EMMA – a Quarterly Model of the Estonian Economy

Rasmus Kattai

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EMMA – a Quarterly Model of the Estonian Economy

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Abstract

This paper describes the first version of Eesti Pank's structural macro-econometric model EMMA. EMMA belongs to the second generation of macro models, with Neo-Classical supply determined long run properties and Keynesian demand driven short run adjustment.

The model has been designed for forecasting as well as for simulation exercises. In order to fulfil both tasks, the emphasis has been put on capturing the main characteristics of the Estonian economy. The model describes a very small and open economy, in which long run economic growth and inflation are strongly influenced by real and nominal convergence towards EU15 levels.

JEL Code: C5, E12, E17

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Contents

1. Introduction

The current paper introduces the first version of Eesti Pank's small macro-econometric model EMMA, which has been built for forecasting and policy analysis. The theoretical background of the model is what could be referred to as Neo-Classical Synthesis — long run behaviour is determined by supply factors (Neo-Classical theory) and short run fluctuations are demand driven because prices do adjust only slowly (Keynesian theory). EMMA is completely backward looking — adaptive expectations are included in the form of lagged values of variables in behavioural equations, specified in the form of the error correction model. EMMA consists of 14 behavioural equations and about 60 identities. The empirical model is estimated using data from the period 1996–2003, which implies that changes in national accounts statistics made by the Estonian Statistical Office in June 2005 are not taken into account in this version of the model.

In general, EMMA follows the ESCB MCM (European System of Central Banks' Multy-Country Model) country block building framework, with some departures in order better fit Estonia-specifics — a small, open economy catching up the average income and price levels of the more advanced economies. Due to these features we face several difficulties. Available data series are short and contain many structural breaks. Therefore, emphasis is put on finding stable and easily interpretable cointegration relationships. Due to the somewhat peculiar data, we pay a lot of attention to finding the best combination of estimating, calibrating or imposing the parameters of the model. In the cointegration relationships, the selection of the method is based on which of the three methods enables to produce the best long run scenario, while in dynamic equations the selection of method depends on the simulation properties of the single equation that the set of parameters generates.

Another implication of dealing with a catching up (or converging) economy is that the comparatively low relative income level compared to the reference group of countries, here the EU15, makes it difficult to incorporate any growth theory to explain the real convergence process. The same applies to the Neo-Classical growth models, in which convergence to a balanced growth path is analytically solved by linearising the model close to a steady state.[1] Hence we seek opportunities to modify the Neo-Classical growth model in a way that enables it to explain income level convergence in a country, which initially has a relative income far below the level to which it will ultimately converge.

[1]Balanced growth path and steady state are used as synonyms in the rest of the paper.

Conclusively, the state of development and several other factors, such as short and volatile time series (because being a small and very open economy), structural breaks and complicated theory applicability, imply that the range of problematic issues that must be dealt with is somewhat wider in the case of modelling the Estonian economy compared to constructing the same type of model of advanced economies. The same difficulties are traceable in models constructed for two other Baltic countries (Vetlov (2004), Benkovskis and Stikuts (2005)). This paper attempts to contribute to modelling converging economies and gives some suggestions for how to overcome the problems listed above.

The paper is structured as follows. The second section presents the underlying theoretical framework. In the third section real and nominal convergence issues are dealt with. The estimation of the model and simulation exercises are carried out in the fourth section and the fifth section concludes.

2. Theoretical Set Up of the Macro Model of the Estonian Economy

2.1. Demand Side of the Economy

In the following, a generic demand determination is derived, the construction of which is similar to those of the European System of Central Banks Multy-Country Model (ESCB MCM) country blocks (Boissay and Villetelle (2005); Willman and Estrada (2002); McGuire and Ryan (2000)). The purpose of deriving this general demand function is to bind relative prices and demand for goods, which is necessary for setting up the representative firm's profit maximisation problem.

The consumption basket includes all types of goods — domestic and foreign goods, public goods and investment goods. Demand for these goods is derived from a utility maximisation problem. As it is not particularly necessary to specify the exact form of the consumer utility function $U(C)$ here, no attention has been paid to that. The representative household consumes a basket of differentiated goods c_i with constant elasticity of substitution (CES), indicated as C:

$$C = \left(\int_0^1 c_i^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{1}$$

where ε (satisfying the condition $\varepsilon > 1$) is the elasticity of demand of good c_i to the respective relative price P/P_i. P denotes the price of generic good and P_i stands for the price of the product c_i. Consumers maximise their utility with respect to the following iso-elastic demand curves:

$$c_i = C \left(\frac{P}{P_i} \right)^{\varepsilon}. \tag{2}$$

Equation 2 implies that if the price of good c_i increases by one percent relative to the general price level, the demand for this particular good decreases by ε percent. For the aggregate price index P we can write:

$$P = \left(\int_0^1 P_i^{1-\varepsilon} di \right)^{1-\varepsilon}. \tag{3}$$

There are L consumers in the economy consuming goods produced by firms. We know that in the equilibrium, the production of good c_i (given as Y_i) must equal the demand for it (c_i^*). Having this, we can write an equilibrium equation for each good c_i, being dependent on relative prices:

$$Y_i = c_i^* L = C^* L \left(\frac{P}{P_i} \right)^{\varepsilon}. \tag{4}$$

Similarly, as for one specific good c_i, we can state that in the equilibrium the aggregate demand equals the aggregate supply, which would take the form $Y = C^* L$. The latter constitutes market equilibrium for goods in the open economy because we defined earlier that C includes all types of goods, including foreign goods. If we substitute $C^* L = Y$ into equation 4 and rearrange the terms, we obtain the relevant relationship for the representative firms profit maximisation problem, which relates the price of production of the i-th firm to the general price level, relative to the amount of production and the price elasticity of demand: $P_i = P(Y/Y_i)^{1/\varepsilon}$.

2.2. Supply Side of the Economy

The supply of goods — determining the behaviour of the model economy in the long run — is derived from the representative firm's optimisation problem. Firms operate on a monopolistically competitive market, which implies that they have certain power to fix the price of their goods above its production costs and earn profits.

The market consists of i monopolistically competing firms ($i \in [0,1]$). Each firm produces a differentiated product Y_i using a traditional Cobb-Douglas production function with constant returns to scale and Harrod-neutral (labour augmenting) technological progress.[2] The representative firm maximises its profit (Π):

$$
\begin{aligned}
max_{P_i,Y_i,L_i,K_i}\Pi(Y_i) &= P_i(1-z)Y_i - W(1+q)L_i - P_K K_i \qquad (5)\\
s.t. & \\
& Y_i = K_i^{\alpha} L_i^{(1-\alpha)} A_0 e^{(1-\alpha)gt}, \qquad (6)\\
& P_i = P\left(\frac{Y}{Y_i}\right)^{\frac{1}{\varepsilon}}. \qquad (7)
\end{aligned}
$$

In what is presented above, z denotes an indirect tax rate. By multiplying the gross price of produced good Y_i — P_i by expression (1 -z) we result in having the production price at factor costs — the price that the firm gets for selling its products. Thus, the expression P_i(1 - z)Y_i corresponds to the firm's earnings. Production possibilities are determined by the production function (equation 6), where parameter α indicates the income share of capital and A_0 denotes the initial level of technology, growing at the rate g. The firm's ultimate decision is how much of labour and capital inputs to use. An increase in these raises output, but also increases costs. As the Cobb-Douglas function meets the Inada conditions — that is, marginal products of the production inputs are positive, but diminishing — there exists a certain combination of them, which maximises profits.[3]

Labour costs are expressed as $W(1+q)L_i$, where W is the given nominal wage (the firm cannot influence the market wage rate), L_i is the amount of labour hired by the i-th firm and q stands for the tax rate levied on labour. Here the usual firm's profit maximisation problem is augmented by labour taxation, by which we mean social security payments. This is done because the firm must take this as an additional component of labour cost.

[2]The suitability of the Cobb-Douglas function to Estonian data should be investigated more thoroughly in a separate study. This is suggested by the peculiar trends in the labour market: employment fell monotonically until 2000 and then the trend was broken and employment started to increase again. The same happened in Finland's labour market in the first half of the 1990s and Ripatti and Vilmunen (2001) came to the conclusion that to capture this phenomena the CES function gives better results.

[3]For more details see Inada (1964).

The total payment for using capital is $P_K K_i$, where P_K is the given nominal user cost of capital (the same for all market participants) and K_i is the capital stock rented by the firm i. The nominal user cost of capital is defined as:

$$P_K = P(1-z)(r+\delta+\rho), \tag{8}$$

where r is the real interest rate, δ is the physical depreciation rate of accumulated capital stock and ρ is risk premium.[4] The real interest rate is defined as $r = i - \pi$, where i denotes the nominal interest rate and π is the actual inflation rate. The former describes firms that are not behaving rationally (nor irrationally) because no inflation expectations are taken into account.

The price of good Y_i depends on the generic price (see equation 7). Substituting P_i from equation 5 with equation 7 and rearranging terms, we have the maximisation problem in the following form:

$$max_{Y_i,L_i,K_i}\Pi(Y_i) = P(1-z)Y^{\frac{1}{\varepsilon}}Y_i^{\frac{\varepsilon-1}{\varepsilon}} - W(1+q)L_i - P_K K_i \tag{9}$$

$$s.t.$$

$$Y_i = K_i^{\alpha} L_i^{(1-\alpha)} A_0 e^{(1-\alpha)gt}. \tag{10}$$

Differentiating function 9 with respect to K_i and assuming that the system is in a symmetrical equilibrium ($K_i = K_j = K$, $Y_i = Y_j = Y \quad \forall \quad i$, j) we obtain the overall desired capital stock in the economy:

$$K = \frac{1}{\eta}\alpha Y \frac{P(1-z)}{P_K}, \tag{11}$$

where parameter η stands for the mark up, which is defined as $\varepsilon/(\varepsilon - 1)$.

Also aggregate labour demand is assessed through representative firm's decision-making process. Taking each firm's inverted production function and assuming symmetric equilibrium again ($L_i = L_j = L$, $K_i = K_j = K$, $Y_i = Y_j = Y \quad \forall \quad i, j$), the total labour demand in economy is:

[4]The meaning of the risk premium is somewhat broader here. To fit the theoretical framework to actual data, we assume that investors are rational and thereby ρ does not reflect only country specific risks but also the investors' wish to gain higher capital income when the growth in the economy is greater.

$$L = \left(\frac{Y}{K^{\alpha}}\right)^{\frac{1}{1-\alpha}} A_0^{-\frac{1}{1-\alpha}} e^{gt}. \tag{12}$$

The real wage rate is derived from the first order condition, which equates the marginal cost labour to its marginal product revenue. By differentiating the profit maximisation function (equation 9) with respect to L_i and assuming symmetrical equilibrium ($P_i = P_j = P$, $Y_i = Y_j = Y \quad \forall \quad i, j$) we obtain:

$$\frac{W}{P} = \frac{(1-\alpha)(1-t)}{\eta(1+t^L)}\frac{Y}{L}. \tag{13}$$

The value of mark up is greater than one by definition because we assume that the firms are profitable. This enables us to see that equation 13 implies that due to the firms' monopolistic competition, the real wage paid to the owners of labour is η times smaller than the marginal productivity of labour. Despite the spread in levels, the growth of the real wage follows the growth of labour productivity.

The key price in the model is the price of production (which corresponds to the output deflator in empirical modelling). The equilibrium level of this has been defined as marginal labour cost (unit labour cost — ULC) times mark up:

$$P = \eta\frac{LW(1+q)}{Y(1-z)(1-\alpha)}. \tag{14}$$

The previous set of equations (11, 12, 13 and 14) is the one that shapes the model's long run growth path. The convergence to a balanced growth path is affected by the parameters of this system. In the following we have calibrated the values for α, η, ε, ρ and A_0.[5] All calibrated values are denoted with a hat over the parameter ($\hat{}$). The income share of capital calculation is based on the firms' expenditures on capital and labour inputs:

$$\hat{\alpha} = E\left(\frac{(r+\delta+\hat{\rho})K}{\frac{WL(1+q)}{P(1-z)} + (r+\delta+\hat{\rho})K}\right). \tag{15}$$

[5] An alternative option to calibration would be econometric estimating. Here the former is preferred for the sake of consistency between all parameters.

The operator $E(.)$ indicates the sample mean. Using data from 1997 to 2003 we obtain the value for $\hat{\alpha}$ 0.37. The risk premium $\hat{\rho}$ is calibrated so that it ensures that the marginal productivity of the capital condition holds — that is, the marginal revenue of capital equals the marginal cost of it. As this was present in the case of labour, the marginal revenue of capital is η times higher than the marginal cost of it and thus $\hat{\alpha}(Y/K) = \hat{\eta}(r+\delta+\hat{\rho})$. The calibration sows that $\hat{\rho} = 0.054$. The mark up becomes:

$$\hat{\eta} = E\left(\frac{(1-\hat{\alpha})(1-z)PY}{(1+q)WL}\right). \tag{16}$$

The value of $\hat{\eta}$ was 1.124, implying that firms set the price 12.4% over the production cost.[6] Elasticity of demand to relative price level $\hat{\varepsilon}$ is $\hat{\eta}/(\hat{\eta}-1)$=9.1, hence it does not have any clear impact on the model's behaviour. Unlike the mark up, elasticity with respect to relative price is not included in the demand function later on.

The initial level of labour-augmenting technology comes directly from the production function:

$$\hat{A}_0 = E\left(\frac{Y}{K^{\hat{\alpha}}(e^{gt}L)^{(1-\hat{\alpha})}}\right). \tag{17}$$

The calibrated value for A_0 guarantees that supply-based (potential) GDP calculated with the production function equals the demand determined (actual) GDP in the sample period. The level of technology available in the economy grows at the rate g, the derivation of which is presented in the next section.

3. Underlying Assumptions for the Long Run Growth Path

3.1. Income Level Convergence

An underlying concept of modelling the real growth of the Estonian economy in the long run is that the income level converges to the EU15 level by year T. In addition it is assumed that rates of economic growth

[6] The mark up that is used in the IMF's Global Econometric Model (GEM) for analysing Estonia's goods market flexibility is only slightly different — depending on scenario 1.12 or 1.16. The goods market mark up in the EU is calibrated to be 1.16 (Lutz and Stavrev (2004)).

will equalise by the same time. This implies that the speed of convergence is diminishing — the closer the Estonian income level gets to the EU15 level, the slower the output growth. Knowing the initial relative income level and the growth rates in Estonia and the EU15, it is possible to calculate the time it takes to reach the EU15 income level.[7] The outcome of the following atheoretical approach measuring the speed of convergence is later used for setting restrictions on the dynamic equations so that the model would produce consistent convergence scenario.

We assume that the EU15 is in a steady state already. The definition of being in a steady state (or on a balanced growth path) is hereby taken from Neo-Classical growth theory — output per unit labour grows at the rate of technological progress (Romer, 2001). If Estonia's income level reaches that of the EU15 and growth rates also equalise, both economies would grow at the same speed as (foreign) technological progress $\widetilde{g}^f$ (tilde indicates that we deal with the presumed value of actual g^f).

In what follows, we try to see what the growth rates of the production factors — capital stock and level of labour augmenting technology — have to be in order to ensure the desired income level convergence. For simplicity, we assume the change in population and employment to be zero in the long run. In the light of the latter, we try to see whether capital deepening under the circumstances of sharing the same technological progress with the EU15 is sufficient to increase output by the required amount.

Firstly, we project income level growth and calculate the time period it takes to reach the EU15 income level. We distinguish between two time periods. The first period covers 1996–2003 and is denoted by $t = [0;\, \tau]$ ($\tau = 2003$). The second period covers from 2004 up to the end of the convergence process, and is denoted as $t = [\tau + 1;\, T]$. The total length of the time period under observation is thus $t = [0;\, T]$. The following equation is applied to calculate T:

[7] It is debatable whether the EU15 is the right reference group or not. Firstly, we use a group of countries in order to have a heterogeneous sample. It is more difficult to justify converging to a particular country's income level. But even in this case, if we consider Finland and Sweden — countries that the Estonian economy has integrated the most with — the relative income level of these countries is close to 100% of that of the EU15. Another issue is whether the Estonian relative income level will converge exactly to 100% or not. Lacking the information on whether the actual outcome will be above or below 100%, we make this simplification and assume a halfway solution. Anyway, it does not have a very significant impact on the model's properties in the medium run.

$$\frac{y_\tau}{y_\tau^f} e^{\int_\tau^T \left((\overline{\gamma}_y - \upsilon) - \frac{\left(\overline{\gamma}_y - \upsilon - \widetilde{\gamma}_y^f\right)(t-\tau)}{T-\tau} \right) dt} - e^{\int_\tau^T \widetilde{\gamma}_y^f dt} = 0, \tag{18}$$

where y_τ denotes the Estonian income level (output per capita) in period τ (last available actual data observation), measured at the purchasing power parity (PPP). y_τ^f is foreign (EU15) income level during the same period, which is assumed to grow in the future at the constant rate $\widetilde{\gamma}_y^f$. Parameter $\overline{\gamma}_y$ is the average observed growth rate in Estonia in 1996–2003.

Equation 18 expresses linearly diminishing output growth rate — the growth in the forecast period starts from the level $\overline{\gamma}_y - \upsilon$ and goes down to the foreign (steady state) growth rate $\widetilde{\gamma}_y^f = \widetilde{g}^f$ by the time of period T. The drawback of using such a linear function is that it is valid only in $[0;\ T]$. For the sake of simplicity, this approach is used here and no attention has been paid to inconsistency in the steady state and actual growth rates after the year T (one could think that there is a kink in the growth rate in period T, staying constantly $\widetilde{g}^f$, which is the rate of technological progress).

υ stands for the differential in the average output growth rate during $[0;\ \tau]$ and the growth rate in period τ. Using $\overline{\gamma}_y - \upsilon$ as the initial growth rate from which to start projecting the growth in the long run from, we end up having a linear trend over the whole period ($[0;\ T]$) and avoid having a kink in period τ (see Figure 1). It is also noteworthy that the value for T depends negatively on the initial growth rate. The growth differential υ is expressed in the following way:

$$\upsilon = \frac{\frac{\tau}{2}(\overline{\gamma}_y - \widetilde{\gamma}_y^f)}{T - \frac{\tau}{2}}. \tag{19}$$

As the EU15 is assumed to be in the steady state already, it grows at the speed of technological progress, which in our calculations is $\widetilde{g}^f = \widetilde{\gamma}_y^f =$ 2% per year. Estonia's initial relative income in purchasing power parity terms is 44% (Eurostat database Newcronos) and calibration provides for the initial income growth $\overline{\gamma}_y - \upsilon = 5.6\%$. Applying these numbers in equation 18, we arrive at $T - \tau$ being 48 years or in other words, income levels and growth rates will, according to this purely mathematical experiment, equalise in 2052.

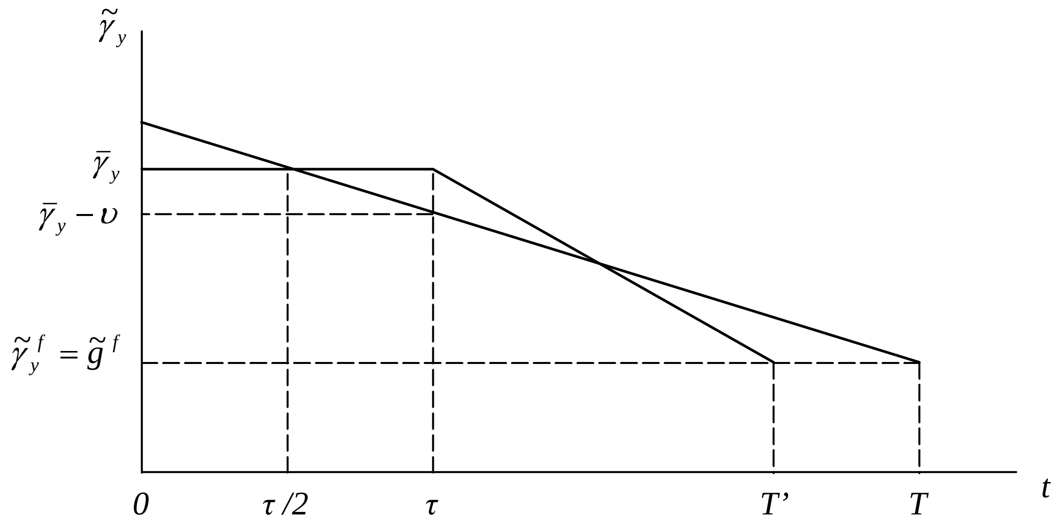

Figure 1: Projecting diminishing growth rates.

Equation 18 implies that Estonian output has to grow by about six times till it reaches the EU15 level in the year T. In the following, we try to obtain some evidence to discover whether an increase in capital stock and the level of technology are enough to generate output growth by that much.

The idea of capital deepening is in line with the golden rule of capital accumulation in Neo-Classical growth theory (see Barro and Sala-i-Martin (1999)). By period T we want K to grow at the same rate as Y does — 2% a year. This means that the long run behaviour of capital is similar to that of output — initial higher productivity of capital stock makes it grow faster but the growth gradually slows down (in our case linearly).

First of all, a measure for the initial capital stock is required. Unfortunately, there are no official statistics on capital stock in the Estonian economy, and economists have constructed an approximation on their own. One of the first attempts to produce an estimate of Estonian capital stock, in known literature, was conducted by Rõõm (2001) when measuring potential output with the production function. Rõõm used standard PIM (perpetual inventory method) methodology, but that estimate did not include housing stock as a part of total capital in the economy and thus is not valid for this particular model. Another methodology, applied by Basdevant and Kaasik (2002), was the state-space model technique. They used the Kalman filter to give an estimate of the capital stock. But being suspicious of the depreciation rate they calibrated, the filtered time series is not used here.

The following method uses investments and capital consumption data as well as the future vision of capital stock dynamics to construct its time series. The technique is completely driven by the necessities of the model and does not constitute an actual forecast of the growth process. In this approach we project that the capital to output ratio will converge to three by the end of real and nominal convergence.[8] In period T, capital stock growth equals real output growth, which means that in the steady state the capital output ratio remains unchanged.

The average growth of capital stock ($\overline{\gamma}_K$) in $[0;\ \tau]$ (covers the years 1996–2003), can be expressed as the capital stock in period τ (K_τ) divided by its initial value (K_0) and taken in power to $1/\tau$:

$$\overline{\gamma}_K = \left(\frac{K_\tau}{K_0}\right)^{\frac{1}{\tau}} - 1. \tag{20}$$

Capital accumulation is generated by additional investments and extracting capital consumption $K = (1-\delta)K_{-1} + I_{-1}$. Therefore for K_τ we can write:

$$K_\tau = K_0(1-\delta)^\tau + \sum_{t=0}^{\tau-1} I_t. \tag{21}$$

We use the following equation to filter the data for the capital stock. We let the capital stock grow to three times the level of GDP with a linearly diminishing growth rate just as with the income level projections:

$$\begin{aligned}
\frac{K_T}{Y_T} &= \frac{K_\tau}{Y_\tau} e^{\int_\tau^T \left(\overline{\gamma}_K - \varsigma - \frac{\left(\overline{\gamma}_K - \varsigma - \tilde{\gamma}_y^f\right)(t-\tau)}{T-\tau}\right) dt} \\
&- e^{\int_\tau^T \left((\overline{\gamma}_y - \upsilon) - \frac{\left(\overline{\gamma}_y - \upsilon - \tilde{\gamma}_y^f\right)(t-\tau)}{T-\tau}\right) dt} \\
&= 3,
\end{aligned}$$

where the growth differential ζ is

[8] The ratio comes straight from the literature. According to the World Bank dataset the average capital stock output ratio in the EU is three (quoted by Pula (2003)). An important notification here is that this measure includes residential buildings. When residential buildings are excluded, the ratio would be around 2.3 according to Maddison (1995), implying that buildings form about 70% of GDP.

$$\varsigma = \frac{\frac{\tau}{2}(\overline{\gamma}_K - \widetilde{\gamma}_y^f)}{T - \frac{\tau}{2}}. \tag{22}$$

From equation 20 it is possible to see that the higher K_0 is, the slower the average growth rate of capital stock $\overline{\gamma}_K$ and *vice versa.* So there exists a certain value for K_0 that allows us to have K_T/Y_T at three and the capital growth rate to equalise to $\widetilde{\gamma}_y$ in period T. By solving equation 22 we arrive at K_0/Y_0 being 1.98 ($K_\tau\ /Y_\tau = 2.23$) and $\overline{\gamma}_K = 0.073$ (see Figure 2).

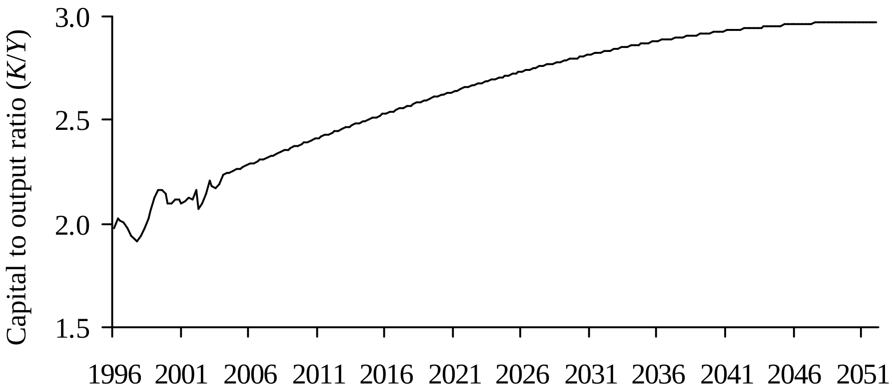

Figure 2: Presumed capital deepening.

The calculations presented above imply that capital stock increases by approximately eight times during the period $[\tau;\ T]$. It is easy to see that if presumed technological progress $\widetilde{g}$ is constantly equal to $\widetilde{g}^f = 2\%$, and taking $\hat{\alpha}$ as being calibrated to 0.37, then a capital deepening by eight times does not guarantee the required output growth (which has to grow by about six times to catch up with the EU15). The conclusion here is that technological progress must be higher initially than in the steady state. The reasoning is that technological progress slows down in line with the closing technological gap between Estonia and the EU15. Taking average labour growth over the long horizon as zero out of the sample period $E(\widetilde{n}) = 0$, g can be presented in the following way:

$$\widetilde{g} = \frac{\widetilde{\gamma}_y - \hat{\alpha}\widetilde{\gamma}_K}{1 - \hat{\alpha}}. \tag{23}$$

As real growth $\widetilde{\gamma}_y$ and growth in capital stock $\widetilde{\gamma}_K$ are time dependent, $\widetilde{g}$ also has to change over time. By the end of the convergence period technological progress is projected to grow at the same rate as output and capital stock, which is 2% per year (see Figure 3).

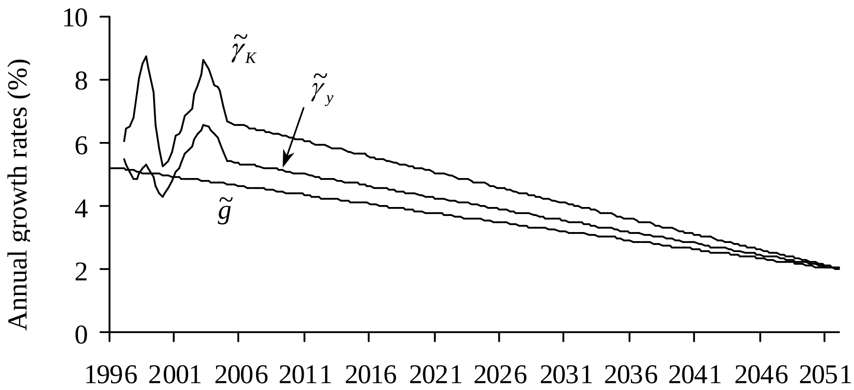

Figure 3: Growth of capital, output and technological progress.

In the steady state, the capital to output ratio has reached its optimal level and remains unchanged ($\widetilde{\gamma}_y = \widetilde{\gamma}_K = \widetilde{g} = \widetilde{g}^f = 2\%$). The constant physical depreciation rate implies that the investments to GDP ratio must fall gradually in line with the capital deepening process till the ratio settles to its steady state value and investments start to grow at the same rate as the remaining real variables.

Reaching and staying at 2% annual growth on a balanced growth path is a pure technical assumption. In our projections, growth rates are not described by convex curves (that could be more realistic) but by linear trends, which implies that they have to kink after real convergence is achieved. The implication of convex growth rates ($\partial\widetilde{\gamma}_y/\partial t < 0, \partial^2\widetilde{\gamma}_y/\partial t^2 < 0$) would be a longer convergence period than was calculated previously.

3.2. Prices and Nominal Convergence

Price inflation is currently higher in Estonia compared to the EU15, consistent with a continual decrease in the gap between Estonian and EU15 price levels. The driving force is higher productivity growth in Estonia, which leads to a convergence of structure and price levels as well.[9] The underlying assumption for the nominal convergence is that the

[9] This process is believed to cause 1.5–2.5 percentage point inflation difference compared to inflation in advanced economies, shown by Randveer (2000). Égert (2003)

EU15 level should be reached by the time of income level equalisation.

Following the same framework as used to determine income level convergence, it is possible to calculate an initial domestic price inflation[10] that ensures nominal convergence (also in terms of levels and growth rates) to end at the same time as real convergence and to compare it to actual data to see whether the projection exercise is flawed or not:

$$\frac{P_\tau}{P_\tau^f} e^{\int_\tau^T \left((\overline{\pi}-\omega) - \frac{\left(\overline{\pi}-\omega-\widetilde{\pi}^f\right)(t-\tau)}{T-\tau} \right) dt} - e^{\int_\tau^T \widetilde{\pi}^f dt} = 0. \tag{24}$$

Taking the initial foreign price level as being equal to one hundred ($P_t^f = 100$), Estonian price level, expressed in a GDP deflator, makes up 52% of it ($P_\tau = 52$) (Eurostat database Newcronos). Foreign inflation is taken to be $\widetilde{\pi}^f = 2\%$ for future periods. According to equation 24, the initial yearly inflation rate $\overline{\pi} - \omega$, which ensures that price level convergence ends at the same time as real convergence, is 4.7% (analogously to what υ means in equation 19, ω reflects the difference in average inflation rates in $[0; \tau]$ and point value in τ. This result is also consistent with actual data observations. We can conclude, as was projected in the case of real growth, that inflation also slows down and becomes equal to the EU15 rate by the time the steady state has been reached, i.e. in 48 years.

4. Estimating and Setting up the Model

4.1. Data and Estimation Method

The data used to construct the model originates from three sources: Estonian national accounts data is provided by the Estonian Statistical Office, Estonian financial statistics by Eesti Pank and foreign sector data by the Eurostat database Newcronos. The model operates using quarterly data, which is available for most of the series. Interpolation and own construction is used otherwise.

All time series in the model are seasonally adjusted. The method used for seasonal adjustment is Tramo/Seats (Time Series Regression with ARIMA Noise, Missing Observations and Outliers/Signal Extraction in

stated that this effect had been stronger in the beginning of the transition period in Estonia, but it still remains a significant factor.

[10]We consider inflation in GDP deflator because the model treats GDP deflator as a key price index.

ARIMA Time Series). Tramo/Seats is based on the ARIMA model with estimated parameters. One reason why this method is used is that the alternative tools (most common are X12 and X11) are based on smoothing time series (non-parametric method), which may generate an end-point problem. Biased estimates for the adjusted data in the end of the sample would create problems in the model's forecast properties.

Tramo/Seats is also a useful tool when dealing with time series that include missing data. Also, it successfully identifies outliers and eliminates their impact on adjusted time series (which is not apparent in the case of moving-average methods, where the adjusted series is affected by the extreme values).

In the case of aggregate time series (i.e. series that consist of the sum of two or more components), indirect seasonal adjustment is always used. This means that a seasonally adjusted aggregate equals the sum of its seasonally adjusted components. The reason for using indirect adjustment is that each component may have a different seasonal pattern and this fact is ignored when applying the adjustment technique to aggregate values. Another argument for not adjusting the aggregate and its components separately is that the sum of adjusted components does not add up to the directly adjusted aggregate.

All behavioural equations of the model are presented in the form of an error correction model (ECM), constructed using a two-step Engle-Granger technique. Parameters in behavioural equations are estimated using Two Stage Least Squares (2SLS). Ordinary Least Squares (OLS) is considered to be inappropriate because it is sensitive to the selection of explanatory variables, or their correlation with the error term. The usefulness of 2SLS in small samples may be questionable as well, but it is considered here that 2SLS estimates are at least as good as those of OLS. Still, as a first step in the estimation process, OLS is always used to carry out coefficient stability tests. The default time period used for estimating is 1996 first quarter till 2003 fourth quarter. Up to a subjective judgement on data quality, a shorter period is sometimes used. The sample size may shorten due to instrument list specification as well — we equalise instruments to the lagged values of explanatory variables in an equation.

When estimating supply side equations (i.e. employment, GDP deflator and real wage), we ensure that a dynamic homogeneity condition holds. The purpose of including a dynamic homogeneity condition is to ensure that the supply side of the economy converges exactly to that suggested by the theory.[11] Let us consider the following general form of the error correction model:

$$\Psi(\Lambda)\Delta ln(Y_t) = c + \Gamma(\Lambda)\Delta ln(X_t) - \theta\left(ln(Y_{t-k}) - \varpi ln(X_{t-k})\right) + v_t \quad (25)$$

where c is the intercept,$\Psi(\Lambda)\Delta ln(Y_t)$ is the lag polynomial of endogenous variable Y and $\Gamma(\Lambda)\Delta ln(X_t)$ is the lag polynomial of the exogenous variables' vector X. The expression $ln(Y_{t-k}) - \varpi ln(X_{t-k})$ is the error correction term and v is the disturbance term. On the balanced growth path the endogenous variable and the vector of exogenous variables grow at the rates γ_Y and γ_X respectively. Denoting steady state values of Y with Y^* and X with X^*, the following relationship must hold on the balanced growth path:

$$\Psi(\Lambda)\gamma_Y = c + \Gamma(\Lambda)\gamma_X - \theta\left(ln(Y_t^*) - \varpi ln(X_t^*)\right) \quad (26)$$

In the steady state, the endogenous variable equals its intermediate (long run) target $ln(Y_t^*) = \varpi ln(X_t^*)$, implying that $\gamma_Y = \varpi\gamma_X$. As a result, the short run dynamics of the error correction model are consistent with the long run part of it only if $\varpi\Psi(\Lambda)\gamma_X = c + \Gamma(\Lambda)\gamma_X$. As shown in the previous chapter, the model deals with diminishing growth rates. Therefore, the dynamic homogeneity restriction becomes more complex and differs from the "traditional". The intercept of the model must capture the change in growth rate of explanatory variables γ_X and thereby is time dependent. The actual restriction imposed on estimated error correction models is $c_t = [\varpi\Psi(\Lambda) - \Gamma(\Lambda)]\widetilde{\gamma}_X$, where $\widetilde{\gamma}_X$ is the trend growth of explanatory variables.

The procedure of imposing a dynamic homogeneity condition is as follows. Firstly an unrestricted equation is estimated to specify the lag structure and to select the set of short run determinants. In the second stage we derive a restricted form of the equation and re-estimate the equation using an instrumental variable method.

The current macro model is designed to be suitable both for medium term forecasting and simulation analysis. It makes the estimation procedure more difficult. For a forecasting model it is better not to put any

[11] Using a dynamic homogeneity restriction is a rather standard feature and is widely used, but in contrast to this Botas and Marques (2002) show that there exists no difference between the static and the dynamic long run equilibrium and thus from the theoretical point of view there is no need to impose restrictions.

restrictions on coefficients in the dynamic part and let the information included in the data take the precedence. This gives the best data fit and forecasting accuracy. On the other hand, in order to have plausible simulation properties, calibrating the parameters and restricting short run coefficients is preferred. In the current work, a balance has been found between those alternatives, depending on their relative effect on the model's behaviour.

4.2. Structure of the Model

The model describes four institutional sectors: households, government, firms and the rest of the world. The main relationships between those sectors are presented in Table 1. Total expenditure equals the sum of private and public consumption (C_P and C_G respectively), private and government investments (I_P and I_G respectively), change in inventories (Z) and exports (X), which matches the receipts by firms (Y) and the rest of the world (M) (see Table 1 and the list of acronyms in Appendix 1).

Table 1: The main accounting relationships

	Expenditures				**Receipts**			
	Hh.	Gov.	Firms	RoW	Hh.	Gov.	Firms	RoW
Total expenditure†	C_P	C_G+I_G	I_P+Z	X			Y	M
Consumption†	C_P	C_G						
Investments†		I_G	I_P					
Inventories†			Z					
Compensations#			WL		WL			
Disposable income#					$Y_D P_C$	R	ςO	
Direct taxes#	T_P		T_S			T_S+T_P		
Indirect taxes#	T_I					T_I		
Gov. transfers#		G_T			G_T			
Savings†					S_H	S_G	S_F	
Net foreign income#				iN			iN	
Net foreign transfers#				F_T			F_T	
Foreign trade#				XP_X				MP_M

Notes: Hh. – households, Gov. – government, RoW – rest of the world, † – real value, # – nominal value.

Part of the total income earned by firms is distributed to households as a compensation for the labour input (WL) and the rest of it — the gross operating surplus (O) is divided between firms and households. Households, as ultimate owners of firms, receive a share of the gross operating surplus while the rest of it (ςO) — is used for financing the firms' investments. Apart from a share of the gross operating surplus, the total nominal disposable income of households ($Y_D P_C$) consists of net labour income ($WL - T_P$) plus government transfers (G_T). Adding government disposable income (R) and the firms' share of the gross operating surplus (ςO) to the disposable income of households we get the total disposable income in the economy. Government disposable income consists of collected tax revenues — social contributions paid by firms (T_S), income tax (T_P) and indirect taxes (T_I) paid by households — plus other income.

Total disposable income of domestic agents is either consumed ($C_P + C_G$) or saved ($S_H + S_G + S_F$). The spread between gross capital formation and savings corresponds to the current account balance ($XP_X - MP_M + iN + F_T$), interpretable as a flow of net lending from abroad. Depending on whether net lending is positive or negative, firms receive or pay interest on net foreign assets (iN).

4.3. Real Sector

The domestic real sector is split into four components: capital formation, private consumption, inventory investments and NPISH (non-profit institutions serving households) consumption. The latter is left exogenous because of its marginal contribution to output.

Investments

Investments (I) are clearly one of the key variables in the macro model affecting long run potential growth via capital accumulation and also shaping economic activity in the short run. Investments are modelled according to a top-down principle. An estimated behavioural equation provides the total demand for investment goods in the economy. Government sector investments (I_G) are exogenous, which enables private sector investments to be expressed as total investments minus government investments — $I_P = I - I_G$. Accordingly, private capital stock K_P equals total capital stock K minus government capital stock K_G.

The intermediate target of total investment demand reflects the change in desired overall capital stock K^*. The latter is derived from the representative firm's profit maximisation problem. By writing equation 11 in logarithmic form we get:

$$ln(K^*) = ln\left(\frac{\hat{\alpha}}{\hat{\eta}}\right) + ln(Y) - ln(r + \delta + \hat{\rho}). \quad (27)$$

Taking equation 27 and using the capital accumulation identity $K = (1 - \delta)K_{-1} + I_{-1}$ gives us investment demand in the steady state —

$ln(I^*) = ln(K^*) + ln(g + n + \delta)$. The latter shows that on a balanced growth path investments grow at the same speed as capital stock (given that $\partial(g + n + \delta)/\partial t = 0$ on a balanced growth path). In other words, investments are just sufficient to ensure that the capital to output ratio remains constant. It is important to mention here that this relationship only holds in the steady state. For as long as the economy is not on the balanced growth path, a higher marginal productivity of capital causes an increase in the capital to output ratio. The long run path for investments, noted with I^*, is presented in Table 2 (upper panel).

Table 2: The long run rate and dynamics of gross capital formation

Long run relationship
$\ln(I^*) = \ln(K^*) + \ln(g + n + \delta)$, where $\ln(K^*) = \ln(\hat{\alpha}/\hat{\eta}) + \ln(Y) - \ln(r + \delta + \hat{\rho})$
Dynamic equation
$\Delta\ln(I) = \underset{(0.575)}{0.003} - \underset{(-)}{0.100}\ln(I_{-1}/I^*_{-1}) + \underset{(2.673)}{0.682}\Delta\ln(Y) + \underset{(2.673)}{0.318}\Delta\ln(Y_{-1}) - \underset{(-2.262)}{0.254}\Delta\ln(P_{K-1})$
R^2 = 0.700; *DW* = 2.193; *s.e.* = 0.033; *NOB* = 23
Notes: IV estimator. R^2 – statistical fit; *DW* – Durbin-Watson statistic; *s.e.* – standard error of regression; *NOB* – number of observations. *t*-statistics are presented in parentheses below the coefficient point estimates.

The speed of adjustment to the intermediate target of investments is moderate. Exactly 10% of the deviation in investments from the long run rate is eliminated in one quarter (see the lower panel of Table 2). We have imposed the error correction coefficient to have plausible adjustment path. The estimation procedure gave a coefficient value twice as high, generating responses to changes in cost of capital that were too extensive. In addition, following the model of the Bank of Greece (Sideris and Zonzilos, 2005), we define the cost of capital as a partially autoregressive process to lessen the reaction magnitude in simulation exercises: $P_K = 0.6P_{K-1} + 0.4P(1 - z)(r + \delta + \rho)$.

The short run determinants of investments include output and user cost of capital. Investments respond to output fluctuations with unitary elasticity. The coefficient for the cost of capital in combination with 10% of the immediate adjustment implies that an increase in the cost of capital by one percent diminishes demand for investment goods by about 0.35% (see Appendix 2 for more detail).

The real interest rate, defined as the nominal interest rate minus the inflation rate $r = i - \pi$, is the only component in the user cost of capital that can affect investing decisions in the short run (other components, i.e. risk premium and depreciation rate are exogenous). As there is practically no country risk component in the nominal interest rate[12] and nominal interest rate margin (the difference between the Estonian and euro-zone interest rates) equals the Estonian and the euro area inflation differential (Sepp and Randveer, 2002), changes in interest rates directly reflect the impact of the euro area monetary policy decisions on Estonian investment demand.

Private Consumption

The configuration of the equation, which describes private consumption in the long run, originates from Muellbauer and Lattimore (1995). According to the life-cycle hypothesis, the representative agent's consumption is determined by permanent income and the real interest rate. Permanent income would be the sum of wealth and discounted value of labour income. Following Muellbauer and Lattimore (1995) private consumption (C_P) is:

$$C_P = (aV + bY_D)(1 + v), \tag{28}$$

where V is real financial wealth defined as private capital stock plus net foreign assets. Y_D is a household's real disposable income and v represents a stochastic error term. Rearranging the expression 28 we get:

$$C_P = bY_D \left[1 + \frac{a}{b}\frac{V}{Y_D}\right](1 + v). \tag{29}$$

By taking logs and using linear approximation, the equation takes the following form:

$$ln(C_P) \approx c + ln(Y_D) + d\frac{V}{Y_D} + v. \tag{30}$$

The latter equation implies the long run homogeneity of consumption with respect to income. The homogeneity condition implies that in

[12]The country specific risk component in the nominal interest rates has diminished to zero and its behaviour is generated by a random walk process (Kattai, 2004).

equation 30, the permanent income hypothesis holds. Estimating equation 30 econometrically for the long run rate of private consumption (C_P^* gives the value of d as 0.02, showing that a one percentage increase in permanent-current income proportion increases consumption by two percent (see the upper panel of Table 3). This measure corresponds exactly to the parameter value in the Spanish model (see Willman and Estrada (2002))

The calculation of disposable income to some extent follows Willman and Estrada (2002). Nominal disposable income ($Y_D P_P$, where P_P is private consumption deflator) is the sum of gross labour income (gross wage W times labour in employment L), government transfers to households (G_T) and other income (Y_O) minus social tax (T_S) and tax on income and property (T_P):

$$Y_D P_P = W(1+q)L + G_T - T_S - T_P + Y_O, \tag{31}$$

where other income is

$$Y_O = a_1(O - \delta P_K K + rN) + a_2 P_K K. \tag{32}$$

O stands for the gross operating surplus, P_K is the investment deflator and N is net foreign assets. The coefficient a_1 explains how much households get from the gross operating surplus. What remains, is used by firms to finance their investments. Parameter a_2 measures the imputed housing income.

The dynamics of private consumption is affected by exactly the same factors as in the long run. The impact of financial wealth remains modest, while 70% of current disposable income is instantly consumed (see the lower panel of Table 3). When drawing a parallel with the Euler equation, the importance of current income in determining current consumption indicates that a large share of households are liquidity constrained and do not have a chance to consume their permanent income.

There is quite a strong autoregressive pattern detected, which implies that consumption tends to overreact to any given shock to exogenous variables. The way consumption adjusts seems to suggest that households are initially cautious about a change in their income. This kind of behaviour conflicts with the life-cycle hypothesis. Hall (1978) explains that rationally behaving households ought to be able to offset any cyclical pattern and restore the non-cyclical optimal consumption predicted by the hypothesis. Non-cyclicality cannot be observed in the actual data, and therefore we conclude that consumers do not have perfect foresight about their future income and they do not behave rationally, at least not in the short run.

Table 3: The long run rate and dynamics of private consumption

Long run relationship
$\ln(C_P^*) = \underset{(-4.777)}{-0.175} + \underset{(5.323)}{0.020}(V/Y_D) + \underset{(-)}{1.000}\ln(Y_D)$
$R^2 = 0.983$; $DW = 0.519$; $s.e. = 0.015$; $NOB = 28$
Dynamic equation
$\Delta\ln(C_P) = \underset{(-2.540)}{-0.006} - \underset{(-2.391)}{0.225}\ln(C_{P-1}/C_{P-1}^*) + \underset{(2.037)}{0.129}\Delta\ln(V) + \underset{(3.650)}{0.708}\Delta\ln(Y_D) + \underset{4.029}{0.584}\Delta\ln(C_{P-1})$
$R^2 = 0.913$; $DW = 2.090$; $s.e. = 0.006$; $NOB = 28$
Notes: See Table 2.

Let's consider an increase in disposable income. The behaviour of households remains conservative because of the uncertainty about whether the change in income is permanent or not. This makes households spend only a share of the additional income. If it turns out that the increase was permanent, households then spend the current higher income plus income saved during the period of uncertainty and the result of it is delayed overreaction to an increase in income (see Appendix 2 for the reaction response graph). Although not being modelled explicitly, household savings are endogenous, expressed as a difference between current disposable income and consumption ($Y_D - C_P$).

Inventory Investments

The basic principle of modelling a change in inventory investments (Z) involves fixing its stock value (Z_S^*) to output in the long run (Y^*). Any deviation from the "natural" level is associated with higher costs for firms' — higher stock value increases maintenance costs, whereas stock value that is too low may not be a sufficient buffer during downturns. This is reflected by the adjustment term in the dynamic equation — the coefficient 0.27 implies that corrections are relatively quick (see the lower panel of Table 4).

Changes in inventories mirror the sales cycle. Under sales (J) we mean storable goods, which in this particular work are proxied by the sum of private consumption and exports. The relationship is pro-cyclical — if sales exceed their long-run level, given as a proportion of potential output, firms create buffer stocks of raw materials used in the production process.

Table 4: The long run rate and dynamics of inventory investments

Long run relationship
$\ln(Z_S^*) = \underset{(-154.978)}{-0.444} + \underset{(-)}{1.000}\ln(Y^*)$
$R^2 = 0.981$; $DW = 0.348$; $s.e. = 0.014$; $NOB = 27$
Dynamic equation
$\Delta Z = \underset{(-3.809)}{-0.277}(Z_{-1} - \Delta Z_{S-1}^*) + \underset{(3.432)}{0.059}\left(\Delta J_{-1} - 1.444\Delta Y_{-1}^*\right) - \underset{(-2.406)}{0.219}\Delta\left(r_{-1}Y_{-1}^*\right)$
$R^2 = 0.960$; $DW = 2.468$; $s.e. = 81.900$; $NOB = 25$
Notes: See Table 2.

The term $r_{-1}Y_{-1}^*$ captures the cost of holding inventories. The price faced by firms is reflected by the real interest rate r. An increase in the interest rate raises opportunity costs and thereby motivates firms to lessen their stock of inventories. Overall, due to the small share of changes in inventories in GDP (3% on average), it affects the dynamics of GDP only a little.

4.4. External Sector

External trade is split into exports and imports of goods and services.[13] We have previously defined that goods produced and consumed are of the same generic category. The same applies for goods that are traded externally. In the model it is assumed that imported and domestically produced goods are perfect substitutes.

Imports

We begin modelling the cointegration relationship of imports (M) from the general form — being a function of the domestic import demand indicator and relative prices. The import demand D_M is proxied by the weighted sum of private and public consumption, private investments and

[13] Some efforts have been made to model exports and imports of goods, services and re-exports separately, but without any particular success. Pinning the components down to smaller aggregates added some uncertainty to the model, which was not acceptable due to the external sector's high contribution to output growth.

exports. The weights for each demand component are calibrated from the input-output tables. The relative price of domestic and foreign goods is measured in the GDP deflator at factor cost $P(1-z)$ and import deflator (P_M) ratio. The equation we are considering is the following:

$$M = D_M \left(\frac{P(1-z)}{P_M} \right)^{\beta_M} . \tag{33}$$

Due to nominal convergence domestic production prices increase faster than foreign prices, which implies that domestically produced goods become more expensive compared with the imported ones. Under the assumption of perfect substitutability, this would increase demand for imported goods. The initial level of the GDP deflator is 52% of the EU15 average as shown before. The respective measure for the import deflator is 80%. Both of them reach 100% by the end of the convergence period by definition. As a result, the value of the $P(1-z)/P_M$ ratio goes up by 70%, causing an increase in imports by factor 0.7^{β_M} *ceteris paribus*, where β_M is import elasticity to relative price. If we estimate equation 33 econometrically, we get β_M as 0.9, implying that the overall effect would be 80%. This means that the imports to output ratio roughly doubles by the end of the convergence period and takes the value of about 150% of GDP.

The increase in the openness of the economy could be explained by various factors, such as finding niches in world markets for example. This may be true for a small economy that could benefit from economies of scale through concentrating on producing a narrower range of goods and trading those against a more diversified basket of goods. Even if the latter justification seems plausible when describing an increase in trade intensity, we find imports being about 150% of GDP unrealistic — Estonia is already one of the most open economies.

The latter suggests that the relative price should be neglected from the cointegration relationship. This is consistent with Hinnosaar et al. (2005) and Filipozzi (2000), who found that the Estonian kroon's exchange rate has been in equilibrium or close to it. Therefore, one could expect no long run effect on import volumes originating from the real exchange rate, i.e. relative price movements. This is also supported by Juks (2003), who found that the real exchange rate plays a secondary role in achieving a sustainable position of external balance. According to this, imports are fully income driven and without any substitution effect in the long run. On the other hand, model simulation exercises proved that the absence of relative prices made the adjustment process flawed. These exercises showed that the presence of the relative price in the cointegration relationship is essential for unemployment to return to its natural level and to stabilise the model's behaviour via labour market clearance. As a result, we add the term $P_M/P(1-z)-\phi_M$ instead of the initial price ratio $P_M/P(1-z)$, where ϕ_M is a special trend parameter, which offsets the long run effect of a relative price change on imports (see the upper panel of Table 5). As a consequence, only price deviations from the long run growth path matter for the long run level of imports and we have achieved a compromise between simulation and forecasting properties of the model. The respective coefficient value is calibrated based on the dynamic equation.

The historical increase of the imports to GDP ratio that in the initial econometric estimation is picked up by a change in relative prices is caused by institutional changes and integration to the EU. We control this process by adding a calibrated indicator $\hat{m}_s$ to the list of explanatory variables of the long run relationship (see the upper panel of Table 5). $\hat{m}_s$ increases in the sample period at the slowing growth rate and remains constant outside the sample period.

Table 5: The long run rate and dynamics of imports

Long run relationship $\ln(M^*) = \underset{(4.651)}{0.032} + \underset{(-)}{1.000}\ln(D_M) + \underset{(-)}{1.000}\ln(\hat{m}_S) - \underset{(-)}{0.647}\ln(P_M/P(1-z)-\phi_M)$ $R^2 = 0.951$; $DW = 0.679$; $s.e. = 0.036$; $NOB = 27$
Dynamic equation $\Delta\ln(M) = -\underset{(-0.523)}{0.002} - \underset{(-2.652)}{0.313}\ln(M_{-1}/M^*_{-1}) + \underset{(-)}{1.000}\Delta\ln(D_M)$ $-\underset{(-1.928)}{0.647}\Delta\ln(P_{M-2}/P_{-2}(1-z))$ $R^2 = 0.867$; $DW = 1.718$; $s.e. = 0.020$; $NOB = 24$
Notes: See Table 2.

In the short run, imports dynamics are determined by the weighted demand for imported goods with unit elasticity. The parameter value was imposed to ensure that any reaction in expenditure components would transmit immediately to the demand for imports. This is also supported by the coefficient test, which showed that the estimated coefficient was not significantly different from one. In addition to the impact of the relative price deviations on imports in the long run, it is a significant factor for determining import volume in the short run. An increase in the domestic production price by one percent increases the amount of imported goods by 0.65 percent if foreign prices remain unchanged (see the lower panel of Table 5).

Exports

We start constructing the cointegration relationship for exports of goods and services (X) using the same configuration as the import equation. Initially exports are assumed to grow at a rate equal to growth in foreign demand (D_W) plus the change in relative prices. The foreign demand indicator consits of the weighted imports of Estonia's main trade partners.

In general, the higher increase in export prices (P_X) compared to competitors' prices (P_{CX}) lowers the price competitiveness of local producers resulting in an expected fall in the volume of exported goods and services (*ceteris paribus*). The long run equation for exports is given in the following general form:

$$X = D_W \left(\frac{P_{CX}}{P_X} \right)^{\beta_X} . \tag{34}$$

Taking the initial levels of P_{CX} and P_X and given that the relative export price converges to one, we calculate that the pure negative effect on exports caused by loosing price competitiveness is 20%. The total effect depends on the price elasticity parameter β_X.

When estimating equation 34 econometrically, we find the relative price to be insignificant. This is due to the fact that export prices and foreign prices are not that different in level or dynamics. But the inclusion of the relative price in the exports cointegration equation is motivated by the same factors as for imports — it is necessary for the simulation properties of the model. For that reason we did not neglect relative price, but allowed the long run path of exports to be affected by the deviation of the relative price from its long run target. As with imports, we included the term $P_X/P_{CX} - \phi_X$, where ϕ_X is the offsetting trend parameter. The coefficient value is calibrated based on the dynamic equation result.

Historically however, the average growth of exports has been higher than foreign demand. This is partly due to the integration process with the EU, finding new markets and an increase in understanding about foreign markets. Therefore we introduced an additional explanatory variable $\hat{x}_s$ to capture this effect. Its impact dies out gradually in the sample period and it has no effect outside of the sample period — in the forecasting period only foreign demand drives exports (see the upper panel of Table 6).

Table 6: The long run rate and dynamics of exports

Long run relationship
$\ln(X^*) = -\underset{(-2.567)}{0.023} + \underset{(-)}{1.000}\ln(D_W) + \underset{(-)}{1.000}\ln(\hat{x}_S) - \underset{(-)}{0.391}\ln(P_X / P_{CX} - \phi_X)$
R^2 = 0.921; *DW* = 0.859; *s.e.* = 0.047; *NOB* = 28
Dynamic equation
$\Delta\ln(X) = \underset{(0.707)}{0.005} - \underset{(-3.662)}{0.392}\ln(X_{-1} / X^*_{-1}) + \underset{(4.659)}{1.034}\Delta\ln(D_W) - \underset{(-2.218)}{0.391}\Delta\ln(P_{X-2} / P_{CX-2}) + \underset{(-)}{0.200}\Delta\ln(M)$
R^2 = 0.710; *DW* = 2.271; *s.e.* = 0.031; *NOB* = 27
Notes: See Table 2.

In the short run, exports respond to an increase in effective foreign demand with almost unitary elasticity. There is a slight overreaction, but a high error correction coefficient (–0.4) eliminates this overreaction almost immediately (see also Appendix 2 for the response graph). In one version of Eesti Pank's macro model Finnish GDP was taken to proxy foreign demand shocks in the short run (Sepp and Randveer, 2002). This was inspired by the fact that the Estonian business cycle had the highest correlation with that of Finland (also shown in Kaasik et al. (2003)). In this regard, effective export demand, which is used in this work, has better explanatory properties, which is also supported by the high significance of the estimated coefficient value.

The relative price effect on exports is two times milder than it was in the case of imports. This outcome of the estimation procedure may reflect that foreign consumers are less price-sensitive than Estonian consumers.

A proportion of Estonian exports also includes re-exports — the exports of goods that are temporarily imported for inward processing. The share of this category has stabilised at about 20% of total exports and we calibrate the coefficient for the imports based on that. Contemporaneous imports are inserted into the equation, because inward processing takes less than one quarter and goods are re-exported during the same period.

4.5. Prices

Real Wage

The dynamics of the real wage are described by means of the Phillips curve. As a first step we try to identify the natural unemployment rate using the "restated Phillips curve" initially developed by Friedman (1968). The algebraic expression of Friedman's interpretation of the Phillips curve is as follows (Whelan, 1999):

$$ln(W) - ln(P^e) = ln(W_{-1}) - ln(P_{-1}) + ln(Y/L) + \beta_1 - \beta_2 u. \qquad (35)$$

The nominal wage divided by expected price level (P^e) constitutes the real wage that rationally behaving households are asking for their labour. The growth of the real wage is determined by the growth rate of labour productivity. Here inflation expectations are treated in the simplest way and taken to be adaptive $\ln(P^e)$ - $\ln(P_{-1})$ = $\ln(P_{-1})$ - $\ln(P_{-2})$. By rearranging equation 35 and replacing the expected price level with the identity shown, we get:

$$\Delta ln(W) = \Delta ln(P_{-1}) + \Delta ln(Y/L) + \beta_1 - \beta_2 u. \qquad (36)$$

From equation 14 it is already known that the representative firm sets the price of its production as a constant mark up over unit labour cost. Skipping tax rates and the income share of capital for notational simplicity, in logarithmic form the price determination equation would be $\ln(P) = \ln(\eta) + \ln(W) - \ln(Y/L)$. Differentiating this and plugging the outcome into equation 36 yields a standard accelerationist Phillips curve:

$$\Delta ln(P) = \Delta ln(P_{-1}) + \beta_1 - \beta_2 u. \qquad (37)$$

By definition, inflation is stable only if the unemployment rate (u) is equal to the NAIRU (u_n) (Non-Accelerating Inflation Rate of Unemployment). Equating $\Delta\ln(P)$ and $\Delta\ln(P_{-1})$, or in other words, assuming stable inflation — NAIRU (u_n becomes β_1/β_2). The estimation of the parameters β_1 and β_2 in the accelerationist Phillips curve gives quite a high value for the NAIRU — 11.7% of the labour force (see NAIRU1 in Figure 4). Although the estimate is robust, we do not stick to that measure for two reasons: it is time invariant, but more importantly, it is strongly affected by the high unemployment caused by the Russian crisis.

In 1996 and 1997, inflationary pressures could be detected, indicating that unemployment was below its natural rate NAIRU. In 2002 and 2003, when unemployment returned to approximately 10%, inflation was below its long run rate and we conclude that unemployment exceeded NAIRU at that time. By quantifying these findings we construct a descending NAIRU (see NAIRU2 on Figure 4), which becomes about 8% by the end of 2003, being roughly equal to observations in the euro area at the same time (Logeay and Tober, 2003)).

Figure 4: Unemployment, annual inflation and NAIRU estimates

The long run specification of the real wage $(W^*(1+q)/P^*(1-z))$ is taken directly from the theoretical set up (see equation 13). In section 2.2 we arrived at the result that wage-income in real terms equals labour productivity (Y/L) times labour share of income $(1-\hat{\alpha})$ and divided by the mark up $(\hat{\eta})$ (see the upper panel of Table 7).

Nominal wage is indexed by the private consumption deflator (P_C) in the short run and by the GDP deflator in the long run. The dynamic part of the equation also includes the ratio between these price indices $(P_C/P(1-z))$, indicating the market power of firms. If firms manage to increase consumer prices faster than the price of production, households become worse off in labour income terms. We estimate this effect to be quite significant in magnitude (see the lower panel of Table 7).

The size of the effect of the unemployment rate's deviation from its natural rate NAIRU on wages is imposed because of its insignificance while trying to estimate it.[14] Here we make a clear distinction between the simulation and forecasting purposes of the model. If the equation were only used for forecasting, we would leave the labour market clearing effect out of the set of explanatory variables if suggested by the statistical diagnostics. But as the model also serves the purposes of performing simulation exercises, we would like to have this adjustment channel incorporated. The coefficient is set to –0.0025. The magnitude of this is found by testing the cyclicality it creates to see how extensive it is. Larger coefficient values tended to make the behaviour of the model too volatile (see Appendix 2 for more detailed response graphs).

Table 7: The long run rate and dynamics of the real wage

Long run relationship $\ln(W^*(1+q)/P^*(1-z)) = \ln\big((1-\hat{\alpha})/\hat{\eta}\big) + \ln\big(Y/L\big)$
Dynamic equation $\Delta\ln\big(W(1+q)/P_C\big) = \underset{(-)}{0.009} - \underset{(-3.803)}{0.097}\ln\big(W_{-1}/\big(W^*_{-1}(1+q)/P^*_{-1}(1-z)\big)\big) - \underset{(-)}{0.0025}\ln\big(u/u_N\big)$ $+ \underset{(1.724)}{0.035}\Delta\ln(Y_{-2}/L_{-2}) - \underset{(-7.812)}{0.705}\Delta\ln(P_C/P(1-z))$ $+ \underset{(6.075)}{0.363}\Delta\ln(W_{-1}(1+q)/P_{C-1})$ $R^2 = 0.939$; $DW = 1.462$; $s.e. = 0.002$; $NOB = 20$
Notes: See Table 2.

The dynamic equation satisfies the dynamic homogeneity condition. Having private consumption and the GDP deflator growing roughly at the same rate means that the real wage is growing at the speed of productivity, which, considering zero labour growth in the long run, is equal to output growth γ_y. The restriction set on intercept c becomes $c_t \approx \widetilde{\gamma}_y(1-0.041-0.258) + 0.139(1-t/224)0.0025$, where $\widetilde{\gamma}_y$ represents trend long run growth rate as derived in section 3.1 and $0.139(1-t/224)0.0025$ controls the unemployment gap's convergence to zero outside the sample. As productivity growth diminishes over time, the intercept of the dynamic equation is time dependent as well. In the statistical protocol in Table 7 we report the average value of c in the estimation period.

[14] Masso and Staehr used monthly data to construct a Phillips curve on Estonian data (though they modelled CPI inflation not wages), but also concluded that the labour market gap was an insignificant factor for explaining price movements (Masso and Staehr, 2004).

GDP Deflator

The intermediate target for the GDP deflator equals the unit labour cost times mark up. The equation determining the long run growth rate of the GDP deflator at factor cost ($P^*(1-z)$) is the same as it was for the real wage, we just rearrange it (see the upper panel of Table 8).

Table 8: The long run rate and dynamics of the GDP deflator

Long run relationship $\ln(P^*(1-z)) = \ln(\hat{\eta}/(1-\hat{\alpha})) + \ln(L/Y) + \ln(W(1+q))$
Dynamic equation $\Delta\ln(P(1-z)) = -\underset{(-)}{0.004} - \underset{(-2.130)}{0.072}\ln(P_{-1}/P^*_{-1}) + \underset{(-)}{0.350}\Delta\ln(W(1+q))$ $+ \underset{(-)}{0.200}\Delta\ln(W_{-1}(1+q)) + \underset{(-)}{0.080}\Delta\ln(W_{-2}(1+q))$ $R^2 = 0.583$; $DW = 1.695$; $s.e. = 0.004$; $NOB = 22$
Notes: See Table 2.

The GDP deflator's dynamic equation is almost wholly calibrated. Only the coefficient for the adjustment term is estimated. The calibration is carried out to yield the plausible simulation properties of the model. Short run fluctuations are purely nominal wage induced. The coefficients add up to labour income share in total income, which was calibrated to be 0.63 in section 2.2. We distribute the inflationary impulses originating from the labour input price increase over three consecutive quarters with rapidly diminishing magnitudes.

The nominal wage over the GDP deflator grows at the speed of labour productivity, but the proportions of the nominal wage and the GDP deflator increases are not specified *per se* by cointegration relationships (the price system is not perfectly identified). We use a dynamic homogeneity restriction to guarantee that GDP deflator inflation follows exactly the pattern that we described in section 3.2. It was about having higher inflation initially, that would push producer prices up until the EU15 level is reached by the end of the real convergence process. The nominal wage is given by the growth in the real wage and GDP deflator. Knowing that the nominal wage grows at the rate of productivity growth γ_y plus the GDP deflator inflation π, the homogeneity restriction becomes $c_t \approx 0.37\widetilde{\gamma}_y - 0.63\widetilde{\pi}$, where $\widetilde{\gamma}_y$ and $\widetilde{\pi}$ represent trend output growth and GDP deflator inflation.

Long run relationships for prices other than the GDP deflator are constructed, keeping the same ideology in mind — their levels and growth rates must equalise to those of the EU15 by the time income levels catch up with the EU15. The design of the cointegration relationships is rather simple. Namely, long run values are expressed as a weighted average of the GDP deflator and foreign prices (or import prices in some cases). For example, given the initial relative level of HICP, it has to grow at the rate π_H to reach 100% of the EU15 average by T. Understanding that goods belonging to the HICP basket are partially imported and partially domestically produced, HICP is a weighted average of import and domestic output prices. If import and output prices grow at the rates π_M and π respectively, ensuring required nominal convergence, the long run equation for HICP becomes $\pi_H = x\,\pi_M + (1-x)\,\pi$, where x has the value between zero and one, making the latter identity hold. In order to get those weights for all indices, we firstly have to come up with respective growth rates.

The technique used for growth rate calculation is similar to what was used in sections 3.1 and 3.2, with the simplification that no diminishing growth rates are assumed. Changing growth rates wouldn't allow the performance of the weighting that successfully. Also, the calculations would become too messy. Therefore, firstly we calculate how much time it would require to reach the EU15 income level if Estonian real growth didn't fall over time. The length of the period we get is 28 years. Having T - τ equal to 28 years, a simplified version of equation 24 is applied:

$$\frac{P_{i,\tau}}{P_\tau^f} e^{\int_\tau^T \overline{\pi}_i dt} - e^{\int_\tau^T \pi^f dt} = 0. \tag{38}$$

We obtain long run inflation rates ($\overline{\pi}_i$) for all prices (P_i) incorporated in the price block, taking initial price levels as given in Appendix 3. The results of the weighting exercise are reported in Table 9.

In the case of import and export prices Eurostat has assumed that they are already 100% of those of the EU15 (Estonia behaves as a price taker in world markets). This assumption is somewhat questionable because higher growth in the Estonian export and import deflators compared to the EU15 implies that there must exist an initial gap between them.[15] We set this gap to 80% both for export and import deflators. The ratio is derived from the historical growth differential between domestic deflators and foreign prices.

[15] If the initial relative price level were already 100%, higher growth in Estonia would lead to exceeding the price level in the EU15, which is quite difficult to explain.

Table 9: Calibration of the price indexes long run paths

Price Index (Implied annual growth rate)	**Long Run Determinants** (Annual growth rate (%); weight)	
Import deflator (2.8)	Competitors import deflator (2.0; 0.705)	GDP deflator (4.6; 0.295)
Export deflator (2.8)	Competitors export deflator (2.0; 0.705)	GDP deflator (4.6; 0.295)
Investment deflator (~2.6)	Import deflator (2.8; 1.000)	GDP deflator (4.6; 0.000)
HICP core (4.1)	Import deflator (2.8; 0.200)	GDP deflator (4.6; 0.800)
HICP food (3.3)	EU15 food prices (2.0; 0.441)	GDP deflator (4.6; 0.559)
HICP fuel (3.7)	Oil prices in USD (2.0; 0.295)	GDP deflator (4.6; 0.705)

The gap between local and foreign import and export prices can be explained in various ways. One reason is the structural difference in goods. While the Estonian income level is far below the EU15 average, some goods that are imported may have lower quality and thus lower prices in order to meet local consumer demand. As the income level grows over time, the bigger share of imports consists of goods with higher quality and price. In addition, one could think of price discrimination as well. The initial gap in export prices may be due to entering new markets. As Estonia's free trade period is relatively short, selling goods at lower prices may be necessary in order to enlarge their share in foreign markets.

Import Deflator

In the long run the import deflator (P_M^*) depends on foreign competitors' prices (P_{CM}) and the domestic GDP deflator. The relative shares are 0.7 and 0.3 respectively (see the upper panel of Table 10). The occurrence of the domestic production price in the import deflator's cointegration relationship refers to the pricing to market effect. Foreign producers lower their prices in order to gain competitiveness in the Estonian low-priced markets.

The competitors' price index is by construction the main trade partners' effective CPI, weighted by their share in Estonian imports: $P_{CM} = \chi_M P_{FIXI}$ + (1- χ_M)(P_{FLOI} /E_{FLOI}), where P_{FIXI} is the effective CPI of the main trade partners in the euro area and P_{FLOI} is the effective CPI of the main trade partners, whose currency is floating against the Estonian kroon. E_{FLOI} represents Estonian kroon's effective exchange rate. All indicators are weighted according to the country's share in Estonian imports. The share parameter χ_M reflects the weight of euro-based countries in Estonian imports and equals 0.6.

The latter implies that exchange pass-through is about 30% (0.705×0.4).[16] This is different from what has been found by Campa and Goldberg for OECD countries. They observed approximately 80% pass-through in the long run on average (Campa and Goldberg, 2002).

Table 10: The long run rate and dynamics of the import deflator

Long run relationship $\ln(P_M^*) = -\underset{-9.710}{0.171} + \underset{(-)}{0.705}\ln(P_{CM}) + \underset{(-)}{0.295}\ln(P(1-z))$ $R^2 = 0.953$; $DW = 1.017$; $s.e. = 0.014$; $NOB = 26$
Dynamic equation $\Delta\ln(P_M) = -\underset{(-2.921)}{0.008} - \underset{(-3.479)}{0.462}\ln(P_{M-1}/P_{M-1}^*) + \underset{(1.505)}{0.689}\Delta\ln(P_{FIXI}) + \underset{(4.826)}{0.552}\Delta\ln(P_{FLOI})$ $-\underset{(-3.860)}{0.189}\Delta\ln(E_{FLOI-1}) - \underset{(-4.458)}{0.073}\Delta\ln(E_{FLOI-2})$ $R^2 = 0.939$; $DW = 1.708$; $s.e. = 0.004$; $NOB = 22$
Notes: See Table 2.

In the short run, price impulses from the euro area dominate. Impulses coming from the trade partners' with a floating exchange rate against the kroon are about 25% weaker. Exchange rate pass-through is modest, only about 20%. In comparison, Campa and Goldberg observed a 60% pass-through in the short run (Campa and Goldberg, 2002).

Export Deflator

The set up of the cointegration relationship for the export deflator (P_X) is similar to what we saw in the case of the import deflator. It consists of the weighted average of foreign competitors' prices (P_{CX}) and the domestic GDP deflator. In the export deflator equation foreign competitors' prices are weighted according to the countries' shares in Estonian exports: $P_{CX} = \chi_X\ P_{FIXE} + (1-\chi_X)\ (P_{FLOE}/E_{FLOE})$, where P_{FIXE} is the effective CPI of the main trade partners in the euro-area and P_{FLOE}

[16]Dabušinskas (2003) used the econometric method to assess exchange rate pass-through to prices. He concluded that about 30% of import prices were affected by the exchange rate movements. Overall, the long run pass-through was found to be 40–50%.

is the effective CPI of the main trade partners, whose currency is floating against the Estonian kroon. Both are weighted by countries' share in Estonian exports. E_{FLOE} stands for Estonian kroon's effective exchange rate, also weighted by countries' share in Estonian exports. The share parameter χ_X reflects the weight of euro-based trade partners in Estonian exports, being equal to 0.5. Competitors' prices enter the long run equation with the share of 0.7 and the domestic price has the share 0.3 proportionally (see the upper panel of Table 11).

Table 11: The long run rate and dynamics of the export deflator

Long run relationship $\ln(P_X^*) = -\underset{-51.101}{0.213} + \underset{(-)}{0.705}\ln(P_{CX}) + \underset{(-)}{0.295}\ln(P)$ $R^2 = 0.958$; $DW = 0.777$; $s.e. = 0.016$; $NOB = 28$
Dynamic equation $\Delta\ln(P_X) = \underset{(2.023)}{0.004} - \underset{(-2.901)}{0.388}\ln(P_{X-1}/P_{X-1}^*) + 0.5\times\underset{(-)}{0.705}\Delta\ln(P_{FIXE})$ $+ 0.5\times\underset{(-)}{0.295}\Delta\ln(P_{FLOE}) - \underset{(-5.370)}{0.203}\Delta\ln(E_{FLOE})$ $R^2 = 0.655$; $DW = 2.030$; $s.e. = 0.010$; $NOB = 26$
Notes: See Table 2.

The estimation of the dynamic equation did not show that foreign price impulses were significant in explaining export price movements. But in order to have them as explanatory variables for simulation purposes, the coefficients were calibrated to their magnitudes in the long run. The exchange rate pass-through was estimated to be significant, but the coefficient shows only a mild response in prices (see the lower panel in Table 11).

Investment Deflator

The basic idea of the long run equation for the investment deflator (P_I) is in line with what we have seen before. In principle, as a proportion of investment goods are imported and other portion is produced domestically, the long run rate of the investment deflator is the weighted average of the import deflator and the GDP deflator. According to calibration, the results of which are presented in Table 12, the GDP deflator's share becomes zero. This is due to the investment price level being roughly equal to import prices. The latter may reflect the fact that domestically produced investment goods have the same price as foreign alternatives.

Table 12: The long run rate and dynamics of the investment deflator

Long run relationship $\ln(P_I^*) = \underset{4.253}{0.015} + \underset{(-)}{1.000}\ln(P_M)$ $R^2 = 0.877$; $DW = 0.536$; $s.e. = 0.017$; $NOB = 24$
Dynamic equation $\Delta\ln(P_I) = \underset{(3.282)}{0.004} - \underset{(-3.039)}{0.127}\ln\left(P_{I-1}/P^*_{I\,-1}\right) + \underset{(1.912)}{0.395}\Delta\ln(P_M)$ $R^2 = 0.846$; $DW = 1.927$; $s.e. = 0.005$; $NOB = 27$
Notes: See Table 2.

The adjustment to long run level is due to the estimated error correction coefficient and is hence reasonably fast. This is significant for the stability of the investment deflator in simulations. The only dynamic determinant, the import deflator, could be expected to transmit to investment prices with almost unitary elasticity, but the estimated coefficient is about two times lower. The rest of the adjustment process is captured by an error correction mechanism.

Harmonised Price Index (HICP)

HICP is not modelled explicitly but is the weighted average of four components: HICP core, HICP food, HICP fuel and household energy. Each of them is modelled with a separate error correction equation (except household energy, which is exogenous) based on the same composition technique applied before. HICP is then used to determine the remainder of the deflators. These are the private and government consumption deflators. We equalise the growth rates of these two using the HICP inflation.

Core Harmonised Price Index (HICP Core)

HICP core (P_{HC}) has the highest share in HICP, constituting about 60% of total HICP. The long run equation combines output and import deflators with calibrated shares 0.8 and 0.2 respectively (see the top panel in Table 13).

The short run determinants are taken in the same way as for the cointegration relationship. We find that domestic price impulses are more than two times stronger compared to foreign price signals (see the lower panel of Table 13).

Table 13: The long run rate and dynamics of HICP core

Long run relationship
$\ln(P^*_{HC}) = -\underset{-2.957}{0.008} + \underset{(-)}{0.800}\ln(P) + \underset{(-)}{0.200}\ln(P_M)$
$R^2 = 0.979$; $DW = 0.142$; $s.e. = 0.015$; $NOB = 30$
Dynamic equation
$\Delta\ln(P_{HC}) = \underset{(3.174)}{0.002} - \underset{(-2.422)}{0.074}\ln(P_{HC-1}/P^*_{HC-1}) + \underset{(5.539)}{0.382}\Delta\ln(P) + \underset{(3.128)}{0.147}\Delta\ln(P_M)$
$R^2 = 0.930$; $DW = 2.127$; $s.e. = 0.002$; $NOB = 27$
Notes: See Table 2.

Harmonised Food Prices (HICP Food)

Food's share in the harmonized consumption basket has decreased gradually from 30% to about 20%. Instead of using the import deflator as an indicator of foreign prices, we link food prices (P_{HF}) in Estonia directly to food prices in the EU15 (P_{FF}) with the relative share of 0.44. The rest of the long run growth comes from an increase in local producer prices. We also included the nominal exchange rate (E_{FLOI}) in the cointegration relationship to capture large price movements in the past (mainly during the Russian crisis period). The estimated coefficient was highly significant and the inclusion of the exchange rate improved the equation's statistical properties.

Table 14: The long run rate and dynamics of HICP food

Long run relationship
$\ln(P^*_{HF}) = \underset{7.895}{0.146} + \underset{(-)}{0.559}\ln(P) + \underset{(-)}{0.441}\ln(P_{FF}) - \underset{(-6.876)}{0.106}\ln(E_{FLOI})$
$R^2 = 0.926$; $DW = 0.564$; $s.e. = 0.017$; $NOB = 28$
Dynamic equation
$\Delta\ln(P_{HF}) = -\underset{(-1.981)}{0.009} - \underset{(-1.867)}{0.213}\ln(P_{HF-1}/P^*_{HF-1}) + \underset{(2.640)}{0.731}\Delta\ln(P) + \underset{(2.585)}{1.128}\Delta\ln(P_{FF})$ $+ \underset{(2.187)}{0.293}\Delta\ln(P_{HF-1}) - \underset{(-2.704)}{0.063}\Delta\ln(E_{FLOI-1})$
$R^2 = 0.715$; $DW = 2.270$; $s.e. = 0.009$; $NOB = 27$
Notes: See Table 2.

Food prices are the most volatile component of total HICP. Coefficients for both, GDP and import deflators in the dynamic equation are much greater than their relative shares in the cointegration relationship, indicating that Estonian food prices overreact to any changes in these indices. The coefficient for the GDP deflator shows a 30% overreaction, while the overreaction to foreign price changes is more than two times larger (see Appendix 2 for response graphs). As both estimates are highly robust, we do not restrict them in order to get a milder response.

Harmonised Fuel Prices (HICP Fuel)

HICP fuel has the lowest share in total HICP, equal to only about 5%. The long run value of the fuel price (P^*_{HO}) is assumed to follow the world oil price and the domestic cost component, proxied by the GDP deflator. The oil price is set in U.S. dollars (P_{OIL}) and then converted to a price in Estonian kroons by multiplying price in dollars with the kroon-dollar exchange rate (E_{USD}) (see the upper panel of Table 15).

Table 15: The long run rate and dynamics of HICP fuel

Long run relationship $\ln(P^*_{HO}) = \underset{-212.051}{-1.862} + \underset{(-)}{0.705}\ln(P) + \underset{(-)}{0.295}\ln(P_{OIL}E_{USD})$ $R^2 = 0.947$; $DW = 0.713$; $s.e. = 0.043$; $NOB = 24$
Dynamic equation $\Delta\ln(P_{HO}) = \underset{(2.450)}{0.010} - \underset{(-4.766)}{0.406}\ln(P_{HO-1}/P^*_{HO-1}) + \underset{(2.808)}{0.140}\Delta\ln(P_{OIL}) + \underset{(3.069)}{0.109}\Delta\ln(P_{OIL-1}) + \underset{(2.761)}{0.408}\Delta\ln(E_{USD})$ $R^2 = 0.878$; $DW = 2.053$; $s.e. = 0.019$; $NOB = 24$
Notes: See Table 2.

The dynamics of fuel prices is determined by world oil prices and the exchange rate only. The inclusion of GDP deflator was not supported by its low significance. The domestic price component only matters for gradual price increases in the medium and long term through local service costs and tax harmonisation (note that the GDP deflator also includes the indirect tax rate). Oil price fluctuations on world markets and the exchange rate transmit immediately to local fuel prices with only a slight overreaction, which we did not correct by any restriction (see Appendix 2).

4.6. Labour Market

Long run employment (L^*) is explained using the firms' factor demand via an inverted production function. The determination of production inputs, carried out in section 3.1, treated labour unchanged over a long time horizon. By taking the logarithm of equation 12, we get the cointegration relationship for labour input, which already includes that information and projects no growth in L^* (see the upper panel of Table 16). However, there are short-term deviations from the natural employment level caused by up and downturns in economic activity measured in GDP fluctuations on the demand side, as Keynesian theory predicts.

Table 16: The long run rate and dynamics of labour demand

Long run relationship $\ln(L^*) = 1/(1-\hat{\alpha})\left(\ln(Y) - \hat{\alpha}\ln(K) - (1-\hat{\alpha})\ln(A)\right)$
Dynamic equation $\Delta\ln(L) = -\underset{(-)}{0.005} - \underset{(-)}{0.0125}\ln\left(L_{-1}/L^*_{-1}\right) + \underset{(3.042)}{0.176}\Delta\ln(Y) + \underset{(3.543)}{0.185}\Delta\ln(Y_{-1})$ $R^2 = 0.550$; $DW = 1.137$; $s.e. = 0.005$; $NOB = 26$
Notes: See Table 2.

The cause of high involuntary unemployment in Estonia cannot completely be explained by means of Keynesian theory. It is not the nominal rigidities that have led the labour market to disequilibria, but the restructuring of the economy. As is common to transition economies, so also in Estonia the relative share of the service sector started to increase and more labour input was required by the tertiary sector.[17] Thus, the nature of unemployment has been structural, caused by less than fully mobile labour. On the other hand, compared to other transition countries, unemployment has remained between "reasonable" levels. This is due to relatively mobile labour, as stated by Rõõm (2002). The dynamic homogeneity restriction that keeps labour input unchanged in the long run is specified as $c_t \approx -(0.176 - 0.185)\widetilde{\gamma}_y$.

[17] Randveer (2002) suggests that the structural change in employment has been driven by the change in consumer preferences. The latter is dependent on an increase in income level. But the reason could also be higher productivity growth in agriculture and manufacturing compared to the service sector.

4.7. Government Sector

One of the key elements of the Estonian economy has been using the currency board arrangement (CBA) as an exchange rate regime. Monetary policy signals under CBA are exogenous, since there can be no active monetary policy (i.e. there are no active monetary policy instruments). Monetary transmission in its authentic sense under currency board means transmission of policy signals generated by the external monetary authority. Therefore the model treats a currency board as a completely credible fixed exchange rate regime (without a specific feature describing devaluation expectations) in combination with no monetary policy instruments.[18] The fiscal stance remains the only influencing economic policy tool.

The basic outline of the government block can be described as the dependency of expenditure on collected revenues. In other words, the government takes taxes and other revenues as provided by economic activity and shapes its expenditures according to that constraint. This mechanism is somewhat different from what one can see in ESCB MCM country blocks.[19] In those models, the direct tax rate operates as an instrument to affect revenues in a desired direction. This means that the economy (or the model) closes on the revenue side, not on the expenditure side as in the Estonian model.

Government revenues are split into five categories: social tax (TSN), personal and corporate income tax ($TIWN$ and $TCIN$ respectively), indirect taxes ($TIND$) and other income ($GOIN$). On the expenditures side we distinguish between four items: government transfers to households ($GTRN$), government consumption (GCN), capital formation ($GKFN$) and other expenditures ($GOEN$) (see the identities in Appendix 4).

We use fiscal rule to mimic government actions. According to this rule, the government's fiscal policy has two goals with a natural trade-off between them. One goal for the government is targeting small output variations. This is done by increasing consumption during downturns and causing a budget deficit, and cutting expenditures during upswings resulting in a budget surplus. The other option is having sound fiscal policy, defined as keeping the budget in balance. The optimal choice for the government is given by minimizing a quadratic loss function subject

[18] Doing this we omit political and institutional considerations that in fact distinguish the CBA from the completely credible regime. In principle there is a possibility that the nominal exchange rate changes even under a CBA (see, for example, game-theoretical model in Batiz and Sy (2000)).

[19] For example in Vetlov (2004), Willman and Estrada (2002).

to a linear structure of the economy. The fiscal rule is expressed as:

$$D^* = \overline{D} + \frac{\Omega}{1-\Omega}\lambda\widetilde{y}, \tag{39}$$

where D^* is the optimal level of budget deficit/surplus, $\overline{D}$ is the targeted long run level of deficit, Ω describes the relative weight put on either goals. The higher Ω is, the more important the output stabilisation. Kattai and Lewis (2004) have showed that the values of D^* and Ω are 0 and 0.517 respectively. These findings imply that Estonian fiscal policy is not biased toward deficit or surplus. The Ω value, being approximately 0.5, indicates that the importance of stabilising output and budget is roughly equal. Parameter λ stands for government multiplier, indicating by how much the fiscal balance would react if the observed output gap ($\widetilde{y}$) changed by one percentage point. A λ value greater than one shows that spending one kroon may increase output by more than one kroon and a λ value less than one reflects the opposite. The value for lambda is calibrated based on Eesti Pank's previous macro model and equals 1.13.

The fiscal rule presented in equation 39 is initially derived *ex post* for descriptive analysis and is not directly applicable for simulation purposes. The reason for this is that it is not realistic to assume that any budget deficit or surplus may occur in real life. Therefore, we augment the rule by replacing $\widetilde{y}$ with a function $\Phi(\widetilde{y})$:

$$D^* = \overline{D} + \frac{\Omega}{1-\Omega}\lambda\Phi(\widetilde{y}). \tag{40}$$

$\Phi(\widetilde{y})$ is a restriction, which works so that if the output gap exceeds some critical level defined within the model, the budget surplus or deficit would remain at some predefined level. Restricting the lower boundary of the budget deficit is the most critical in this scenario. In accordance with the Maastricht fiscal soundness criteria, we define $\Phi(\widetilde{y})$ so that the budget deficit would not exceed 3% of GDP, even if the output gap were strikingly negative. Another specific issue is that we do not model government debt explicitly because the debt to GDP ratio is so low.

4.8. Shock Simulations and Properties of the Model

Firstly, we produce a baseline scenario to see what the main variables converge to in the steady state, expressed in percentages of annual GDP.

The time period for reaching the steady state was calculated in section 3.1 and equals the year 2052. We find that the capital to GDP ratio increases to 306%. On a balanced growth path investments ensure that the capital to output ratio remains constant. After the capital deepening has finished, the gross capital formation share in output falls to 25.1% compared to 27.2% in 1996–2003 on average (see Table 17). The share of private consumption in GDP increases just a little — from 55.5% to 58.7%. This is explained using an increase in compensation to employees by the same proportion. Also, government consumption increases relative to GDP, forming 21.8% of GDP in 2052.

The increase in the openness of the economy was restricted by offsetting the impact of the relative price on imports and exports in the long run; therefore their ratio to GDP stays at almost the same level as it was in 2003. Numerically, exports form 83.2% and imports 89.0% of GDP in the steady state. Insufficient domestic savings imply that net foreign assets remain negative, being 141% of annual GDP.

Table 17: Main steady state ratios

	Percentage of annual real GDP		**Percentage of annual nominal GDP**	
	1996–2003	2052	1996–2003	2052
Capital stock	213.0	306.0	-	-
Private consumption	55.5	58.7	-	-
Gross capital formation	27.2	25.1	-	-
Government consumption	20.0	21.8	-	-
Exports	77.0	83.2	-	-
Imports	83.9	89.0	-	-
Compensation to employees	-	-	47.4	49.7
Net foreign assets	-	-	-44.1	-141

We ran three simulations to analyse the model's behavioural properties. The purpose of this experiment is also to explain the main transmission channels and the adjustment processes within the model. We considered those shocks that are most likely to occur and have an economy-wide influence: an increase in interest rates, an increase in world demand and an increase in world oil prices. Besides dynamic homogeneity conditions, there were relatively few restrictions imposed on the dynamic parts of the behavioural equations. Thus, the estimated coefficients reflect historical relationships between the variables and all responses obtained in the simulation exercise could be interpreted, with certain reservations — what could have happened in the past if one of these three shocks occurred. As the model is completely backward looking, the responses to shocks and policy changes could be judged by the Lucas critique. Therefore the adjustments must be interpreted under the assumption that agents do not change their behavioural patterns.

We designed the simulations so that only the real sector and prices are subjects to adjust. In other words, we switch government stabilising actions off and let the budget be balanced in each period. Another issue that must be stressed here is that the results of each simulation experiment must be interpreted as partial reactions because there are several impulses left out of the scope. For example, in the case of a foreign interest rate shock we do not take into account that foreign demand, prices and the exchange rate are also about to change, which may have an important effect on the simulation results.

For the interest rate shock, we introduce a two-year lasting transitory increase in the short-term lending rate, induced by the foreign interest rate Euribor, by 100 base points. This has an immediate effect on the investment behaviour of firms — the user cost of capital rises and makes purchasing new investment goods more expensive. According to the traditional negative price-quantity relationship, gross capital formation decreases. The lowest point is a –2.5% deviation from the baseline in the third year (the responses can be seen in Appendix 5). Aggregate supply also reacts to decreased domestic demand with a contradiction. This means that firms need less labour input, which results in a fall in employment by 0.18% maximum and in an increase in unemployment by 0.18 percentage points (see Figure 5). As GDP is more volatile than labour demand, labour productivity falls by about 0.33%.

Wages were modelled directly dependent on labour productivity and thus decrease accordingly. But wages adjust only slowly and the peak in the fall in compensation per employee occurs in the third year (–0.41% from the baseline) when interest rates have already returned to the baseline level. Lower employment and wages imply that household budget constraints tighten. A large proportion of households are liquidity constrained and consumption is based on contemporaneous earnings. Savings are only little used as a buffer for smoothing consumption (saving rate remains practically unchanged) and thefore the lessened disposable income makes private consumption decrease by almost the same amount, i.e. 0.74% from the baseline. The design of the experiment assumed no government stabilisation — the budget is balanced in each period. This makes government consumption fall in line with its revenue levels, by about 0.56% maximum. The smaller domestic demand transmits to a smaller import demand and the latter shrinks by about 0.9% from the baseline. As exports are mainly driven by effective foreign import demand, which is expected to stay unaffected, the trade balance improves as a result (see Appendix 5).

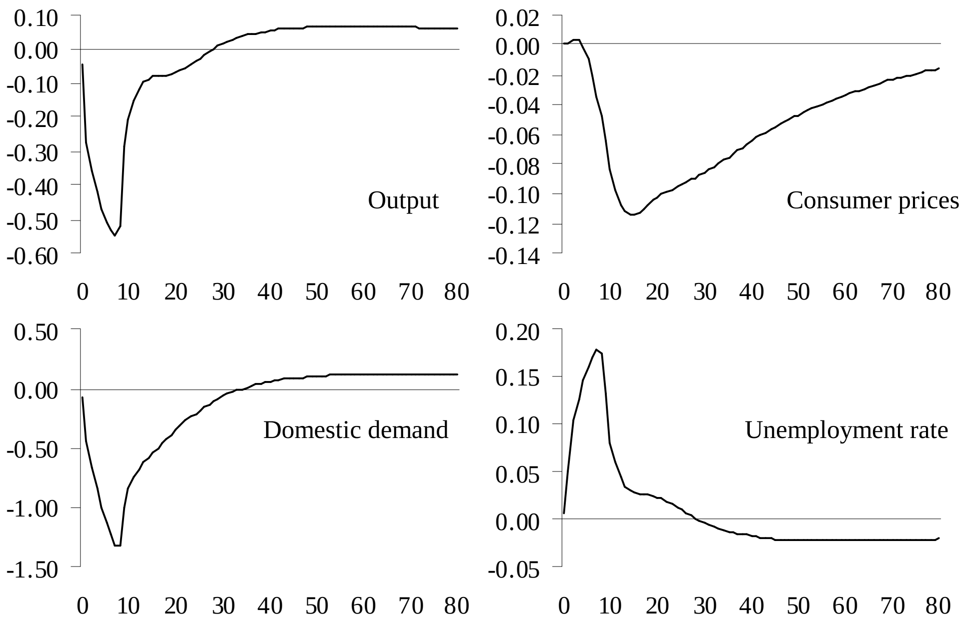

Figure 5: Responses to an interest rate shock (deviations from baseline (%; except unemployment — pp), period length 80 quarters)

The slow response of wages means that the GDP deflator, being directly linked to the wage cost for firms, responds only a little. So do other prices, being partially determined by the cost of domestic production. The overall effect on consumer prices remains rather limited because of the importance of the unaffected (by design of the simulation) foreign price impulses.

The second simulation exercise that we performed investigated foreign demand implications for the Estonian economy. This simulation has special importance because of the openness of the Estonian economy and its dependency on foreign demand. We introduced a permanent increase in the demand for imports of the main trade partners of one percent. The first impulse affects the volume of Estonian exports, which increases by a little bit more than one percent in the first year and then settles to a level about one percent higher compared to the baseline scenario (see Appendix 6). Additional income gained from selling more goods and services in foreign markets boosts domestic demand, and this is reflected in an increase in all expenditure components. Private consumption increases by 0.56% in the first year, reaching 1% in the second year and then starts to return to its base. The increased domestic demand motivates firms to increase production and hire more workers. Employment rises by 0.32% and unemployment drops by 0.3 percentage points initially, slowly returning back to their initial levels afterwards. The overall effect on GDP is about a 0.8–0.9 percent increase compared to the baseline scenario in the first two years, which dies away gradually in the long run (see Figure 6).

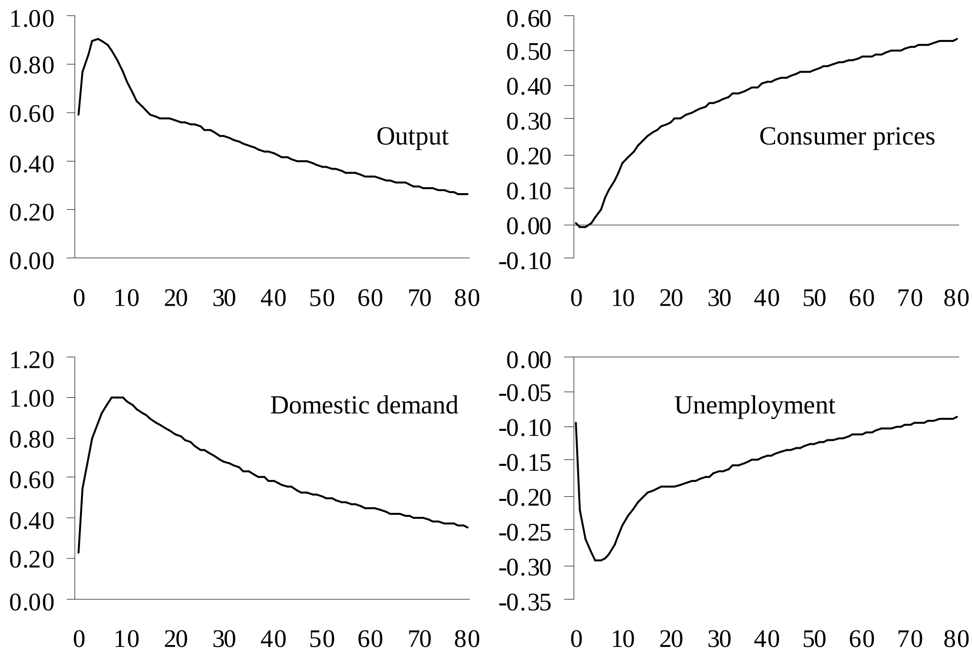

Figure 6: Responses to a foreign demand shock (deviations from the baseline (%; except unemployment — pp), period length 80 quarters)

Consumer prices slowly start to grow after the shock, reaching about a 0.6% difference from the baseline. This is caused by an increase in the price of production — the decreased unemployment rate boosts growth in wages (Phillips curve ideology), which transmits to higher GDP deflator growth and finally to higher consumer prices.

The most interesting outcome of the simulation is that an increase in foreign demand worsens the trade balance for some period after the shock. In the first year, exports grow more than imports, while in the following several years an overreaction in domestic demand makes imports increase by more than exports. The initial source of the overreaction is gross capital formation. Output growth causes an increase in prices and price inflation, which reduces the real interest rate. Being one component of the user cost of capital, the decreased value of the real interest rate causes additional demand for investment goods. As most of the investment goods are imported, imports increase as a result. The negative trade balance dies out gradually, as investments settle down to a new equilibrium.

We must highlight the fact that the worsening of the trade balance is not a straightforward implication of an increase in world import demand. In reality, increased world demand also means that there is demand side pressure on foreign prices, which pushes up foreign inflation, decreasing the price competitiveness of imported goods and lessening import demand in Estonia. If we considered all these changes in foreign markets simultaneously, we would see somewhat different behaviour in the model economy.

The third simulation investigated changes in the economy caused by a permanent 10% increase in U.S. dollar nominated oil prices. Oil prices make up about 30% of fuel prices, and the share of the latter is only about 5% of total HICP. The impact on HICP produced by the model is 0.15%, equal exactly to what could be calculated based on the given relative shares (see Appendix 7). Compensation per employee reacts very slowly to an increase in commodity prices and stays practically unaffected in the first year. The simultaneous increase in consumer prices lowers household real disposable income, cutting private consumption by 0.23% in the first year. The greatest impact on private consumption is observable in the second year, when it contradicts by about 0.4%. The lower domestic demand provides a signal for firms to produce less output. So, less production inputs are needed, the unemployment rate goes up by 0.06 percentage points (see Figure 7) and decreased investments lead to a smaller stock of capital. In this case, capital adjusts more quickly — labour market frictions leave only marginal changes in employment because GDP returns to its baseline (potential level) fairly quickly. The peak in most of the real variables is in the second year (see Figure 7 and Appendix 7).

We conclude that the shock simulations proved satisfactory behaviour of the model. The responses of the Estonian economy that the model replicates are inherent to a small and open catching up economy. Due to the relatively low capital intensity, investments were the most sensitive expenditure component, forming the major source of business cycle fluctuations. The same can be observed in the national accounts data, where the investments to GDP ratio fluctuates between 22–32%. Overall, the model tends to react quite rapidly to shocks while on the other hand its return to the long run growth path is also fairly quick. This kind of property could be found plausible for a very small and open economy, in which it is relatively easy to adjust to the changing economic conditions.

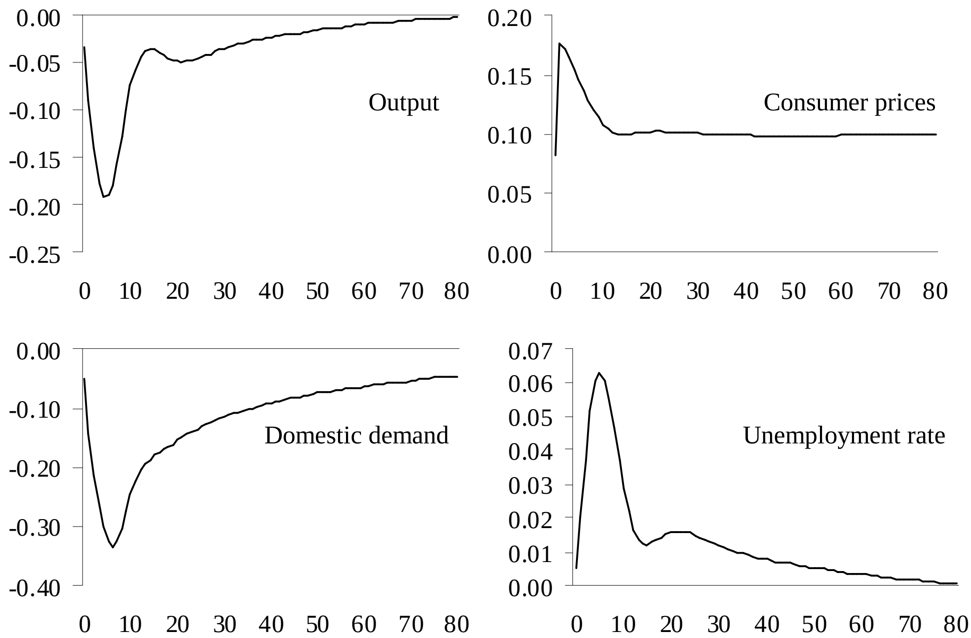

Figure 7: Responses to oil price shock (deviations from the baseline (%; except unemployment — pp), period length 80 quarters)

In addition, we saw that the Estonian economy is highly dependent on external developments. Not only does the foreign interest rate policy transmit directly to the local economy but the Estonian business cycle is also highly correlated with the business cycle of its main trade partners because of its degree of openness. The latter also implies that foreign price impulses are an important source of inflation.

5. Conclusions

The current paper has introduced the first version of Eesti Pank's model of the Estonian economy. Several features characteristic of the Estonian economy made the construction of the model rather complicated. Data series covering the transition phase and including many structural breaks suggested the use of calibration as a means of determining parameters in the cointegration relationships, while parameters in dynamic equations were mainly estimated in order to maximise data fit and forecasting accuracy.

Building a theory consistent model, which could explain convergence of the Estonian income level to the EU-15 level forced us to modify the underlying growth theory slightly. We found that in the Neo-Classical growth model, capital deepening is not sufficient to guarantee convergence of Estonian and EU15 income levels. Therefore, we assumed that initially the speed of technological progress must be faster in Estonia and that the spread between growth rates will disappear as the technological gap vanishes over time.

The model is constructed so that real and nominal convergence not only captures Estonian levels of income and prices reaching those of the EU15 but that the rate of economic growth and inflation also converge by the time a balanced growth path is attained. This phenomenon was achieved by restricting the supply side equations using the time-varying dynamic homogeneity condition.

Simulation tests indicate that the model's response to various shocks is relatively fast and its return to the long run growth path is fast as well. This is a characteristic of a very small and open economy, in which coping with changing economic conditions is relatively easy when compared with big economies.

The model presented in this paper is not a finished project. There are several ways to develop and improve the existing model. First, several variables, such as employment and consumption, could be disaggregated to get a more detailed picture of the economy. Also, the financial sector and the bank-lending channel should be included to make the model more complete. Thirdly, rational expectations could be incorporated to assess its implications on the model behaviour.

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Appendix 1. List of Acronyms

Notation		Description
In the model code	**In the model description**	
A	$A_0 e^{(1-\alpha)gt}$	Level of labour augmenting technology
ALPHA	α	Income share of capital
BBN	D	Government budget balance, nominal
CABN		Current account balance, nominal
CCN		Nominal user cost of capital, nominal
CCR	P_K	Real user cost of capital, real
CEN		Compensation to employees, nominal
CMD	P_{CM}	Competitors' prices, weighted by countries' shares in Estonian imports
CXD	P_{CX}	Competitors' prices, weighted by countries' shares in Estonian exports
D0001		Impulse dummy variable
D0002		Impulse dummy variable
D0003		Impulse dummy variable
D0004		Impulse dummy variable
D0101		Impulse dummy variable
D0102		Impulse dummy variable
D0103		Impulse dummy variable
D0104		Impulse dummy variable
D0201		Impulse dummy variable
D0202		Impulse dummy variable
D0203		Impulse dummy variable
D9701		Impulse dummy variable
D9703		Impulse dummy variable
D9801		Impulse dummy variable
D9802		Impulse dummy variable
D9803		Impulse dummy variable
D9804		impulse dummy variable
D99		Step dummy variable
D9901		Impulse dummy variable
D9902		Impulse dummy variable
D9903		Impulse dummy variable
D9904		Impulse dummy variable
DDR		Domestic demand, real

Notation		Description
In the model code	In the model description	
delta	δ	Depreciation rate
DMR	D_M	Domestic import demand, real
DTO9802		Step dummy variable
DTO9901		Step dummy variable
EPFIXE	P_{FIXE}	Effective CPI of main trade partners in the euro area, weighted by the share in the Estonian exports
EPFIXI	P_{FIXI}	Effective CPI of main trade partners in the euro area, weighted by the share in the Estonian imports
EPFLOE	P_{FLOE}	Effective CPI of main trade partners, which currency is not euro or the exchange rate is not fixed to euro, weighted by share in the Estonian exports
EPFLOI	P_{FLOI}	Effective CPI of main trade partners, which currency is not euro or the exchange rate is not fixed to euro, weighted by share in the Estonian imports
ERFLOE	E_{FLOE}	Nominal effective exchange of kroon, weighted by the trade partners' share in the Estonian export
ERFLOI	E_{FLOI}	Nominal effective exchange of kroon, weighted by the trade partners' share in the Estonian import
ERUSD	E_{USD}	US dollar/Estonian kroon exchange rate
ETA	η	Mark up
EXCN		Excise tax, nominal
FEU15	P_{FF}	Food prices in EU15
FSN	S_F	Firms' savings, nominal
FWN		Financial wealth of households, nominal
FWR	V	Financial wealth of households, real
G	$\tilde{g}$	Speed of labour augmenting technological progress
GCD		Government consumption deflator
GCN		Government consumption, nominal
GCR	G	Government consumption, real
GDG	P	Gross GDP deflator
GDN	$P(1-z)$	Net GDP deflator (GDP deflator at factor cost)
GDNEQ	$P^*(1-z)$	Intermediate target for net GDP deflator
GDPN	YP	Nominal GDP
GDPR	Y	Real GDP
GEN		Government expenditures, nominal
GKFD		Government investment deflator
GKFN		Government investments, nominal
GKFR	I_G	Government investments, real
GKSR	K_G	Government capital stock, real
GOEN		Government other expenditure, nominal

Notation		Description
In the model code	**In the model description**	
GOIN		Government other income, nominal
GSN	S_G	Government savings, nominal
GTRN	G_T	Government transfers to households, nominal
GYN		Government disposable income, nominal
HICP		Harmonised price index
HICPC	P_{HC}	Core harmonised price index
HICPCEQ	P^*_{HC}	Intermediate target for core HICP
HICPE4		Administratively regulated prices
HICPE7	P_{HO}	Energy prices (without administratively regulated prices)
HICPE7EQ	P^*_{HO}	Intermediate target for HICP energy
HICPF	P_{HF}	Food price index
HICPFEQ	P^*_{HF}	Intermediate target for HICP food
HS		Households' saving rate
HSN	S_H	Household savings, nominal
ILAVN		Average nominal lending interest rate
ILAVR	r	Average real lending interest rate
INVD		Inventory investments deflator
INVR	Z	Change in inventory investments, real
INVSEQR	Z^*_S	Intermediate target for inventories
INVSR	Z_S	Stock of inventories
KCN	$\delta P_I K$	Consumption of capital, nominal
KFGD	P_I	Gross investment deflator
KFGDEQ	P^*_I	Intermediate target for investment deflator
KFGEQR	I^*	Intermediate target for investments, real
KFGR	I	Total capital formation in the economy, real
KSEQR	K^*	Firms' desired capital stock
KSR	K	Total capital stock in the economy, real
L	L	Employment (group 15-74)
LEQ	L^*	Intermediate target for employment
LF		Labour force (group 15-74)
MOUT	ϕ_M	Offsetting parameter of the relative price's effect on imports
MD	P_M	Import deflator
MDEQ	P^*_M	Intermediate target for import prices
MGSEQR	M^*	Intermediate target for imports of goods and services
MGSN		Imports of goods and services, nominal
MGSR	M	Imports of goods and services, real
MSTR	$\hat{m}_S$	Imports structural change indicator

Notation		Description
In the model code	**In the model description**	
NAIRU	u_N	Natural rate of unemployment
NCD		NPISH consumption deflator
NCN		NPISH consumption, nominal
NCR		NPISH consumption, real
NFAN	N	Net foreign assets, nominal
OIN	Y_O	Households' other income, nominal
OSGN	O	Gross operating surplus, nominal
PCD		Private consumption deflator
PCEQR	C^*_P	Intermediate target for private consumption, real
PCR	C_P	Private consumption, real
PKFD		Private sector investment deflator
PKFR	I_P	Private sector investments, real
PKSR	K_P	Private sector's capital stock, real
POILUD	P_{OIL}	Price of oil in US dollars
PYN		Households, disposable income, nominal
PYR	Y_D	Households real disposable income, real
RBN		Revenues balance (current account), nominal
RHO	ρ	Risk premium
SALER	J	Sales of storable goods
SG		Average saving rate in the economy
SGN		Total savings in the economy
ZGR		GDP's statistical discrepancy, real
ZNFAN		Net foreign assets discrepancy
ZW		Statistical discrepancy between *CEN* and $L \times WGN$
t		Time trend
TBN		Trade balance (current account), nominal
TCIN		Corporate income tax, nominal
TFN		Households' tax free income, nominal
TINDLSR		Indirect taxes minus subsidies, nominal
TINDN		Indirect tax revenues, nominal
TIWN		Tax on income and property, nominal
TRBN		Transfers balance (current account), nominal
TRIND	z	Effective indirect tax rate (net production taxes minus subsidies)
TRL	q	Tax rate on labour
TSN	T_S	Social tax
UE		Unemployment (group 15-74)
UR	u	Unemployment rate
VATN		Value added tax

Notation		Description
In the model code	In the model description	
WDR	D_W	Weighted imports of Estonian main trade partners
WGEQR	W^*/P^*	Intermediate target for real wage
WGN	W	Three months gross wage, nominal
WGR	W/P	Three months gross wage, real
WHICPC		Weight of core HICP in harmonised price index
WHICPE4		Weight of regulated prices in harmonised price index
WHICPE7		Weight of energy prices (without regulated prices) in harmonised price index
WHICPF		Weight of food prices in harmonised price index
WNN		Three months net wage, nominal
XOUT	ϕ_X	Offsetting parameter of the relative price's effect on exports
XD	P_X	Export deflator
XDEQ	P_X^*	Intermediate target for export prices
XGSEQR	X^*	Intermediate target for exports of goods and services
XGSN		Exports of goods and services, nominal
XGSR	X	Exports of goods and services, real
XSTR	$\hat{x}_S$	Exports structural change indicator

Appendix 2. Equations of the Model

Table 1. Gross capital formation

Long run specification	
LN(KFGEQR)=	LN(G+DELTA+N)
	+LN(ALPHA*GDPR)
	-LN(ETA*CCR)
	+0.41210*(D9802+D9904)
	+0.66237*(D9803+D9902+D9903)
	+0.96856*D9804
	+1.27021*D9901
	-0.35134*D0003
	+0.82557*D0004
Dynamic specification	
ΔLN(KFGR)=	0.00394
	-0.10000*(LN(KFGR(-1))-LN(KFGEQR(-1)))
	+0.68219*ΔLN(GDPR)
	+(1-0.68219)*ΔLN(GDPR(-1))
	-0.25457*ΔLN(CCR(-1))
	+0.06033*D0203
	+0.07499*D0003
	-0.07798*D9901
	-0.04958*D0104

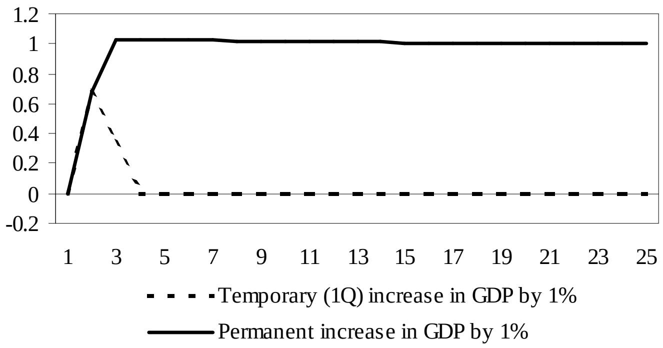

Figure 1. Investments' response to an increase in GDP (% deviation from the baseline)

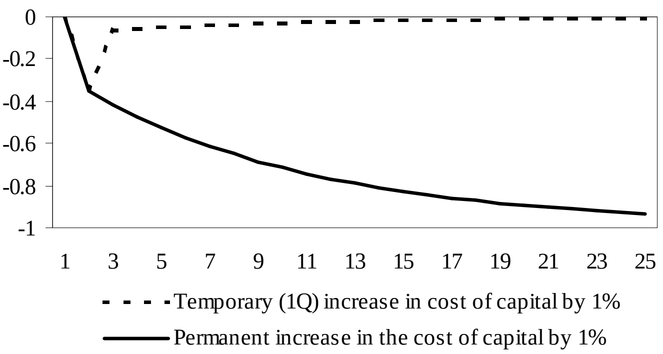

Figure 2. Investments' response to an increase in the cost of capital (% deviation from the baseline)

Table 2. Private consumption

Long run specification	
LN(PCEQR)=	-0.17518
	+0.02059*(FWR/PYR)
	+LN(PYR)
	-0.06843*D9903
Dynamic specification	
ΔLN(PCR)=	-0.00676
	-0.22583*(LN(PCR(-1))-LN(PCEQR(-1)))
	+0.12980*ΔLN(FWR)
	+0.70803*ΔLN(PYR)
	+0.58481*ΔLN(PCR(-1))
	-0.02274*D9903
	+0.08049*D9904
	-0.04700*D0001

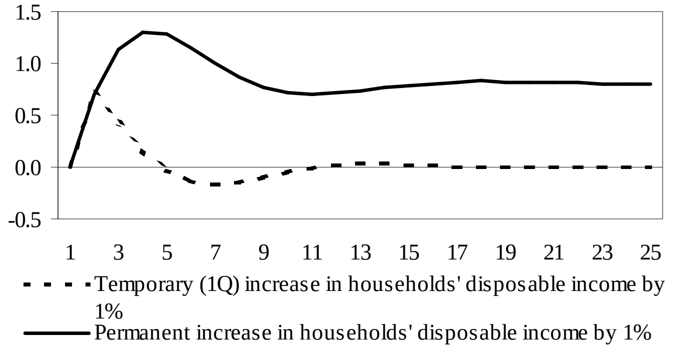

Figure 3. Private consumption's response to an increase in households' disposable income (% deviation from the baseline)

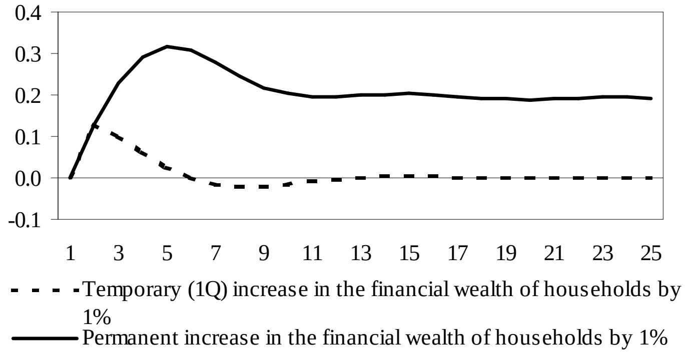

Figure 4. Private consumption's response to an increase in households' financial wealth (% deviation from the baseline)

Table 3. Inventory investments

Long run specification	
LN(INVSEQR)=	0.44430+LN(GDPEQR)
Dynamic specification	
Δ(INVR)=	-0.27770*(INVR(-1)- Δ(INVSEQR(-1)))
	+0.05957*(Δ(SALER(-1))-1.44419*Δ(GDPEQR(-1)))
	-0.21950*Δ(ILAVR(-1)*GDPEQR(-1))
	-1193.40764*D9804
	+416.24193*D9901
	+285.67707*D9902
	+253.80612*D0201

Table 4. Imports of goods and services

Long run specification	
LN(MGSEQR)=	0.03230
	+1.00000*LN(DMR)
	-0.64704*(LN(MD)-LN(GDN)-LN(MOUT))
	+1.00000*LN(MSTR)
Dynamic specification	
ΔLN(MGSR)=	-0.00296
	-0.31327*(LN(MGSR(-1))-LN(MGSEQR(-1)))
	+1.00000*ΔLN(DMR)
	-0.64704*ΔLN(MD(-2)/GDN(-2))
	-0.04989*D9804
	+0.07208*D0004
	-0.04773*D0104

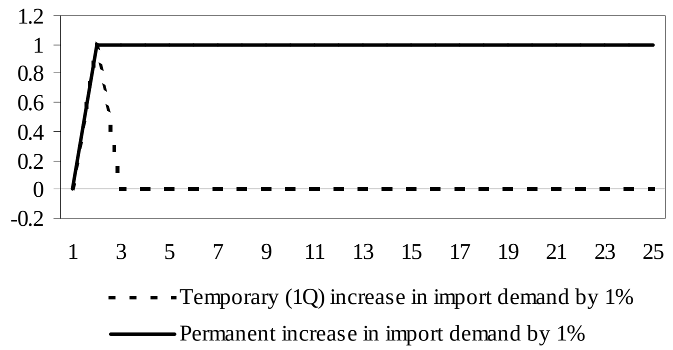

Figure 5. Import's response to an increase in domestic import demand (% deviation from the baseline)

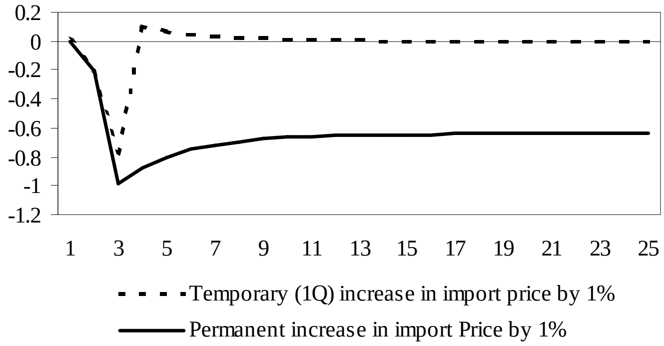

Figure 6. Import's response to an increase in the import price (% deviation from the baseline)

Table 5. Exports of goods and services

Long run specification	
LN(XGSEQR)=	0.02324 +1.00000*LN(WDR) -0.39119*(LN(XD)-LN(CXD)-LN(XOUT)) +1.00000*LN(XSTR)
Dynamic specification	
ΔLN(XGSR)=	0.00581 -0.39256*(LN(XGSR(-1))-LN(XGSEQR(-1))) +1.03430*ΔLN(WDR) -0.39119*ΔLN(XD(-2)/CXD(-2)) +0.20000*ΔLN(MGSR) -0.05971*D0201

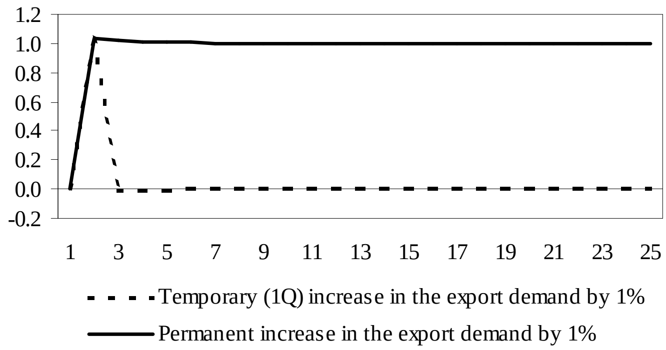

Figure 7. Export's response to an increase in foreign export demand (% deviation from the baseline)

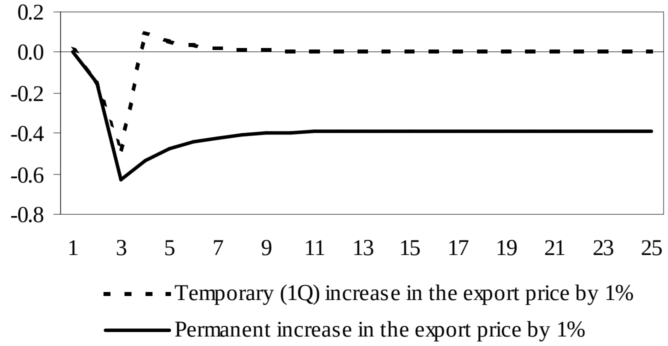

Figure 8. Export's response to an increase in the export price (% deviation from the baseline)

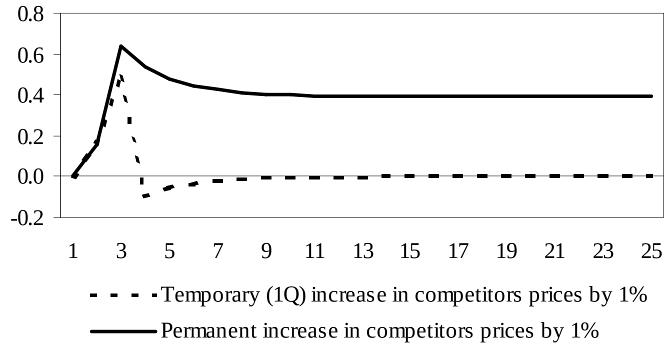

Figure 9. Export's response to an increase in competitors' export prices (% deviation from the baseline)

Table 6. Real wage

Long run specification LN(WGEQR)=	 LN((1-ALPHA)/ETA)+LN(GDPR/L)
Dynamic specification ΔLN(WGN)=	 (0.01494-(0.01494-0.00496)*T/224)*(1-0.03562-0.36361) +(0.1397)*0.0025*(1-T/224) -0.09709*(LN(WGR(-1))-LN(WGEQR(-1))) -0.0025*LN(UR/NAIRU) +0.03562*ΔLN(GDPR(-2)/L(-2)) -0.70584*ΔLN(PCD/GDN) +0.36361*ΔLN(WGN(-1)/PCD(-1)) + ΔLN(PCD) -0.012217*D9804 -0.01159*D0001 -0.00826*D0103

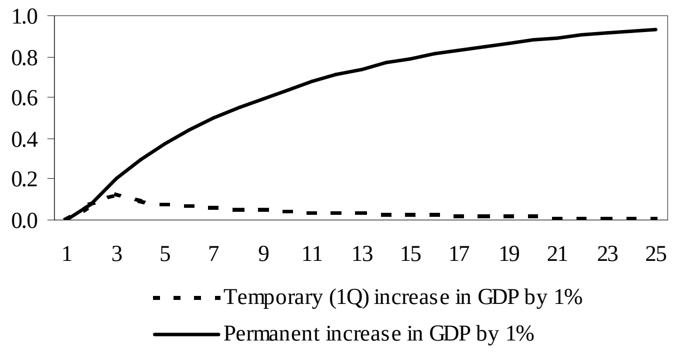

Figure 10. Real wage's response to an increase in GDP (% deviation from the baseline)

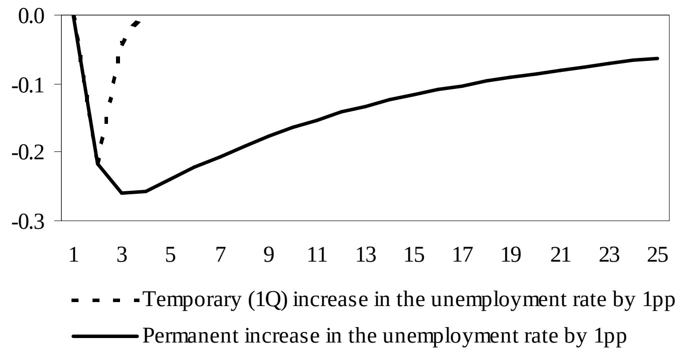

Figure 11. Real wage's response to an increase in the unemployment rate (% deviation from the baseline)

Table 7. GDP deflator

Long run specification	
LN(GDNEQ)=	LN(ETA/(1-ALPHA))+LN(L/GDPR)+LN(WGN)
Dynamic specification	
ΔLN(GDN)=	(0.0117-(0.0117-0.00496)*T/224) -(0.35000+0.20000+0.08000)*((0.01481-(0.01481-0.00496)*T/224) +(0.0117-(0.0117-0.00496)*T/224)) -0.07226*(LN(GDN(-1))-LN(GDNEQ(-1))) +0.35000*ΔLN(WGN) +0.20000*ΔLN(WGN(-1)) +0.08000*ΔLN(WGN(-2))

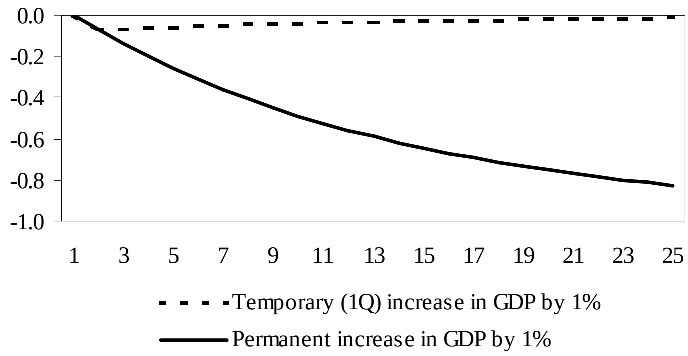

Figure 12. GDP deflator's response to an increase in GDP (% deviation from the baseline)

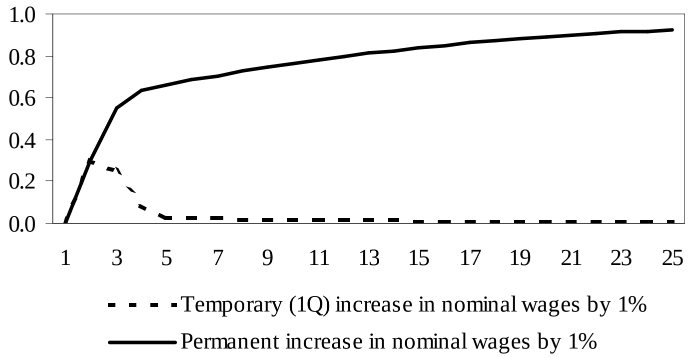

Figure 13. GDP deflator's response to an increase in nominal wages (% deviation from the baseline)

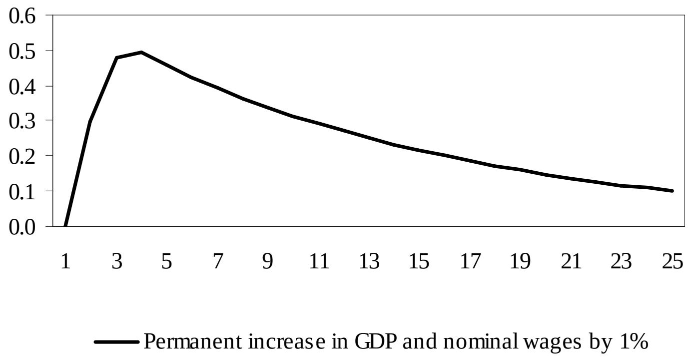

Figure 14. GDP deflator's response to an increase in GDP and nominal wages (% deviation from the baseline)

Table 8. Import deflator

Long run specification	
LN(MDEQ)=	-0.17176
	+0.70568*LN(CMD)
	+(1-0.70568)*LN(GDN)
	+0.07594*D9803
	+0.03949*D9901
Dynamic specification	
ΔLN(MD)=	-0.00818
	-0.46215*(LN(MD(-1))-LN(MDEQ(-1)))
	+0.68992*ΔLN(EPFIXI)
	+0.55247*ΔLN(EPFLOI)
	-0.18960*ΔLN(ERFLOI)
	-0.07360*ΔLN(ERFLOI(-1))
	-0.07193*ΔLN(ERFLOI(-2))
	+0.02646*D0104
	-0.01632*D0201
	+0.01842*D0004
	+0.01805*D9903

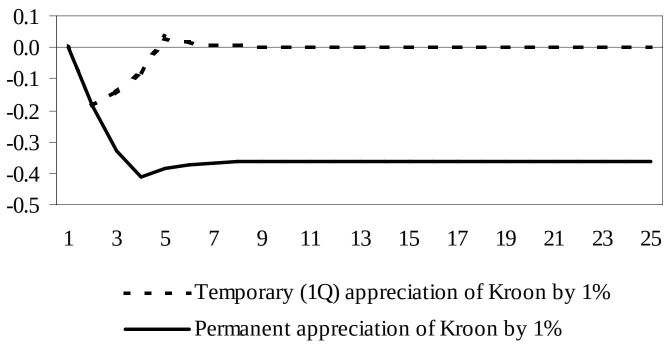

Figure 15. Import deflator’s response to an appreciation of the Estonian Kroon (% deviation from the baseline)

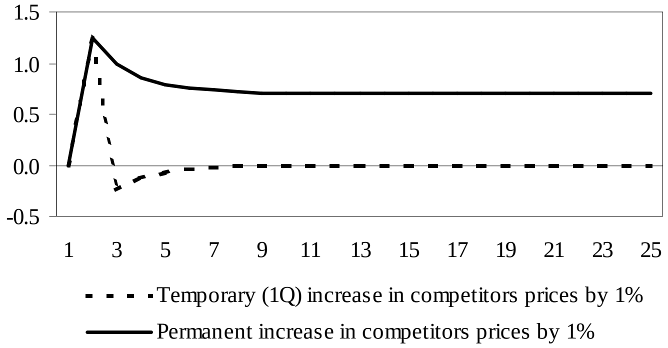

Figure 16. Import deflator’s response to an increase in competitors’ import prices (% deviation from the baseline)

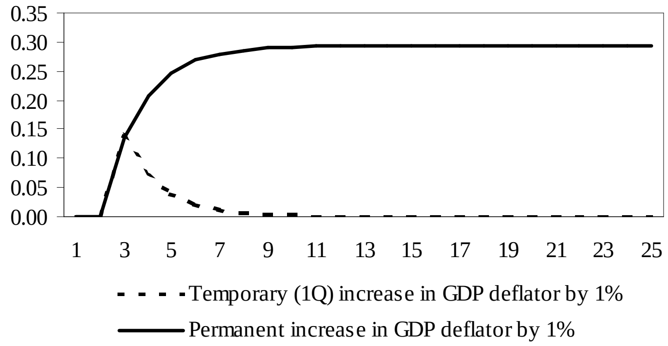

Figure 17. Import deflator’s response to an increase in GDP deflator (% deviation from the baseline)

Table 9. Export deflator

Long run specification	
LN(XDEQ)=	-0.21326 +0.70568*LN(CXD) +(1-0.70568)*LN(GDG) -0.06939*DTO9802 -0.03048*D99
Dynamic specification	
ΔLN(XD)=	0.00471 -0.38865*(LN(XD(-1))-LN(XDEQ(-1))) +0.50000*0.70568*ΔLN(EPFIXE) +0.50000*0.70568*ΔLN(EPFLOE) -0.20346*ΔLN(ERFLOE) -0.03150*D9901 +0.02130*D0001 -0.03182*D0202

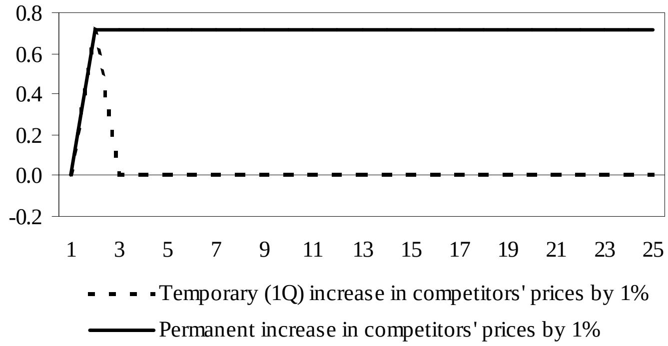

Figure 18. Export deflator’s response to an increase in competitors’ export prices (% deviation from the baseline)

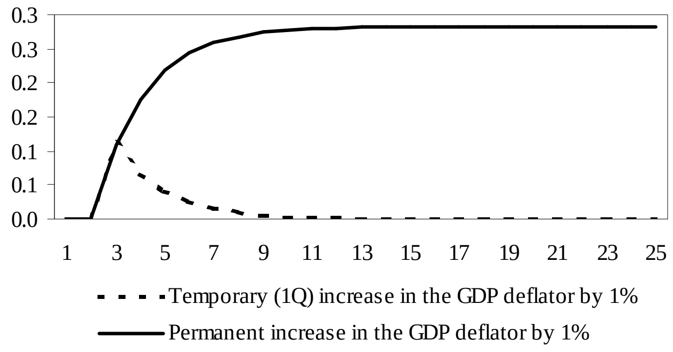

Figure 19. Export deflator’s response to an increase in the GDP deflator (% deviation from the baseline)

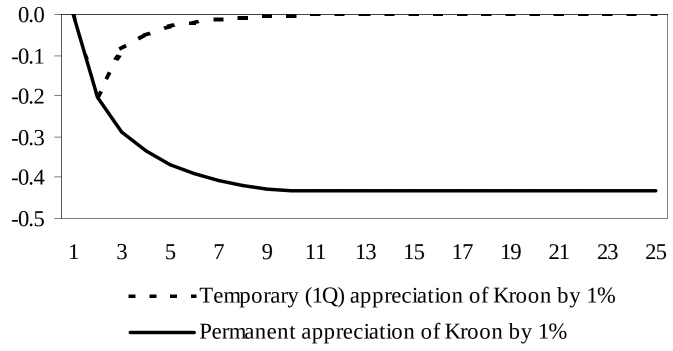

Figure 20. Export deflator’s response to an appreciation of the Estonian Kroon (% deviation from the baseline)

Table 10. Investment deflator

Long run specification LN(KFGDEQ)= 0.01504+1.00000*LN(MD)	
Dynamic specification ΔLN(KFGD)=	 0.00454 -0.12769*(LN(KFGD(-1))-LN(KFGDEQ(-1))) +0.39579*ΔLN(MD) +0.04688*D9801 -0.01808*D9803 -0.01367*D0003

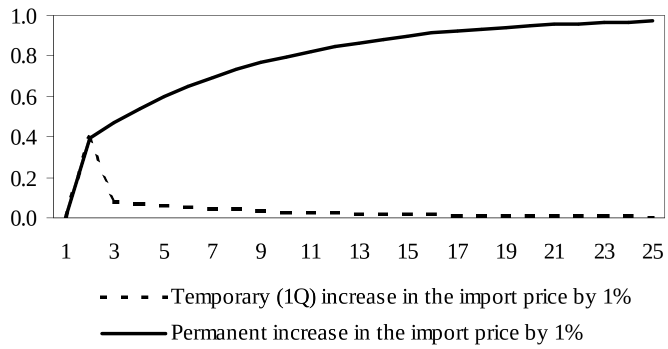

Figure 21. Investment deflator's response to an increase in the import price (% deviation from the baseline)

Table 11. HICP core

Long run specification	
LN(HICPCEQ)=	-0.00820
	+0.80000*LN(GDG)
	+0.20000*LN(MD)
Dynamic specification	
ΔLN(HICPC)=	0.00286
	-0.07437*(LN(HICPC(-1))-LN(HICPCEQ(-1)))
	+0.38220*ΔLN(GDG)
	+0.14714*ΔLN(MD)
	+0.01208*D9801
	+0.00968*DTO9901

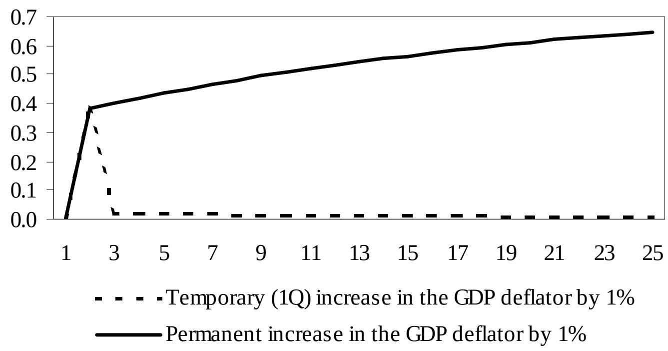

Figure 22. HICP core's response to an increase in the GDP deflator (% deviation from the baseline)

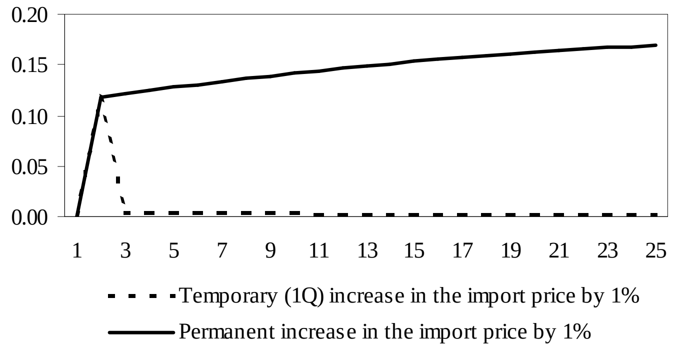

Figure 23. HICP core's response to an increase in the import price (% deviation from the baseline)

Table 12. HICP food

Long run specification LN(HICPFEQ)= 0.14612	 +0.55900*LN(GDG) +0.44100*LN(FEU15) -0.10662*LN(ERFLOI) +0.05650*(D9803+D9804)
Dynamic specification ΔLN(HICPF)=	 -0.00947 -0.21356*(LN(HICPF(-1))-LN(HICPFEQ(-1))) +0.73157*ΔLN(GDG) +1.12828*ΔLN(FEU15) +0.29378*ΔLN(HICPF(-1)) -0.06347*ΔLN(ERFLOI(-1))

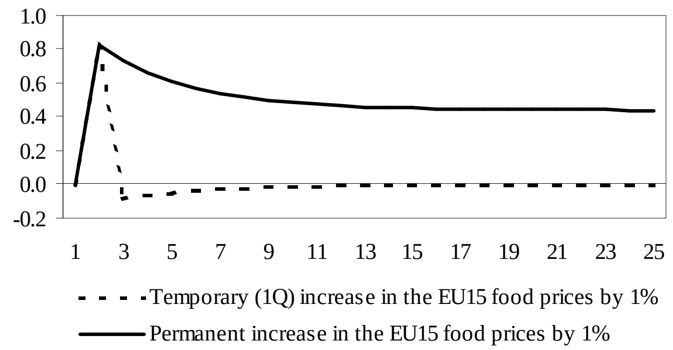

Figure 24. HICP food's response to an increase in the EU15 food prices (% deviation from the baseline)

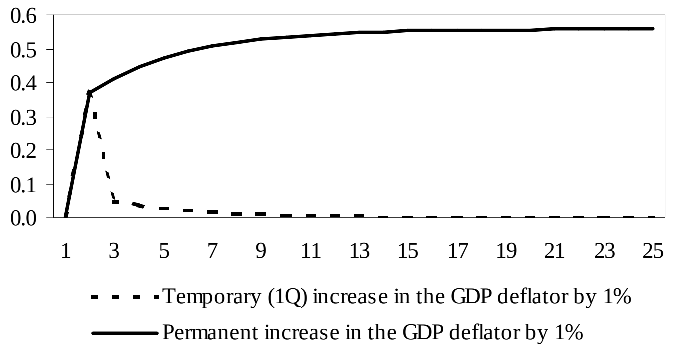

Figure 25. HICP food's response to an increase in the GDP deflator (% deviation from the baseline)

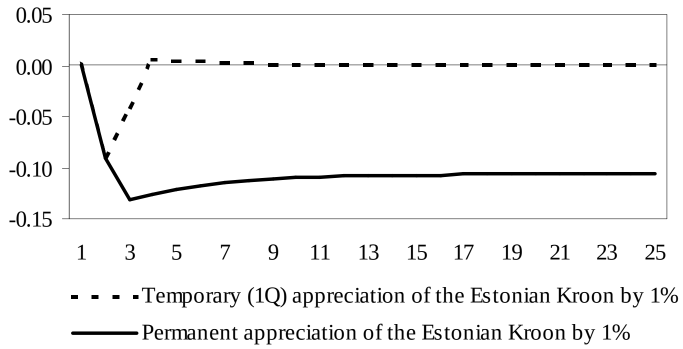

Figure 26. HICP food's response to an appreciation of the Estonian Kroon (% deviation from the baseline)

Table 13. HICP fuel

Long run specification	
LN(HICPE7EQ)=	-1.86223
	+0.70500*LN(GDG)
	+0.29500*LN(POILUD*ERUSD)
Dynamic specification	
ΔLN(HICPE7)=	0.01050
	-0.41102*(LN(HICPE7(-1))-LN(HICPE7EQ(-1)))
	+0.14786*ΔLN(POILUD)
	+0.10625*ΔLN(POILUD(-1))
	+0.40163*ΔLN(ERUSD)
	+0.06029*D0004

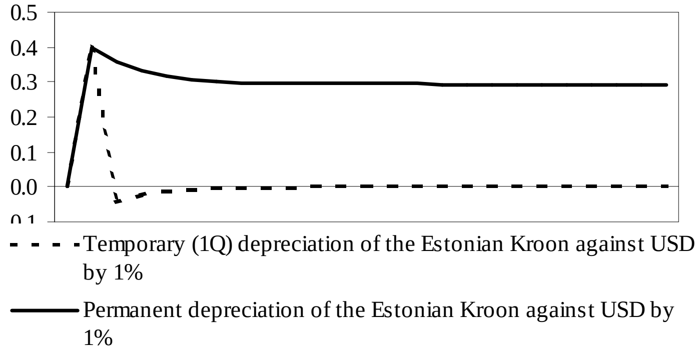

Figure 27. HICP fuel's response to a depreciation of the Estonian Kroon against U.S. dollar (% deviation from the baseline)

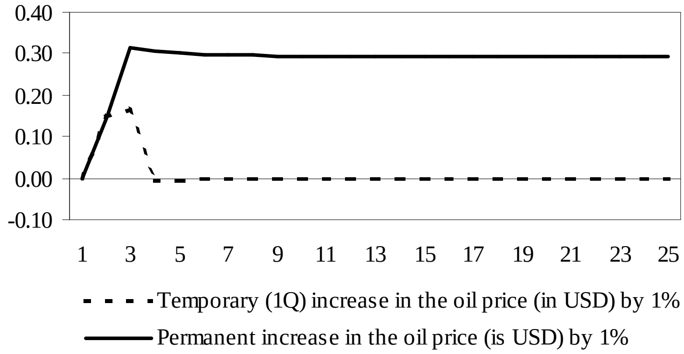

Figure 28. HICP fuel's response to an increase in the oil price (% deviation from the baseline)

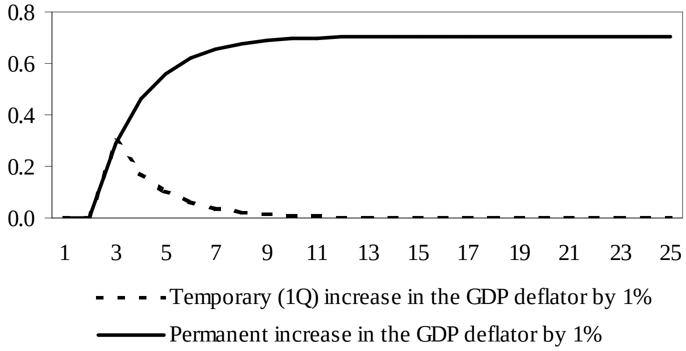

Figure 29. HICP fuel's response to an increase in the GDP deflator (% deviation from the baseline)

Table 14. Labour demand

Long run specification	
LN(LEQ)=	1/(1-ALPHA)*(LN(GDPR)-ALPHA*LN(KSR)-(1-ALPHA)*LN(A))
Dynamic specification	
ΔLN(L)=	-(0.01481-(0.01481-0.004962)*T/224)*(0.176905+0.18575)
	-0.01250*(LN(L(-1)-LN(LEQ(-1)))
	+0.17690*ΔLN(GDPR)
	+0.185752*ΔLN(GDPR(-1))
	+0.016477*D0003
	-0.018190*D0004
	+0.01271*D0102
	+0.01329*D0302

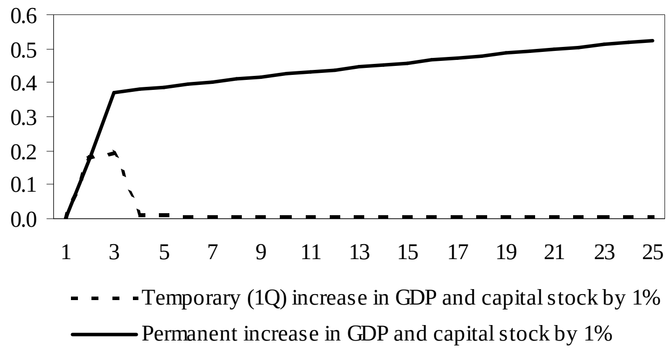

Figure 30. Labour demand’s response to an increase in GDP and capital stock (% deviation from the baseline)

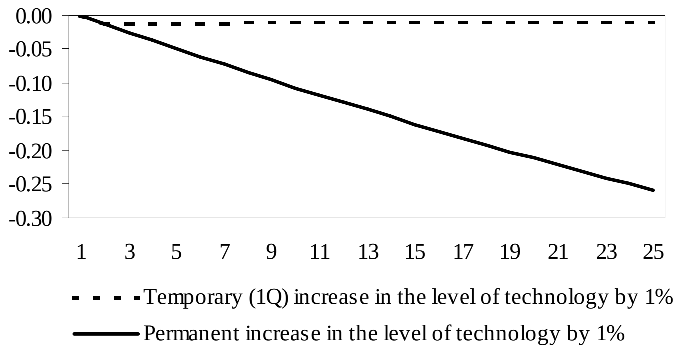

Figure 31. Labour demand’s response to an increase in the level of labour augmenting technology (% deviation from the baseline)

Appendix 3. Estonian Relative Price Level Compared to EU15

Table 1. The initial relative price level (% of the EU15 average in 2003)

Output deflator	52.6
Consumption deflator	56
Investment deflator	85
Government deflator	30
Import deflator	100 (80)*
Export deflator	100 (80)*
HICP, of which	60.2
HICP core[a]	57.3
HICP food	69.7
HICP fuel[b]	63.5
HICP energy[c]	-

Source: EUROSTAT NEWCRONOS database
* The level of export and import deflator is assumed to be 100% of EU15 by EUROSTAT but they both are taken to be equal to 80% in the model.
[a] Excluding food (HICP group 0110), fuel (0722) and household energy (0450)
[b] HICP group 0722 (fuel for personal transport)
[c] HICP group 0450 (electricity, gas and other fuels)

Appendix 4. Identities of the Model

Acronym	Accounting Identity
BBN	*BBN* = *GYN* – *GEN*
CABN	*CABN* = *TBN* + *TRBN* + *RBN*
CCN	*CCN* = *GDN**(*rho*+*delta*+((*ILAVR*+1)^0.25 – 1))
CCR	*CCR* = (*rho*+*delta*+((*ILAVR*+1)^0.25 – 1))
CEN	*CEN* = *L***WGN* + *ZW*
CMD	*CMD* = 0.6**EPFIXI* + 0.4**EPFLOI*/*ERFLOI*
CXD	*CXD* = 0.5**EPFIXE* + 0.5**EPFLOE*/*ERFLOE*
DDR	*DDR* = *PCR* + *GCR* + *KFGR* + *INVR* + *NCR*
GCD	ΔLN(*GCD*) = ΔLN(*HICP*)
GKFD	ΔLN(*GKFD*) = ΔLN(*KFGD*)
PCD	ΔLN(*PCD*) = ΔLN(*HICP*)
DMR	*DMR* = 0.430**PCR* + 0.170**GCR* + 0.630**PKFR* + 0.400**XGSR*
FSN	*FSN* = *SGN* – *HSN* – *GSN*
FWN	*FWN* = *KSR***KFGD* + *NFAN*
FWR	*FWR* = *FWN*/*PCD*
GAP	*GAP* = *GDPR*/*GDPEQR* - 1
GCN	*GCN* = *XGCGDP***GDPN*
GCR	*GCR* = (*XGCGDP***GDPN*)/*GCD*
GDPN	*GDPN* = *GDPR***GDG*
GDPR	*GDPR* = *DDR* + *XGSR* – *MGSR* + *ZGR*
GKSR	*GKSR* = (1 – *delta*)**GKSR*(–1) + *GKFR*(–1)
GOIN	*GOIN* = *XGOIN***GDPN*
GSN	*GSN* = *GYN* – *GEN* + *GKFN*
GTRN	*GTRN* = *XGTRGDP***GDPN*
GYN	*GYN* = *GOIN* + *TSN* + *TIWN* + *TCIN* + *TINDN*
HICP	*HICP* = *WHICPC***HICPC* + *WHICPE7***HICPE7* + *WHICPE4***HICPE4* + *WHICPF***HICPF*
HS	*HS* = *HSN*/*GDPN*
HSN	*HSN* = *PYN* – *PCN*
ILAVR	*ILAVR* = *ILAVN* – (*GDG* – *GDG*(–4))/*GDG*(–4)
INVSR	*INVSR* = *INVSR*(–1) + *INVR*(–1)
KCN	*KCN* = *delta***KSR***KFGD*

Acronym	**Accounting Identity**
KFGN	*KFGN* = *KFGR***KFGD*
KSEQR	*KSEQR* = (*alpha***GDPR*)/(*eta***CCR*)
KSR	*KSR* = *KSR*(–1)*(1 - *delta*) + *KFGR*(–1)
GDG	LN(*GDG*) = LN(*GDN*) - LN(1 – *TRIND*)
MGSN	*MGSN* = *MGSR***MD*
NFAN	*NFAN* = *NFAN*(–1) + *CABN*(–1) + *ZNFAN*
OIN	*OIN* = 0.269*(*OSGN* – *KCN* + ((1+*ILAVR*)^0.25 - 1)**NFAN*) + 0.01**KFGD***KSR*
OSGN	*OSGN* = 0.41**GDPN*
PCN	*PCN* = *PCR***PCD*
PKFD	*PKFD* = *KFGD*
PKFN	*PKFN* = *PKFR***PKFD*
PKSR	*PKSR* = *KSR* - *GKSR*
PYN	*PYN* = *CEN* + *GTRN* – *TSN* – *TIWN* + *OIN*
PYR	*PYR* = *PYN*/*PCD*
SG	*SG* = *SGN*/*GDPN*
SGN	*SGN* = *CABN* + *KFGR*/*KFGD*
TBN	*TBN* = *XGSN* – *MGSN*
TCIN	*TCIN* = *XTCIN***OSGN*
TINDLSR	*TINDLSR* = *TRIND***GDPR*
TINDN	*TINDN* = *XTIND***PCN*
TIWN	*TIWN* = (*CEN* – *TSN* – *TFN***L*)**XTIW*
TSN	*TSN* = *CEN*/(1/*TRL* + 1)
UE	*UE* = *LF* – *L*
UR	*UR* = *UE*/*LF*
WGR	*WGR* = *WGN*/*GDN*
WNN	*WNN* = *WGN*/(1 + *TRL*)
XGSN	*XGSN* = *XGSR***XD*

Appendix 5. Responses to a Transitory Interest Rate Shock

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from the BLS**				
HICP	0.00	-0.02	-0.07	-0.11	-0.11
Consumption deflator	0.00	-0.02	-0.07	-0.11	-0.11
GDP deflator	0.00	-0.04	-0.15	-0.21	-0.18
Unit labour cost	0.16	0.12	-0.21	-0.27	-0.18
Productivity	-0.19	-0.33	-0.17	-0.06	-0.05
Compensation per employee	-0.02	-0.20	-0.41	-0.40	-0.31
Export deflator	0.00	0.00	-0.02	-0.05	-0.06
Import deflator	0.00	0.00	-0.03	-0.05	-0.06
GDP and components (R)**	*Levels, percentage deviations from the BLS*				
GDP	-0.27	-0.52	-0.29	-0.10	-0.08
Private consumption	-0.37	-0.74	-0.49	-0.21	-0.18
Gross capital formation	-0.90	-2.48	-2.50	-1.68	-1.10
Government consumption	-0.06	-0.21	-0.34	-0.37	-0.38
Exports	-0.05	-0.06	0.02	0.05	0.05
Imports	-0.36	-0.89	-0.84	-0.59	-0.41
Contributions to GDP	*Percentage of GDP, absolute deviations from the BLS*				
Domestic demand	-0.57	-1.29	-1.07	-0.67	-0.49
Trade balance	0.29	0.77	0.78	0.57	0.41
Labour market	*Employment – level, percentage change from the BLS Unemployment rate – percentage points, change from the BLS*				
Employment	-0.08	-0.18	-0.12	-0.04	-0.03
Unemployment rate	0.07	0.16	0.11	0.03	0.03
Household accounts (N)***	*Disposable income – level, percentage change from the BLS Saving rate – percentage points, change from the BLS*				
Disposable income	-0.33	-0.63	-0.54	-0.44	-0.35
Saving rate	0.02	0.07	0.01	-0.07	-0.03
Fiscal stance (N)***	*Levels, percentage change from the BLS, except budget deficit – percentage points, change from the BLS*				
Total receipts	-0.22	-0.56	-0.56	-0.41	-0.33
Total expenditure	-0.22	-0.56	-0.56	-0.41	-0.33
Budget surplus (% of GDP)	0.00	0.00	0.00	0.00	0.00
Financial sector	*Percentage points, absolute deviations from the BLS*				
Short-term interest rate	1.00	1.00	0.00	0.00	0.00
Average interest rate	0.50	0.50	0.00	0.00	0.00
Foreign demand (R)**	*Levels, percentage deviations from the BLS*				
World demand	0.00	0.00	0.00	0.00	0.00
Foreign prices	*Levels, percentage deviations from the BLS*				
Effective exchange rate	0.00	0.00	0.00	0.00	0.00
Foreign prices	0.00	0.00	0.00	0.00	0.00
Commodity prices — oil	0.00	0.00	0.00	0.00	0.00

* *BLS* – baseline scenario; (R)** – in real terms; (N)*** – in nominal terms.

Appendix 6. Responses to a Foreign Demand Shock

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from the BLS**				
HICP	0.00	0.06	0.16	0.23	0.28
Consumption deflator	0.00	0.06	0.16	0.23	0.28
GDP deflator	-0.01	0.13	0.32	0.43	0.48
Unit labour cost	-0.40	-0.05	0.28	0.40	0.39
Productivity	0.53	0.56	0.47	0.39	0.37
Compensation per employee	0.10	0.50	0.82	0.95	0.96
Export deflator	0.00	0.01	0.06	0.11	0.13
Import deflator	0.00	0.01	0.06	0.11	0.13
GDP and components (R)**	*Levels, percentage deviations from the BLS*				
GDP	0.78	0.89	0.75	0.62	0.58
Private consumption	0.56	1.01	0.92	0.79	0.75
Gross capital formation	0.71	1.05	1.45	1.55	1.39
Government consumption	0.16	0.32	0.43	0.49	0.53
Exports	1.12	1.04	1.00	0.96	0.94
Imports	0.83	1.08	1.26	1.29	1.24
Contributions to GDP	*Percentage of GDP, absolute deviations from the BLS*				
Domestic demand	0.63	1.03	1.08	1.01	0.95
Trade balance	0.15	-0.15	-0.34	-0.39	-0.37
Labour market	*Employment – level, percentage change from the BLS Unemployment rate – percentage points, change from the BLS*				
Employment	0.24	0.32	0.28	0.23	0.21
Unemployment rate	-0.22	-0.29	-0.25	-0.21	-0.19
Household accounts (N)***	*Disposable income – level, percentage change from the BLS Saving rate – percentage points, change from the BLS*				
Disposable income	0.49	0.91	1.11	1.13	1.12
Saving rate	-0.04	-0.09	0.01	0.06	0.05
Fiscal stance (N)***	*Levels, percentage change from the BLS, except budget deficit – percentage points, change from the BLS*				
Total receipts	0.51	0.99	1.16	1.17	1.17
Total expenditure	0.51	0.99	1.16	1.17	1.17
Budget surplus (% of GDP)	0.00	0.00	0.00	0.00	0.00
Financial sector	*Percentage points, absolute deviations from the BLS*				
Short-term interest rate	0.00	0.00	0.00	0.00	0.00
Average interest rate	0.00	0.00	0.00	0.00	0.00
Foreign demand (R)**	*Levels, percentage deviations from the BLS*				
World demand	1.00	1.00	1.00	1.00	1.00
Foreign prices	*Levels, percentage deviations from the BLS*				
Effective exchange rate	0.00	0.00	0.00	0.00	0.00
Foreign prices	0.00	0.00	0.00	0.00	0.00
Commodity prices — oil	0.00	0.00	0.00	0.00	0.00

* *BLS* – baseline scenario; (R)** – in real terms; (N)*** – in nominal terms.

Appendix 7. Responses to an Oil Price Shock

	Year 1	Year 2	Year 3	Year 4	Year 5
Prices	*Levels, percentage deviations from the BLS**				
HICP	0.15	0.14	0.11	0.10	0.10
Consumption deflator	0.15	0.14	0.11	0.10	0.10
GDP deflator	0.02	-0.03	-0.09	-0.10	-0.09
Unit labour cost	-0.06	-0.16	-0.26	-0.26	-0.22
Productivity	-0.08	-0.11	-0.05	-0.02	-0.03
Compensation per employee	0.01	-0.11	-0.18	-0.17	-0.14
Export deflator	0.00	0.00	-0.02	-0.03	-0.03
Import deflator	0.00	0.00	-0.02	-0.03	-0.03
GDP and components (R)**	*Levels, percentage deviations from the BLS*				
GDP	-0.11	-0.18	-0.09	-0.04	-0.04
Private consumption	-0.23	-0.40	-0.26	-0.16	-0.16
Gross capital formation	-0.07	-0.20	-0.30	-0.27	-0.17
Government consumption	-0.15	-0.22	-0.24	-0.24	-0.23
Exports	-0.01	-0.01	0.01	0.02	0.02
Imports	-0.09	-0.20	-0.21	-0.17	-0.14
Contributions to GDP	*Percentage of GDP, absolute deviations from the BLS*				
Domestic demand	-0.19	-0.36	-0.29	-0.21	-0.19
Trade balance	0.08	0.18	0.20	0.17	0.14
Labour market	*Employment – level, percentage change from the BLS Unemployment rate – percentage points, change from the BLS*				
Employment	-0.03	-0.07	-0.04	-0.02	-0.02
Unemployment rate	0.03	0.06	0.03	0.01	0.01
Household accounts (N)***	*Disposable income – level, percentage change from the BLS Saving rate – percentage points, change from the BLS*				
Disposable income	-0.04	-0.20	-0.21	-0.17	-0.14
Saving rate	0.02	0.03	-0.04	-0.06	-0.04
Fiscal stance (N)***	*Levels, percentage change from the BLS, except budget deficit – percentage points, change from the BLS*				
Total receipts	-0.05	-0.22	-0.20	-0.15	-0.13
Total expenditure	-0.05	-0.22	-0.20	-0.15	-0.13
Budget surplus (% of GDP)	0.00	0.00	0.00	0.00	0.00
Financial sector	*Percentage points, absolute deviations from the BLS*				
Short-term interest rate	0.00	0.00	0.00	0.00	0.00
Average interest rate	0.00	0.00	0.00	0.00	0.00
Foreign demand (R)**	*Levels, percentage deviations from the BLS*				
World demand	0.00	0.00	0.00	0.00	0.00
Foreign prices	*Levels, percentage deviations from the BLS*				
Effective exchange rate	0.00	0.00	0.00	0.00	0.00
Foreign prices	0.00	0.00	0.00	0.00	0.00
Commodity prices — oil	10.00	10.00	10.00	10.00	10.00

* *BLS* – baseline scenario; (R)** – in real terms; (N)*** – in nominal terms.