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ETLA macro model for forecasting and policy simulations

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Abstract

This paper presents a review of a quarterly macroeconomic model built for forecasting and policy simulation purposes at the Research Institute of the Finnish Economy (ETLA). The ETLA model can be labelled as a structural econometric macro model (also known as "SEM" or "policy model" in the recent literature). The ETLA model constitutes of 81 endogenous and 70 exogenous variables and hence at this stage, it is relatively small in size. The model encompasses Keynesian features in the short run, albeit particular attention is paid to its long-term equilibrium properties which are defined from supply side. Owing to these characteristics, its adjustment to external/policy shocks resembles the behavior of New Keynesian DSGE models with sticky prices and wages. The agents of the model are partly forward-looking.

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1. Introduction

This paper presents a quarterly macroeconomic model for the Finnish economy built for forecasting and simulation purposes at the Research Institute of the Finnish Economy (ETLA). The decision of the Research Institute of the Finnish Economy (ETLA) to build a macro model stems from two reasons. First, ETLA is part of the European network of conjuncture institutes whose affiliates are provided with a possibility to use the NiGEM global macro model that is built and sustained at the National Institute for Economic and Social Research (NIESR).[1] Their multi-country macro model, which comprises more than 60 countries, also has a Finnish module as a satellite. However, albeit still capable of producing plausible scenarios for the Finnish economy, the model estimates and part of the specifications are rather old and clearly need for an update. The other reason is more straightforward: to raise the analytical level of forecasting process at ETLA and allow the institute a possibility of producing a range of policy simulations and scenarios for the Finnish economy when needed.

NiGEM with its country entities can be described as a "traditional" econometric model in the sense that it is based on estimation using historical data.[2] This can be said even if particular attention is paid to its long-term equilibrium properties and the model can also accommodate forward looking behavior. These novel properties bring the model, in fact, closer to the New Keynesian DSGE models used at many institutions, especially at central banks. Despite the shared characteristics, NiGEM is not micro-founded in the same way DSGE models are but aims at striking a balance between theory and data.

The ETLA model presented in this paper is primarily planned for as a supportive tool for the forecasting group at the institute. This, together with the fact that the ETLA model is conceived as a complementary tool for the global econometric model (NiGEM), speaks to building an econometric macro model whose parameters are (mainly) estimated using historical data.[3] Nevertheless, much

[1] About NiGEM global econometric macro model, see for instance: https://nimodel.niesr.ac.uk/

[2] These models are also called with a term "SSM" (or "SEM"), Semi-Structural Macromodel in the recent literature, while Blanchard (2017) seems to prefer to using a term "policy model".

[3] It is also planned to link the updated Finnish model, ie. the ETLA model presented here, to this setup of multiple

stress is laid on the steady state, ie. the long-run properties of the model to ensure the theoretical consistency. Even though our strategy cannot avoid the Lucas Critique presented after 1970s, it means building a coherent supply side core of the model which determines the long-run equilibrium paths for the key macro variables implying that the model is able to produce reasonable dynamics also in the long run. That said, the model encompasses Keynesian features in the short run but the economy converges to supply-determined path in the long run.

This type of econometric macro models can be considered as a mix of ’old’ and ’new’.[4] They are still used at a wide range of different institutions: for instance, Hjelm et al. (2015) survey the use of macro models and find that econometric macro models are a conventional tool at several ministries of finance, but they are also used at many independent institutions (such as CPB[5] in the Netherlands and NIESR and OBR[6] in the U.K.) and central banks (e.g. Denmark, the Netherlands, Spain and the USA). Of course, many central banks also have a DSGE macro model and, if possible, they use different models for different policy questions.

With this modeling strategy, the theory of household and firm maximization is used as a guide for the specification of the model equations, that is, to decide the left hand side and right hand side variables in each equation. Thus, in this task, theory is taken seriously, as put by Fair (2015). The equations are, however, not meant to pertain to one individual. Instead, macroeconomic variables are aggregations of huge numbers of micro variables, and the estimated equations are seen to reflect average behavior. As a consequence, Fair (2015) calls the equations in these type of models as approximations of aggregate decision equations. Also, the theory leads to many exclusion restrictions in each equation, and hence lack of identification is rarely an issue.

One of the differences between macro models comes from how the model agents form their expectations. The ETLA model can be solved with forward-looking consumption behavior. In

country models that together comprise NiGEM. Hence at some point, the ETLA model could be a substitute for the Finnish satellite model in the NiGEM.

[4] This is how McAdam and Mestre (2003) describe the AWM macro model developed in the ECB and which bears many similarities with the ETLA model presented here. The AWM macro model is documented in Fagan et al. (2001).

[5] Netherlands Bureau for Economic Policy Analysis

[6] Office for Budget Responsibility

addition, private investments and wage formation are partly forward-looking. Otherwise the model is backward-looking with expectations modelled using the lagged values of interested variables. Thus, the agents in the model are partly forward-looking but nominal rigidities slow the process of adjustment to external shocks. In this sense the parallels with the standard dynamic features of the New Keynesian DSGE macro models are clear to see.

In the ETLA model, the demand must equal supply in the long run. This is captured using the unemployment gap, i.e. the difference between the actual unemployment and NAWRU rate, and the output gap, that keep on putting pressure on prices and wages until the demand and supply are balanced. Naturally, determining these latent variables in a meaningful way is not an easy task. The time series for the Finnish NAWRU is constructed using a state-space Phillips curve model which places a lower weight on the long-term unemployed in line with their weaker ability to influence price and wage dynamics. Also, the estimation period that constitutes of two depressions (first in the beginning of the 1990s' and then after the financial crisis 2009) compels us to somehow control these deep shocks in model equations. As a control, I use a Kalman-filtered dummy variable that is estimated from the technology parameter of the Cobb-Douglas production function. The attained variable can be interpreted as a technology / total factor productivity shock illustrating first the collapse of the Soviet Union and later the shrinking electronic and paper industries. The solution is in line with the practice done in Lehmus (2009) and brings a calibrated element to otherwise (mainly) estimated macro model.

There is still one distinct feature in the ETLA model. In the model, the private value added is divided between the value added of the industrial sector and the rest of the private activities. The former can be seen to describe the open, i.e. export sector of the economy. Even if this division between sectors is rather rough, it enables us to produce some interesting results when introducing selected policy shocks to the economy.

The paper is organized as follows. Section 2 begins with some modeling issues in a context of the evolution of the Finnish economy during last 25 years. After that, the core equations of the model are explained. Section 3 discusses simulation properties of the model and analyzes its dynamic behavior and adjustment to different shocks. The final section concludes.

2. The Model

The ETLA model is a macroeconomic model for the Finnish economy estimated using quarterly data between 1990 and 2016. The model constitutes of 81 endogenous and 70 exogenous variables and hence at this stage, it is relatively small in size. The behavioral equations of the model are estimated with the error correction models (ECM) utilizing the well-known techniques provided by Engle and Granger (1987). The short-run dynamics of the model are definitely Keynesian but while the model has a well-defined supply side its adjustment to external/policy shocks resembles in fact the behavior of New Keynesian (DSGE) models with sticky prices and wages that are nowadays popular in the academic literature.[7]

2.1. A few notes on the Finnish economy

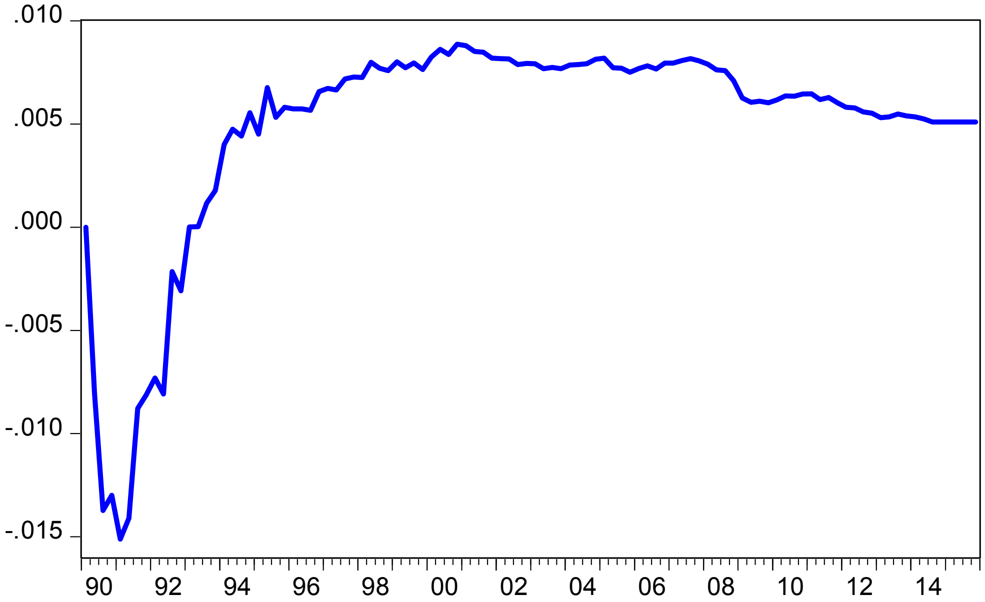
Before explaining the details of the model structure there are some issues in the Finnish economy that need to be addressed. First, the Finnish economy has confronted two deep recessions in the estimation period 1990-2016. The first one, in the beginning of the 1990s', was associated with a combination of negative factors: the overleveraged economy fueled by a rapid deregulation of the financial sector which reached its critical point when asset prices turned down, the monetary policy (supported by pro-cyclical fiscal policy) that maintained imbalances of the economy for too long, and furthermore, the collapse of the Soviet Union that hit the Finnish export sector badly. The other, more recent drama has to do with the financial crisis that began in 2008 and was followed by the euro area aftershocks which in Finland occurred to coincide with more or less structural national factors, namely a shrinking of the electronic sector (that is, Nokia), and also, the paper industries.

To control these particular events, I construct a dummy variable that is estimated from the coefficient of the technology parameter in the Cobb-Douglas production function, using the Kalman-filter. While being in fact the coefficient of a trend variable, the constructed time-variant

[7] The current version of the ETLA model also bears many similarities with EMMA model built at the Labour Institute for Economic Research. EMMA macro model is documented in Lehmus (2009).

variable seems more sensitive to shocks at the beginning of the estimation period. As a consequence, the recession dummy variable looks the following:

Figure 1. Recession(s) dummy variable



Thus, the gained variable is mostly to control the negative shock in the beginning of the 1990s', but to some extent, it also controls the structural problems in the Finnish economy observed in recent years. Later on, this variable is used as a dummy in many model equations. In this, I follow the modeling solution of Lehmus (2009) but now the estimated variable gives some weight to recent years too.

Also, an important variable for the model long-run properties is the NAIRU/NAWRU rate, since it is the difference between that and the actual unemployment rate which defines the unemployment gap in the model. In the ETLA model NAWRU is used as an input in the production function to produce the estimate for the potential output, whose difference from actual output in turn gives the estimate for output gap. Hence in the model, the unemployment gap mimics the output gap.

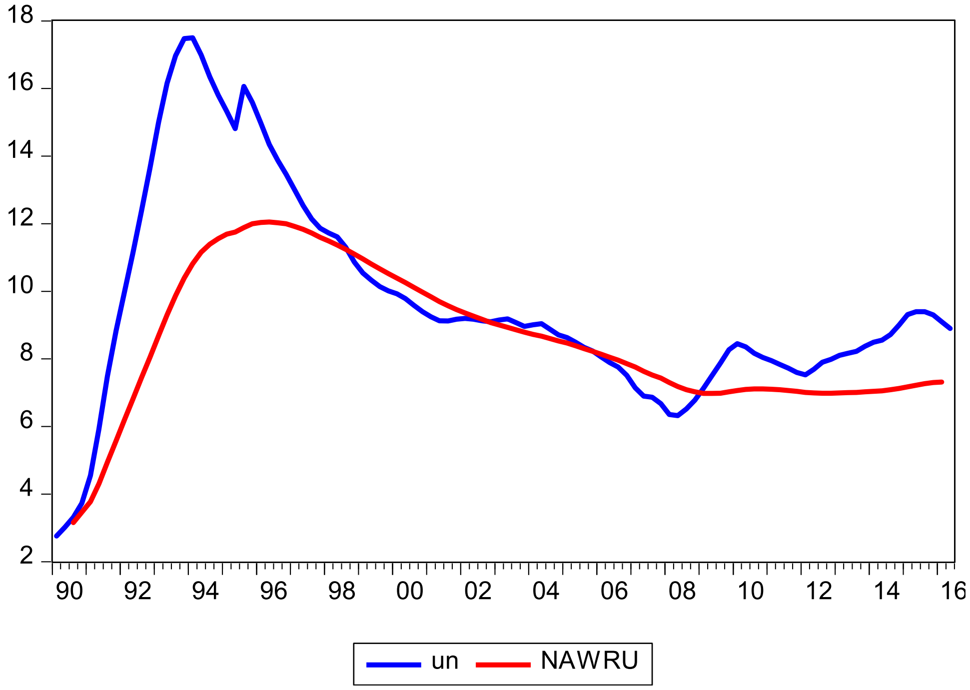
In line with the practice of, for instance, the European Commission, I produce a series for the NAWRU (Non-accelerating wage rate of unemployment) rate that focuses on differences in wages instead of inflation. To construct a series for the Finnish NAWRU, I exploit the idea of Llaudes

(2005) who shows that the NAIRU is more accurately calculated with reference to an unemployment rate which places a lower weight on the long-term unemployed. Thus, I construct the NAWRU using a state-space Phillips curve model which places a lower weight on the long-term unemployed in line with their weaker ability to influence price and wage dynamics. Goldman Sachs (2016) explains this idea by stating that the long-term unemployed have probably little impact on wage formation because: (i) they become discouraged from searching for a job, and consequently are less effective in competing wages downwards; (ii) their human capital is eroded over time leading employers to view long-term unemployment as a negative signal of ability. In both these scenarios the reduced bargaining power of the long-term unemployed leads to restricted influence on wage dynamics.

In this state-space specification for Phillips curve, I start with the standard assumption that changes in wages depend on previous period changes in wages and the gap between the unemployment rate and the NAWRU rate. Hence in this system NAWRU is an unknown variable that needs to be estimated: this is done using the Kalman-Filter.[8] Assessing the weight for the long-term unemployment in this state-space representation is naturally a difficult task. While the estimation results show that that long-term unemployment is not associated with changes in wages but on other hand is related to changes in prices, I simply calibrate the long-term unemployment a weight of 0.5, ie. half of the weight given to other unemployed. This implies that the long-term unemployment has an effect on wage dynamics, but it is rather moderate in magnitude. The Kalman-filtered NAWRU series for Finland finally looks the following:

[8] Here I follow the treatment by Llaudes (2005) by assuming that the standard deviation of the drift component is 0.02, and the signal to noise ratio is 0.04. The coefficient of the gap parameter is initiated from OLS estimation of the Phillips curve that uses only unemployment as an explanatory variable.

Figure 2. Finnish unemployment and the NAWRU estimate



The so called growth accounting method used here constructs an estimate for the potential output from the bottom up, looking at inputs in production function. It is not too far from the way the European Commission calculates it, although their method, particularly the way the potential productivity is computed, sets up another layer of technical complexity into the framework. (see D'Auria et al. (2010)).

2.2. The data

The model is estimated using the Finnish quarterly data from 1990 to 2016. Most of the data come from the quarterly national accounts data provided by the Statistics Finland. Some of the data, mainly the public sector balances and household income accounting are only of a yearly basis, so these are disaggregated to a quarterly level using the (low to high) frequency methods given as a default option in Eviews 9 program.[9] Also, some of the financial data are from the databases of the

[9] One can use either the Denton or simpler constant variable methods.

Bank of Finland, and part of the labor market data use the Ministry of Employment and the Economy as their source.

The foreign demand and the (relative) price levels that are the main factors determining the Finnish exports are built as a satellite block with the help of Excel (in contrast to the core model that uses Eviews). The data for this foreign block are collected from the databases of Eurostat, the OECD and also the World Bank for some developing countries. Among these, Eurostat is the most important data source. Also the Finnish effective tax rate series are based on both the Eurostat and OECD data. Most of the data used in the model are seasonally adjusted by the provider of the data, hence, in most cases by the Statistics Finland. Nevertheless, there are some series that can only be found in a non-seasonally adjusted form. In these cases, I have seasonally-adjusted the series with the Tramo-Seats method, which, in fact, is the method currently routinely used at the Statistics Finland too.

2.3. The model structure

2.3.1. The production function

The ETLA model is relatively aggregated so that there are basically three sectors in the model economy: the private sector, divided into the industrial sector and the other private sector activity, and, the public sector.[10] Before modeling the production for private sector, one needs to construct a quarterly series for the private capital stock. This is done simply by accumulating quarterly private investments to the initial value of the net private capital stock given by the Statistics Finland. The depreciation rate for the capital stock is calculated by matching the accumulated quarterly capital stock to the official yearly value of the net private capital stock as calculated by the Statistics Finland. This ensures the consistency of the model's estimate of the capital stock with the official national accounts number. The production function then produces an estimate for private value added and it looks the following:

[10] I assume that private sector is the residual between total valued added and the public services as defined by the Statistics Finland. As for industrial sectors, I assume them to consist of the sectors B-E defined by the Statistics Finland.

(1) $$VAQP = Ae^{rd*t}L^{\alpha}K^{1-\alpha}$$

Thus, the production function is the standard Cobb-Douglas type, with $VAQP$ symbolizing the private value added, L employed hours in the private sector, and K the net private sector capital stock. With Cobb-Douglas production function, the elasticity of substitution between labor and capital is unity. The factor share of labor (α) is assumed to be 0.65 and hence that for capital, 0.35. The technical development is assumed to be Hicks-Neutral with constant returns to scale (parameter A in (1)).

There is still one distinctive feature in the estimated production function: a variable rd, which is estimated from the coefficient of the trend variable t in the production function. As explained earlier, this variable is a dummy variable used to control the depression at the beginning of the 1990s' and also, to a lesser extent, the structural change due to the melting of the Finnish electronic and paper industries in recent years. It is estimated using the Kalman-filter and as a consequence, it varies in time as depicted in Figure 1. This solution brings a calibrated element to the model while allowing us to achieve more plausible coefficient values in many model equations. In some sense, it also gives more weight to the "structure" of the model.

As mentioned earlier, the private value added is further divided into the industrial sector ("open part of the economy"), and on the other hand, into other private activities (these activities are mostly services).[11] The modeling of these two is not perfectly rigorous but separating these sectors will provide us with some interesting results when simulating policy shocks to the economy later in the paper. First, I estimate an equation for the industrial sector value added in which it is explained by total private value added, the relative share of exports to GDP, and the ratio between the private wages and the trade-weighted average of foreign import prices. According to the estimation, the Finnish industrial activity responds positively to changes in private activity and the exports' share to GDP. On the other hand, the relative wage level in Finland is negatively associated with the industrial activity while it weakens competitiveness of the Finnish exports. Instead, the other private

[11] Roughly speaking, the other private sector activities equals to combined value added of private services, construction, and agriculture.

activities are defined simply as a residual between total private value added and the valued added of the industrial sector.

The Cobb-Douglas production function is in fact a special case of the CES production function with substitution elasticities between factors of production equal to 1.[12] From the CES production function, it is conventional to derive the demands for the factors of production, labor and capital. It gives us the following factor demand equations:

$$\log(K) = c_k + \log(VAQP) - \eta \log(UCC) + \lambda(\eta - 1)t \tag{2}$$

$$\log(L) = c_l + \log(VAQP) - \eta \log(WRQ) + \lambda(\eta - 1)t \tag{3}$$

In these, UCC denotes to (real) user cost of capital and WRQ is the real wage confronted by a producer. The constant terms c_k and c_l are complicated functions of the parameters of the production function. With the Cobb-Douglas function, the elasticity parameter η is equal to 1.

Before modeling investments, we need to build a time series describing the user cost of capital. The variable is based on a concept of real interest rate, but in this model, it also captures the relative prices of investments and hence looks the following:

$$UCC_t = \frac{PI_t}{PQP_t}(R_t - LOG(CP_t - CP_{t-4}) + \delta_t) \tag{4}$$

where PI is the price of private investments, PQP is the price of private value added, R is the government 10-year bond yield, CP is consumer prices, and δ is the depreciation rate for capital. This set-up also makes it easy to add a risk premium to the user cost if necessary (this option is available also in NiGEM). I make an implicit assumption that in normal times there is no spread

[12] CES production function is $Q = Ae^{\lambda t}\left(\alpha K^{\frac{\eta-1}{\eta}} + (1-\alpha)L^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}}$

between the government 10-year bond yield and the interest rates confronted by firms when they borrow money from banks (or markets in general) to finance their investments. Yet the spread is relatively easy to add to this equation for the user cost when needed.

When considering the accumulation of private capital, what we actually model is the private investments. They are explained by one-quarter *lead* of the private value added, thus there is forward-looking element in our investment equation. Implicitly, there is also a forward-looking element in the user cost of capital, since it is the 10-year bond yield that is used in the model equation. Yet using Finnish macro data it is quite difficult to attain a proper user cost of capital elasticity for investment demand that would also be consistent with the Cobb-Douglas elasticities as defined in (2). That may have to do with the zero-lower bound environment and investment slump of recent years in Finland. For that reason, in the simulation mode of the model I use a calibrated UCC elasticity of 0.5 for investments while the forecasting mode utilizes a somewhat smaller, estimated parameter value (0.1).

Thus, the model's investment equation dates back to Jorgenson (1963) but it can also be seen to resonate with Tobin's Q theory that combines the market value of an additional unit of capital to its replacement cost.[13]

In labor demand equation (3), WRQ also includes the employer's payroll tax since it is part of the wage cost for a firm when it hires a worker. Estimation of the real wage (i.e. wages deflated by the private value added prices) elasticity of labor demand gives us a coefficient value of -0.5. This is a rather disputed parameter value, but for instance the meta-analysis by Lichter (2014) finds an average estimate of -0.25 based on as much as 104 empirical studies about the topic. On the other hand, an earlier study by Honkapohja et al. (1999) estimates a real wage elasticity of -0.68 for Finland. On this basis, the estimated elasticity of -0.5 used in the baseline version of the model seems quite plausible. Of course, it is easy to test the sensitivity of the model results to alternative elasticity values too.

[13] See also Chirinko (1993).

While in the model the private sector is split in two, the industrial and the other private activity, I also need to estimate/define labor demands for these separately. In fact, the behavioral equation is only estimated for the industrial sector, while the labor hours in other private sector activities are defined as a residual between total private labor hours defined as in (3) and labor hours in the industrial sector. The estimated specification for the industrial sector labor demand looks like as the equation (3). For the real wage elasticity, now I get a coefficient value of -0.25. Also the estimated coefficient for the value added elasticity of labor demand in industries is smaller than the same parameter in the equation for total private sector. These results seem plausible while it is a well-known fact that the industrial sector is more capital-intensive when compared to the rest of the economy. Also, the gained elasticity for real wage is precisely the same as the average estimate found in the meta-analysis by Lichter (2014).

The model also has an equation for labor supply (in persons). In this type of a model, it defines an upper limit for (potential) employment. It is explained by a convex combination of a measure of working-age population and lagged labor demand. The latter variable is used to describe job opportunities in the labor markets, indirectly measuring attendance to labor force. Also, labor supply is assumed to respond to changes in real wages net of taxes. For this response, the estimated coefficient is modest but still statistically significant.

2.3.2. Consumption and foreign demand

The supply side determines the long-run steady state of the model. The demand-side variables adjust towards the steady state owing to output gap and unemployment gap that affect prices and wages in the model. While the production side is important for the model steady state, most of the short- and medium-run dynamics of the model come from the demand side.

The standard determinants of consumption in the empirical literature are permanent income and wealth. The consumption equation of the model can be solved two ways. First, it can be solved with partly backward-looking agents. That assumption may be useful when the model is used for forecasting purposes. In that case the consumption is modelled as a convex combination of the households' disposable income and wealth and is as follows:

$$(5) \qquad \log(CQ_t) = \alpha \log((Y_{t+4} + Y_{t+3} + \cdots + Y_{t-3})/8) + (1-\alpha)\log(W_t) \quad ,$$

where Y is the households' real disposable income and W denotes to wealth. Hence the permanent income here is compounded of a two-years moving average – one year forward and three quarters backwards - of the households' real disposable incomes. According to this, both the past and expected (future) values for real incomes matter for household consumption. Thus, this variable can be seen as a proxy of a more complete definition for permanent income of households. The model is solved using $\alpha = 0.9$ while estimations seem to give even greater values for this parameter.

Also the wealth variable used in (5) requires few comments. In Finland, household wealth mainly consists of houses that are owned by households. According to the Wealth Study of Statistics Finland (2015), housing comprises 69% of total wealth of the Finnish households. Thus, the constructed wealth variable in (5) is formed as a weighted average of the Finnish house price and stock market indexes, where the housing is weighted by 0.69 and the stock market index by 0.31.[14]

The model can also be solved with a more complete version of forward-looking consumption equation. In this mode, it is assumed that half of the agents react to changes in the value of the constructed wealth variable while the other half responds to changes in their quarterly income. The latter group is regarded as liquidity constrained in the literature. In this mode, the wealth is determined as a negative function of the expected long-term real interest rates. The idea behind this is a (negative) relation between expected interest rates and house prices (which is the most important component in the household wealth).

[14] I use the real price index for old apartment buildings; the stock market series is the HEX index (recently changed to OMX).

While the Finnish economy is relatively open with nominal exports comprising 38% of the GDP (in 2015), careful modeling of foreign block is needed. The dynamics of exports and imports are explained with the combination of demand and price (competitivity) variables. To model the foreign demand for Finnish exports, I construct a variable that is a trade-weighted average of GDP of the 22 most important countries for Finnish exports. Also, I need a relevant real exchange rate variable to quantify the effect of relative price levels, describing the price competitiveness of the export sector, on Finnish export volumes. To capture this, I construct another variable that is a trade-weighted average of the exchange rate-adjusted import prices of the same 22 countries. The gained exchange rate- and trade weight-adjusted import price variable is then compared with the Finnish export prices. Hence finally, I get the export demand equation that looks the following:

$$(6) \qquad \log(XQ) = \alpha \log(PX/PWI22) + \gamma \log(X22) + \eta\,(RD) \quad ,$$

where PX is the domestic export price level, $PWI22$ is the trade-weighted and exchange rate-adjusted average of import prices of the 22 most important countries for Finnish exports, and $X22$ is the trade-weighted GDP of these same 22 countries. RD is the dummy to control the depression at the beginning of the 1990s' and to some extent, recent years too. Estimating (6) gives the price elasticity of export demand (α) a value of 0.6. There is no consensus about the value of this parameter but the estimated coefficient is however not in contradiction with previous literature (see for instance, IMF (2015)).

Imports are modelled as a convex combination of domestic and export demand. The latter is relevant here while the export industries also use imports as inputs in their production. When the domestic demand increases, part of it is directed to imports, which explains the domestic demand term in the equation. Imports are also explained by their relative prices, ie. their prices with respect to domestic consumption prices. This gives us:

$$(7) \quad \log(MQ) = \alpha \log(CQ + IPQ + GQ) + (1-\alpha)XQ + \theta\left(\frac{PM}{PC}\right) \quad ,$$

where CQ is the private consumption, IPQ private investments, GQ public consumption, and XQ is exports. The price elasticity of import demand consists of import prices (PM) divided by private consumption prices (PC).

2.3.3. Prices and Wages

Building the price block of the model becomes necessary while the variables determining GDP on the demand and supply side need to be expressed both in real and nominal values. In order to eliminate arbitrage possibilities, prices are based on the law of one price. This implies static homogeneity, and hence, the long-run price equations are modelled in terms of relative prices. The relative prices are typically expressed as linear combinations of domestic and foreign prices. Wages are then linked to other prices of the model. The wage equation is based on the idea of New-Keynesian Phillips curve but it incorporates some elements from trade union wage bargaining too.

As for domestic prices, the variable used in many model equations is value added prices. As for a reference of foreign prices, I use the variable constructed for (6), that is the trade-weighted and exchange rate-adjusted average of import prices of the 22 most important countries for Finnish exports ($PWI22$). The output gap and unemployment gap are also utilized as explanatory variables in some price equations to capture the idea that also supply side factors generate inflationary pressures. Also, these variables ensure that demand cannot deviate from supply in the long-run solution of the model.

Private value added prices are positively associated with nominal private wage cost (including employer's payroll tax) but negatively affected by productivity. This implicates that increases in productivity tend to lower domestic price level. As well as all the other behavioral equations of the model the price equations are modelled as error correction models whose estimated coefficient values are presented in Appendix 1.

The model equation(s) for wages needs some further attention. First, the model splits the private wages in two variables that are modelled separately: the standard private wage rate index and on the other hand, the wage drift, which is the difference between actualized private wage rate and the standard private wage rate index. The standard private wage rate index is explained by next-period prices and the unemployment gap. In this sense, it resembles the New-Keynesian Phillips curve in which wages depend on expected inflation and output gap (keep in mind that in the ETLA model unemployment gap is a central element defining the output gap). In addition, it is assumed that higher labor taxes push pressure on wages, since trade unions try to compensate the increases in taxes borne by employees in the wage negotiations. At least up to now, wages in Finland have been negotiated in a relatively concentrated system combining trade unions and employer organizations.[15] Finally, the private wage rate index is explained by private productivity while real wage should in theory correspond to marginal productivity of labor. Hence the long-run relation for the private wage rate index looks the following[16]:

$$(8) \quad \log(PWS_t) = \alpha \log(PC_{t+1}) + \beta(UGAP_t) + \gamma \log(1-\tau_t) + \eta \, log(PROD_t) + \theta(RD_t)$$

When estimating (8), I need to calibrate the parameter values of α and η to achieve reasonable coefficient estimates for the tax wedge and unemployment gap. Thus, it is assumed that $\alpha = 0.85$ and $\eta = 0.45$. In fact, these are pretty close to initially estimated parameter values from data. For the labor tax (wedge) elasticity (γ) of private wages, estimation gives a value -0.3.[17]

The wage drift is in turn explained with productivity and unemployment rate. According to the estimation when unemployment goes down and there is an upturn in the economy, wage drifts tend to increase. For the productivity elasticity of wage drift, estimation gives a value 0.33. There is also a behavioral equation for public sector wages included in the model, although that relation is rather straightforward. The public sector wages are modeled to follow private sector wages, but they are yet negatively associated with movements in output gap. This indicates that during booms private wages tend to increase more than public sector wages, which is quite an intuitive outcome.

[15] This feature may change in the future while it seems that wages will be negotiated more and more at the firm level.
[16] Again, variable RD is used in the equation to control the deep (structural) shocks.
[17] One ought to remember that this is in logarithmic terms.

2.3.4. Public sector and household income formation

At this stage, there is no disaggregation of the public sector in the ETLA model, hence the government, the municipalities, the pension funds, and the social security funds are calculated together to form the public sector. The public sector of the model mainly constitutes of identities. However part of the public sector identities look like behavioral equations while there are also estimated relationships for many public sector variables. Yet the residual series gained from estimation are added to the equations in order to make the right hand side of the model equal to the left hand side. For instance, the model equation for corporate tax revenues collected by public sector looks the following:

$$(9) \quad \text{TAXCOR} = c + \alpha(tax_c CORBASE) + RES\_TAXCOR \quad .$$

In this, tax_c is the effective tax rate for corporate income and $CORBASE$ is the corporate income tax base. Constant c and parameter α are estimated from data. RES_TAXCOR is the estimated residual series that closes the equation. Of course, building the public sector block aims at analyzing questions concerning public deficit and debt. To demonstrate this, the changes in public deficit in response to different policy shocks will be shown in the last section of the paper which discusses simulation properties of the ETLA model. It is also possible to solve the model with different policy rules imposed to balance the government budget.

Household income formation is built along similar lines as the above discussed public sector variables, thus the subseries comprising the household disposable income are modelled with simple behavioral relations plus added residual series that close the equations. As well as with public sector identities, the whole block is built to be consistent with the Finnish national accounts.

In this first version of the ETLA model, there are not many financial linkages included in the model structure. Nevertheless, the model includes short-term interest rates (12 month Euribor) and government 10-year bond yield. Of these two variables, the government bond yield is endogenous and explained by both the level and difference of the short-term interest rates (12 month Euribor). Also, it is affected by the level of public sector deficit. While Finland is a small member of the euro area, it assumed that it takes the 12 month Euribor rate as given. Nevertheless, as discussed in Section 2, it is also possible to add interest rate spread to the model's definition of the user cost of capital. A future issue with ETLA model will probably be to construct banking sector with all the relevant linkages to the rest of the economy, while the recent years have proved that these linkages may be of a great importance to real economic outcomes.

3. Simulations

In the following simulations, the model is solved with partly backward-looking consumption equation, so the consumption is determined as in (5). Nevertheless, also this specification for consumption contains future (as well as past) values of the endogenous variables. To solve the model containing future values such as this, Eviews applies Gauss-Seidel iterative scheme across all the sample observations.[18]

The main purpose of the ETLA model is to forecast economic aggregates. Among these, it is the GDP that typically gets the greatest attention. The model is first solved with a historical fit of the produced GDP shown in Figure 3. The fit of the GDP series is slightly improved due to use of an added series in the export equation to capture the sharp reduction in its volume in 2009. While it is naturally not only the GDP one is interested in, Figure 4 shows the model solution for private consumption which can be compared with its actual evolution over the same period.

In order to analyze the long-run properties, ie. the steady state of the model, one needs to simulate the model for more distant future. Figure 5 presents the model solution for year 2050 with the series presenting the evolution of GDP determined both from demand and supply side of the economy. As

[18] As described in the EViews manual, the method involves looping repeatedly through every observation in the forecast sample at each observation solving the model while keeping the past and future values as fixed. The loop is repeated until changes in the values of the endogenous variables become smaller than a specified tolerance.

was expected, they go hand-in-hand in the long run while output gap and unemployment gap contribute to convergence of the series.

In addition to forecasting purposes, the model is built for the purpose of analyzing effects of policy changes and/or external shocks. Furthermore, examining the model responses to policy shocks is useful in understanding the model properties and dynamics. With 70 exogenous variables included in the current version of the model, there are several possibilities for policy simulations. In the following, all the shocks - except for the fiscal devaluation shock - are assumed to be permanent with the government budget changing freely, ie. there is no balanced budget rule included in these simulations. I simulate the following shocks:

- A one percent increase in government purchases
- A one percentage point decrease in labor income tax rate
- A one percentage point decrease in employer's pay roll tax rate
- A one percentage point decrease in consumption tax rate
- A one percentage point decrease in employees' social contribution rate
- A one percent increase in foreign demand
- A one percentage point decrease in NAWRU rate
- Fiscal devaluation

The effect of a 1 percent increase in public purchases is depicted in Figure 6. First, the expansionary fiscal policy leads to an increase in GDP with the Keynesian multiplier effect close to 1. Nevertheless, the increase in domestic demand soon leads to inflationary pressures, which is also depicted in the same figure. Higher prices implicate an appreciation of the real exchange rate which weakens competitiveness of the Finnish export sector. Also, the rise of public deficit produces a small increase in government bond yields which, to some extent, raises the price of capital contributing to firms' incentives to invest. Thus, mainly due to the negative effects on exports, the positive effects of stimulus begin to fade away so that in the long run, the GDP effect of the permanent increase in public purchases is close to zero.

Figure 7 shows the GDP effects of both one percentage point decrease in labor income tax rate and an equal size decrease in employer's pay roll tax rate. As can be seen, the both have an expansionary effect on GDP. However, the short-run effect of lowering labor income taxes is more pronounced, while a substantial part of the consequent increase in households' disposable income goes to consumption which then immediately appears in GDP numbers. Whereas the positive effects of the lower employer's pay roll taxes materialize with a lag, while it takes some time for the lower wage cost effect to kick out. Nevertheless, by improving price competitiveness it gradually leads to an increase in exports, and as a consequence, also investments respond to this increased demand. On the other hand, also the labor income tax cut has a positive effect on price competitiveness. This is due to the fact that the improved purchasing power of wages reduces the wage claims of the trade unions in the wage negotiations. This way it also leads to a rise in exports, which then has a positive impact on investments (and also, on imports). Also labor supply reacts modestly but positively to the income tax cut. In the long run, there is not much difference in the GDP effect resulting from these two policy changes. However, these policies are also associated with increases in public debt which can be seen from the right hand side of Figure 7.

Decreasing employees' social contribution rate affects mostly the same way as cutting labor income taxes. The policy increases the purchasing power of wage earners who consequently increase their consumption. At the same time, it lowers the wage claims of trade unions because what they are interested in is the wages net of taxes. This improves competitiveness of the export sector and hence, after a short lag, the export volumes. The decrease in a VAT tax rate in turn induces a negative effect on consumption prices, but it takes time for prices to adjust. For this reason, it also takes time for consumption to adjust to its new higher level. The lower consumption prices on their part mitigate wage pressures, which turns to better price competitiveness of the export sector. Thus, exports tend to increase as a result of the decrease in the VAT rate as well. Again, there is also a small positive effect on labor supply owing to both these tax cuts. Nevertheless, for the government budget one percentage point decrease in the VAT tax rate is more expensive than the equal change in employees' social contribution rate, which can easily be seen from the right hand side of Figure 8.

A one percent increase in foreign demand is in fact modelled as a one percent increase in the trade-weighted GDP of the 22 most important countries for Finnish exports. The foreign demand shock leads to an instant increase in Finnish exports. At the same, also imports increase while it is typical for Finnish export industries to use imported goods as inputs in their production. The increase in imports is also, to a smaller extent, due to the increased domestic demand which is associated with soaring exports industries that are now hiring new workers. Nevertheless, decreasing unemployment gives rise to wage pressures which leads to an appreciation of the real exchange rate. This mitigates the rise in exports in the long run. While the increase in foreign demand is assumed to be permanent, also GDP remains permanently higher in the long run despite higher domestic price and wage levels.

A one percentage point decrease in the NAWRU rate increases the potential output of the economy. It mitigates wage pressures in the wage negotiations and reduces other prices in the economy too, producing a decrease in the general price level. This increases competitiveness of the export sector and gradually improves the purchasing power of households as well, generating a substantial increase in GDP in the long run. At the same time, improving economy creates new jobs which decreases the unemployment rate, albeit the change in unemployment rate is moderate in comparison with the simulated decline in the NAWRU rate.

In a *fiscal devaluation* shock the economy is confronted by a one percentage point decrease in employer's pay roll tax rate which is compensated for the government budget by increasing the VAT tax rate. Thus, in this simulation the change in the structure of taxation is made neutral for the government budget. As could be seen from Figure 7 and Figure 8, decreases in both the VAT tax rate and employer's pay roll tax induce a positive effect on GDP. Nevertheless, equal-size changes in VAT and pay roll tax rate differ in how much they affect the government's tax revenues, i.e. their corresponding tax bases differ. Also, the effect of the change in VAT rate is more pronounced in the domestic markets and hence in private consumption while the effect of payroll tax is more equally shared between both the closed and open sectors of the economy, so it boosts private consumption, but what is more important, also exports. These differences can be seen from the right side of Figure 11a, where as a result of the fiscal devaluation, the value added in the industrial sector grows more than the value added in the rest of the economy (constituting of mainly services) in the short and middle run. In fact, the value added growth in the rest of the economy is only slightly positive. Still, the overall long-run effect on the economy stays positive, while the export sector (and the industrial sector) benefits from fiscal devaluation. Also, hours worked increase in both of the two sectors analyzed here until the final span of the simulation period. Thus, in the long run, the positive effect of fiscal devaluation loses its vigor and the shock's impact approaches to zero.

4. Conclusions

This paper summarizes the structure of the ETLA macro model built for forecasting and policy simulation purposes at the Research Institute of the Finnish Economy (ETLA). The model is also built for updating the Finnish module in the NiGEM global macroeconomic model developed and maintained at the NIESR. As well as NiGEM, the ETLA model is based on behavioral relations estimated from macro data. The model is relatively small and aggregated constituting of 81 endogenous and 70 exogenous variables. The model has three sectors: the public sector, the private industrial and the private (mostly) service sector.

The behavioral equations of the model are estimated as error-correction models using the well-known methods provided by Engle and Granger (1987). Even though the ETLA model can be described as an "old school" econometric macro model, it also has some novel features, for instance partly forward-looking agents together with Kalman-filtered total factor productivity shock and NAWRU variables that, in fact, bring the model closer to calibrated DSGE models used at many institutions. What is also common with New Keynesian DSGE models is that nominal rigidities – sticky prices and wages - slow the process of adjustment to external shocks. However, the model is not micro-founded in the same way DSGE models are. While the steady-state properties of the model are well-defined, the model aims at striking a balance between theory and data. Thus, the model can be labelled as "SSM" (Semi-Structural Macromodel), "SEM" (Structural Econometric Model), or "policy model", a term used by Blanchard (2017).

The model presented in this paper can already be used for forecasting and simulating, for instance, policy shocks to the Finnish economy. Nevertheless, to improve the model, it would be useful to separate different public bodies (municipals, pension funds, and the government) or include specific commodity prices in the model structure (as is the case with NiGEM). Yet even more ambitious future project would be to include banking sector with relevant linkages to rest of the economy into the model.

Figure 3. Actual and simulated GDP 1990-2015

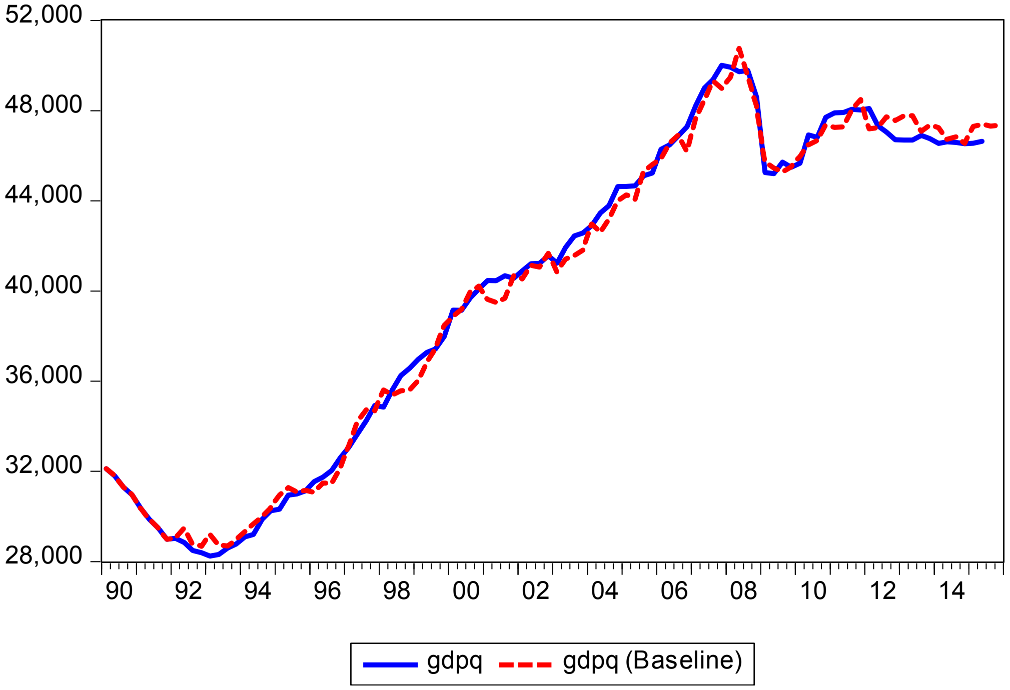


Figure 4. Actual and simulated consumption 1990-2015

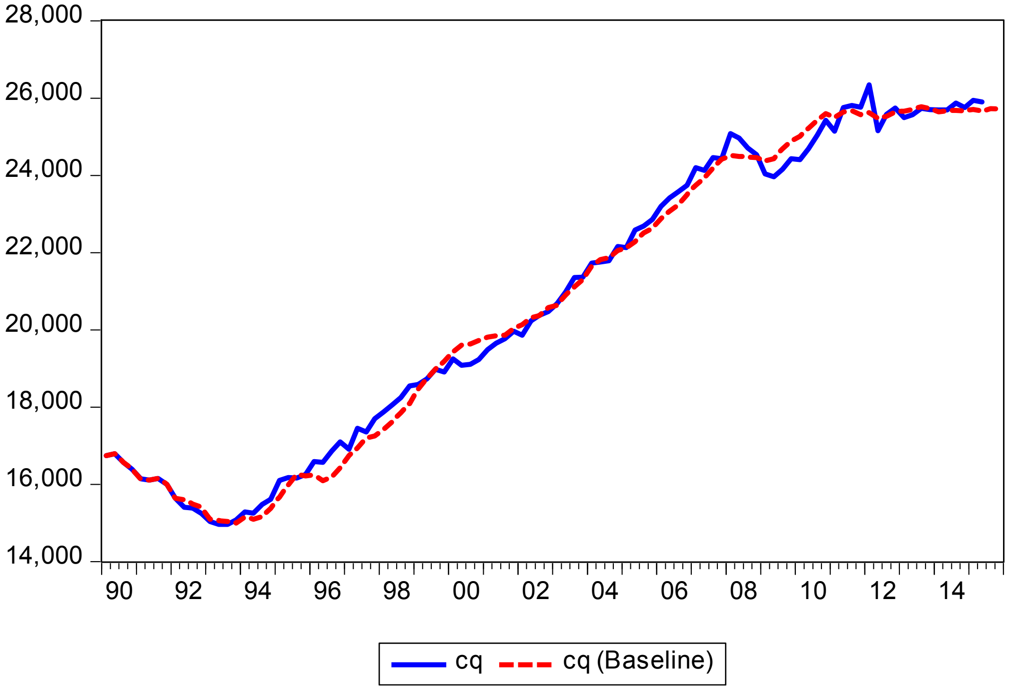


Figure 5. Long-run GDP determined from demand and supply

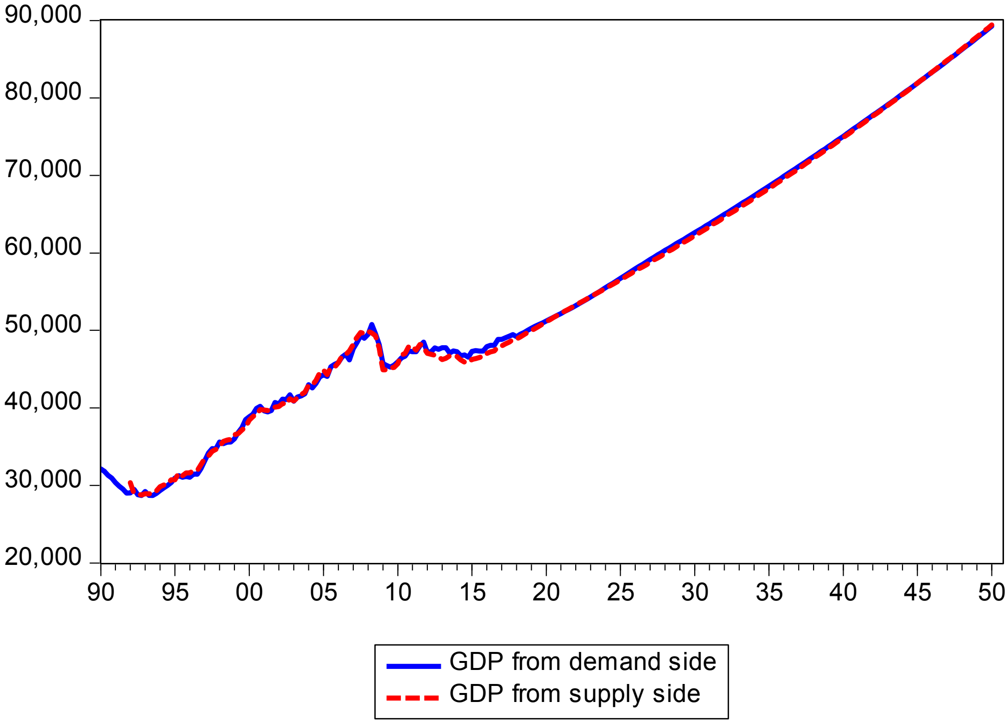


Figure 6. Permanent shock to government purchases

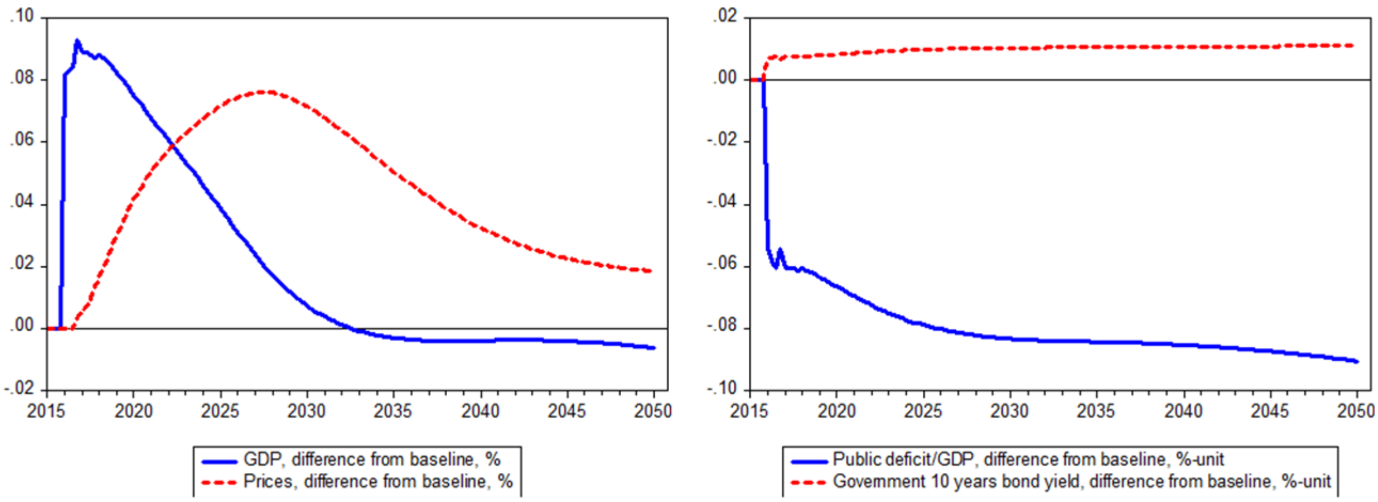


Figure 7. Decreases in labor and employer's pay roll tax rate

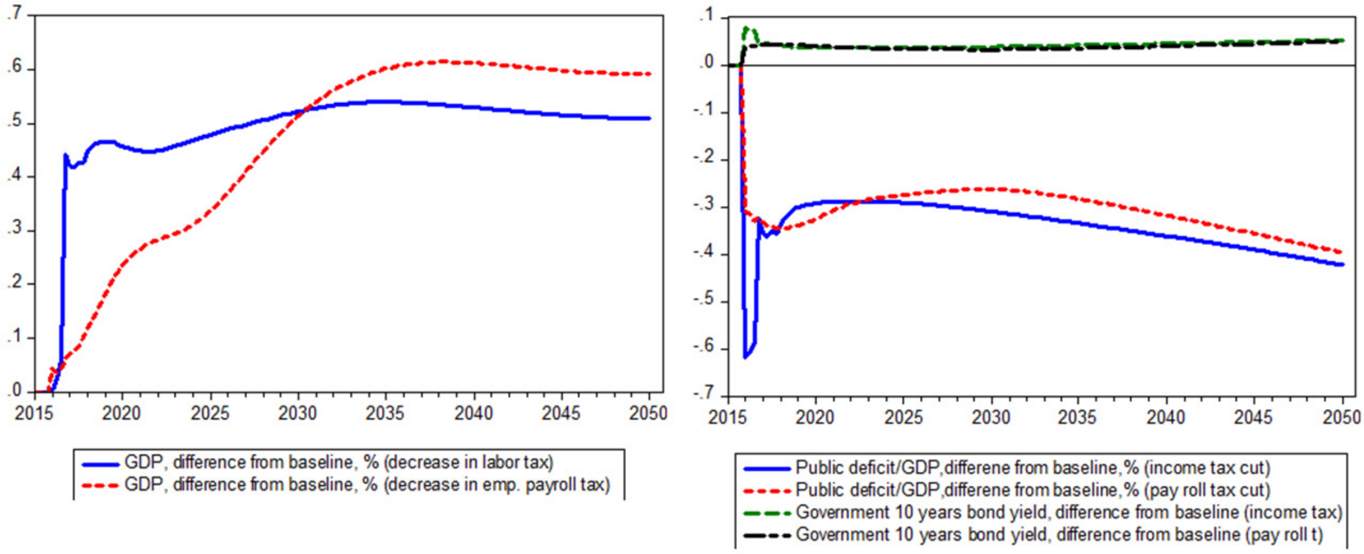


Figure 8. Decreases in VAT and employees' social contribution tax rate

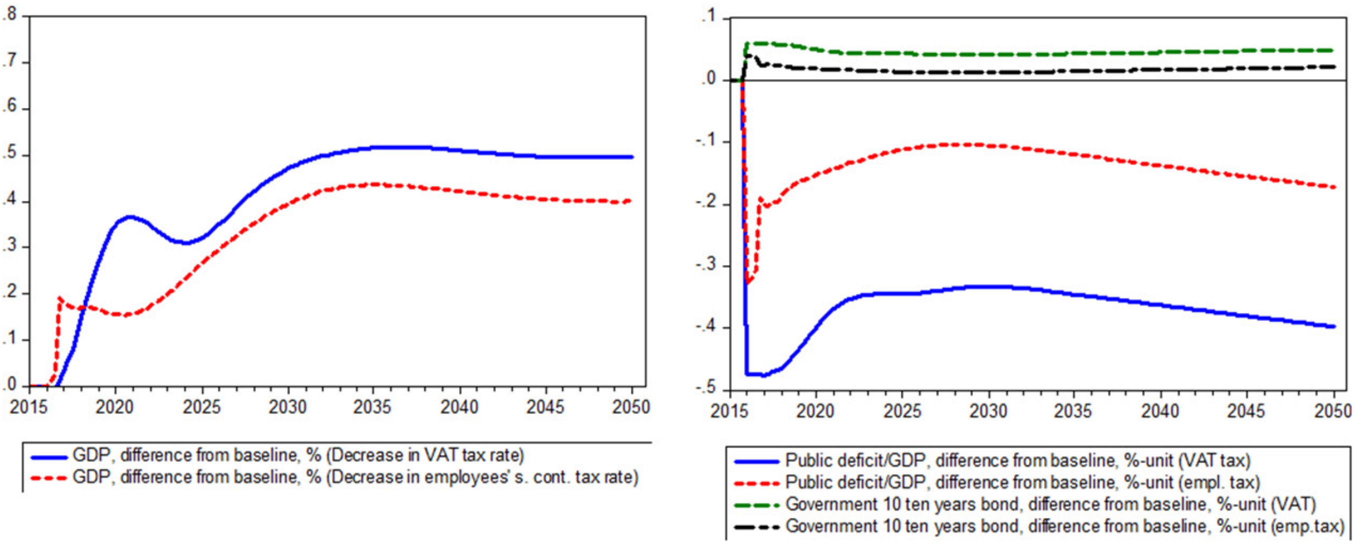
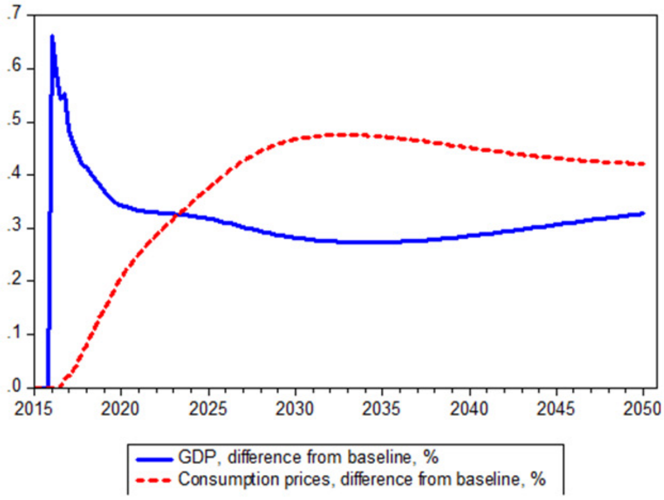


Figure 9. Increase in foreign demand



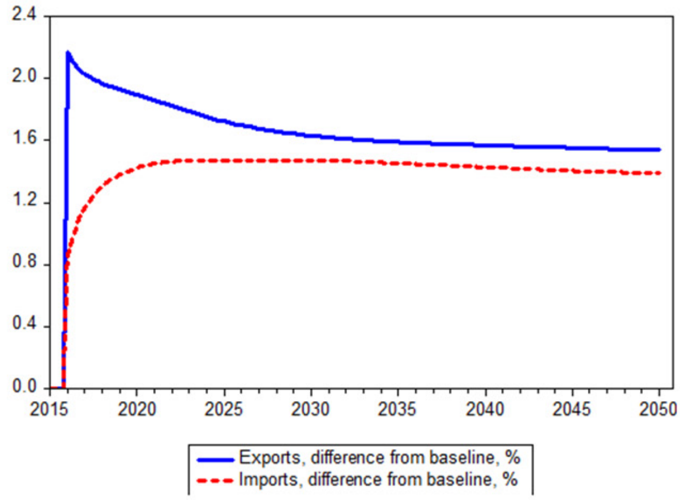
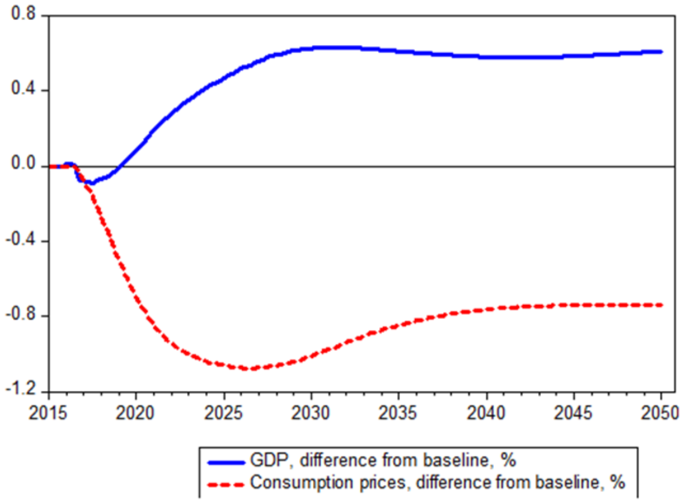


Figure 10. Decrease in NAWRU rate



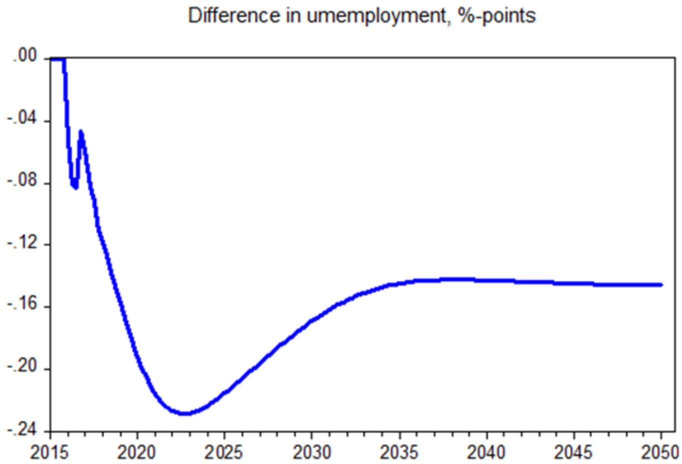


Figure 11a. Fiscal devaluation

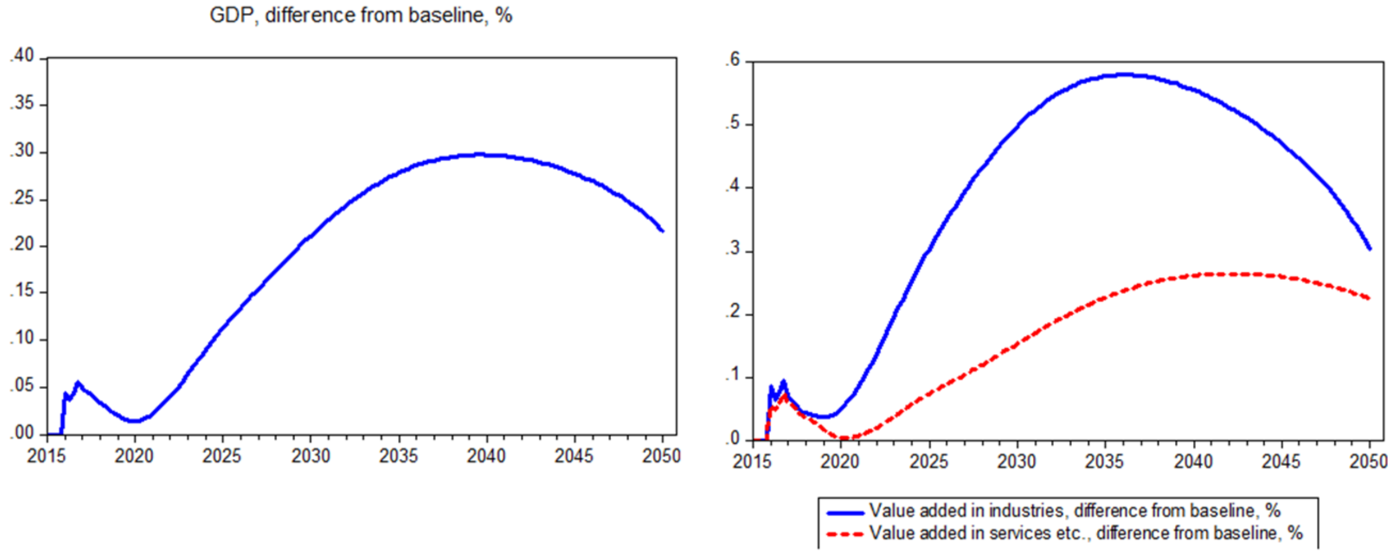
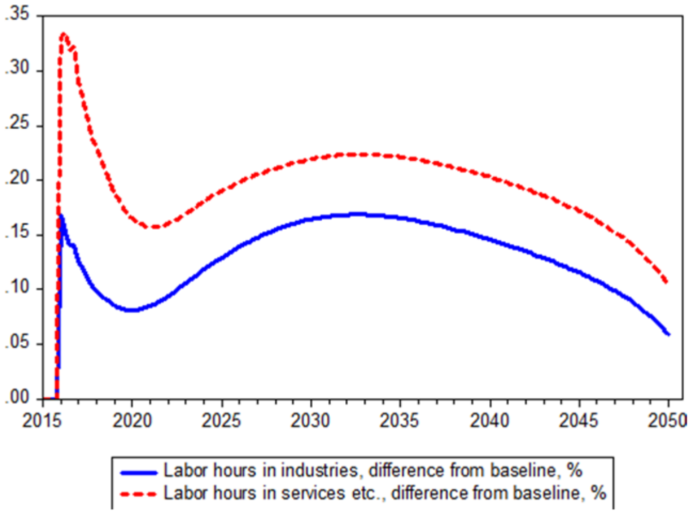


Figure 11b. Fiscal devaluation



Appendix 1. Model equations

Following reports all the model equations with t-values for the estimated coefficients, and adjusted coefficients of determination (R2) for each behavioral relations. In addition, it reports the ADF test statistics for the residual series of the long-run relations gained from the error correction models. For these, the critical 5 per cent value is 2,89. Symbol D in equations denotes to difference; - and + refer to lags and leads, respectively. T = n is a dummy variable which gets a value of 1 in the period n. All the variable names are explained in the variable list that can be found below.

Production and factor demands

Private capital stock

KP = IPQ + (1 - DEPR) * KP(-1)

Production function

LOG(VAQP_S) = - 0.438 + .65 * log(LHP) + .35 * log(KP) + RD * T

Private sector labor demand

DLOG(LHP) = 0.656 * DLOG(VAQP) - 0.440 * DLOG(WRP * (1 + (0.01 * EMPTAX)) / PQP) - 10.1 * D(RD) - 0.647 * (LOG(LHP(-1)) - 0.601 * LOG(VAQP(-1)) + 0.505 * LOG(WRP(-1) * (1 + (0.01*EMPTAX(-1))) / PQP(-1)) + 0.000851*T(-1) - 5.43 + 9.06*RD(-1))

R2 = 0.643 t1 = 7.52 t2 = -2.33 t3 = -6.27 t4 = -7.164785 ADF = -5.71

Industrial sector labor demand

LOG(LHI) = 6.19 + 0.278 * LOG(VAQI) - 0.251 * LOG(WRI * (1 + (0.01 * EMPTAX)) / PQI) - 0.00153 * T + 18.9 * RD

R2 = 0.939 t1 = 19.9 t2 = 3.72 t3 = -2.29 t4 = -2.36 t5 = 2.64

Private investments

DLOG(IPQ) = -9.14 * D(RD) + 0.887 * DLOG(VAQP) - 0.0163 * DLOG(UCC) - 0.0129 * (LOG(IPQ(-1)) + 0.5*LOG(UCC(-1)) - LOG(VAQP) + 0.0118 * T2(-1) + 2.24 + 46.0* RD(-1)- 37.2 * RD(-5))

$R^2 = 0.237 \quad t1 = -2.04 \quad t2 = 4.99 \quad t3 = -1.61 \quad t4 = -0.866 \quad ADF = -2.74$

User cost of capital

$$UCC = ((PI / PQP) * (R10 * 0.01 - \log(CPI / CPI(-4)) + DEPR))$$

Private value added

$$VAQP = GDPQ - VAQG - DEP$$

Nominal private value added

$$VAP = VAQP * PQP$$

Industrial sector value added

$$LOG(VAQI) = 1.31 * LOG(VAQP) - 3.94 + 0.296 * LOG(XV/GDPV) - 0.341 * LOG(WRP/PWI22)$$

$R^2 = 0.978 \quad t1 = 18.7 \quad t2 = -5.76 \quad t3 = 8.06 \quad t4 = -3.09$

Value added in service (and construction) sector

$$VAQSE = VAQP - VAQI$$

Total value added

$$VAQ = VAQP + VAQG$$

Gross domestic product (in real terms)

$$GDPQ = IPQ + IGQ + CQ + GQ + XQ - MQ + INVQ$$

Potential output

$$QPOT = \exp(-0.438 + .65 * \log(LHP + ((UN - NAWRU) * LHS / 100)) + .35 * LOG(KP) + RD * T)$$

Output gap

$$QGAP = 100 * (VAQP - QPOT) / QPOT$$

Public value added

$$LOG(VAQG) = 8.15 + 0.107 * LOG(LHG)$$

R2 = 0.154   t1 = 18.0   t2 = 1.89

Nominal public value added

VAG = PQG * VAQG

Nominal value added

VA = VAP + VAG

Gross domestic product determined from supply side (in real terms)

GDPQ_S = VAQP_S + VAQG + DEP

Residual series for GDP from supply side

LOG(DEP) = 1.039 * log(VAQ(-4)) - 2.34 + RESID_DEP

Labor hours in service (and construction) sector

LHSE = LHP - LHI

Total labor hours

LH = LHG + LHP

Total employment (in persons)

LOG(LN) = -1.34 + 0.986 * LOG(LH) + 0.000401 * T + 0.0147 * (T=38) - 0.0239 * (T=9) + RESID_LN

Labor supply

LOG(LS) = -0.276 + 0.0207 * LOG(WRP * (1 - ((TAX_APW + TEKSOVA + ALV) / 100))) + 0.746 * LOG(POPEMP1564) + (1 - 0.746) * LOG(LN(-2))

R2 = 0.960   t1 = -17.3   t2 = 7.36   t3 = 50.5

Unemployment rate

UN = 100 * (LS - LN) / LS

Private sector productivity

PROD = VAQP / LHP

Total productivity

PRODQ = VAQ / LH

Consumption and foreign trade

Private consumption

DLOG(CQ) = 0.00214 - 0.0137 * D(D93) + 0.512 * DLOG(YHQ/PC) + 0.0540 * DLOG(W) - 0.203 * (LOG(CQ(-1)) - 0.475 - 0.9 * LOG(@MOVAV((YHQ(3))/PC(3),8)) - (1 - 0.9) * LOG(W(-1)) - 0.0300 * D95(-1))

R2 = 0.270 t1 = 1.47 t2 = -4.42 t3 = 4.34 t4 = 2.43 t5 = -2.38 ADF = -3.89

Private consumption (2) with forward-looking agents

DLOG(CQ) = 0.00270 - 0.0133 * D(D93) + 0.0308 * DLOG(W) + 0.514 * DLOG(YHQ/PC) - 0.00197 * (LOG(CQ(-1)) - 2.55 -0.5 * LOG(W(-1)) - 0.5 * LOG(YHQ(-1)/PC(-1)) + 12.2 * RD(-2))

R2 = 0.201 t1 = 1.99 t2 = -4.04 t3 = 1.15 t4 = 4.19 t5 = -0.160 ADF = -1.71

Private wealth

LOG(W) = 4.33 - 0.0264 * @MOVAV(R10(20) - (((PC(20)/PC(16) - 1) * 100)),20) + 0.0142 * @TREND

R2 = 0.807 t1 = 20.5 t2 = -0.844 t3 = 5.16

Nominal private consumption

CV = PC * CQ

Public consumption

GQ = GQP + (WSG / PG)

Nominal public consumption

GV = PG * GQ

Exports

DLOG(XQ) = 2.03 * DLOG(IMU22) + 11.7*D(RD) - 1.065 * DLOG(PX/PWI22) - 0.326 * (LOG(XQ(-1)) - 1.60 * LOG(X22(-1)) + 0.633 * LOG(PX(-1)/PWI22(-1)) - 31.1 * RD(-1)+0.661)

R2 = 0.491 t1 = 4.25 t2 = 3.42 t3 = -3.93 t4 = -3.62 ADF = -3.26

Nominal exports

XV = PX * XQ

Imports

DLOG(MQ) = 0.00338 + 0.361 * DLOG(XQ) + 0.429 * DLOG(CQ + IPQ + GQ) - 0.181 * (LOG(MQ(-1)) + 0.341 - 0.685 * LOG(XQ(-1)) - (1 - 0.685) * LOG(CQ(-1) + IPQ(-1) + GQ(-1)) + 0.679 * LOG(PM(-1) / PC(-1)))

R2 = 0.407 t1 = 1.16 t2 = 4.78 t3 = 1.43 t4 = -3.82 ADF = -2.72

Nominal imports

MV = PM * MQ

Trade balance

TB = PX * XQ - PM * MQ

Prices and wages

Private consumption deflator

DLOG(PC)=0.000583*D(QGAP) + 0.0991*DLOG(PQP) + 0.650*DLOG(PC(-4)) + 0.00339*D(T=40) + 0.149*DLOG(PM) - 0.112*(LOG(PC(-1)) + 0.271 - 0.8*LOG(PQP(-1)) - (1-0.8)*LOG(PM(-1)) - 0.7*LOG(1 + (0.01*ALV(-1))) + 0.783*VFF(-1) - 0.00181*T(-1) - 0.00181*(QGAP(-1)))

R2 = 0.317 t1 = 0.515 t2 = 1.81 t3 = 10.9 t4 = 5.33 t5 = 5.79 t6 = -4.74 ADF = -4.37

Public consumption deflator

DLOG(PG) = 0.798 * DLOG(WRG) - 0.238 * (LOG(PG(-1)) + 4.85 - 0.948 * LOG(WRG(-1)))

$R2 = 0.231 \quad t1 = 13.7 \quad t2 = -3.69 \quad ADF = -2.11$

Private investment deflator

DLOG(PI) = 0.645*DLOG(PQP) + 0.157*DLOG(PM) + 0.00365*D(QGAP) - 0.0314*(LOG(PI(-1)) - 0.461*LOG(PQP(-1)) - (1 - 0.461)*LOG(PM(-1)) - 0.0169*(QGAP(-1)) + 0.0286)

$R2 = 0.130 \quad t1 = 2.44 \quad t2 = 1.75 \quad t3 = 0.752 \quad t4 = -1.89 \quad ADF = -3.62$

Export prices

DLOG(PX) = 0.332 * DLOG(PWI22) + (1 - 0.332) * DLOG(PQP) + 4.72 * D(RD) - 0.329 * (LOG(PX(-1)) + 2.03 - 0.480 * LOG(PWI22(-1)) - (1 - 0.480) * LOG(PQP(-1)) + 0.00312 * T2(-1) - 8.25 * RD(-1) - 0.149 * LOG(EURDOL(-1)))

$R2 = 0.230 \quad t1 = 3.48 \quad t2 = 3.40 \quad t3 = -4.43 \quad ADF = -5.11$

Import prices

DLOG(PM) = 0.0194 * DLOG(OILDOL) + 0.508 * DLOG(PWI22) + 1.49 * D(RD) - 0.0762 * (LOG(PM(-1)) - 1*LOG(PWI22(-1)) + 4.65 - 0.0219 * LOG(OILDOL(-1)) - 3.75 * RD(-1) + 0.000956 * T(-1))

$R2 = 0.325 \quad t1 = 1.26 \quad t2 = 5.85 \quad t3 = 1.34 \quad t4 = -1.70 \quad ADF = -3.33$

Nominal private investments

IPV = PI * IPQ

Nominal public investments

IGV = IGQ * PIG

Gross domestic product in nominal terms

GDPV = PI * IPQ + PIG * IGQ + PC * CQ + PG * GQ + PX * XQ - PM * MQ + PINV * INVQ

GDP deflator

PQ = GDPV / GDP

Private value added prices

DLOG(PQP) = 0.193 * DLOG(PQP(-2)) + 0.234 * DLOG(WRP) + 0.270 * DLOG(1 + (0.01*EMPTAX)) - 0.0201 * DLOG(PROD) - 0.0377 * (LOG(PQP(-1)) - LOG(WRP(-1) * (1 + (0.01*EMPTAX(-1)))) + @MEAN(LOG(PROD(-1)),"1990q1 2015q4") - 0.196 * RD(-1) + 0.00607 * T(-1) + 3.53)

R2 = 0.0212   t1 = 1.90   t2 = 2.56   t3 = 1.21   t4 = -0.841 t5 = -1.39 ADF = -0.85

Industrial sector value added deflator

LOG(PQI) - LOG(PQP) = 0.306 - 0.00348 * T

R2 = 0.922   t1 = 51.7   t2 = -34.5

Standard private wage rate index

DLOG(PWS) = -0.00176*D(UN - NAWRU) + 0.628*DLOG(PWS(-1)) + 0.283*DLOG(PWS(-4)) - 0.0119*D(T=31) + 0.0107*D(T=32) + 0.0218*D(T=71) - 0.0243*(LOG(PWS(-1)) - 4.22 - 0.85*LOG(PC) + 0.00397*((UN(-1) - NAWRU(-1))) + 0.301*LOG(1 - (0.01*(TAX_APW(-1) + TEKSOVA(-1)))) - 0.45*LOG(PROD(-1)) + 7.78*VFF(-5))

R2 = 0.474   t1 = -1.91   t2 = 4.68   t3 = 2.17   t4 = -12.7   t5 = 5.48   t6 = 7.67   t7 = -1.06   ADF = -6.10

Private wage drift

DLOG(WRP) = 1.24 * DLOG(PWS) + 0.0423 * DLOG(PROD) - 0.0414 * (LOG(WRP(-1)) - LOG(PWS(-1)) - 0.322 * LOG(PROD(-1)) + 0.00108 * UN(-1) + 0.336)

R2 = 0.688   t1 = 29.5   t2 = 2.95   t3 = -1.93   ADF = -1.30

Public wage rate

DLOG(WRG) = -0.00307*D(QGAP) + 0.936*DLOG(WRP) + 0.00360*D(D2008) - 0.142*(LOG(WRG(-1)) - LOG(WRP(-1)) - 0.00208 + 0.000405*T(-1) + 0.00546*QGAP(-1) + 1.21*VFF(-1) - 0.0202*D2008(-1))

R2 = 0.648   t1 = -2.59   t2 = 19.6   t3 = 4.36   t4 = -3.77   ADF = -10.3

Industrial sector wage rate

LOG(WRI) = 0.0640 + 0.988 * LOG(WRP)

$R2 = 0.999 \quad t1 = 1.91 \quad t2 = 145$

Public sector balance and household income formation (mainly identities)

Households' disposable income

YHQ = WS + PROPIN - PROPEXP + ENTPIN + SOBEN + SOSOBEN + SOASS + OTTRANS - DITAX - HPAYROLL + YHQ_NONP

Wage sum

WS = WSP + WSG

Private wage sum

WSP = WSP_RES + (WRP / 100 * 9.395 * LHP / 10)

Public wage sum

WSG = WSG_RES + (WRG / 100 * 13.241 * LHG / 10)

Households' property income

LOG(PROPIN) = - 2.56 + 0.0671 * R12 + 0.402 * LOG(RENT) + 0.887 * LOG(VAP) + RESID_PROPIN

Households' property expenditure

LOG(PROPEXP) = 3.06 + 0.164 * R12 + 1.18 * log(RENT) + RESID_PROPEXP

Entrepreneurial income (net)

LOG(ENTPIN) = 2.35 + 0.402 * LOG(VAP) + 0.713 * LOG(RENT) + RESID_ENTPIN

Social security benefits received by households

LOG(SOBEN) = 2.90 + 1.14 * LOG(WRP) + RESID_SOBEN

Social assistance benefits received by households

LOG(SOASS) = 2.39 + 0.864 * LOG(WRP) + 18.4 * RD + 0.0471 * UN + RESID_SOASS

Other transfers received by households

LOG(-OTTRANS) = 5.58 - 0.0225 * UN + 0.00868 * T + RESID_OTTRANS

Direct taxes paid by households

LOG(DITAX) = - 0.264 + 1.037 * LOG(TAXINC) + RESID_DITAX

Payroll taxes paid by households

HPAYROLL = 265 + 1 * (TEKSOVA * 0.01 * WS) + RESID_HPAYROLL

Taxes revenues collected by public sector

B1 = TAXQM + TAXINC + TAXCOR + B1R - B1p

Employer's pay roll taxes collected by public sector

B2 = EMPSOC - CSOC

Employee's social contributions to public sector

B3 = HPAYROLL + CPAY

Social security benefits paid by public sector

B6 = SOBEN + SOSOBEN - CSOBEN – FSOBEN

Social assistance benefits paid by public sector

B7 = SOASS - NONPASS

Government's property expenditures (interest payments)

B10 = 428 + 0.131 * (r10 / 100) * DEBT(-1) + RESID_B10

Deprecation of public sector capital

LOG(B13) = 5.60 + 0.503 * LOG(IGV) - 0.377 * log(IGV(-1)) + 0.00991 * T + RESID_B13

Employee's social contributions

EMPSOC = 119 + 1 * (EMPTAX * 0.01 * WS) + RESID_EMPSOC

Corporate tax revenues

TAXCOR = 0.890 * TAX_C * 0.01 * CORBASE - 201 + RESID_TAXCOR

Corporate tax base

CORBASE = SURPLUS - ENTPIN

Household income taxes

TAXINC = - 1060 + 1 * (TAX_APW * 0.01 * EINBASE) + 1 * (TAX_K * 0.01 * PROPIN) + RESID_TAXINC

Entrepreneurial income (gross)

LOG(ENTBIN) = - 1.63 + 1.24 * LOG(ENTPIN) + RESID_ENTBIN

Earned income tax base

EINBASE = WS + ENTBIN - HOINC + SOBEN + SOSOBEN + SOASS - HPAYROLL + OTTRANS

Indirect tax revenues

TAXQM = 1210 + 0.980 * (ALV * 0.01 * (CV)) + RESID_TAXQM

Public deficit

GDEF = B1 + B2 + B3 + B4 - B5 - B6 - B7 + B8 + B9 - B10 - B11 + B12 + B13 - IGV - GV

Operating surplus

SURPLUS = GDPV - WS - EMPSOC - TAXQM + SUBP - KDEPR

Depreciation of capital

LOG(KDEPR) = - 1.20 + 0.965 * LOG(VA(-1)) + RESID_KDEPR

Government 10-year bond yield

R10 = 0.852 * R12(+1) - 0.385 * D(R12) + 1.83 - 12.5 * GDEF / GDPV

R2 = 0.881 t1 = 10.3 t2 = -2.30 t3 = 5.59 t4 = -2.98

Public debt

DEBT = DEBT(-1) - GDEF + DEBT_RES

VARIABLE NAMES

ALV	Effective indirect tax rate
B1	Taxes revenues collected by public sector
B10	Government's property expenditures
B11	Publicly paid subsidies
B12	Capital transfers received by public sector
B13	Deprecation of public sector capital
B1B	Taxes paid by public sector
B1R	Other tax revenues received by public sector
B2	Employer's pay roll taxes paid to public sector
B3	Employee's social contributions paid to public sector
B4	Net transfers from domestic to public sector
B5	Net foreign transfers
B6	Social security benefits paid by public sector
B7	Social assistance ben. paid by public sector
B8	Net indemnity security paym. to public sector
B9	Net operating surplus and property incomes
CORBASE	Corporate tax base
CPAY	Corporate paid employee's social contributions
CPI	Consumer price index
CQ	Private consumption
CSOBEN	Social security benefits paid by corporates
CSOC	Employer's pay roll taxes paid to corporates
CV	Nominal private consumption
D2008	Dummy for year 2008
D93	Dummy for year 1993
D95	Dummy for year 1995
DEBT	Public (EMU-)debt
DEBT_RES	Residual series for public debt
DEP	Residual series for GDP from supply side
DEPR	Depreciation rate for private capital
DITAX	Direct taxes paid by households

EINBASE	Earned income tax base
EMPSOC	Employee’s social contributions
EMPTAX	Effective employer’s pay roll tax rate
ENTBIN	Entrepreneurial income (gross)
ENTPIN	Entrepreneurial income (net)
EURDOL	Euro / dollar exchange rate
FSOBEN	Social security benefits paid by foreign sectors
GDEF	Public deficit
GDPQ	Gross domestic product
GDPQ_S	Gross domestic product from supply side
GDPV	Gross domestic product in nominal terms
GQ	Public consumption
GQP	Public purchases
GV	Nominal public consumption
HOINC	Income from housing
HPAYROLL	Payroll taxes paid by households
IGQ	Public investments
IGV	Nominal public investments
INVQ	Change in inventories
IPQ	Private investments
IPV	Nominal private investments
KDEPR	Depreciation of capital
KP	Private capital stock
LH	Total labor hours
LHG	Public sector labor hours
LHI	Industrial sector labor hours
LHP	Private sector labor hours
LHS	Supplied labor hours
LHSE	Labor hours in service (and construction) sector
LN	Total employment (in persons)
LS	Labor supply
MQ	Imports
MV	Nominal imports

NAWRU	NAWRU rate
NONPASS	Social assistance benefits paid by non-profit organ.
OILDOL	Price of (Brent) oil in dollar terms
OTTRANS	Other transfers received by households
PC	Private consumption deflator
PG	Public consumption deflator
PI	Private investments deflator
PIG	Public investments deflator
PINV	Change in inventories deflator
PM	Price of imports
POPEMP1564	Population with age between 15 and 64
PQ	GDP deflator
PQG	Public value added deflator
PQI	Industrial value added deflator
PQP	Private value added deflator
PROD	Private sector productivity
PRODQ	Total productivity
PROPEXP	Households' property expenditure
PROPIN	Households' property income
PWI22	Trade-weighted import prices of the 22 countries*
PWS	Standard private wage rate index
PX	Price of exports
QGAP	Output gap
QPOT	Potential output
R10	Government 10-year bond yield
R12	12 months Euribor
RESID_B10	Residual series for gov. property expenditures
RESID_B13	Residual series for deprecation of public sector capital
RESID_DEP	Residual series for variable DEP
RESID_DITAX	Residual series for sirect taxes paid by households
RESID_EMPSOC	Residual series for employee's social contributions
RESID_ENTBIN	Residual series for entrepreneurial income (gross)
RESID_ENTPIN	Residual series for entrepreneurial income (net)

RESID_HPAYROLL	Residual series for payroll taxes paid by households
RESID_KDEPR	Residual series for depreciation of capital
RESID_LN	Residual series for total employment (in persons)
RESID_OTTRANS	Residual series for other transfers received by househ.
RESID_PROPEXP	Residual series for households' property expenditure
RESID_PROPIN	Residual series for households' property income
RESID_SOASS	Residual series for social assistance b. received by h.
RESID_SOBEN	Residual series for soc. security benefits received by h.
RESID_TAXCOR	Residual series for corporate tax revenues
RESID_TAXINC	Residual series for household income taxes
RESID_TAXQM	Residual series for indirect taxes
SOASS	Social assistance benefits received by households
SOBEN	Social security benefits received by households
SOSOBEN	Other social security benefits received by households
SUBP	Subsidies
SURPLUS	Operating surplus
T	Trend
T2	Historical trend
TAX_APW	Effective tax rate for labor income
TAX_C	Effective corporate tax rate
TAX_K	Effective capital tax rate
TAXCOR	Corporate tax revenues
TAXINC	Household income taxes
TAXQM	Indirect tax revenues
TB	Trade balance
TEKSOVA	Employee's social contribution rate
UCC	User cost of capital
UN	Unemployment rate
VA	Nominal value added
VAG	Nominal public sector value added
VAP	Nominal private sector value added
VAQ	Value added
VAQG	Public sector value added

VAQI	Industrial sector value added
VAQP	Private sector value added
VAQP_S	Private value added defined from production function
VAQSE	Service sector value added
RD	Recession(s) dummy
RENT	Rent prices index
W	Households' real wealth
WRG	Public sector wage rate
WRI	Industrial sector wage rate
WRP	Private sector wage rate
WS	Wage sum
WSG	Public sector wage sum
WSG_RES	Residual of public sector wage sum
WSP	Private sector wage sum
WSP_RES	Residual of private sector wage sum
XQ	Exports
XV	Nominal exports
YHQ	Households' disposable income
YHQ_NONP	Disposable income of non-profit organizations
X22	Trade-weighted GDP of the 22 countries*

* The 22 most important countries for the Finnish exports

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