Supply-side performance and structure in the Czech republic (1995-2005)

Dybczak, Kamil; Flek, Vladislav; Hájková, Dana; Hurník, Jaromír
2006

WORKING PAPER SERIES 4

2006

Kamil Dybczak, Vladislav Flek, Dana Hájková and Jaromír Hurník:
Supply-Side Performance and Structure in the Czech Republic (1995-2005)

CZECH NATIONAL BANK

WORKING PAPER SERIES

Supply-Side Performance and Structure in the Czech Republic (1995–2005)

Kamil Dybczak
Vladislav Flek
Dana Hájková
Jaromír Hurník

4/2006

CNB WORKING PAPER SERIES

The Working Paper Series of the Czech National Bank (CNB) is intended to disseminate the results of the CNB's research projects as well as the other research activities of both the staff of the CNB and collaborating outside contributor, including invited speakers. The Series aims to present original research contributions relevant to central banks. It is refereed internationally. The referee process is managed by the CNB Research Department. The working papers are circulated to stimulate discussion. The views expressed are those of the authors and do not necessarily reflect the official views of the CNB.

Printed and distributed by the Czech National Bank. Available at http://www.cnb.cz.

Reviewed by:	Jan Frait	(Czech National Bank)
	Vilém Valenta	(Ministry of Finance of the Czech Republic)
	Pete Richardson	(OECD)

Project Coordinator: Vladislav Flek

Supply-Side Performance and Structure in the Czech Republic (1995–2005)

Kamil Dybczak, Vladislav Flek, Dana Hájková and Jaromír Hurník*

Abstract

In this paper, we apply the aggregate production function to approximate the path of potential output. We use a time-varying NAIRU to derive the amount of potential labour and a newly developed measure of capital services to account for the productive impact of capital. In addition, trend total factor productivity is estimated. Production functions for the key sectors (Agriculture, Industry, etc.) are also calculated, exploring the growth accounting approach and decomposition of total factor productivity growth. During 1995–2005, the growth in potential output was constrained by a gradual increase in the NAIRU, a temporary drop in investment activity and, most importantly, by only a modest rise in total factor productivity. In this period, the Czech economy also suffered from a structural burden, i.e. all growth in total factor productivity was exclusively due to better utilisation of resources, given their initial allocation, with an even negative contribution of resource reallocation. Just from 2001 onwards, we observe substantial improvements in supply-side performance, except for the functioning of the labour market.

JEL Codes: E23, O11, O12, O47.

Keywords: Capital services, factor allocation and utilisation, growth accounting, NAIRU, potential output, production function, structural changes, total factor productivity.

* Kamil Dybczak, Czech National Bank, Economic Research Department (e-mail:kamil.dybczak@cnb.cz); Vladislav Flek, Czech National Bank, Adviser to the Bank Board, Economic Research Department, and Institute of Economic Studies, FSV, Charles University, Prague (e-mail:vladislav.flek@cnb.cz); Dana Hájková, Czech National Bank, Monetary Department, and CERGE-EI, Prague (e-mail:dana.hajkova@cnb.cz); Jaromír Hurník, Czech National Bank, Adviser to the Governor (e-mail:jaromir.hurnik@cnb.cz).
This work was supported by Czech National Bank Research Project No. D1/2002.
The authors wish to thank Jan Frait, Mojmír Hájek, Pete Richardson and Vilém Valenta for helpful comments.
The views expressed are those of the authors and do not necessarily reflect the views of the Czech National Bank.

Nontechnical Summary

A macroeconomic expression of supply-side performance is the rate of potential output growth. For a central bank, this indicator is of primary importance – its changes over time determine the leeway for monetary policy options. If we do not consider inflows of labour and capital, the rate of potential output growth is conventionally attributed to the trend growth in total factor productivity.

There are two methodological advances that are worth mentioning. First, we incorporate the concept of a time-varying NAIRU into the production function approach, to derive "potential labour". Second, we introduce the concept of "capital services" to adjust the aggregate capital stock with respect to the real productive impact of this factor input.

Apart from calculating the rate of potential output growth, the aim of this paper is to assist the process of macroeconomic analysis, modelling and prediction by delivering an empirical, micro-structured view of the functioning of the supply side over the past decade.

That is why we analyse supply-side adjustments also at the mezzo level, i.e. at a level of seven productive sectors (Agriculture, Industry, Construction, Trade, Transport and Communications, Financial Intermediation and Other Services). We first compare aggregate developments with sector-specific modes of economic growth and identify the driving forces behind the aggregate supply-side dynamics. Next, we analyse the structural changes and link these changes to the evolution of TFP. Finally, we examine an analogous link between the within-sector factor input utilisation and TFP.

We found that during 1995–2005, the growth in potential output was constrained by a gradual increase in the NAIRU, a temporary drop in investment activity and, most importantly, by only a modest rise in total factor productivity. In this period, the Czech economy also suffered from a structural burden, i.e. all growth in total factor productivity was exclusively due to better utilisation of resources, given their initial allocation, with an even negative contribution of resource reallocation. Just from 2001 onwards, we observe substantial improvements in supply-side performance, except for the functioning of the labour market.

1. Introduction

A macroeconomic expression of supply-side performance is the rate of potential output growth. For a central bank, this indicator is of primary importance – its changes over time determine the leeway for monetary policy options.[1] If we do not consider inflows of labour and capital, the rate of potential output growth is conventionally attributed to the trend in total factor productivity. However, we should not overlook the fact that supply-side performance still depends on efficient use of resources in their given allocation, as well as on supply-side flexibility. Both technological and allocative efficiency are among the key forces behind changes in the rate of potential output growth, therefore such structural characteristics matter in the context of monetary policy.

It is, however, difficult to examine these processes exclusively on the macro-level. Apart from calculating the rate of potential output growth, the aim of this paper is to assist the process of macroeconomic analysis, modelling and prediction by delivering an empirical, micro-structured view of the functioning of the supply side over the past decade. As a result, obstacles to better economic performance should be identified (micro-founded) in the form of stylised facts, and the future (changing) trajectory of potential output growth discussed.

When assessing the nature of aggregate supply-side functioning in the longer run, it is central to distinguish between changes in aggregate productive capacity due to a varying amount of factor inputs (labour and capital) and due to improvements in the productive use of inputs (total factor productivity, TFP). A natural starting point for evaluating aggregate supply-side functioning is therefore to look at developments at the macro level and decompose the trend aggregate output (potential output) into its determinants.

Such an approach should also indicate possible restrictions on future potential output growth stemming from the actual development of its determinants. For instance, increasing equilibrium unemployment indicates worsening labour market efficiency. This in turn reduces “potential employment” and, finally, diminishes potential output growth. Similarly, low TFP would indicate a low extent of technological innovations, again with a negative impact on potential output growth.

We are also interested in supply-side performance and flexibility at the mezzo level. Our point is that low TFP, possibly observable at the macro level, could be caused by rigid allocation of factor inputs and/or low utilisation thereof. Low supply-side flexibility then makes the economy operate at aggregate growth rates that are lower than otherwise sustainable, thus adversely affecting the path of potential output growth.

The rest of this paper is organised as follows: section 2 focuses on developments and determinants of aggregate productive capacity, i.e. on potential output. There are two methodological advances that are worth mentioning. First, following our previous research, we incorporate the concept of a time-varying NAIRU into the production function approach, to derive “potential labour”. Second,

[1] For example, an increased rate of potential output growth improves *ceteris paribus* the budget deficit, which in turn allows long-term real interest rates to be reduced. In this way, investment will be stimulated, causing potential output to increase again, etc. Furthermore, a higher rate of potential output growth positively affects the growth-inflation “trade-off”: it shifts the boundary from which the growing economy would experience inflationary pressures.

we introduce newly the concept of "capital services" to adjust the aggregate capital stock with respect to the real productive impact of this factor input.

Section 3 analyses supply-side adjustments at the mezzo level, i.e. at a level of seven productive sectors (Agriculture, Industry, Construction, Trade, Transport and Communications, Financial Intermediation and Other Services). We first compare aggregate developments with sector-specific modes of economic growth and identify the driving forces behind the aggregate supply-side dynamics. Next, we analyse the structural changes and link these changes to the evolution of TFP. Finally, we examine an analogous link between the within-sector factor input utilisation and TFP. The last section then concludes.

2. Supply-Side Performance: A Macroeconomic View

According to Giorno *et al.* (1995), the production function approach to modelling potential output helps to overcome the shortcomings of time-series smoothing methods. These are considered to be largely mechanistic and, in addition, bear no information about the structural constraints and limitations on production through the availability of factors of production or other endogenous influences.

This holds even when multivariate filters, such as the Kalman filter, are applied to modelling potential output (Beneš and N'Diaye, 2004). While the Kalman filter is useful for detecting current inflationary pressures (the output gap), it is less practical for determining the factors of potential output growth (technological progress, capital and labour) or estimating future potential output developments stemming from supply-side evolution.

The present section describes the development of potential output in the Czech Republic during 1995–2005, identifies its main factors, and from this viewpoint evaluates the supply-side functioning. Whereas in subsection 2.1 we discuss the methodology applied, subsection 2.2 deals with the description of data. Subsequently, in subsection 2.3, we comment on our basic results, and finally, subsection 2.4 provides a sensitivity analysis.

2.1 The Model

Following Giorno *et al*. (1995), we assume the standard neo-classical two factor Cobb–Douglas production function with Hicks-neutral technology:

$$Y_t = A_t \cdot L_t^{\alpha} \cdot K_t^{\beta}, \tag{2.1}$$

where Y, L, K and A are real GDP, labour input, capital input and the TFP level respectively. This specification is a special case of the constant-elasticity-of-substitution production function (CES), with an elasticity of substitution equal to one. There are some usual theoretical assumptions about this production function specification used in the empirical literature:[2]

[2] See, for example, Romer (1990), Grossman and Helpman (1991), Barro and Sala-i-Martin (1995), Giorno *et al.* (1995), Barro (1998) or Scacciavillani and Swagel (1999) for a more detailed discussion as well as criticism of the standard assumptions used in modelling the production function.

First, positive and diminishing marginal products with respect to each input (*L*, *K*) are assumed. This restricts both α and β to values between 0 and 1. Second, an often adopted assumption on returns to scale is that they are constant, i.e. $\beta = (1 - \alpha)$. However, this assumption is not obvious in reality and the use of increasing returns has been suggested instead (see, for example, Barro, 1998). Increasing returns for the whole economy would then reflect the existence of a specific research and development sector that would be able to produce positive spillovers for the rest of the economy. The research and development sector would operate under strongly increasing returns to scale whereas the rest of the economy would operate under constant returns to scale.

Hurník and Navrátil (2005b), however, do not find any significant evidence for the existence of such a specific sector in the Czech economy, so they apply the assumption of constant returns to scale. Here we simply follow the same approach. Given the assumption about perfectly competitive markets, constant returns to scale and no unobserved inputs, the parameter α then corresponds to the income share of labour in produced output.[3]

Giorno *et al*. (1995) assume the parameter α (and, hence, β) to be constant over time.[4] This assumption is perhaps not fully appropriate for the Czech economy, which has not yet reached its steady state (in which GDP per capita grows at the rate of technological progress and the parameters are constant), since the process of economic convergence has not finished. For the sake of simplicity, however, we follow this assumption as well.[5]

Parameter α is calculated as (2.2), where tlc_t represents total nominal labour cost per employee, L_t stands for total employment (including self-employment and adjusted for hours worked) and gva_t is the economy's gross value added at current prices (i.e. GDP net of indirect taxes and subsidies):

$$\alpha_t = \frac{tlc_t \cdot L_t}{gva_t} . \tag{2.2}$$

The empirical value of parameter α is computed as the average of the observed ratio of labour costs and gross value added over the whole period. The estimation of potential output obtained therefore assumes α to be constant over time and the observed fluctuations to reflect errors of measurement. Parameter β then simply equals (1- α).

The TFP level (see parameter *A* in equation 2.1) cannot be measured directly. We can estimate a so-called *gross* TFP, which consists of two parts: (i) the long-run trend of total factor productivity (A^*); and (ii) a short-term fluctuation, which is assumed to correspond to the business cycle. Rewriting equation 2.1, the level of gross TFP for each period is given by 2.3 (regardless of the sustainability of its amount in the long term):

---

3 If the factor markets are competitive, then the marginal product of each input equals its factor price, so $\partial Y / \partial L = w$ and $\partial Y / \partial K = R$, where w and R are the wage rate and the rental rate of capital respectively. See Schreyer (2004) for the consequences when these assumptions are not fulfilled.

4 In cross-country comparisons, some researchers use a generally accepted calibrated value close to 0.3 for the capital share – see, for example, Bosworth and Collins (2003).

5 A detailed discussion of the income share of labour converging to its steady state value can be found in Hájková and Hurník (2006).

$$A_t = \left[\frac{Y_t}{L_t^{\alpha} \cdot \widetilde{K}_t^{1-\alpha}} \right], \tag{2.3}$$

where Y is real GDP, L is the labour input measured by total employment adjusted for hours worked and $\widetilde{K}$ is the capital input measured by capital services. Then, the trend of A is assumed to represent the long-run trend TFP (A^*) and deviations from this trend are assumed to be short-term fluctuations.[6] In subsection 2.3, estimated values of A^* are presented in Figure 2.1. and Table 2.1. One must admit that the results are sensitive to the smoothing techniques used to detrend gross total factor productivity. For our trend estimation, we employ, instead of the commonly used Hodrick–Prescott filter, the Band–Pass filter suggested by Baxter and King (1995). Among others, Christiano and Fitzgerald (1999) prove that the Band–Pass filter outperforms the Hodrick–Prescott filter regarding end-point bias.

Potential output is calculated using a trend measure of TFP, as described above, in combination with the estimated potential employment (L^*) and the measure of capital services ($\widetilde{K}$). Potential employment is the level of employment which can be sustained without inducing additional inflationary pressures, i.e.:

$$L^* = \hat{L} \cdot (1 - NAIRU), \tag{2.4}$$

where $\hat{L}$ represents the labour force[7] and the term NAIRU stands for the non-accelerating inflation rate of unemployment. To derive the NAIRU, we use the model developed for the Czech economy by Hurník and Navrátil (2005a).[8] This model for estimating the NAIRU starts with the following inflation equation:

$$p_t^{core} = \alpha_1 \cdot E_t p_{t+1}^{core} + \alpha_2 \cdot p_{t-1}^{core} + (1 - \alpha_1 - \alpha_2) \cdot p_t^{imp} + \beta \cdot (u_{t-1} - u_{t-1}^*) + \gamma \cdot z_{t-1} + e_t, \tag{2.5}$$

where p_t^{core}, p_t^{imp}, u_t, u_t^* and z_t denote quarterly annualised core inflation, quarterly annualised import price inflation, the actual unemployment rate, the time varying NAIRU and the real effective exchange rate respectively.

Based on the use of the Gaussian maximum likelihood method, the model combines inflation equation (2.5) with equation (2.6), which describes the explicit path of the NAIRU:

[6] The variations in the measure of TFP include not only pure changes in technology, but also other factors of improving aggregate productivity, such as improvements in allocative efficiency as well as the existence of mark-ups or technological spillovers (see also section 3 for a discussion).

[7] The labour force is represented by the economically active population, i.e. all persons aged 15 years or over who are classified as employed or unemployed according to the ILO methodology (see CZSO, 2005b).

[8] See this source for a detailed description of the model applied to estimate the time-varying NAIRU.

$$u_t^* = u_{t-1}^* + \varepsilon_t \tag{2.6}$$

$$e_t \sim \mathrm{N}(0, \sigma_{\mathrm{e}}^2); \varepsilon_t \sim \mathrm{N}(0, \sigma_\varepsilon^2)$$

$$\mathrm{cov}(e_j, \varepsilon_k) = 0.$$

The error term ε_t in the "state" equation (2.6) is expected to be white noise with standard deviation σ_ε. If $\sigma_\varepsilon = 0$, the NAIRU is constrained to be constant and the estimation is quite simple. But if $\sigma_\varepsilon \neq 0$, the NAIRU is changing over time and the estimation is more complicated. Specification (2.6) implies that the NAIRU follows a random walk and that changes in the NAIRU are driven by σ_ε. The disturbance vectors e_t and ε_t are assumed to be uncorrelated with each other in all time periods. Figure 2.2 in subsection 2.3 presents the results.

Finally, we have to explain our approach to incorporating the capital input into the production function model. A rather standard measure accounting for capital input is the change in the net capital stock, as applied in section 3 of this paper. There are, however, several problems connected with such a measure (OECD, 2001).

First, the factors of production should be measured as flows. Second, conventional measures of the net capital stock do not reflect the productive efficiency of capital assets (evaluating assets in market prices will most likely underestimate the productive efficiency, as prices usually decline quite rapidly in the early years of the service life). And finally, these measures weight each asset by its market value in aggregation, which basically implies that two assets with the same value have the same contribution to production. Thus, expensive assets with a long service life are assumed to have a relatively larger contribution to production than cheaper assets with a short life.

In order to address the above-mentioned drawbacks at least at the macro level, the capital input is measured by the volume of capital services derived from the existing productive capital stock. We follow the methodology described by OECD (2001) and Schreyer *et al.* (2003) and use an experimental measure of capital services that better accounts for the heterogeneity and productive efficiency of capital assets. The present paper is the first attempt to quantify in the Czech conditions the capital input contribution to potential product using this experimental measure.[9]

Capital services are viewed as a flow of productive services from the cumulative stock of past investments. According to Schreyer *et al.* (2003), the quantity of productive services $\widetilde{K}_t^i$ in year *t* of a capital asset of type *i* is assumed to be a function of past volumes of vintage investment to this asset, adjusted for the retirement pattern. It is shown that the value of capital services from i-type assets $uk_t^i \widetilde{K}_t^i$ is equal to the product of the productive stock of these assets, S_{t-1}^i expressed in "new equivalent" units, and its user cost u_t^i:[10]

$$uk_t^i \widetilde{K}_t^i = u_t^i S_{t-1}^i. \tag{2.7}$$

[9] See Hájková (2006) for more details on the construction of this measure for the Czech conditions.

[10] The productive stock S_{t-1}^i of a type-*i* asset at the end of period *t-1* can be computed by the perpetual inventory method as the sum of all vintage investment (*s* years ago) in this type of asset, I_{t-s-1}^i, expressed in base-year prices, corrected for the probability of retirement and for the loss of productive capacity.

This identity, along with the fact that the cost of using one unit of vintage investment is proportional to the price of its capital service, can be used in quantifying the flow of capital services. The change in the volume of capital services flowing from an asset *i* is then measured by the index of the productive stock. An important difference between the measures of capital stock and capital services consists in aggregation across assets. In order to construct the aggregate measure, it is necessary to keep in mind that each type of asset produces a specific flow of capital services in proportion to its productive stock and that this proportion differs across assets.

The weights for aggregations, therefore, must reflect the marginal productivity of different assets. Market prices of capital assets are not suitable weights because they reflect the flow of capital services of the assets over their expected remaining service life, but not for a single year. By contrast, the user cost, in equilibrium, equals the marginal revenue of an asset and is, hence, the correct weight. The user cost of an asset *i* at time *t* is defined as follows:

$$u_t^i = q_{t-1}^i \left(r + d_t^i - \zeta_t^i + d_t^i \zeta_t^i \right), \tag{2.8}$$

where q_{t-1}^i is the purchase price of the asset, r is the nominal discount rate, d_t^i is the depreciation rate and ζ_t^i is the rate of asset price change.

The length of time series of publicly available Czech data is insufficient to derive the volume of capital services precisely according to the methodology described above. It can, however, be assumed that the measure of the net stock of capital at replacement cost, as computed by the Czech Statistical Office (CZSO), accounts for most of the age and obsolescence of assets and hence the loss of productive capacity. That is why it can be used as a good approximation of the productive stock of capital. It is therefore not computed, and the corresponding measure of the net stock of capital at constant replacement cost published in industry breakdown is used instead. The change in the volume of capital services is then given by:

$$\frac{S_t}{S_{t-1}} = \sum_i \frac{1}{2} \left(\frac{u_t^i S_{t-1}^i}{u_t S_{t-1}} + \frac{u_{t+1}^i S_t^i}{u_{t+1} S_t} \right) \frac{S_t^i}{S_{t-1}^i}. \tag{2.9}$$

The Thörnqvist index[11] of the share of each industry in total capital income then represents the weight that is assigned to the growth in the net stock of fixed assets at constant prices in this industry. The sum of these contributions represents the growth of the capital input (capital services) in a given year. Hence, we are able to construct a volume index of capital services for the period 1996–2003.

When we consider our measure of capital services for $\widetilde{K}$, the trend total factor productivity A^* and potential employment L^*, we obtain the following equation, which captures the determinants of potential output (see subsection 2.3 for the results):

$$Y_t^* = A_t^* \cdot L_t^{*\alpha} \cdot \widetilde{K}_t^{\beta}. \tag{2.10}$$

[11] See Thörnqvist (1936).

2.2 The Data

The period covered in this section starts with the first quarter of 1995. This comes as an outcome of the availability of consistent time series of real GDP and gross value added data. The end of our sample is then constrained by the fourth quarter of 2005. All data are seasonally adjusted.

The income share of labour is defined in the previous paragraph by equation (2.2). Total labour costs per employee are directly published by the Czech Statistical Office (CZSO, 2005a) over the period 1994–2004. Total labour costs per employee for the year 2005 are then approximated using the information on the average wage (CZSO, 2006) and the ratio of 1.44 between the average wage and total labour costs observed in 2004. Labour force data are published quarterly for the period 1994–2004 – see CZSO (2005b). Quarterly labour force data for 2005 are then based on CZSO (2006). Finally, the data on gross value added and GDP over the period 1995–2005 are available with quarterly periodicity from CZSO (2006).

TFP is computed according to (2.3), with the use of real GDP, potential labour, capital services and the labour share. The measure of potential labour L^*, as defined by (2.4), is based on seasonally adjusted labour force data and estimates of the NAIRU.[12]

Capital input $\widetilde{K}$ is measured by the volume of capital services, as explained in the previous paragraph. Consistent time series of the net stock of fixed assets (replacement costs; end-year data), gross fixed capital formation and capital consumption in a breakdown by 60 industries are available for the period 1995–2002 in CZSO (2004). Data on gross fixed capital formation broken down into 16 NACE industries are available for the period 1995–2004. The weights for aggregation, the user costs, are constructed according to (2.8). To establish the required nominal rate of return at time t, we take into account the financing structure of firms and the effects of taxation.[13]

The depreciation rates in each industry, d_i, are computed as averages of the realised depreciation rates in the period 1996–2002.[14] The expected price change of capital is computed as the three-year centred average of the deflator of gross fixed capital formation.[15] The capital income in each industry is then computed for each year as product of the average net stock of fixed assets at current replacement cost and the required rate of return. Because of the availability of additional information, in particular gross fixed capital formation for the years 1995 (in detail for 60 industries) and 2003–2004 (in detail for 16 industries), it is possible, with some reasonable

[12] For the NAIRU estimation, unemployment and labour force data from CZSO (2005b) and CZSO (2006) were used. Core inflation, import prices and the real exchange rate come from the CNB's internal database and can be obtained from the authors on request.

[13] The constant required real rate of return (the opportunity cost of financial capital invested in an asset) is computed by deflating (using CPI inflation) the weighted average of the yields on a 10-year interest rate swap and the yield on corporate bonds adjusted for the tax shield, and averaged over the period of availability (1997–2005). The corresponding weights are 0.4 and 0.6 respectively and approximately reflect the prevailing financial structure of Czech corporations. The required nominal rate of return is then obtained by adding an expected inflation component (the three-year centred average of observed inflation). The data for 1997–2005 for 10-year interest rate swaps come from the CNB's internal database and can be obtained from the authors on request. The yield on corporate bonds is the Patria PRI index downloaded from Bloomberg.

[14] The depreciation rate in each industry and year is computed as the ratio of the consumption of fixed capital and the average net stock of fixed capital in the respective year, both at current prices.

[15] The purchase prices of assets are implicitly contained in the measure of the net capital stock at current replacement prices (all data from CZSO, 2004).

assumptions, to approximate the development of capital services in the years 1995 and 2004–2005.

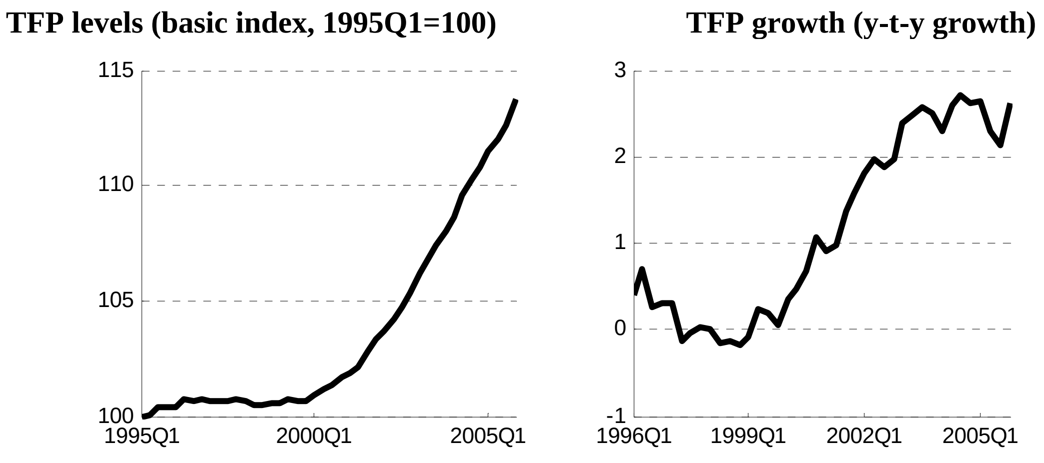
Based on the growth rates, we construct the levels. We depart from the year 1996 and use the fact that the value of capital services is equal to the price paid for them, i.e. the user cost of the prevailing productive stock of capital (cf. equation 2.7). These are expressed in 1995 prices and thus we can apply the real growth rates computed above to obtain the time series. However, it has to be kept in mind that these time series are in fact index numbers and, in particular, the levels are not additive across industries, with the exception of the base year. This is also the reason why these numbers cannot be used for calculations at the mezzo level in section 3. Finally, for the analysis at the aggregate level, we interpolate the annual values by fitting a local quadratic polynomial so that the sum of the quarterly values matches the annual data actually observed.[16]

2.3 The Results

The income share of labour (α) for the period 1995–2005 is defined by (2.2). Its empirical value 0.57 represents the average of the observed ratio of labour costs and gross value added over the whole period analysed. The robustness of the average value used is supported by the labour share standard deviation of 0.02.

Figure 2.1 shows the results of calculating TFP (A^*). Relatively remarkable and stable annual growth of TFP took place only from mid-2000 onwards. Based on this observation, one could assume a rather negligible role of TFP for potential output growth in the second half of the 1990s.[17] This assumption is tested and the underlying factors of low TFP growth discussed more accurately later in this section, as well as in section 3.

Figure 2.1: Trend Total Factor Productivity (1995QI–2005Q4)



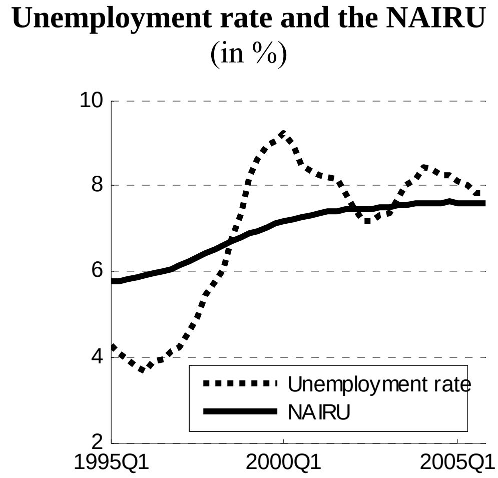
Source: Czech Statistical Office and own computations.

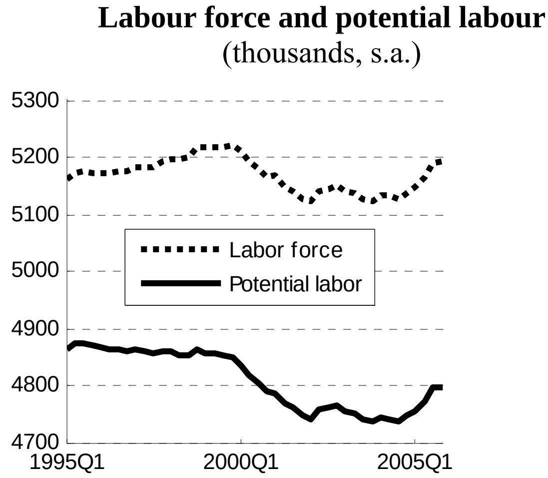
[16] For the sake of space, the details are not presented here, but are available from the authors on request.

[17] Our results for the second half of the 1990s correspond to those of Flek *et al.* (2001) and Hájek (2005).

The measure of potential labour is computed using seasonally adjusted labour force data and estimates of the NAIRU. The left-hand graph in Figure 2.2 shows the estimates of the NAIRU and the actual unemployment rate, while the right-hand one compares potential labour with the actual amount of the labour force (see footnote 7 for the definition of the labour force).

Figure 2.2: The Components of Potential Labour (1995Q1–2005Q4)





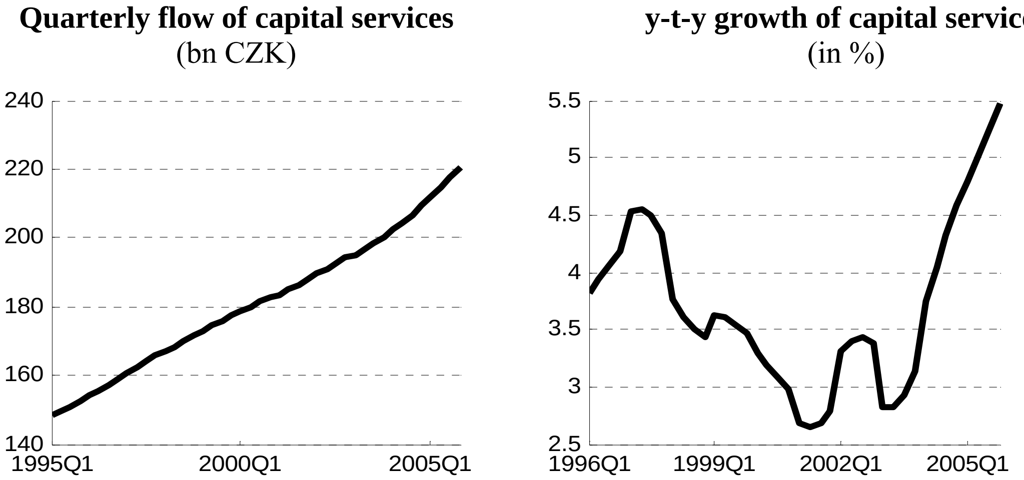
***Source*:** Czech Statistical Office and own computations.

Our estimation shows that the NAIRU increased from roughly 5.5% in 1995 to 7.5% in 2002. The critical period in which we observe a rising NAIRU started in the last quarter of 1996 and ended in the first quarter of 1999. Since then, the NAIRU has remained roughly stable. The reported increase in the NAIRU has adversely affected potential labour, with an expected negative contribution of labour input to potential output growth. The reasons for the increase in the NAIRU can in general be attributed to worsening labour market efficiency.[18]

Figure 2.3 indicates that the volume of capital services rose over the studied period. On the right-hand graph, however, it is visible that, after a period of still relatively high dynamics in 1996 and 1997, the annual growth rate of capital services flow gradually slowed, reaching a low in 2001. Subsequently, the annual growth rate remained around 3 per cent and accelerated from 2004 onwards.

[18] In particular, we should mention counterproductive labour market regulations passed under political pressure from the trade unions (an increase in the minimum wage, a level of social benefits discouraging job search, excessive employment protection, etc.), low or even declining labour mobility and an increasing share of labour in GDP. Nevertheless, it is fair to say that not only increases in the NAIRU, but also a gradual decline in the labour force itself have contributed to the estimated gradual decrease in potential labour. See Hurník and Navrátil (2005a) for more comments on the increases in the NAIRU, and Flek and Večerník (2005) for a detailed overview of the shortcomings of the Czech labour market. Vašíček and Fukač (2000), Hájek and Bezděk (2001), Flek *et al.* (2001), Fukač (2003) and Bezděk, Dybczak and Krejdl (2003) also estimate the path of the NAIRU. All these estimates robustly show the NAIRU growing since 1996.

Figure 2.3: Flow of Capital Services (1995Q1–2005Q4)



Source: Own calculations.

When interpreting the data on the year-to-year growth of capital services, it is necessary to keep in mind that capital services are derived from the installed stock of capital. The fast growth of capital services around 1997 reflects the investment boom of the years 1994–1996 (a reflection of the first wave of foreign direct investment in the Czech Republic). The rate of growth of capital services somewhat declined afterwards, but remained relatively solid despite the slump in economic activity in 1997 and 1998 and the generally weak investment activity in the rest of the 1990s.

In the second half of the 1990s, the investment activity of Czech companies consisted chiefly of infrastructure and restructuring investment, the reproduction of the capital stock concentrating mostly in the sectors of energy, telecommunications and production of motor vehicles.[19] These sectors were also the main drivers of the aggregate growth in capital services. The second half of the 1990s also saw relatively dynamic investment in information and communications technology.[20] The pick-up in capital services after 2003 is connected with the rise in investment activity since 2000 and related growth in the productive stock of capital.

Using equation (2.10), we finally calculate the path of potential output. Figure 2.4 (left-hand graph) displays potential output together with the evolution of real GDP.[21] From the business cycle perspective, the analysis shows that the Czech economy experienced both phases of the business cycle over the period 1995–2000. Whereas the overheating reached its peak in 1996, the bottom was reached at the beginning of 1998. The relatively quick swing from expansion towards

[19] A description of investment activity in the late 1990s is provided by Hanzlová (2001).

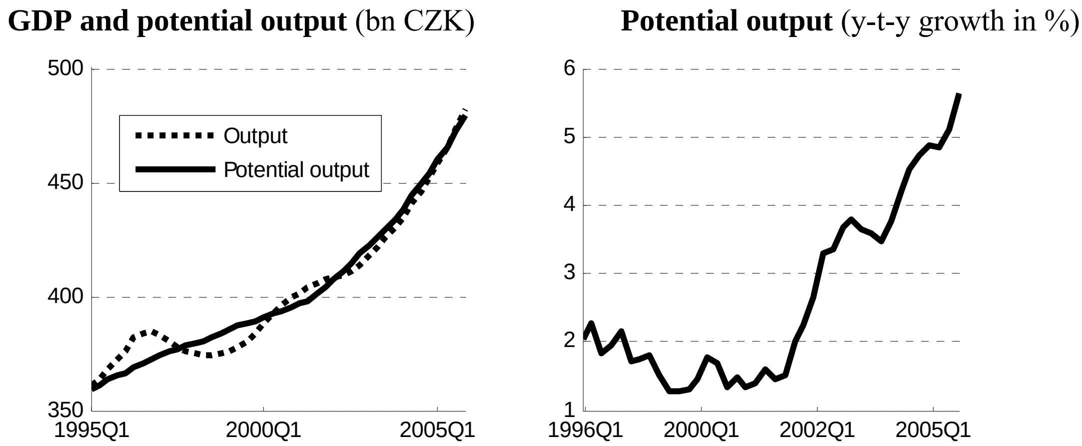
[20] Data on gross fixed capital formation by commodity show very high dynamics of investment in radio, television and communication equipment and computer technology services. High growth in information and communication technology-related expenditures is also reported by Piatkowski (2003).

[21] Hájek and Bezděk (2001) estimate that annual potential output grew on average by 1.5% during 1993–1999. Contrary to our approach, they use the Hodrick–Prescott filter to determine the time-varying NAIRU. In addition, Flek *et al*. (2001) use the exponential trend to estimate potential output growth, arriving at an estimated average growth rate during 1992–1999 close to 1%. Hurník and Navrátil (2005b) report 2% average potential output growth for 1996–2003 using a similar methodology for the NAIRU estimation, but without the concept of capital services.

recession can be viewed as evidence of relatively weak aggregate supply-side performance in the second half of the 1990s, as the supply side was largely unable to adjust to demand fluctuations.

Since 2000, the development of the Czech economy has been more stable. One can argue that, unlike the previous expansion period (1995–1996), the new expansion phase of the business cycle (starting in 2002) was accompanied by improvements in supply-side functioning, i.e. by a pick-up in potential output growth. Figure 2.4 (right-hand graph) shows that positive, although relatively low, potential output growth persisted until the end of 2000, with a clear tendency to accelerate since the second half of 2001.

Figure 2.4: The Path of Potential Output (1995Q1–2005Q4)



Source: Czech Statistical Office and own computations.

The above-described path of potential output can be further illustrated by the evolution of its determinants. Table 2.1 summarises the contributions of TFP, potential labour and capital services to potential output growth.

Given the roughly zero contribution of potential labour in the second half of the 1990s and, after 1995, also a similar contribution of total factor productivity, the main driver of the relatively sluggish potential output growth in that period was the flow of capital services. Although the latter was growing, the zero TFP growth at the same time signals that the investment activity was probably far from effective. As the potential output growth was fully dependent on the growth of just one input, i.e. capital services, this can hardly be viewed as consistent with an efficiently functioning supply side.[22]

[22] See Section 3 for more discussion on the transition-specific reasons that kept the TFP at relatively low growth rates in the 1990s.

Table 2.1: Decomposition of Potential Output Growth *(average of q-t-q annualised growth)*

Potential output (%)		**Contribution to growth** (in p.p.) **TFP** (A*)	**Potential labour** (L*)	**Capital services** ($\widetilde{K}$)
1995	2.2	0.6	0.2	1.6
1996	2.0	0.3	-0.1	1.7
1997	1.8	0.0	0.0	1.8
1998	1.3	-0.2	0.0	1.4
1999	1.3	0.0	-0.2	1.4
2000	1.6	1.1	-0.7	1.2
2001	2.2	1.6	-0.5	1.2
2002	3.6	2.0	0.2	1.4
2003	3.4	2.5	-0.4	1.3
2004	4.6	2.6	0.1	1.9
2005	5.1	2.2	0.6	2.2
1995–2005	**2.7**	**1.2**	**-0.1**	**1.6**

***Source**:* Czech Statistical Office and own computations.

Many capital resources in that period were never used for their initially declared investment purposes, as they turned out to be unrealistic. Consequently, the real values of investment were revised to lower levels. A slowdown in the contribution of capital services, along with negative TFP growth, then caused a slowdown in potential output growth to almost 1% in 1998. This may support the idea of rather ineffective investment in the preceding years.

After 2001, the annual average contribution of TFP to potential output growth exceeded 2%. This, along with accelerating capital services and a positive contribution of labour in the last two years, gradually raised the annual growth of potential output to 5% in 2005. Such an increase in potential output growth, together with the growth in both capital services and TFP, signals more efficient use of resources, i.e. improvements in supply-side performance.

In our view, this can be attributed to gradually increasing efficiency of investment since the very end of the 1990s, which coincides with the acceleration of FDI inflows. The positive and increasing TFP growth rates since 2000 could be taken as support for that. One can assume that the FDI has been used efficiently and has contributed to increases in productivity.

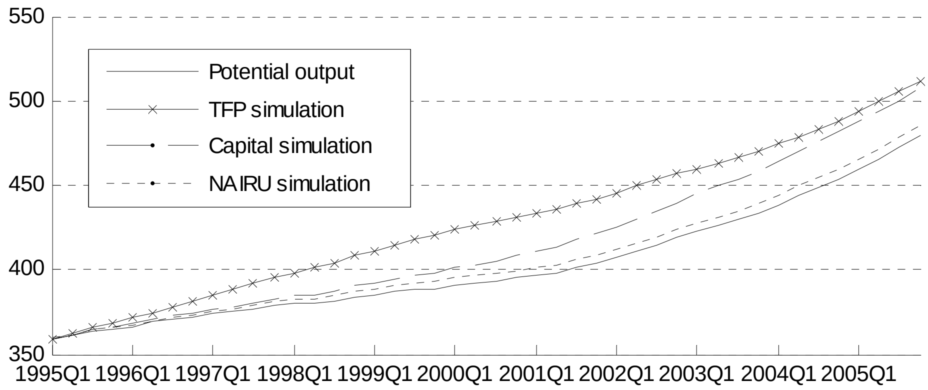
Despite the improvements in supply-side functioning reported above, labour market efficiency still remains an issue, since the stability of the NAIRU at around 7.5% represents a rather high trade-off between inflation and unemployment. Our analysis naturally raises the question of what the potential output would have been had the supply side been working more efficiently. Answers to such questions can be obtained from potential output growth simulations.

2.4 Simulations

Simulations can be used to identify the relative importance of particular factors of potential output growth. Put differently, potential output simulations help us to classify the impact of different market inefficiencies. For instance, one can address the question of what the potential output would have been had the NAIRU remained stable at 5.5%. In order to address these questions, we carry out several simulations using arbitrary assumptions for the development of particular factors. To do so, we substitute into the production function hypothetical values for the relevant variables instead of the originally computed data.

We run three simulations (NAIRU, Capital and TFP – see Figure 2.5). Within the NAIRU simulation, we assume stability of the NAIRU at 5.5%, which was the NAIRU level in 1996. This should quantify the loss stemming from absent (or inefficient) structural labour market policies and flexible labour market institutions that stimulate potential output growth. In the capital simulation, we assume that the annual growth in capital services has remained at 5% since 1996, i.e. assuming that the drop in investment activity at the end of the 1990s was avoided. Finally, in the TFP simulation, we assume stable annual TFP growth of 1.8%, i.e. a substantially higher degree of technological innovation and better productive use of factor inputs (this is the average annual TFP growth in Germany between 1963–1999; Lehman Brothers, 2000).

Figure 2.5: Simulations of Potential Output Development (1995Q1–2005Q4)



Source: Czech Statistical Office and own computations.

As can be seen in Figure 2.5, the positive impact of a lower NAIRU level on potential output is not too marked – at the end of 2005 the simulated value of the NAIRU would have increased the potential output level by 1.3% compared to the baseline scenario. This would imply an average annual increase in potential output growth over the analysed period of only 0.1 p.p.

Furthermore, Figure 2.5 shows that the difference between the baseline scenario and the capital services simulation has become substantial since 2000, and at the end of 2005 the difference in potential output levels between the simulation and the baseline scenario is around 5.9%. This represents an average annual increase in potential output growth of 0.6 p.p. over 1995–2005. Thus it appears that the observed drop in capital stock formation in the late 1990s constrained potential output growth more substantially than the rise in the NAIRU.

The TFP simulation implies that the level of potential output would have been 6.6% higher at the end of 2005 compared to the baseline scenario. In other words, the simulated TFP growth would imply an average annual increase in potential output growth of 0.7 p.p. in the period covered by our analysis. Such an impact of TFP reflects the crucial role of efficient resource allocation and utilisation for potential output growth. It could even be argued that the difference between the TFP baseline and simulation chiefly reflects the extent of the imperfections in supply-side functioning that the Czech economy was facing, especially during the 1990s.[23]

3. Supply-Side Adjustments in a Cross-Sector Perspective

Section 2 analyses long-term trends in economic growth and their driving forces at the macro level. It identifies turbulent economic developments for the second half of the 1990s, as opposed to a much more stabilised growth pattern observed from 2001 onwards. The previous section also points to a decisive role of TFP in the structure of economic growth. When analysing supply-side evolution, however, a disaggregated analysis is needed as well, to deliver more structured insights into the aggregate developments.

The rest of this section is organised as follows: subsection 3.1 presents the growth accounting analytical framework and TFP growth decomposition. Subsequently, subsection 3.2 analyses the role of particular factors of economic growth (i.e. capital, labour and TFP) in the key productive sectors. Finally, subsection 3.3 quantifies the contribution of structural changes in resource allocation to TFP-driven economic growth, as well as the analogous contribution of resource utilisation, given their initial allocation.

3.1 Analytical Framework

In the previous section, advanced approaches to modelling the economy's potential output with the use of the production function were presented. By contrast, in this section we rely on standard growth accounting formulas.[24] Their purpose is to identify the specific contributions of factor inputs and TFP to the observed economic growth in seven productive sectors, given the aggregate supply-side functioning as described in the previous section. Within this framework, the Cobb–Douglas production function with constant returns to scale is transformed from levels into growth rates. Growth in TFP can be then derived as a Solow residual:

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \alpha(t)\frac{\dot{L}}{L} + (1-\alpha(t))\frac{\dot{K}}{K}, \tag{3.1}$$

where Y stands for output, A for TFP, L for labour, K for capital stock and α and (1-α) for labour and capital shares respectively ($\alpha = (w.L)/Y$, with w denoting labour cost per employed person).

[23] Both the capital and NAIRU simulations do not assume any impact on TFP. For instance, in the case of the NAIRU, a policy could be arranged which would lead to a more skilled labour force. This would be reflected in lower unemployment, but also in higher productivity of the "better skilled" labour. Our simulation, however, reflects just the decline in unemployment, leaving TFP unchanged.

[24] One has to mention the pioneering work of Mojmír Hájek in the application of the growth accounting approach in the Czech conditions – see especially Hájek *et al.* (1995) and Hájek (2005) and also Flek *et al.* (2001).

In our empirical analysis, we work with discrete (annual) data for the period 1995–2004. Therefore, using a continuous time transformation (3.1) directly for deriving the growth in TFP does not seem appropriate. Instead, Thörnqvist discrete time approximation is recommended in the literature. This yields the following approximation, which can be implemented for our disaggregated analysis:[25]

$$\log\left(\frac{A(i,t+1)}{A(i,t)}\right) = \log\left(\frac{Y(i,t+1)}{Y(i,t)}\right) - \left[\bar{\alpha}(i,t)\log\left(\frac{L(i,t+1)}{L(i,t)}\right)\right] - \left[(1-\bar{\alpha}(i,t))\log\left(\frac{K(i,t+1)}{K(i,t)}\right)\right] \quad (3.2)$$

where: $\bar{\alpha}(i,t) = \dfrac{\alpha(i,t+1)+\alpha(i,t)}{2}$ and (i = 1,…7).

For each sector i, Y denotes gross value added at constant 1995 prices, L stands for total employment adjusted for days actually worked (including self-employment) and K represents the net capital stock at 1995 replacement costs.[26] In addition, $\bar{\alpha}$ denotes the Thörnqvist share (with w representing total nominal labour costs per employee) and $(1-\bar{\alpha})$ the share of capital respectively. Finally, A stands for the residual, i.e. TFP. All data are obtained from publications of the Czech Statistical Office (CZSO 2005a–g).

We also need to calculate properly changes in the aggregate TFP residual.[27] There is a seemingly straightforward way to do so:

$$\log\left(\frac{A(t+1)}{A(t)}\right) = \log\left(\frac{Y(t+1)}{Y(t)}\right) - \left[\hat{\alpha}(t)\log\left(\frac{L(t+1)}{L(t)}\right)\right] - \left[\hat{\beta}(t)\log\left(\frac{K(t+1)}{K(t)}\right)\right], \quad (3.3)$$

where: $\hat{\alpha} = \dfrac{\sum_i w_i \cdot L_i}{Y}; \hat{\beta} = \dfrac{\sum_i (Y_i - w_i \cdot L_i)}{Y}$ and $Y = \sum_i Y_i; L = \sum_i L_i; K = \sum_i K_i$.

In reality, however, individual sectors differ in the amount of production factors they employ. Also, factor income shares vary across sectors. That is why we cannot simply aggregate sectoral labour and capital and subsequently weight the growth rates of the aggregated factors by their respective total income shares.[28] To calculate overall TFP growth in a proper way, sector-specific growth rates of labour and capital have to be weighted by the corresponding, sector-specific, income shares. The following formula therefore represents a superior approach to calculating the aggregate TFP residual:

[25] See, for example, Barro and Sala-i-Martin (1995, p. 347).

[26] For the reasons mentioned in section 2, we do not follow the capital services approach in our disaggregated analysis. Instead, official data from the Czech Statistical Office are used.

[27] When we refer in this section to "aggregate" figures, we have in mind figures summarising developments in seven productive sectors. By contrast, in section 2, where real GDP growth and the factors influencing the economy's potential output are analysed, the term "aggregate" has a slightly different meaning.

[28] See Barro (1998) for more discussion on the inadequacy of formula (3.3).

$$\log\left(\frac{A(t+1)}{A(t)}\right)=\log\left(\frac{Y(t+1)}{Y(t)}\right)-\sum_i\left[\overset{\approx}{\alpha}(i,t)\log\left(\frac{L(i,t+1)}{L(i,t)}\right)\right]-\sum_i\left[(1-\overset{\approx}{\alpha}(i,t))\log\left(\frac{K(i,t+1)}{K(i,t)}\right)\right], \tag{3.4}$$

where: $\overset{\approx}{\alpha}(i,t)=\dfrac{\overset{*}{\alpha}(i,t+1)+\overset{*}{\alpha}(i,t)}{2};\overset{*}{\alpha}(i,t)=\dfrac{w(i,t)\cdot L(i,t)}{Y(t)}$.

The growth accounting approach assumes that the fundamental determinants of factor growth rates are substantially independent from those that matter for technological change. Furthermore, if the assumptions on constant returns to scale, competitive factor markets and marginal productivity pricing do not hold, then the TFP residual might be contaminated by elements with no specific link with "productivity". This possibly also includes omitted variables and measurement errors.

Many partial improvements to the growth accounting methodology above have been developed in the literature.[29] These concern especially multiple types of factors, where both labour and capital are categorised by age or by quality classes. Furthermore, increasing returns to scale, spillover effects and R&D expenditures are increasingly used in analyses to capture the TFP residual more accurately. As an alternative, TFP growth has also started to be estimated econometrically.

Despite its potential shortcomings, the TFP residual is still one of the key building blocks of contemporary analysis of supply-side performance. This applies both to the world of academic research and to international institutions. That is why Hulten (2000, p. 63) concludes his critical assessment in the following way: "The residual still is, after more than forty years, the work horse of empirical growth analysis…Not bad for a forty-year old."

We also intend to analyse the relationship between TFP-driven economic growth, cross-sector reallocation of resources and changes in resource utilisation within sectors, given their initial allocation. For this reason, we break down changes in the overall TFP into three different effects. Each of them provides us with a meaningful economic interpretation.

Overall TFP growth, i.e. $\dfrac{TFP(t+1)-TFP(t)}{TFP(t)}$ can be decomposed as follows:[30]

1. $$\frac{\sum_i\left(S(i,t+1)-S(i,t)\right)\cdot TFP(i,t)}{TFP(t)}; \tag{3.5}$$

where:

$$\left[S(i,t)=\frac{TIF(i,t)}{\sum_i TIF(i,t)};TIF(i,t)=L(i,t)^{\alpha(i,t)}\cdot K(i,t)^{1-\alpha(i,t)}\right].$$

[29] See Barro (1998) or Hulten (2000) for an overview, and Griffin and Odaki (2006), Ganev (2005), Limam and Miller (2004), Baier, Dwyer and Tamura (2002) or Senhadji (2000) for recent examples of application. In the present analysis, we do not follow these new research directions, mainly due to a lack of data in the breakdown needed for our cross-sector analysis or due to aggregation problems.

[30] For an analogous decomposition, see, for example, Fonfria and Alvarez (2005, p. 11) or Ark, Inklaar and McGuckin (2002, p. 15). These authors, however, limited themselves to labour productivity growth decomposition only.

Formula (3.5) is defined as the *structural effect* (or the inter-industry or static-shift effect). The term S stands for the share of the total input factor (TIF) of each individual sector in the overall TIF. The relative change in S is weighted by the TFP level in the initial period recorded for each sector and, finally, is divided by the overall TFP level in the initial period. Positive values of the structural effect indicate, in percentage points, how much of the observed overall TFP growth (and growth in total value added) can be attributed to resource reallocation in favour of those sectors with high initial levels of TFP. It can therefore be used as a specific measure of the economic gains linked with structural changes in resource allocation.

2. $$\frac{\sum_i \big(TFP(i,t+1) - TFP(i,t)\big) \cdot S(i,t)}{TFP(t)}; \qquad (3.6)$$

By contrast, formula (3.6) expresses the *within-growth effect* (or competitiveness or intra-industry effect). It captures the intra-sector relative changes in TFP, weighted by the initial TIF share of the respective sector and, finally, divided by the overall TFP level in the initial period. Positive values of the within-growth effect indicate the fraction of the actual growth in overall TFP (value added) which can be attributed to better utilisation of resources, given their initial, sector-specific allocation.

3. $$\frac{\sum_i \big(S(i,t+1) - S(i,t)\big) \cdot \big(TFP(i,t+1) - TFP(i,t)\big)}{TFP(t)}. \qquad (3.7)$$

Finally, formula (3.7) is associated with the *dynamic-shift effect* (or specialisation or mixed-interactive effect). It refers to sector-specific changes in both TIF share and TFP. Positive values of this effect indicate that resources have been reallocated in favour of sectors with positive TFP growth and quantify the specific contribution of this reallocation to the overall growth in TFP (value added). In this sense, formula (3.7) is an additional specific measure of the impact of structural changes on supply-side performance.

For our analytical purposes, we also need a specific measure for analysing the *dynamics* of structural changes over time. For this reason, we apply a special index of structural changes, S_L:[31]

$$S_L = \sqrt{\sum_i \left[x(i,t) - x(i,t-1)\right]^2 \cdot \frac{x(i,t)}{100}} \qquad (3.8)$$

The index is a weighted sum of relative changes in a specific variable (value added, capital stock, labour) over the sectors analysed. The weight corresponds to the share of each sector in the initial period. The index S_L takes values ranging from 0 to 100. The closer the value of S_L to zero, the lower the dynamics of structural changes over time and *vice versa*.

3.2 Modes of Economic Growth: Aggregate vs. Sector-Specific

The period of early transition (1990–1995) is not explicitly covered by the present analysis. Some short reference, however, is necessary to understand the (dis)continuity with the more recent supply-side developments. Regarding the structure of economic growth, the first half of the 1990s

[31] See Landesman and Szekely (1995). See also Landesman (2000), Gács (2001) or Flek *et al.* (2001) for additional examples of application.

was characterised by a negative contribution of labour, combined with growth in the capital stock, and a modest or even negative contribution of TFP.[32]

This "initial" pattern of economic growth was inherent for the first stage of transition to a market economy. It was linked with the need to reduce the over-employment inherited from the era of central planning and to replace the obsolete capital stock. The fact that TFP growth remained negligible or even negative in that period can be attributed to many factors. Strong external and internal economic shocks apparently played a crucial role. However, there was a wide range of other, transition-specific factors. These were linked mainly with institutional, legal and structural shortcomings that, in our opinion, prevented the economy from operating closer to the efficiency frontier.[33]

The increases in TFP reported in Table 3.1 for the period 1996–2004 (and for 2001–2004)[34] represent a substantial qualitative change in the structure of economic growth compared to the early transition period. Contrary to the early transition stage, TFP has become the main contributor to economic growth. Indeed, as Table 3.1 reports, total value added grew on average by 2.5% per year during 1996–2004, with TFP accounting for 1.8 percentage points of this growth (i.e. 72% of the growth in value added was due to TFP).

The above tendencies mean that, over 1996–2004, the Czech economy moved to an "interim" growth pattern. This is characterised by the key role of TFP in the structure of economic growth, as opposed to the capital-driven economic growth in the first half of the 1990s. In both stages, however, the contribution of labour to economic growth remained negative.

The developments during 2001–2004 were even more favourable. Apart from maintaining the key role of TFP in the structure of economic growth, [35] the contribution of labour has become slightly positive and that of capital has increased somewhat in comparison with the long-term tendency. This represents the first signs of an "advanced" pattern of economic growth, with relatively high growth rates of TFP induced by a continuing inflow of new technologies, and an emerging positive contribution of labour to economic growth. As shown in the previous section, this "advanced" pattern of economic growth does not represent just a cyclical swing, but is firmly based on relatively robust growth in potential output.

---

[32] According to Hájek *et al.* (1995), the average annual rate of TFP growth was -6.6% in the period 1990–1992 and 0.9% for 1993–1994.

[33] See, for example, Čapek (1995) or Mervart (1998) for the main problems (such as the accumulation of non-performing loans and the resulting pressures on banks' balance sheets) that characterised the Czech banking sector in the first half of the 1990s. Flek (1993, 1995) gives, among other things, a summary of the problems linked with corporate governance, restructuring, anti-trust action and bankruptcy enforcement in the early transition period. Lemoine (1997), Poschl *et al.* (2000) and Tomšík (2002) document the losses in international competitiveness during that period. Flek (2004) shows in detail various aspects of the labour market imperfections behind the façade of the Czech "unemployment miracle" in the mid-1990s.

[34] As established in section 2, the period 2001–2004(5) represents a new phase of the business cycle, which is characterised by relatively rapid growth in potential output, as well as real GDP, with the two growth rates being approximately identical. We are therefore interested in knowing to what extent, if at all, the current business cycle phase is associated with sector-specific modifications in the long-term supply-side performance. Given the relatively short history of the transition, the use of the term "long-term" is obviously rather provisional.

[35] Despite slightly different approaches to the aggregation of sectoral data and not fully compatible time-spans and data sets, Hájek (2005) also confirms a rapid rise in TFP from the beginning of the 2000s, as well as the key role of TFP in the structure of economic growth.

Table 3.1: Factors of Economic Growth

	Value added*		Labour*		Capital*		TFP*	
	96-04	**01-04**	**96-04**	**01-04**	**96-04**	**01-04**	**96-04**	**01-04**
Agriculture	4.2	5.3	-4.7	-3.7	-0.5	0.9	7.1	6.8
Industry	3.2	3.1	-1.0	-0.4	5.3	4.6	1,3	1.3
Construction	-4.7	0.8	-2.7	-0.3	3.3	5.2	-4.2	-0.5
Trade	3.7	2.1	0.0	0.8	3.5	3.2	2.6	0.6
Transport+Telecoms	2.2	6.3	-0.4	-0.5	1.5	1.4	1.5	5.8
Financial Intermed	7.2	6.3	-0.7	-1.5	3.8	3.5	5.8	5.8
Services	1.6	2.1	2.3	2.9	0.1	0.0	0.6	0.8
Average**	**2.5**	**3.3**	**-0.8**	**0.0**	**2.2**	**2.1**	**1.8**	**2.0**
Contribution***	**2.5**	**3.3**	**-0.4**	**0.1**	**1.1**	**1.2**	**1.8**	**2.0**

***Notes**:* *average annual growth rates in per cent; **geometrical mean; ***contribution of individual factors to economic growth in percentage points.
Source: CZSO and own calculations.

Table 3.2: Sector-Specific Modes of Economic Growth

	Value added*		Labour**		Capital**		TFP**		Contribution***	
	96-04	**01-04**	**96-04**	**01-04**	**96-04**	**01-04**	**96-04**	**01-04**	**96-04**	**01-04**
TFP-driven growth :******	3.7	4.2	-0.4	0.1	1.1	1.2	**3.0**	**2.9**	1.4	1.8
Of which:										
Agriculture	4.2	5.3	-2.7	-2.0	-0.2	0.4	**7.1**	**6.9**	0.2	0.3
Trade	3.7	2.1	0.1	0.5	1.0	**1.0**	**2.6**	0.6	0.6	0.4
Transport + Telecoms	2.2	6.3	-0.2	-0.2	0.9	0.7	**1.5**	**5.8**	0.2	0.7
Financial Intermediation	7.2	6.3	-0.3	-0.9	1.7	1.4	**5.8**	**5.8**	0.4	0.4
Capital-driven growth:										
Industry	3.2	3.1	-0.5	-0.2	**2.4**	**2.0**	1.3	1.3	1.2	1.2
Labour-driven growth:										
Services	1.6	2.1	**1.0**	**1.3**	0.1	0.0	0.5	0.8	0.2	0.3
Negative growth:										
Construction	**-4.7**	0.8	-1.8	-0.2	1.3	**1.4**	-4.2	-0.4	-0.3	0.0
Total	2.5	3.3	x		x		x		2.5	3.3

Notes**:* *annual average rate of growth in per cent; **contributions of particular factors to growth in value added in each sector in percentage points; ***contribution of each sector to growth in total value added in percentage points.*Sectors with "TFP-driven" economic growth are those where the *contribution* of sectoral TFP (in percentage points) to growth in sectoral value added is decisive, i.e. remarkably higher than the contributions of labour and capital. These sectors also recorded the highest *rates* of growth in TFP itself and belong to sectors with the highest TFP *levels*. (We do not report here the levels of TFP, but they are available from the authors.)
***Source*:** Czech Statistical Office and own calculations.

Now we intend to analyse in more detail specifics of the growth structure in particular sectors (Table 3.2).

During 1996–2004, Industry was the major contributor to aggregate economic growth. Industry maintained the highest relative contribution to growth in total value added as well as the highest share in total value added (see also Table 3.3). Despite its leadership, however, the growth pattern of Industry did not decisively affect the economy as a whole. As documented earlier, the growth in total value added was driven predominantly by TFP, while the growth in Industry value added was still capital-driven.

The fastest growing sectors over 1996–2004 were Financial Intermediation and Agriculture, both displaying a TFP-driven pattern of growth. During 2001–2004, Transport and Telecommunications succeeded in catching up with these leaders, due to a strong intensification of TFP-driven growth.

To sum up, the sectors included in our analysis can be classified into four sub-groups with respect to the structure of their long-term economic performance and the resulting modes of economic growth. These sector-specific modes of growth appear relatively stable over time,[36] thus documenting the variety of paths in supply-side adjustments at the mezzo level.

1. In four sectors (Agriculture, Trade, Transportation and Telecommunications, and Financial Intermediation), *TFP is the most important factor of long-term growth* in value added. This may generally be associated with either relatively higher utilisation of the given resources or higher economic gains stemming from engaging additional resources than in the remaining sectors (see subsection 3.3 for more discussion).

2. In Industry, *the capital stock has contributed decisively to growth* in value added. Although technological progress is typically embodied in new capital investment, the ongoing rapid capacity modernisation in Industry has not yet led to significant gains in TFP. This represents a limitation on the growth rate of value added in Industry as well as in the economy as a whole. Simulations for the period 1996–2004 document that an improvement in the average annual growth rate of TFP in Industry of one percentage point would have increased, *ceteris paribus*, the average annual growth rate of total value added by some 0.5 percentage points. Without accelerating the rate of TFP growth, the leading role of Industry in the Czech economy will probably erode.

3. In Services,[37] *the growth is associated predominantly with labour*. Such a result seems intuitive enough, given the relative under-employment and low capital requirements in most branches of this sector. But at the same time, one must admit that the reliance on labour inflows has clearly constrained the expected structural change in favour of Services. Only the recent developments signal some intensification in both TFP and capital contributions. Thus the reliance of this sector on labour inflows has weakened, with the prospect of a more rapid expansion in Services.

4. Construction is the only industry with *negative growth* in value added over the investigated period.[38] This is primarily a result of huge downturns in the second half of the 1990s. Since then, the economic performance of this sector has been relatively solid, bearing the features of capital-driven growth.

---

[36] See the figures written in bold in Table 3, indicating, with just a few exceptions, the same patterns of sector-specific growth for both 1996–2004 and 2001–2004.

[37] This sector includes real estate services, renting services, computer and related services, and R&D.

[38] This result might seem counter-intuitive, considering the significant wave of capital stock modernisation over the period 1996–2004. Some observers attribute this paradox to rapid technological progress shifting a significant part of value added towards other industries (such as production of construction materials).

3.3 TFP Growth, Structural Changes and Factor Utilisation

The results reported in Table 3.3 summarise the *direction and extent of the changes* in sector shares in total value added. There are two remarkable structural shifts over the period investigated: (i) sectors with TFP-driven economic growth have increased their share in total value added by 4 percentage points; and (ii) the share of Construction in total value added has declined by 5 percentage points. These shifts occurred mostly in the period 1996–2001. Since then, the changes in the productive structure appear to have been lower, reaching at most ± 2 percentage points.

Table 3.3: Changes in the Productive Structure

	VA share*			Difference**		
	95	**01**	**04**	**04 – 95**	**01-95**	**04-01**
TFP-driven sectors	0.38	0.42	0.42	0.04	0.04	0.0
Of which:						
Agriculture	0.05	0.05	0.06	0.01	0.00	0.01
Trade	0.17	0.20	0.18	0.01	0.03	-0.02
Transport + Telecoms	0.12	0.11	0.12	0.00	-0.01	0.01
Financial Intermediation	0.04	0.06	0.06	0.02	0.02	0.00
Capital-driven sectors						
Industry	0.36	0.36	0.38	0.02	0.00	0.02
Labour-driven sectors						
Services	0.15	0.16	0.14	-0.01	0.01	-0.02
Negative growth						
Construction	0.11	0.05	0.06	-0.05	-0.06	0.01

Notes: *shares in total value added in %;
**differences in sector shares between the indicated periods in p.p.
Source: Own calculations.

To verify alternatively the seemingly declining extent of structural changes, an additional measure of the *dynamics of structural change* is introduced, as defined in subsection 3.1:

We can deduce from Table 3.4 that the dynamics of the changes in the productive structure (VA) are indeed relatively modest and diminishing over time, especially from 2001 onwards. Cross-sector changes in the allocation of labour (*L*) and capital (*K*) exhibit even lower and more stagnant dynamics than the changes in the productive structure themselves.

Table 3.4: Indices of Structural Changes

	1996	1997	1998	1999	2000	2001	2002	2003	2004
VA	2.3	1.0	2.7	1.6	0.7	1.9	1.6	0.9	0.6
L	0.8	0.6	0.3	0.7	0.6	0.5	0.5	0.8	0.3
K	0.8	0.7	0.4	0.7	0.8	0.6	0.4	0.6	0.6

Note: The value of the index can vary between 0 and 100. Zero means no change in the structure of sector shares in total value added (VA), employment (L) and capital (K), while 100 means a complete structural reversal.
Source: Own calculations.

The relatively low dynamics of structural change over 1996–2004 (especially with regard to cross-sector factor reallocation) validate the following assumption: The bulk of the TFP growth (and aggregate economic growth) was achieved due to increasing factor utilisation within sectors. By contrast, the potential economic gains stemming from reallocation of resources towards the most productive ones were probably wasted. This hypothesis will now be tested in more detail.

What really matters is the *efficiency aspect of structural change*. In other words, can we say how exactly the economy suffers from a low degree of structural change? To answer this question, we explore the decomposition of TFP growth, as formulated in subsection 3.1. The results are summarised in Table 3.5.

Table 3.5: Breakdown of TFP Growth

Average TFP Growth		**Structural Effect** (static-shift)		**Mixed Effect** (dynamic-shift)		**Intra-Sector Growth**	
96-04	**01-04**	**96-04**	**01-04**	**96-04**	**01-04**	**96-04**	**01-04**
1.8	2.0	-0.1	0.1	0.0	0.0	1.9	1.9

Source: Own calculations.

Table 3.5 documents a negative change in aggregate TFP due to reallocation of resources over 1996–2004 (see the negative sign on the static-shift effect in Table 3.5). This is a consequence of absent factor inflows from sectors with low TFP levels to those with high TFP levels. Thus, the actual factor reallocation was probably driven by other motives than those fully consistent with allocative efficiency.

The actual factor input reallocation over 1996–2004 even diminished the annual average rate of aggregate TFP growth (and growth in total value added) by 0.1 percentage point. This means that the relatively stagnant structure of the Czech economy at the mezzo level may, in the long run, be associated with concrete costs, and specifically with a certain *structural burden*.[39]

Furthermore, for 1996–2004 there is no effect stemming from factor reallocation to sectors with high TFP growth (see the zero values of the dynamic-shift effect in Table 3.5). Consequently, all the growth in TFP observable at the aggregate level in the period 1996–2004 appears to be exclusively a result of better factor utilisation within sectors (see the positive values of the within-growth effect in Table 3.5). This suggests a decisive role of technological efficiency for TFP growth.

Although the extent of the structural changes themselves remained relatively low or even further declined during 2001–2004, it was no longer associated with a structural burden. This can be understood as an additional important feature of the stage of "advanced" economic growth, as defined for the same period in subsection 3.2.[40]

---

[39] See, for example, Fonfría and Álvarez (2005) for testing of an analogous "structural burden hypothesis" for Spanish industry, or Kurosaki (2001) for the agriculture sectors in India and Pakistan.

[40] Our results for the period 2001–2004 differ from those obtained by Hájek (2005), who reports that, during 1999–2004, the intra-sector growth in TFP reached 2.5 and the structural effect was negative (-0.1).

Table 3.6: Contribution of Individual Sectors to Overall TFP Growth

	Overall TFP Growth		**Structural Effect** (static-shift)		**Mixed Effect** (dynamic-shift)		**Intra-Sector Growth**	
	96-04	**01-04**	**96-04**	**01-04**	**96-04**	**01-04**	**96-04**	**01-04**
TFP-driven sectors:	1.35	1.07	-0.30	-0.18	-0.02	-0.02	1.67	1.27
of which:								
Agriculture	0.09	0.33	-0.26	-0.14	-0.02	-0.01	0.38	0.48
Trade	0.38	0.07	-0.01	0.07	0.00	0.00	0.39	0.00
Transport + Telecoms	0.33	0.46	-0.03	-0.06	0.00	0.00	0.35	0.52
Financial Intermediation	0.56	0.22	0.01	-0.05	0.00	0.00	0.55	0.27
Capital-driven sectors:								
Industry	0.82	0.76	0.29	0.20	0.01	0.00	0.52	0.56
Labour-driven sectors:								
Services	0.13	0.13	0.01	0.02	0.00	0.00	0.12	0.11
Negative growth:								
Construction	-0.49	-0.01	-0.12	0.02	0.01	0.00	-0.37	-0.03
Total	1.80	2.00	-0.10	0.10	0.00	0.00	1.90	1.90

Source: Own calculations.

We also report the results for individual sectors (Table 3.6). Over 1996–2004, all "TFP-driven" sectors (except Financial Intermediation) lost in their respective sector shares in total factor input (see the negative signs on the static-shift effect in Table 3.6). This means that all the growth in TFP in these sectors was exclusively due to improving factor utilisation. Since this is also a group of sectors with high TFP levels, the negative aggregate structural effect reported in Table 3.5 is explained by the above-noted outflow of resources from these sectors.

Industry is the only sector attracting a remarkable amount of additional resources over 1996–2004, thus having a positive sign on the structural effect. But Industry itself could not have reversed the resulting aggregate structural burden (note that the TFP level in Industry is lower than in most of the "TFP-driven" sectors).

For 2001–2004, there were two remarkable new tendencies: (i) Construction improved its performance significantly and even succeeded in attracting additional resources; (ii) all the growth in TFP in Trade was due to emerging inflows of factor inputs. These two tendencies increased the relative weight of factor input reallocation in explaining the growth in overall TFP. Thus the resulting positive aggregate structural effect for 2001–2004 is explained. One must admit, however, that this effect is still very close to zero. The crucial role of within-sector factor utilisation for aggregate TFP growth therefore prevails.

4. Conclusion

As established by our analysis, the Czech economy experienced relatively slow annual average growth in potential output of around 2.7% over the last ten years. Whereas during the period 1995–2000 the average annual potential output growth reached 1.7%, the period from 2001 onwards is characterised by a potential output growth rate of around 3.8%, with a tendency to accelerate. In addition, it is worth mentioning that while the first period was accompanied by significant fluctuations in current output relative to the estimated potential, in the second period the development of current output has been quite smooth with respect to the estimated potential.

Had the economic recovery starting in 2001 not been accompanied by a pick-up in potential output growth, the economy would have had to undergo another painful adjustment. This macroeconomic evidence thus suggests a remarkable improvement in supply-side functioning. This has primarily involved an acceleration in total factor productivity growth, linked with increasing efficiency of investment.

Simulations of various paths of potential output growth show that a low contribution of total factor productivity can be seen as the main reason for the slow potential output growth during the second half of the 1990s. The future prospects for potential output growth critically depend on the stability of total factor productivity growth. Should the existing improvement in total factor productivity and the contribution of capital services last over the longer run, the future potential output growth can be expected to maintain its current magnitude of 5–6%. However, for a further pick-up in potential output growth, an increase in labour market efficiency is necessary – i.e. the current stagnation of the NAIRU at a relatively high level has to be eliminated by an adequate set of labour market legislation and policy measures.

Having explored the growth accounting approach, we established that the growth in real value added over the investigated period has been driven mainly by increases in TFP. As shown in our mezzo level analysis, however, this aggregate growth pattern does not hold for all productive sectors. In fact, there are only four sectors with a decisive contribution of TFP (Agriculture, Trade, Transportation and Telecommunications, and Financial Intermediation). These sectors have expanded most rapidly and increased their weight in total value added. One has to note that their expansion has occurred exclusively due to better utilisation of resources, with no contribution of resource reallocation in favour of these expanding sectors. As a result, the potential economic gains stemming from resource reallocation towards sectors with high TFP levels/growth rates have probably been wasted due to the fairly stagnant structure of the Czech economy. This view is supported by the presence of a structural burden for the period 1996–2004. More recent developments (2001–2004), however, caused this burden to disappear.

The role of the Industry sector is still crucial in terms of its share in total value added, its engagement of factor inputs and its quantitative contribution to growth in total value added. At the same time, however, the main driver of economic growth in Industry is still an increase in capital stock, with TFP playing a less decisive role. As documented by simulations, this represents a limitation on the growth rate of value added in Industry as well as in the economy as a whole. Without accelerating the rate of TFP growth, the leading role of Industry in the Czech economy will probably further erode.

By contrast, we have found some support for faster structural change to be expected in favour of the Service sector. Its past reliance on labour inflows apparently constrained the pace of expansion of this sector. But the recent developments signal some intensification in both TFP and capital contributions. Thus the reliance of this sector on labour inflows has weakened, with prospects of a more rapid expansion of this sector.

The recent developments (2001–2004) in productive sectors can be viewed as an "advanced" mode of economic growth, based predominantly on improvements in TFP, along with positive contributions from both capital and labour. As shown earlier in our analysis, these favourable developments in real value added do not represent just a cyclical swing, but are firmly based on an acceleration in potential output growth.

References:

ARK, B., R. INKLAAR, AND R. MCGUCKIN (2002): "Changing Gear: Productivity, ICT and Services: Europe and the United States", Research Memorandum GD-60. Groningen: Groningen Growth and Development Centre.

BAIER S., G. DWYER, AND R. TAMURA (2002): "How Important Are Capital and Total Factor Productivity for Economic Growth?" Federal Reserve Bank of Atlanta Working Paper 2002-2a.

BARRO, R. J. (1998): "Notes on Growth Accounting", NBER Working Paper No. 6654.

BARRO, R. AND X. SALA-I-MARTIN (1995): *Economic Growth (2nd edition),* Cambridge (M): MIT Press.

BAXTER, M. AND R. KING (1995): "Measuring Business Cycles Approximate Band-Pass Filters for Economic Time Series", NBER Working Paper No. 5022.

BENEŠ, J. AND P. N'DIAYE (2004): "A Multivariate Filter for Measuring Potential Output and the NAIRU: Application to the Czech Republic", IMF Working Paper No. 45.

BEZDĚK, V., K. DYBCZAK, AND A. KREJDL (2003): "Czech Fiscal Policy: Introductory Analysis", Working Paper No. 7, Prague: Czech National Bank.

BOSWORTH, B. P. AND F. M. COLLINS (2003): "The Empirics of Growth: An Update", *Brookings Papers on Economic Activity*, 2, pp. 113–179.

ČAPEK, A. (1995): "The Bad Loans and the Commercial Bank Policies in the Czech Republic", Working Paper No. 39, Prague: Czech National Bank, Institute of Economics.

CHRISTIANO, L. AND J. FITZGERALD (1999): "The Band-Pass Filter", NBER Working Paper No. 7257.

FLEK, V. (1993): "Efficiency Approach and Progress in Privatization in ex-Czechoslovakia", Discussion Papers on the Economic Transformation: Policy, Institutions and Structure, Leuven: LICOS, Catholic University of Leuven.

FLEK, V. (1995): "The Strategy of Marketization and Problems of the Competitiveness of Industry in the Former Czechoslovakia", In M. Jackson and W. Biesbrouck, eds.: *Marketization, Restructuring and Competition in Transition Industries in Central and Eastern Europe*. Aldershot (UK): Avebury, pp. 121–162.

FLEK, V. ET AL. (2001): "Supply-Side Performance and Structure" (in Czech), Working Paper No. 27, Prague: Czech National Bank, Monetary Department.

FLEK, V. ED. (2004): "Anatomy of the Czech Labour Market: From Over-Employment to Under-Employment in Ten Years?" Working Paper No. 7, Prague: Czech National Bank.

FLEK, V. AND J. VEČERNÍK (2005): "The Labour Market in the Czech Republic: Trends, Policies, and Attitudes", *Czech Journal of Economics and Finance* (1–2), pp. 5–24.

FONFRÍA, A. AND I. ÁLVAREZ (2005): "Structural Change and Performance in Spanish Manufacturing: Some Evidence on the Structural Bonus Hypothesis and Explanatory Factors", Mimeo, Madrid: Universidad Complutense de Madrid (http://www.case.com.pl/dyn/plik--8874778.pdf).

FUKAČ, M. (2003): "Non-Accelerating Inflation Rate of Unemployment", Mimeo, Prague: CERGE-EI (http://home.cerge-ei.cz/fukac).

GÁCS, J. (2001): "Structural Change and Catching Up: Experience of the Ten Candidate Countries", Conference Paper. *Convergence and Divergence in Europe,* Vienna: Oesterreichische Nationalbank, November 5–6.

GANEV, K. (2005): "Measuring Total Factor Productivity: Growth Accounting for Bulgaria", Mimeo (http://econwpa.wustl.edu/eps/ge/papers/0504/0504004.pdf).

GIORNO, C., P. RICHARDSON, D. ROSEVEARE, AND P. VAN DEN NOORD (1995): "Estimating Potential Output, Output Gaps and Structural Budget Balances", OECD Working Paper No. 152.

GRIFFIN, N. AND K. ODAKI (2006): "Reallocation and Productivity Growth in Japan: Revisiting the Lost Decade of the 1990s", Congressional Budget Office Paper. Washington, D.C.

GROSSMAN, G. M. AND E. HELPMAN (1991): *Innovation and Growth in the Global Economy*. Cambridge (M): MIT Press.

HÁJKOVÁ, D. (2006): "The Capital Input into Czech Production: An Experimental Measure of Capital Services", Mimeo, Prague: Czech National Bank.

HÁJKOVÁ, D. AND J. HURNÍK (2006): "Production Function: A Case of a Converging Economy", Mimeo, Prague: Czech National Bank.

HÁJEK, M. ET AL. (1995): "A Macroeconomic Analysis of the Czech Economy (1990–1994)", Working Paper No. 34, Prague: Czech National Bank, Institute of Economics.

HÁJEK, M. (2005): "Ekonomický růst a souhrnná produktivita faktorů v České republice v letech 1992–2004", Working Paper No. 4, Prague: CSE-CSEM.

HÁJEK, M. AND V. BEZDĚK (2001): "Estimate of the Potential Product and the Output Gap in the Czech Republic" (in Czech), Working Paper No. 26. Prague: Czech National Bank, Monetary Department.

HANZLOVÁ, D. (2001): "Analýza vývoje hrubých hmotných investic v průběhu 90. let" ("Analysis of the Development of Gross Fixed Investment in the 1990s."), Czech Statistical Office.

HULTEN, C. R. (2000): "Total Factor Productivity: A Short Bibliography", NBER Working Paper No. 7471.

HURNÍK, J. AND D. NAVRÁTIL (2005a): "Labor Market Performance and Macroeconomic Policy: The Time Varying NAIRU in the Czech Republic", *Czech Journal of Economics and Finance*, (1–2), pp. 25–40.

HURNÍK, J. AND D. NAVRÁTIL (2005b): "Potential Output in the Czech Republic: A Production Function Approach", *Prague Economic Papers* (3), pp. 253–266.

KUROSAKI, T. (2001): "Agriculture in India and Pakistan, 1990–1995: A Further Note", Mimeo, Tokyo: Institute of Economic Research, Hitotsubashi University.

LANDESMAN, M. (2000): "Structural Change in Transition Economies, 1989 to 1999", Research Report No. 269, Vienna: WIIW.

LANDESMAN, M. AND I. SZEKELY, EDS. (1995): *Industrial Restructuring and Trade Reorientation in Eastern Europe,* Cambridge (UK): Cambridge University Press.

LEHMAN BROTHERS (2000): "Euro 2000: They Think It's All Over…", Structural Economics Research Papers No. 1, London.

LEMOINE, F. (1997): "Industrial Recovery in Central European Countries: Sectoral Trends, Foreign Trade and Direct Investments", ACE-Phare Workshop, Budapest: CEU, 9–11 May.

LIMAM, Y. AND S. MILLER (2004): "Explaining Economic Growth: Factor Accumulation, Total Factor Productivity Growth, and Production Efficiency Improvement", Working Paper Series. Connecticut: University of Connecticut, Department of Economics.

MERVART, J. (1998): *České banky v kontextu světového vývoje,* Nakladatelství Lidové noviny.

OECD (2001): *Measuring Capital – OECD Manual,* Paris.

PIATKOWSKI, M. (2003): "Does ICT Investment Matter for Growth and Labor Productivity in Transition Economies?" TIGER Working Paper Series, No. 47.

POSCHL, J. ET AL. (2000): "Transition Countries Clamber Aboard the Business Boom in Western Europe. Upswing Masks Persistent Transition-Related Problems", Research Report No. 264, Vienna: WIIW.

ROMER, D. (2002): *Advanced Macroeconomics,* (2nd edition), New York: McGraw-Hill.

ROMER, P. M. (1990): "Endogenous Technological Change", *Journal of Political Economy*, 98, pp. 71–102.

SCACCIAVILLANI, F. AND P. SWAGEL (1999): "Measures of Potential Output: An Application to Israel", IMF Working Paper No. 96.

SCHREYER, P. (2004): "Measuring MFP when Rates of Return are Exogenous", Paper presented at the SSHRC International Conference on Index Number Theory and the Measurement of Prices and Productivity, Vancouver, June 30 – July 3, 2004.

SCHREYER, P., E. BIGNON, AND J. DUPONT (2003): "OECD Capital Services Estimates: Methodology and First Results", Statistics Directorate Working Paper No. 6, Paris: OECD.

SENHADJI, A. (2000): "Sources of Economic Growth: An Extensive Growth Accounting Exercise", *IMF Staff Papers, 47* (1), pp. 129–158.

SOLLOW, R. M. (1956): "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, 70, (1), pp. 65–94.

THÖRNQVIST, L. (1936): "The Bank of Finland's Consumption Price Index", Bank of Finland, *Monthly Bulletin* No. 10, pp. 1–8.

TOMŠÍK, V. (2002): "Structural Adaptability of Manufacturing in Central European Countries During the Transition", *Newton Holding Country Report*, February.

VAŠÍČEK, O. AND M. FUKAČ (2000): "Quantitative Analysis of Non-Accelerating Inflation Rate of Unemployment and Non-Accelerating Inflation Product. Application for the Czech Republic", Working Paper. Brno: Masaryk University.

CZSO (2004): *Balance of Non-Financial Assets,* 1995–2002, Prague: Czech Statistical Office.

CZSO (2005a): *Total Labour Costs,* 1994–2004.

CZSO (2005b): *Labour Market in the Czech Republic,* 1993–2004.

CZSO (2005c): *Gross Value Added – Industry Breakdown (current prices)*, 1995–2004.

CZSO (2005d): *Gross Value Added – Industry Breakdown (constant prices of 1995)*, 1995–2004.

CZSO (2005e): *Total Employment (full- time equivalents)*, 1995–2004.

CZSO (2005f): *Net Stocks of Fixed Assets – Industry Breakdown (current replacement costs of 1995)*, 1995–2004.

CZSO (2005g): *Labour Costs – Industry Breakdown,* 1995–2004.

CZSO (2006): *Selected Time Series.*

CNB WORKING PAPER SERIES

4/2006	Kamil Dybczak: Vladislav Flek Dana Hájková Jaromír Hurník	*Supply-side performance and structure in the Czech Republic (1995–2005)*
3/2006	Aleš Krejdl:	*Fiscal sustainability – definition, indicators and assessment of Czech public finance sustainability*
2/2006	Kamil Dybczak:	*Generational accounts in the Czech Republic*
1/2006	Ian Babetskii:	*Aggregate wage flexibility in selected new EU member states*
14/2005	Stephen G. Cecchetti:	*The brave new world of central banking: The policy challenges posed by asset price booms and busts*
13/2005	Robert F. Engle: Jose Gonzalo Rangel	*The spline GARCH model for unconditional volatility and its global macroeconomic causes*
12/2005	Jaromír Beneš: Tibor Hlédik Michael Kumhof David Vávra	*An economy in transition and DSGE: What the Czech national bank's new projection model needs*
11/2005	Marek Hlaváček: Michael Koňák Josef Čada	*The application of structured feedforward neural networks to the modelling of daily series of currency in circulation*
10/2005	Ondřej Kameník:	*Solving SDGE models: A new algorithm for the sylvester equation*
9/2005	Roman Šustek:	*Plant-level nonconvexities and the monetary transmission mechanism*
8/2005	Roman Horváth:	*Exchange rate variability, pressures and optimum currency area criteria: Implications for the central and eastern european countries*
7/2005	Balázs Égert: Luboš Komárek	*Foreign exchange interventions and interest rate policy in the Czech Republic: Hand in glove?*
6/2005	Anca Podpiera: Jiří Podpiera	*Deteriorating cost efficiency in commercial banks signals an increasing risk of failure*
5/2005	Luboš Komárek: Martin Melecký	*The behavioural equilibrium exchange rate of the Czech koruna*
4/2005	Kateřina Arnoštová: Jaromír Hurník	*The monetary transmission mechanism in the Czech Republic (evidence from VAR analysis)*
3/2005	Vladimír Benáček: Jiří Podpiera Ladislav Prokop	*Determining factors of Czech foreign trade: A cross-section time series perspective*
2/2005	Kamil Galuščák: Daniel Münich	*Structural and cyclical unemployment: What can we derive from the matching function?*
1/2005	Ivan Babouček: Martin Jančar	*Effects of macroeconomic shocks to the quality of the aggregate loan portfolio*
10/2004	Aleš Bulíř: Kateřina Šmídková	*Exchange rates in the new EU accession countries: What have we learned from the forerunners*

9/2004	Martin Cincibuch: Jiří Podpiera	*Beyond Balassa-Samuelson: Real appreciation in tradables in transition countries*
8/2004	Jaromír Beneš: David Vávra	*Eigenvalue decomposition of time series with application to the Czech business cycle*
7/2004	Vladislav Flek, ed.:	*Anatomy of the Czech labour market: From over-employment to under-employment in ten years?*
6/2004	Narcisa Kadlčáková: Joerg Keplinger	*Credit risk and bank lending in the Czech Republic*
5/2004	Petr Král:	*Identification and measurement of relationships concerning inflow of FDI: The case of the Czech Republic*
4/2004	Jiří Podpiera:	*Consumers, consumer prices and the Czech business cycle identification*
3/2004	Anca Pruteanu:	*The role of banks in the Czech monetary policy transmission mechanism*
2/2004	Ian Babetskii:	*EU enlargement and endogeneity of some OCA criteria: Evidence from the CEECs*
1/2004	Alexis Derviz: Jiří Podpiera	*Predicting bank CAMELS and S&P ratings: The case of the Czech Republic*

12/2003	Tibor Hlédik:	*Modelling the second-round effects of supply-side shocks on inflation*
11/2003	Luboš Komárek: Zdeněk Čech Roman Horváth	*ERM II membership – the view of the accession countries*
10/2003	Luboš Komárek: Zdeněk Čech Roman Horváth	*Optimum currency area indices – how close is the Czech Republic to the eurozone?*
9/2003	Alexis Derviz: Narcisa Kadlčáková Lucie Kobzová	*Credit risk, systemic uncertainties and economic capital requirements for an artificial bank loan portfolio*
8/2003	Tomáš Holub: Martin Čihák	*Price convergence: What can the Balassa–Samuelson model tell us?*
7/2003	Vladimír Bezděk: Kamil Dybczak Aleš Krejdl	*Czech fiscal policy: Introductory analysis*
6/2003	Alexis Derviz:	*FOREX microstructure, invisible price determinants, and the central bank's understanding of exchange rate formation*
5/2003	Aleš Bulíř:	*Some exchange rates are more stable than others: Short-run evidence from transition countries*
4/2003	Alexis Derviz:	*Components of the Czech koruna risk premium in a multiple-dealer FX market*
3/2003	Vladimír Benáček: Ladislav Prokop Jan Á. Víšek	*Determining factors of the Czech foreign trade balance: Structural issues in trade creation*
2/2003	Martin Čihák: Tomáš Holub	*Price convergence to the EU: What do the 1999 ICP data tell us?*

1/2003	Kamil Galuščák: Daniel Münich	*Microfoundations of the wage inflation in the Czech Republic*
4/2002	Vladislav Flek: Lenka Marková Jiří Podpiera	*Sectoral productivity and real exchange rate appreciation: Much ado about nothing?*
3/2002	Kateřina Šmídková: Ray Barrell Dawn Holland	*Estimates of fundamental real exchange rates for the five EU pre-accession countries*
2/2002	Martin Hlušek:	*Estimating market probabilities of future interest rate changes*
1/2002	Viktor Kotlán:	*Monetary policy and the term spread in a macro model of a small open economy*

CNB RESEARCH AND POLICY NOTES

5/2005	Jan Stráský:	*Optimal forward-looking policy rules in the quarterly projection model of the Czech National Bank*
4/2005	Vít Bárta:	*Fulfilment of the Maastricht inflation criterion by the Czech Republic: Potential costs and policy options*
3/2005	Helena Sůvová: Eva Kozelková David Zeman Jaroslava Bauerová	*Eligibility of external credit assessment institutions*
2/2005	Martin Čihák: Jaroslav Heřmánek	*Stress testing the Czech banking system: Where are we? Where are we going?*
1/2005	David Navrátil: Viktor Kotlán	*The CNB's policy decisions – Are they priced in by the markets?*
4/2004	Aleš Bulíř:	*External and fiscal sustainability of the Czech economy: A quick look through the IMF's night-vision goggles*
3/2004	Martin Čihák:	*Designing stress tests for the Czech banking system*
2/2004	Martin Čihák:	*Stress testing: A review of key concepts*
1/2004	Tomáš Holub:	*Foreign exchange interventions under inflation targeting: The Czech experience*
2/2003	Kateřina Šmídková:	*Targeting inflation under uncertainty: Policy makers' perspective*
1/2003	Michal Skořepa: Viktor Kotlán	*Inflation targeting: To forecast or to simulate?*

CNB ECONOMIC RESEARCH BULLETIN	
August 2006	*Research priorities and central banks*
November 2005	*Financial stability*
May 2005	*Potential output*
October 2004	*Fiscal issues*
May 2004	*Inflation targeting*
December 2003	*Equilibrium exchange rate*

Czech National Bank
Economic Research Department
Na Příkopě 28, 115 03 Praha 1
Czech Republic
phone: +420 2 244 12 321
fax: +420 2 244 14 278
http://www.cnb.cz
e-mail: research@cnb.cz