

**DYNAMO** 

(**D**ynamic **N**ational **A**ccounts based **M**odel)

**Ministry for National Economy of Hungary**

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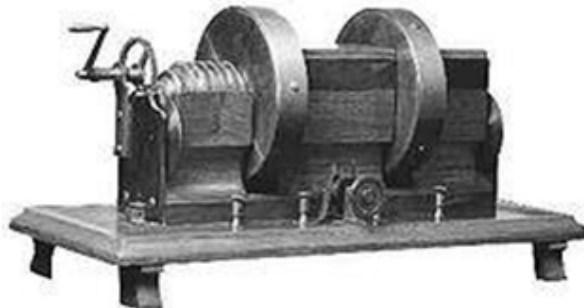
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*Ányos Jedlik (Szímő, 11 January 1800 – Győr, 13 December 1895) created among others the first electric motor, recognized how to amplify voltage and he was also the first who described self-induction: the principle of dynamo. The dynamo-electric principle was a landmark discovery, first ever laid down by Jedlik in 1856. Based on the dynamo principle, a unipolar inductor was in operation already in 1859.*

*The process of self-induction described by Jedlik has common characteristics with the multiplier effect known in economics. Both define the accelerator effects through feedbacks of initial impulse. In macromodels, including the macroeconomic model of Ministry for National Economy there are several feedback mechanism. Therefore, beyond the fact that the principles driving the model are similar to that of the dynamo, the authors also pay tribute to the work of the Hungarian scientist, inventor, Benedictine and outstanding teacher by the model name itself.*



## Introduction

The macroeconomic prognosis of Ministry for National Economy (MfNE) has a special importance among other forecasts regarding the future performance of Hungarian economy. A realistic and reliable macroeconomic and budgetary projection on the one hand, fosters the compilation of a credible budget and on the other hand, orientates the expectations of economic agents about the future economic environment in terms of their business, economic or consumption decisions. Thanks to regularly published and well-established forecasts not only domestic economic agents but both foreign ones and international organisations can obtain credible information about the prospects of Hungarian economy. In addition, as a result of the transposition of an EU directive, since 1 January 2014 the Hungarian legislation has also defined the frameworks respecting macroeconomic forecasts.

The Hungarian EU presidency in the first half of 2011 also played a significant role in compiling Council Directive 2011/85/EU on requirements for budgetary frameworks of member states. This is an important element of the legislation package called the Six Pack, which aims at strengthening economic governance. The Six Pack entered into force on 1 December 2011, and its purpose is to enhance the economic policy coordination of EU. The directive had to be transposed by the member states into their legislation until 31 December 2013 with entry into force on 1 January 2014. One of the crucial points of this directive is that macroeconomic and budgetary forecasts, as well as their methodologies must be made public.

In the recent years, forecasts for the economic growth and the main macroeconomic variables were usually published twice a year by the Ministry for National Economy: on the one hand, during April in the Convergence Programme and on the other hand, in September when the budget for the following year is submitted. This practice is reinforced by the Act on Public Finances (hereinafter *Áht.*), relying on the Council Directive. In line with *Áht.* Section 13/B. the Government at least twice a year shall prepare a macroeconomic and budgetary forecast for the current and the following three years and the forecast and its methodology must be made public. The budgetary planning defined in Sections 13 and 29 shall be based on the latest forecast made in this way. The government shall determine the detailed frameworks for the forecasts and the method of publication in a decree.<sup>1</sup>

The Government Decree 368/2011 (XII. 31.) on the Implementation of Section 13/B. of *Áht.* (hereinafter *Ávr.*) defined the realization of legislation as follows:

1) The Section 18/a (1) of *Ávr.* states that in accordance with Section 13/B of *Áht.* the minister responsible for general government shall prepare the forecast and publish it with the underlying methods, assumptions and relating parameters on the website of ministry until the 30th of April and until the submission of draft bill on central budget to the Parliament. When the prognosis is prepared, the evaluation of earlier forecasts shall be taken into consideration in line with subsection (4).

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<sup>1</sup>Section 13/B of *Áht.* was included by Section 3 of Act 222 of 2013.

2) In accordance with the subsection (1) forecasts shall contain on the one hand, the differences from the latest prognoses compiled by European Commission and on the other hand, the reasons in the case of significant differences.

3) In the macroeconomic and budgetary forecasts, the development of main budgetary variables shall be examined – in different scenarios regarding growth and changes in interest rate – in the context of a sensitivity analysis. When choosing the range of alternative assumptions used in macroeconomic and budgetary forecasts, the past reliability of forecasts shall be relevant, moreover the related risk scenarios should also be taken into consideration.

4) On the basis of objective criteria, the minister responsible for general government budget shall carry out an extensive annual and ex post evaluation of macroeconomic and budgetary forecasts used for planning the central budget. The minister shall publish on the website of ministry the methodology – including the establishment of objective criteria –, schedule, timing and result of the evaluation. If on the basis of this evaluation, in at least four consecutive years significant differences can be observed respecting the macroeconomic forecasts, the methodology or the parameters shall be changed.<sup>2</sup>

In accordance with the Act on Public Finances and the Government Decree on their implementation, in this paper the DYNAMO model is presented in detail, which is used in forecast and applied for impact assessments. It is important to note that the test version of DYNAMO model was also used in convergence programme of 2013 for the sensitivity analysis of alternative scenarios related to the macroeconomic paths. Presently, this model serves as the basis of official forecasts and impact assessments. The evaluation of to what extent the facts have justified the official forecast will be carried out in the future in accordance with the above mentioned act.

In connection with the presentation of DYNAMO model, after an international overview the second chapter contains a historic review of models used by the Macroeconomic Department of Ministry for National Economy. Then in the third chapter the description of model structure and the characteristics of economic agents are presented. In addition, the process of preparing a forecast is also described in detail, where a key element is the correction by the experts. In the fourth chapter of this description, the impact assessments of various alternative scenarios are introduced, which are presented by the impulse response functions obtained as the result of simulations. In the technical appendix the equations of this forecasting model are also presented.

## 1 International overview

In accordance with the Council Directive created within the framework of the Six Pack, all Member States must publish the methodology of their macroeconomic and budgetary forecasts starting from 2014. A few member countries, however, made available the description of the methodology even before that date. In general, macroeconomic models used by European min-

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<sup>2</sup>Section 18/A of Ávr. was included by Section 10 of Government Decree 497/2013 (XII. 29.), and entered into force on 1 January 2014.

istries responsible for budget related decisions are important tools to forecast short-term and mid-term developments and to explore the effects of economic policy options. At the same time, different institutions are responsible for the development and maintenance of the models in individual countries and the size of the models and in some cases the scope of the users is also different.

The intended purpose of a macroeconomic model determines which sectors of the economy should get special attention during the model's development. Accordingly, in the models used by the ministries responsible for the budget the modelling of the government sector is a priority since the most important task is to explain the transmission mechanisms and effect of various fiscal policy interventions.

A short description of the experiences of Poland, Denmark, The Netherlands, Ireland, Spain and Italy in model building, forecasts and impact assessments, as well as the specific characteristics of their practices is presented below.

### **1.1 Poland – eMPF**

In accordance with the requirements of the economic and financial ministries, the aim of the development of the eMPF (Econometric Model of Public Finance) model was closely related to the goal of conducting an optimal fiscal framework by the Ministry of Finance and the government. The first steps towards developing the macroeconomic model were taken in 2000. Before, the lack of reliable quarterly time series limited the possibility of econometric modelling. The first version of the model was created in cooperation with three experts from the French Ministry of Finance and with the National Institute for Forecasting and Economic Studies (INSEE). Apart from a shortage of data, a fundamental data issues has to be sound i.e. a division between market and non-market activities. During this stage a test version of the model was prepared. In the second phase of the project, the Polish team of four, together with two colleagues from the Finnish Ministry of Finance further developed the model within the framework of a PHARE project. The bulk of the time was still spent on data preparation. Data consistent with ESA95 methodology was estimated using some statistical techniques. The final version of the model was consulted with external experts and was published as the internal document of the Polish Ministry of Finance in 2003. The model was then maintained by the team and further developed by two members of the French Ministry of Finance. However, after the publication in 2003, the development of the model practically stopped. A decision to update the model and to reorganise the team was made at the end of 2008. The current version is a medium-sized macroeconometric model containing 352 variables. (Dudek et al., 2012)

### **1.2 Denmark – ADAM**

The comprehensive model of the Danish economy has been developed and operated by the statistical office since 1972. The model is mainly used by the Ministry of Economy, but it is

also applied for a wide range of calculations in the private sector, among others, by banks and economic lobbies. The equations and variables of ADAM (Annual Danish Aggregate Model) are described on the model's website, and users are offered courses in using ADAM. A team of thirteen is responsible for the model's operation and related documentation tasks.

ADAM was first conceived as a short-term, demand-oriented model where the supply side played a minor role. Description of short-term business cycles continues to play a significant role, however over the years there has been a focus on developing the long-term properties of the model, which made the more detailed inclusion of the supply side crucial. The dynamic characteristics of the model may also improve with the inclusion of both the short and the long term, and an additional advantage is that it also means that the model describes the transition between the two. Therefore, ADAM can be regarded as a compromise between empirically oriented time series models and theoretically oriented equilibrium models.

Following the traditional estimation procedures of macroeconomic models, the parameters of the behavioural equations are estimated individually before the equations are inserted into ADAM. The advantage of this procedure is that the equations will have good empirical properties. At the same time, the interpretation of the model might become difficult if the characteristics of the estimated equations do not match those expected based on theory, or if the equations do not work well together. In practice, most macroeconomic modelling comprise a phase of iteration, where the modeller goes back and try to re-estimates or re-formulate the equations that make the interpretation difficult. The model is only accepted if the whole model is economically explicable. ADAM is a large-scale model containing 2,500 endogenous and 1,000 exogenous variables. (Statistics Denmark, 2013)

### **1.3 The Netherlands – SAFFIER**

The task of providing an extensive model of the Dutch economy is carried out by the Bureau for Economic Policy Analysis. Until 2004 two separate models operated simultaneously: a quarterly and an annual model for the purpose of short-term and long-term assessments respectively. However, as the two models often led to diverging results, the creation of the SAFFIER (Short- and medium-term Analysis and Forecasting using Formal Implementation of Economic Reasoning) model through merging the two existing models was decided. The two models were integrated by a team of fourteen experts. The merged model operates in two identical versions in every respect other than data frequency. So the earlier problems related to forecasts were eliminated. The quarterly configuration serves short-term while the annual configuration serves long-term forecasting purposes. The model is also suitable for the assessment of the impacts of economic policy options, election platforms and coalition deals. (Kranendonk-Verbuggen, 2007)



#### **1.4 Ireland – HERMES**

The HERMES model operated by the Economic and Social Research Institute (ESRI) has been used for more than 25 years for mid-term forecasts and impact assessments. During that time, the model has gone through several modifications to be adapted to the changes in the structure of the Irish economy, the changing user requirements and the development of modelling techniques. The latest, 2013 version of the model (in short: HERMES-13) reflects the lessons from the latest crisis, paying more attention to the relationship between debt levels and economic activity. The HERMES model is a large-scale, supply-oriented model with 180 behavioural equations and containing altogether 824 equations. Its first version was formulated in the 1980s. It was based on the model developed in the Central Bank and the Ministry of Finance in the 1970s, which put special focus on the oil price shock of those times. The model is operated in a theory-oriented way, therefore compliance with past data is subordinated to compliance with the economic theory describing the behaviour of companies and households. (Bergin et al., 2013)

#### **1.5 Spain – REMS**

The Spanish REMS (Rational Expectations Model for the Spanish economy) model is the main simulation tool of the country's Ministry of Economy. REMS is a small open economy dynamic general equilibrium (DGE) model with micro-founded equations. The most valuable asset of the model is the detailed examination of the transmission channels of policy options with economic outcomes. A separate database (REMSDB) has been elaborated that satisfies the model's estimation and calibration requirements and serves to generate a baseline scenario for REMS. (Boscá et al., 2010)

#### **1.6 Italy – IGEM**

The IGEM (Italian General Equilibrium Model) model describing the Italian economy was developed by the Department of Treasury of the Italian Ministry of the Economy and Finance. One of the most important characteristics of the model is the detailed elaboration of the labour market, which takes into consideration several types of employment contracts. The purpose of this specific characteristic is to reflect the heterogeneity of the Italian labour market and the ambiguity of the Italian economic system. This approach aims to provide an explanation for the presence of low-income households with uncertain employment and isolated from the financial markets, as well as the presence of high-income employees with union coverage and strong job security protection. The self-employed make up the third separate group that is overlapping with both previously mentioned groups. The ambiguity of the labour market coupled with a high degree of real and nominal rigidities are essential in explaining the transmission mechanism and the effects on employment and income of economic policy interventions and the business cycle. (Annicchiarico et al., 2013)

## 2 An overview of the models used by the Macroeconomic Department of MfNE

When analysing the effects of policy measures and external shocks, and preparing sensitivity analyses and simulations, the Ministry for National Economy (and the Ministry of Finance, its legal predecessor) has used macroeconomic models since the mid 2000s. However, until 2013, the macroeconomic forecast supporting the budget relied on relatively few time series estimates and was mainly based on expert knowledge.

The fundamental aim of preparing the forecasts is to give a prognosis of the future developments in the economy. The most important output of the forecasts were the GDP, its expenditure side components and the changes of the tax bases. The calculations were based on annual national accounts data. The detailed prognosis was prepared for six main blocks (household consumption, public consumption, investment, trade balance, current account balance and public finances) representing the specific mechanics of the different areas. Since ensuring consistency was a priority, the variables of the blocks were also related to each other to make up a coherent system.

The variables necessary for operating the system can be put in two groups as several indicators were defined within the system, while others were set exogenously. External inputs were for example the export and import prices, exchange rate, external demand, import coefficients related to the components of the expenditure side of the GDP, EU transfers, tax parameters and budgetary expenditure, as well as the estimated indicators of the labour market (evolution of wages and number of employees of the corporate and government sectors).

Based on the inputs, household's disposable income, consumption and investment expenditure, and financial savings were determined in the consumption block. The forecast for public consumption expenditure was prepared on the basis of government expenses in the relevant sectors. The development of investments depended on the investment demand of the three economic sectors (government, household, corporate) and the volume of the capital transfers from the European Union. In foreign trade, the export was determined by the external economic situation, while the import was mainly shaped by internal demand and the import content of exports. The revenue side of the public finances block was determined by macroeconomic parameters, while its expenditure side was determined by the elements of public consumption, government investments and capital transfers, as well as social transfers in cash. In the current account block a forecast was prepared for external trade which, together with the capital account, determines the external financing needs of the national economy.

In addition to short-term and mid-term real economic forecasts, this method made it possible to estimate the impact of policy measures and legal changes on macroeconomic indicators and the general government balance. However, in addition to calculations relying mainly on experts' projections, simulations prepared with various models and impact assessments also supported decision making. The Ministry of Finance initiated the development of the TÁRSZIM static

microsimulation model which was developed by experts at TÁRKI. The model was suitable to assess the redistribution effect of the system of taxes and benefits (Benedek–Lelkes, 2005).

Within the context of the cooperation between the Ministry of Finance and the Institute of Economics of the Hungarian Academy of Sciences started in 2005, a mid-scale model was built, called PM-KTI model. This quarterly model contained about twenty behavioural equations and several identities, and was divided into six blocks: production, export, investment, prices, labour market, households and public finances (Bíró et al., 2007). The PM-KTI model was a small open economy model, so export and import prices were exogenous. In the short run demand determined the output, however, the frictions represented by the changes of the capacity utilisation indicator were feeding back into the model. Domestic prices depended on the prices of production inputs (external prices and unit labour costs) in the long run, while wages in the competitive sector were determined by productivity. The disposable income of households was the sum of the wages, government transfers and other incomes. Consumption depended on household income and wealth. Capital formation followed the accelerator principle. The driving force behind export was external demand and real wages in euros, while import was driven by household and public consumption, investment and the import content of export.

The main area of using the PM-KTI model remained simulations and sensitivity analyses. For example, it was used to analyse the alternative scenarios described in the convergence programme, presenting the impact of different risks associated with the baseline scenario on macroeconomic indicators and the government budget.

In the past few years, the QUEST III model developed by the European Commission has been used for the preparation of several government documents (convergence programmes, Széll Kálmán Plan) to assess the impact of policy measures on economic growth. QUEST belongs to the family of dynamic stochastic general equilibrium (DSGE) models that are macroeconomic models based on microeconomic fundamentals. In these models the equations describe the intertemporal optimising behaviour of economic agents given different technological, institutional and budgetary restrictions. The adequate fitting of data is ensured by several real, nominal and financial frictions.

The QUEST model is suitable for the analysis of diverse effects of structural reforms in the Hungarian economy: households are divided into three types based on its qualification level, while in the corporate sector, in addition to final and intermediate goods producing firms a R&D industry is also included in the model (Roeger et al., 2008). The aim of European Commission in establishing the model framework was to clearly assess the short-, mid- and long-term impacts of measures on the revenue and expenditure sides on the economic growth and the development of its elements through the transmission mechanisms. The simulations were prepared using the parameters calibrated to the Hungarian economy by the experts of Commission which contributed to the accurate quantification of macroeconomic effects.

It is a specific feature of DSGE models similar to QUEST that the variables in the model are diverted from their steady state by different shocks. Analyses carried out with this type

of models focus on the path of evolving reactions around the model's steady state, through the propagation mechanism, which means that they are primarily suitable for preparing impact assessments. However, modelling and forecasting the equilibrium trends is usually a different task, and therefore the QUEST model was not used for forecasting.

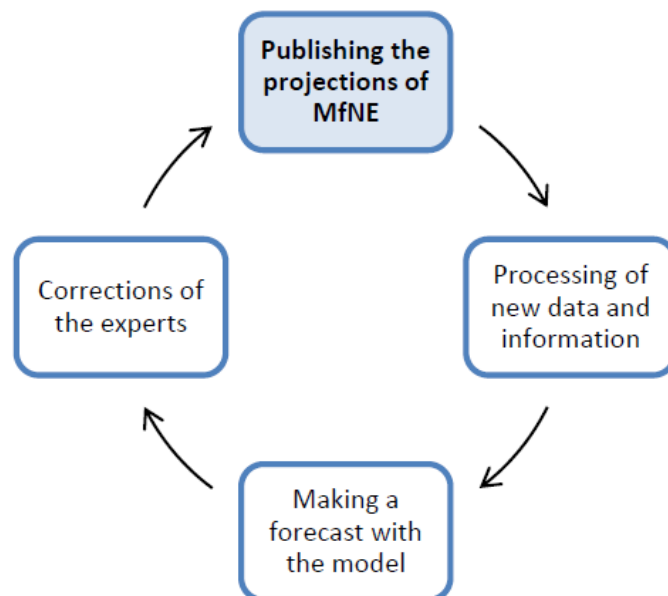
The sensitivity analysis of alternative scenarios related to macroeconomic paths was carried out in 2012 with the BVAR model using the Litterman prior. However, in 2013 the risks were already simulated with the current model still under testing at the time. Today the DYNAMO model allows preparing not only simulations and sensitivity analyses, but also forecasts based on adequate modelling techniques.

### 3 Preparing a forecast

Models are simplified descriptions of reality providing a manageable context for analysing economic trends. Although modelling plays a key role in preparing forecasts, no such system of equations can be expected to provide a complete and final macroeconomic prognosis without any corrections by experts. In order to the forecasts reflect properly the effects of specific factors, the corrections of model results by experts are indispensable. It has been proven by several studies that including experts' knowledge improves the precision of forecasts. (Clements, 1995; Fildes–Stekler, 2002).

When a macroeconomic prognosis is prepared, the model contains several variables that are determined within the system. However external inputs are also used e.g. fiscal expenditure items, exchange rate, interest rate, external demand and oil price.

The process of preparing the forecast is illustrated by the following figure:



In line with this figure the starting point of all prognoses for both the experts and the model is the latest forecast. Through processing new information and statistical data revealed in the intermittent period, the experts prepare the database that the forecasting model will use while it is run, and if necessary the parameters are also re-estimated. Next, the model results are adjusted by the experts. During this phase, the specific factors and/or factors with short-term impacts are also taken into consideration whose full integration into the model is not feasible and would make the main transmission channels of model difficult to discern. Finally, the model forecast completed with the experts' corrections is published.

## 4 The structure of forecasting model

The structure of quarterly DYNAMO model is based on the DELPHI model developed earlier by the Central Bank of Hungary (Horváth et al., 2010; 2011). The reason why this macroeconomic model structure is suitable for forecasting the future performance of economy and preparing fiscal impact assessments is that it implements consistently the properly detailed relationships of national accounts and the financial accounts of general government sector. The implementation of mentioned identities is also completely ensured by the modelling database.

To make the DYNAMO model suitable for forecasting and preparing impact assessments, most parameters were re-estimated and re-calibrated moreover the program codes for running the model were also revised.

The model relies on the neoclassical growth theory in the long run, however in the short run it has New Keynesian characteristics due to the built in nominal and real rigidities. These adjustment processes start when in the economy the level of actual output is diverted from the level of potential output by demand impacts. Thus the frictions essentially provide a convergence path to the economy from its current state to its so-called long run, steady state. All this is ensured in the model by the error correction form of behavioural equations.

### 4.1 The behaviour of sectors

Following the structure of national accounts, the model includes four sectors: households<sup>3</sup>, corporations, government and the rest of the world. In the economy value added is produced by the government and corporate sector. In the long run the output of corporations is influenced by three factors: the expansion of capital stock, the disposable labour force and the development of production technology. The value added is divided into factor incomes moreover the income flows among the four sectors is also fully consistent with national accounts. The remaining part of this chapter describes the behaviour of economic agents in sectoral breakdown and their balance sheets.

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<sup>3</sup>The household sector also includes the non-profit sector serving households (NPISHs) in the model.

#### 4.1.1 Government

The government sector has a key role in the model of Ministry for National Economy. Therefore the revenue and expenditure sides of general government balance sheet are broke down in detail:

<b>REVENUES</b>	<b>EXPENDITURES</b>
1. Personal income tax	1. Compensation of employees
2. Employers' social contribution	2. Expenditures on goods and services
3. Value added tax and excise duty	3. Transfers to households in kind
4. Profit tax	4. Government investment
5. Net other income from corporations	5. Financial transfers to households
6. Copayments	6. Interest payment after government debt
7. Transfers (from abroad)	

The development of items on the income side is related to the performance of the economy. For example higher households' consumption increases the budget revenues from value added taxes and excise duties moreover well performing companies will pay higher corporate and business taxes. The government influences the behaviour of economic agents and thus the development of macroeconomic variables by changing tax rates and its expenditures. The balance of expenditures and revenues constitutes the general government balance, which influences the government accumulation.

#### 4.1.2 Households

The table below enumerates the revenues and expenditures of households:

<b>REVENUES</b>	<b>EXPENDITURES</b>
1. Labour income	1. Households consumption
2. Financial transfers (from government)	2. Housing investment
3. Other income	3. Income tax (on gross wages)
4. Transfers (from abroad)	

The balance of revenues and expenditures contributes to the net financial assets of the sector. The households adjust their consumption expenditures to these accumulated assets and to their disposable incomes. Consumption expenditure depends on the distribution of disposable income, since households' consumption is much more influenced by regular incomes than by more volatile ones. In the short run, the consumption of households is also affected by the difference from the trend of net borrowing to income ratio. Besides consumption expenditures and income tax payments, households may also make housing investments and then accumulate their remaining wealth.

### 4.1.3 Corporations

The corporations produce value added using the production factors and technology. They can ensure by changing their capacity utilisation that the supply meets the demand. In the long run, the corporations meet the demand using a given technology with full capacity utilisation and adjust their capital and labour needs to that. In the model the output gap is the difference of the actual and potential output.

The revenue and expenditure sides of corporate balance sheet are the following:

<b>REVENUES</b>	<b>EXPENDITURES</b>
1. Gross profit	1. Corporate investment
	2. Changes in inventories
	3. Interest payment to the government
	4. Interest payment to the foreigners
	5. Dividend and interest payments to households
	6. Other corporate taxes

The corporations pay gross wages for labour supplied by households. They also pay employer's social contribution. The rest of corporations' income is subject to profit tax and other corporate taxes. The result is the gross profit on the revenue side in the corporate balance sheet. The corporations have a financial intermediary role as well: they reallocate financial resources (net savings) and incomes among the sectors. In order to finance the working capital need of corporations and the government as well, they draw capital from households and from abroad, thus they redistribute interest payments after net financial wealth of the sectors.

### 4.1.4 Foreign sector

The foreign sector is linked to the domestic economy through three channels: foreign trade, foreign debts accumulated by the sectors and EU transfers to the private and government sectors. The balance sheet of foreign sector is the following:

<b>REVENUES</b>	<b>EXPENDITURES</b>
1. Interest earnings	1. Net export
	2. Net transfers to government
	3. Net transfers to private sector

The following figure presents the connections and the income flows between the four sectors of the model:





## 5 Sensitivity analysis

This chapter describes the impact assessment of the following shocks:

1. Income tax
2. Income transfer
3. Employer's social contribution
4. Corporate profit tax
5. Government investments
6. Nominal interest rate
7. External demand

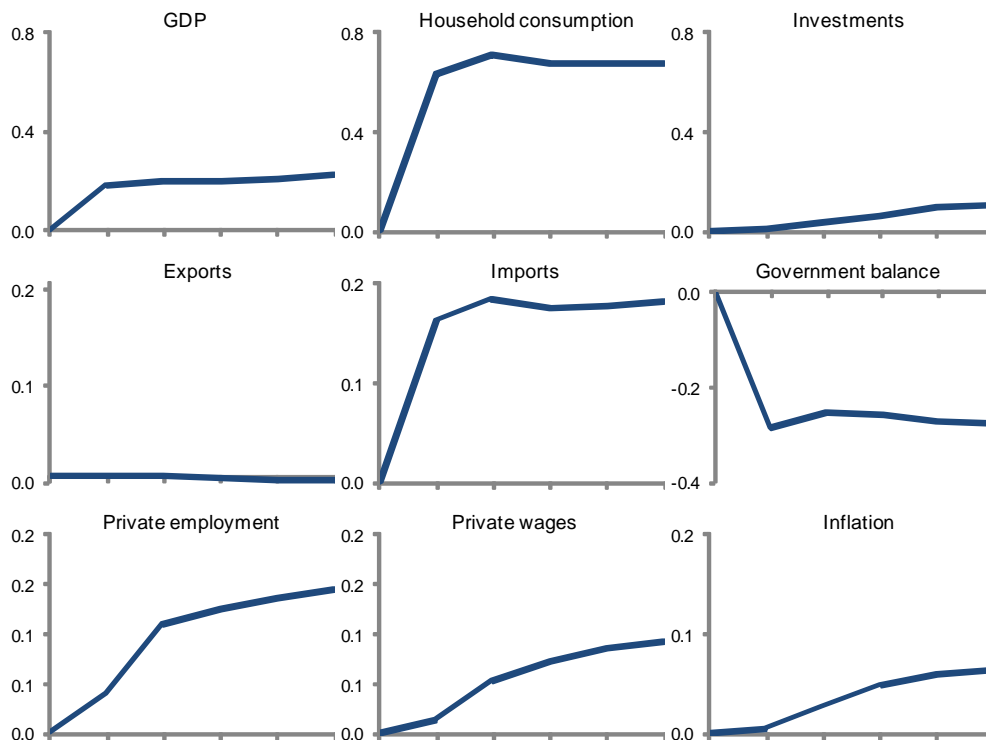
The effects of above shocks are presented as a difference from the baseline scenario. In this section the figures of the impulse response functions illustrate the development of households' consumption, investment, export, import, inflation, employment and wages in the competitive sector, as well as the balance of public finances in percentage of GDP. In the case of GDP, households' consumption, investment, export, import and employment in the competitive sector the impulse response functions show the difference from the baseline scenario in percentage. In the case of wages in the competitive sector, inflation and the balance of public finances the year on year differences in percentage points are presented. In the figures, the scales of horizontal axis indicate the years following the shock.

In the course of the sensitivity analysis, except for the variable being examined, tax rates, expenditure items of public finances, interests and exchange rate were considered fixed. Rest of the variables are determined endogenously.

## 5.1 Income tax

In this scenario the government reduces permanently by 1 percentage point the effective rate of household income tax. In practice this could mean for instance a change in personal income tax rates.

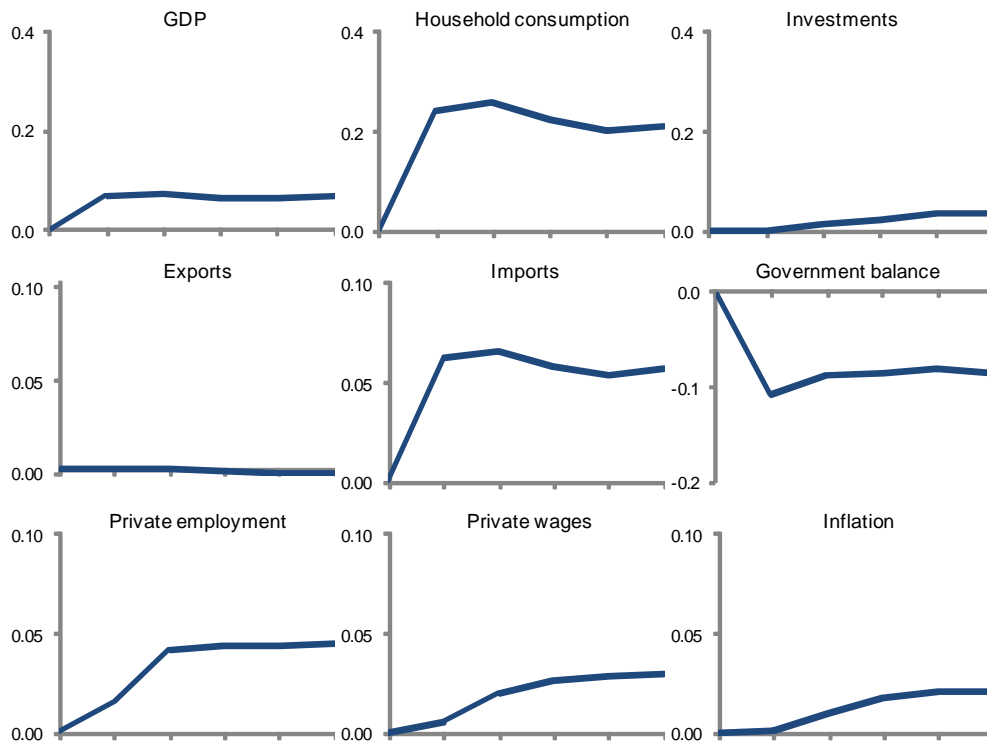
Reducing the tax rates on households' wage incomes increases regular households' incomes, which enhances consumption and as a result the domestic demand will increase. This also means a higher labour demand, which in turn increases both wages and employment enhancing further the households' consumption. The expansion in demand will lead to a positive output gap, which results in rising inflation. Due to the assumption of fixed nominal interest rate this will create a lower real interest rate and consequently expanding investments. As a result of these impacts the GDP will grow. Higher consumption and investment levels also increase import, weakening the trade balance. Due to lower tax revenues the budget balance will be negatively affected in the first period but later this impairment will be reduced simultaneously with the increase in output.



## 5.2 Financial transfer from government

In this scenario the government permanently increases the financial transfers to households by 1 per cent. For example the impact of an increase in pensions or family allowances can be evaluated as a shock of this kind.

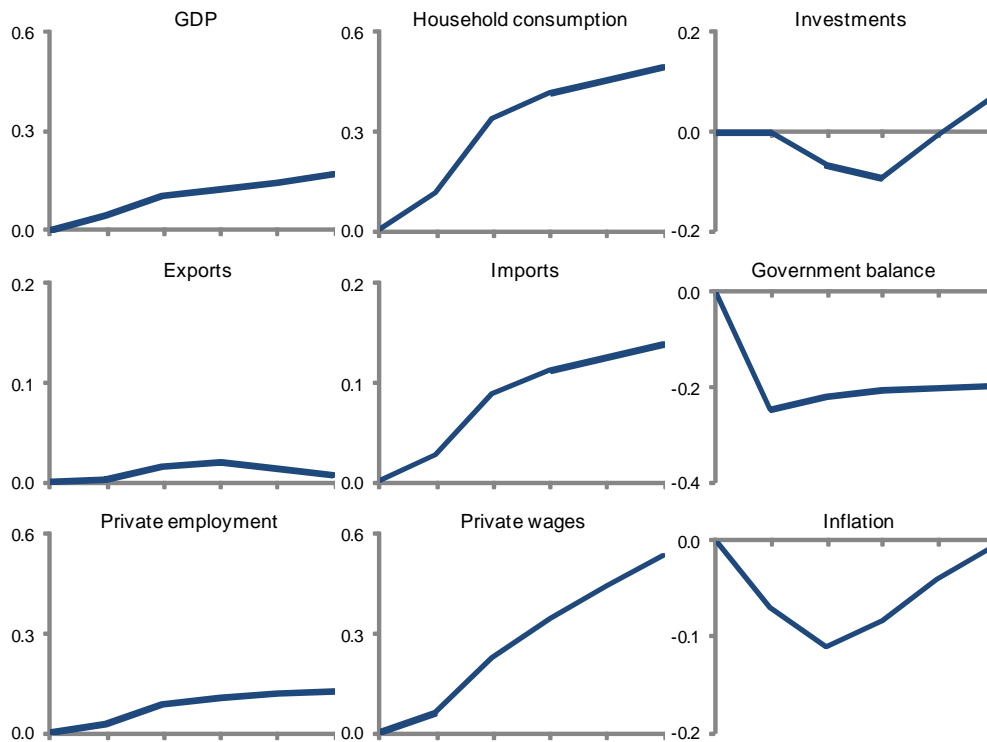
The increase of government expenditure will lead to the increase in domestic demand – primarily in consumption – resulting in enhanced labour market demand, which in turn will boost both wages and employment. Increasing households' income implies a higher consumption and the expanding demand will result in a positive output gap leading to higher inflation. Enhanced demand and investment result in growing import, which will deteriorate the trade balance. On the whole the GDP will permanently grow while the budget balance deteriorates.



### 5.3 Employer's social contribution

This case investigates the effect of a permanent 1 percentage point reduction in the employer's social contribution. Shocking this variable allows for the macroeconomic impact assessment of government measures which aim at mitigating the pressure on companies regarding labour costs. Such measures include for example the targeted reductions of employer's social contribution within the framework of Job Protection Action Plan.

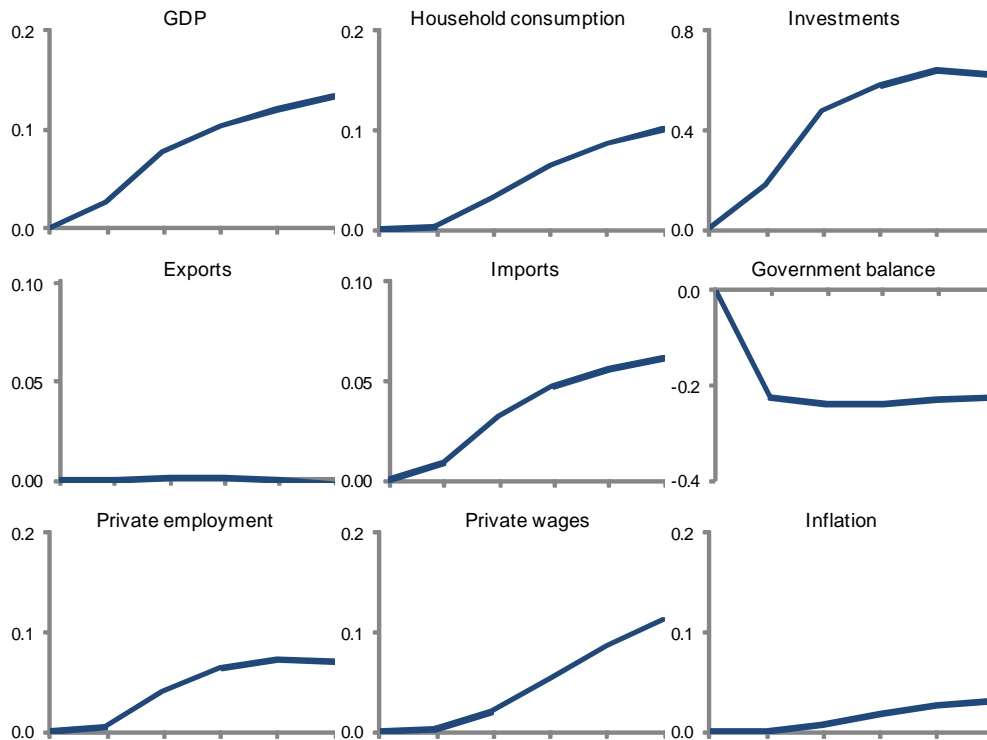
During the shock the employer's social contributions are permanently lower by 1 percentage point. As a result of lower costs the labour demand of companies will start growing, which projects a permanently higher employment rate and better wage dynamics. As a result of the increased wages and salaries, households' consumption expenditure will grow supporting the economic boost through the enhanced domestic demand.



## 5.4 Corporate profit tax

In this scenario the government reduces the effective tax rate on companies' profit by 1 percentage point.

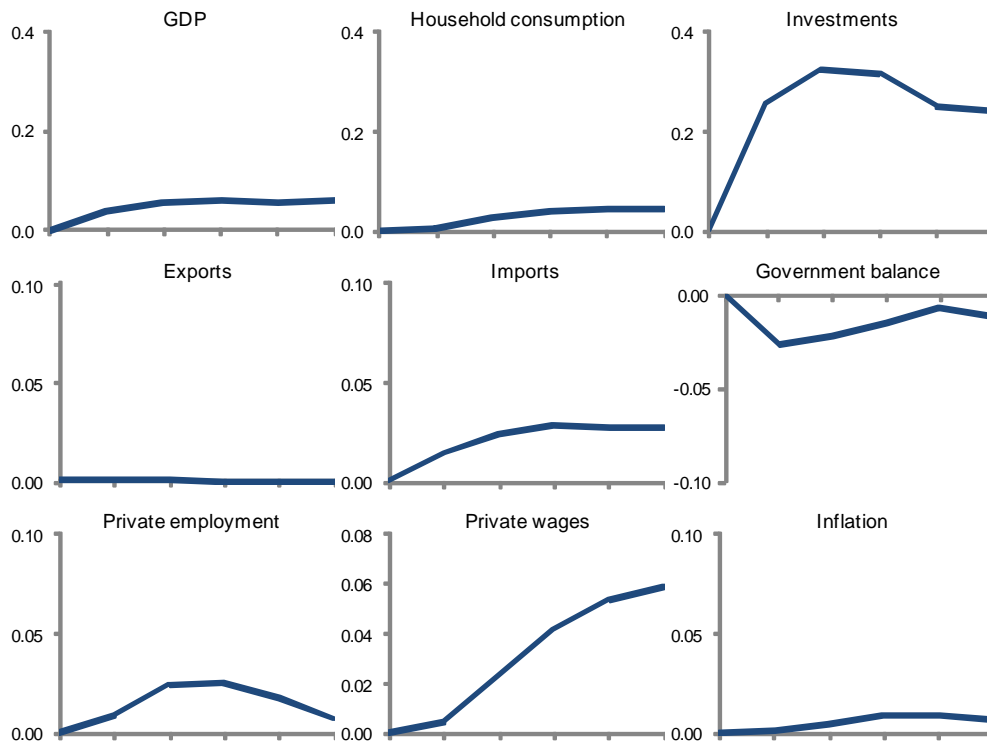
Due to the tax reduction corporate investments will increase in line with the higher return on capital invested in the production. As a result of the increased capital stock, labour market demand and thus the wages and employment also grow. Growing households' income implies higher consumption, which in turn leads to a positive output gap and increases inflation. Higher consumption and investments imply an expansion in imports, which in the long run deteriorates the trade balance. On the whole, the GDP will permanently grow while the budget balance deteriorates.



## 5.5 Government investments

In this scenario the government investments increase by 1 percentage point permanently.

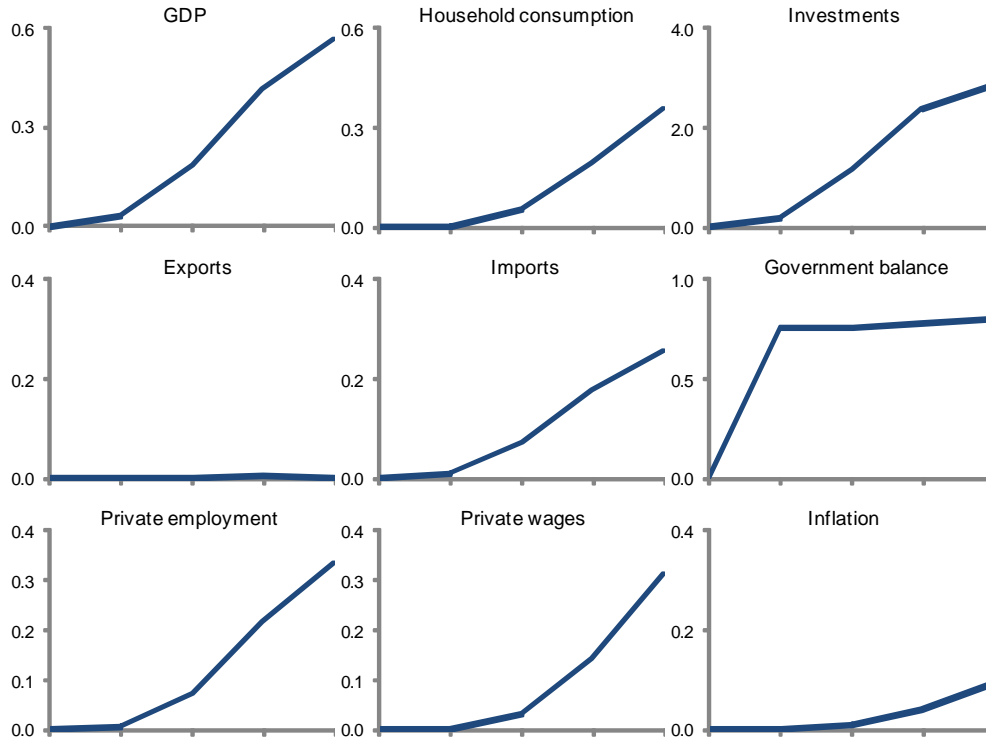
The permanently higher level of government investments enhances the total investments. As a result of the high import need of investments and the unchanged export performance, the net export will decrease. In the course of implementing new projects the government will create several new jobs, which increases the number of employees and consequently the wages in both the private and public sectors. Although the budget deficit to GDP ratio increases due to the investment spending, as a result of enhanced consumption and investments the economic performance of the country will significantly improve in the short run, while in the middle run the GDP will grow in the wake of the capacity-expanding investments.



## 5.6 Interest rate

In this scenario the impact of a 100 base point reduction of country risk premium is quantified. In the course of this simulation, the reduction in the yields is completely reflected in domestic yields, thus the exchange rate will remain the same due to the interest parity.

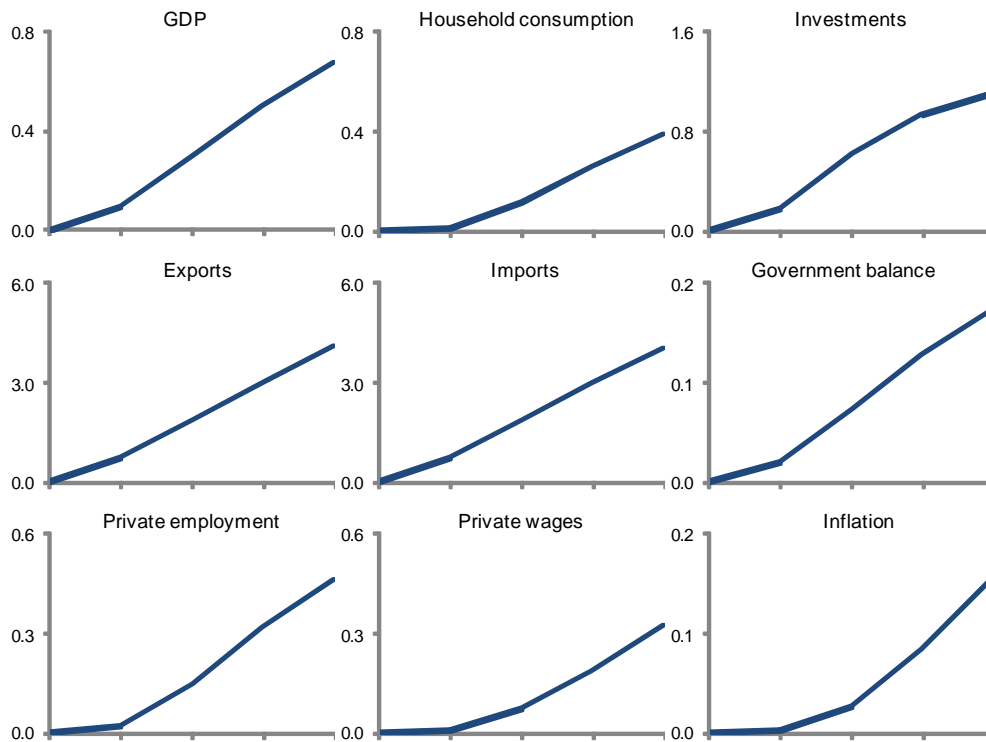
The yield reduction provides cheaper access to resources, thus the investment activity of companies will pick up, increasing labour demand. The impact also appears in households' consumption through enhanced employment and wages. The import need of investments and the increasing domestic consumption result in a deteriorated trade balance. In addition growing demand will slightly increase inflation. On the whole, the GDP is expected to increase permanently and the budget balance will also improve due to reduced interest costs and higher tax revenues.



## 5.7 External demand

In this scenario a more dynamic boost in external demand is quantified where the external economic activity is dynamised by 1 percentage point faster.

As a result of increased external demand, export prospects are improved, i.e. the export of the country expands. As the import content of exported goods is significant, the import will also grow. Thanks to the improving economic prospects profit expectations become also more favourable, which prompts the companies to expand their production factors. Consequently, on the one hand, the labour demand of corporate sector will increase, which means improved employment and wages. On the other hand, the investment activity of companies will also pick up. As a result of higher real wages the consumption also grows. On the whole, the volume of GDP and simultaneously the budget deficit to GDP ratio decrease while inflation rises.





## Bibliography

Annicchiarico, B. et al. (2013): IGEM: A Dynamic General Equilibrium Model for Italy. Working Papers. Ministry of Economy and Finance, Department of Treasury. WP No. 4, April. ISSN 1972-411X

Benedek Dóra–Lelkes Orsolya (2005): A magyarországi jövedelem újraelosztás vizsgálata mikroszimulációs modellel, PM Kutatási füzetek 10. szám, 2005. január

Bergin, A. et al. (2013): The Hermes-13 Macroeconomic Model of the Irish Economy. ESRI Working Papers. The Economic and Social Research Institute, WP No. 460, July.

Bíró Anikó–Elek Péter–Vincze János (2007): Szimulációk és érzékenységvizsgálatok a magyar gazdaság egy középmezőre-tű makromodelljével, Közgazdasági Szemle, LIV. évf., 2007. szeptember

Boscá, J. E. et al. (2010): A Rational Expectations Model for Simulation and Policy Evaluation of the Spanish Economy, SERIEs. Spanish Economic Association, vol. 1(1), pp. 135-169, March.

Clements, M. (1995): Rationality and the Role of Judgement in Macroeconomic Forecasting. The Economic Journal, március, Vol. 105. No. 429. pp. 410–420.

Dudek, S. et al. (2012): eMPF Econometric Model of Public Finance. MF Working Paper Series. Ministry of Finance, Republic of Poland, WP No. 14, June.

Fildes, R.–Stekler, H. (2002): The state of macroeconomic forecasting. Journal of Macroeconomics, 24. pp. 435–468.

Horváth Ágnes – Horváth Áron – Krusper Balázs – Várnai Tímea – Várpalotai Viktor (2010): A DELPHI modell. Magyar Közgazdaságtudományi Egyesület Konferencia, 2010, <http://www.mktudegy.hu/files/DELPHImodellVarpalotaiViktor.pdf>

Horváth Ágnes – Horváth Áron – Krusper Balázs – Nobilis Benedek – Várnai Tímea – Várpalotai Viktor (2011): The DELPHI model. Ecomod Konferencia, 2011, <http://ecomod.net/conferences/ecomod2011?tab=downloads>

Kranendonk, H.–Verbuggen, J. (2007): SAFFIER: A Multi-purpose Model of the Dutch Economy for Short-term and medium-term analyses. CPB Document. CPB Netherlands Bureau for Economic Policy Analysis, No. 144, April. ISBN 978-90-5833-318-6

Roeger, W. et al. (2008): Structural Reforms in the EU: A simulation-based analysis using the QUEST model with endogenous growth. European Commission Economic Papers 351., December 2008.

Statistics Denmark (2013): ADAM – a Model of the Danish Economy. ISBN 978-87-501-2056-8

Source of Jedlik Ányos's biography: [http://hu.wikipedia.org/wiki/Jedlik\\_%C3%81nyos](http://hu.wikipedia.org/wiki/Jedlik_%C3%81nyos)

## Technical appendix

In this section the model equations are presented. The following notations are applied. The time indices of model variables are neglected except for lags (or leads). It means that if there is no time subscript in a particular equation then each variable applies to the same time period. In general, not only model variables but parameters also can vary over time. The values of time invariant parameters are defined in the model. In most cases, behavioral equations are written in error correction form, where  $X^*$  denotes the long run value of variable  $X$ .

Some of the behavioral equations are calibrated, others are estimated. Under the estimated scalars the value of t-statistics are shown in square brackets. In the case of equations containing estimated parameter(s) the figures of fitting are also presented. The dynamic behaviour of these equations is illustrated by partial impulse response functions, where the horizontal axis represents quarters, thus the development of defined variable is observed during five years after the shock.

### A Supply side

Value added is produced in corporate and government sectors. The private potential output is the potential output of the corporate sector ( $YP$ ). It is pinned down by a Cobb-Douglas type production function:

$$YP = TFP \cdot KG_{-1}^{\alpha_G} \cdot KC_{-1}^{\alpha_E} \cdot EPTR^{1-\alpha_E}, \quad (\text{A.1})$$

where  $KG_{-1}$  and  $KC_{-1}$  are end of previous period government and private capital stocks, respectively.  $TFP$  is the level of the technology.  $EPTR$  is the equilibrium number of employed in the private sector set by the number of trend of active population determined by demography ( $LFTR$ ), by the equilibrium unemployment rate ( $UTR$ ) and by the equilibrium ratio of employed in private sector to total employment ( $EPRATIO$ ):

$$EPTR = (1 - UTR) \cdot LFTR \cdot EPRATIO. \quad (\text{A.2})$$

Potential output of the government sector is set by accounting identity (analogous to one describing the actual output of government sector):

$$YG^* = \frac{G\_COMP^* + INC\_KG^*}{PYG}, \quad (\text{A.3})$$

where  $G\_COMP^*$  and  $INC\_KG^*$  are compensation of employee in the government sector and amortization of government capital stock at current prices.  $PYG$  is the deflator of value added of the government sector. The equilibrium value of compensation of employees in

government sector is an exogenously given fix proportion to private potential output:<sup>4</sup>

$$G\_COMP^* = \gamma_{COMP} \cdot \frac{PYP \cdot YP}{\frac{PYP \cdot YP}{PY \cdot Y}}, \quad (A.4)$$

where  $\frac{PYP \cdot YP}{PY \cdot Y}$  is the private value added to total value added ratio in equilibrium,  $PYP$  is the deflator of the private value added, thus expression  $\frac{PYP \cdot YP}{PY \cdot Y}$  is the potential GDP at current prices.  $\gamma_{COMP}$  is the proportion of the nominal GDP spent on compensation of employees.

The equilibrium amount of amortization of government capital stock is:

$$INC\_KG^* = \delta_{INC\_KG^*} \cdot KG_{-1} \cdot PGI, \quad (A.5)$$

where  $\delta_{INC\_KG}$  is the amortization rate of government capital for accounting purpose.

The total potential output at factor prices ( $YP\_TOT$ ) is the chain-weighted average of the potential outputs of the two sectors:

$$YP\_TOT = \frac{PYP\_CHAIN \cdot YP + PYG\_CHAIN \cdot YG^*}{PY\_CHAIN} + \frac{PC\_CHAIN \cdot \frac{TAX\_VAT}{PC}}{PY\_CHAIN}, \quad (A.6)$$

where  $PYP_{CHAIN}$ ,  $PYG_{CHAIN}$  and  $PY_{CHAIN}$  are the chain index of private, government and total value added (GDP), respectively.

Using the potential and actual outputs the private, government and total output gap measures are calculated as it follows:

$$GAP\_PRIV = \frac{YPD}{YP} - 1 \quad (A.7)$$

$$GAP\_GOV = \frac{YG}{YG^*} - 1 \quad (A.8)$$

$$GAP = \frac{YP\_TOT}{YD} - 1. \quad (A.9)$$

## B Factor demand

### B.1 Labor demand (employment)

Equation (A.1) determines the potential output of the private sector. However actual output is pinned down by actual aggregate demand (see equation (N.11)). Therefore actual demand for factors is affected by actual output. The equilibrium private employment ( $EP^*$ ) is labor input needed to match actual output with given technology and accumulated capital stock (inverse

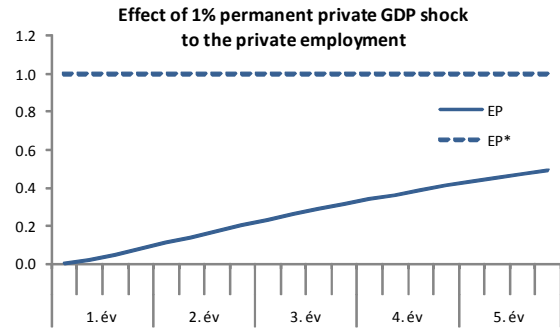
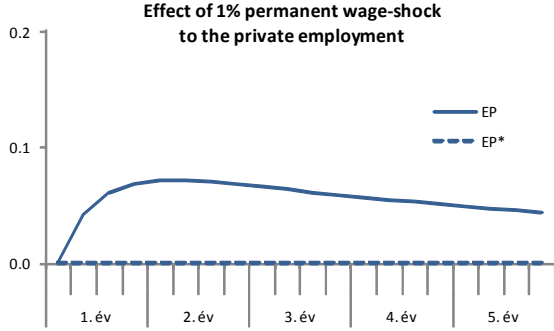
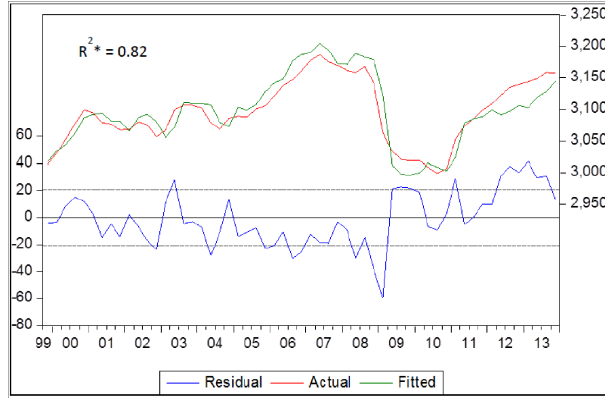
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<sup>4</sup>The reason behind assuming fix proportion in the long run is that the private economy is able to pay only a certain part of its income as tax. Furthermore, only a part of the collected taxes can be spent on compensation of employees.

production function). Actual employment may differ from its equilibrium level:<sup>5</sup>

$$EP^* = \left[ \frac{YPD}{TFP \cdot KG_{-1}^{\alpha_G} \cdot KC_{-1}^{\alpha_E}} \right]^{\frac{1}{1-\alpha_E}} \quad (\text{B.1})$$

$$\begin{aligned} \text{dlog}(EP) = & \underset{[2.85]}{0.400} \cdot \text{dlog}(EP_{-1}) + 0.050 \cdot \text{dlog}(YPD_{-1}) + \\ & + 0.050 \cdot \text{dlog}(YPD_{-2}) - 0.200 \cdot (\log(EP_{-1}) - \log(EP_{-1}^*)) - \\ & - 0.033 \cdot (\log(WP_{-1}) - \log(WP_{-1}^*)), \end{aligned} \quad (\text{B.2})$$



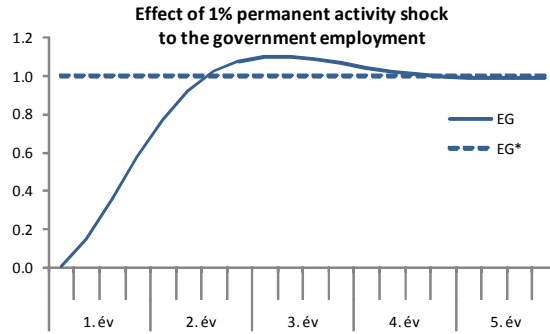
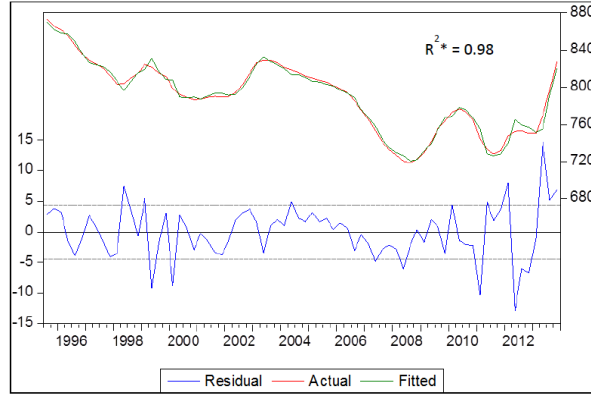
where  $WP$  and  $WP^*$  are the private actual and equilibrium wage, respectively.

The equilibrium employment in the government sector is the difference of number of active people and the equilibrium employment in the private sector:

$$EG^* = LFTR \cdot (1 - UTR) \cdot (1 - EPRATIO TR) \quad (\text{B.3})$$

$$\text{dlog}(EG) = 0.600 \cdot \text{dlog}(EG_{-1}) - \underset{[4.05]}{0.145} \cdot (\log(EG_{-1}) - \log(EG_{-1}^*)). \quad (\text{B.4})$$

<sup>5</sup>It means that we implicitly assume time varying capacity utilization in the model.



Unemployment rate ( $U$ ) is the ratio of total number of employed in private and government sectors to number of active population ( $LF$ ):

$$U = 1 - \frac{EP + EG}{LF}. \quad (\text{B.5})$$

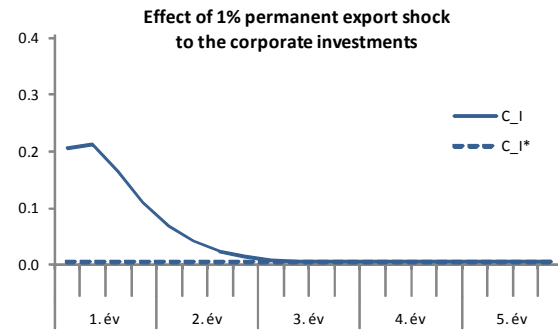
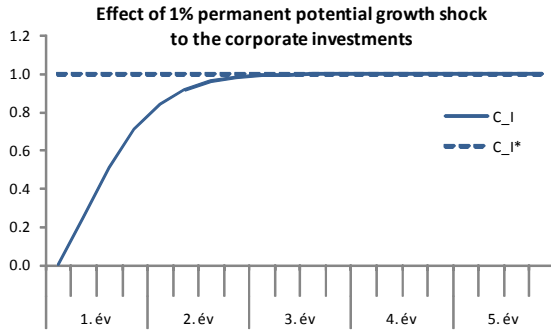
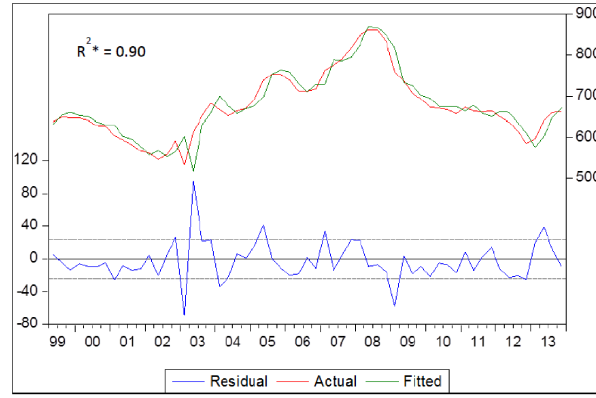
## B.2 Capital demand (corporate investment)

Corporate investment is pinned down by profit maximization of corporations. Investments are subject to adjustment cost, thus the profit maximizing investment ( $CI$ ) depends on the excess rate of return on investment ( $QE$ )<sup>6</sup>, adjustment costs ( $\lambda_{KC}$ ), amortization rate ( $\delta_{KC}$ ) and the growth rate of potential output ( $g_P \equiv \frac{Y_P}{Y_{P-1}} - 1$ ):

$$C_{-I}^* = \left( \frac{QE}{\lambda_{KC}} + \delta_{KC} + g_P \right) \cdot KC_{-1}, \quad (\text{B.6})$$

$$\begin{aligned} \text{dlog}(C_{-I}) &= \text{dlog}(C_{-I}^*) + \underset{[2.21]}{0.290} \cdot \text{dlog}(C_{-I_{-1}}) + \\ &\quad + \underset{[1.20]}{0.200} \cdot \text{dlog}(X) - 0.250 \cdot (\log(C_{-I_{-1}}) - \log(C_{-I_{-1}}^*)) \end{aligned} \quad (\text{B.7})$$

<sup>6</sup>The particular form of  $QE$  is analogous to expressions one can get if assumes present value maximizing firms subject to quadratic adjustment costs. See equation (B.8).



where  $X$  is the export volume.

It is assumed that the price index of private capital equals to that of private investment. Thus, the excess rate of return ( $QE$ ) is a function of after tax marginal product of capital, amortization ( $\delta_{KC}$ ), long run interest rate ( $RL$ ) and the investment risk premium ( $kprem\_hp$ ):

$$QE = (1 - \tau_{PROF}) \cdot \alpha_E \cdot \frac{YP}{KC_{-1}} \cdot \frac{PYP}{PCI} - (\delta_{KC} + RL + kprem\_hp) \quad (B.8)$$

where  $PCI$  is the deflator of corporate investment,  $RL$  is the two-year moving average of the long term interest rate ( $R$ ).

## C Price setting

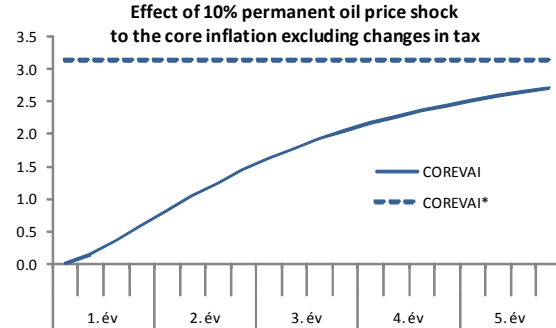
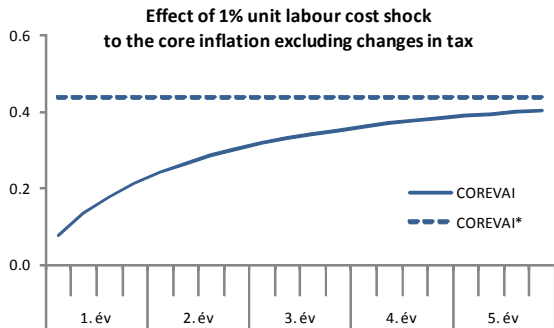
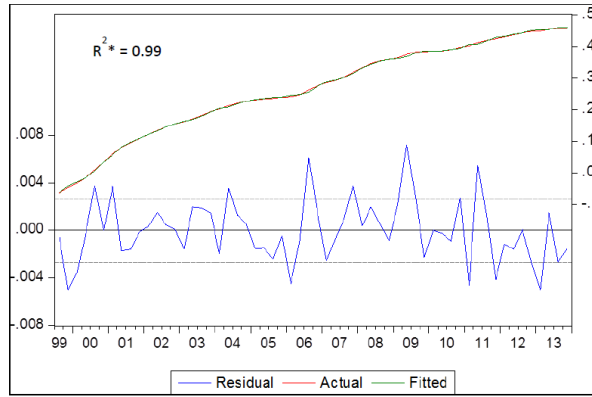
### C.1 Consumer prices

The dependent variable of the Phillips curve is the core inflation filtered from changes in indirect taxes ( $COREVAI$ ). In the long run, core price level is determined by exchange rate ( $NEER$ ), foreign prices ( $PF$ ) and oil price ( $P\_OIL$ ) both expressed in domestic currency, price level of a basket of agricultural goods ( $P\_MG$ ) and unit labor cost ( $ULC$ ). As a consequence of this cost based approach, the Phillips curve is vertical in the long run. In the short run, however, there exists nominal rigidities, thus core inflation is affected by the output gap, the actual growth and

the inflation expectation ( $INF\_EXP$ ):

$$\begin{aligned} \log(COREVAI^*) = & -1.332 + 0.436 \cdot \log(ULC) + 0.063 \cdot \log(P\_MG) + & (C.1) \\ & + 0.323 \cdot \log(NEER) + 0.223 \cdot \log(PF\_EU) + \\ & + 0.035 \cdot \log(P\_OIL) - 0.010 \cdot \\ & \cdot (1 - 0.035 - 0.063 - 0.223 - 0.436) \cdot trend \end{aligned}$$

$$\begin{aligned} d\log(COREVAI) = & \underset{[5.81]}{0.549} \cdot d\log(COREVAI_{-1}) + 0.076 \cdot d\log(ULC) + & (C.2) \\ & + 0.3898 \cdot INF\_EXP + 0.084 \cdot GAP + 0.060 \cdot d\log(YD) + \\ & + 0.0195 \cdot d\log(P\_MG) + 0.016 \cdot d\log(NEER) + \\ & + 0.029 \cdot d\log(PF\_EU) + 0.002 \cdot d\log(P\_OIL) - \\ & - \underset{[3.24]}{0.042} \cdot (\log(COREVAI_{-1}) - \log(COREVAI^*_{-1})) + \\ & + \underset{[5.81]}{0.005} \cdot (1 - 0.002 - 0.0195 - 0.076 - 0.029 - 0.549) \end{aligned}$$



Unit labor cost ( $ULC$ ) is set by the wage cost, employment and output:

$$ULC = \frac{(1.4 + \tau_{SSC}) \cdot WP \cdot EP \cdot \frac{3}{1000000}}{YPD} \quad (C.3)$$

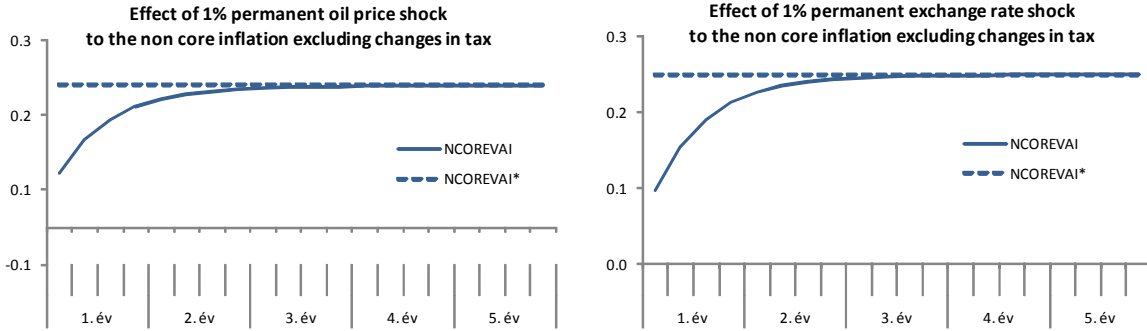
Inflation expectation is a combination of past inflation and the weighted average of actual and target inflation:

$$\begin{aligned} \log(INF\_EXP) = & 0.800 \cdot \log(INF\_EXP_{-1}) + (1 - 0.800) \cdot \\ & \cdot (0.667 \cdot \text{dlog}(CPI_{-1}) + 0.333 \cdot \log((1 + TARGET)^{0.25})) \end{aligned} \quad (C.4)$$

In the long run, price level filtered from indirect tax changes of out-of-core item ( $N\_COREVAI$ ) is pinned down by exchange rate, oil prices, agricultural prices and a residual term ( $P\_NCMISC$ ). The short run dynamics of is affected by dynamics of the previously enumerated variables:

$$\begin{aligned} \log(NCOREVAI^*) = & 0.2495 \cdot \log(NEER) + 0.1896 \cdot \log(P\_OIL) + \\ & + 0.1414 \cdot \log(P\_MG) + 0.669 \cdot \log(P\_NCMISC) \end{aligned} \quad (C.5)$$

$$\begin{aligned} \text{dlog}(NCOREVAI) = & 0.4404 \cdot \text{dlog}(NCOREVAI_{-1}) + 0.0954 \cdot \text{dlog}(NEER) + \\ & + 0.0718 \cdot \text{dlog}(P\_OIL) + 0.0784 \cdot \text{dlog}(P\_MG) + \\ & + 0.4094 \cdot \text{dlog}(P\_NCMISC) - \\ & - 0.1071 \cdot (\log(NCOREVAI_{-1}) - \log(NCOREVAI^*_{-1})) \end{aligned} \quad (C.6)$$



Consumer price index filtered from changes in indirect taxes is the weighted average of the core and the non-core index filtered from changes in indirect taxes:

$$\log(CPIVAI) = 0.656 \cdot \log(COREVAI) + (1 - 0.656) \cdot \log(NCOREVAI) \quad (C.7)$$

Adding the indirect tax change effect ( $VAI\_CORE$  and  $VAI\_NCORE$ ) the results are the core ( $CORE$ ) and non-core ( $N\_CORE$ ) indices:

$$CORE = VAI\_CORE \cdot COREVAI \quad (C.8)$$

$$NCORE = VAI\_NCORE \cdot NCOREVAI \quad (C.9)$$



Consumer price index is the weighted average of the core and the non-core index. Analogously, the effect of indirect tax changes on consumer price ( $VAI\_CPI$ ) is calculated as follows:

$$\log(CPI) = 0.656 \cdot \log(CORE) + (1 - 0.656) \cdot \log(NCORE) \quad (C.10)$$

$$\begin{aligned} \log(VAI\_CPI) &= 0.656 \cdot \log(VAI\_CORE) + \\ &+(1 - 0.656) \cdot \log(VAI\_NCORE) \end{aligned} \quad (C.11)$$

For simulation and forecasting purposes it is assumed that in indirect taxes rates remain unchanged:

$$VAI\_CORE = VAI\_CORE_{-1} \quad (C.12)$$

$$VAI\_NCORE = VAI\_NCORE_{-1}. \quad (C.13)$$

Moreover, the following price indices are prognosticated by a simple rule:

$$P\_OIL = P\_OIL_{-1} \cdot (1 + \pi_F) \quad (C.14)$$

$$PF = PF_{-1} \cdot (1 + \pi_F) \quad (C.15)$$

$$P\_MG = P\_MG_{-1} \cdot (1 + \pi) \quad (C.16)$$

$$P\_NCMISC = P\_NCMISC_{-1} \cdot (1 + \pi), \quad (C.17)$$

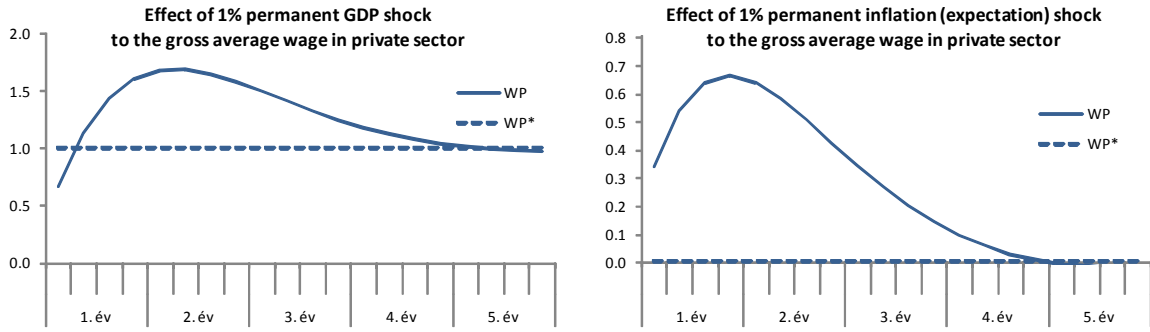
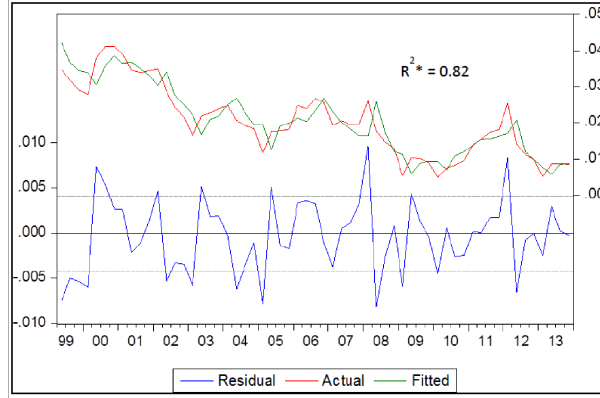
where  $\pi_F$  and  $\pi$  are the foreign and domestic equilibrium inflation rate, respectively. (Foreign inflation is set to annual 2% and domestic inflation is set to annual 3%.)

## C.2 Wages

Real wages cost of employed in the private sector is pinned down by the marginal product of labor in the long run. Due to the employed Cobb-Douglas production function, the wage cost share is a fix share of the output. The gross wage ( $WP$ ) is the wage cost less the social contribution proportion to gross wages (tax rate is  $\tau_{SSCP}$ ). In the short run gross wages are affected by output growth ( $g_P$ ), inflation expectation ( $INF\_EXP$ ).

$$\frac{WP^*}{PYP} \cdot EP = \frac{1 - \alpha_E}{1.4 + \tau_{SSC}} \cdot YPD \cdot \frac{1000000}{3}. \quad (C.18)$$

$$\begin{aligned} \text{dlog}(WP) &= (1 - 0.666) \cdot (\log(1 + g_P) + INF\_EXP) + \\ &\quad \text{[6.53]} \\ &+ 0.666 \cdot \text{dlog}(WP_{-1}) - 0.064 \cdot (\log(WP_{-1}) - \log(WP_{-1}^*)) \\ &\quad \text{[6.53]} \end{aligned} \quad (C.19)$$



The wage bill of employed in the government sector is a fixed proportion of the GDP in the long run:

$$\frac{WG^*}{PYP} \cdot EG = \frac{\gamma_{COMP}}{1 + \tau_{SSC}} \cdot YD \cdot PY \cdot \frac{1000000}{3} \quad (C.20)$$

$$d\log(WG) = (1 - 0.700) \cdot d\log(WG^*) + 0.700 \cdot d\log(WG_{-1}) - 0.075 \cdot (\log(WG_{-1}) - \log(WG^*)) \quad (C.21)$$

## D Monetary policy

As a technical assumption, nominal exchange rate ( $NEER$ ) and interest rate ( $RNOM$ ) remain unchanged:

$$NEER = NEER_{-1} \quad (D.1)$$

$$RNOM = RNOM_{-1}, \quad (D.2)$$

where  $RNOM$  is the 3 month interbank interest rate.

The real interest rate ( $R$ ) is:

$$R = \frac{(1 + RNOM)}{INFD} - 1, \quad (D.3)$$

where  $INF$  is the inflation of the households' consumption deflator:

$$INF = \frac{PC}{PC_{-1}} - 1. \quad (D.4)$$

The long term interest rate ( $RL$ ) is a two-year moving average of the short term interest rate:

$$RL = \sum_{i=-7}^0 R. \quad (D.5)$$

The foreign 3 month interest rate ( $RFNOM$ ) is:

$$RFNOM = RFNOM_{-1}. \quad (D.6)$$

In the model  $RNOM\_GFA$  and  $RNOM\_FFA$  denote the yield of government and foreign debt, respectively:

$$RNOM\_GFA = RNOM + GFA\_PREM \quad (D.7)$$

$$RNOM\_FFA = RFNOM + FFA\_PREM, \quad (D.8)$$

where  $GFA\_PREM$  and  $FFA\_PREM$  are the yield premium of government and foreign debt, respectively.

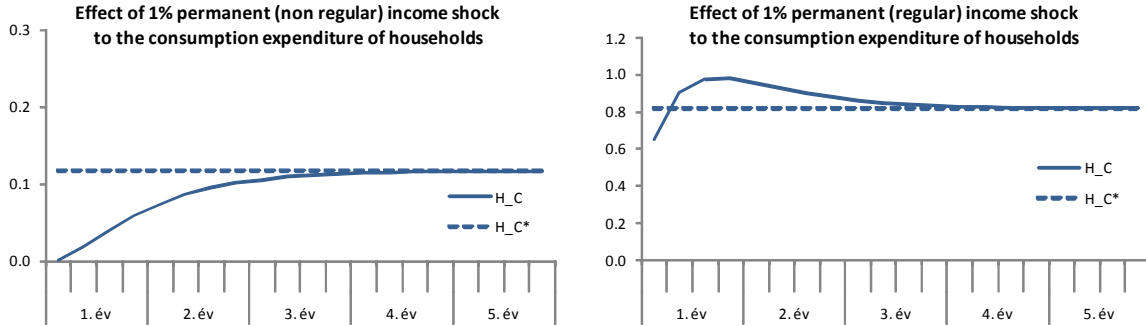
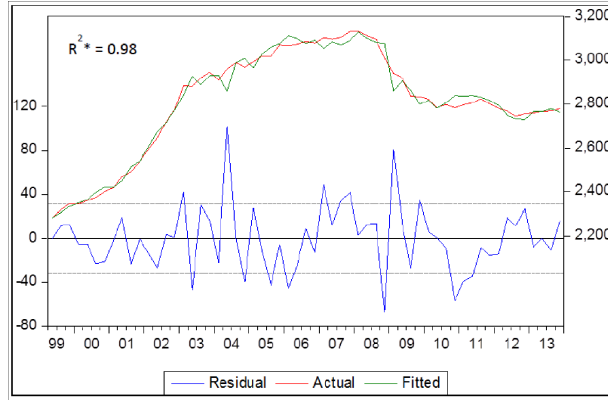
## E Domestic demand

### E.1 Household's consumption

Households' consumption ( $H\_C$ ) depends on disposable income and end of previous period net financial wealth ( $HFA$ ). Consumption reacts almost one to one after a change in net labor income ( $INCLAB - TAXPRIV$ ) or financial transfer ( $G\_FTRAN$ ), however, the reaction is much more restrained after a change in other personal income ( $OPI$ ) or foreign transfer ( $H\_FORTR$ ). In the short run consumption is also affected by the difference of net credit flow to income ratio from the trend ( $CRED\_CYC$ ):

$$\begin{aligned} \log(H\_C^*) = & 0.1499 + \\ & +0.817 \cdot \log\left(\frac{INC\_LAB - TAX\_PRIV + G\_FTRAN}{PC}\right) + \\ & +0.117 \cdot \log\left(\frac{OPI + H\_FORTR}{PC}\right) + \\ & +(1 - 0.817 - 0.117) \cdot \log\left(\frac{HFA_{-1}}{PC}\right) \end{aligned} \quad (E.1)$$

$$\begin{aligned}
\text{dlog}(H\_C) = & \underset{[3.69]}{0.352} \cdot \text{dlog}(H\_C_{-1}) - & (E.2) \\
& -0.171 \cdot (\log(H\_C_{-1}) - \log(H\_C^*_{-1})) + \\
& +(1 - \underset{[3.69]}{0.352}) \cdot \text{dlog}\left(\frac{INC\_LAB - TAX\_PRIV + G\_FTRAN}{PC}\right) + \\
& +0.350 \cdot \left(CRED\_CYC - \left(1 + \underset{[3.69]}{0.352} - 0.171\right) \cdot CRED\_CYC_{-1}\right) + \beta_{H\_C}
\end{aligned}$$



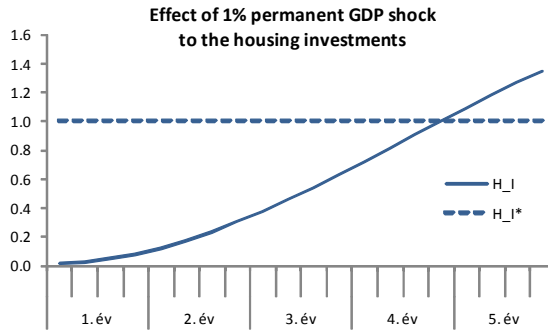
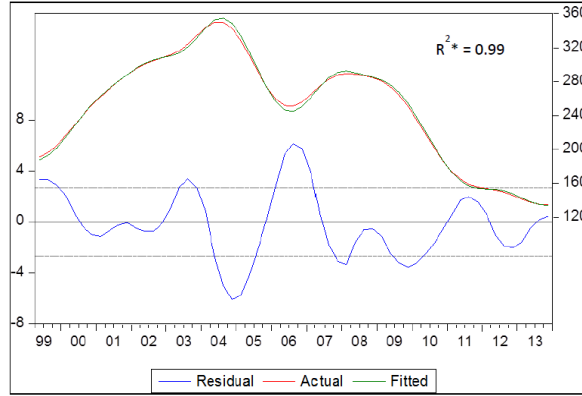
where constant parameter in equation (E.1) ensures the consistency of equilibrium net financial wealth and consumption of the households and  $\beta_{H\_C}$  is a linear trend.

## E.2 Housing investment

Households spend their income on housing investment ( $H\_I$ ) as well. Housing investment augments the housing stock ( $KH$ ). In the long run, housing investment is a fix share ( $\gamma_{H\_I}$ ) of the GDP:

$$H\_I^* = \frac{\gamma_{H\_I}}{PHI} \cdot \frac{PYP \cdot YP}{\frac{PYP \cdot YP}{PY \cdot \bar{Y}}}, \quad (E.3)$$

$$\begin{aligned}
\text{dlog}(H\_I) = & \underset{[27.64]}{0.984} \cdot \text{dlog}(H\_I_{-1}) + \underset{[27.64]}{(1 - 0.984)} \cdot \text{dlog}(H\_I^*) - & (E.4) \\
& -0.011 \cdot (\log(H\_I_{-1}) - \log(H\_I^*_{-1}))
\end{aligned}$$



where  $PHI$  denotes the housing investment deflator.

### E.3 Government consumption

Government consumption ( $G_C$ ) both in real and nominal term is calculated by national account identities. Thus, the value of government consumption is ultimately determined by its component:

$$G_C = \frac{1}{PG\_CHAIN} \cdot \left( YG \cdot PYG\_CHAIN + \frac{G\_MAT \cdot PC\_CHAIN}{PC} \right) + \quad (E.5)$$

$$+ \frac{1}{PG\_CHAIN} \cdot \left( \frac{G\_NAT \cdot PG\_CHAIN}{PG} - \frac{TAX\_CPAY \cdot PG\_CHAIN}{PG} \right),$$

where  $PC$  and  $PG$  are the households' and government consumption deflators, respectively,  $G\_MAT$  denotes the expenditures on goods and services,  $G\_NAT$  is government transfers to households in kind,  $YG\_NOM$  is the value added of the government sector at current prices and  $TAX\_CPAY$  denotes copayments.

### E.4 Changes in inventories

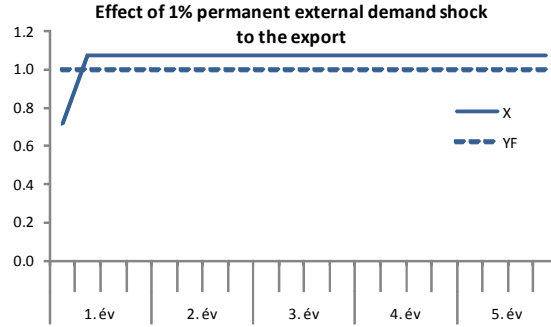
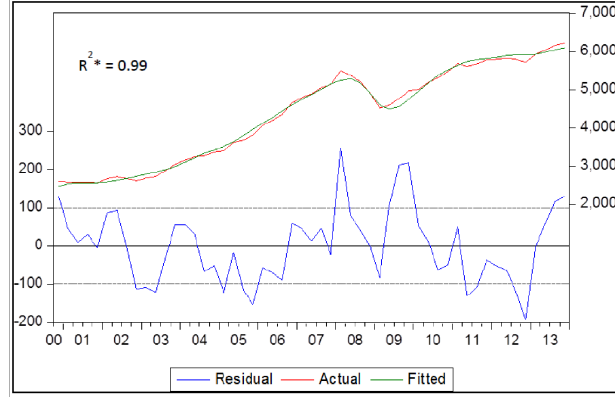
Changes in inventories ( $DS$ ) are a fixed share of the nominal GDP:

$$DS = \phi_{DS} \cdot \frac{PY}{PDS} \cdot YD \quad (E.6)$$

## F International trade

The export volume ( $X$ ) is pinned down by foreign demand and competitiveness:

$$\log(X) = \beta_X + 1.0768 \cdot \sum_{i=-1}^1 \log(YF_i) + 0.200 \cdot RULC\_SMOOTH \quad (F.1)$$

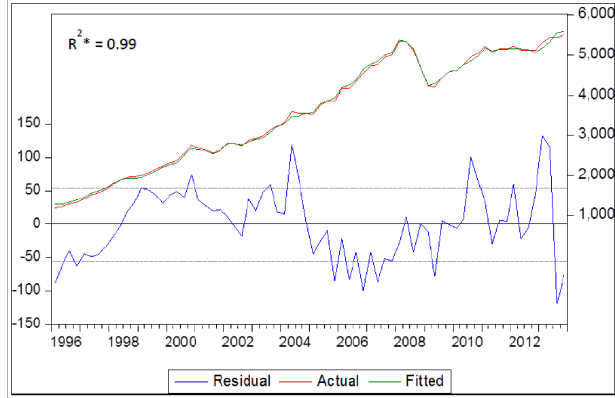


where  $\beta_X$  is a time-varying parameter (quadratic trend),  $YF$  is the foreign demand (in the equation above a centered 3 quarter moving average of the logarithm of foreign demand is used),  $RULC\_SMOOTH$  measures competitiveness which is the 8 quarter moving average of  $RULC$ . Competiveness ( $RULC$ ) is measured as a ratio of foreign price level converted into forint ( $NEER \cdot PF$ ) to private value added deflator ( $PYP$ ):

$$RULC = \frac{NEER \cdot PF}{PYP} \quad (F.2)$$

Import ( $M$ ) is the sum of import content of each demand component:

$$\begin{aligned} M = & \frac{0.529}{[11.59]} \cdot H\_C + \frac{0.429}{[4.61]} \cdot G\_C + \\ & + \frac{0.261}{[7.05]} \cdot ((H\_I + G\_I + C\_I + DS) + \frac{0.894}{[138.49]} \cdot X + \beta_M) \cdot \\ & \cdot \left(1 + \frac{0.112}{[2.60]} \cdot \left(\log(REER\_EQC) - \log\left(PF \cdot \frac{NEER}{PC}\right)\right)\right), \end{aligned} \quad (F.3)$$



where  $\beta_M$  is a time-varying parameter (quadratic trend).

Trade balance is the gap between export and import:

$$NX = X - M \quad (\text{F.4})$$

## G Balance sheet of government sector

In the model the balance sheet of government sector is detailed for the following aspects. On the one hand, it allows that the account of income redistribution is complete. On the other hand, it ensures consistent implementation of the properly detailed relationships between national accounts and the financial accounts of general government sector. Moreover due to this detailed balance sheet it is possible to quantify the effects of different fiscal measures considering the interactions among the variables.

### G.1 Fiscal policy rule

The development of general government balance ( $G\_BAL$ ) defined by several domestic laws and EU directives. However the model contains just a simple fiscal rule for simulation purposes, which ensures on the one hand, the achievement of MTO and on the other hand, the convergence of budget debt to GDP ratio to 50%.

The next equation calculates the government budget balance which is consistent with the mentioned criterias:

$$\frac{G\_BAL^*}{\overline{PY} \cdot YD} = \max \left\{ \overline{D}_{\max}; \left[ \left( \frac{\overline{PY}_{-1} \cdot YD_{-1}}{\overline{PY} \cdot YD} - 1 \right) \frac{GFA_{-1}}{\overline{PY}_{-1} \cdot YD_{-1}} - \frac{GFA\_REVAL}{\overline{PY} \cdot YD} - \lambda_{GFA} \left( \frac{GFA_{-1}}{\overline{PY}_{-1} \cdot YD_{-1}} - \frac{\overline{GFA}}{\overline{PY} \cdot YD} \right) \right] \right\}, \quad (\text{G.1})$$

where  $\overline{D}_{\max}$  is the maximal value of structural budget deficit as a percentage of GDP<sup>7</sup>,  $GFA$  denotes the net financial asset of the government (government debt times -1),  $\lambda_{GFA}$  is the speed of adjustment toward equilibrium government debt (e.g. if government debt to GDP ratio

<sup>7</sup>Current MTO is 1.7%. Structural deficit is pinned down by headline budget deficit corrected by output gap.

( $GFA/Y$ ) is greater (less) than equilibrium  $\overline{GFA/Y}$  ratio, then government spends less (more) on financial transfers).

## G.2 Government incomes

Government collect the following (tax)incomes:

1. Private income tax ( $TAX\_PRIV$ )
2. Social contribution ( $TAX\_SSC$ )
3. Value added tax and excise duties ( $TAX\_VAT$ );
4. Profit tax ( $TAX\_PROF$ )
5. Net other income from corporations ( $TAX\_CREST$ );
6. Copayments ( $TAX\_CPAY$ );
7. Transfers from EU ( $G\_FORTR$ ).

Government levies private income tax on the total gross wage bill ( $INC\_LAB$ ) which is earned in the private sector ( $INC\_LABP$ ) and in government sector ( $INC\_LABG$ ). The private income tax rate is denoted by  $\tau_{PRIV}$ :

$$TAX\_PRIV = \tau_{PRIV} \cdot INC\_LAB. \quad (G.2)$$

Employers have to pay social contribution proportion to gross wage bill. The tax rate of social contribution is  $\tau_{SSC}$  in the private and the government sector:

$$TAX\_SSC = \tau_{SSC} \cdot INC\_LABP + \tau_{SSC} \cdot INC\_LABG. \quad (G.3)$$

The consumption expenditures of the households ( $PC \cdot HC$ ), where  $PC$  and  $H\_C$  are the deflator of and the volume of consumption expenditure, the housing investments ( $PHI \cdot H\_I$ ), the government expenditure on goods and services ( $G\_MAT$ ) and government investments ( $PGI \cdot G\_I$ ) are subject to so called consumption tax ( $\tau_{VAT}$ ) including both value added tax and excise duties:

$$TAX\_VAT = \frac{\tau_{VAT}}{1 + \tau_{VAT}} \cdot (PC \cdot H\_C + G\_MAT + PGI \cdot G\_I + PHI \cdot H\_I). \quad (G.4)$$

Firms' income after paying off wage bills ( $INC\_KC$ ) subject to profit tax.  $\tau_{PROF}$  denotes the effective profit tax rate:<sup>8</sup>

$$TAX\_PROF = \frac{\tau_{PROF}}{1 - \tau_{PROF}} \cdot INC\_KC. \quad (G.5)$$

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<sup>8</sup>Despite of that the excise duties and other taxes on products/subsidies are the part of the gap between the value added of basic and market prices, these items are also classified into the profit incomes.



Income flows between firms and government are captured by variables ( $TAX\_CREST$ ). The value of  $TAX\_CREST$  is proportional to GDP:

$$TAX\_CREST = \tau_{CREST} \cdot PYP \cdot YPD. \quad (G.6)$$

Households pay copayments ( $TAX\_CPAY$ ) for use of common goods. The value of  $TAX\_CPAY$  is proportional to GDP:

$$TAX\_CPAY = \frac{\tau_{CPAY}}{1 + \tau_{VAT}} \cdot PC \cdot H\_C \quad (G.7)$$

The  $1 - \varphi_{FORTR}$  ratio of foreign transfer ( $FORTR$ ) denominated in Euro goes to government expressed in Forint:

$$G\_FORTR = (1 - \varphi_{FORTR}) \cdot NEER \cdot FORTR. \quad (G.8)$$

Total income of the government is the sum of the seven items listed above:

$$G\_INC = TAX\_PRIV + TAX\_SSC + TAX\_VAT + TAX\_PROF + \quad (G.9) \\ + TAX\_CREST + TAX\_CPAY + G\_FORTR.$$

Though, amortization of government capital stock is not listed in financial account of the government, however, it is a part of government value added according to national accounts:<sup>9</sup>

$$INC\_KG = \delta_{INC\_KG} \cdot PGI \cdot KG_{-1} \quad (G.10)$$

### G.3 Government expenditures

The expenditure items of the government are:<sup>10</sup>

1. Compensation of employees ( $G\_COMP$ )
2. Expenditures on goods and services ( $G\_MAT$ )
3. Transfers to households in kind ( $G\_NAT$ )
4. Government investment ( $G\_I$ );
5. Financial transfers to households ( $G\_FTRAN$ );
6. Interest payment after government debt ( $INC\_GFA$ ).

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<sup>9</sup>In accordance with the National Accounts the operating surplus of government consist of the recorded amortization almost entirely, thus in the government sector just marginally profit is generated

<sup>10</sup>In the long run, one item out of six is determined by end of previous period financial wealth of the government ( $INC\_GFA$ ), four items are pinned down by behavioral equations ( $G\_COMP$ ,  $G\_MAT$ ,  $G\_NAT$  és  $G\_I$ ) and finally one item is determined by the fiscal rule ( $G\_FTRAN$ ).

Compensation of employees in the government sector is determined by the number of employed ( $EG$ ) and gross wage ( $WG$ ):

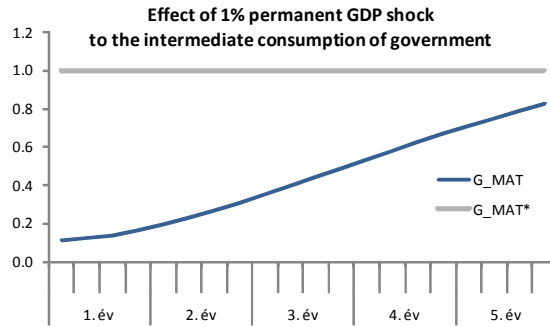
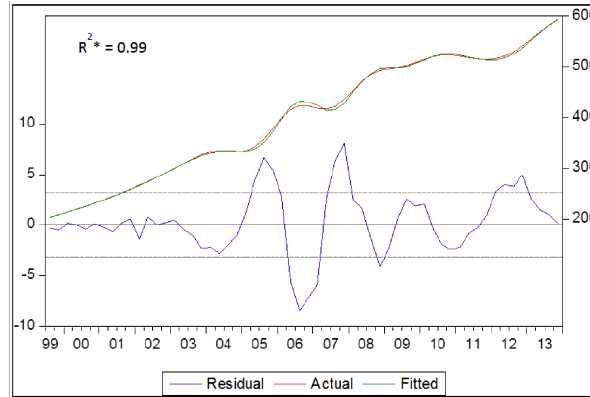
$$G\_COMP = (1 + \tau_{SSC}) \cdot INC\_LABG, \quad (G.11)$$

where  $\tau_{SSC}$  is the social contribution tax rate.

The amount of purchased goods and services is fix share of the GDP in the long run, short run dynamics gradually adjust to long run equilibrium:

$$G\_MAT^* = \gamma_{GMAT} \cdot PY \cdot YD \quad (G.12)$$

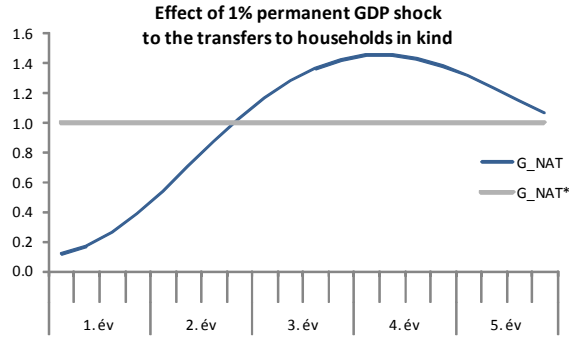
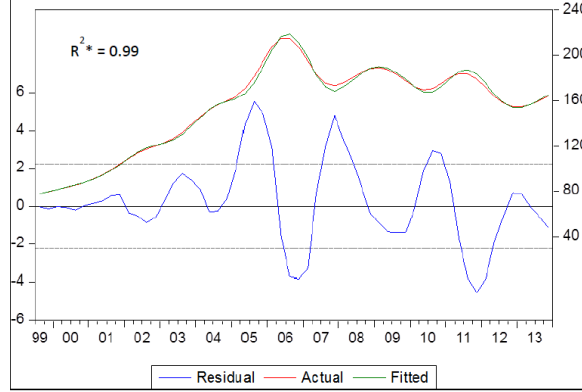
$$\begin{aligned} \text{dlog}(G\_MAT) = & \underset{[20.01]}{0.886} \cdot \text{dlog}(G\_MAT_{-1}) + (1 - \underset{[20.01]}{0.886}) \cdot \text{dlog}(G\_MAT^*) - \\ & \underset{[0.98]}{-0.010} \cdot (\log(G\_MAT_{-1}) - \log(G\_MAT^*_{-1})) \end{aligned} \quad (G.13)$$



The amount of transfers to households in kind is a fixed proportion of the GDP in the long run, short run dynamics gradually adjust to long run equilibrium:

$$G\_NAT^* = \gamma_{GNAT} \cdot PY \cdot YD \quad (G.14)$$

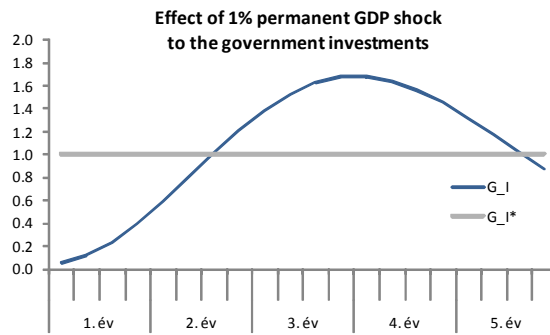
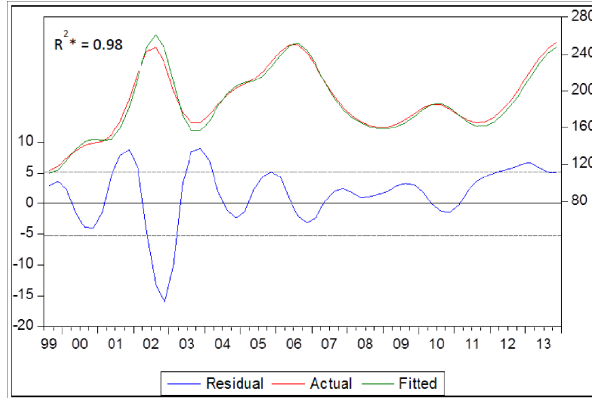
$$\begin{aligned} \text{dlog}(G\_NAT) &= \underset{[17.59]}{0.903} \cdot \text{dlog}(G\_NAT_{-1}) + (1 - \underset{[17.59]}{0.903}) \cdot \text{dlog}(G\_NAT^*) - \quad (\text{G.15}) \\ &\quad - \underset{[4.58]}{0.058} \cdot (\log(G\_NAT_{-1}) - \log(G\_NAT^*)) \end{aligned}$$



Government investment is a fixed share of GDP in the long run ( $\gamma_{G\_I}$ ). Assuming fixed share also means that the government capital stock will also be a fixed share of the GDP ( $\frac{\overline{KG} \cdot \overline{PGI}}{\overline{YD} \cdot \overline{PY}}$ ). In the long run equation of government investment, parameter ( $\lambda_{KG}$  controls the speed of adjustment:

$$G\_I^* = \gamma_{G\_I} \cdot \frac{PY \cdot YD}{PGI} - \lambda_{KG} \left( \frac{KG_{-1} \cdot PGI_{-1}}{YD_{-1} \cdot PY_{-1}} - \frac{\overline{KG} \cdot \overline{PGI}}{\overline{YD} \cdot \overline{PY}} \right) \cdot YP \quad (\text{G.16})$$

$$\begin{aligned} \text{dlog}(G\_I) &= 0.854 \cdot \text{dlog}(G\_I_{-1}) + (1 - 0.854) \cdot \text{dlog}(G\_I^*) - \quad (\text{G.17}) \\ &\quad - 0.107 \cdot (\log(G\_I^*_{-1}) - \log(G\_I_{-1})), \end{aligned}$$



where  $PGI$  denotes the government investment deflator.

Financial transfers to households ( $G\_FTRAN$ ) is determined as a residual of the aimed budget deficit ( $G\_BAL^*$ ), and the other income and expenditure items, thus *this is the control variable of government fiscal rule*. In the short run financial transfers are indexed to inflation:

$$G\_FTRAN^* = G\_INC - G\_BAL^* - G\_MAT - G\_NAT - PGI \cdot G\_I - G\_COMP + INC\_GFA, \quad (G.18)$$

$$G\_FTRAN = G\_FTRAN_{-1} \cdot \frac{CPI_{-1}}{CPI_{-2}} - \lambda_{G\_FTRAN} \left( \frac{G\_FTRAN_{-1} - G\_FTRAN_{-1}^*}{PY_{-1} \cdot YD_{-1}} \right). \quad (G.19)$$

The total expenditure of the government (without interest payment) is the sum of the five items listed below:

$$G\_EXP = G\_MAT + G\_NAT + PGI \cdot G\_I + G\_COMP + G\_FTRAN. \quad (G.20)$$

The interest payment after the net financial asset of the government is ( $INC\_GFA$ ):

$$INC\_GFA = RNOM\_GFA \cdot GFA_{-1}, \quad (G.21)$$

where  $GFA$  denotes the net financial asset of the government,  $RNOM\_GFA$  is the effective interest rate of government debt.

#### G.4 Budget balance

Primary balance of the government is calculated as the balance of total incomes and expenditures (without interest payment):

$$G\_PBAL = G\_INC - G\_EXP. \quad (G.22)$$

Adding the interest payment to primary balance results the total balance:

$$G\_BAL = G\_PBAL + INC\_GFA. \quad (G.23)$$

## H Balance sheet of the households

Personal disposable income of the households ( $PDI$ ) is the sum of gross wage income ( $INC\_LAB$ ) less private income tax ( $TAX\_PRIV$ ), financial transfer from government<sup>11</sup> ( $G\_FTRAN$ ), a certain share of foreign transfer ( $H\_FORTR$ ) and other personal income ( $OPI$ ) from firms. Latter one incorporates interest income of financial asset accumulated by the households:

$$PDI = INC\_LAB - TAX\_PRIV + G\_FTRAN + H\_FORTR + OPI, \quad (H.1)$$

The gross income earned in private and government sector is denoted by  $INC\_LABP$  and  $INC\_LABG$ , respectively, and it is calculated as the product of (average) wage and number of employed<sup>12</sup>. Total gross wage bill ( $INC\_LAB$ ) is a total sum of gross wage bill earned in the private and government sector:

$$INC\_LABP = WP \cdot EP \cdot \frac{3}{1000000} \quad (H.2)$$

$$INC\_LABG = WG \cdot EG \cdot \frac{3}{1000000} \cdot WG\_KORR \quad (H.3)$$

$$INC\_LAB = 1.4 \cdot INC\_LABP + INC\_LABG \quad (H.4)$$

Households get transfers from abroad ( $H\_FORTR$ , which is  $\varphi_{FORTR}$  share of total transfers from abroad ( $FORTR$ ):<sup>13</sup>

$$H\_FORTR = \varphi_{FORTR} \cdot NEER \cdot FORTR. \quad (H.5)$$

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<sup>11</sup>The measure of financial transfers from government is defined by the rules concerning to the budget deficit and debt. (See more details in chapter G Balance sheet of government sector).

<sup>12</sup>Factor  $\frac{3}{1000000}$  corrects the different unit and frequency of labor and wage statistics.

<sup>13</sup>This item is practically the same as the EU transfers.

Personal disposable income finances consumption and housing investment. Unspent income becomes households' saving ( $H\_SAV$ ):

$$H\_SAV = PDI - PC \cdot H\_C - PHI \cdot H\_I. \quad (H.6)$$

## I Balance sheet of the firms

The firms' earned gross profit equals to output less wage bills and it is subject to profit tax:

$$INC\_KC = (1 - \tau_{PROF}) \cdot (YPD \cdot PYP - (1.4 + \tau_{SSC}) \cdot INC\_LABP) \quad (I.1)$$

Corporate sector includes both financial and non financial corporations. Besides its production and investment activities, it accumulates financial wealth ( $CFA$ ) and intermediate capital and capital income among other sectors. The net saving of the firms is:

$$C\_SAV = INC\_KC - TAX\_CREST - PCI \cdot C\_I - PDS \cdot DS - OPI - INC\_GFA - INC\_FFA \quad (I.2)$$

where  $TAX\_CREST$  is the net value of other government taxes and subsidies,  $OPI$  denotes other personal incomes of the households (mainly capital and interest income) paid to households,  $INC\_GFA$  is the interest payment of the government,  $INC\_FFA$  is interest income of foreigners. Firms sets income paid to households ( $OPI$ ) such that it ensures obtaining an equilibrium (exogenously set)  $\left(\frac{CFA}{PY \cdot Y}\right)$  ratio in the long run:

$$OPI^* = \frac{\overline{OPI}}{\overline{PY} \cdot \overline{Y}} - \lambda_{CFA} \cdot \left( \frac{CFA_{-1}}{YD_{-1} \cdot PY_{-1}} - \frac{\overline{OPI}}{\overline{PY} \cdot \overline{Y}} \right) \cdot PYP \cdot YP \quad (I.3)$$

$$OPI = (OPI_{-1} + H\_FORTR_{-1}) \cdot \frac{INC\_LABP}{INC\_LABP_{-1}} - H\_FORTR \quad (I.4)$$

where  $\frac{\overline{OPI}}{\overline{PY} \cdot \overline{Y}}$  is the other personal income share consistent with equilibrium  $\frac{CFA}{PY \cdot Y}$  ratio.

## J Balance sheet of foreign sector

Current account incorporates net export, net income transfers and transfers from abroad (mainly from EU funds)<sup>14</sup>:

$$CA = PX \cdot X - PM \cdot M - INC\_FFA + NEER \cdot FORTR. \quad (J.1)$$

The (interest) income of net foreign financial wealth denominated in Forint is a function of net foreign assets ( $FFA$ ), nominal exchange rate ( $NEER$ ) and foreign interest rate

<sup>14</sup>Transfers from foreign sector include the (net) EU transfers.

( $RNOM\_FFA$ ):

$$INC\_FFA = RNOM\_FFA \cdot NEER \cdot FFA_{-1}. \quad (J.2)$$

It is assumed that transfers from abroad ( $FORTR$ ) to GDP ratio is gradually decreases:

$$\frac{FORTR}{YP \cdot PYP} = 0.900 \cdot \frac{FORTR_{-1}}{YP_{-1} \cdot PYP_{-1}} \quad (J.3)$$

## K Accumulation of stocks

Capital accumulation equations define the investments of firms, households and government. Capital stocks stem from these equations in line with the standard accumulation rule:

$$KC = C\_I + (1 - \delta_{KC}) \cdot KC_{-1} \quad (K.1)$$

$$KH = H\_I + (1 - \delta_{KH}) \cdot KH_{-1} \quad (K.2)$$

$$KG = G\_I + (1 - \delta_{KG}) \cdot KG_{-1}, \quad (K.3)$$

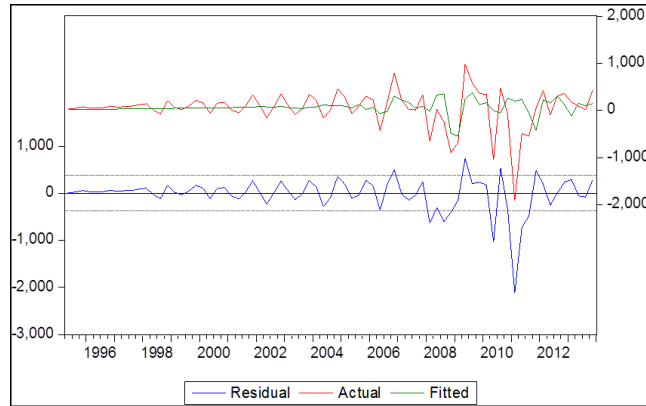
where  $KC$  is the firms' capital stock,  $KG$  denotes the government capital stock and  $KH$  is the housing stock.

Change in net financial wealth of the household ( $\Delta HFA$ ) is the sum of households' saving ( $H\_SAV$ ) and revaluation of previous period financial wealth:

$$\Delta HFA = H\_SAV + HFA\_REVAL, \quad (K.4)$$

where the revaluation term is expressed as a percentage of net financial wealth:

$$\frac{HFA\_REVAL}{HFA(-1)} = 0.007 - \underset{[-3.41]}{0.512} \cdot HFA\_DEV\_RATIO \cdot \frac{\Delta NEER}{NEER(-1)}, \quad (K.5)$$



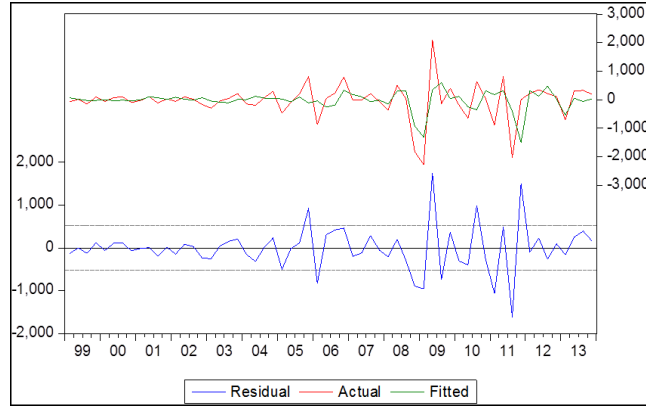
where  $HFA\_DEV\_RATIO$  is the ratio of households' debt denominated in foreign currency relative to their total debt.

Change in net financial wealth of the government (i.e. amount of newly issued government bond) is the sum of actual deficit and the revaluation:

$$\Delta GFA = G\_BAL + GFA\_REVAL, \quad (K.6)$$

where the revaluation term  $GFA\_REVAL$  is expressed as a percentage of net financial wealth of the government:

$$\frac{GFA\_REVAL}{GFA(-1)} = -0.001 + \frac{1.219}{[5.09]} \cdot GFA\_DEV\_RATIO \cdot \frac{\Delta NEER}{NEER(-1)}, \quad (K.7)$$



where  $GFA\_DEV\_RATIO$  is the ratio of government debt denominated in foreign currency relative to total government debt.

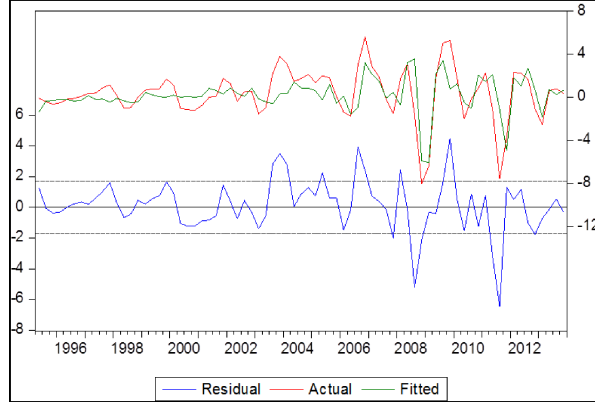
Change in net financial wealth of the rest of the world ( $\Delta FFA$ ) is the sum of current account ( $CA$ ) and revaluation ( $FFA\_REVAL$ )

$$\Delta FFA = -\frac{CA}{NEER} + FFA\_REVAL, \quad (K.8)$$

where the revaluation of the net financial wealth of the foreign sector is:

$$\frac{FFA\_REVAL}{FFA(-1)} = 0.007_{[2.54]} - \frac{0.531}{[-8.20]} \frac{\Delta NEER}{NEER(-1)}. \quad (K.9)$$





Change in net financial asset of corporations ( $\Delta CFA$ ) is the sum of corporate saving and revaluation of previously accumulated asset ( $CFA\_REVAL$ ). Latter term is residual ensuring that the sum of the four sectors' revaluation equals to 0:

$$\Delta CFA = C\_SAV + CFA\_REVAL, \quad (K.10)$$

$$CFA\_REVAL = -NEER \cdot FFA\_REVAL - HFA\_REVAL - GFA\_REVAL, \quad (K.11)$$

where  $FFA\_REVAL$ ,  $HFA\_REVAL$  and  $GFA\_REVAL$  are the revaluations of net foreign, households and government financial asset, respectively.

## L Deflators of demand components

In the DYNAMO model there are two types of deflator: (1) deflators of demand components each set by a behavioral equation, (2) deflators of aggregates (GDP, private and government value added) which are computed as the ratio of proper current price value to chained indexed volume. The second type of deflators is presented in section N.

Consumption deflator is:

$$PC^* = PF \cdot \frac{NEER}{REER\_EQC} \quad (L.1)$$

$$d\log(PC) = d\log(CPI) \quad (L.2)$$

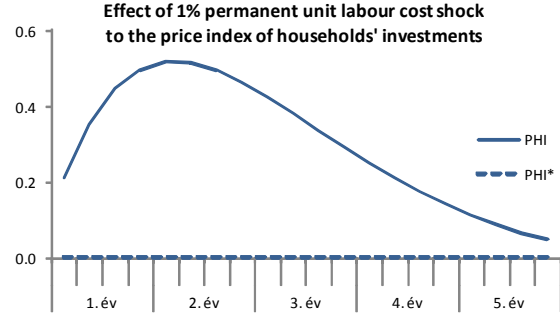
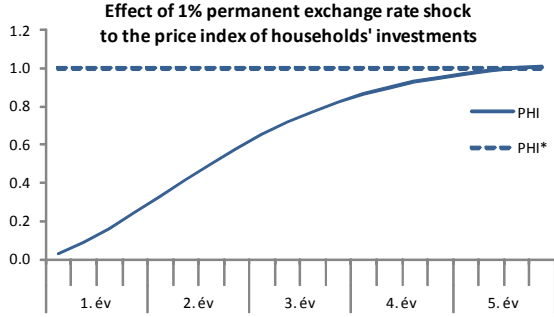
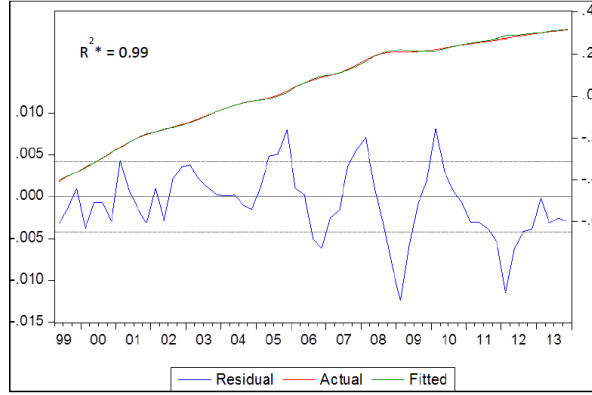
Government consumption deflator is:

$$PG = \frac{(YG\_NOM + G\_MAT + G\_NAT - TAX\_CPAY)}{G\_C} \quad (L.3)$$

Housing investment deflator is:

$$PHI^* = PF \cdot \frac{NEER}{REER\_EQHI} \quad (L.4)$$

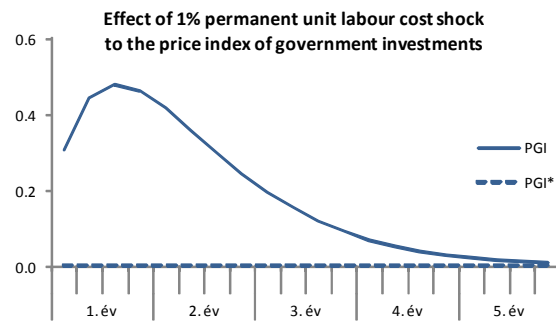
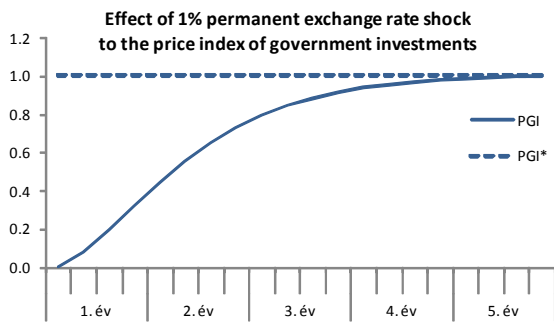
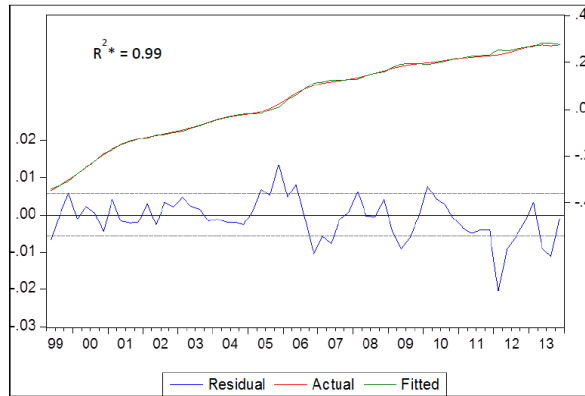
$$\begin{aligned}
d\log(PHI) = & (1 - \underset{[14.25]}{0.730} - 0.029 - 0.206) \cdot \log(1 + \pi) + & (L.5) \\
& + \underset{[14.25]}{0.730} \cdot d\log(PHI_{-1}) + 0.029 \cdot d\log(PF \cdot NEER) + \\
& + 0.206 \cdot d\log(ULC) - 0.035 \cdot (\log(PHI_{-1}) - \log(PHI^*_{-1}))
\end{aligned}$$



Government investment deflator is:

$$PGI^* = PF \cdot \frac{NEER}{REER\_EQGI} \quad (L.6)$$

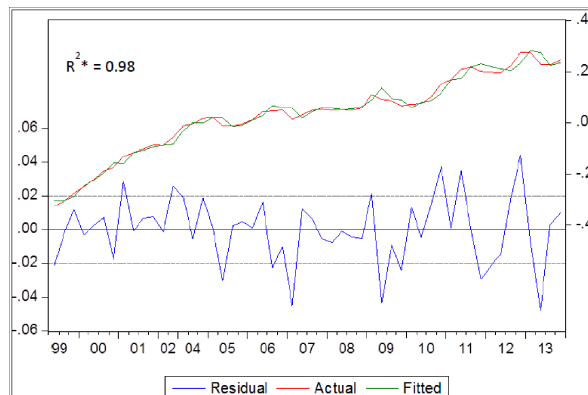
$$\begin{aligned}
d\log(PGI) = & (1 - \underset{[6.86]}{0.535} + 0.007 - 0.302) \cdot \log(1 + \pi) + & (L.7) \\
& + \underset{[6.86]}{0.535} \cdot d\log(PGI_{-1}) - 0.007 \cdot d\log(PF \cdot NEER) + \\
& + 0.302 \cdot d\log(ULC) - 0.080 \cdot (\log(PGI_{-1}) - \log(PGI^*_{-1}))
\end{aligned}$$

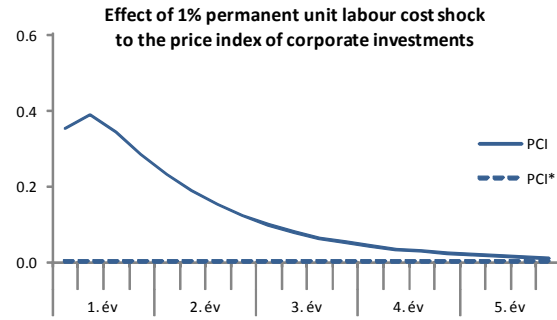
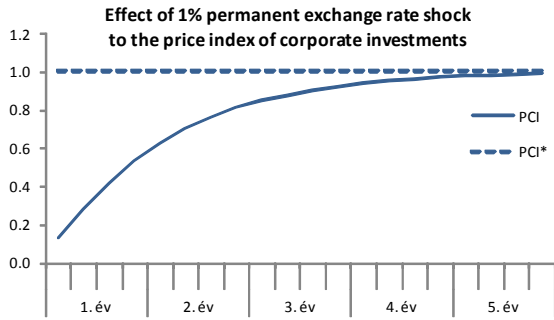


Corporate investment deflator is:

$$PCI^* = PF \cdot \frac{NEER}{REER\_EQCI} \quad (L.8)$$

$$\begin{aligned} d\log(PCI) = & (1 - 0.236 - 0.121 - 0.349) \cdot (1 - d\log(REER\_EQCI) \cdot \log(1 + \pi)) + (L.9) \\ & + 0.236 \cdot d\log(PCI_{-1}) + 0.121 \cdot d\log(PF \cdot NEER) + \\ & + 0.349 \cdot d\log(ULC) - 0.140 \cdot (\log(PCI_{-1}) - \log(PCI^*_{-1})) \end{aligned}$$





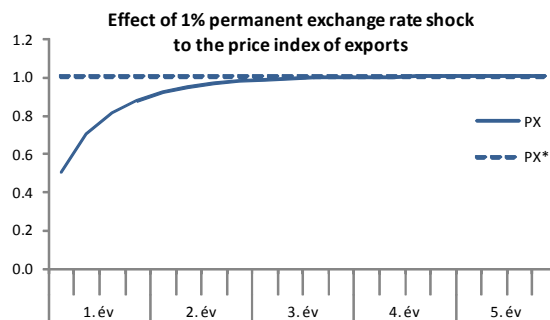
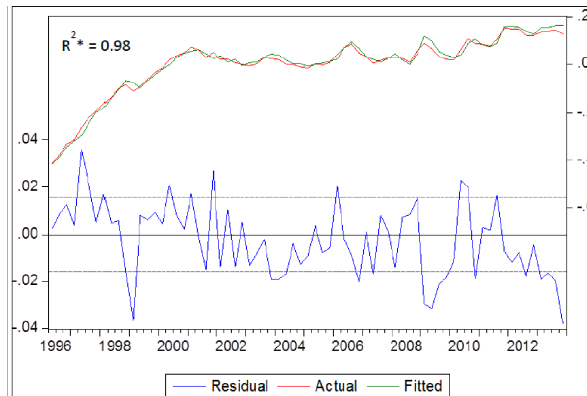
Total investment deflator is:

$$PITOT = \frac{PCI \cdot C\_I + PGI \cdot G\_I + PHI \cdot H\_I}{C\_I + G\_I + H\_I} \quad (L.10)$$

Export deflator is:

$$PX^* = \frac{PF \cdot NEER}{REER\_EQX} \quad (L.11)$$

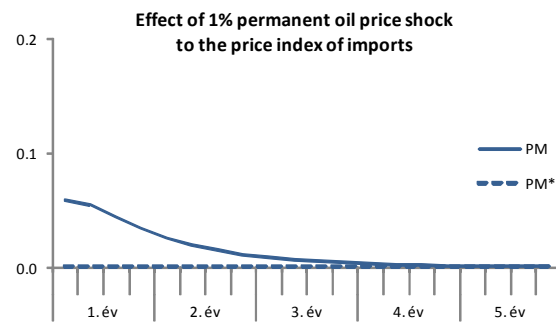
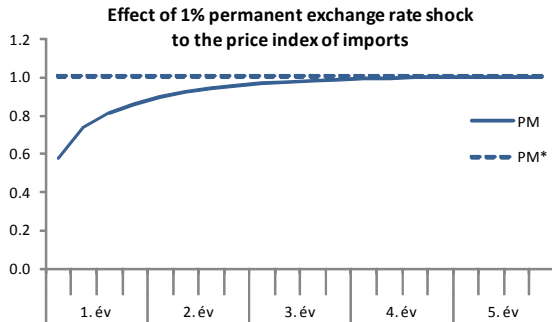
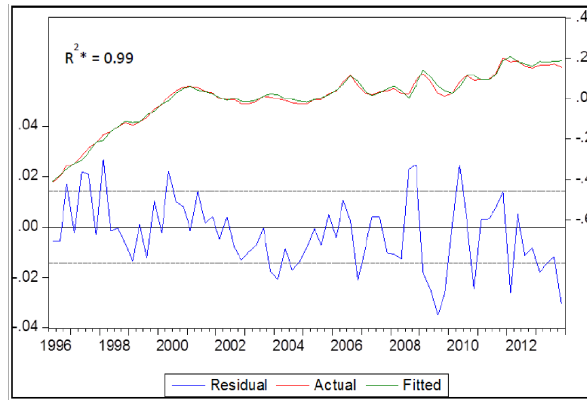
$$\begin{aligned} d\log(PX) = & (1 - \frac{0.128}{[1.80]} - \frac{0.496}{[1.80]}) \cdot \log(1 + \pi) + \frac{0.128}{[1.80]} \cdot d\log(PX_{-1}) + \\ & + 0.496 \cdot d\log(PF \cdot NEER) - 0.270 \cdot (\log(PX_{-1}) - \log(PX_{-1}^*)) \end{aligned} \quad (L.12)$$



Import deflator is:

$$PM^* = PF \cdot \frac{NEER}{REER\_EQM} \quad (L.13)$$

$$\begin{aligned} d\log(PM) = & (1 - 0.130 - 0.510 - 0.059) \cdot \log(1 + \pi) + 0.130 \cdot d\log(PM_{-1}) + \quad (L.14) \\ & + 0.510 \cdot d\log(PF \cdot NEER) + 0.059 \cdot d\log(P\_OIL \cdot NEER) - \\ & - 0.200 \cdot (\log(PM_{-1}) - \log(PM_{-1}^*)) \end{aligned}$$



Changes in inventories deflator is:

$$PDS = PDS_{-4} \quad (L.15)$$

## M Value added at current prices

In the model there are three value added variables. Value added of private and government sector ( $YPD\_NOM$  and  $YG\_NOM$ ) are measured at factor price, while the total value added produced in the economy ( $YD\_NOM$ ) i.e. GDP is measured at market price:

$$\begin{aligned}
YPD\_NOM &= PC \cdot H\_C + PCI \cdot C\_I + PGI \cdot G\_I + PHI \cdot H\_I + & (M.1) \\
&+ PDS \cdot DS + PX \cdot X - PM \cdot M + G\_MAT + \\
&+ G\_NAT - TAX\_CPAY - TAX\_VAT
\end{aligned}$$

$$YG\_NOM = G\_COMP + INC\_KG \quad (M.2)$$

$$\begin{aligned}
YD\_NOM &= PC \cdot H\_C + PG \cdot G\_C + PCI \cdot C\_I + PGI \cdot G\_I + & (M.3) \\
&+ PHI \cdot H\_I + PDS \cdot DS + PX \cdot X - PM \cdot M.
\end{aligned}$$

## N Chain indexation

### N.1 Chain indices

To replicate national account aggregation chain indexing is used to calculate GDP from its components. To do so the following chain indices are calculated:

$$PC\_CHAIN = DQ1 \cdot \frac{\sum_{i=-1}^{-4} PC_i \cdot H\_C_i}{\sum_{i=-1}^{-4} H\_C_i} + (1 - DQ1) \cdot PC\_CHAIN_{-1} \quad (N.1)$$

$$PG\_CHAIN = DQ1 \cdot \frac{\sum_{i=-1}^{-4} PG_i \cdot G\_C_i}{\sum_{i=-1}^{-4} G\_C_i} + (1 - DQ1) \cdot PG\_CHAIN_{-1} \quad (N.2)$$

$$PI\_CHAIN = DQ1 \cdot \frac{\sum_{i=-1}^{-4} PITOT_i \cdot I_i}{\sum_{i=-1}^{-4} I_i} + (1 - DQ1) \cdot PI\_CHAIN_{-1} \quad (N.3)$$

$$PDS\_CHAIN = DQ1 \cdot \frac{\sum_{i=-1}^{-4} PDS_i \cdot DS_i}{\sum_{i=-1}^{-4} DS_i} + (1 - DQ1) \cdot PDS\_CHAIN_{-1} \quad (N.4)$$

$$PX\_CHAIN = DQ1 \cdot \frac{\sum_{i=-1}^{-4} PX_i \cdot X_i}{\sum_{i=-1}^{-4} X_i} + (1 - DQ1) \cdot PX\_CHAIN_{-1} \quad (N.5)$$

$$PM\_CHAIN = DQ1 \cdot \frac{\sum_{i=-1}^{-4} PM_i \cdot M_i}{\sum_{i=-1}^{-4} M_i} + (1 - DQ1) \cdot PM\_CHAIN_{-1}, \quad (N.6)$$

$$PY\_CHAIN = DQ1 \cdot \frac{\sum_{i=-1}^{-4} PY_i \cdot YD_i}{\sum_{i=-1}^{-4} YD_i} + (1 - DQ1) \cdot PY\_CHAIN_{-1}, \quad (N.7)$$

$$PYP\_CHAIN = DQ1 \cdot \frac{\sum_{i=-1}^{-4} PYP_i \cdot YP_i}{\sum_{i=-1}^{-4} YP_i} + (1 - DQ1) \cdot PYP\_CHAIN_{-1}, \quad (N.8)$$

$$PYG\_CHAIN = DQ1 \cdot \frac{\sum_{i=-1}^{-4} PYG_i \cdot YG_i}{\sum_{i=-1}^{-4} YG_i} + (1 - DQ1) \cdot PYG\_CHAIN_{-1}, \quad (N.9)$$

where  $DQ1$  is a time series with value 1 in the first quarter of each year and value 0 otherwise.

## N.2 Chain indexed aggregate volumes

The private, government and total value added are aggregated with chain indices. According to the chain indexation rule the actual year chain index can be calculated from previous year deflators, and using actual year chain index one can calculate aggregates for the actual year. Using the actual year aggregates and knowing the actual year aggregates at current prices one can calculate the actual year deflators that can be used to chain indexing for the next year data.

The volume of the government value added ( $YG$ ) is:

$$YG = \frac{PG\_CHAIN \cdot \left( G\_C - \frac{G\_NAT+TAX\_CPAY}{PG} \right) - PC\_CHAIN \cdot \frac{G\_MAT}{PC}}{PYG\_CHAIN} \quad (N.10)$$

The volume of the private value added ( $YPD$ ) is:

$$\begin{aligned}
YPD &= \frac{PC\_CHAIN \cdot H\_C + PI\_CHAIN \cdot I + PDS\_CHAIN \cdot DS}{PYP\_CHAIN} + & (N.11) \\
&+ \frac{PX\_CHAIN \cdot X - PM\_CHAIN \cdot M}{PYP\_CHAIN} + \\
&\frac{PC\_CHAIN \cdot \left(\frac{G\_MAT-TAX\_VAT}{PC}\right) + PG\_CHAIN \cdot \left(\frac{G\_NAT-TAX\_CPAY}{PG}\right)}{PYP\_CHAIN}
\end{aligned}$$

The volume of GDP ( $YD$ ) is:

$$\begin{aligned}
YD &= \frac{PC\_CHAIN \cdot H\_C + PG\_CHAIN \cdot G\_C + PI\_CHAIN \cdot I}{PY\_CHAIN} + & (N.12) \\
&+ \frac{PDS\_CHAIN \cdot DS + PX\_CHAIN \cdot X - PM\_CHAIN \cdot M}{PY\_CHAIN}
\end{aligned}$$

In the previous equations,  $I$  denotes the sum of housing, government and corporate investments:

$$I = C\_I + G\_I + H\_I \quad (N.13)$$

### N.3 Deflators calculated from chain indexed aggregate

The deflators of GDP, private and government value added are the ratios of proper current price values to chain indexed volumes:

$$PY = \frac{YD\_NOM}{YD} \quad (N.14)$$

$$PYP = \frac{YPD\_NOM}{YPD} \quad (N.15)$$

$$PYG = \frac{YG\_NOM}{YG} \quad (N.16)$$

## O Further identities

Taking account the national account identities, the model automatically fulfils some further identities listed below.

Sum of the private and government value added at factor prices and indirect taxes gives the total value added at current market prices (GDP):

$$YD\_NOM = YPD\_NOM + YG\_NOM + TAX\_VAT. \quad (O.1)$$



The value added can be sum up from income side as well:

$$YD\_NOM = INC\_LABP + INC\_LABG + INC\_KC + INC\_KG + \quad (O.2) \\ +TAX\_SSC + TAX\_PROF + TAX\_VAT$$

$$YPD\_NOM = (1.4 + \tau_{SSC}) \cdot INC\_LABP + INC\_KC + TAX\_PROF \quad (O.3)$$

$$YG\_NOM = G\_COMP + INC\_KG. \quad (O.4)$$

Current account equals the sum of the net saving of the domestic sectors:

$$CA = H\_SAV + G\_BAL + C\_SAV. \quad (O.5)$$

Net foreign debt equals the sum of the net financial wealth of the domestic sectors:

$$FFA = -\frac{HFA + GFA + CFA}{NEER}. \quad (O.6)$$

## List of variables

Notation	Description	Type	Equation	Deflator
C_I	Corporate investment	R	(B.6) (B.7)	PCI
C_SAV	Corporate sector's saving	N	(I.2)	
CA	Current account	N	(J.1)	
CFA	Net financial assets of corporations	N	(K.10)	
CFA_REVAL	Revaluation of net financial assets of corporations	N	(K.11)	
CORE	Core inflation	N	(C.8)	
COREVAI	Core inflation excluding changes in tax	N	(C.1) (C.2)	
CPI	Consumer price index	N	(C.10)	
DS	Changes in inventories	R	(E.6)	PDS
EG	Number of employed in government sector (LFS statistics)		(B.3) (B.4)	
EP	Number of employed in private sector (LFS statistics)		(B.1) (B.2)	
EPRATIOTR	Ratio of number of employees in private and government sector	R		
FFA	Net financial assets of foreigners	N	(K.8)	
FFA_REVAL	Revaluation of net financial assets of foreigners	N	(K.9)	
FORTR	Net transfers from abroad	N	(J.3)	
G_BAL	Budget balance	N	(G.1) (G.23)	
G_C	Government consumption	R	(E.5)	PG
G_EXP	Government expenditures (without interest payment)	N	(G.20)	
G_FORTR	Transfers to government from abroad	N	(G.8)	
G_FTRAN	Financial transfers to households	N	(G.18) (G.19)	
G_I	Government investment	R	(G.16) (G.17)	PGI
G_INC	Government incomes	N	(G.9)	
G_MAT	Purchased goods and services	R	(G.12) (G.13)	PC
G_NAT	Transfers to households in kind	N	(G.14) (G.15)	
G_PBAL	Primary budget balance	N	(G.22)	
GAP	Output gap (%)	R	(A.9)	
GFA	Net financial assets of government (= - debt)	N	(K.6)	
GFA_DEV_RATIO	Ratio of foreign currency denominated debt in gov. assets %	R		
GFA_REVAL	Revaluation of the net financial assets of government	N	(K.7)	
H_C	Households consumption	R	(E.1) (E.2)	PC
H_FORTR	Transfers to households from abroad	N	(H.5)	
H_I	Housing investment	R	(E.3) (E.4)	PH
H_SAV	Households saving	N	(H.6)	
HFA	Net financial assets of households	N	(K.4)	

Notation	Description	Type	Equation	Deflator
HFA_DEV_RATIO	Ratio of foreign currency denominated debt in househ. assets %	R		
HFA_REVAL	Revaluation of the net assets of households	N	(K.5)	
I	Total investment	R	(N.13)	PITOT
INC_FFA	Interest earnings of foreigners	N	(G.21)	
INC_GFA	Interest payment of the government	N	(J.2)	
INC_KC	Profit income in private sector	N	(I.1)	
INC_KG	Profit income in government sector	N	(G.10)	
INC_LAB	Total gross labor income	N	(H.2)	
INC_LABG	Gross labor income in government sector	N	(G.11) (H.3)	
INC_LABP	Gross labor income in private sector	N	(H.4)	
INF	Inflation (%)	R	(D.4)	
KC	Capital stock	R	(K.1)	PCI
INF_EXP	Inflation expectation	N	(C.4)	
KG	Government capital stock	R	(K.3)	PGI
KH	Housing stock	R	(K.2)	PH
KPREM_HP	Risk premium (HP trend)	R		
LF	Number of active population	R		
LFTR	Number of active population (trend)	R		
M	Import	R	(F.3)	PM
NCORE	Non core inflation	N	(C.6) (C.9)	
NEER	Exchange rate	N	(D.1)	
NX	Net export	N	(F.4)	
OPI	Other personal income	N	(I.3) (I.4)	
P_OIL	Oil price (Brent in EUR)	N	(C.14)	
PC	Consumption deflator	N	(L.1) (L.2)	
PC_CHAIN	Chain index of households' consumption	N	(N.1)	
PCI	Corporate investment deflator	N	(L.9) (L.8)	
PDI	Personal disposable income	N	(H.1)	
PDS	Changes in inventories deflator	N	(L.15)	
PF	Foreign price level	N	(C.15)	
PG	Government consumption deflator	N	(L.3)	
PG_CHAIN	Chain index of government consumption	N	(N.2)	
PGI	Government investment deflator	N	(L.6) (L.7)	
PHI	Housing investment deflator	N	(L.4) (L.5)	

Notation	Description	Type	Equation	Deflator
PI_CHAIN	Chain index of total investment	N	(N.3)	
PITOT	Total investment deflator	N	(L.10)	
PM	Import deflator	N	(L.13) (L.14)	
PM_CHAIN	Chain index of import	N	(N.6)	
PX	Export deflator	N	(L.11) (L.12)	
PX_CHAIN	Chain index of export	N	(N.5)	
PY	GDP deflator	N	(N.14)	
PY_CHAIN	Chain index of GDP	N	(N.7)	
PYG	Government value added deflator	N	(N.16)	
PYP	Private value added deflator	N	(N.15)	
QE	Excess rate of return on investment (Tobin-q)	N	(B.8)	
R	Real interest rate	R		
REER_EQC	Equilibrium real exchange rate of consumption	R		
REER_EQCI	Equilibrium real exchange rate of corporate investment	R		
REER_EQG	Equilibrium real exchange rate of government consumption	R		
REER_EQGI	Equilibrium real exchange rate of government investment	R		
REER_EQHI	Equilibrium real exchange rate of housing investment	R		
REER_EQM	Equilibrium real exchange rate of import	R		
REER_EQX	Equilibrium real exchange rate of export	R		
RNOM	Interest rate (annualized 3 month interbank rate)	N	(D.2)	
RNOM_FFA	Interest rate on foreign assets	N	(D.8)	
RNOM_GFA	Interest rate on government assets	N	(D.7)	
RULC	Real unit labor cost	R	(F.2)	
TARGET	Inflation target	N		
TAX_CPAY	Copayments	N	(G.7)	
TAX_PRIV	Income tax	N	(G.2)	
TAX_PROF	Profit tax	N	(G.5)	
TAX_SSC	Social contribution	N	(G.3)	
TAX_VAT	Value added tax and excise duties	N	(G.4)	
TFP	Total factor productivity	R		
U	unemployment rate	R	(B.5)	
ULC	Unit labor cost	N	(C.3)	
UTR	Unemployment (trend)	R		
VAI	Price effect of changes in tax	R		
WG	Gross average wage in government sector	N	(C.20) (C.21)	

Notation	Description	Type	Equation	Deflator
WP	Gross average wage in private sector	N	(C.18) (C.19)	
X	Export	R	(F.1)	PX
Y_EU	Output of EU members' average	R		
YD	GDP	R	(N.12)	PY
YF	Foreign demand	R		
YD_NOM	GDP at current prices		(M.3)	
YG	Value added in government sector	R	(A.3) (N.10)	PYG
YP	Potential output in private sector	R	(A.1)	PYP
YP_TOT	Potential output	R	(A.6)	
YPD	Value added in private sector	R	(N.11)	PYP