# Potential Output Estimates for Central and East European Countries Using Production Function Method

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In the paper potential output of four Central and East European countries is estimated using the Cobb-Douglas production function. Estonian production function uses data of employment, sectoral restructuring, estimated capital stock and foreign direct investments. Capital stock and level of technology are estimated for the Central and East European countries using the same form of production function and parameter estimates of Estonian economy. Potential output is calculated using the long-term unemployment to approximate potential labour input in the production. According to the estimates potential output is higher than actual in all the countries during most of the period, except in the fast economic growth periods (in the Czech Republic in 1995–1996, Estonia in 1997–1998 and Latvia in 1997, respectively).

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**The views expressed are those of the author and do not necessarily represent the official view of Eesti Pank.**

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## Introduction

The economic development of transition economies has been widely discussed and there is much empirical research done on this topic. It is generally admitted that the transition period has lasted longer and the initial fall in output was sharper than first suggested. In most of the empirical research done, economic development and differences in growth are explained by the initial conditions of the countries, structural reforms and factors like inflation or budget deficit. In several papers it has been found that countries' initial conditions have been important in determining the dimension of economic depression (Berg *et al* 1999, Havrylyshyn *et al* 2000). Structural reforms are accounted to be the driving force of economic growth (Berg *et al* 1999, Kolodko 2000, Fischer *et al* 2000). The influence of supply side factors on economic development in transition countries has been less discussed.

In the current paper the link between total output and supply side factors in four transition economies is analysed. The function, which relates capital and labour as production function inputs to aggregate output, is estimated. Using the estimated parameter values potential output is calculated at the potential level of production factors.

Potential output can be defined as an output level where production factors are fully employed at the current level of technology. Output gap, the difference between actual and potential output, has positive values when there exists excess demand and negative values with excess capacity. In the short term measuring potential output and output gap gives information about the balance between supply and demand and the estimate of inflationary pressures. In the long run potential output describes aggregate supply capabilities and provides the assessment of the sustainable non-inflationary growth path.

Potential output as an unobserved variable can be estimated using several statistical and theoretical methods (for a discussion of the methods mentioned in the following part see for example Cerra and Saxena 2000). Statistical methods eliminate cyclical behaviour from the actual output time series. Statistical methods include Hodrick-Prescott (HP) filter, Beveridge-Nelson approach and various unobserved components methods (univariate, bivariate, and common, permanent and cyclical components). Statistical methods do not need various data except about actual output, which makes them quite popular. The negative side of these methods is the low efficiency of estimates and forecasts. The second methodology is to estimate structural relationships to identify the cyclical and structural influences on output using economic theory. This group of methods includes the structural vector autoregression approach by Blanchard and Quah, production function method, demand-side model and multivariate system models.

In this paper production function is used to estimate potential output. Production function method gives the possibility to identify different factors contributing to the growth of potential output. The method can be used with data from rather limited time-period, which makes it possible to imply it on transition economies. The method has been criticised for several reasons. The correct form of production function has to be chosen. Problem arises when there are structural changes in the economy but stable relationship in the production has to be estimated. To estimate the production function knowledge is needed about the amounts of capital and labour used in the production process. Data about labour force is usually more accurate but statistics about capital stock is of poor quality in many countries. It can be seen later that the estimates of potential output are strongly influenced by the level of potential employment, therefore the main data problem in using production function method, is to estimate the potential level of employment. Still production function approach has strong intuitive appeal and is widely used.

In the current paper an overview is given of the empirical research done in estimating potential output using production function method. The method is implied to estimate Estonian potential output. Using the same form of production function, the capital stock and level of technology estimates are obtained for the Baltic countries and the Czech Republic and potential output is calculated for these countries.

The structure of the paper is as follows. The first part of the paper describes the production function method and gives an overview of empirical research on this topic. In the second chapter the production function and potential output for Estonian economy are estimated. In the last part of the paper first the capital stock and technology level and then the potential output is estimated for the four Central and East European countries.

# 1. Production function method to estimate potential output

In the following section the idea and implementation of production function method is described. Main steps in estimating potential output using this approach are shown. The overview of empirical literature on this topic is given. Discussion concerns mainly research done on industrial countries.

## 1.1. Theoretical concept

Implying the method to estimate potential output the production function, which link capital and labour as production function inputs and output, has to be estimated. In the simple form Cobb-Douglas (C-D) production function is employed. Potential output is calculated at the potential level of employment, the current level of capital and the trend level of technology, using the estimated parameter values of production function. Potential employment is defined as the level of labour resources, which can be employed without generating inflationary pressure.

Estimation method should be implied using the following steps. First the form of production function has to be specified. C-D production function is used in many cases. C-D production function has several restricting features: constant returns to scale; the elasticity of substitution between production function inputs equal to unity. If the last assumption about the data used is not correct the general form of constant elasticity of substitution (CES) production function should be used. As C-D production function is easily transformed to the linear form, which is simple to estimate, using the function is still very popular.

Using C-D production function technological progress is often estimated as the so-called Solow residual, the output less the weighted sum of labour and capital inputs. An alternative approach is to estimate technological progress using simple trend or approximate it by some measure like education, research and development expenditure.

Potential production function inputs are calculated in the following way. Capital is assumed to be at its potential level. To find potential level of technology, trend is fitted to the actual measure. The crucial input to calculate potential output and output gap is the potential employment. The idea is to find the level of employment, which does not accelerate inflation. One approach is to approximate it using the value of NAIRU (non-accelerating inflation rate of unemployment) or NAWRU (non-accelerating wage rate of unemployment). In empirical papers potential employment has also been approximated using trend level of unemployment or long-term unemployment rate.

## 1.2. Empirical research

The empirical work done in estimating potential output using production function method is concentrated mainly on developed countries. For industrial countries IMF regularly publishes potential output estimates. Mainly the production function method is used both by IMF and OECD, but there is no standardised methodology (De Masi 1997). The differences in applying the method arise from the economic factors specific to the country and also the availability of data.

Estimating potential output usually a simple form of production function is assumed. Data is mostly tested for the assumptions of C-D production function. In case C-D production function can not be used the general form of CES production function should be used. Most authors have found that the data does not significantly violate C-D function assumptions. In both IMF and OECD potential output estimations C-D production function is used (Bolt *et al* 2000).

Determining the parameters of production function, whether the estimations are done or in case of C-D function the elasticity of output in respect to production inputs can be approximated from the share of labour and capital income in the value added. The last approach is based on the assumption of perfect competition in the markets. The share of labour income in advanced countries is usually found to be around 2/3 of the value added. In transition economies this can be assumed to be lower to attract investments. Estonian data is presented in the following graph, where can be seen that the share of labour income in the value added has been changing during the period in consideration. Calculating the labour income share, GDP has been corrected with indirect taxes.

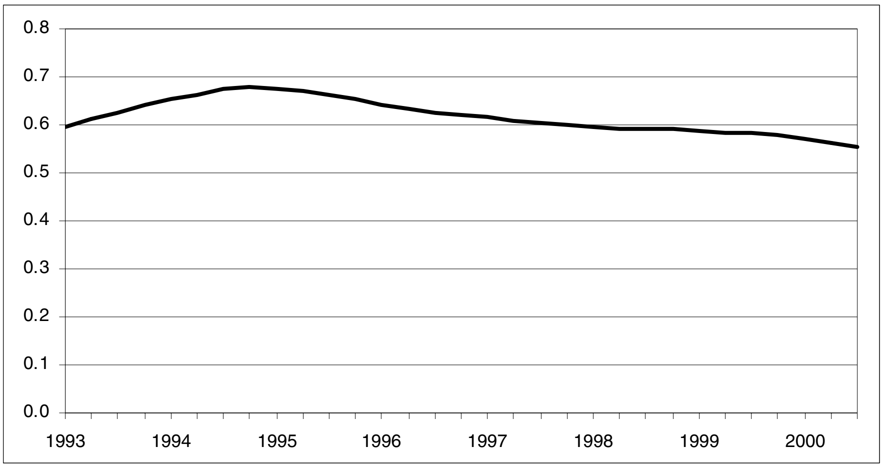


**Figure 1.1. The share of labour income in Estonian economy**

The fall of the labour share in value added by 10 percentage points is caused by decrease in employment, which could be the result of labour augmenting technological progress. The trends in labour market in Estonia and other transition economies are discussed further in next chapters.

In Appendix 1 the short descriptions of the models are given which are used to estimate the potential output using the production function method. The given selection includes empirical papers about the potential output estimation and two macro-models of transition economies.

## 2. Empirical estimation of potential output for Estonian economy

Empirical estimates of production function and potential output of Estonian economy are obtained in this chapter. The following section describes the data, which is used to estimate Estonian production function. The problems in measuring production function inputs labour and capital are analysed. The C-D production function is employed to estimate the supply side relation. Potential output is calculated using the long-term unemployment rate to approximate the potential labour input in the production.

### 2.1. The data

Estonian production function is estimated using data from the period 1993 till the 3rd quarter of 2000. All values, which are measured in Estonian kroons are presented in real terms in 1995-year constant prices. Total output is described by gross domestic product.

Employment is used to approximate labour input in the production function. In Estonia as in most other transition economies labour force has been declining during the last decade. Some of the people who lost their job left labour force, some started to look for a job. As can be seen from Figure 1.1 capital-labour ratio has been increasing substantially. Sharp fall in the labour force was mainly due to labour augmenting technological progress. Potential employment is calculated according to the assumption that technological change causes decrease of skills of people currently not working. The longer the person stays unemployed the more his qualification depreciates. Therefore potential employment for Estonian economy is calculated using the long-term (over 1 year) unemployment rate, so that people unemployed for more than 1 year are excluded from the labour force. Potential employment is calculated according to the following formula:

$$L_t^{POT} = L_t + u_t(1 - u_t^L) \qquad (2.1)$$

where $L^{POT}$ – potential employment,

$L$ – employment,

$u$ – unemployment,

$u^L$ – share of long-term unemployment in total unemployment,

$t$ – index to describe period.

When employment falls its potential level will first remain the same, but after some time the potential labour force decreases by the share of people who have stayed unemployed for a certain longer period.

In labour input no correction is made for the change in actual hours worked and labour has not been differentiated in terms of quality generated from the level of education. To take into account differences in productivity in different sectors, an index is calculated which describes the total productivity change generated from labour reallocation. The index has higher values when people move to more productive sectors, assuming that real wage can be used as an approximation of productivity. The assumption is also made that relative productivity in sectors is constant during the time period. The index is calculated according to the following formula:

$$h_t = \sum_j \frac{\frac{1}{T}\sum_{t=1}^{T} w_{tj}}{\overline{w}} \cdot \frac{L_{tj}}{L_t} \tag{2.2}$$

where $h$ – index to describe the labour reallocation to more productive sectors,
$w$ – real wages,
$\overline{w}$ – average real wages,
$L$ – employment,
$T$ – number of periods,
indices $t$ and $j$ describe period and sector.

The calculated index helps to correct the general measure of employment, expressing the labour augmenting technological progress generated from sectoral restructuring. In Estonia as well as in other transition economies the sectoral restructuring of the economy has taken place in a short time period. As can be seen from the following graph the sectoral shares of employment have changed substantially.

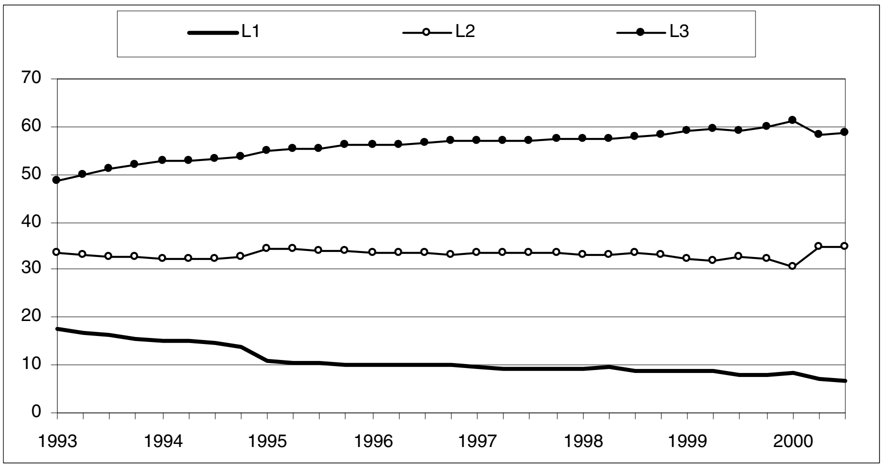


**Figure 2.1. Share of labour in primary (L1), secondary (L2) and tertiary (L3) sector (% of total employment)**

The decrease of employment in the primary sector has been sharp. Relative share of tertiary sector has been rising but the increase in absolute terms has not compensated the fall in other sectors, so that overall employment has been declining.

Estonia does not have data available about total stock of capital in the economy. Statistical office collects data from enterprises balance sheets but this does not include information of the government sector, non-profit organisations and self-entrepreneurs. From SNA (System of National Accounts) statistics data is available about total investment and depreciation. Unfortunately time series are too short to calculate the value of capital stock using Perpetual Inventory Method (PIM) the idea of which is that capital stock equals the sum of past investments (in real terms). To imply PIM method the initial stock of capital has to be estimated. For Estonian economy the measure of initial stock of capital is approximated from the enterprises official data. The nominal capital stock value was deflated using the fixed investment deflator from national accounts. Starting from 1993 PIM is used to calculate the stock of capital. The data about investment and depreciation of capital is from national accounts statistics.

According to the assumption made to get the total stock of capital in the economy, the value from enterprises balance sheets is multiplied by 1.5. The assumption that in 1993 the capital stock in the economy was by 50% higher than the value in enterprises balance is based on several aspects. First, as was suggested by Bratanova (1998), in transition economies capital stock still in use in the beginning of 90s was much higher than written in the balance sheets. Partly because asset lives were much longer than taken into account in calculating the depreciation rate. Secondly, depreciation of capital in enterprises sector in 1993 was about 2/3 of the total depreciation from SNA statistics.

In the following graph data is presented about capital in Estonian economy. Time series K3 is the value of capital in enterprises balance sheets. K1 and K2 are calculated using PIM method. The initial value is assumed to be 1.5 times higher than in 1993 according to the data of enterprises. Investment from SNA statistics is used to implement PIM method. The measure of depreciation is in case of K1 from SNA statistics. K2 is calculated using the depreciation rate of 10% per year.

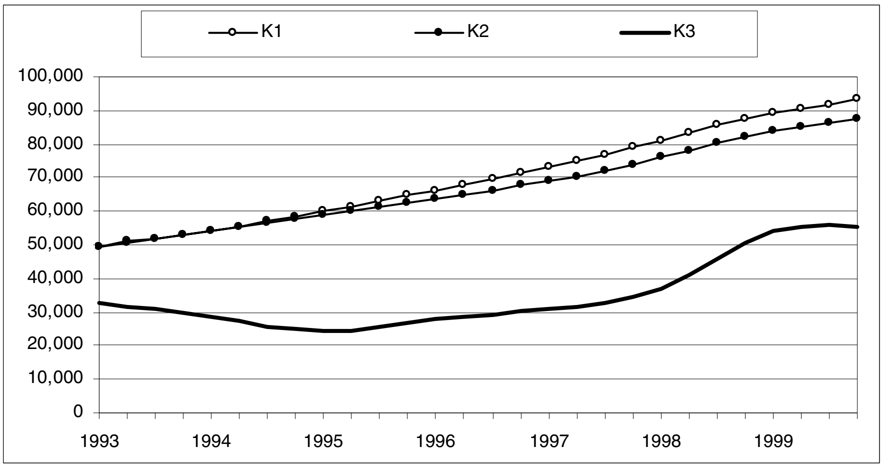


**Figure 2.2. Capital stock in Estonian economy (millions of Estonian kroons in 1995-year constant prices)**

Capital stock is generally assumed to be fully utilised. In the current paper the same assumption is made but it should be noted that in the transition countries' context this might not be correct. Transition period led to the massive shift in demand, which made large proportion of the existing capital stock obsolete. The utilisation of existing capital stock is sometimes approximated using data about energy consumption. In case of Estonia this data is not of good quality which is the reason the approach is not implied in this paper.

To describe technological progress of Estonian economy foreign direct investment is used. Progress generated by the research and development efforts has been low in Estonia, as was suggested by Hernesniemi (2000). As can be seen from the following graph, all three Baltic countries have the lowest level of R&D investments among the CEE countries.

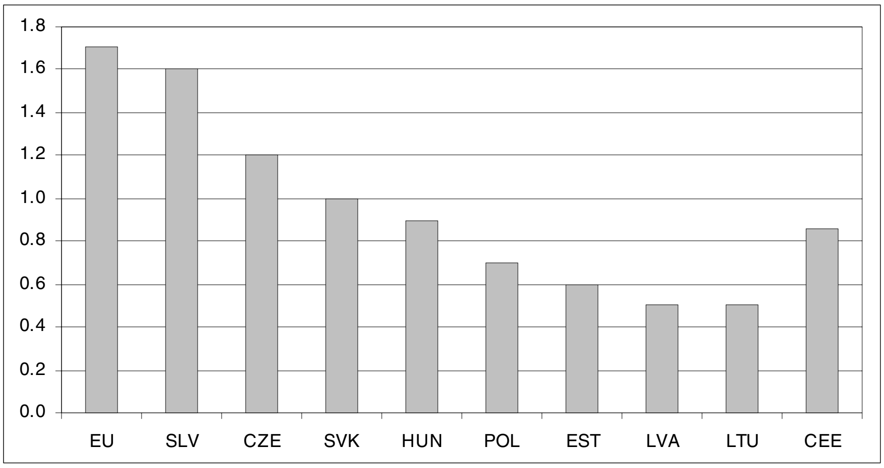


**Figure 2.3. R&D investments' share in GDP in Central and East European countries and the European Union (EU)**

In growth literature it is usually found that foreign direct investments have positive effect (Barrell *et al* 1999). They accelerate technological progress by importing new technologies, so that there is less need for research work in the country. According to the analyses done by IMF on Latvia labour productivity and capital effectiveness is higher in companies with foreign capital share (IMF 2000). Hernesniemi (2000) suggests that foreign direct investment has been the main driving force of technological progress in Estonia. The stock of foreign direct investment in Estonia has been calculated starting from the year 1996. Until that period it is possible to obtain data only about the flows of foreign direct investment. To find the measure for the stock of foreign direct investment in the economy cumulative foreign direct investment is calculated using the deflator of investments to find the real values.

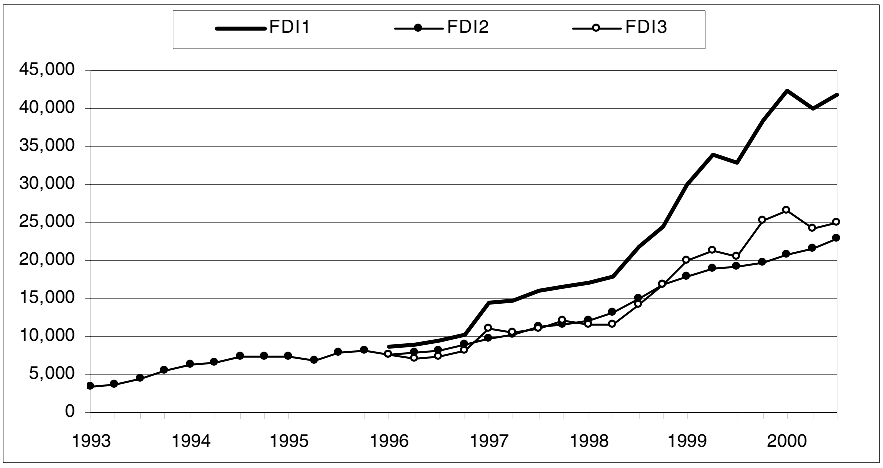


**Figure 2.4. Foreign direct investment position in Estonia (millions of kroons)**

On Figure 2.4 FDI1 is official data about foreign direct investments in Estonian economy. FDI3 is the same measure deflated using investment deflator from SNA statistics and FDI2 is cumulative foreign direct investments in Estonian economy, again calculated in constant 1995-year prices using investment deflator. It can be seen that cumulative foreign direct investment measure does not differ substantially from the deflated values of the official foreign direct investment stock.

## 2.2. Production function

In the following part of the paper neoclassical growth model is employed to estimate production function of Estonian economy. The output is described by employment, the index of restructuring, capital stock and Hicks neutral technical progress using the following function:

$$GDP_t = A_t (L_t h_t)^{\alpha} (K_t)^{1-\alpha} \qquad (2.3)$$

where *GDP* – gross domestic product,
*A* – level of technology,
*L* – employment,
*h* – index describing sectoral restructuring of employment,
*K* – capital stock,
$\alpha$ – output elasticity of labour input,
*t* – index to describe time-period.

Technology is described by the following function:

$$A_t = e^{A_0 + TFP_t} \qquad (2.4)$$

where $A_0$ – initial level of technology,
*TFP* – Hicks neutral technological progress, which in case of positive values increases total output at the constant level of capital and labour input.

In the production function technical progress is estimated using time trend.

The final specification of the production function estimated, was in the following form.

*LOG(GDP) = 0.665*LOG(L*h) + (1-0.665)*LOG(K) + 5.775 + 0.001*T^1.5* (2.5)
*(9.836)* *(7.570) (3.201)*

$R^2 = 0.928$ $Adj.\ R^2 = 0.923$ $DW = 0.680$

In the estimated regression Durbin-Watson statistic indicates the existence of strong autocorrelation, which can be caused by the specification of the regression. The intention is to estimate total output taking into account only production side influence. It can be assumed that autocorrelation indicates the omittance of significant explanatory variables from the equation.

According to equation 2.5 estimated technological progress during the period increased and by the year 2000 was about 0.8% per quarter, which is 3.2% in the year.

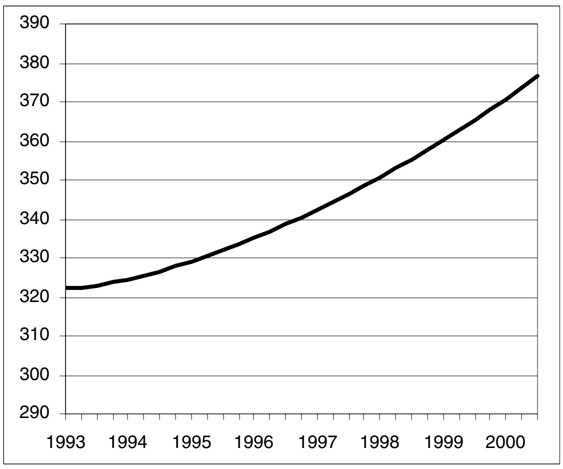


**Figure 2.5. Estimated level of technology**

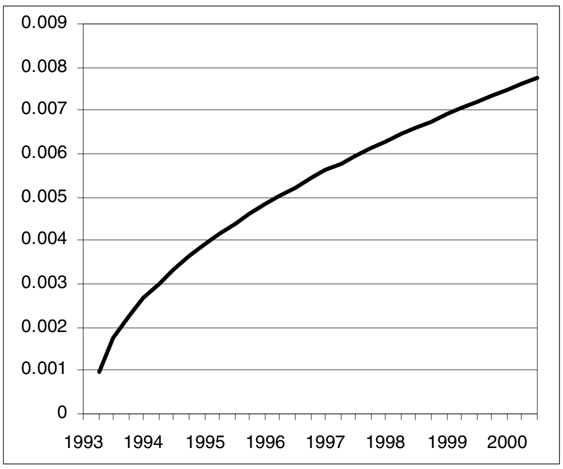


**Figure 2.6. Estimated technological progress**

For better understanding of real forces driving economic growth estimated technological progress should be approximated by some economic factors. From the analyses done by Hernesniemi (2000) the technological progress in Estonia is caused by foreign direct investment. Defining parameter X as estimated technology level X=5.775 *+0.001*T^1.5*, X will be estimated using the cumulative foreign direct investment per person (FDI/POP):

$$X = 5.761 + 1.042e\text{-}05 * FDI/POP \qquad (2.6)$$
$$(1159.919)\ (17.648)$$
$$R^2 = 0.906 \quad Adj.\ R^2 = 0.903 \quad DW = 0.389$$

Substituting estimated X back to the initial production function the estimates of Estonian total output are obtained according to the following equation:

$$GDP_t = e^{5.761+10^{-4}\frac{FDI_t}{POP_t}} \cdot (L_t \cdot h_t)^{0,665} \cdot (K_t)^{1-0,665} \qquad (2.7)$$

The reason why foreign direct investment is not estimated directly in the same equation with capital is the arising multicollinearity problem, as total capital stock and stock of foreign direct investments are strongly related.

## 2.3. Potential output for Estonian economy

Potential output is calculated using the estimates of production function. The potential employment is approximated using data about long-term unemployment. Potential technology level is found by using HP filter to find its trend level. In the following graph the estimates of actual and potential output are presented.

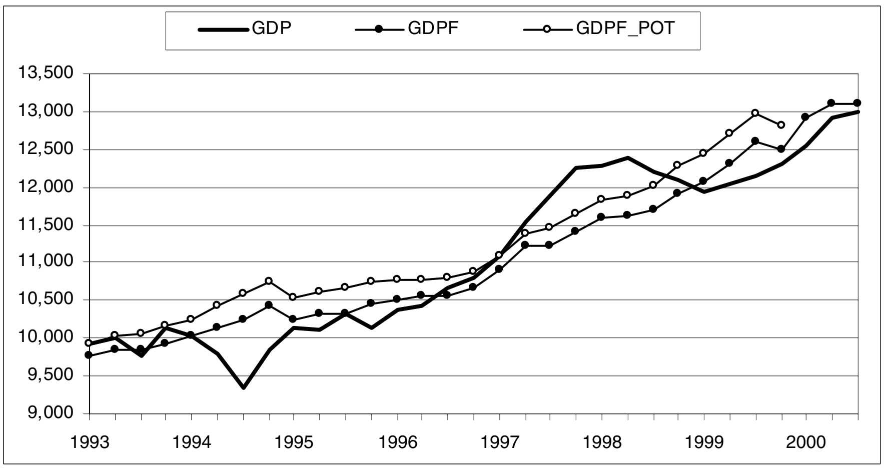


**Figure 2.7. Actual, estimated and potential output, millions of kroons (in constant 1995-year prices)**

The potential output in Estonia has been increasing. The actual output was bigger than potential only during the economic boom period in 1997–1998. From the estimates it can be concluded that economic depression was caused by demand side factors.

In the following graph the growth of output and factor inputs is described. Output and inputs are presented in logarithm form so that 1993-year 1st quarter value is equal to 100. Output gap is presented as percentage of actual output.

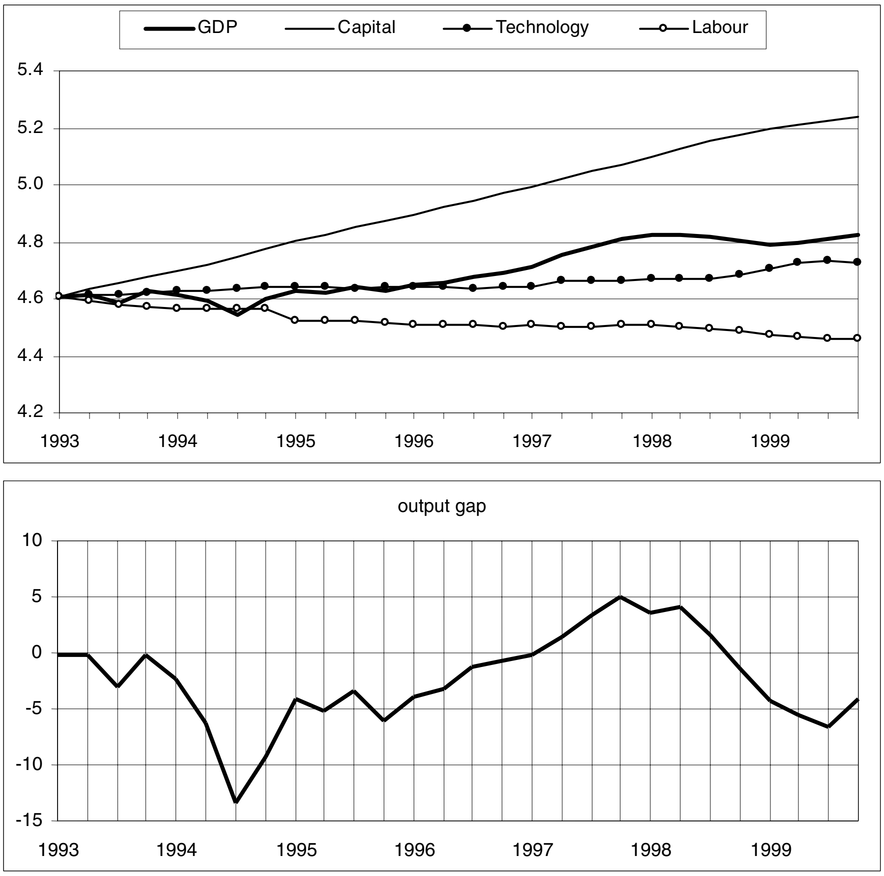


**Figure 2.8. Growth of production function inputs and output and output gap (as % of actual output)**

It can be seen that sharp decline in labour input is stabilised by the rise in capital and technological progress. The rise in output is accounted for increasing level of technology and capital stock. The estimated size of output gap is having exceptionally high values in 1994. The rest of the period it is around five percent of the actual output level.

# 3. Empirical estimation of potential output for Central and East European countries

In the last chapter production function is used to estimate the amount of capital and level of technology in the Baltic countries and the Czech Republic. First the data used in the estimations is described. The initial stock of capital and level of technology are estimated using the production function defined in the previous chapter for Estonian economy. Using the estimation results potential output and output gap are calculated for the transition countries.

### 3.1. The data

The potential output is calculated for the countries using data from the period 1993–1999. The countries included in the estimation are the Czech Republic (CZE), Estonia (EST), Latvia (LVA) and Lithuania (LTU). All the transition economies experienced decrease in output in the beginning of 1990s. In the Baltic countries the output decline was especially deep, as they were part of the Soviet Union. Both the Baltic countries and the Czech Republic were in the group of the first transition economies to overcome the economic depreciation period and their economy reached the growth period in 1993–94. After the initial growth these countries have experienced the economy's slowdown, which distinguishes them from other transition economies. The possibility to include economic cycle in the analysed period allows in this case observing positive and negative output gap in the economy.

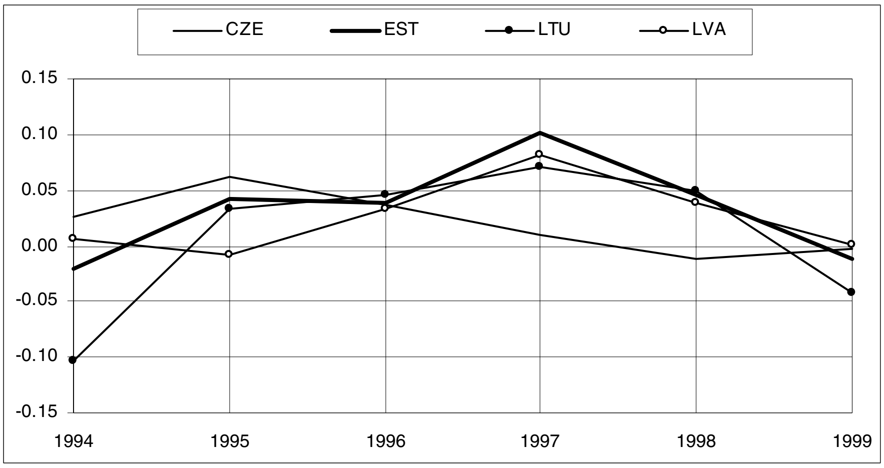


**Figure 3.1. Economic growth (% change in GDP compared to the previous period) in CEE countries**

All the data measured in US dollars is calculated into real terms and presented in 1995-year constant prices. Gross domestic product is used to measure the total output of the economy. Capital is estimated using PIM method starting from 1993. Data about investments is used from SNA statistics. Depreciation rate is assumed to be 10% per year. Technological progress in described by cumulative foreign direct investments. As there is no data available about the initial capital stock of all the countries either about the initial level of technology, the estimates of the initial stock of capital and technological level are obtained from the same C-D form production function.

Labour input is approximated again by total employment. In transition economies two main trends describe employment. In the beginning of transition unemployment increased because labour demand was falling in the restructuring of the economy. Some people left without work became unemployed, a lot of them went to inactivity which resulted in total decrease of labour force. The decrease in employment depended on the privatisation process and economic development. Secondly, in transition countries there has been the increase of the share of long-term unemployment in total unemployment. Changes in technology have caused the ageing of the quality of labour force. Faggio and Konings (1999) have found that labour mobility between sectors is low with the exception of Estonia.

In the next graph the actual and potential employment are presented for the Baltic countries and the Czech Republic. The bold line describes the actual employment and dotted line, respectively, potential employment, which is calculated according to formula 2.1 using the measure of long-term unemployment. Changes in the labour market are described according to the paper by Eamets and Arro about CEE countries' labour markets (2000).

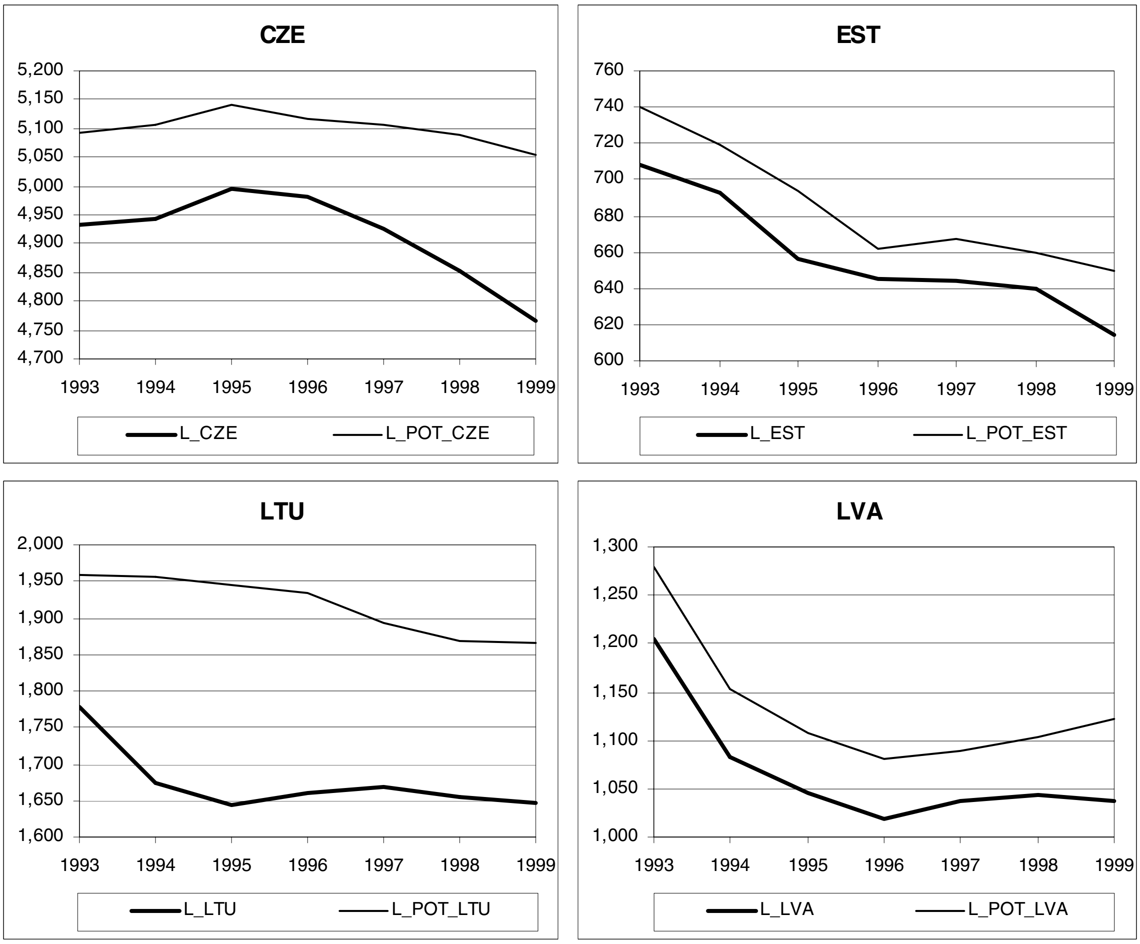


**Figure 3.2. Actual and potential employment (thousands of people) in Central and East European countries**

The trends in Estonian labour market were described in the previous chapter. In the Czech Republic the activity rate has been stable. At the same time employment has been falling substantially, which has led to the increase in unemployment.

In Lithuania in the beginning of the transition period employment fell drastically in industries, but did not fall much in primary sector. The restructuring process is not finished in Lithuania, so that there will possibly be changes in employment. A small share of long-term unemployment (only about 10%) describes Lithuanian unemployment. This could be the reason causing output gap to be large in Lithuania. It should be noted again that using long-term unemployment as a measure for natural rate of unemployment the measure of output gap is based on labour statistics.

In Latvia till 1996 employment fell mostly because the decrease of the production in manufacturing, while moderate decrease in employment took place in primary sector. In

Latvia as well as in Estonia the economic crises in 1998 caused an increase in unemployment, which led to the decline in the long-term unemployment share. Registered unemployment is used in the current paper to describe Latvian labour market. The rise in potential employment in 1999 can be explained by the increase in registered unemployment.

### 3.2. Capital stock and technology level

In this section initial capital stock and initial technology level estimates are obtained using C-D production function, the parameter values of which were estimated in Chapter 2 for Estonian economy ($\alpha = 2/3$).

The production function is specified in the following form:

$$GDP_{it} = A_{it}(L_{it}h_{it})^{\alpha}(NI_{it} + 0{,}9^{t}K_{i0})^{1-\alpha} \qquad (3.1)$$

where $NI$ – net investments; investments which are corrected by the depreciation rate of 10%,

$K_0$ – initial stock of capital,

indices $i$ and $t$ describe country and period.

The level of technology $A$ is described by the following function:

$$A_{it} = e^{A_{i0} + 10^{-4}\frac{FDI_{it}}{POP_{it}}} \qquad (3.2)$$

where $A_0$ – initial level of technology.

Assuming the production function parameter $\alpha$ to be equal to 2/3, in the logarithm form the estimated function is written as:

$$LOG(GDP_{it}) = \frac{2}{3}LOG(L_{it} \cdot h_{it}) + \frac{1}{3}LOG(NI_{it} + 0{,}9^{t} \cdot K_{i0}) + A_{i0} + 10^{-4}\frac{FDI_{it}}{POP_{it}} \qquad (3.3)$$

where estimates are obtained of $K_{i0}$ and $A_{i0}$. Estimation results are presented in the following table.

**Table 3.1 Estimates of capital stock and technology**

| | Czech Republic | Estonia | Lithuania | Latvia |
|---|---|---|---|---|
| $K_0$ | 1.03E+11 | 3.03E+09 | 6.45E+09 | 2.99E+09 |
| | (7.094) | (7.179) | (5.101) | (7.349) |
| $A_0$ | 5.856 | 5.693 | 5.424 | 5.644 |
| | (172.366) | (201.000) | (125.714) | (190.777) |
| $R^2$ | 0.781 | 0.888 | 0.675 | 0.824 |
| adj. $R^2$ | 0.738 | 0.866 | 0.610 | 0.790 |
| DW | 0.820 | 1.911 | 2.001 | 1.486 |

The ratio of capital stock to the total output is calculated to compare the levels of capital among countries. In developed countries capital stock is about 2 to 2.5 times larger than total output (Darvas *et al* 2000). The following graph describes the estimated ratio in four transition economies.

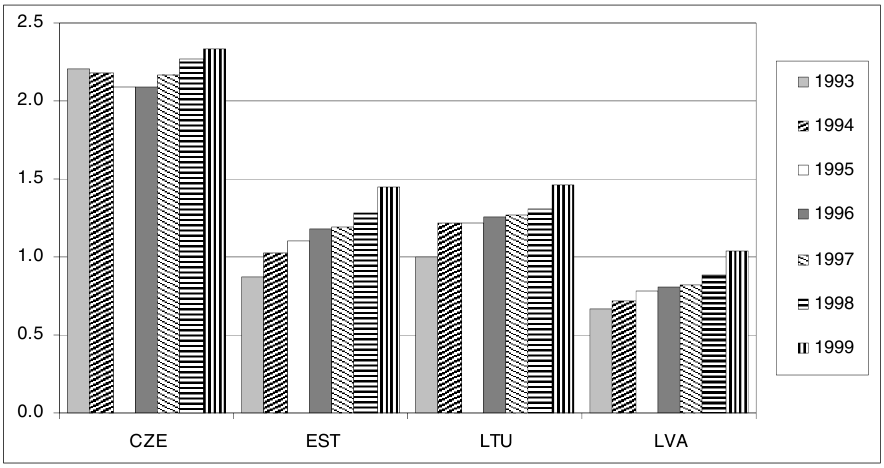


**Figure 3.3. Estimated stock of capital (times GDP)**

According to the estimates obtained from the regression 3.3 the highest capital-output ratio is in the Czech Republic where capital is more than two times larger than aggregate output. From 1993 till 1999 the ratio has fallen in the beginning of the time period and since 1997 it is rising again. In Estonia and Lithuania the capital-output ratio has increased substantially and by 1999 has the value around 1.5. The lowest capital-GDP ratio is in Latvia. In 1993 the estimated ratio in Estonia was 0.87 which is about the same as the ratio of capital from enterprises balance sheets to GDP.

In the following graph the estimated technology levels are presented.

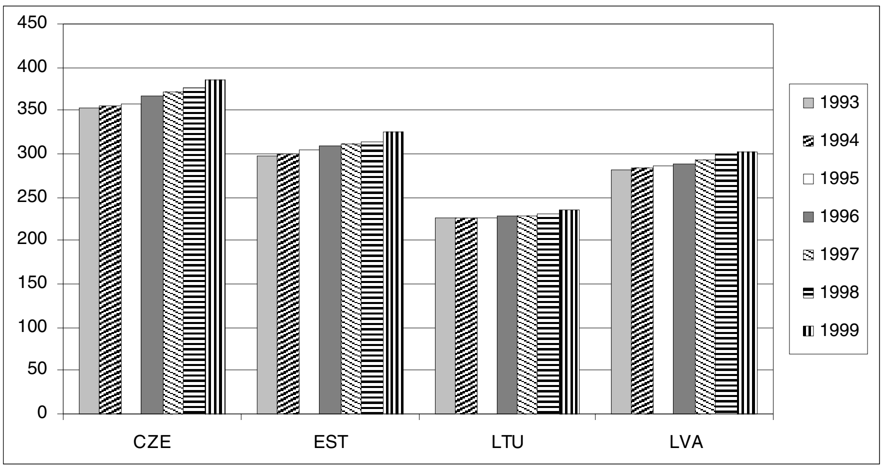


**Figure 3.4. Estimated level of technology**

According to the estimation results the highest level of technology is in the Czech Republic. Latvia and Estonia are at about the same level. Lithuania has the lowest level of technology. Lower level of technology in the Baltic countries compared to the Czech Republic should be explained by worse initial conditions. It can be assumed that the Czech Republic, which had trade relationships with Western economies already before 1990s, had also more efficient production. Using the estimates of capital stock and technology levels the potential output is calculated in the next part of the paper.

### 3.3. Potential output for Central and East European countries

The potential output for CEE countries is calculated using the production function in the form 3.3 and the estimates of initial stock of capital and initial technology level. The potential employment is approximated using long-term unemployment rate. In the following graph the actual, estimated and potential output are presented.

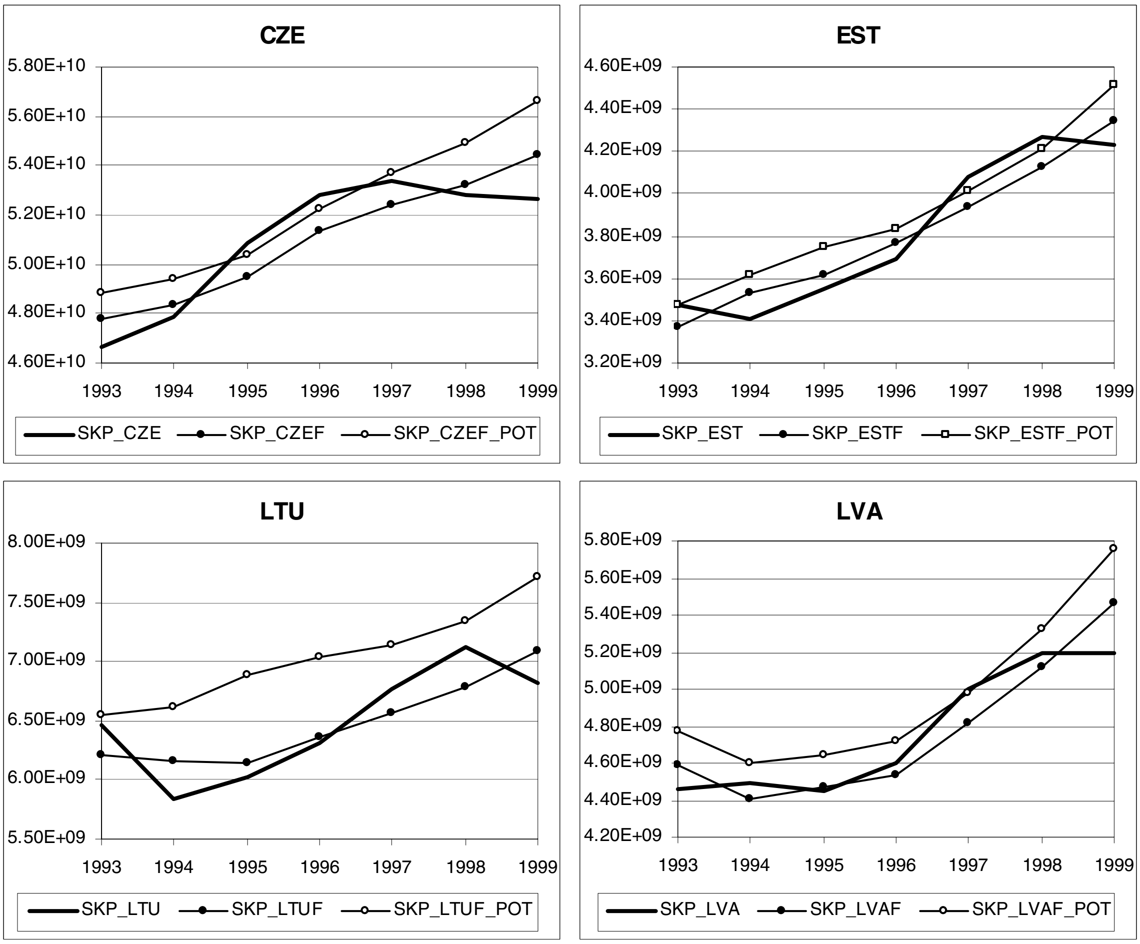


**Figure 3.5. Actual, estimated and potential output of CEE countries**

Estimated potential output has been increasing in all the countries (except in Latvia in 1994). The growth of potential output has been caused by increase of capital stock and technological progress.

The decrease of total output in the Czech Republic in 1997 was caused by the economic policy, which decreased domestic demand after the currency crises (EBRD 1997). This resulted in negative output gap. The negative growth of output in Estonia, Latvia and Lithuania in 1999 was, as estimation shows, caused by demand side factors. Russian crises affected those countries' export, which led to the decrease of total output in the Baltic countries. The sharper fall in output in Lithuania was caused by another shock – the

Lithuanian main industry, oil industry, suffered from incomplete purvey from Russia. Latvian GDP did not fall, because investments and government expenditures still rose but the growth slowed down. The effect of the Russian crises on the Czech Republic was not so strong.

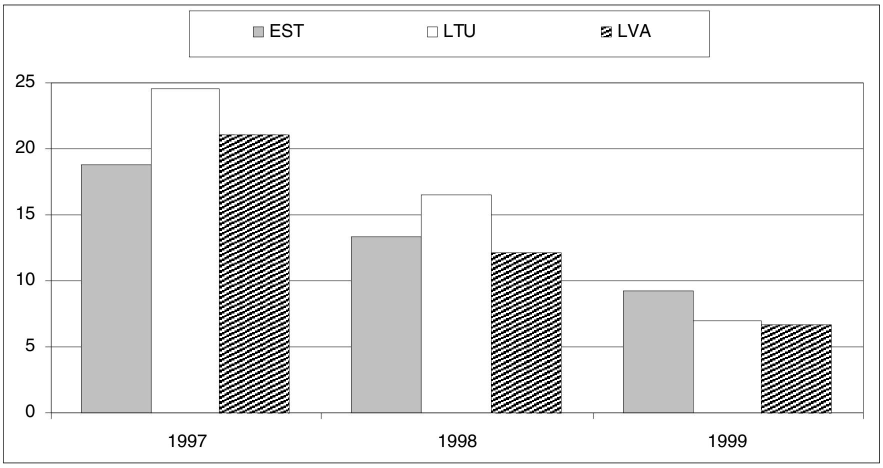


**Figure 3.6. Export to Russia (% of total export)**

As can be seen from the graph the share of export to Russia declined sharply in 1998–1999, which affected total output in the Baltic countries.

In the Czech Republic, Estonia and Latvia the economic boom took place in 1995–1996, 1997–1998 and 1997, respectively, which led to the positive output gap.

The size of output gap differs substantially. Estimated potential output in Lithuania differs the most from its actual level. In 1994–1996 the size of output gap in Lithuania has been more than 10% of the actual output. In 1999 the absolute value of output gap increases in all the countries.

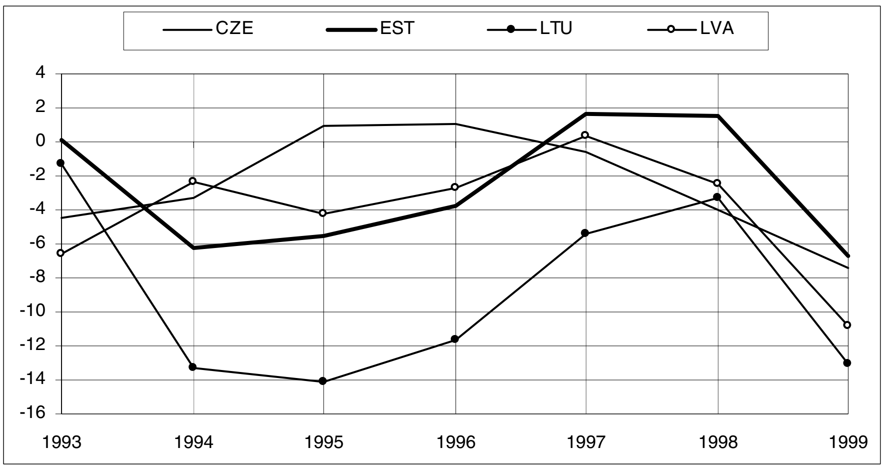


**Figure 3.7. Output gap (% of actual output)**

A small share of long-term unemployment (only about 10%) describes Lithuanian unemployment developments. This is the reason for large output gap in the Lithuanian economy. As noted earlier potential output estimates rely strongly on potential employment estimations. And using long-term unemployment as a measure for natural rate of unemployment, the estimates of output gap are strongly affected by labour statistics. Smaller GDP gap is the result of lower unemployment rate and bigger share of long term unemployment.

From current estimates for policy implications it can be concluded that countries with positive GDP gap (the Czech Republic, Estonia and Latvia) should pay more attention to increasing their production possibilities. At the same time in Lithuania the rise in demand is essential for economic development.

## Conclusions

In the paper Cobb-Douglas production function is used to estimate Central and East European countries' potential output. First, using data of employment, sectoral restructuring and foreign direct investments and the value of calculated capital stock, Estonian production is estimated. Potential output for Estonian economy is calculated using the long-term unemployment to approximate potential labour input in the production. The same form of production function is used to estimate capital stock and level of technology for the Baltic countries and the Czech Republic and potential output is calculated for the countries.

According to the estimations potential output in Estonia has been increasing. Output gap has been positive, the actual output bigger than potential only during the fast economic growth period in 1997–1998. The rise in output is accounted for increasing level of technology and capital stock. It can be seen that the rise in capital and technological progress stabilises the sharp decline in labour input. The estimated size of output gap had exceptionally high absolute values in 1994. The rest of the period it is around five percent of the actual output level.

According to the estimations the highest capital-output ratio is in the Czech Republic, capital stock in the economy is more than 2 times larger than the aggregate output of that period. The ratio has the lowest values in Latvia. In 1993 the estimated capital-output ratio in Estonia was 0.87, which is about the same as the capital from enterprises balance sheets compared to GDP. The estimated technology level is the highest in the Czech Republic. The lowest estimated level of technology is in Lithuania.

Potential output, which is calculated according to the estimated capital and technology using the Cobb-Douglas production function, is higher than actual in all the countries during most of the period (except in the Czech Republic in 1995–1996, Estonia in 1997–1998 and Latvia in 1997)[1]. The potential output is increasing during the whole period (except in Latvia in 1994). The highest negative output gap is estimated in Lithuania.

[1] The positive output gap indicates the *over-utilisation* of production inputs. It should be noted again that potential output estimates rely strongly on the measure of potential employment. Choosing the natural level of employment for the country is a matter of definition.

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# Appendix 1. Models estimating potential output using the production function method

| Model | Description |
|---|---|
| **8 industrial countries**:<br>**Artus, J. R.** Measures of Potential Output in Manufacturing for Eight Industrial Countries, 1955-78. - IMF Staff Paper, 1977, Vol 24 | Production function: C-D<br>Technology: as residuals from the production function<br>Potential labour input: 1) NAWRU;<br>2) log-linear trend through the maximum points of employment |
| **OECD INTERLINK model of 7 industrial countries**:<br>Turner, D., Richardson, P., Rauffet, S. Modelling the Supply Side of the Seven Major OECD Economies. - OECD Working Papers, 1996, No 133 | Production function: C-D, (except in case of Japan where CES is used)<br>Labour input: employment + average number of hours worked + index for the labour productivity<br>Potential labour input: using the long run labour demand equation |
| **OECD countries**:<br>Giorno, C., Richardson, P., Roseveare, D., van der Noord, P. Estimating Potential Output, Output Gaps and Structural Budget Balances. - OECD Working Papers, 1995, No 152 | Production function: C-D<br>Technology: as residuals from the production function<br>Potential labour input: NAWRU |
| **11 EU countries, Japan and USA**:<br>Bolt, W., van Els, P. J. A. Output Gap and Inflation in EU. - De Nederlandsche Bank Staff Reports, 2000, No 44 | Estimated for enterprise sector<br>Production function: CES (C-D in case of Spain and USA)<br>Potential labour input: NAWRU |
| **Australia**:<br>De Brouwer, G. Estimating Output Gaps. - Reserve Bank of Australia Research Discussion Paper, 1998, August, No 9809 | Production function: C-D, labour share 57%<br>Potential labour input: NAIRU |
| **Israel**:<br>Scacciavillani, F., Swagel, P. Measures of Potential Output: An Application to Israel. - IMF Working Paper, 1999, No 96 | Production function: C-D, labour share 68%<br>Technology: linear trend<br>Potential labour input: using the minimum level of unemployment |
| **Sweden**:<br>Cerra, V., Saxena, S. C. Alternative Methods of Estimating Potential Output and the Output Gap: An Application to Sweden. - IMF Working Paper, 2000, No 59 | Production function: C-D, labour share 65%<br>Potential labour input: NAWRU |
| **Chili**:<br>Roldos, J. Potential Output Growth in Emerging Market Countries: The Case of Chile. - IMF Working Paper, 1997, No 104 | Technology: HP filter<br>Potential labour input: 1) the natural rate of unemployment is assumed to be 5.5%;<br>2) the trend level of actual unemployment rate |
| **Russia**:<br>Basdevant, O., An Econometric Model of the Russian Federation. - Economic Modelling, 2000, No 17 | Production function: C-D |
| **Slovenia**:<br>Weyerstrass, K. SLOPOL1 - A Macroeconomic Model for Slovenia, University of Klagenfurt, Department of Economics, Klagenfurt, Austria | Production function: C-D<br>Technology: linear trend |

# Appendix 2. List of variables

| Variable | Variable description | Data sources |
|---|---|---|
| L | employment | ILO, local statistics offices |
| u | unemployment | |
| $u^L$ | share of long-term unemployment in total unemployment | |
| LF | labour force | |
| GDP | gross domestic product | IMF, local statistics offices |
| I | investments | |
| E | exchange rate | |
| CPI | consumer price index | |
| FDI | cumulative foreign direct investments | EBRD |
| POP | population | |
| h | index describing the sectoral restructuring of labour force | |
| L_POT | potential employment | |
| T | time trend | |

| Abbreviation | Country |
|---|---|
| CZE | Czech Republic |
| EST | Estonia |
| HUN | Hungary |
| LTU | Lithuania |
| LVA | Latvia |
| POL | Poland |
| SLV | Slovenia |
| SVK | Slovakia |