Potential Output Estimations for Hungary: A Survey of Different Approaches*

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Abstract

This paper performs a comprehensive analysis on the Hungarian potential output. Since the concept of potential output is not unique, we present various interpretations of the potential GDP along with a large set of techniques for estimating it. Various estimates are presented and robustness analyses performed. Finally, an illustrative scenario is set forth for the following few years.

Keywords: potential output, output gap, production function, business cycle, filtering

JEL: E32, C22, C32

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1 Introduction

In this paper we investigate different potential output estimations for Hungary. The question is especially important both for the conduct of monetary policy and for inflation forecasting. The MNB presents a comprehensive macroeconomic projection in its Quarterly Report on Inflation. The Report assesses inflationary developments by using „demand side” pressures on inflation. These demand side effects are generally linked to the question wether the economy’s capacity utilization is below or above some potential level. When capacities are not enough in the short run , they will also affect pricing policies of firms and possibly inflationary pressures arise. Hence, determining the „capacity neutral” output or the „no-inflation generating” output is crucial for the design of monetary policy. Another important application of the measures of potential output and output gap is the determination of the cyclically adjusted government budget balance as an indicator of the underlying stance of fiscal policy.

The concept of potential output is not unique. The first part of our paper tries to define what potential output is. It turns out that there are different concepts of potential output with very different theoretical backgrounds. Due to theoretical diversity, different methods produce different results. Then, we turn our attention to estimation for the past. The methods used range from simple time series (filtering) techniques through structural VAR estimation to different production function techniques. Comparing different results we seek to arrive at a „consensus” view on Hungarian potential output. Numerical results from different approaches would draw a „range chart” on our view on Hungarian potential output. This picture might also help in understanding how we think of demand-side inflationary pressures. In the last part some medium term projections are also presented. The robustness of these statements are also highlighted.

1.1 How to define potential output?

There are several definitions of potential output ranging from very atheoretical ones to more sophisticated general equilibrium theory-based definitions. The common feature of these definitions may be that all of these try to find an output which can be regarded as an equilibrium or a long-term growth path for the economy. The question is, however, how to define this long term equilibrium.

The first group of candidates for potential output can be regarded as „trend-output" concepts. Regardless of how the trend is defined, the basic assumption is that the economy fluctuates around this trend at business cycle frequencies. We call this extreme as the group of pure time-series (filtering) methods. These methods determine potential output as filtered time-series which are „smooth enough" and from which the deviation from actual output is zero on the average. This also implies that the (unconditional) variance of (growth rates of) potential output should be lower than that of actual.

The other group is based on the traditions of dynamic macroeconomic theory (see e.g. Smets and Wouters (2003), Gali and Monacelli (2005)) where the optimal or equilibrium output is defined as the level of output prevailing under perfect price (and wage) flexibility. This concept is often distinguished from potential output and sometimes is called natural output. In modern macroeconomics natural output depends on several key structural factors, such as labour, capital, the terms-of-trade, foreign output, real exchange rate, etc. According to this view natural output fulfills profit and utility maximization conditions, all budget and transversality conditions hold and the economy is in a rational equilibrium. It can be easily shown that in New Keynesian Macroeconomics if the economy is at the natural output then inflation is zero (or at some steady state value) and hence frictions arising from price or wage stickiness are negligible.

One cannot clearly determine the relation between natural and actual output. The direction depends on the shocks hitting the economy. It can easily happen (e.g. when supply shocks are dominant) that natural output is more volatile than the actual one. Moreover, the deviation of natural and actual output need not be zero on average.

The theory-based potential output concept is not unique, however. Production possibilities, production functions are part of the old tradition of macroeconomics. One can define potential output as the one which depends only on supply-side terms. In this wave of literature potential output is the output level when labour, capital and human capital are used optimally, at their full-capacity level. This concept also links output to some optimality conditions: full-capacity state is achieved when all profit-maximizing conditions hold. We call this the production function-based potential output concept. One should mention, however, that the production function-based potential output can also be regarded as a restricted natural output, where profit maximization, budget and transversality constraints are fulfilled, except utility maximization. In this setup all growth terms (well known in growth theory) are the natural driving variables, such as labour, capital and human capital, technology, education, healthcare, etc. The basic assumption of this method is that in the long run output is supply determined and demand (and other, e.g. nominal) shocks create only fluctuations at business cycle frequencies. In contrast to the previous theory-based natural output concept, and similarly to the time-series techniques, this method requires the output gap (deviation of actual from potential output) to be zero on average.

In practice, however, the distinction between different concepts is not always clear: there are methods which can be categorized into both of the above mentioned categories: e.g. time series techniques with some Phillips-curve, etc. We do not intend to take a clear stand between different concepts of natural/potential output. The aim of this paper is to estimate the whole range of methods for Hungary and make some robust (and possibly forward-looking) statements about the economy's growth performance.

Some of the concepts and estimation methods of potential output have been discussed in the ECB (2000), and then the problem of the trends in the euro area potential output growth has been raised again in ECB (2005). These studies admit that the estimation of potential output is characterized by a significat degree of uncertainty, and that "it is important to take into account alternative estimates of potential growth, as well as to complement the analysis with an assessment of various sources of information, including developments in the main factors of growth."

1.2 Stylized facts

Assuming that the growth of potential output reflects the long term average growth of the economy, as a starting point potential growth can be approximated with average growth rate on a larger horizon. Table 1 illustrates that the average growth rate of Hungary over 1996-2004 was higher than that of old EU-member countries and somewhat lower than the average of New Member States. As a converging country, Hungary lies in the middle of new members, Baltic countries generally grew faster, while some other countries grew at a lower pace. From this long term view, our prior for potential growth of Hungary is around 3.8 for the past nine years. We will show later that this prior is not very far from the results of more sophisticated methods.

2 Methods of estimating potential GDP

Several methods have emerged in the literature for estimating potential output. The various concepts and definitions of potential GDP correspond to different methods; however, there are a set of methods that combine two or more concepts of the potential GDP with the hope that a combination of several concepts provides a more precise estimate of the potential output.

The first definition of potential output as trend-output around which the economy fluctuates at business cycle frequencies, gave rise to various filtering and decomposition techniques. These are usually univariate methods

European Union (25 countries)	2.3
European Union (15 countries)	2.2
New Member States*	4.1
Czech Republic	2.1
Estonia	6.3
Cyprus	3.4
Latvia	6.4
Lithuania	5.6
Hungary	3.8
Malta	1.2
Poland	4.1
Slovenia	3.8
Slovakia	4.1

* Arithmetic average

Table 1: Average growth rate of GDP in EU countries and New Member States, 1996-2004

and aim to extract the cyclical component from the economic time series. The most widely used techniques in the literature are the filter proposed by Hodrick and Prescott (1997), the band-pass filter described in Baxter and King (1999) and the Beveridge-Nelson (1981) decomposition. The problem with these methods is that the extracted cyclical component may differ considerably from one method to another. Canova (1998) also points out that alternative detrending filters extract different types of information from the original series. In spite of these problems, the Hodrick-Prescott filter is still widely used to identify the permanent component of output on the basis that it extracts the relevant business-cycle frequencies of output, and it closely approximates the cyclical component implied by reasonable time-series models of output.

Contrary to the univariate filters and time series methods, the production function approach to estimating potential output allows for a more direct link to sources of structural information and for an easier interpretation of the source of changes in the potential output or output gap. This approach defines potential output as a function of full-capacity supply-side terms. However, the full-capacity of capital and labor inputs is again a matter of interpretation, and it often involves the individual filtering of the input factors. Whatever the definition of the input factor is, potential output is given as a combination of the input factors through a production function which in most of the cases takes a constant-returns-to-scale Cobb-Douglas or CES form. This is the approach taken also in the Quarterly Projection Model (NEM) of the Hungarian economy, described in Jakab et al (2004).

Various methods have attempted to combine the strengths of different interpretations and methods of estimation the output gap (univariate filters with structural approaches). The most wide-spread is probably the multivariate HP filter, implemented by Laxton and Tetlow (1992) and Butler (1996). They argue that the knowledge about the true structural determinants of the supply side of the economy may be incomplete, and the information on supply and demand shocks caused movements should be augmented with information on the permanent and transitory components of output. The methodology consists of adding the residuals of a structural economic relationship to the minimization problem that the HP filter is intended to solve.

Another approach to combine time-series methods with structural approaches is to impose long-run restrictions on estimated vector autoregression models. This approach identifies structural shocks and structural components on the basis of a limited number of economic restrictions imposed on VAR-s. The underlying theory is an aggregate supply and demand model and the assumption that nominal shocks are neutral in the long run and only supply shocks determine the long run level of output.[1] This method has been put forward by Blanchard and Quah (1989), Shapiro and Watson (1988) and King et al. (1991).

Serious differences might result from the application of various methods.

[1] Most of modern New Keynesian Macromodels can be transformed to an underlying aggregate supply-demand model. Hence, SVARs can be more or less viewed as a method capturing the New Keynesian „natural output" concept.

The potential output resulting from univariate time series filtering techniques can be regarded as the true output out of which a specific frequency range has been extracted. However, in the RBC literature the cycle lengths depend on the persistence of the supply shocks and its stochastic properties. On the other hand, the potential output defined through a production function does not say anything about how fast the economy reaches its full capacity utilization. Thus, the potential output resulting from filtering techniques is hardly comparable to that obtained from production function methods unless the speed of adjustment of the input factors correspond to the frequency range of the commonly used filters. And since lots of evidence exist on the low speed of adjustment of the factors of production (especially for the capital stock), the results of the two approaches are not fully comparable.

Beside these difficulties, the "black-box" feature is another disadvantage of the time series methods, since it delivers the result "as it is" without providing any explanation for the level of the potential GDP. Further, these techniques are suitable mainly for ex-post analyses with only a very limited use for making projections for the future. Finally, they may also be sensible to the choice of the sample size, which might be a problem for the short Hungarian time series.

Potential output given by time series methods, whichever to choose, does not correspond to the natural level of output (flexible price equilibrium) either, since the former are based on the principles that the expected deviation from output from its potential is zero, and the variance of the potential output is less than that of actual output. Neokeynesian theory, on the other hand, does not guarantee any of these conditions; on the contrary, it may well happen that the variance of the flexible-price output is larger than that of actual. On example could be the externalities of the sticky wages or prices (Blanchard-type aggregate demand externality) which may dampen the volatility of output.

In that follows, we discuss these approaches in detail, together with their

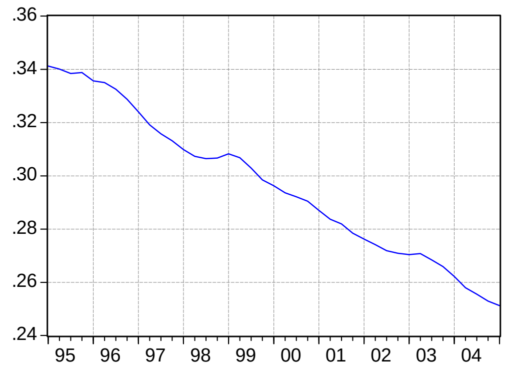

Figure 1: Labour/GDP in Hungary (anualized)

application to estimating the Hungarian potential output.

2.1 Production function approach

In the NEM model (Quarterly Projection Model) developed at the Magyar Nemzeti Bank (see Jakab et al. (2004)) potential GDP is defined within a production function approach with a Constant Elasticity of Substitution (CES) production function. Technological progress is taken as exogenous. The labour-augmenting form of technological progress was chosen because (effective) labour-to-GDP ratio has been falling in recent years at a relatively constant rate (see Figure 1) while capital-to-GDP ratio has been fluctuating (see Figure 2).

The other key assumption about technology in the model is that although capital and labour are split into private and government components, they are treated symmetrically in the production function. Public capital and labour usage work similarly than their private counterparts: there are no externality effects, no increasing returns from e.g. public investments.

$$Y_t^P = A\left\{\alpha K_t^{\frac{\sigma-1}{\sigma}} + (1-\alpha)\left[LF_t(1-\tilde{U}_t)T_t\right]^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

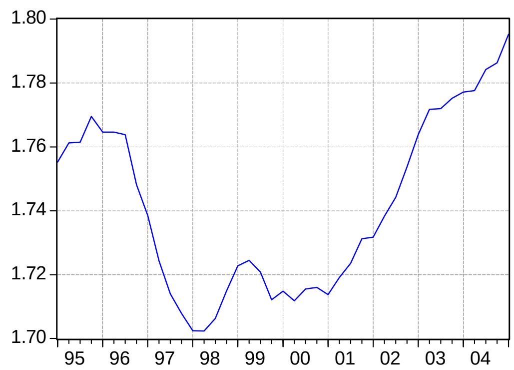

Figure 2: Capital/GDP in Hungary (anualized)

where LF_t refers to the number of actives and T_t captures exogenous (labour-augmenting) technological progress. As mentioned, capital is split into two categories, K_t^p and K_t^g denoting private and public capital, respectively.[2]

$$K_t = K_t^p + K_t^g. \tag{2}$$

Potential output is then defined as the one prevailing under trend (full-capacity) employment. However, determining full-capacity employment (especially in Hungary) is far from obvious. Theoretically, full-capacity employment depends on several factors (such as terms of trade, tax-wedge, demographics, etc.). Most of these explanatory variables are exogenous in the model, and their relation with effective labour supply is relatively complicated to show (in most of the cases they are not significant empirically). Consequently, full-capacity employment is calculated by using HP-filtered unemployment rate. Similarly to capital, labour is also split into private and public, and these two components are treated symmetrically in the production function.

$$U_t = 1 - \frac{E_t^p + E_t^g}{LF_t}, \tag{3}$$

[2]Capital stock data are taken from Pula (2003)

and

$$\tilde{U}_t = HP\text{-}filtered(U_t), \tag{4}$$

where U_t, E_t^p, E_t^g and LF_t denotes unemployment, private and public employment and labour supply (number of actives), respectively. Figure 3 shows that unemployment during 1995-2000 in Hungary had a clear downward sloping trend. This trend however, was more or less linked to increasing labour productivity and supply side factors (restructuring of the economy, newly developed industries induced by large foreign direct investments). Due to these facts, one can assume that at least part of the decline in unemployment indicates an increasing growth rate of potential output as well. Consequently, by using the production function approach one should correct for the supply side changes by enabling the trend (or full-capacity) unemployment to vary over time. The NEM model treats this „supply-side" phenomenon by imposing a HP-filtered full-capacity unemployment ($\tilde{U}_t$) in the CES production function.[3]

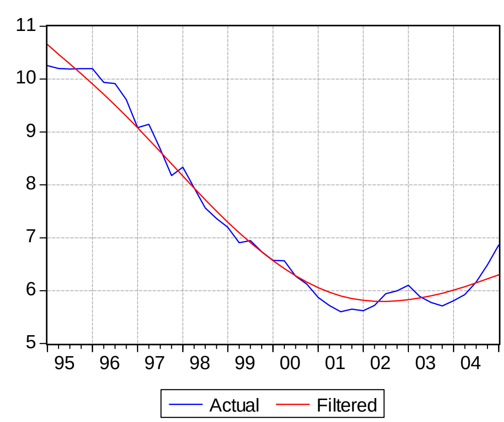

Figure 3: Unemployment rate in Hungary (%)

[3]HP-filtering was performed by using $\lambda = 400$.

	Coeff.	s.e.
A	0.268	0.018
α	0.907	0.016
σ	0.367	-

Table 2: CES-production function parameters in the NEM model

2.1.1 Some issues regarding the production function approach

As mentioned previously, production function based potential output estimations generally pose some issues. For example, the method is not explicit in the speed of convergence to the full-capacity output. Moreover, the full-capacity factor demands should be determined from outside. Hence, even if the production function is estimated in a robust and consistent way, outside information or some filtering of factor demands should be inserted into the production function. This gives rise to external intervention and judgment, which can be a source of uncertainty in results as they depend on the assessment on what, for example, trend unemployment is. Another issue is how to treat or determine the (usually) unobserved technological progress variables. This is again a field for outside intervention and makes expert judgment necessary when using this approach. Problem might also arise from the estimation of the parameters in the production function: in some cases the level and the growth rate of potential GDP might be very sensitive to some of the coefficients.

Therefore, we performed some robustness checks with the production function. In the Hungarian case one might suspect that fluctuation in the unemployment rate can be partly explained by technological and labour supply factors. Hence, our assessment on trend unemployment might not necessarily be robust enough. Moreover, large shifts in unemployment can be observed at the end of the sample, and thus one cannot be fully certain about its persistence. Therefore we present some robustness checks with regard to different assumptions on trend unemployment.

The key coefficient in the production function, the elasticity of substitution between labour and capital (σ) is not estimated directly, it is imported from the panel estimate of Kátay (2003). However, the numerical value for this parameter varies across different estimations. Although, according to Reppa (2005) the unobserved component estimate lies around our calibrated value, estimations on other countries usually result in higher values for this parameter. Moreover, even Kátay (2004) and Kátay and Wolf (2004)[4] estimated a much higher value for σ as well.

2.2 Univariate filters

Univariate filters are commonly used in the literature for estimating potential output. These techniques are based on the definition of potential output as trend output around which the economy fluctuates at business cycle frequencies. As such, these methods are designed to extract the trend and the cyclical component of the underlying economic time series.

Univariate detrending methods of general use in the literature are the computation of a linear or quadratic trend, the Hodrick and Prescott (1997) filter, the band-pass filter described in Baxter and King (1999), and the Beveridge-Nelson (1981) decomposition.

Quadratic time trends were among the first methods to estimate potential output. The method consists of estimating a trend line and its square on the output time series, where the potential output is given by the fitted values of the regression. The slope of the trend might be constant through the full period or the trend line might break at several points in time.

The Hodrick-Prescott filter is probably the most extensively used method in the literature. It aims to extract the "growth" and the "cycle" component of a time series by minimizing a combination of the gap between actual output and trend output and the rate of change in trend output for the whole sample

[4] The long-term elasticity of user cost on capital demand in Kátay and Wolf (2004) corresponds to $-\sigma$.

of observations.

The band-bass filter is based on the idea that business cycles can be defined as fluctuations of a certain frequency. Fluctuations with a higher frequency is considered as irregular or seasonal, while those of lower frequency is seen as trend. Given a judgement on the true frequency of the business cycle, the filter extracts frequencies within a specified frequency range from the underlying time series.

The Beveridge-Nelson decomposition works on the principle that any first order integrated process whose first difference satisfies certain conditions can be written as the sum of a random walk, initial conditions and a stationary process. Thus an ARMA model is estimated on changes in output and the permanent component defined as the random walk can be regarded as potential output while the stationary part as cycle.

Darvas and Vadas (2005) estimate potential output by using the abovementioned univariate methods plus wavelet transformation. We extend their sample and replicate their results here. We are aware of the critiques of these univariate filters, that alternative detrending filters extract different types of information from the original series. Therefore, we employ the method of Darvas and Vadas for calculating a consensus estimate for potential output. Namely, the estimates of various techniques are weighted with weights proportional to the inverse of revisions of the potential output estimates for all dates estimated for recursive samples. Following their methodology, we put higher weight on methods that lead to more stable inference for the end of the sample. These weights are also corrected by the variance and the correlation structure of output gaps of individual methods. We then report only this consensus estimate of the potential output.

2.3 Multivariate filters

The weaknesses and limitations of the univariate methods have been pointed out by many authors (e.g. Canova, 1998). As the Hodrick-Prescott (HP) filter was the most widely used one, several strategies have been proposed in the literature to improve its identification properties by taking into consideration additional information, namely, that the supply side of the economy evolves subject to random disturbances (Laxton and Tetlow, 1992, Butler, 1996). The strategy followed is to augment the HP filter by relevant economic information, that is, to add the residuals of a structural economic relationship to the minimization problem that the HP filter is seeking to solve.

The multivariate Hodrick-Prescott filter (MHP) has no general form, however, the basic intuition behind it can be formalized by:

$$\min_{x^*_{1,t}\cdots x^*_{n,t}} \left\{ \begin{array}{c} \omega_1 \left[\sum_{t=1}^{T} (x_{1,t} - x^*_{1,t})^2 - \lambda \sum_{t=2}^{T} (\Delta x^*_{1,t} - \Delta x^*_{1,t-1})^2 \right] + \\ \vdots \\ \omega_n \left[\sum_{t=1}^{T} (x_{n,t} - x^*_{n,t})^2 - \lambda \sum_{t=2}^{T} (\Delta x^*_{n,t} - \Delta x^*_{n,t-1})^2 \right] + \\ \omega_{n+1} \sum_{t=1}^{T} \left(y_1 - f(\mathbf{x}, \mathbf{x}^*)\right)^2 + \\ \vdots \\ \omega_{n+m} \left[\left(y_m - f(\mathbf{x}, \mathbf{x}^*)\right)^2 \right] \end{array} \right\}, \qquad (5)$$

where we assumed n variables and m behavioral equations. As the purpose is to minimize a weighted sum of residuals, a crucial question could be how to avoid arbitrary weights. There are two possible approaches to ensure this. One is to leave every variable on its own scale, namely $\omega_i = \omega_j, \forall i, j$. Second, every variable is normalized which implies equivalent volatility, or alternatively, we could set ω as $\omega_i = \frac{1}{\sigma^2_{x_i}}$.

Let us introduce the notation Y_t for the GDP in real term, Y^*_t for potential GDP in real term, W_t for average wage in real term, P_t for price level, α for labour income share, T_t for labour augmenting technological progress, U_t for unemployment rate, . Denoting by small letter and superscript star the log-transformation and the potential value of corresponding variable, and by U^*_t

the NAIRU, the behavioral equations that we use are:

CES production function:

$$Y_t = A\left\{\alpha K_t^{\frac{\sigma-1}{\sigma}} + (1-\alpha)\left[LF_t(1-U_t)T_t\right]^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{\sigma}{\sigma-1}} + \varepsilon_{Y,t} \tag{6}$$

Phillips curve:

$$\Delta p_t = \gamma\Delta p_{t-1} + (1-\gamma)\Delta p_{t+1} + \beta(y_t - y_t^*) + \varepsilon_{p,t} \tag{7}$$

Wage equation:

$$\Delta w_t = \eta\Delta w_{t-1} + (1-\eta)\Delta w_{t+1} + \delta(U_t - U_t^*) + \varepsilon_{w,t} \tag{8}$$

The „potential form" of equation (6) contains the NAIRU (U^*) instead of actual unemployment rate. By definition, potential form is a deterministic equation, however, since we use the estimated parameters (A, α and σ), we consider the stochastic form of potential GDP:

$$Y_t^* = A\left\{\alpha K_t^{\frac{\sigma-1}{\sigma}} + (1-\alpha)\left[LF_t(1-U_t^*)T_t\right]^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{\sigma}{\sigma-1}} + \varepsilon_{Y^*,t} \tag{9}$$

Using equation (9), (7) and (8) we can form the following MHP:

$$\min_{y_t^*, U_t^*, \gamma, \beta, \delta, \eta} \left\{ \begin{array}{c} \omega_y \left[\sum_{t=1}^{T}(y_t - y_t^*)^2 - \lambda\sum_{t=2}^{T}(\Delta y_t^* - \Delta y_{t-1}^*)^2\right] + \\ \omega_u \left[\sum_{t=1}^{T}(U_t - U_{n,t}^*)^2 - \lambda\sum_{t=2}^{T}(\Delta U_t^* - \Delta U_{t-1}^*)^2\right] + \\ \omega_{y^*}\sum_{t=1}^{T}(\varepsilon_{Y^*,t})^2 + \\ \omega_p\sum_{t=1}^{T}(\varepsilon_{p,t})^2 + \\ \omega_w\sum_{t=1}^{T}(\varepsilon_{w,t})^2 \end{array} \right\} \tag{10}$$

In order to examine the convergence of minimization (10), we used different starting values. As far as the filtered values concern we consider both $y_t^* = y_t$, $U_t^* = U_t$ and $y_t^* = HP(y_t)$, $U_t^* = HP(U_t)$, where $HP(X_t)$ denotes the univariate HP filtered values. We also compute two weighting schemes, namely $\omega_i = \omega_j, \forall i, j$ where $i, j \in (y, U, \varepsilon_{Y^*}, \varepsilon_p, \varepsilon_w)$ and $\omega_y = \frac{1}{\sigma_y^2}, \omega_U = \frac{1}{\sigma_U^2}, \omega_{y^*} = \frac{1}{\sigma_{\varepsilon_{Y^*}}^2}$ or $\omega_{y^*} = \frac{1}{\sigma_{\varepsilon_{gap}}^2}, \omega_{p^*} = \frac{1}{\sigma_{\varepsilon_p}^2}, \omega_{y^*} = \frac{1}{\sigma_{\varepsilon_w}^2}$. The estimates with various starting values and weighting schemes are close to each other; we report the results only for the case where the starting values are identical to the actuals, and the weights are normalized.

As far as the equation parameters concern, the parameters of the Phillips curve are those estimated by Lendvai (2004), $\gamma = 0.561$, $\beta = 0.057$. The production function is parametrized identically with that from section 2.1, while for the wage equation we set $\eta = 0.5$ and $\delta = -0.00347$ (the unemployment elasticity from the NEM model).

2.4 Structural Vector Autoregressions

The Structural VAR approach to estimating potential output is based on simple theoretical aggregate supply - aggregate demand models. The idea is to estimate such a model in a vector autoregression form, to use theoretical restrictions to identify the major shocks to the system and to decompose movements in output into permanent and transitory components. The shocks can then be used to construct the measures of the output gap. Several techniques exist for recovering the shocks affecting the variables of a VAR. The reduced-form errors of a reduced-form VAR can be used to recover the structural shocks. However, the recovery of the structural shocks from the reduced-form errors requires the identification of the elements of the matrix of contemporaneous coefficients that relates the structural shocks to the reduced-form errors.

There are several approaches for recovering the structural shocks. One common way is to use a Choleski decomposition, which assumes that some variables do not have contemporaneous effects on the others. This method, which in fact restricts the matrix of contemporaneous coefficients to be a lower triangular matrix, is very sensitive to the ordering of the variables within the VAR, especially when the correlations among the reduced-form errors are high. An alternative approach is that used by Blanchard and Quah (1989) and Shapiro and Watson (1988), which is based on the long-run dynamic effects of the shocks on particular variables in the system to identify the structural shocks.

Our approach will follow that of Blanchard and Quah (1989) and Shapiro and Watson (1988), and will rest on long-run restrictions on output. In particular, we assume an aggregate supply and aggregate demand model, where aggregate supply shocks have permanent effects on the level of output while aggregate demand shocks, and temporary aggregate supply shocks, have only temporary effects. Thus, nominal shocks are neutral in the long run. In principle, the approach is close to the „natural" output concept well known in New Keynesian Macroeconomics by focusing on inflation dynamics and its relationship with demand.

We illustrate the identification process below. Assume that the structural form of the model is expressed in an infinite moving-average form, where the model variables (stacked in the vector X_t) are expressed as a linear combination of current and past structural shocks (e_t):

$$X_t = S(L)e_t, \tag{11}$$

where $S(L)$ is a matrix of polynomials in the lag operator and e_t is a vector of structural shocks, $E[e_t] = 0$, and $E[e_t e_t'] = I_n$, n is the number of variables in the VAR. Assume that the VAR is first estimated in its unrestricted form:

$$X_t = \Phi(L)X_{t-1} + \varepsilon_t, \tag{12}$$

that amounts to applying ordinary least squares separately to each equation in (12). This reduced form model then can be inverted using the Wold decomposition, resulting in the reduced-form moving average representation:

$$X_t = C(L)\varepsilon_t, \tag{13}$$

where $C(L) = (I - \Phi(L)L)^{-1}$. ε_t is a vector of reduced-form residuals with variance-covariance matrix $E[\varepsilon_t \varepsilon_t'] = \Omega$.

From (11) and (13) it follows that the structural innovations are a linear transformation of the reduced-form innovation:

$$\varepsilon_t = S(0)e_t. \tag{14}$$

We can further derive the following relationships:

$$S(0)S(0)' = \Omega, \tag{15}$$

and

$$C(L) = S(L)S(0)^{-1}. \tag{16}$$

The long run covariance matrix of the reduced form is given by:

$$C(1)\Omega C(1)' = S(1)S(1)'. \tag{17}$$

To recover the structural innovations it is necessary to provide sufficient restrictions to identify the elements of the matrix $S(0)$. The equations above identify $n(n+1)/2$ elements of the matrix $S(0)$, the remaining $n(n-1)/2$ can be identified by making $S(L)$ lower triangular, that is, by imposing restrictions that demand shocks have only temporary effect on output, and the cumulated effects of demand shocks on output are zero.

Assuming that the first element of vector X is the growth rate of real output (Δy_t), real output can be written in the form:

$$\Delta y_t = \mu_y + S_1^p(L)e_t^p + S_1^c(L)e_t^c, \tag{18}$$

where e_t^p is the vector of permanent shocks affecting output, e_t^c is the vector of shocks having transitory effects on output, $S_1^p(L)$ and $S_1^c(L)$ represent the dynamics of these shocks. Potential output is constructed as the permanent component of output, that is, the level to which output reverts when demand shocks and temporary supply shocks die out:

$$\Delta y_t^* = \mu_y + S_1^p(L)e_t^p. \tag{19}$$

For our application of the SVAR methodology, we estimate several SVAR systems using quarterly data over the period 1995q1-2005q1 on a large set of variables used by the SVAR literature, such as output (y), CPI inflation (Δcpi), core inflation ($\Delta core$), unit labour cost (ulc), (trend of) employment (e and etr), unemployment (u), real exchange rate (rer) and capacity utilization (cu) (where lowercase letters denote the log of the variable). The estimation requires that the variables in the SVAR follow a stationary stochastic process, therefore we generally employ the growth rates of the variables as they proved to be integrated of order one. The order of integration of the consumer price level however is hard to decide (I(1) vs. I(2)), therefore we estimated the SVAR-s both with the inflation and with changes in inflation. The lag lengths of the VAR-s are determined on the basis of information criteria.

Regarding the various specifications of the VAR, we followed the models existing in the literature. Chagny and Döpke (2001) estimate the SVAR for the Euro-zone in the form $[\Delta y, \Delta cpi]$, while Morling (2002) estimates it for a larger set of countries. They impose the restriction that the impact of change of the inflation rate on the change in real output is zero in the log-run.

The inclusion of unemployment rate in the SVAR dates back to Blanchard and Quah (1989), and is also used by Chagny et al. (2004) and by St-Amant and van Norden (1997). Based on their various specifications, we estimate our SVAR-s in the forms $[\Delta y, \Delta u, \Delta cpi]$ and $[\Delta y, \Delta u, \Delta\Delta cpi]$. In this specification the long term restrictions imposed are that supply shocks affect only output in the long run, demand shocks affect unemployment and inflation, while the third structural shock, the inflation shock affects only inflation and has no long-run effect on output or unemployment. We also estimate specifications where the unemployment rate is replaced by change in (the trend of) employment. The rationale behind these systems are that demand shocks might be better captured by changes in employment, since changes in unemployment are also driven by variations in the labour force, which cannot be necessarily attributed to changes in aggregate demand. Moreover, employment is used also by Shapiro and Watson (1988) and by Claus (2000) in their VAR-s. Thus, this rationale generated other four specifications, $[\Delta y, \Delta e, \Delta cpi]$, $[\Delta y, \Delta etr, \Delta cpi]$, $[\Delta y, \Delta e, \Delta\Delta cpi]$ and $[\Delta y, \Delta etr, \Delta\Delta cpi]$. We also estimated these specifications by using both core inflation and unit labour cost instead of CPI inflation. As core inflation and unit labour cost turned to be an I(1) process, we estimated only the $[\Delta y, \Delta e, \Delta\Delta core]$, $[\Delta y, \Delta etr, \Delta\Delta core]$, $[\Delta y, \Delta e, \Delta ulc]$ and $[\Delta y, \Delta etr, \Delta ulc]$ systems. The inclusion of the unit labour cost into the systems has been motivated by the New Keynesian Macroeconomic theory: as the real unit labour cost is an indicator of the tensions existing in the goods market, the nominal unit labout cost might serve as an indicatior of the inflationary developments.

Beside employment, Claus (2000) when estimating potential output for New Zealand, includes also the capacity utilization as it is an information that is conceptually close to the notion of potential output. Accordingly, beside the change in output and (trend of) employment, we included in our VAR-s the change in the capacity utilization ($[\Delta y, \Delta e, \Delta cu]$, $[\Delta y, \Delta etr, \Delta cu]$), with the restrictions that the cumulated effects of demand shocks on output must be equal to zero.

Our final specification is similar to that of Cerra and Saxena (2000) and Clarida and Gali (1994), who include the change in the real exchange rate in their VAR when estimating the potential output ($[\Delta y, \Delta rer, \Delta cpi]$, $[\Delta y, \Delta rer, \Delta\Delta cpi]$). The restrictions imposed imply that in the long-run output is affected only by supply shocks, while demand shocks and nominal shocks have zero impact. Nominal shocks have permanent effect only on the inflation rate, while demand shocks affect both inflation and the real exchange rate.

Among these SVAR-s, the systems involving unemployment or the real exchange rate and the two-variable system provided unreliable results, as they were unsuccessful in capturing the permanent shocks and thus the variations in the potential GDP. In the two-variable case, it was presumably the small dimension of the system which made it difficult the identification of the different types of shocks affecting the system. Unemployment did not perform well in the identification of shocks because the unemployment time series was driven mainly by variations in the labour force participation and not by variations in employment. The real exchange rate presents only moderate fluctuations because of the crawling peg system between 1995 and 2001, thus, variations in the real exchange rate reflect mainly the exchange-rate based stabilization and disinflationary policy and not variations that are linked to changes in potential output.

2.5 Unobserved component method based on external equilibrium

Another approach for estimating output gap within a structural model is an unobserved components approach taken by Darvas and Simon (2000). They give an alternative interpretation for potential output in small open economies. They argue that in open economies the definition of output gap as excess demand leading to inflationary pressures, might be misleading. Excess demand may simply result in increased imports without a short-run effect on inflation, which may or may not have an impact on future inflation depending on policy adopted.

In conformity with this view, Darvas and Simon set up a model which does not use inflation or unemployment data, but rather foreign trade data.

Unlike in traditional models where potential output is an output sustainable from the aspect of inflation, here potential output is defined as an output level sustainable from the aspect of external equilibrium. The key elements of the model are the trade equations that incorporate two latent variables: "relative supply" and "economic integration". This state-space form is then estimated by using Kalman filter, and then a world supply model is estimated independently with a univariate model, where world demand is defined as the sum of world supply and a cycle variable. Finally, output is decomposed as the sum of supply (="relative supply" + "world supply") and a stationary output gap.

In this paper we replicate and extend the results of Darvas and Simon (2000) for the sample period 1960-2004.[5]

3 Results

After estimating several methods, a robust picture emerges with regard to Hungarian potential output and output gap (actual/potential output) developments. Though different methods lie on different theoretical backgrounds and capture different movement in the economy, the numerical results became relatively robust. Our data set is based on the quarterly, seasonally adjusted figures published by the Central Statistical Office up to 2005Q1, future data revisions might affect our results.[6]

3.1 The underlying trend

Tables 3 and 4 illustrate our estimates for the potential GDP and potential GDP/employee, using various methods. It can be observed that all methods

[5] The calculations were performed by Zsolt Darvas.

[6] Recently, GDP figures were revised due to some methodological changes on the accounting of interest payments in GDP. Quarterly numbers and data prior to 2003 were not published at the moment of the finalization of our paper.

show an acceleration of the growth rate of potential output after 1995 from around 1.8-3.7 percent to around 4-5 percent by 2000. After then, the relatively high growth rate started to slow down, and currently for 2004-2005 we estimate a potential growth rate between 3.5-4 percent. This deceleration was more or less gradual, though some methods indicate a temporary decline in growth rate for 2003. One can also observe that dispersion of estimates gradually dropped from the beginning of our sample and by 2004 the results fairly converged. The convergence of results has two sources, one methodological and one economic. The economic source is that in late 1990s the economy experienced various shocks, large supply shocks, stabilization measures and inflationary and disinflationary shocks. Hence, different methods focusing on different features of the economy naturally end up with divergent results. The methodological source lies on the nature of the estimation techniques, i.e. the methods are quite sensitive at the start of the sample (except for the unobserved component model estimated on a longer sample).

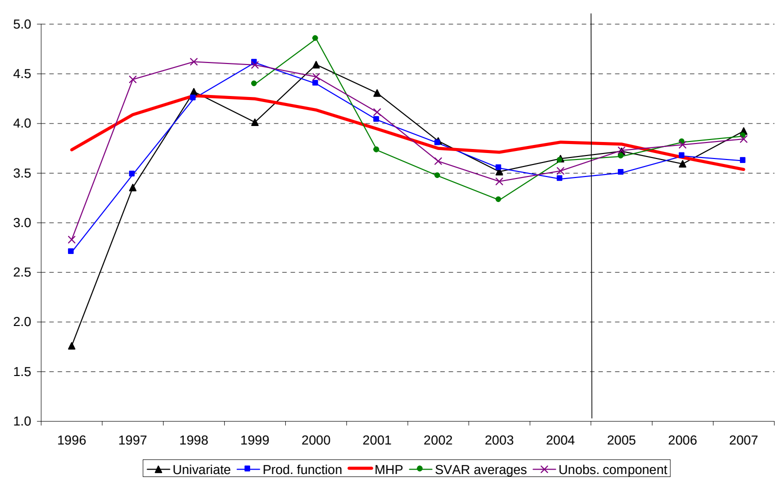

Figure 4: Annual growth rate of potential output

The estimated growth rates, however, do not clearly characterize the speed of convergence of the Hungarian economy towards more developed

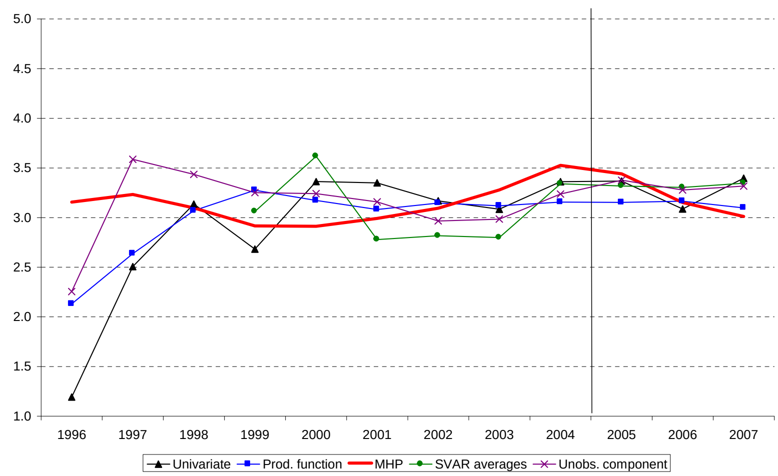

Figure 5: Annual growth rate of potential output/employee

regions of the world. In effective (per employee) terms this convergence is more stable. Trend growth in (average) labour productivity has been fluctuating around 3-3.5 percent. There was no clear acceleration and deceleration during late 1990s. The same uncertainty applies for these results at the beginning of the sample as well.

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3.1.1 Determinants of growth

Determinants of growth can be analyzed by the production function approach. We have constructed some counterfactual measures to illustrate the contribution of the three factors of production (labour, capital and labour augmenting technological progress). Figures 7 and 8 demonstrate that the acceleration of potential growth in late 90s was merely a result of capital accumulation, which added at most 1.5 percent to growth. This can be explained by changes in the sectorial distribution of production, new industries emerged with the help of significant foreign direct investment flows. Invest-

	Univar	NEM	MHP	Unobs.	SVAR									
				comp	Δy Δe Δcpi	Δy Δe $\Delta\Delta cpi$	Δy Δetr Δcpi	Δy Δetr $\Delta\Delta cpi$	Δy Δe Δcu^*	Δy Δetr Δcu^*	Δy Δe $\Delta\Delta core$	Δy Δetr $\Delta\Delta core$	Δy Δe Δulc	Δy Δetr Δulc
1996	1.76	2.70	3.74	2.83	-	-	-	-	-	-	-	-	-	-
1997	3.36	3.49	4.09	4.44	-	-	-	-	-	-	-	-	-	-
1998	4.32	4.25	4.28	4.62	-	-	-	-	-	-	-	-	-	-
1999	4.01	4.61	4.25	4.59	4.38	4.49	4.35	4.46	4.37	4.33	4.40	4.39	4.43	4.38
2000	4.59	4.40	4.14	4.47	4.81	4.78	4.84	4.81	4.95	4.98	4.81	4.84	4.76	4.81
2001	4.31	4.04	3.95	4.11	3.76	3.74	3.78	3.75	3.62	3.66	3.76	3.77	3.72	3.76
2002	3.82	3.80	3.75	3.62	3.46	3.46	3.47	3.47	3.46	3.47	3.49	3.50	3.57	3.56
2003	3.52	3.55	3.71	3.42	3.18	3.22	3.18	3.22	3.34	3.32	3.18	3.19	3.19	3.17
2004	3.65	3.44	3.81	3.52	3.67	3.60	3.70	3.62	3.53	3.58	3.65	3.65	3.69	3.71
Fcast														
2005	3.68	3.50	3.75	3.73	3.61	3.60	3.74	3.73	3.57	3.70	3.69	3.70	3.70	3.71
2006	3.58	3.67	3.65	3.79	3.86	3.86	3.82	3.82	3.88	3.84	3.74	3.68	3.92	3.89
2007	3.92	3.62	3.54	3.84	3.97	3.98	3.87	3.86	3.97	3.86	3.76	3.72	3.88	3.86
2008	-	3.56	-	-	-	-	-	-	-	-	-	-	-	-
2009	-	3.54	-	-	-	-	-	-	-	-	-	-	-	-
2010	-	3.52	-	-	-	-	-	-	-	-	-	-	-	-

*forecast for capacity utilization has been made with the SVAR

Table 3: Potential GDP growth rate forecasts (the underlying variables have been forecasted by using the NEM model)

	Univar	NEM	MHP	Unobs.	SVAR									
				comp	Δy Δe Δcpi	Δy Δe $\Delta\Delta cpi$	Δy Δetr Δcpi	Δy Δetr $\Delta\Delta cpi$	Δy Δe Δcu^*	Δy Δetr Δcu^*	Δy Δe $\Delta\Delta core$	Δy Δetr $\Delta\Delta core$	Δy Δe Δulc	Δy Δetr Δulc
1996	1.65	2.13	3.62	2.26	-	-	-	-	-	-	-	-	-	-
1997	2.26	2.64	2.98	3.59	-	-	-	-	-	-	-	-	-	-
1998	2.95	3.07	2.91	3.44	-	-	-	-	-	-	-	-	-	-
1999	2.68	3.28	2.91	3.25	3.04	3.15	3.02	3.12	3.03	2.99	3.06	3.05	3.10	3.05
2000	3.45	3.17	3.00	3.24	3.66	3.64	3.70	3.66	3.80	3.83	3.67	3.69	3.53	3.57
2001	3.09	3.08	2.73	3.16	2.55	2.52	2.57	2.54	2.41	2.45	2.55	2.55	2.77	2.80
2002	3.44	3.15	3.37	2.97	3.07	3.07	3.09	3.09	3.07	3.09	3.11	3.11	2.91	2.90
2003	3.03	3.12	3.23	2.98	2.70	2.74	2.70	2.74	2.86	2.84	2.70	2.71	2.76	2.74
2004	3.38	3.16	3.54	3.24	3.40	3.34	3.43	3.35	3.27	3.31	3.38	3.38	3.40	3.43
Fcast														
2005	3.94	3.15	4.02	3.38	3.87	3.86	4.00	4.00	3.84	3.97	3.96	3.97	3.35	3.36
2006	3.05	3.17	3.11	3.28	3.33	3.32	3.29	3.29	3.35	3.31	3.21	3.15	3.41	3.38
2007	3.40	3.10	3.02	3.32	3.46	3.46	3.35	3.34	3.45	3.34	3.24	3.20	3.35	3.34
2008	-	3.08	-	-	-	-	-	-	-	-	-	-	-	-
2009	-	3.08	-	-	-	-	-	-	-	-	-	-	-	-
2010	-	3.07	-	-	-	-	-	-	-	-	-	-	-	-

*forecast for capacity utilization has been made with the SVAR

Table 4: Potential GDP/employee growth rate forecasts (the underlying variables have been forecasted by using the NEM model)

ment ratio increased and the Hungarian economy's capital intensity started to increase after 1997 as well (see Figure 2). Since then the contribution of capital has almost stabilized and labour fluctuations were responsible for the variance of growth.

Meanwhile large shifts can also be observed in the labour market (see Figure 6). After a slight drop, labour supply (partly due to demographic changes, i.e. entering of younger cohorts to the labour market) increased. Quality and skill of increasing labour supply was met by the increasing labour demand of new industries. Hence, labour has also contributed to the acceleration of growth. However, after around 2001 maybe due to skill-mismatches, labour shortages in several industries or sluggish nominal wage adjustment to a lower inflationary environment, labour demand was no longer enough to absorb the still increasing labour supply. Consequently, unemployment started to increase, and one can observe a deceleration in the growth rate of trend employment as well. The contribution of labour to growth almost reached zero by 2004. One should also mention the effect of capital-labour substitution. Partly due to relatively high growth rate of real wages, corporate sector adjusted its capital intensity and hence we could observe a slight increase in capital's share since 2001.

At the same time, the contribution of technological progress was stable. This however points to some problem of our estimation, because this is the least precisely measured factor of production.

3.2 Fluctuations

Table 5 and Figure 9 illustrate the output gap resulting from various potential output estimates. Estimates are reported for the period 1995q1-2005q1 with the exception for the SVAR methods, where calculations start from 1998.[7]

[7] In fact, SVARs were also estimated for the whole sample between 1995 and 2005q1, but due to the need for calculating the Vector Moving Average decomposition, potential output could only be calculated on the sample between 1998 and 2005q1.

Figure 6: Employment developments (thousands of employees)

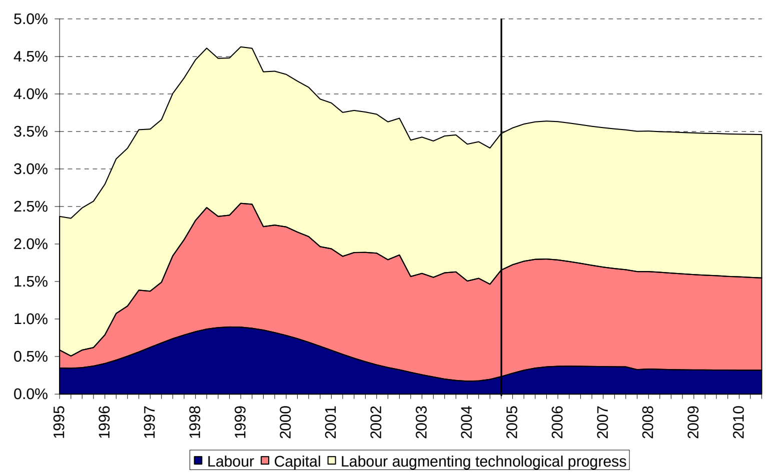


Figure 7: Contribution of labor (L), capital (K) and labor augmenting technological progress (LATP) to the potential GDP growth (production function approach)

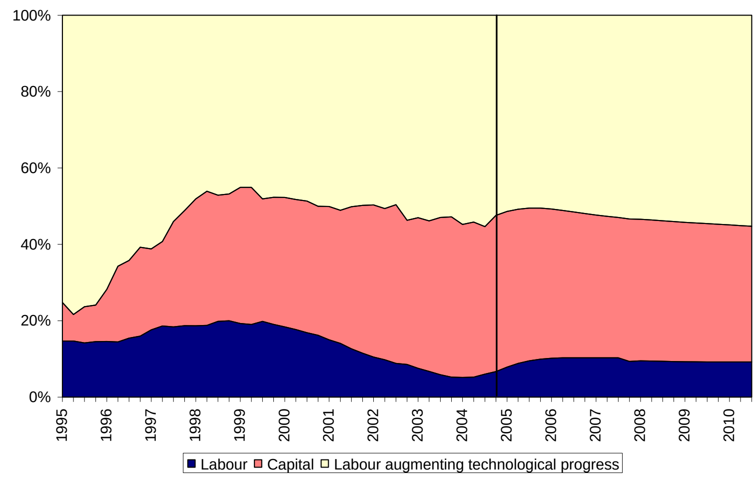


Figure 8: Contribution of labor (L), capital (K) and labor augmenting technological progress (LATP) to the potential GDP growth (production function approach, shares)

The various methods provide a rather consistent image of the output gap. After the deterioration of the external and government balance in 1993-1994, stabilization measures were introduced in March 1995. As a consequence, GDP growth slowed down considerably. All methods capture very well this slowdown where output fell below its potential by more than 1.5%. After the stabilization measures growth accelerated in 1997-1998, reaching its potential in 1997 and exceeding it in 1998. The outbreak of the Russian crisis in August 1998 (and the slowdown in Europe) influenced temporarily the economy as it cut the demand for Hungarian exports while the production capacity remained unchanged. All methods indicate that output fell below its potential by the end of 1998 generating a negative output gap of almost 0.5% by the middle of 1999. All of our methods show however that this was only a short-lived phenomenon. Starting with 1999, GDP grew steadily until 2001 and output gap reversed and became positive. At the same time, SVAR methods report a near zero gap for 2000. In 2001 output is above its potential according to all estimates while in 2002 some methods already signal a reversal, ending with a consensus of negative gap in 2003, although its magnitude varies across methods. In 2004 we experience an acceleration of the economy, and output rises above its potential by 0.2-0.5%.

3.3 Monetary policy implications

Figures 9 and 11 show our main and most robust findings on output gap. The important message for monetary policy from this picture is that in 1999 (partly due to Russian crisis) a mini-recession occurred. The SVARs, which are the most sensitive to inflationary pressures, also point a disinflationary shock at that time. In fact, inflation also dropped at that time to almost 10 percent from much higher levels. After that, Hungarian economy consolidated output gap became slightly positive. However, inflation did not accelerate back, and this is also shown by our SVAR results, which point to a close to zero output gap. Other methods focusing more on production capacities, labour market pressures, indicate positive gap, but at that time these bottlenecks were not enough to create significant inflationary pressures, at least for a few years. Starting in early 2001, however, this picture changed quite rapidly. All methods, including SVAR-s, imply an increasing output gap which could end up with rising inflation. This enforced a monetary policy reaction as well. An inflation targeting regime was introduced with allowing the exchange rate to appreciate leading to a tightening of monetary conditions. At the same time fiscal policy was expansionary, mitigating the potentially recessionary effects of monetary tightening. However, foreign business cycle conditions started to deteriorate and output gap again reached zero or slightly negative level in 2003. This partly led to some easing of inflationary pressures as well. In 2004 the economy again returned back to a slightly positive output gap with inflationary pressures present (again

SVARs show positive values for output gap).[8]

3.4 Uncertainty of results

Unfortunately most of the methods do not allow the computation of a confidence interval for the potential output and output gap estimates. There are, however, a few techniques according to which we can asses the uncertainty of our estimates.

The errors of the univariate estimates can be assessed by using the technique in Darvas and Vadas (2005). Table 6 presents the average revisions of the output gap according to the various univariate methods. According to this, the average revision of our (consensus) univariate estimate is 0.044 percentage points. One can observe that although the revision error for Hungary is slightly higher than that of EU countries' average, the figures are generally of the same magnitude. Higher errors might be explained by the changing structure of Hungarian economy and the presence of larger supply shocks.

Without determining the exact distribution properties of our results, there is another way of describing the uncertainty surrounding them. Figure 11 illustrates a minimum-maximum band within which our output gap estimates lie, along with the average of the estimates. The width of this band was 0.6 percentage points on the average. Figure 10 shows minimum-maximum band for the growth rate of potential output. Potential output growth estimates were significantly disperse in the first part of our estimation sample. However, since 2001 the results converged to each other to an average bandwidth of 0.4 percentage points.

It is importan to emphasize though, that the minimum-maximum band is likely to widen out with an increase in the number of methods employed, thus, it does not behave like a confidence band. However, a larger set of methods

[8] The unobserved component model shows very similar dynamics for the output gap. This can be explained with a common factor for inflation, external balance and output. Real exchange rate is a natural candidate for being such a common factor.

	Univar	NEM	MHP	Unobs.	SVAR									
				comp	Δy Δe Δcpi	Δy Δe $\Delta\Delta cpi$	Δy Δetr Δcpi	Δy Δetr $\Delta\Delta cpi$	Δy Δe Δcu	Δy Δetr Δcu	Δy Δe $\Delta\Delta core$	Δy Δetr $\Delta\Delta core$	Δy Δe Δulc	Δy Δetr Δulc
1995	-1.03	0.12	1.47	1.39	-	-	-	-	-	-	-	-	-	-
1996	-1.61	-1.40	-1.05	-0.25	-	-	-	-	-	-	-	-	-	-
1997	-0.32	-0.26	-0.45	0.01	-	-	-	-	-	-	-	-	-	-
1998	0.21	0.32	0.10	0.24	0.14	0.11	0.19	0.16	0.22	0.26	0.13	0.19	0.17	0.22
1999	0.33	-0.13	0.00	-0.18	-0.08	-0.21	-0.01	-0.15	0.01	0.09	-0.11	-0.04	-0.10	0.00
2000	0.78	0.50	0.89	0.38	0.15	0.05	0.20	0.10	0.12	0.17	0.13	0.17	0.18	0.24
2001	0.49	0.46	0.94	0.27	0.38	0.30	0.40	0.33	0.47	0.50	0.35	0.39	0.44	0.47
2002	0.17	0.17	0.70	0.15	0.42	0.34	0.43	0.36	0.51	0.52	0.36	0.39	0.37	0.41
2003	-0.39	-0.43	-0.05	-0.31	0.18	0.07	0.19	0.08	0.12	0.16	0.13	0.15	0.13	0.19
2004	0.03	0.19	0.20	0.23	0.58	0.53	0.56	0.53	0.65	0.64	0.55	0.57	0.51	0.54
Fcast														
2005	-0.11	0.24	0.00	0.08	0.51	0.47	0.37	0.34	0.62	0.48	0.40	0.41	0.39	0.41
2006	0.16	0.40	0.20	0.16	0.51	0.47	0.40	0.38	0.60	0.50	0.51	0.58	0.34	0.39
2007	0.06	0.59	0.47	0.14	0.36	0.32	0.35	0.33	0.45	0.46	0.57	0.67	0.28	0.35

Table 5: Output gap estimates

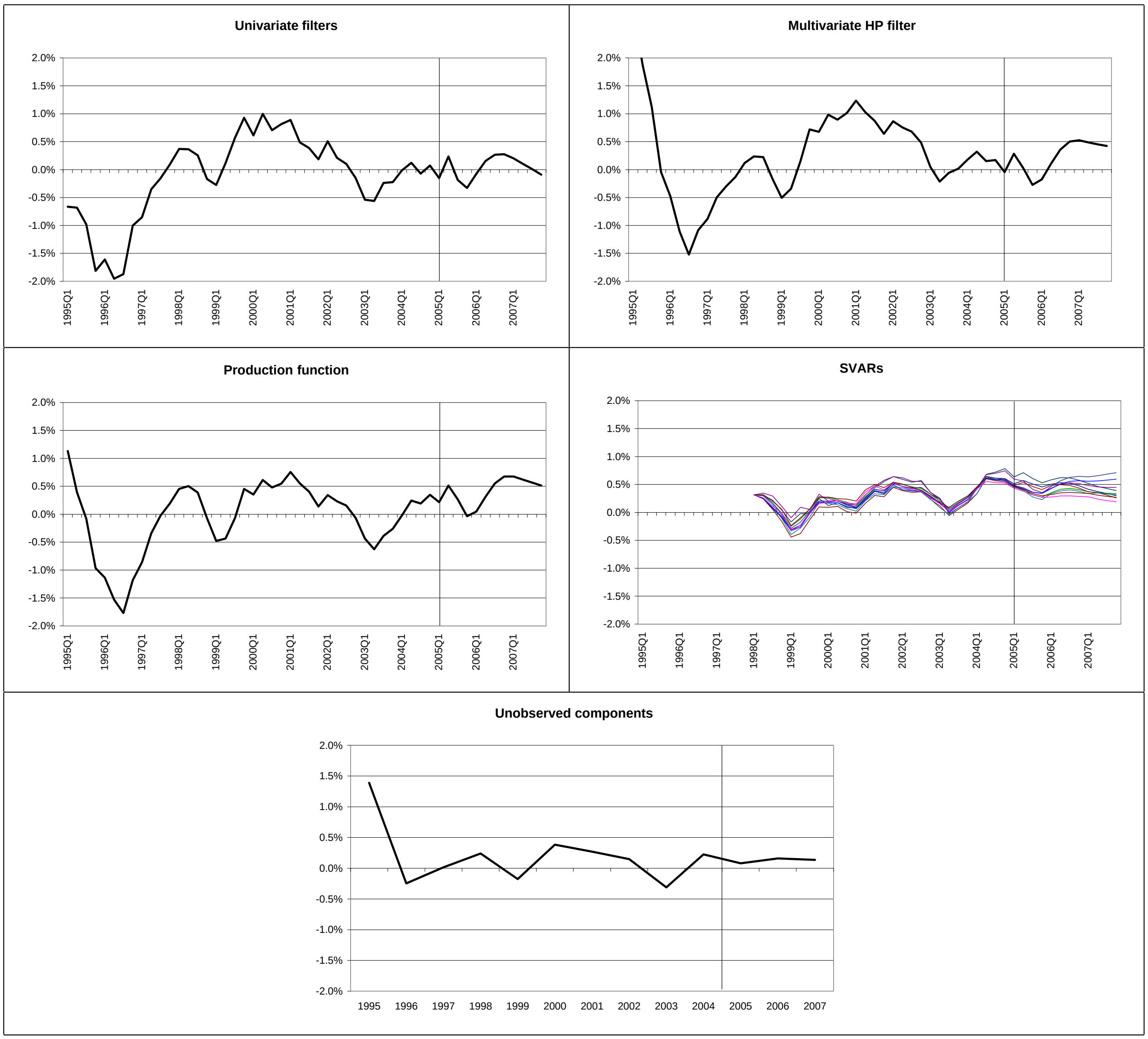


Figure 9: Output gap estimates and forecasts, various methods

	Hungary	EU average
Quadratic trend	0.129	0.082
HP-filter	0.044	0.050
Band-Pass filter	0.027	0.036
Beveridge-Nelson decomposition	0.078	0.014
Darvas-Vadas (2005) Consensus	0.044	0.029

Table 6: Revision errors of univariate time series methods, source: Darvas-Vadas (2005)

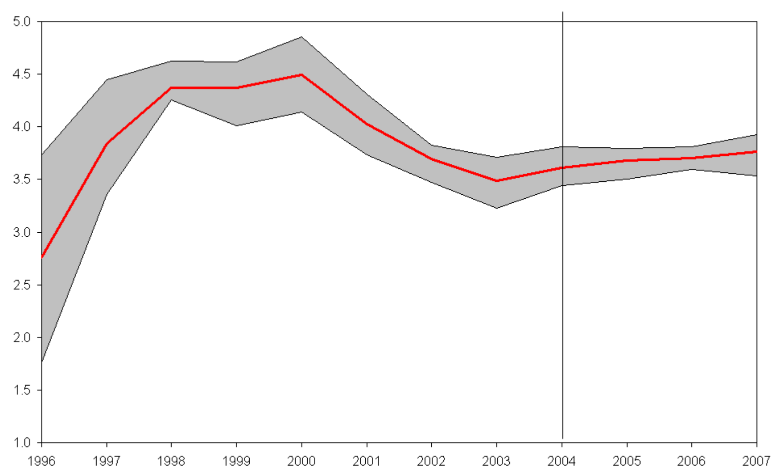


Figure 10: Annual growth rate of potential output, minimum-maximum bands

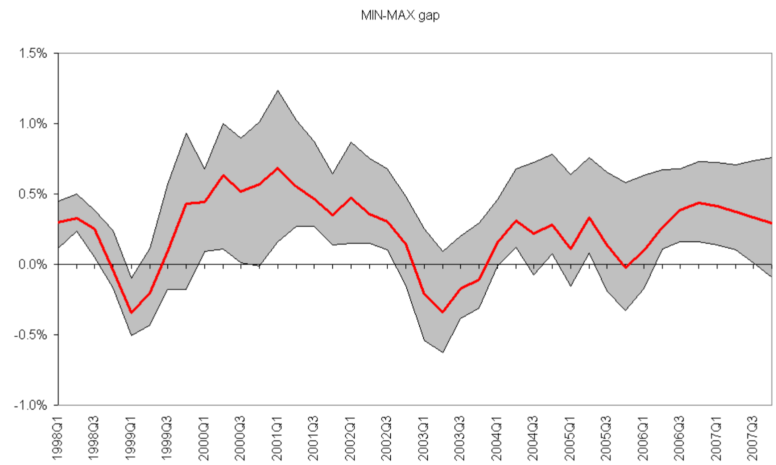


Figure 11: Output gap estimates and forecasts, minimum-maximum range, and average.

increases the reliability of the average estimate of the potential output and output gap.

3.5 Sample choice

All our quarterly estimations have been performed on a sample which started at 1995, mainly due to data problems, namely, quarterly GDP figures exist only starting from 1995. However, as a robustness check, we also estimated the potential GDP on a sample which started at 1993 by using the GDP estimates of Várpalotai (2003) for the period 1993q1-1994q4.[9,10] One exception was, however, the univariate filter method, which has been originally estimated on a sample starting from 1993, in order to deal with starting point problem. In this case, we extended the sample with another two years,

[9]In fact Várpalotai (2003) calculated GDP series dating back to 1991, but labour force data were only available since 1993.

[10]Since the unobserved component method have been estimated on annual GDP series for which data did exist before 1995, this sample extention exercise does not apply for the unobserved component method.

1991-1992.

Figure 12 illustrates the differences in the estimates on different samples. Results proved to be rather stable: for the methods which are imprecise at the beginning of the sample, that is, for the univariate and the MHP filter, we found that larger differences can only be detected at the beginning of the sample (1993-1994). On the other hand, the production function method provided the same estimates by construction. Finally, the SVAR estimates proved to be more disperse. SVAR containing the level of inflation changed substantially. However, other SVARs using differenced CPI and core inflation or ulc were stable. As Hungarian inflation dynamics during 1995-1997 was very volatile and possibly close to an I(1) process, these findings are not surprising. Summing up, our conclusions on potential output and the output gap, except for some SVARs, were robust.

3.5.1 Were Hungarian output gap fluctuations volatile?

A natural question arises how our output gap estimates relate to international ones. Darvas and Szapáry (2004) estimate cyclical component volatilities for a large set of countries, including developed and New EU Member countries. Based on their estimates we computed the implied output gap volatilities (standard deviations around the mean zero) reported in Table 7[11] along with the average volatilities of our estimates. Similarly to the results of Darvas and Szapáry (2004), our average measure also shows that Hungarian output were more volatile during 1993-1997 than that of the euro area or the US. In comparison to other Central and Eastern European countries, at that time Hungarian fluctuations were in the middle. Further, we also experience a smoothing of output to a lower volatility than that of the euro area in the period of 1998-2002, though there are some numerical differences.

[11] Darvas and Szapáry (2004) computed statistics for both HP and band-pass filtered outputs. For simplicity, we deal only with their HP-filtered data.

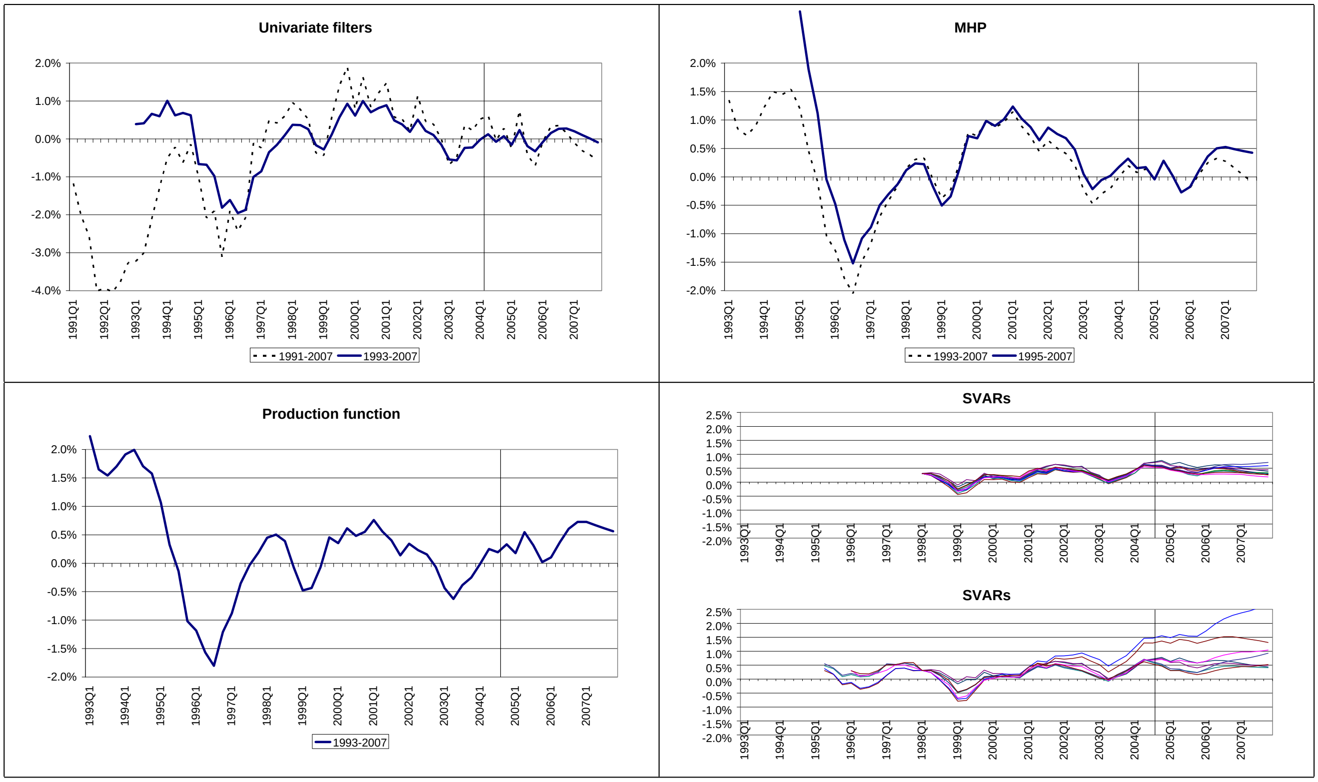


Figure 12: Output gap estimates and forecasts, various methods, various samples

	1993-97	1998-2002		1993-97	1998-2002
CEE countries			**Other countries**		
Czech Rep.	2.1	1.5	Denmark	0.6	1.3
Estonia	3.0	2.1	Sweden	2.0	1.2
Hungary	1.8	0.7	Switzerland	0.8	0.9
Latvia	2.5	1.4	UK	0.9	0.6
Lithuania	5.3	2.8	Norway	1.7	1.1
Poland	1.3	1.3	Japan	1.5	1.1
Slovakia	0.8	1.2	USA	0.6	1.2
Slovenia	0.7	0.9	Russia	3.5	3.7
EMU-member states			Euro area	0.8	0.8
Austria	0.79	0.89			
Belgium	1.06	1.21	**Our results:**		
Finland	2.30	1.46	**Hungary**		
France	0.95	0.91	Univariate	1.01	0.53
Germany	0.75	0.84	MHP	1.27	0.71
Italy	1.11	0.73	Prod. function	0.99	0.42
Netherlands	0.90	1.22	SVAR average	-	0.30
Portugal	1.39	1.98	Unobs. component	0.81	0.26
Spain	1.15	0.81	Average	0.80	0.41

Source: Darvas and Szapáry (2004) and authors' own calculations

Table 7: Output gap volatilities, international comparison

4 An illustrative medium-term projection

The next question we seek to answer is how large potential growth rate we can expect for the future. This is not so obvious, as only a small proportion of the wide spectrum of our methods can generate projections, e.g. univariate time-series techniques can only interpolate past trends. Therefore we used only the production function method, because it can only project growth rates with relatively simple assumptions.

Figure 7 shows that according to the production function approach potential growth rate of the Hungarian economy will stabilize at around 3.5-3.6 percent for the next few years ahead. One should mention that in the very short term some acceleration of potential can be expected. In the longer run, due to demographic factors (see Figure 6) the growth rate of labour force will slow down (cohorts with relatively large population will drop out from labour supply , while the incomers' cohorts are of relatively small size). However, due to our assumption that current increase in unemployment is partly of temporary nature, trend unemployment growth will not follow the decline in growth rate of total labour supply. In sum, contribution of labour will stabilize at the levels experienced in 2002-2004. As far as the contribution of capital is concerned, we project a steady share with a very small decrease. In our illustrative projection the growth enhancing effect of labour augmenting technological progress was kept constant.

Any statements on future developments of potential output with other than production function methods can only be made by an explicit projection for the relevant explanatory variables. In order to achieve this we took the macroeconomic projections of the Magyar Nemzeti Bank published in the August 2005 issue of the Quarterly Report on Inflation. Then, by taking the projected values as actuals, we estimated potential output and output gap until 2007. Figures 3 and 5 and Tables 3 and 4 also contain the projections. By using this indicative method, all the other methods reinforce the statements based on the production function. Potential growth will fluctuate between 3.5-3.9 percent. Methods using inflation as explanatory variable (such as SVARs and MHP) generally show higher potential because of the expected fall in inflation and a modest rise in employment.

Figures 9 and 11 show the results regarding the output gap for the future. Most of the methods point to a temporary decrease in output gap for 2005 and a significant positive gap starting in 2006.

4.1 International comparison

The literature of potential output projections for Hungary is rather weak. European Commission (EC (2004)) has prepared some estimations for the growth potential of New Member States. Table 8 shows our results compared to the one published by the EC. Contributions of growth factors can only be compared with our results prepared with the production function method. Generally, one can observe that potential growth rates are very close to each other. Both the EC and our methods give around 3.6 percent potential growth rate for the next five years. However, there is a slight difference between the EC and us with regard to the contribution of growth factors. Although labour shares are similar, our estimations indicate a much lower share for capital, both for the past and for the future. In sum, the EC's method reinforces our results with regard to potential growth rate. Hence, in our view our results seem to be quite robust.

4.2 Robustness to changes in assumptions

The forecasts we provided for the potential growth in the previous subsections lie within a relatively narrow band. However, a key question is whether this forecast is robust to changes in the underlying assumptions. We investigate especially the impact of the assumptions about we are rather uncertain: namely, the elasticity of substitution between capital and labor (σ) and the

	1996-2005				2006-2010*			
	GDP	Labour	Capital	Technology	GDP	Labour	Capital	Technology
EC:								
Cyprus	3.4	0.7	1.5	1.2	3.6	0.5	1.8	1.3
Czech Rep.	2.2	-0.9	2.6	0.6	3.5	-0.6	2.5	1.6
Estonia	5.9	-0.6	2.9	3.5	5.8	0.3	2.9	2.4
Latvia	6.3	-0.1	2.8	3.5	6.3	0.1	3.3	2.8
Lithuania	5.6	-0.4	2.8	3.1	5.7	0.3	2.7	2.6
Malta	2.5	0.2	2.1	0.2	2.0	0.0	1.6	0.4
Poland	4.3	-0.1	2.1	2.2	4.4	0.5	1.9	1.9
Slovakia	4.0	-0.5	2.5	2.0	3.9	0.5	1.2	2.1
Slovenia	3.8	-0.1	2.6	1.3	3.1	-0.2	2.2	1.2
Hungary	**3.8**	**0.7**	**2.0**	**1.1**	**3.6**	**0.2**	**2.1**	**1.2**
Our estimates:								
Hungary (production function)**	**3.8**	**0.5**	**1.3**	**2.0**	**3.6**	**0.3**	**1.4**	**1.9**
Hungary (average of all methods)**	**3.8**	**-**	**-**	**-**	**3.6**	**-**	**-**	**-**

Source: EC (2004)

*Not a forecast, but a projection of the trend in the case of EC numbers**Based on the forecasts from the NEM model

Table 8: Projections for potential growth

future path of trend unemployment. We do this investigation within the framework of the production function method.

Regarding the elasticity of substitution (σ), we investigate values within the range of $0.15 - 0.7$. Figure 13 illustrates the effect of σ on the projected growth rate of potential output. Higher σ implies higher growth rate, although the band within which the growth rate varies is rather small, $0.1 - 0.2$ percentage points.

As for trend unemployment, we computed the trend unemployment by using a HP filter with various λ values, resulting in various levels for the end-points, which have been fixed on the forecast horizon (Figure 14). Thus, trend unemployment varied within the range of $6\% - 7\%$. This resulted in a change in potential growth rate of 0.05% at most. The change in the output gap estimates were higher though, of magnitude of 0.5%.

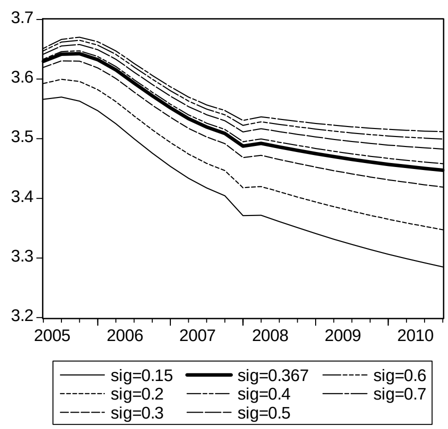
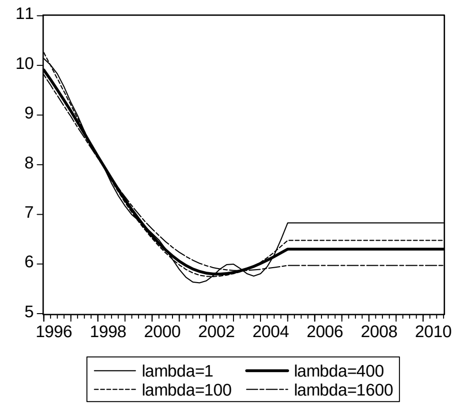
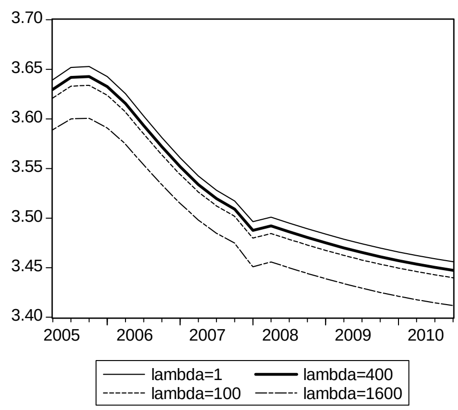


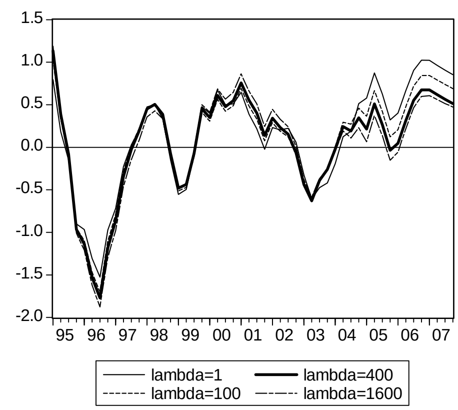
Figure 13: Robustness of potential GDP prowth projections, based on various assumptions on σ.



Trend unemployment, HP-filtered



Potential output growth



Output gap

Figure 14: Robustness of potential GDP growth and output gap projections, based on various assumptions on the trend unemployment

5 Conclusions

This paper deals with the question of potential output in Hungary. Potential output is of crucial importance with regard to inflation projections, monetary policy and the assessment of longer term growth developments for Hungary. The concept of potential output is not unique, however. Different theories highlight different properties of the equilibrium around that the economy fluctuates. We do not intend to take a clear stand between theoretical concepts, but try to arrive at a robust picture on underlying growth of Hungarian economy. In order to achieve robust statements, we estimate potential output with a large set of methods, ranging from pure univariate time series methods to structural approaches which relate potential output to production functions or inflationary developments. Our main result is that potential output growth for Hungary lies between 3.5-4 percent at the end of our sample. For the next few years, an illustrative scenario was also set up with relatively similar growth rates. The results proved to be robust to sample choice, the treatment of trend unemployment and the elasticity of substitution between capital and labour.

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