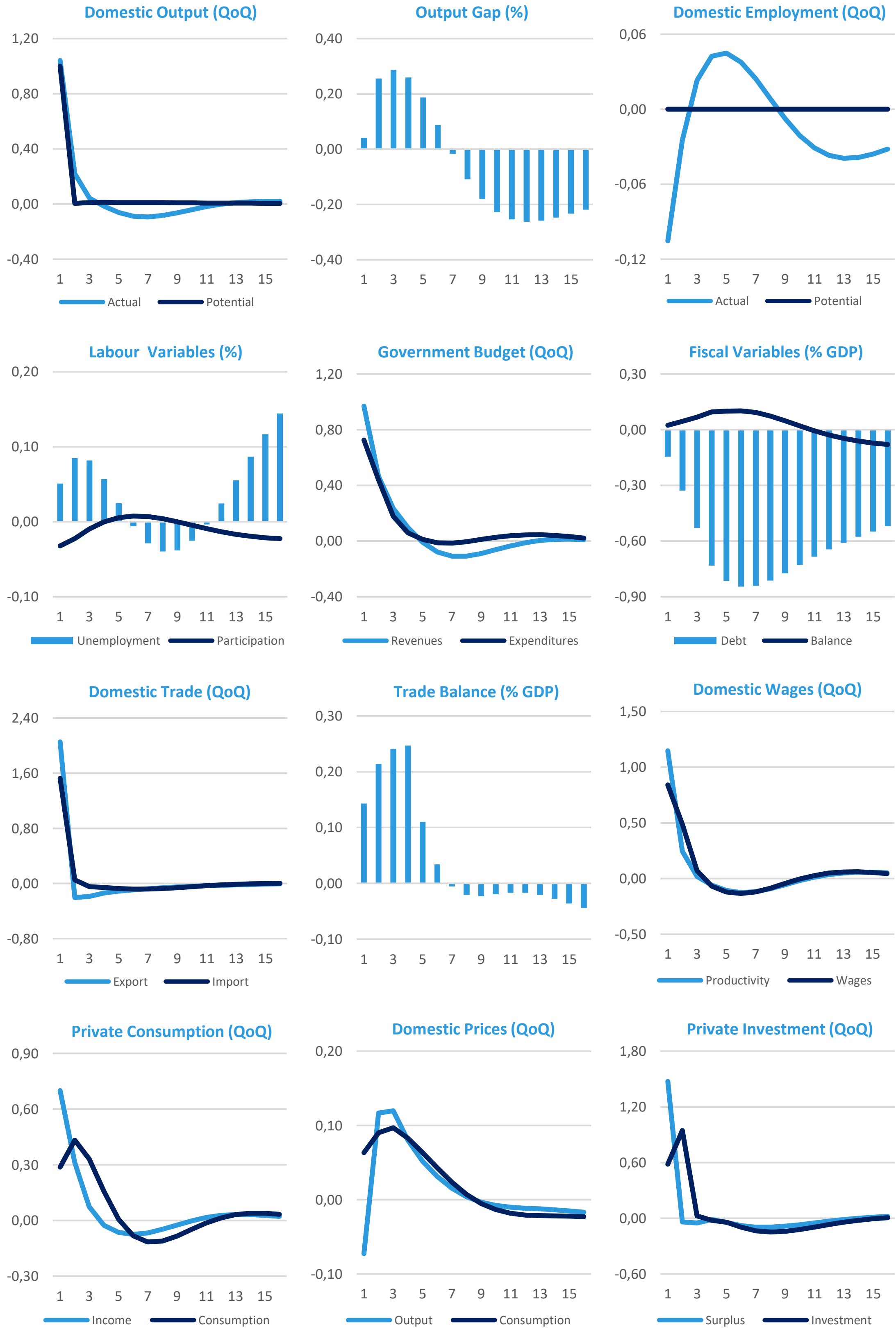


Fig.S1: A permanent shock to a total factor productivity that corresponds to an increase of a growth rate by 1.00 p.p. in the first quarter with the parameter xt_8 set from 1.00 to 2.00. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

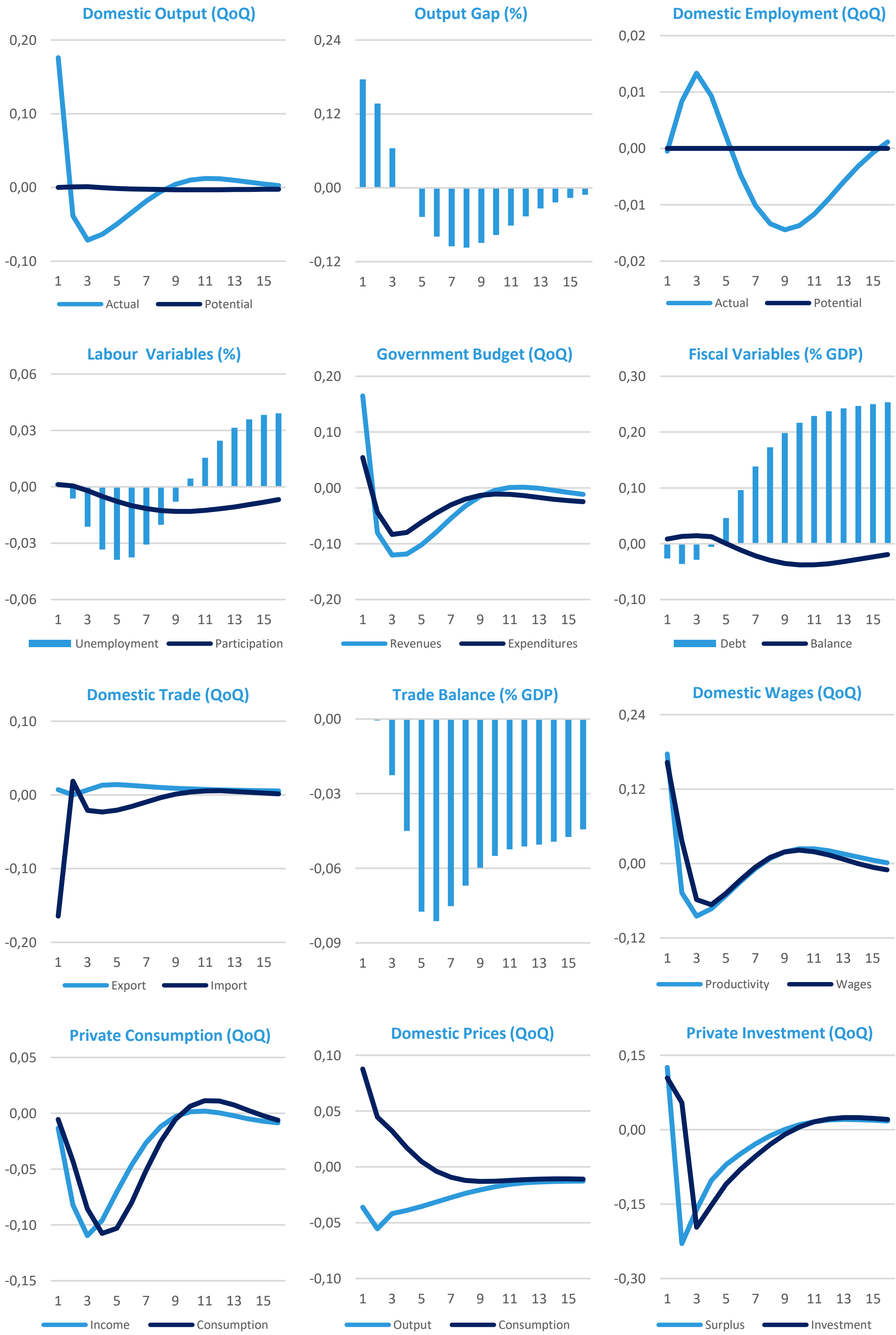


Fig.S2: A permanent shock to world crude oil prices that corresponds to an increase of a growth rate by 10.0 p.p. in the first quarter with the parameter mt_8 set from 0.00 to 0.02. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

Shocks to revenues

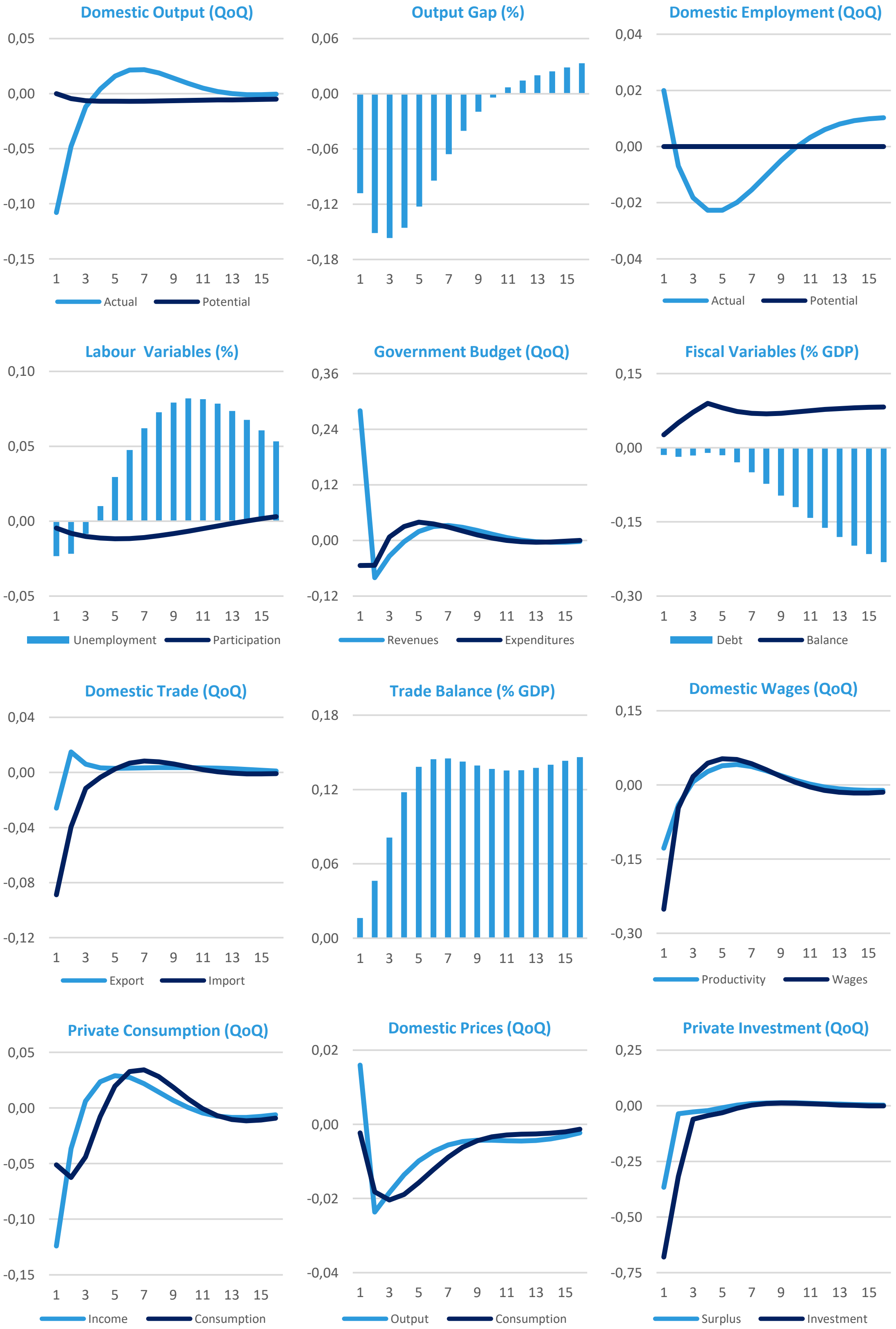


Fig.R1: A permanent shock to taxation of corporates that corresponds to an increase of an effective rate by 1.00 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

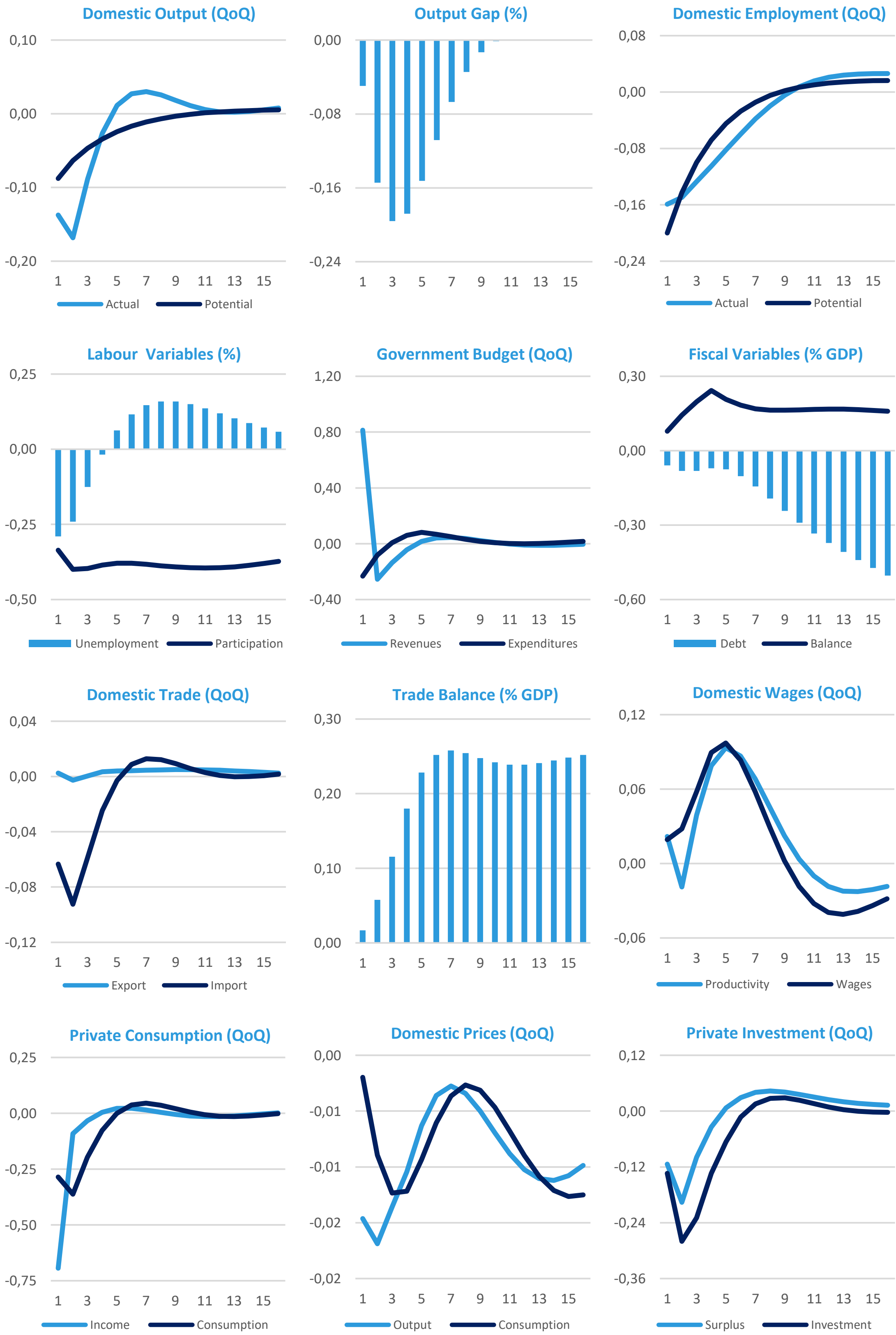


Fig.R2: A permanent shock to taxation of employees that corresponds to an increase of an effective rate by 1.00 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

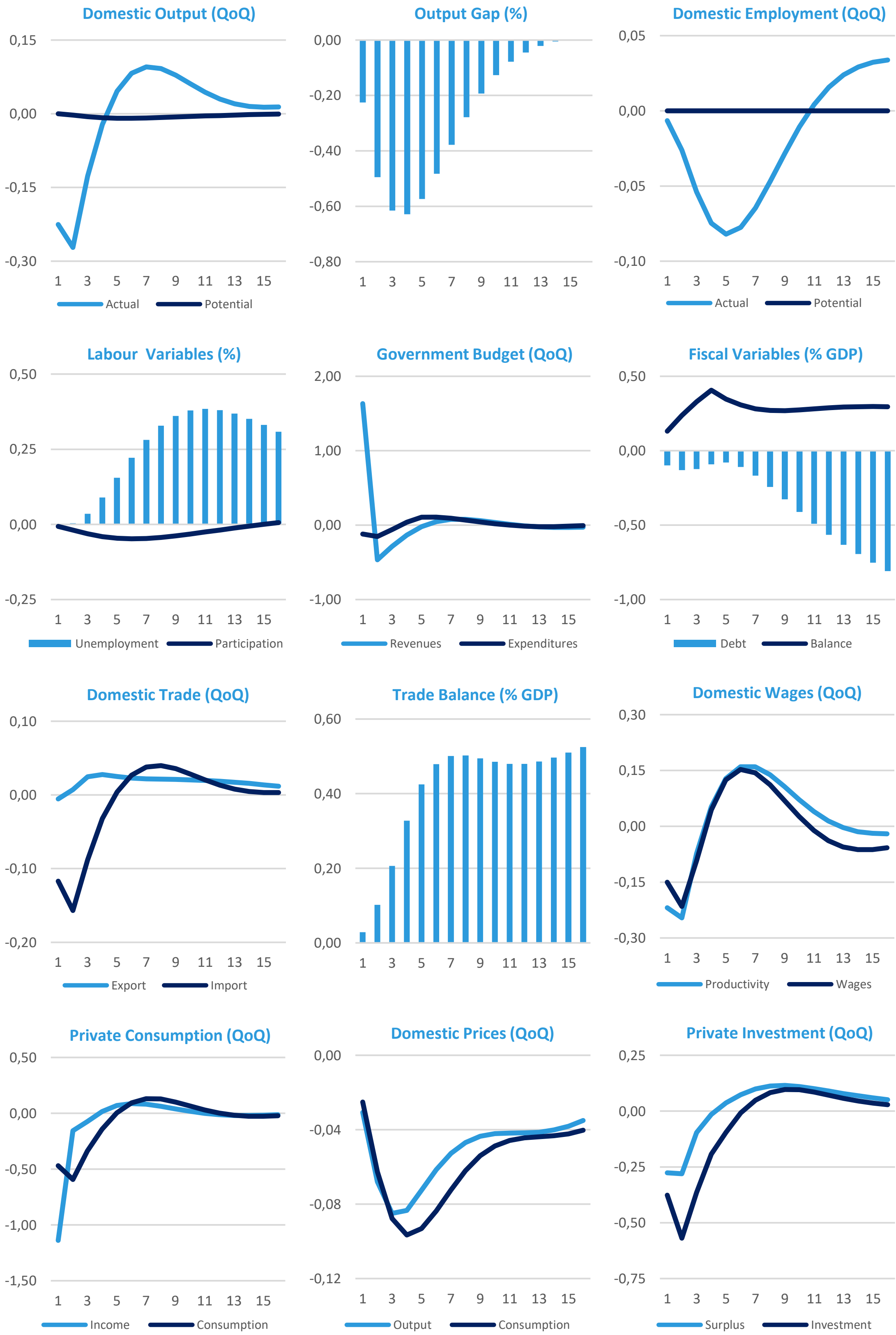


Fig.R3: A permanent shock to taxation of properties that corresponds to an increase of an effective rate by 1.00 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

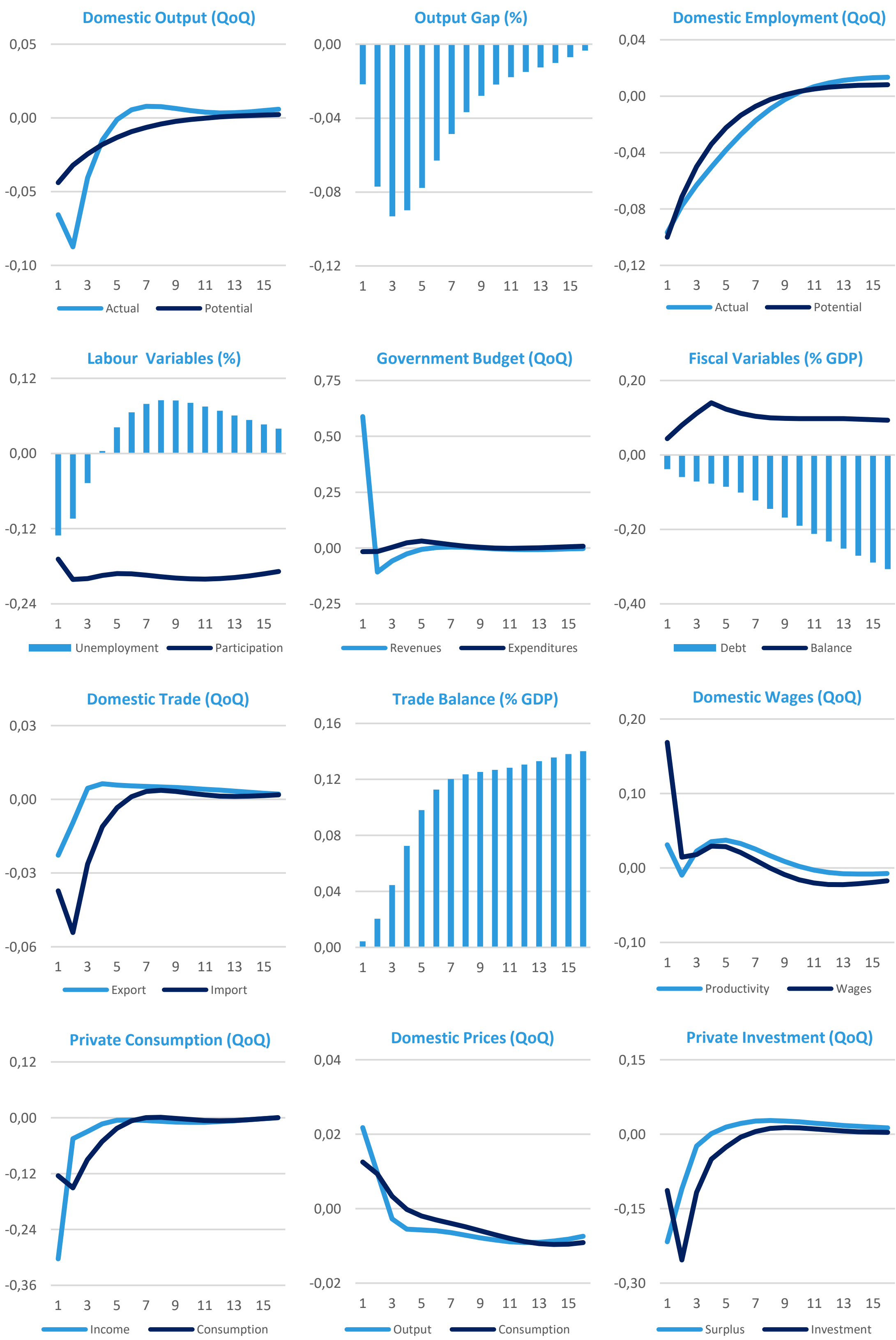


Fig.R4: A permanent shock to taxation of employers that corresponds to an increase of an effective rate by 1.00 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

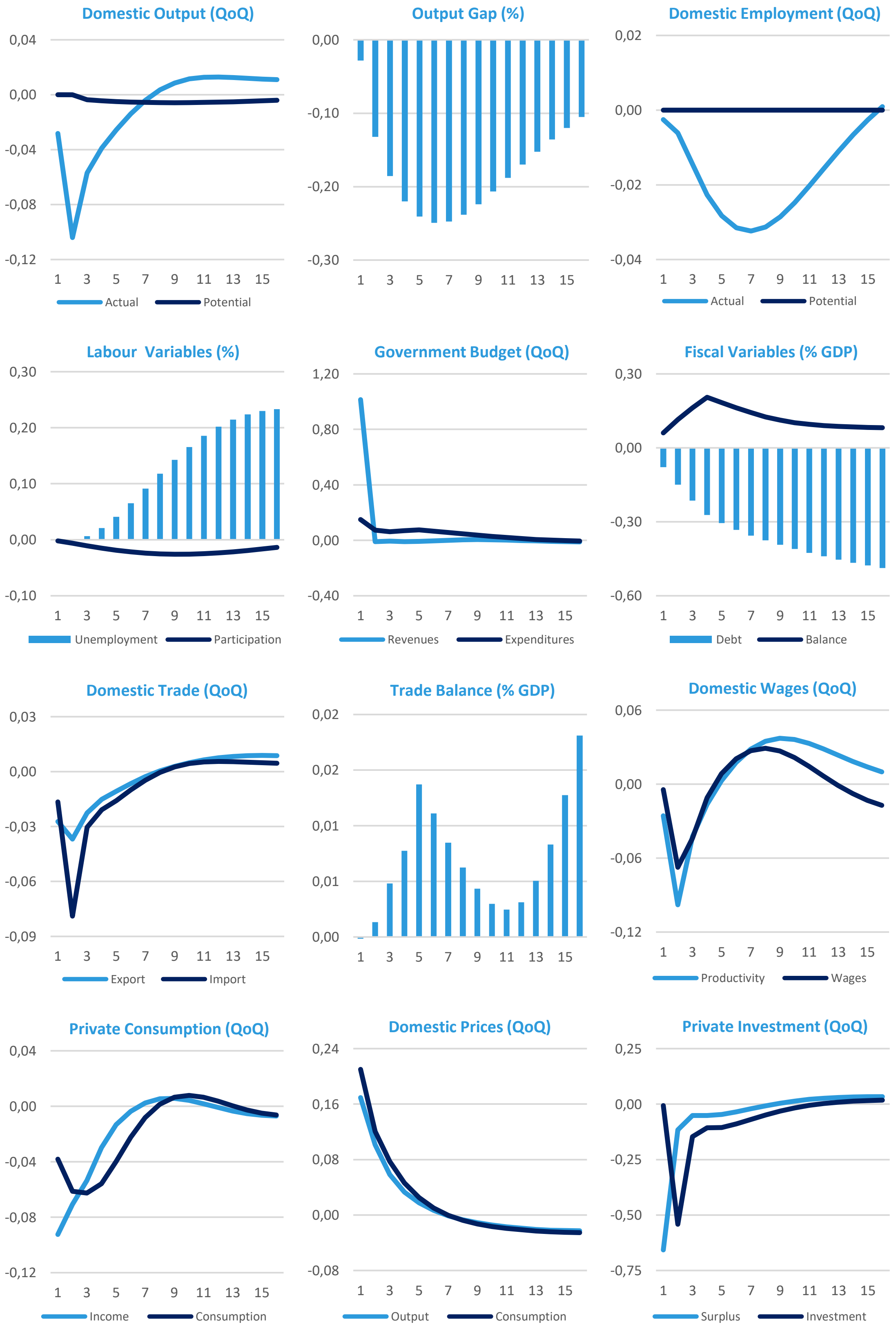


Fig.R5: A permanent shock to value added taxes that corresponds to an increase of an effective rate by 1.00 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

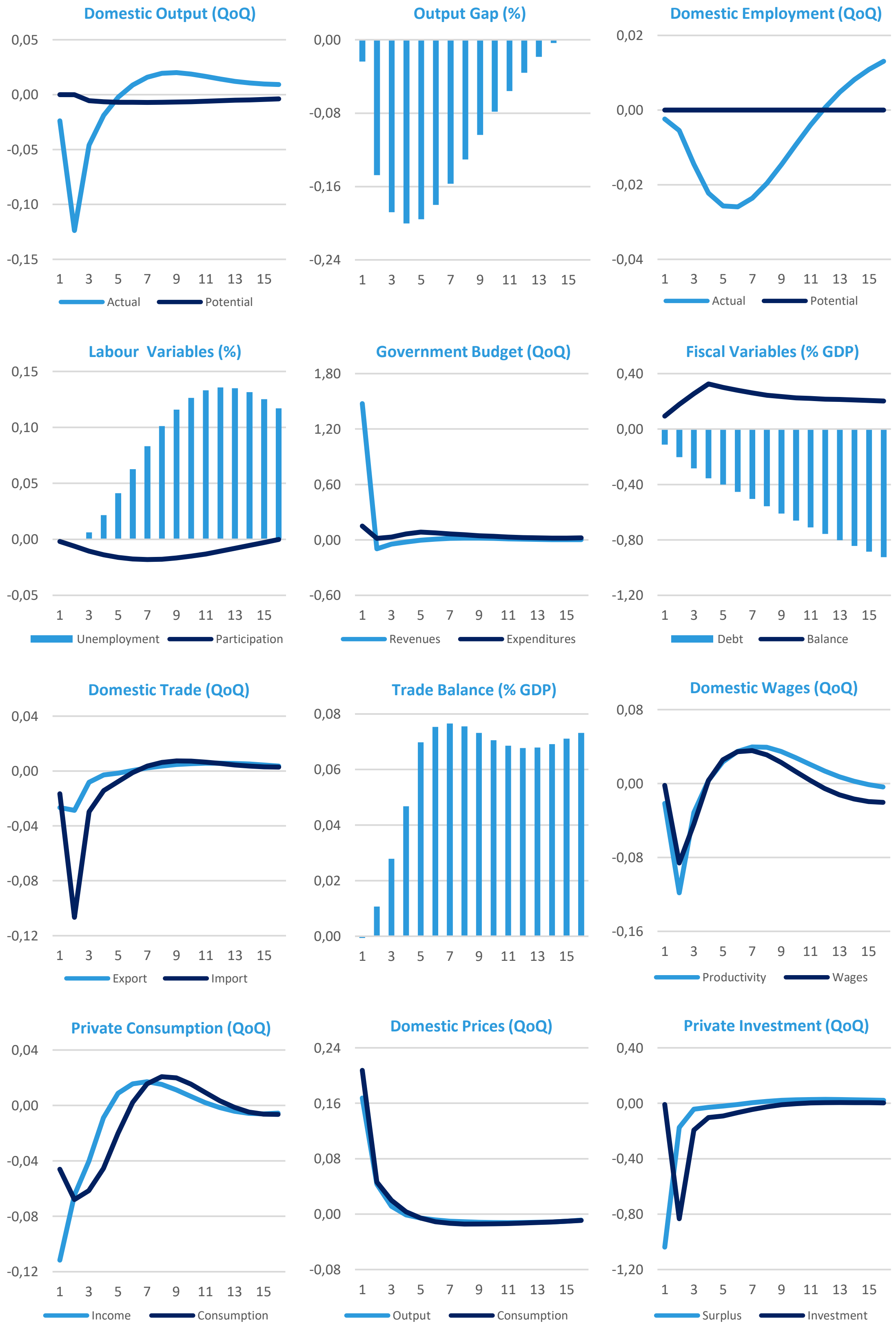


Fig.R6: A permanent shock to net consumption taxes that corresponds to an increase of an effective rate by 1.00 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

Shocks to expenditures

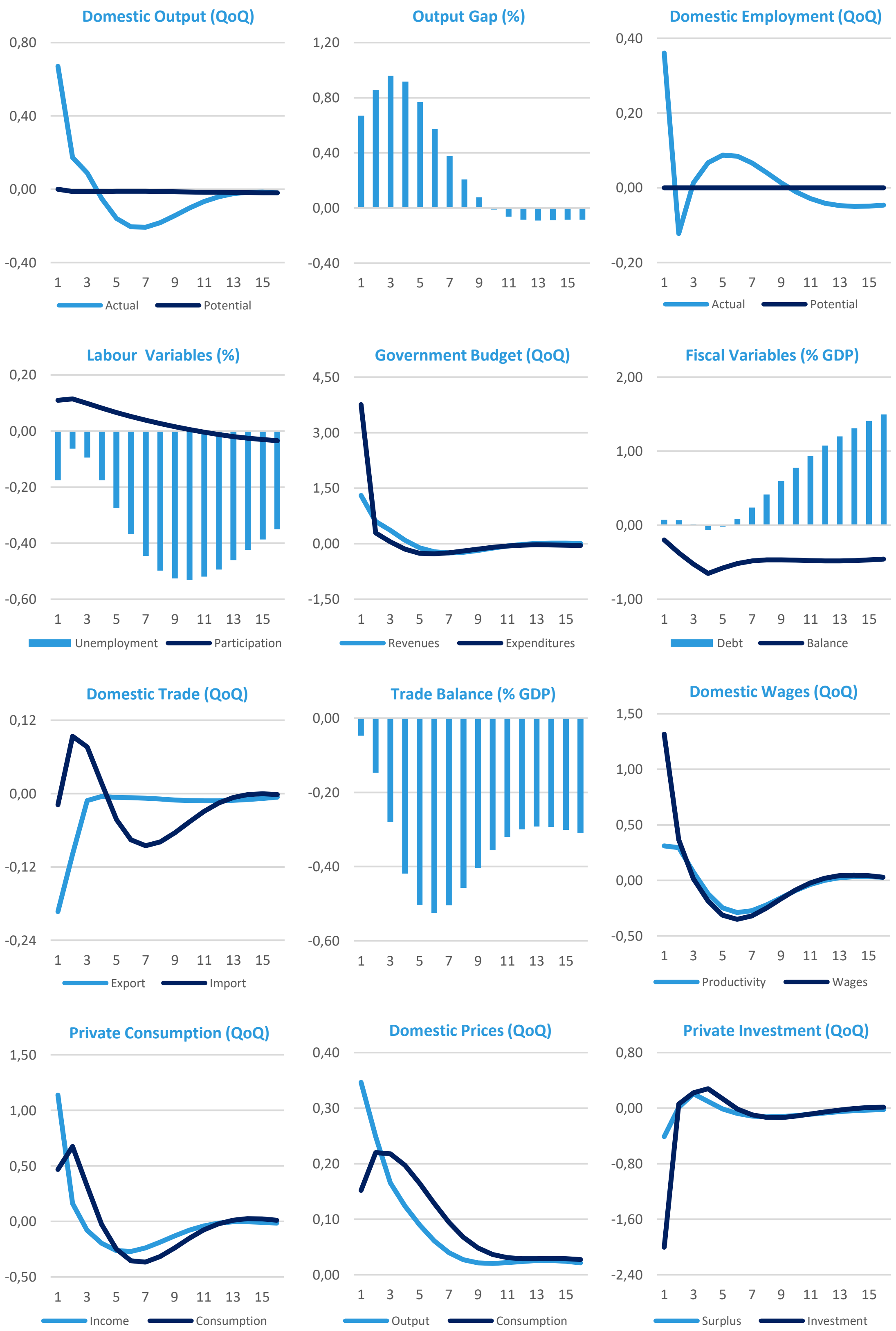


Fig.E1: A permanent shock to public compensations that corresponds to an increase of a growth rate by 10.0 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

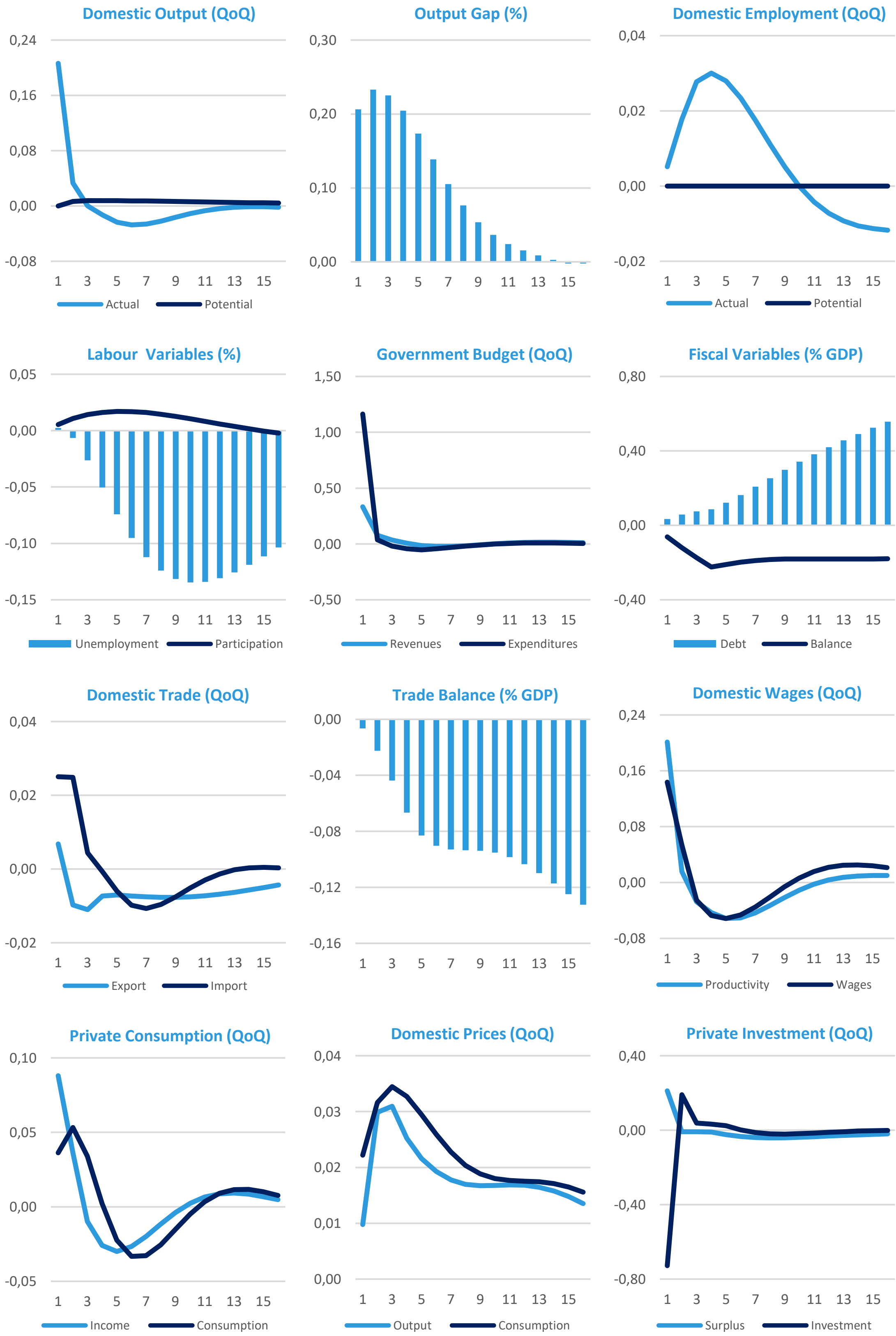


Fig.E2: A permanent shock to government investment that corresponds to an increase of a growth rate by 10.0 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

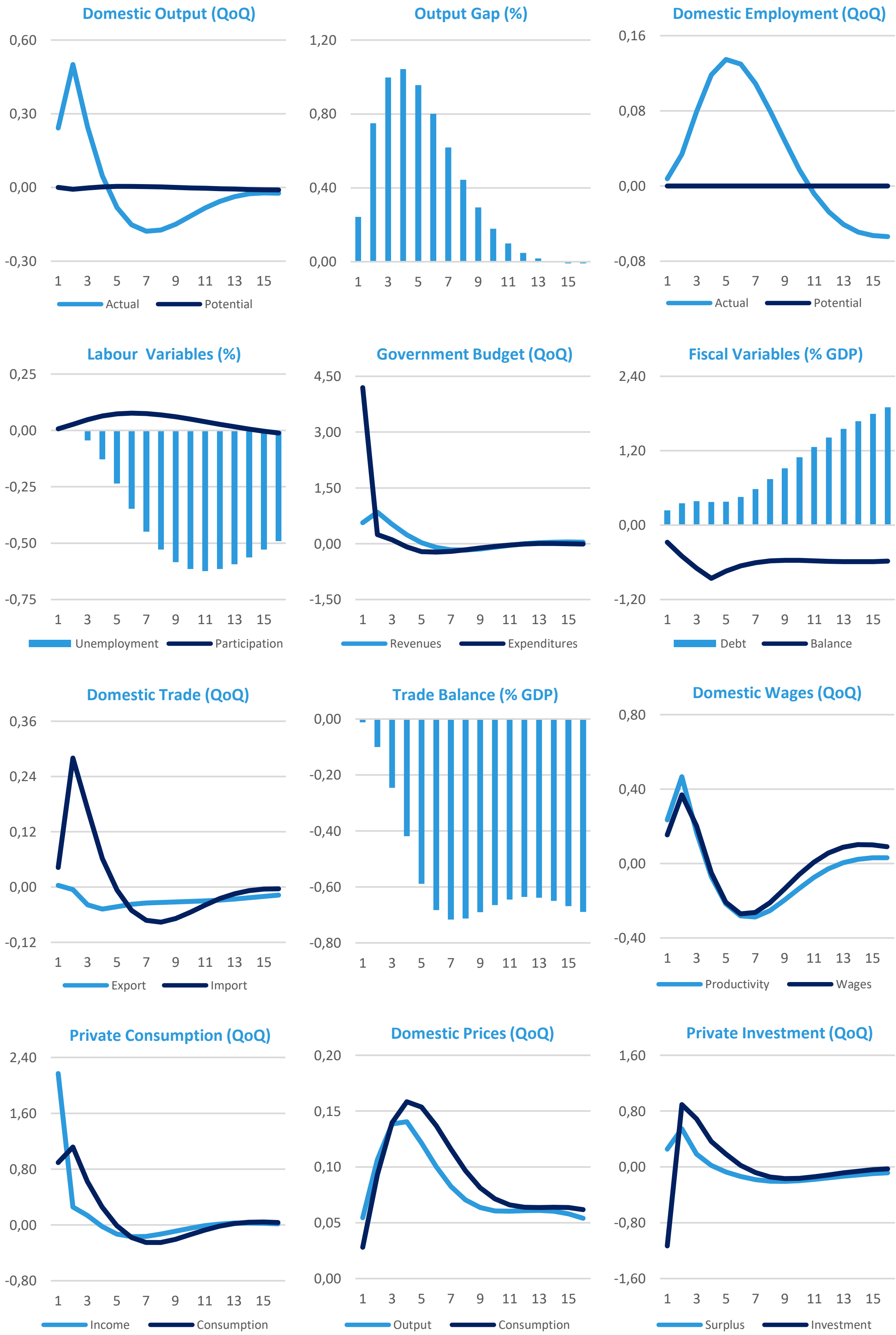


Fig.E3: A permanent shock to public social transfers that corresponds to an increase of a growth rate by 10.0 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

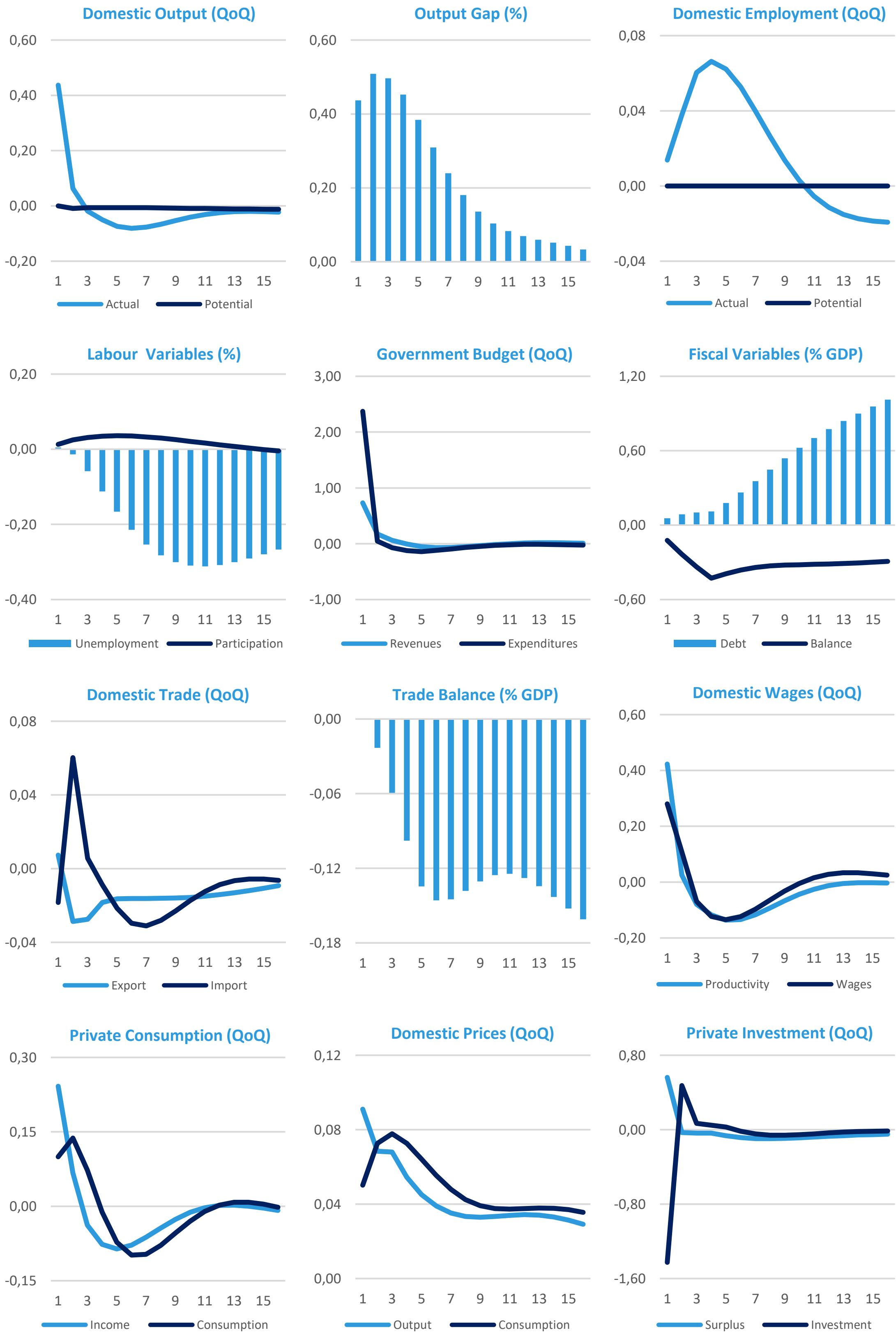


Fig.E4: A permanent shock to intermediate consumption that corresponds to an increase of a growth rate by 10.0 p.p. in the first quarter. X axes label quarters after the shock and Y axes label deviations of model variables from baseline growth rates in percentage points.

Supply side estimation

Private investment

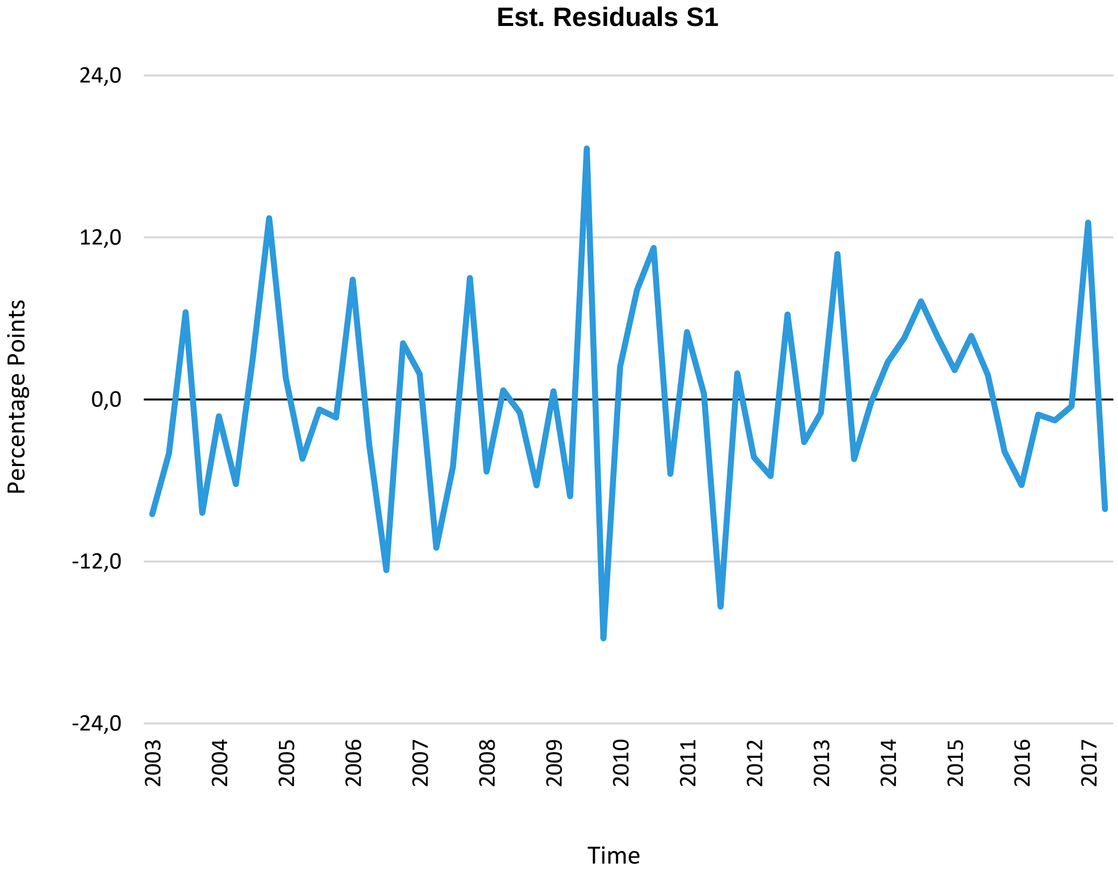
Est. Equation S1: $\mathrm{dlog}(\mathrm{if}_t) = \mathrm{if}_1 * \mathrm{dlog}(\mathrm{yt}_t) - \mathrm{if}_2 * \mathrm{dlog}(\mathrm{ig}_t) + \mathrm{if}_3 * \mathrm{dlog}(\mathrm{rs}_{t-1}) - \mathrm{if}_4 * \mathrm{dlog}(\mathrm{lg}_t) - \mathrm{if}_4 * \mathrm{dlog}(\mathrm{rg}_t) - \mathrm{if}_5 * \mathrm{dlog}(\mathrm{ic}_t) - \mathrm{if}_6 * \mathrm{dlog}(\mathrm{st}_t) - \mathrm{if}_7 * \mathrm{diff}\left(\tau_t^{ci}\right) - \mathrm{if}_8 * \mathrm{diff}(\mathrm{lr}_{t-1}) + \mathrm{if}_9 * \mathrm{cor}(\mathrm{it}_{t-1}) + \varepsilon_t^{if}$

Model Calibration: $\mathrm{if}_2 = 0.10$; $\mathrm{if}_4 = 0.30$; $\mathrm{if}_5 = 0.20$; $\mathrm{if}_6 = 0.20$; $\mathrm{if}_7 = 0.80$; $\mathrm{if}_8 = 0.20$; $\mathrm{if}_9 = 0.10$;

Model Restrictions: $\mathrm{if}_1 = 1 - \mathrm{if}_2 - \mathrm{if}_3 - \mathrm{if}_4 - \mathrm{if}_5 - \mathrm{if}_6$

Standard R^2: 0.36 **Adjusted R^2:** 0.36 **First Period:** 2003Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
if_3	0.60	0.12	5.09	0.00



Personal investment

Est. Equation S2: $\mathrm{dlog}(\mathrm{ih}_t) = \mathrm{ih}_1 * \mathrm{dlog}(\mathrm{hi}_t) - \mathrm{ih}_2 * \mathrm{dlog}(\mathrm{ig}_t) + \mathrm{ih}_3 * \mathrm{dlog}(\mathrm{hi}_{t-1}) - \mathrm{ih}_4 * \mathrm{dlog}(\mathrm{lg}_t) - \mathrm{ih}_4 * \mathrm{dlog}(\mathrm{rg}_t) - \mathrm{ih}_5 * \mathrm{dlog}(\mathrm{ic}_t) - \mathrm{ih}_6 * \mathrm{dlog}(\mathrm{st}_t) - \mathrm{ih}_7 * \mathrm{diff}(\tau_t^{ci}) - \mathrm{ih}_8 * \mathrm{diff}(\mathrm{lr}_{t-1}) + \mathrm{ih}_9 * \mathrm{cor}(\mathrm{it}_{t-1}) - \mathrm{ih}_{10} * 2004\mathrm{Q}1 + \varepsilon_t^{ih}$

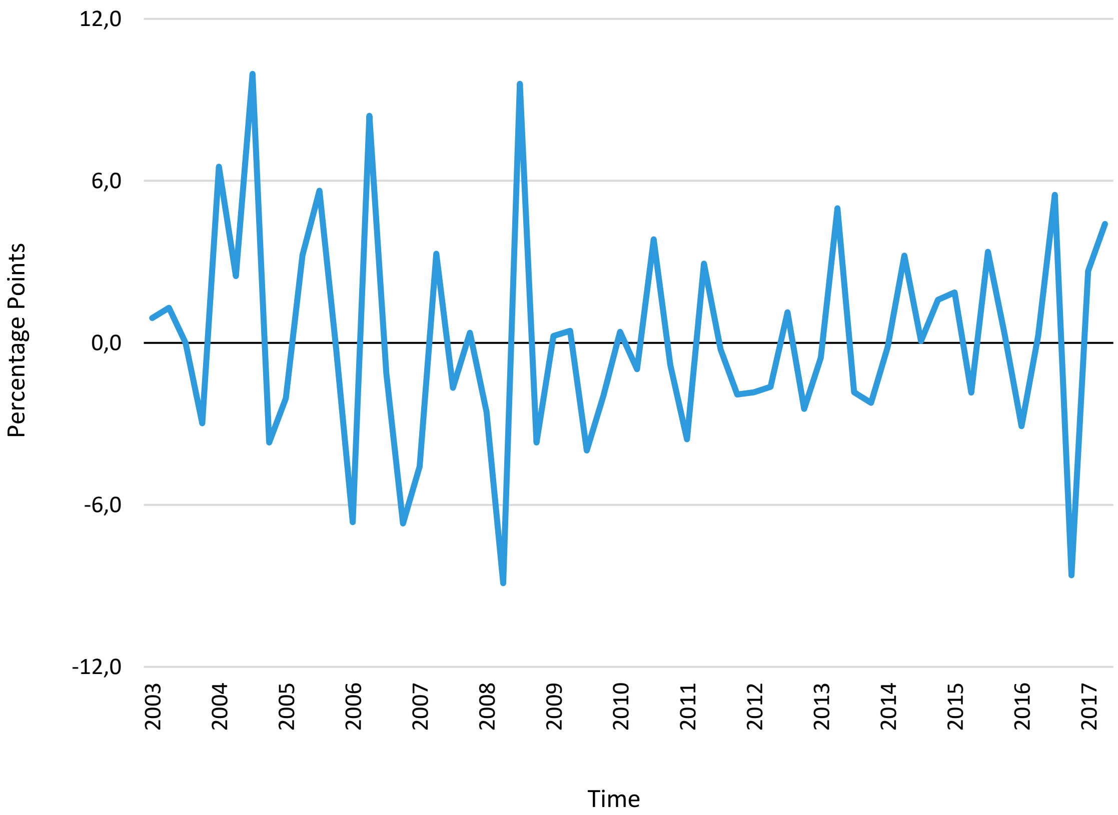
Model Calibration: $\mathrm{ih}_2 = 0.05$; $\mathrm{ih}_4 = 0.15$; $\mathrm{ih}_5 = 0.10$; $\mathrm{ih}_6 = 0.10$; $\mathrm{ih}_7 = 0.00$; $\mathrm{ih}_8 = 0.10$; $\mathrm{ih}_9 = 0.05$;

Model Restrictions: $\mathrm{ih}_1 = 1 - \mathrm{ih}_2 - \mathrm{ih}_3 - \mathrm{ih}_4 - \mathrm{ih}_5 - \mathrm{ih}_6$

Standard R^2: 0.13 **Adjusted R^2:** 0.12 **First Period:** 2003Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
ih_3	0.58	0.14	4.15	0.00
ih_{10}	0.15	0.04	3.88	0.00

Est. Residuals S2



Public investment

Est. Equation S3: $\mathrm{dlog(ig_t) = ig_1 * dlog(yt_t^*) + ig_2 * dlog(yt_t) - ig_3 * gap(yt_{t-1}) +}$
$\mathrm{ig_4 * dev(bp_{t-1}^*) - ig_5 * dev(dp_{t-1}^*) + ig_6 * cor(it_{t-1}) - ig_7 * 2016Q1 + \varepsilon_t^{ig}}$

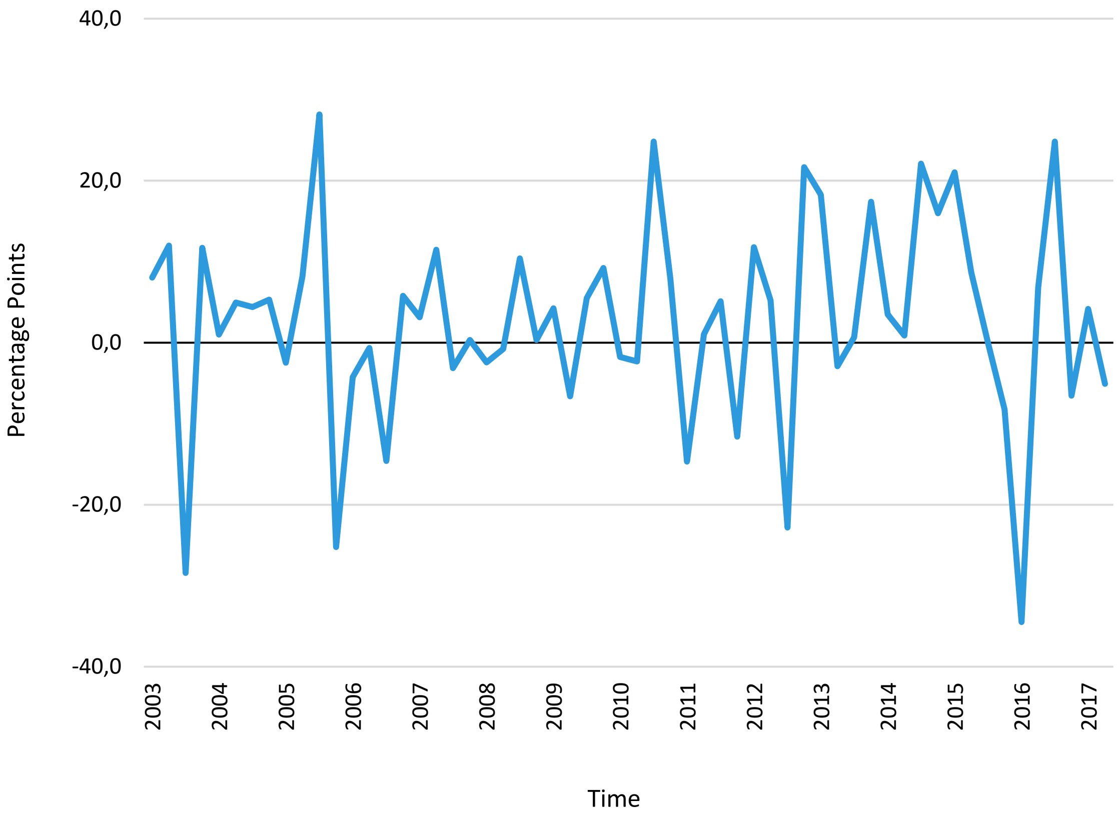
Model Calibration: $\mathrm{ig_3 = 0.20;\ \ ig_4 = 0.80;\ \ ig_5 = 0.10;\ \ ig_6 = 0.00;}$

Model Restrictions: $\mathrm{ig_1 = 1 - ig_2}$

Standard R^2: 0.25 **Adjusted R^2:** 0.24 **First Period:** 2003Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
$\mathrm{ig_2}$	0.30	1.09	0.28	0.78
$\mathrm{ig_7}$	0.59	0.13	4.49	0.00

Est. Residuals S3



Domestic labour force

Est. Equation S4: $\mathrm{dlog}(\mathrm{ls_t}) = \mathrm{ls_1} * \mathrm{dlog}(\mathrm{np_t}) + \mathrm{ls_2} * \mathrm{dlog}(\mathrm{lt_t}) + \mathrm{ls_3} * \mathrm{dlog}(\mathrm{ls_{t-1}}) +$
$\mathrm{ls_4} * \mathrm{dtfp}(\mathrm{rn_t}) - \mathrm{ls_5} * \mathrm{diff}(\tau_t^{tc}) - \mathrm{ls_6} * \log(\mathrm{ls_{t-1}}/\mathrm{ls^*_{t-1}}) + \varepsilon_t^{ls}$

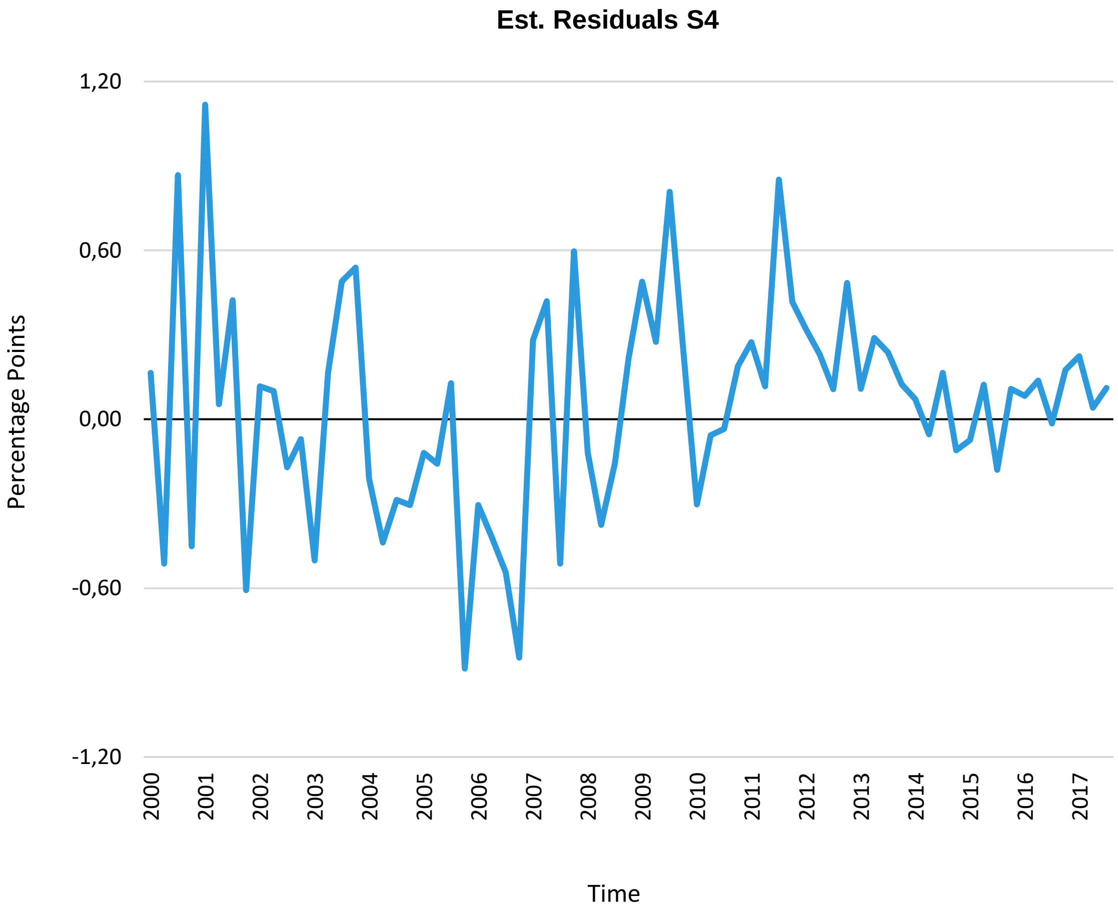
Est. Equation S8: $\mathrm{diff}(\tau_t^{tc}) = \mathrm{ls_7} * \mathrm{diff}(\tau_t^{lc}) + \mathrm{ls_8} * \mathrm{diff}(\tau_t^{gc}) + \mathrm{ls_9} * \mathrm{diff}(\tau_t^{li}) + \mathrm{ls_{10}} * \mathrm{diff}(\tau_t^{fc})$

Model Calibration: $\mathrm{ls_4} = 0.05;\quad \mathrm{ls_5} = 0.50;\quad \mathrm{ls_7} = 0.80;\quad \mathrm{ls_8} = 0.40;$
$\mathrm{ls_9} = 0.80;\quad \mathrm{ls_{10}} = 0.00;$

Model Restrictions: $\mathrm{ls_1} = 1 - \mathrm{ls_2} - \mathrm{ls_3}$

Standard R^2: 0.05 **Adjusted R^2:** 0.02 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
$\mathrm{ls_2}$	0.24	0.08	3.04	0.00
$\mathrm{ls_3}$	0.27	0.12	2.30	0.02
$\mathrm{ls_6}$	0.15	0.08	1.86	0.07



Private employment

Est. Equation S5: $\mathrm{dlog}(\mathrm{lf}_t) = \mathrm{lf}_1 * \mathrm{dlog}(\mathrm{lt}_t^*) - \mathrm{lf}_2 * \mathrm{dlog}(\mathrm{lg}_t) + \mathrm{lf}_3 * \mathrm{dlog}(\mathrm{lf}_{t-1}) +$
$\mathrm{lf}_4 * \mathrm{dtfp}(\mathrm{yt}_t) - \mathrm{lf}_5 * \mathrm{dtfp}(\mathrm{rf}_t) + \mathrm{lf}_6 * \mathrm{cor}(\mathrm{lt}_{t-1}) + \varepsilon_t^{\mathrm{lf}}$

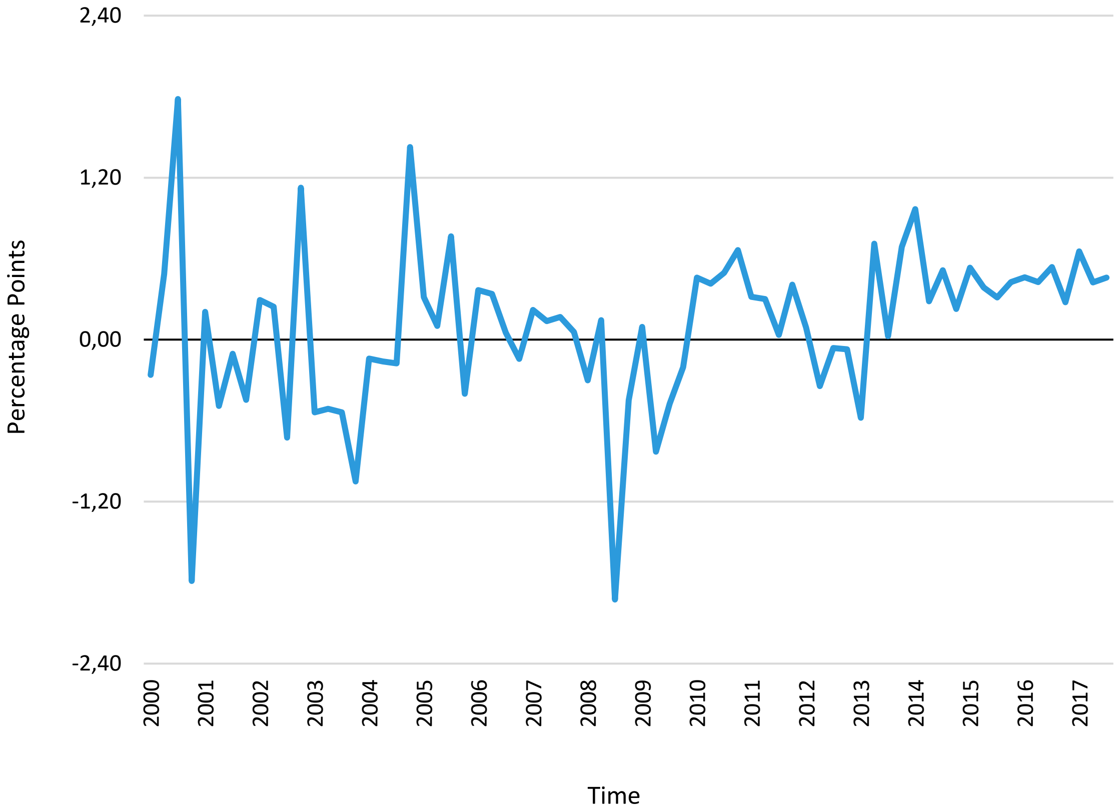
Model Calibration: $\mathrm{lf}_2 = 0.15$

Model Restrictions: $\mathrm{lf}_1 = 1 - \mathrm{lf}_2 - \mathrm{lf}_3 - \mathrm{lf}_4$

Standard R^2: 0.41 **Adjusted R^2:** 0.38 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
lf_3	0.12	0.11	1.14	0.26
lf_4	0.14	0.05	2.68	0.01
lf_5	0.12	0.04	2.81	0.00
lf_6	0.13	0.05	2.72	0.01

Est. Residuals S5



Personal employment

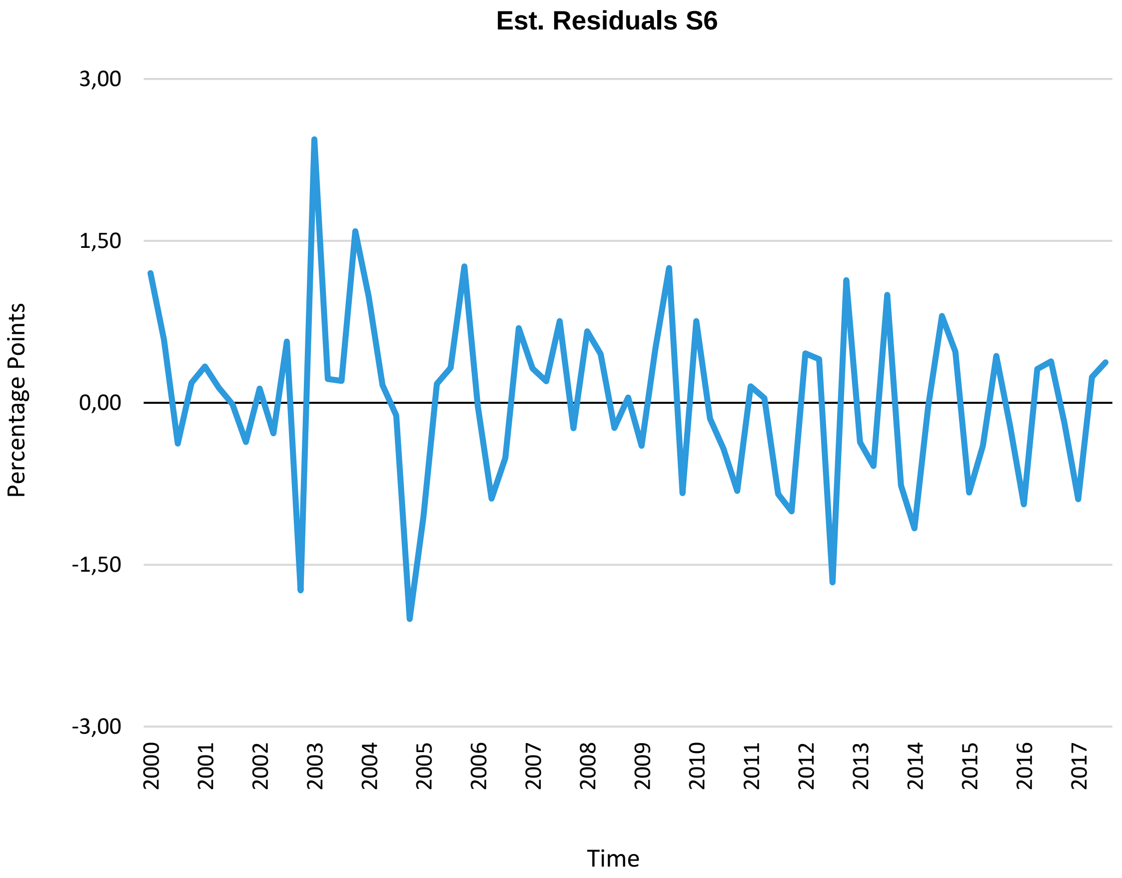
Est. Equation S6: $\mathrm{dlog}(\mathrm{lh}_t) = \mathrm{lh}_1 * \mathrm{dlog}(\mathrm{lt}_t^*) - \mathrm{lh}_2 * \mathrm{dlog}(\mathrm{lg}_t) + \mathrm{lh}_3 * \mathrm{dlog}(\mathrm{lh}_{t-1}) + \mathrm{lh}_4 * \mathrm{dtfp}(\mathrm{yt}_t) - \mathrm{lh}_5 * \mathrm{dtfp}(\mathrm{rt}_t) + \mathrm{lh}_6 * \mathrm{cor}(\mathrm{lt}_{t-1}) + \varepsilon_t^{\mathrm{lh}}$

Model Calibration: $\mathrm{lh}_2 = 0.15$

Model Restrictions: $\mathrm{lh}_1 = 1 - \mathrm{lh}_2 - \mathrm{lh}_3 - \mathrm{lh}_4$

Standard R^2: 0.68 **Adjusted R^2:** 0.67 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
lh_3	0.72	0.07	10.0	0.00
lh_4	0.05	0.07	0.69	0.50
lh_5	0.18	0.06	2.98	0.00
lh_6	0.10	0.06	1.76	0.08



Public employment

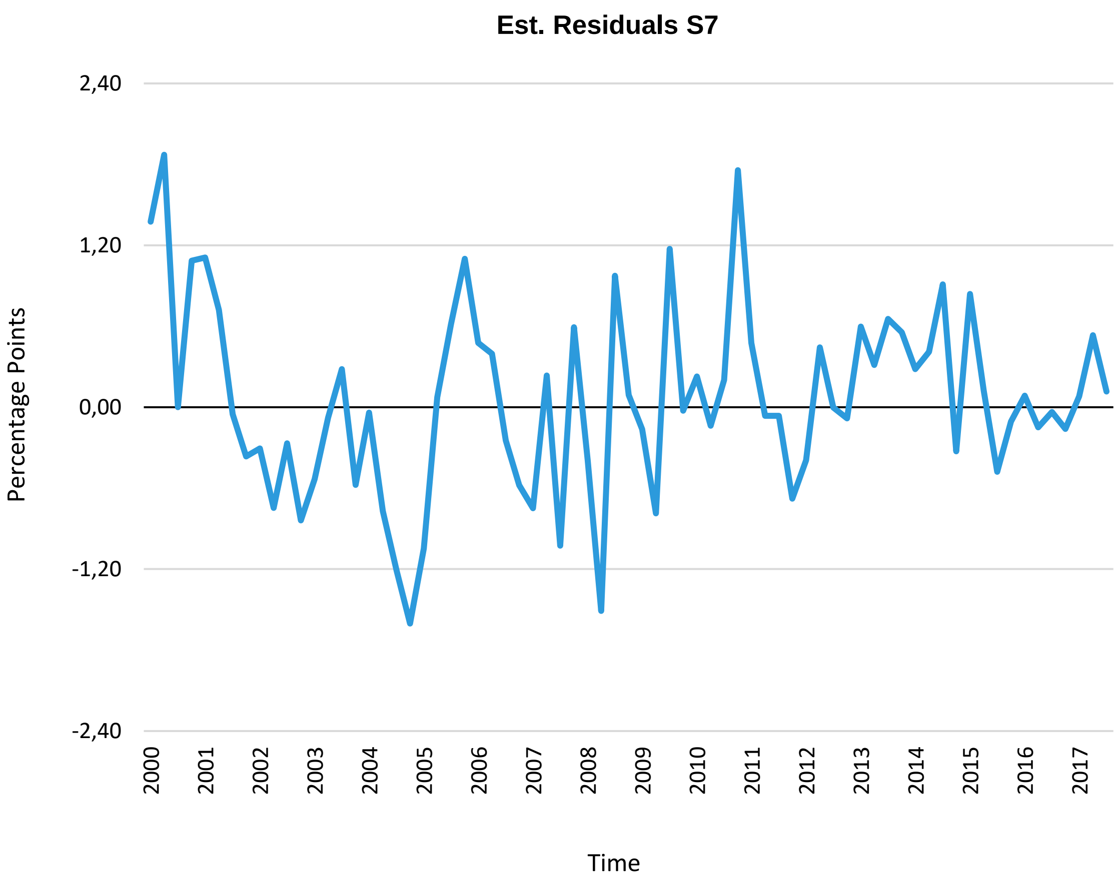
Est. Equation S7: $\mathrm{dlog(lg_t)} = \mathrm{lg_1} * \mathrm{dlog(lt_t^*)} + \mathrm{lg_2} * \mathrm{dtfp(yt_t)} - \mathrm{lg_3} * \mathrm{dtfp(rg_t)} - \mathrm{lg_4} * \mathrm{gap(yt_{t-1})} + \mathrm{lg_5} * \mathrm{dev(bp_{t-1}^*)} - \mathrm{lg_6} * \mathrm{dev(dp_{t-1}^*)} + \mathrm{lg_7} * \mathrm{cor(lt_{t-1})} + \mathrm{lg_8} * 2016\mathrm{Q1} + \varepsilon_t^{\mathrm{lg}}$

Model Calibration: $\mathrm{lg_4} = 0.02;\ \ \mathrm{lg_5} = 0.04;\ \ \mathrm{lg_6} = 0.01;\ \ \mathrm{lg_7} = 0.00;$

Model Restrictions: $\mathrm{lg_1} = 1 - \mathrm{lg_2}$

Standard R^2: 0.10 **Adjusted R^2:** 0.07 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
$\mathrm{lg_2}$	0.13	0.05	2.74	0.01
$\mathrm{lg_3}$	0.03	0.02	1.62	0.11
$\mathrm{lg_8}$	0.02	0.01	3.39	0.00



Demand side estimation

Potential consumption

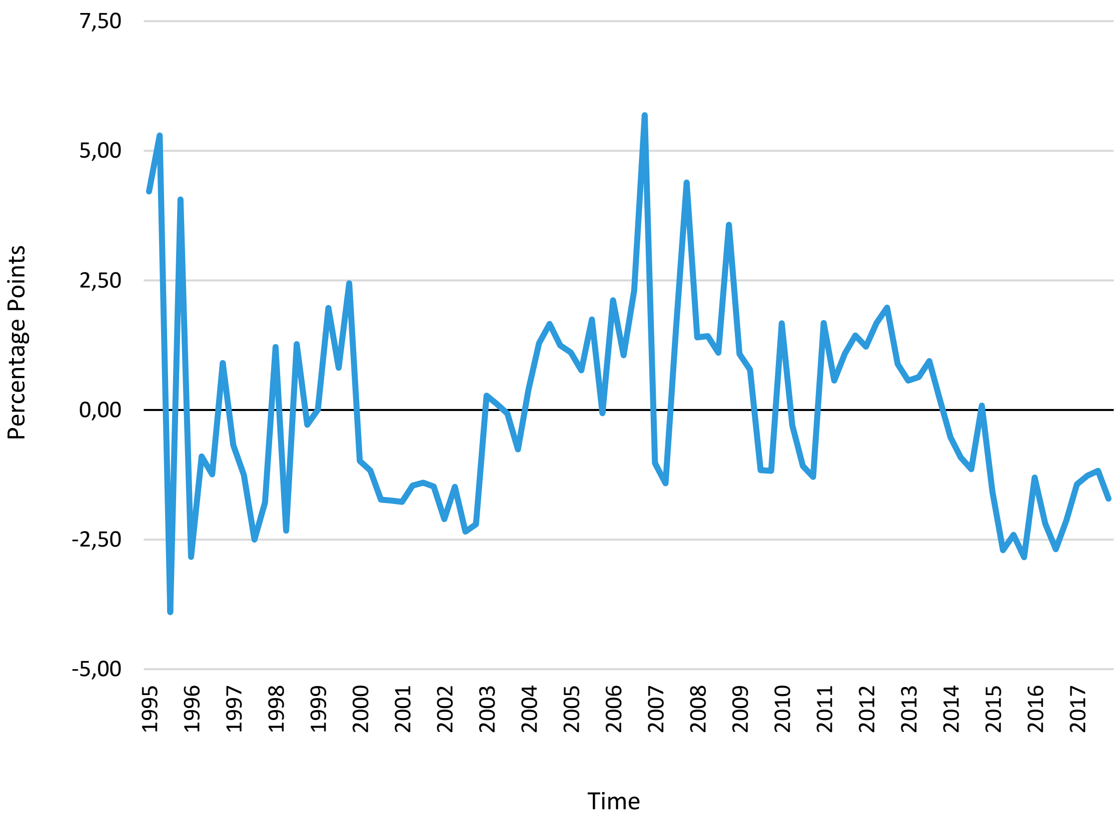
Est. Equation D1: $\log(\mathrm{ct}_t^*) = \mathrm{ct}_1 - \mathrm{ct}_2/\mathrm{sqrt}(t) + \mathrm{ct}_3 * \log(\mathrm{hc}_t) + \alpha_t^{\mathrm{ct}}$

Model Calibration: $\mathrm{ct}_3 = 1.00$

Standard R^2: 0.99 **Adjusted R^2:** 0.99 **First Period:** 1995Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
ct_1	-0.03	0.00	-10.1	0.00
ct_2	0.09	0.01	15.2	0.00

Est. Residuals D1



Private consumption

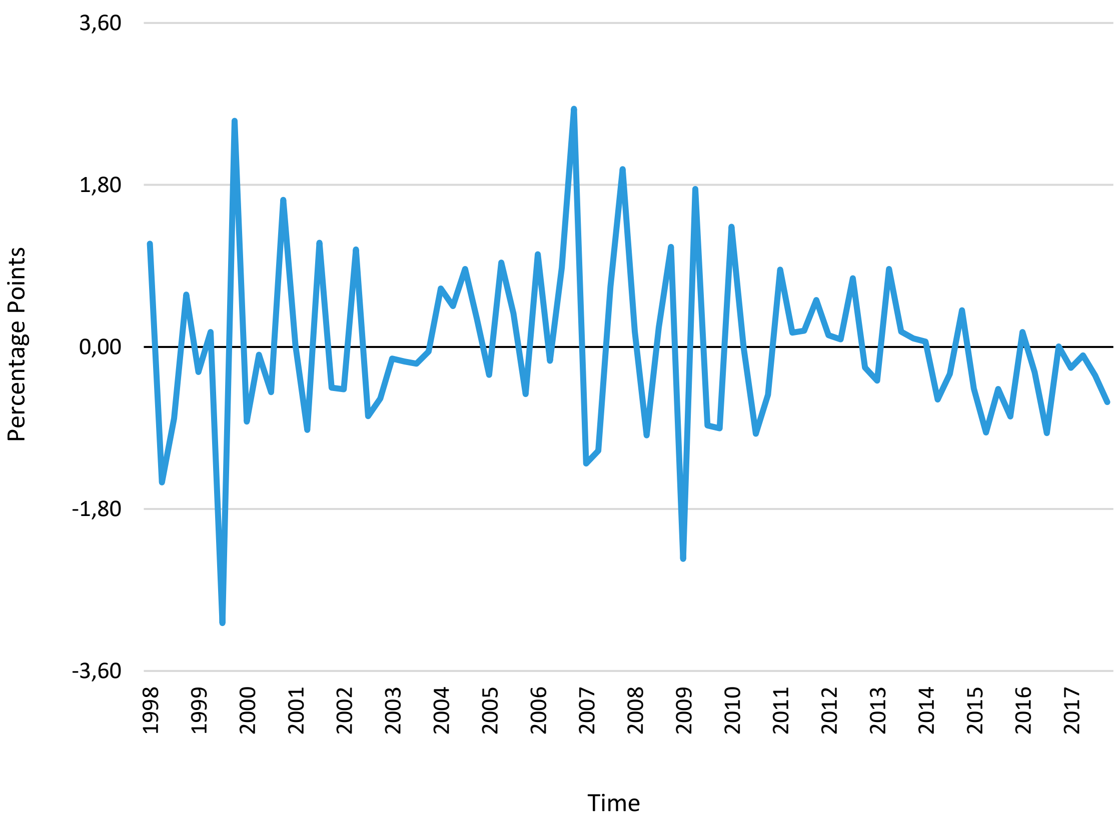
Est. Equation D2: $\mathrm{dlog}(\mathrm{ct}_t) = \mathrm{ct}_4 * \mathrm{dlog}(\mathrm{hc}_t) + \mathrm{ct}_5 * \mathrm{dlog}(\mathrm{ct}_{t-1}) + \mathrm{ct}_6 * \mathrm{dlog}(\mathrm{hc}_{t-1}) - \mathrm{ct}_7 * \mathrm{diff}(\mathrm{sr}_{t-1}) - \mathrm{ct}_8 * \log(\mathrm{ct}_{t-1}/\mathrm{ct}^*_{t-1}) + \varepsilon_t^{\mathrm{ct}}$

Model Restrictions: $\mathrm{ct}_4 = 1 - \mathrm{ct}_5 - \mathrm{ct}_6$

Standard R^2: 0.23 **Adjusted R^2:** 0.19 **First Period:** 1998Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
ct_5	0.39	0.09	4.18	0.00
ct_6	0.20	0.07	2.70	0.01
ct_7	0.16	0.05	3.22	0.00
ct_8	0.18	0.07	2.45	0.02

Est. Residuals D2



Total potential export

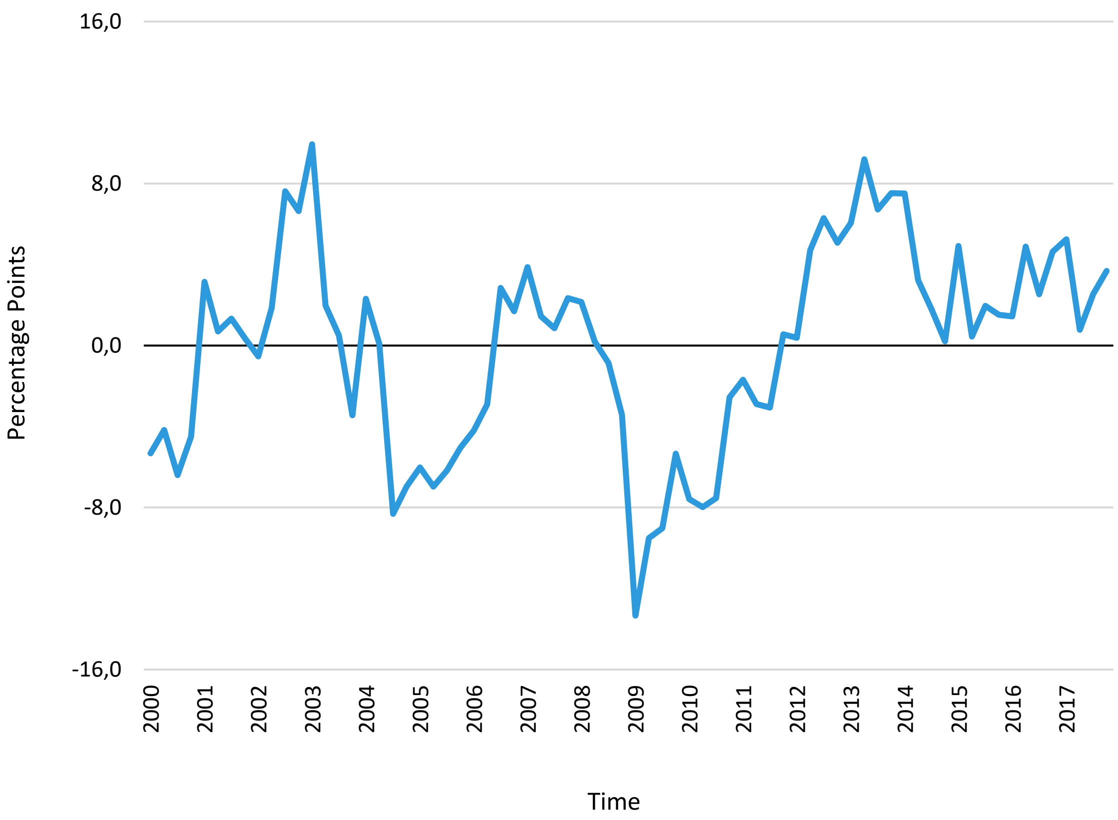
Est. Equation D3: $\log(xt_t^*) = xt_1 - xt_2/\mathrm{sqrt}(t) + xt_3 * \log(dx_t) + xt_4 * \log(zx_t) + xt_5 * \log(da_t) + \alpha_t^{xt}$

Model Calibration: $xt_3 = 1.00;\quad xt_5 = 1.00;$

Standard R^2: 0.99 **Adjusted R^2:** 0.99 **First Period:** 2000Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
xt_1	9.98	0.03	356	0.00
xt_2	0.40	0.05	7.78	0.00
xt_4	0.47	0.14	3.28	0.00

Est. Residuals D3



Total domestic export

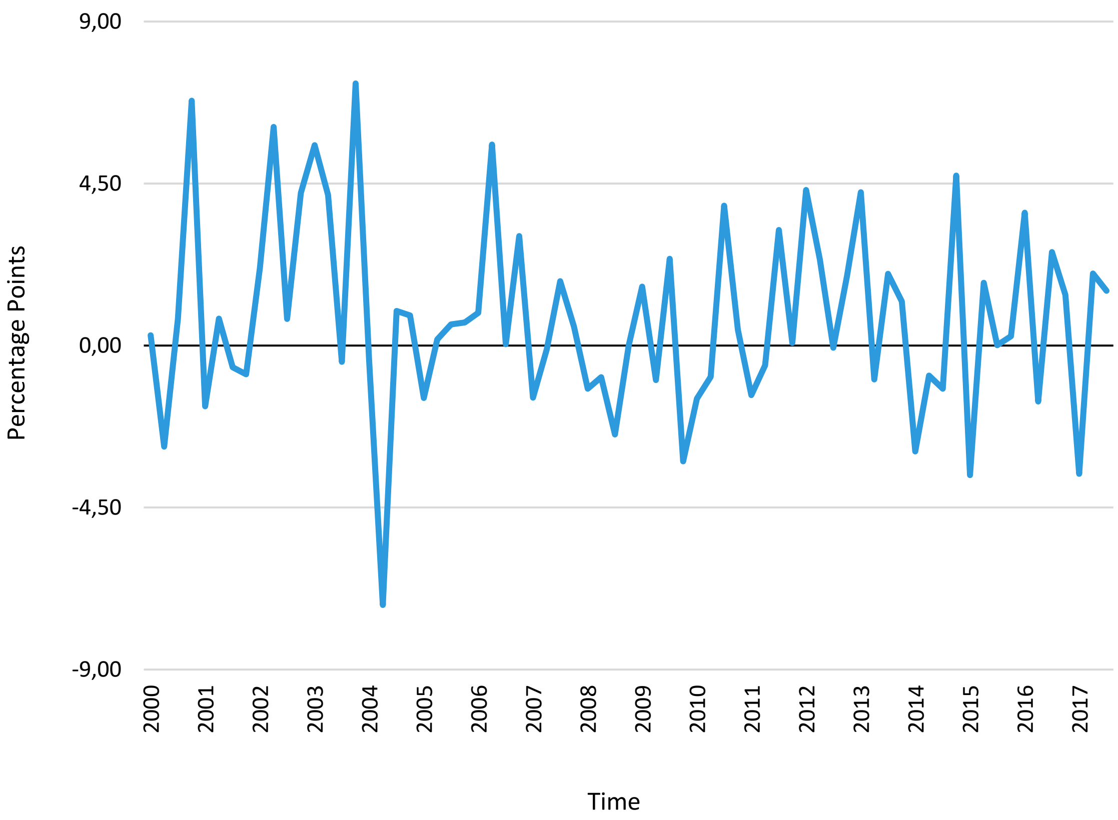
Est. Equation D4: $\mathrm{dlog(xt_t) = xt_6 * dlog(dx_t) + xt_7 * dlog(zx_t) + xt_8 * dlog(da_t) - xt_9 * log(xt_{t-1}/xt^*_{t-1}) - xt_{10} * 2009Q1} + \varepsilon_t^{xt}$

Model Calibration: $\mathrm{xt_6} = 1.00$; $\mathrm{xt_8} = 1.00$;

Standard R²: 0.58 **Adjusted R²:** 0.57 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
$\mathrm{xt_7}$	0.54	0.17	3.17	0.00
$\mathrm{xt_9}$	0.17	0.07	2.44	0.02
$\mathrm{xt_{10}}$	0.10	0.03	3.30	0.00

Est. Residuals D4



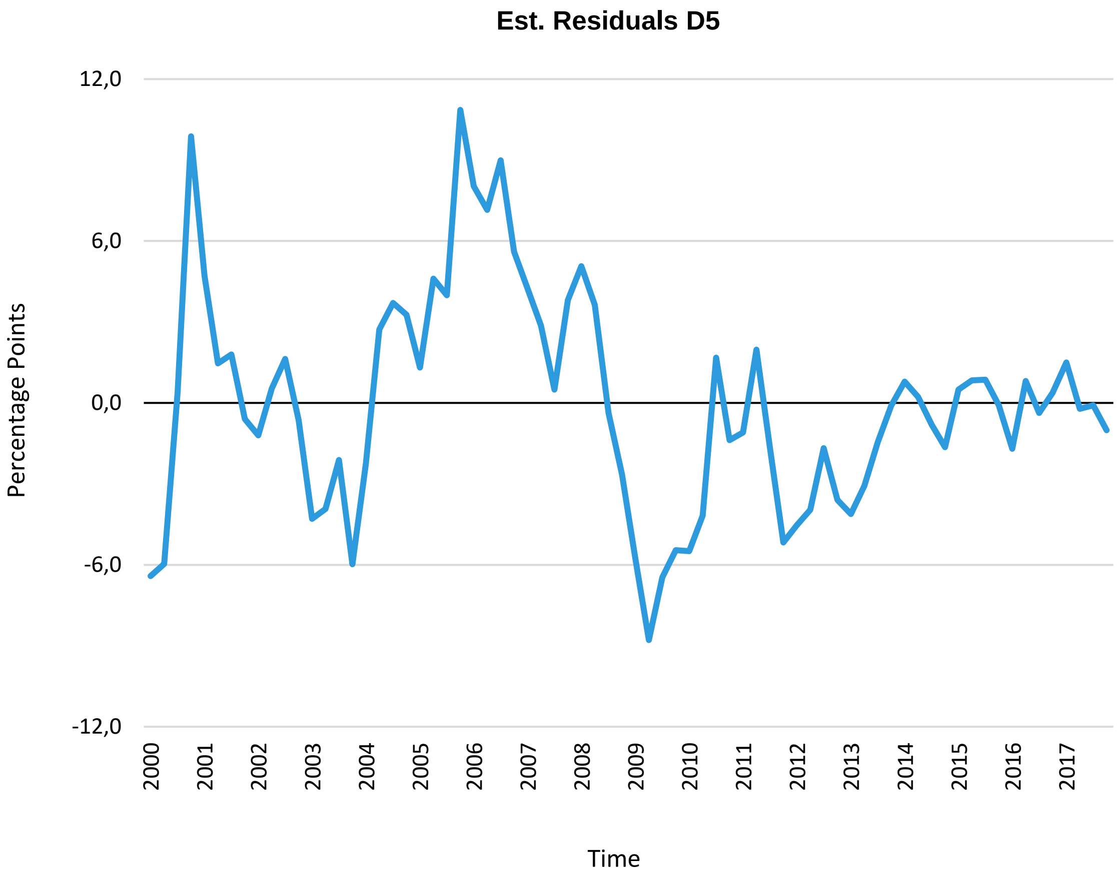
Total potential import

Est. Equation D5: $\log(mt_t^*) = mt_1 - mt_2/\mathrm{sqrt}(t) + mt_3 * \log(dm_t) - mt_4 * \log(zm_t) - mt_5 * \log(do_t) + \alpha_t^{mt}$

Model Calibration: $mt_3 = 1.00$; $mt_4 = 0.20$; $mt_5 = 0.02$;

Standard R^2: 0.99 **Adjusted R^2:** 0.99 **First Period:** 2000Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
mt_1	0.10	0.01	13.2	0.00
mt_2	0.11	0.02	4.34	0.00



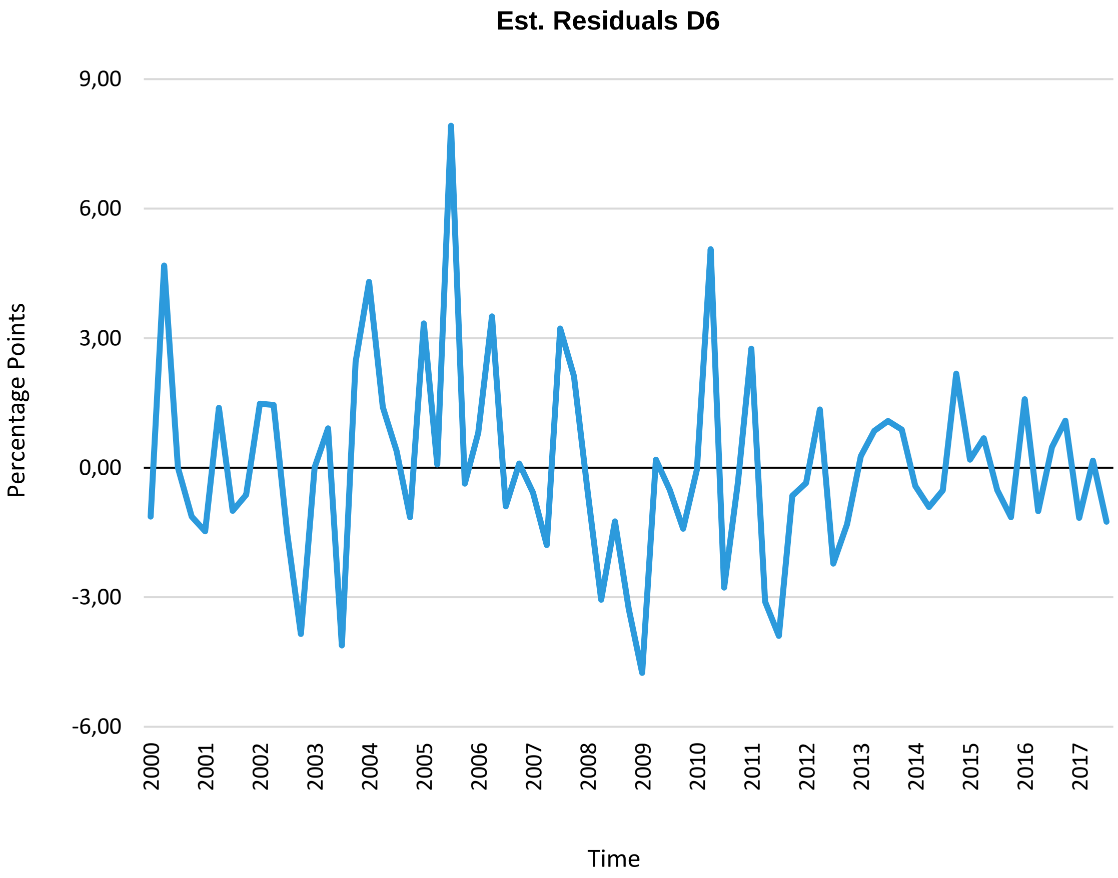
Total domestic import

Est. Equation D6: $\mathrm{dlog(mt_t) = mt_6 * dlog(dm_t) - mt_7 * dlog(zm_t) - mt_8 * dlog(do_t) -}$ $\mathrm{mt_9 * log(mt_{t-1}/mt^*_{t-1}) + mt_{10} * 2000Q4 + \varepsilon^{mt}_t}$

Model Calibration: $\mathrm{mt_6 = 1.00; \quad mt_7 = 0.20; \quad mt_8 = 0.00;}$

Standard R²: 0.75 **Adjusted R²:** 0.74 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
$\mathrm{mt_9}$	0.22	0.07	3.39	0.00
$\mathrm{mt_{10}}$	0.13	0.02	5.67	0.00



Private mixed surplus

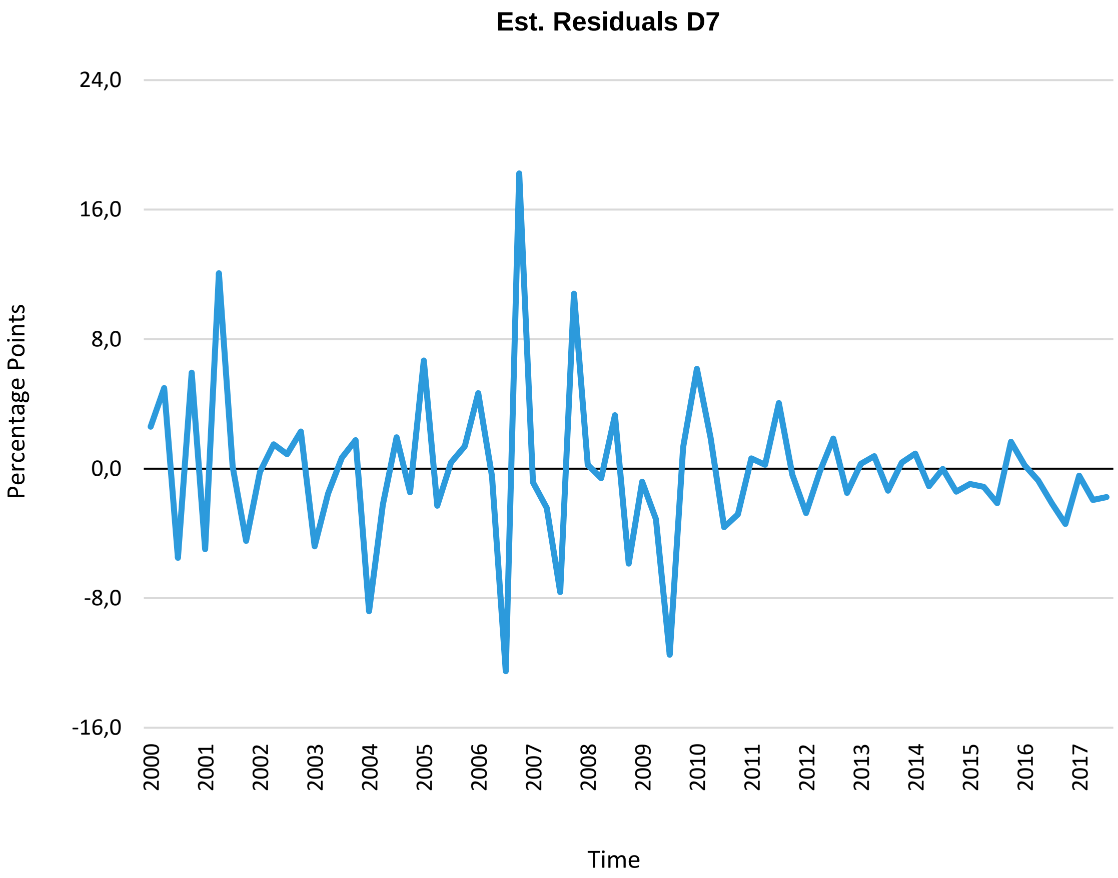
Est. Equation D7: $dlog(ms_t) = ms_2 * dlog(yt_t^*) + ms_3 * dlog(ds_t) + ms_4 * cor(ms_{t-1}) + \varepsilon_t^{ms}$

Model Calibration: $ms_4 = 0.00;$

Model Restrictions: $ms_2 = 1 - ms_3$

Standard R^2: 0.06 **Adjusted R^2:** 0.06 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
ms_3	0.15	0.10	1.55	0.13



Interest rate estimation

Domestic risk premium

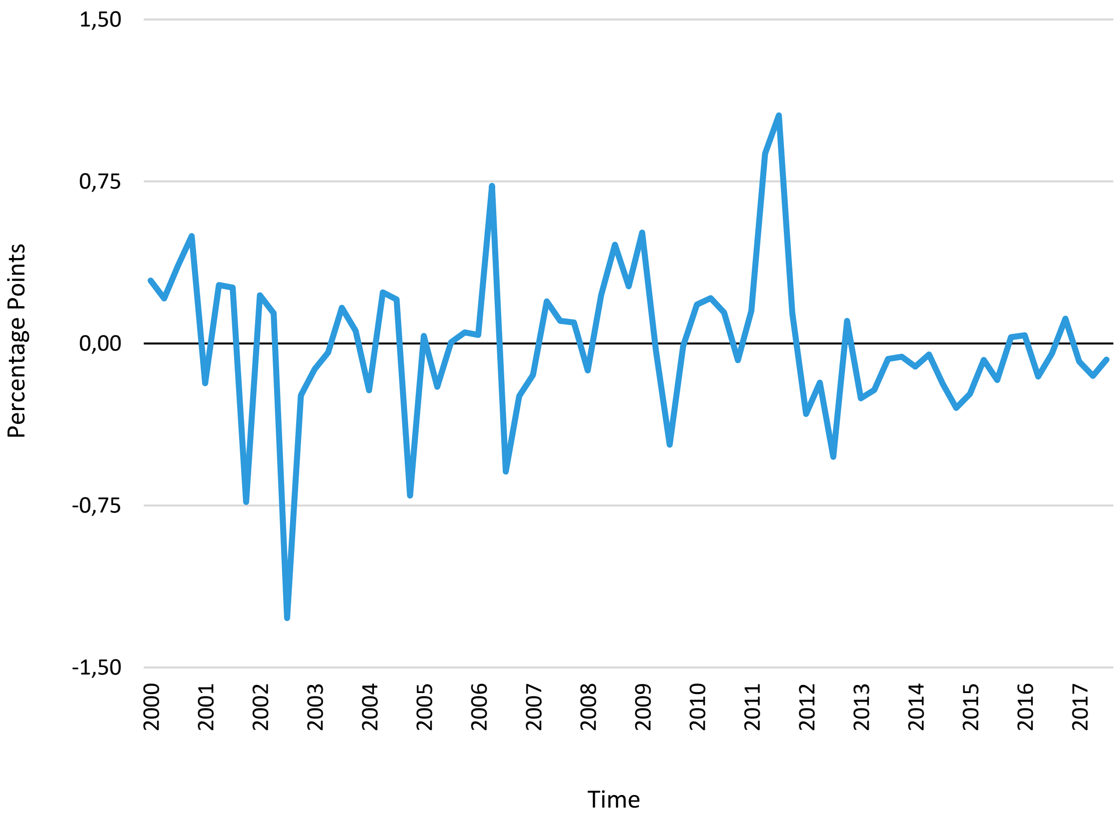
Est. Equation R1: $pr_t = \phi_1 + \phi_2 * pr_{t-1} + \phi_3 * dp_t^* - \phi_4 * ca_t^* + \varepsilon_t^{pr}$

Model Calibration: $\phi_3 = 0.0052; \quad \phi_4 = 0.0055;$

Standard R^2: 0.86 **Adjusted R^2:** 0.86 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
ϕ_1	-0.13	0.00	-1.84	0.07
ϕ_2	0.89	0.04	20.0	0.00

Est. Residuals R1



Wage block estimation

Private labour costs

Est. Equation W1: $\mathrm{dlog}(\mathrm{wf}_t) = \mathrm{wf}_1 * \mathrm{dlog}(\mathrm{lp}_t) + \mathrm{wf}_2 * \mathrm{dlog}(\mathrm{wg}_{t-1}) + \mathrm{wf}_3 * \mathrm{dlog}(\mathrm{lp}_{t-1}) + \mathrm{wf}_4 * \mathrm{dlog}(\mathrm{cp}_t) + \mathrm{wf}_5 * \mathrm{dlog}(\mathrm{pt}_t) + \mathrm{wf}_6 * \mathrm{diff}(\tau_t^{gc}) + \mathrm{wf}_7 * \mathrm{diff}(\tau_t^{fc}) - \mathrm{wf}_8 * \mathrm{gap}(\mu_t) - \mathrm{wf}_9 * \mathrm{diff}(\tau_t^{ci}) - \mathrm{wf}_{10} * \log(\mathrm{wt}_{t-1}/\mathrm{wt}^*_{t-1}) + \mathrm{wf}_{11} * 2009\mathrm{Q}1 + \varepsilon_t^{wf}$

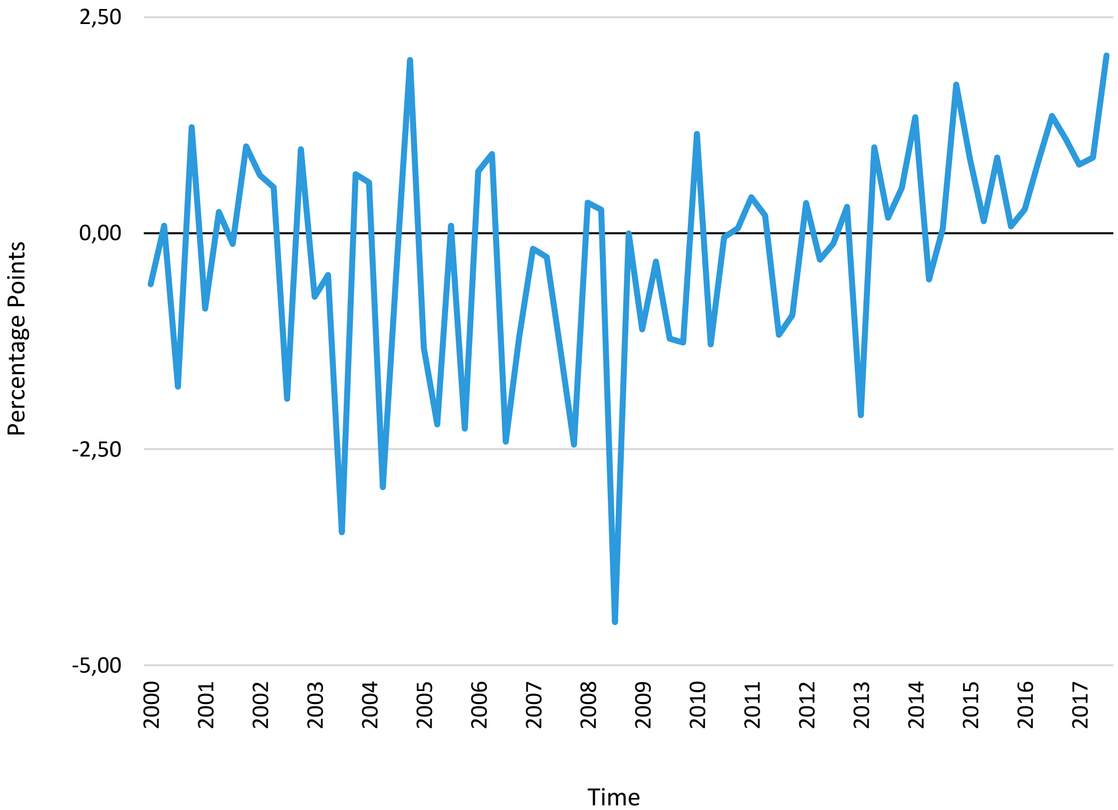
Model Calibration: $\mathrm{wf}_2 = 0.05$; $\mathrm{wf}_6 = 0.15$; $\mathrm{wf}_7 = 0.15$; $\mathrm{wf}_8 = 0.10$; $\mathrm{wf}_9 = 0.20$; $\mathrm{wf}_{10} = 0.10$;

Model Restrictions: $\mathrm{wf}_1 = 1 - \mathrm{wf}_2 - \mathrm{wf}_3$; $\mathrm{wf}_5 = 1 - \mathrm{wf}_4$;

Standard R^2: 0.34 **Adjusted R^2:** 0.32 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
wf_3	0.19	0.10	1.92	0.06
wf_4	0.38	0.19	1.97	0.05
wf_{11}	0.08	0.02	4.93	0.00

Est. Residuals W1



Public labour costs

Est. Equation W2: $\mathrm{dlog}(\mathrm{wg}_t) = \mathrm{wg}_1 * \mathrm{dlog}(\mathrm{lp}_t) + \mathrm{wg}_2 * \mathrm{dlog}(\mathrm{wf}_{t-1}) + \mathrm{wg}_3 * \mathrm{dlog}(\mathrm{lp}_{t-1}) + \mathrm{wg}_4 * \mathrm{dlog}(\mathrm{cp}_t) + \mathrm{wg}_5 * \mathrm{dlog}(\mathrm{pt}_t) + \mathrm{wg}_6 * \mathrm{diff}\left(\tau_t^{gc}\right) + \mathrm{wg}_7 * \mathrm{diff}\left(\tau_t^{fc}\right) - \mathrm{wg}_8 * \log(\mathrm{wt}_{t-1}/\mathrm{wt}_{t-1}^*) - \mathrm{wg}_9 * 2004Q1 + \varepsilon_t^{wg}$

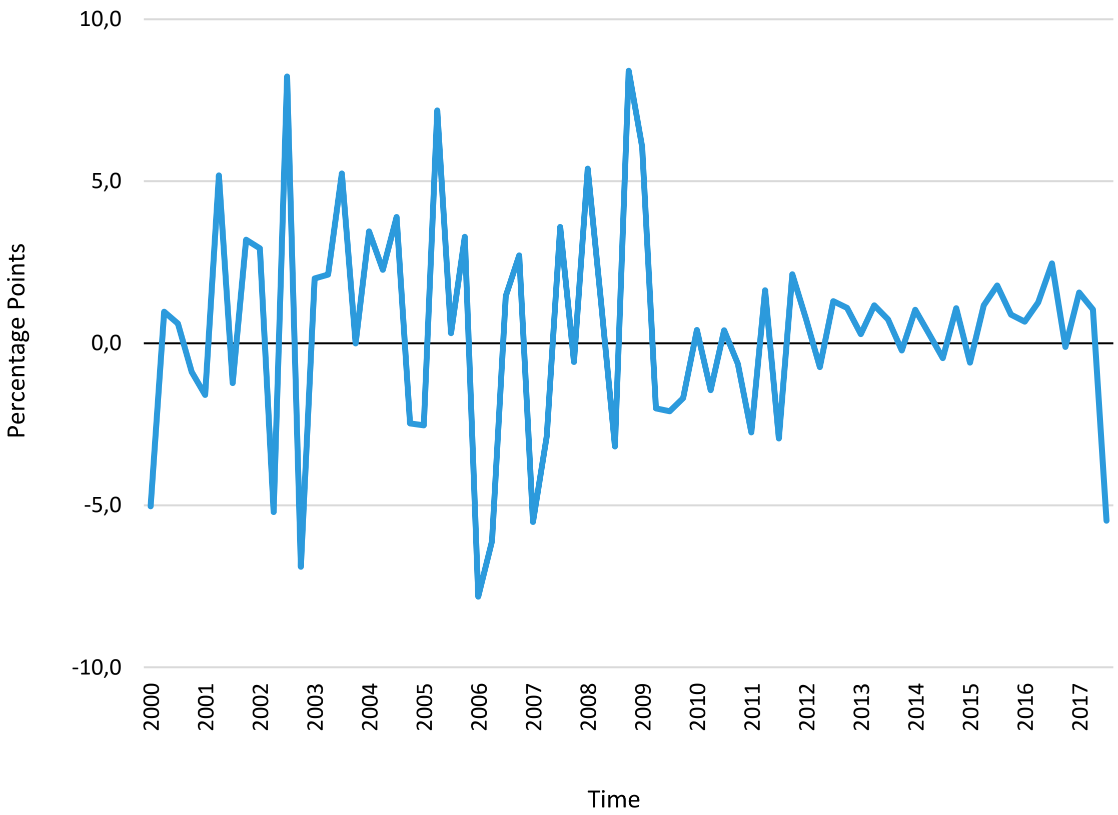
Model Calibration: $\mathrm{wg}_2 = 0.20$; $\mathrm{wg}_6 = 0.15$; $\mathrm{wg}_7 = 0.15$; $\mathrm{wg}_8 = 0.05$;

Model Restrictions: $\mathrm{wg}_1 = 1 - \mathrm{wg}_2 - \mathrm{wg}_3$; $\mathrm{wg}_5 = 1 - \mathrm{wg}_4$;

Standard R^2: 0.22 **Adjusted R^2:** 0.20 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
wg_3	0.36	0.21	1.68	0.10
wg_4	0.14	0.50	0.28	0.78
wg_9	0.18	0.03	5.16	0.00

Est. Residuals W2



Price block estimation

Total production prices

Est. Equation P1: $\mathrm{dlog(pp_t) = pp_1 * dlog(ulc_t) + pp_2 * dlog(pl_t) + pp_3 * dlog(ulc_{t-1}) +}$
$\mathrm{pp_4 * up(\tau_t^{ci}) + pp_5 * down(\tau_t^{ci}) - pp_6 * \ log(pt_{t-1}/pt^*_{t-1}) - pp_7 * 2009Q2 + \varepsilon_t^{pp}}$

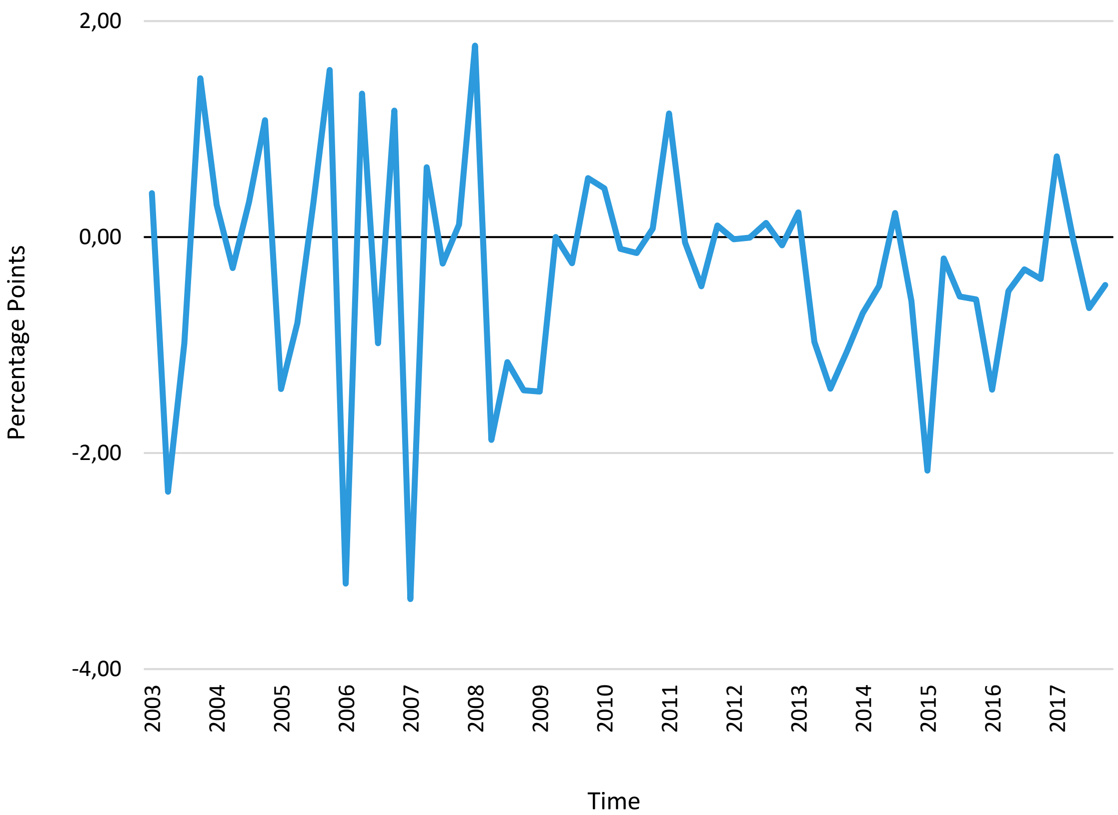
Model Calibration: $\mathrm{pp_4} = 0.10;\quad \mathrm{pp_5} = 0.05;\quad \mathrm{pp_6} = 0.00;$

Model Restrictions: $\mathrm{pp_1 = 1 - pp_2 - pp_3}$

Standard R^2: 0.26 **Adjusted R^2:** 0.24 **First Period:** 2003Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
$\mathrm{pp_2}$	0.53	0.14	3.75	0.00
$\mathrm{pp_3}$	0.13	0.10	1.27	0.21
$\mathrm{pp_7}$	0.04	0.01	2.48	0.02

Est. Residuals P1



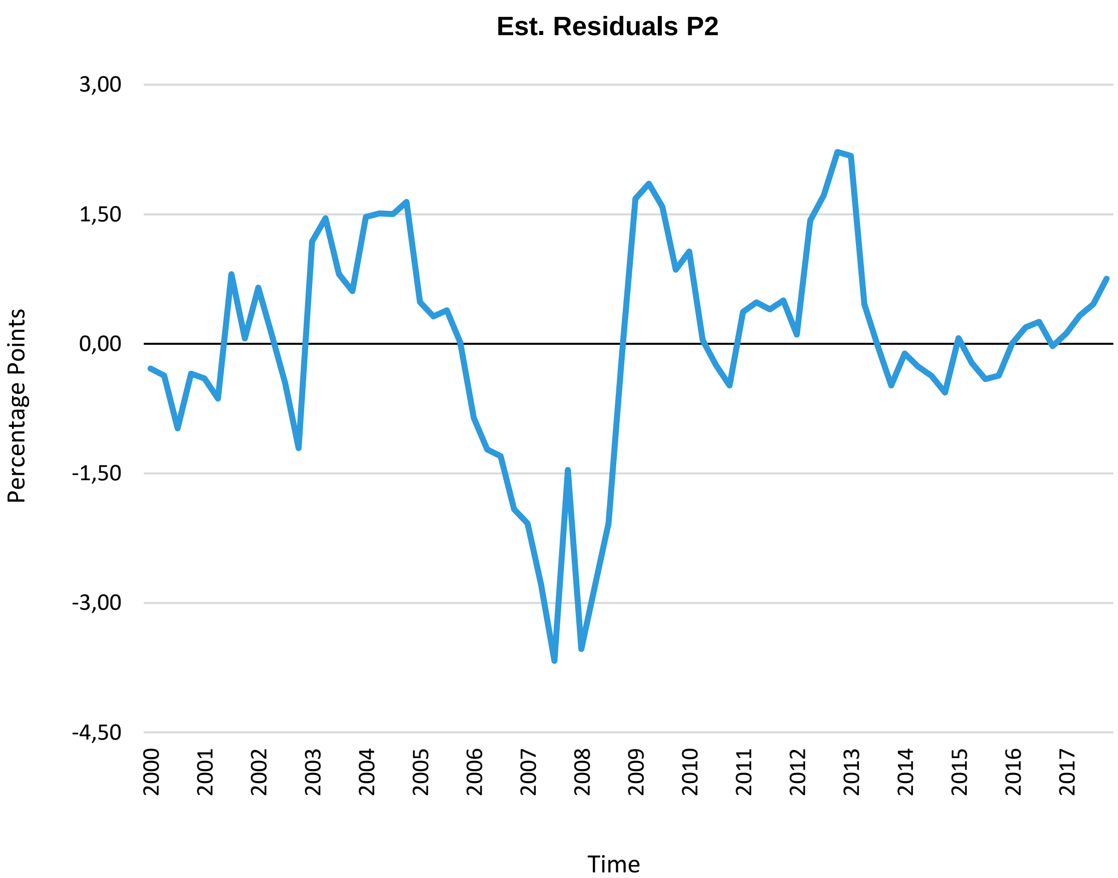
Core potential prices

Est. Equation P2: $\log(pn_t^*) = pn_1 - pn_2/\mathrm{sqrt}(t) + pn_3 * \log(pt_t) + pn_4 * \log(pm_t) + pn_5 * \log(bs_t) + \alpha_t^{pn}$

Model Restrictions: $pn_3 = 1 - pn_4$

Standard R^2: 0.99 **Adjusted R^2:** 0.99 **First Period:** 2000Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
pn_1	4.02	0.04	95.7	0.00
pn_2	0.07	0.01	11.5	0.00
pn_4	0.31	0.05	6.32	0.00
pn_5	0.30	0.02	14.2	0.00



Core consumer prices

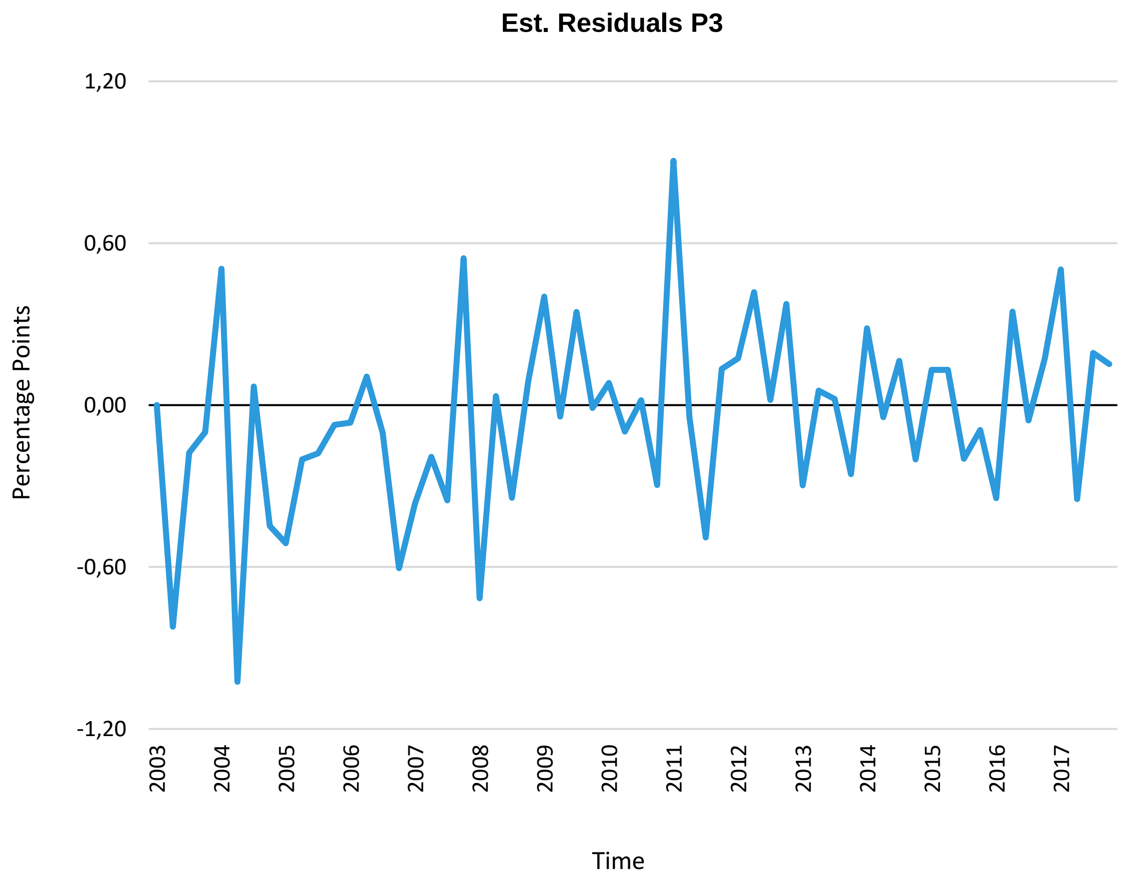
Est. Equation P3: $\mathrm{dlog}(pn_t) = pn_6 * \mathrm{dlog}(pp_t) + pn_7 * \mathrm{dlog}(pl_t) + pn_8 * \mathrm{dlog}(pm_t) + pn_9 * \mathrm{dlog}(pn_{t-1}) + pn_{10} * \mathrm{dlog}(bs_t) + pn_{11} * \mathrm{gap}(yt_t) + pn_{12} * \mathrm{up}(\tau_t^{va}) + pn_{13} * \mathrm{down}(\tau_t^{va}) + pn_{14} * \mathrm{up}(\tau_t^{cn}) + pn_{15} * \mathrm{down}(\tau_t^{cn}) - pn_{16} * \log(pn_{t-1}/pn_{t-1}^{*}) + pn_{17} * 2003Q1 + \varepsilon_t^{pn}$

Model Calibration: $pn_{12} = 0.20$; $pn_{13} = 0.10$; $pn_{14} = 0.10$; $pn_{15} = 0.05$; $pn_{16} = 0.00$;

Model Restrictions: $pn_6 = 1 - pn_7 - pn_8 - pn_9$

Standard R^2: 0.62 **Adjusted R^2:** 0.58 **First Period:** 2003Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
pn_7	0.14	0.10	1.43	0.16
pn_8	0.08	0.03	2.48	0.02
pn_9	0.66	0.10	6.59	0.00
pn_{10}	0.09	0.05	1.84	0.07
pn_{11}	0.06	0.03	2.08	0.04
pn_{17}	0.01	0.00	3.83	0.00



Energy potential prices

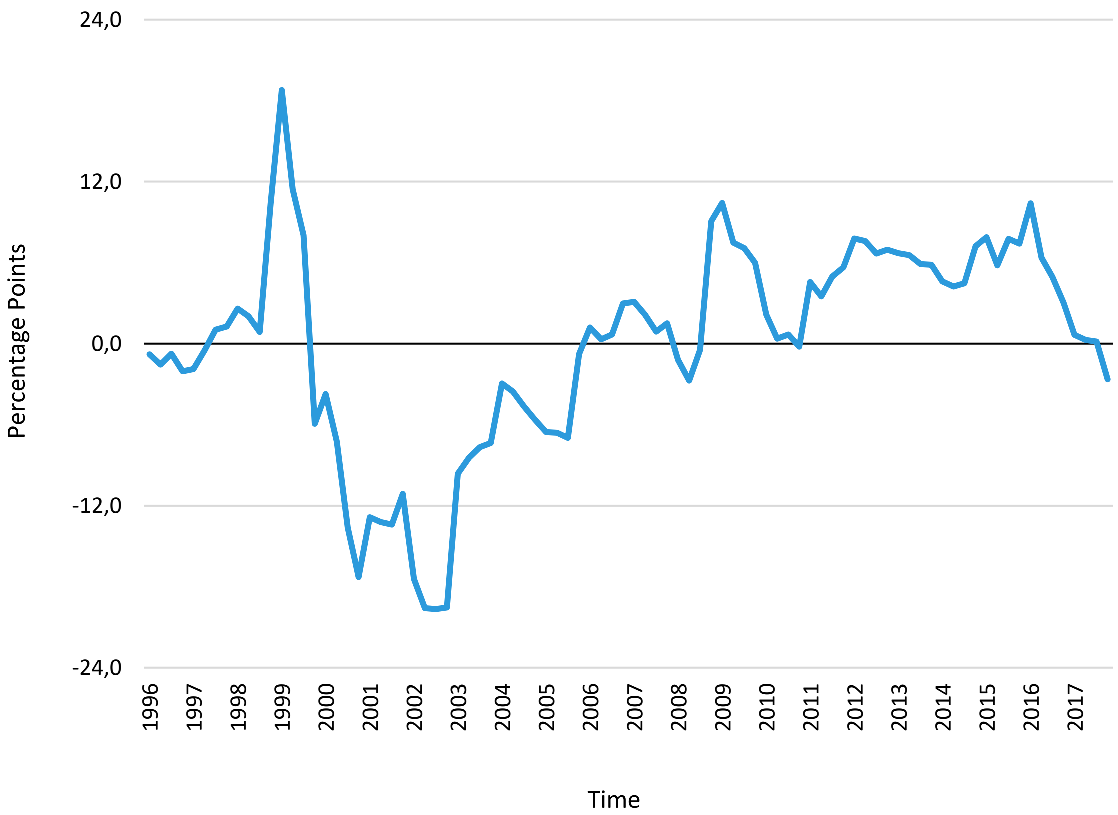
Est. Equation P4: $\log(pe_t^*) = pe_1 - pe_2/\mathrm{sqrt}(t) + pe_3 * \log(pt_t) + pe_4 * \log(oil_t) + pe_4 * \log(us_t) + \alpha_t^{pe}$

Model Restrictions: $pe_3 = 1 - pe_4$

Standard R^2: 0.98 **Adjusted R^2:** 0.98 **First Period:** 1996Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
pe_1	3.57	0.26	14.0	0.00
pe_2	1.01	0.04	27.4	0.00
pe_4	0.15	0.03	4.30	0.00

Est. Residuals P4



Energy consumer prices

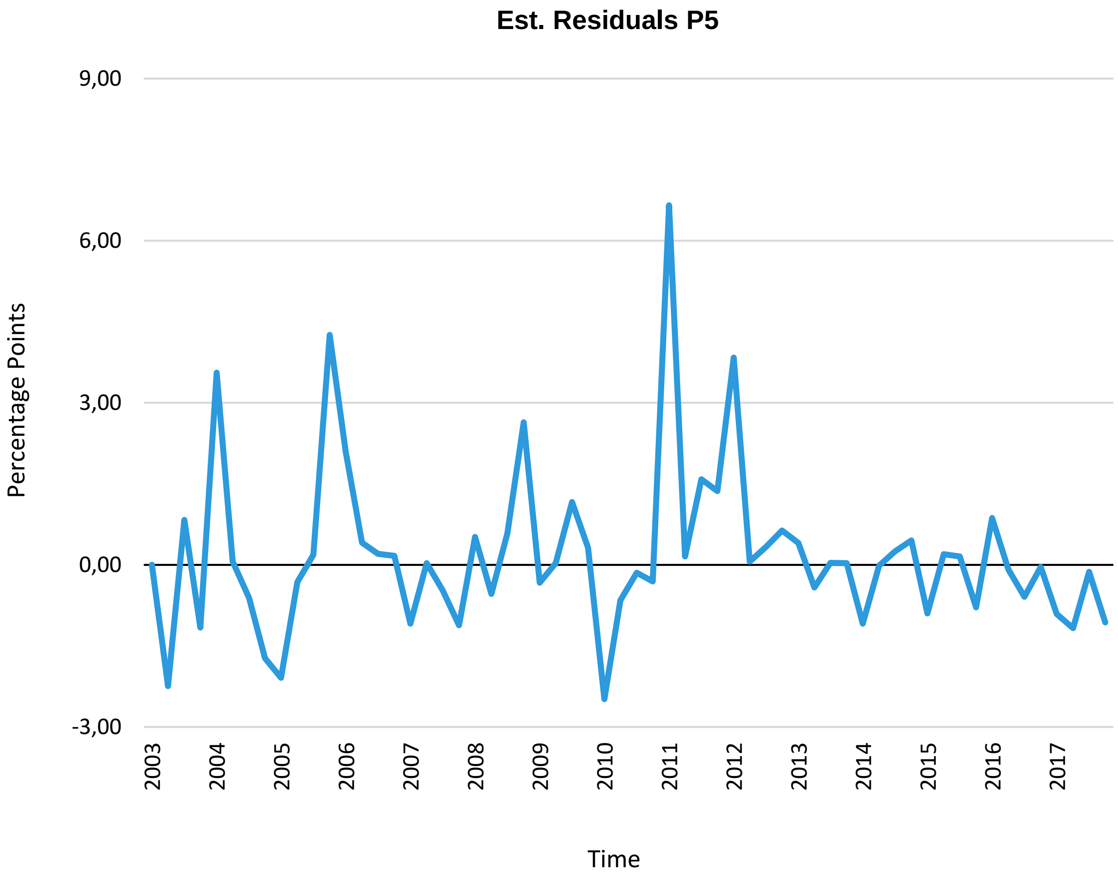
Est. Equation P5: $\mathrm{dlog(pe_t) = pe_5 * dlog(pp_t) + pe_6 * dlog(pl_t) + pe_7 * dlog(oil_t) + pe_7 * dlog(us_t) + pe_8 * up(\tau_t^{va}) + pe_9 * down(\tau_t^{va}) + pe_{10} * up(\tau_t^{cn}) + pe_{11} * down(\tau_t^{cn}) - pe_{12} * log(pe_{t-1}/pe_{t-1}^*) + pe_{13} * 2003Q1 + \varepsilon_t^{pe}}$

Model Calibration: $\mathrm{pe_8} = 0.20$; $\mathrm{pe_9} = 0.10$; $\mathrm{pe_{10}} = 0.80$; $\mathrm{pe_{11}} = 0.40$;

Model Restrictions: $\mathrm{pe_5 = 1 - pe_6 - pe_7}$

Standard R^2: 0.64 **Adjusted R^2:** 0.62 **First Period:** 2003Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
$\mathrm{pe_6}$	0.72	0.20	3.60	0.00
$\mathrm{pe_7}$	0.04	0.01	3.11	0.00
$\mathrm{pe_{12}}$	0.13	0.04	3.45	0.00
$\mathrm{pe_{13}}$	0.08	0.02	4.47	0.00



Deflator block estimation

Potential capital prices

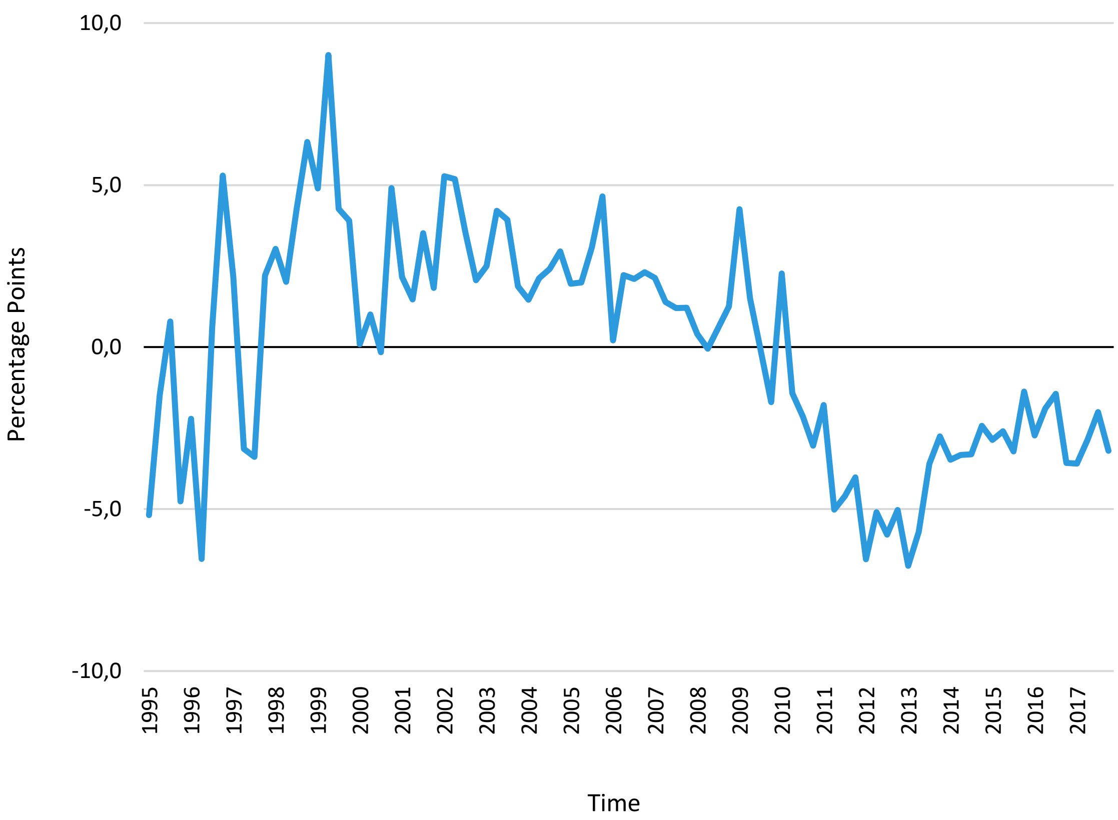
Est. Equation Π1: $\log(pi_t^*) = pi_1 + pi_2 * \log(pt_t) + pi_3 * \log(pm_t) + \alpha_t^{pi}$

Model Restrictions: $pi_2 = 1 - pi_3$

Standard R^2: 0.96 **Adjusted R^2:** 0.96 **First Period:** 1995Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
pi_1	0.01	0.00	2.66	0.01
pi_3	0.55	0.06	9.87	0.00

Est. Residuals Π1



Domestic capital prices

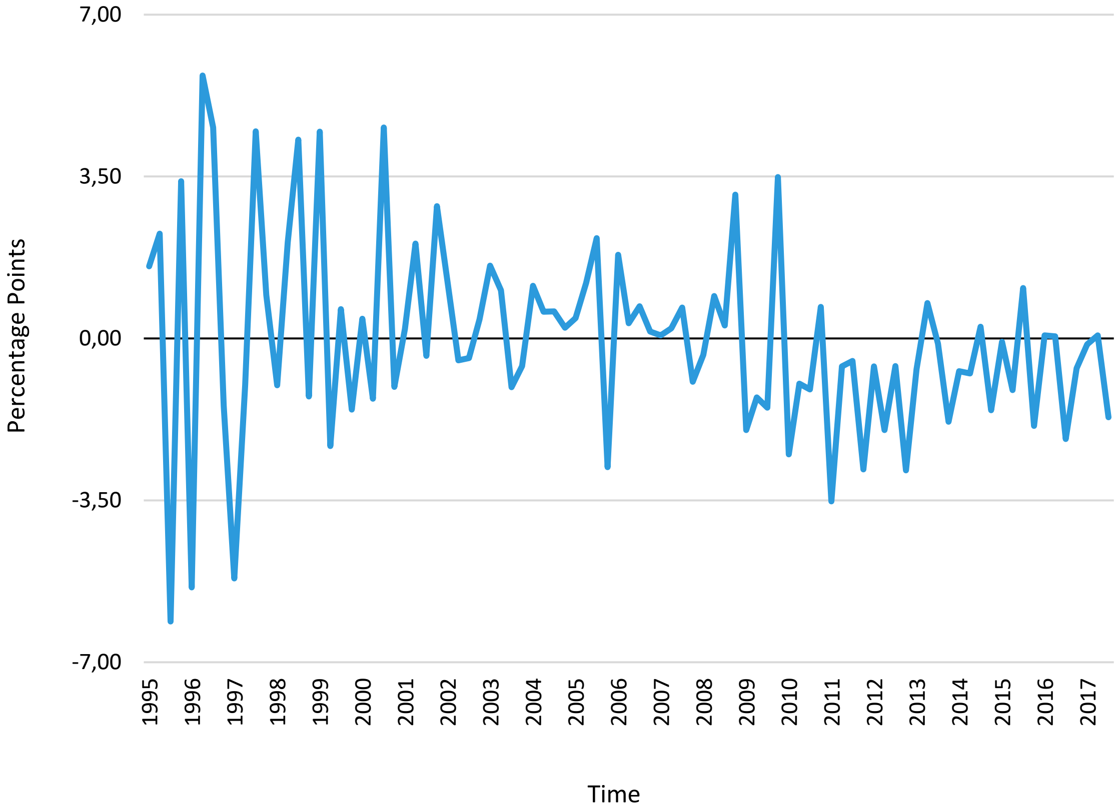
Est. Equation Π2: $\mathrm{dlog}(\mathrm{pi}_t) = \mathrm{pi}_4 * \mathrm{dlog}(\mathrm{pp}_t) + \mathrm{pi}_5 * \mathrm{dlog}(\mathrm{pm}_t) - \mathrm{pi}_6 * \log(\mathrm{pi}_{t-1}/\mathrm{pi}^*_{t-1}) + \varepsilon^{\mathrm{pi}}_t$

Model Restrictions: $\mathrm{pi}_4 = 1 - \mathrm{pi}_5$

Standard R^2: 0.41 **Adjusted R^2:** 0.41 **First Period:** 1995Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
pi_5	0.36	0.09	4.13	0.00
pi_6	0.23	0.07	3.53	0.00

Est. Residuals Π2



Potential public prices

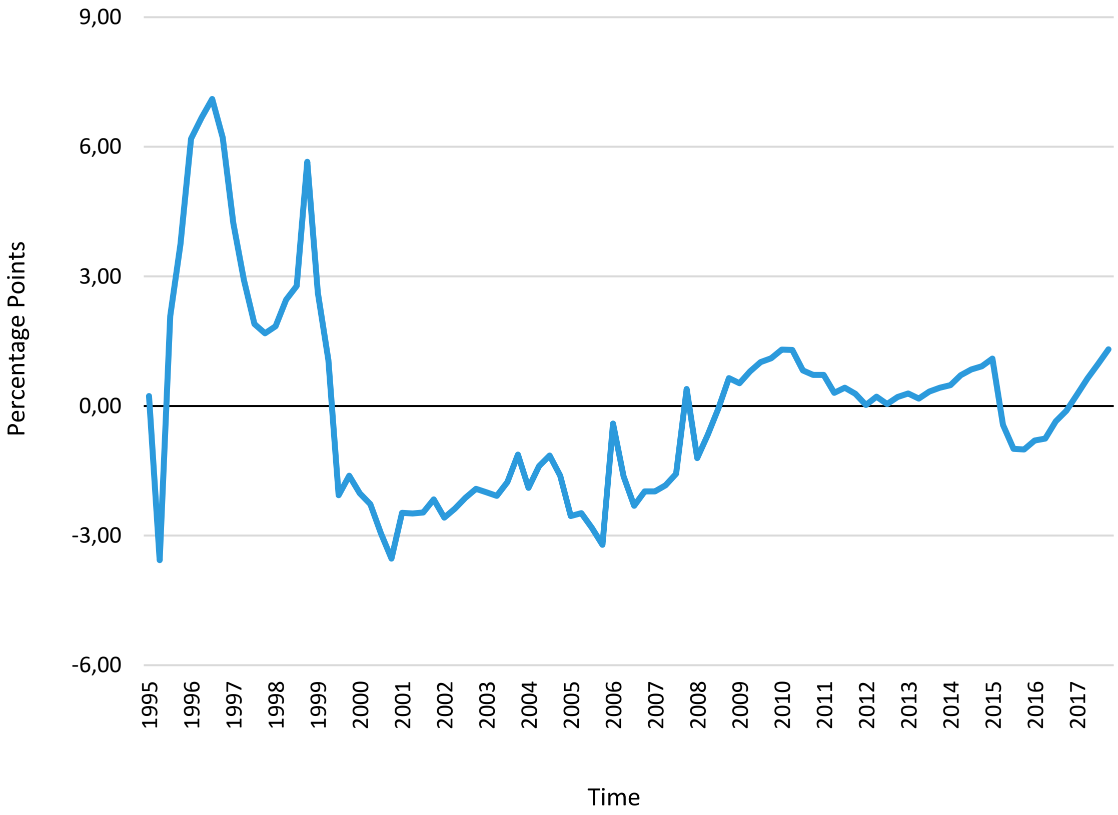
Est. Equation Π3: $\log(pg_t^*) = pg_1 - pg_2/\mathrm{sqrt}(t) + pg_3 * \log(pt_t) + pg_4 * \log(cp_t) + \alpha_t^{pg}$

Model Restrictions: $pg_3 = 1 - pg_4$

Standard R^2: 0.99 **Adjusted R^2:** 0.99 **First Period:** 1995Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
pg_1	0.05	0.01	4.05	0.00
pg_2	0.06	0.01	4.36	0.00
pg_4	0.44	0.04	9.85	0.00

Est. Residuals Π3



Domestic public prices

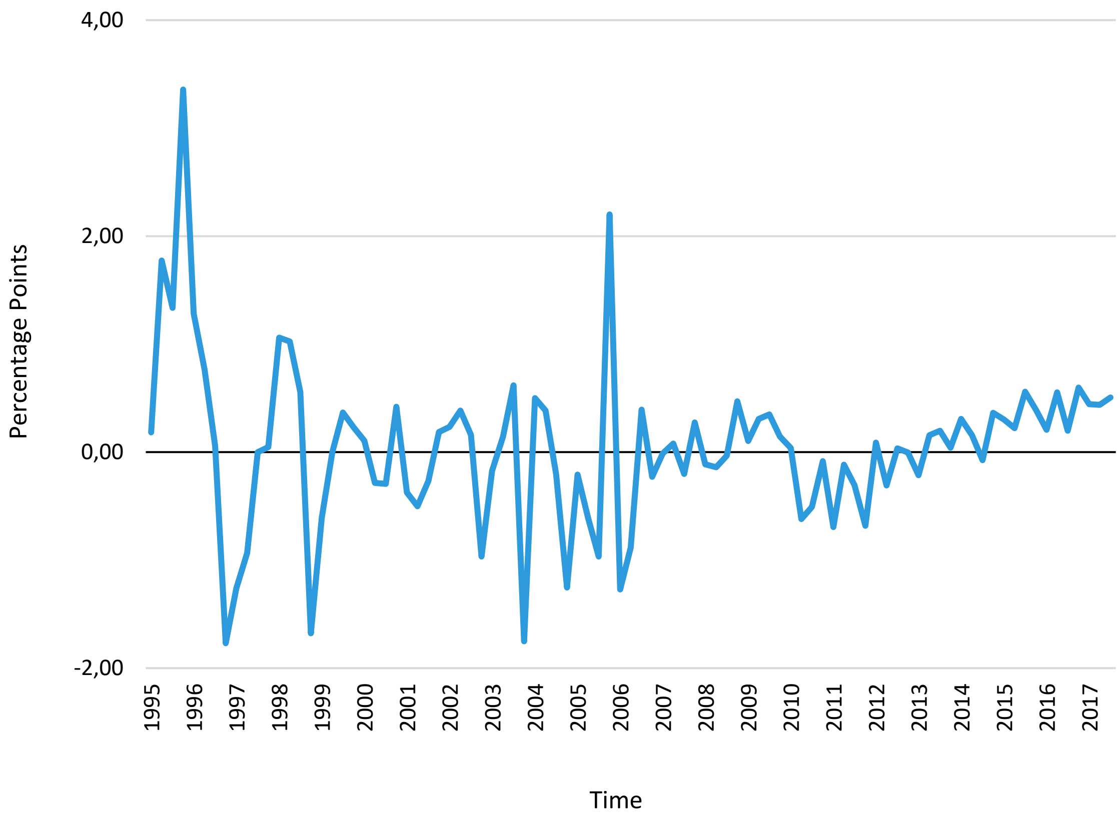
Est. Equation П4: $\mathrm{dlog}(\mathrm{pg}_t) = \mathrm{pg}_5 * \mathrm{dlog}(\mathrm{pp}_t) + \mathrm{pg}_6 * \mathrm{dlog}(\mathrm{cp}_t) - \mathrm{pg}_7 * \log(\mathrm{pg}_{t-1}/\mathrm{pg}^*_{t-1}) - \mathrm{pg}_8 * 1999\mathrm{Q}4 + \varepsilon_t^{\mathrm{pg}}$

Model Restrictions: $\mathrm{pg}_5 = 1 - \mathrm{pg}_6$

Standard R^2: 0.26 **Adjusted R^2:** 0.24 **First Period:** 1995Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
pg_6	0.90	0.05	18.5	0.00
pg_7	0.06	0.04	1.56	0.12
pg_8	0.06	0.01	6.89	0.00

Est. Residuals П4



Potential export prices

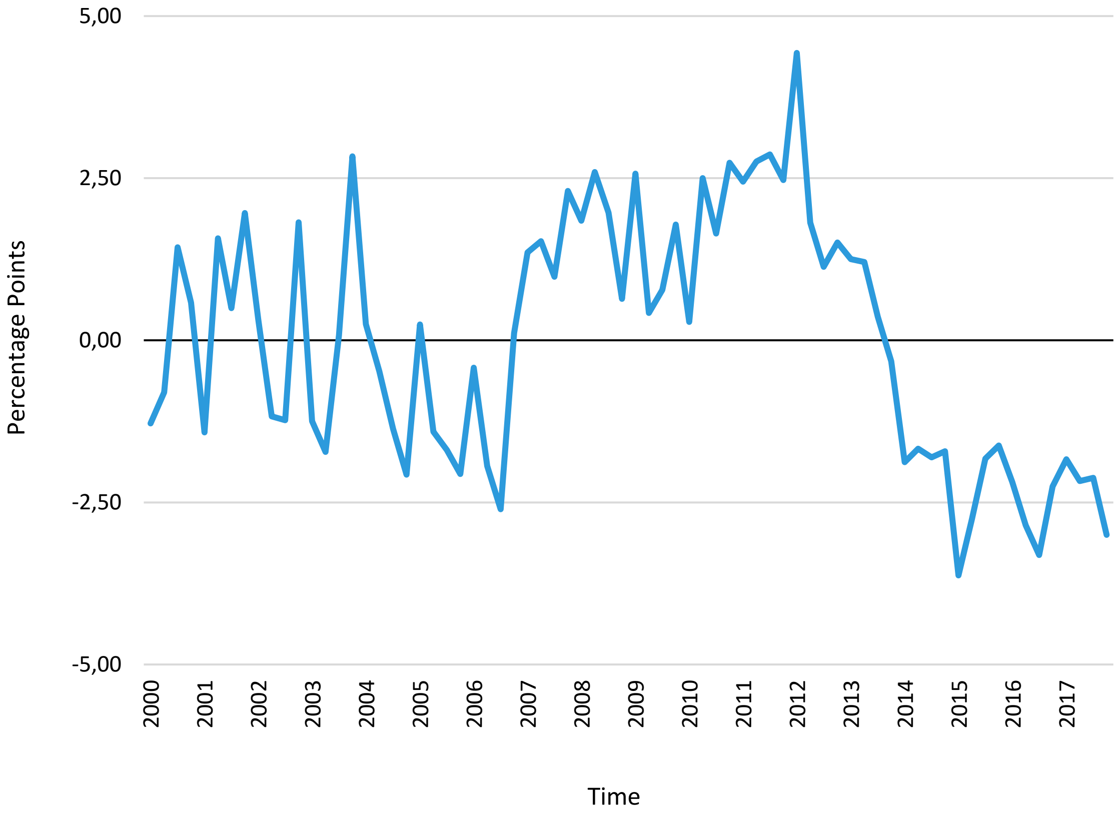
Est. Equation П5: $\log(px_t^*) = px_1 + px_2 * \log(pt_t) + px_3 * \log(ip_t) + px_3 * \log(er_t) + \alpha_t^{px}$

Model Restrictions: $px_2 = 1 - px_3$

Standard R^2: 0.82 **Adjusted R^2:** 0.82 **First Period:** 2000Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
px_1	0.04	0.00	18.6	0.00
px_3	0.36	0.01	27.8	0.00

Est. Residuals П5



Domestic export prices

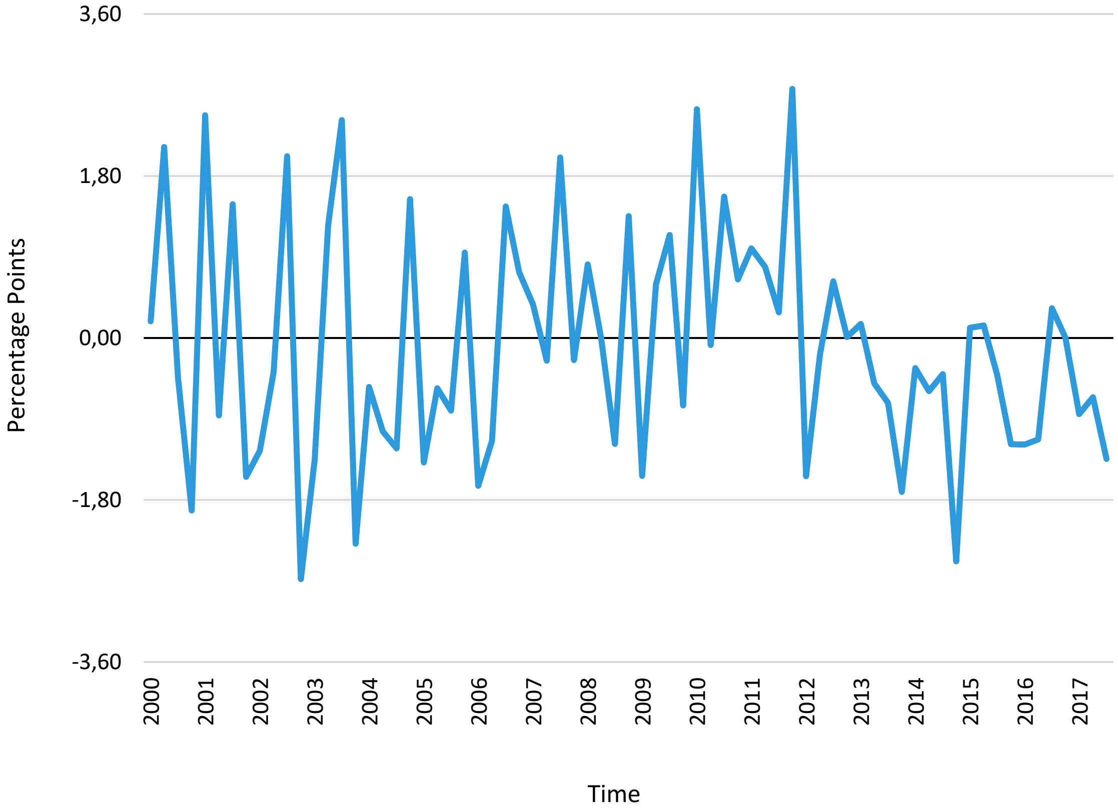
Est. Equation П6: $\mathrm{dlog}(\mathrm{px}_t) = \mathrm{px}_4 * \mathrm{dlog}(\mathrm{pp}_t) + \mathrm{px}_5 * \mathrm{dlog}(\mathrm{ip}_t) + \mathrm{px}_5 * \mathrm{dlog}(\mathrm{er}_t) - \mathrm{px}_6 * \log(\mathrm{px}_{t-1}/\mathrm{px}^*_{t-1}) + \varepsilon_t^{\mathrm{px}}$

Model Restrictions: $\mathrm{px}_4 = 1 - \mathrm{px}_5$

Standard R^2: 0.36 **Adjusted R^2:** 0.35 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
px_5	0.25	0.07	3.58	0.00
px_6	0.25	0.08	3.10	0.00

Est. Residuals П6



Potential import prices

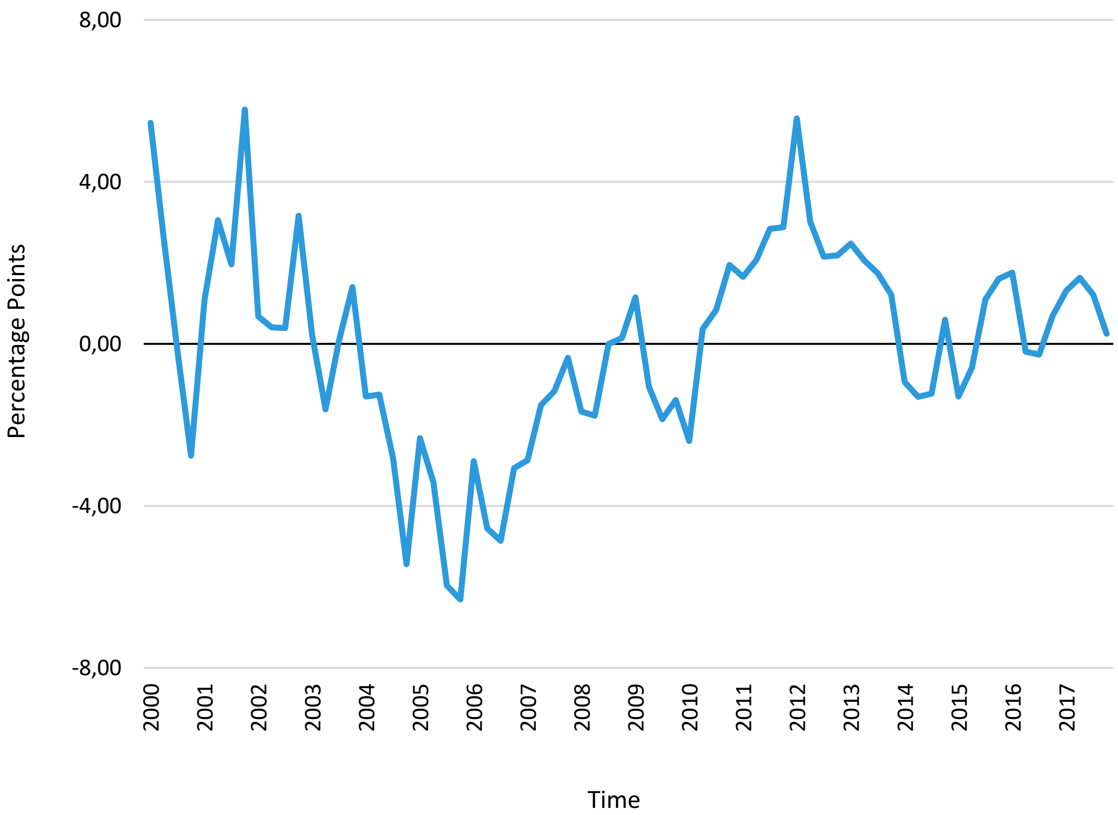
Est. Equation П7: $\log(\mathrm{pm}_t^*) = \mathrm{pm}_1 + \mathrm{pm}_2 * \log(\mathrm{pt}_t) + \mathrm{pm}_3 * \log(\mathrm{ep}_t) + \mathrm{pm}_3 * \log(\mathrm{er}_t) + \mathrm{pm}_4 * \log(\mathrm{oil}_t) + \mathrm{pm}_4 * \log(\mathrm{us}_t) + \alpha_t^{\mathrm{pm}}$

Model Restrictions: $\mathrm{pm}_2 = 1 - \mathrm{pm}_3 - \mathrm{pm}_4$

Standard R^2: 0.90 **Adjusted R^2:** 0.89 **First Period:** 2000Q1 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
pm_1	-0.32	0.09	-3.70	0.00
pm_3	0.16	0.02	8.97	0.00
pm_4	0.05	0.01	3.91	0.00

Est. Residuals П7



Domestic import prices

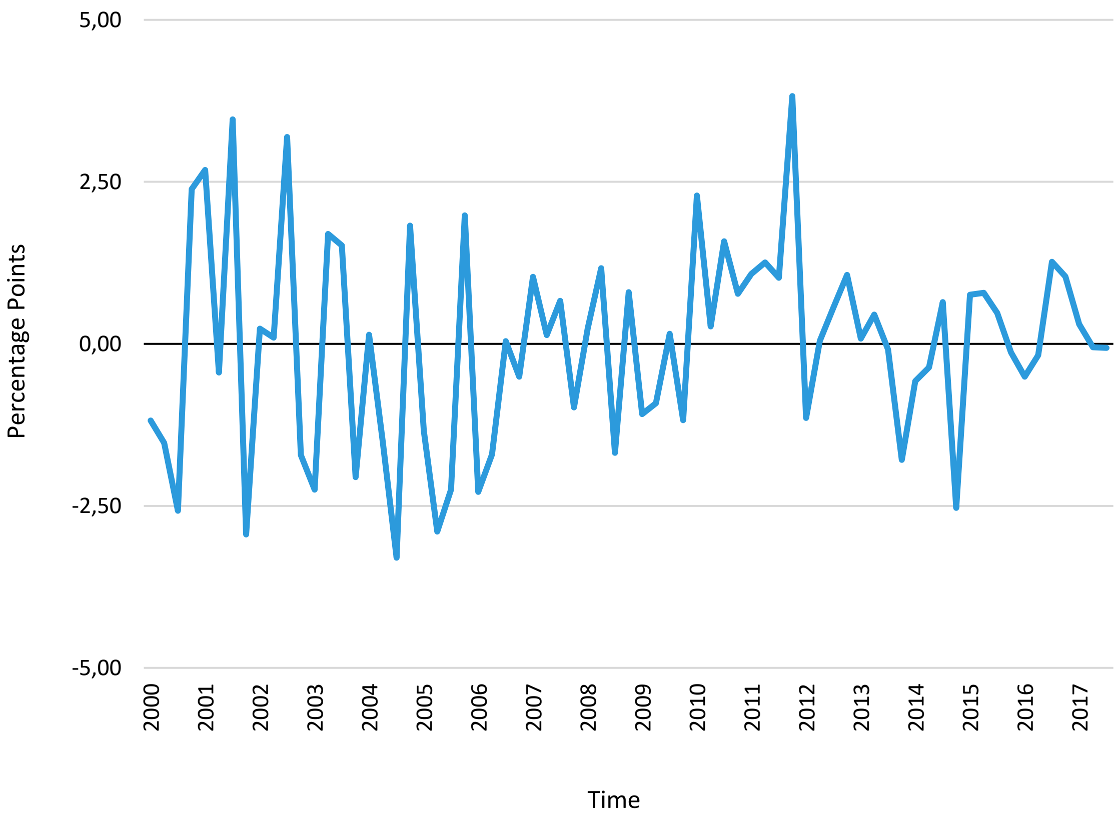
Est. Equation П8: $\text{dlog}(\text{pm}_t) = \text{pm}_5 * \text{dlog}(\text{pp}_t) + \text{pm}_6 * \text{dlog}(\text{ep}_t) + \text{pm}_6 * \text{dlog}(\text{er}_t) + \text{pm}_7 * \text{dlog}(\text{oil}_t) + \text{pm}_7 * \text{dlog}(\text{us}_t) - \text{pm}_8 * \log(\text{pm}_{t-1}/\text{pm}^*_{t-1}) + \varepsilon^{\text{pm}}_t$

Model Restrictions: $\text{pm}_5 = 1 - \text{pm}_6 - \text{pm}_7$

Standard R²: 0.18 **Adjusted R²:** 0.15 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
pm_6	0.26	0.11	2.45	0.02
pm_7	0.01	0.01	0.75	0.46
pm_8	0.29	0.08	3.83	0.00

Est. Residuals П8



Fiscal policy estimation

Public social transfers

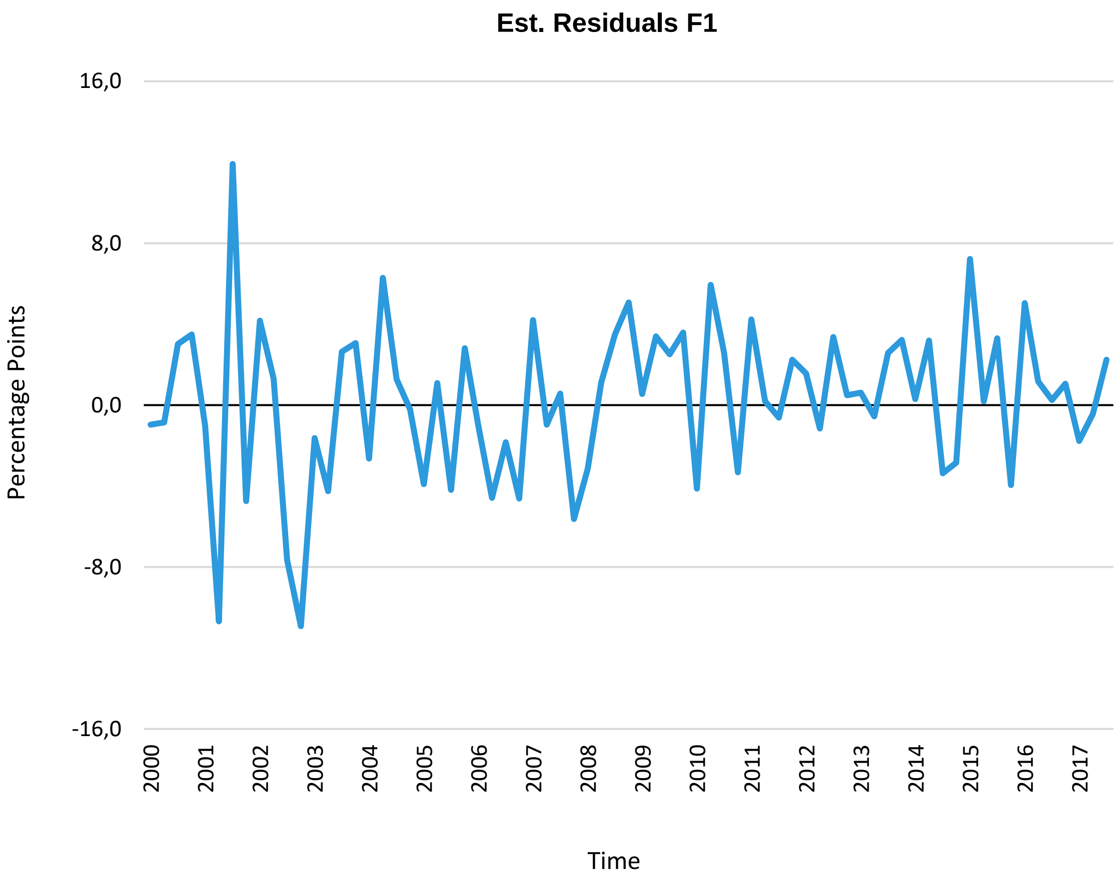
Est. Equation F1: $\mathrm{dlog}(\mathrm{st_t}) = \mathrm{st_2} * \mathrm{dlog}(\mathrm{yt_t^*}) + \mathrm{st_3} * \mathrm{dlog}(\mathrm{lt_t}) + \mathrm{st_3} * \mathrm{dlog}(\mathrm{rt_t}) + \mathrm{st_4} * \mathrm{dlog}(\eta_t) + \mathrm{st_4} * \mathrm{dlog}(\mu_t) - \mathrm{st_5} * \mathrm{gap}(\mathrm{yt_{t-1}}) + \mathrm{st_6} * \mathrm{dev}(\mathrm{bp_{t-1}^*}) - \mathrm{st_7} * \mathrm{dev}(\mathrm{dp_{t-1}^*}) + \mathrm{st_8} * \mathrm{cor}(\mathrm{st_{t-1}}) + \varepsilon_t^{st}$

Model Calibration: $\mathrm{st_4} = 0.05$; $\mathrm{st_5} = 0.04$; $\mathrm{st_6} = 0.08$; $\mathrm{st_7} = 0.02$;

Model Restrictions: $\mathrm{st_2} = 1 - \mathrm{st_3}$

Standard R^2: 0.09 **Adjusted R^2:** 0.07 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
$\mathrm{st_3}$	0.32	0.38	0.82	0.41
$\mathrm{st_8}$	0.11	0.06	2.00	0.05



Intermediate consumption

Est. Equation F2: $\mathrm{dlog}(\mathrm{ic}_t) = \mathrm{ic}_2 * \mathrm{dlog}(\mathrm{yt}_t^*) + \mathrm{ic}_3 * \mathrm{dlog}(\mathrm{yt}_t) - \mathrm{ic}_4 * \mathrm{gap}(\mathrm{yt}_{t-1}) + \mathrm{ic}_5 * \mathrm{dev}(\mathrm{bp}_{t-1}^*) - \mathrm{ic}_6 * \mathrm{dev}(\mathrm{dp}_{t-1}^*) + \mathrm{ic}_7 * \mathrm{cor}(\mathrm{ic}_{t-1}) + \varepsilon_t^{\mathrm{ic}}$

Model Calibration: $\mathrm{ic}_4 = 0.10$; $\mathrm{ic}_5 = 0.40$; $\mathrm{ic}_6 = 0.05$;

Model Restrictions: $\mathrm{ic}_2 = 1 - \mathrm{ic}_3$

Standard R^2: 0.10 **Adjusted R^2:** 0.08 **First Period:** 2000Q2 **Last Period:** 2017Q4

Parameter	Est. Mean	Std. Error	T-Statistics	P-Value
ic_3	0.66	0.53	1.24	0.22
ic_7	0.33	0.11	3.13	0.00

Est. Residuals F2