The Possibilities to Estimate Labour Productivity and Total Factor Productivity for Czech Regions

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Abstract

Productivity measuring is a popular part of economic and statistical analysis of a country. The simplest productivity measure is based on labour productivity. It is a revealing indicator among economic indicators because it offers dynamic measures of economic growth, competitiveness and living standard. Besides labour productivity, it is common to carry out total factor productivity measurement including both labour and capital input. This paper focuses on the total factor productivity measurement on a regional level between the years 2006 and 2009. Regional productivity measurements show a different approach to regional analyses. There are very few analyses focusing on regional capital formation and capital stocks. This paper describes the possibility of using regional factors (labour and capital stocks) to complete total factor productivity measurement.

Keywords

Gross value added, labour productivity, region, total factor productivity

JEL code

E01, O47

INTRODUCTION

Productivity is one of the most important tools to evaluate economic growth of the country. In the case of the Czech Republic, this issue was mainly dealt with on the industrial level of national data but there is a possibility to apply the productivity measurement on regions. Employing regional indicators has become very popular. The supply of regional indicators is slowly and continuously rising with the importance of regional analyses. From the economic point of view, regional statistics may allow us to identify more statistical patterns and the difference in trends in comparison with national data.

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Labour productivity, which is defined as the volume of output divided by the input used, is probably the most important part of economic and statistical analysis of a country. It is a revealing indicator that offers dynamic measures of economic growth, competitiveness and living standards. It helps to explain the principal economic foundations that are necessary for economic growth and social development (OECD, 2001). As the input variable, one can use hours worked, total number of employees or labour services which reflect the quality of labour force. As the output variable, gross value added is recommended instead of gross domestic product because gross value added excludes taxes.

The simplest version of total factor productivity deals with two input variables — labour and capital. Total employment, hours worked and labour services can be used in terms of labour input (OECD, 2001, ESA, 1995[3]). As the capital input, net capital stock of fixed assets or capital services can be used. Capital stocks are easily accessible on the national level but on the regional level such data are not usually published and users have to carry out these estimates themselves. Capital services can serve as a better input of capital because the quality of the capital is taken into account (Sixta, Fischer, 2009). Capital services can also be constructed on the regional level but this is very demanding in terms of data and therefore capital stocks are used.

The aim of this paper is to show another possible way of regional analysis via productivity. Firstly, one estimates labour productivity and consequently total factor productivity. The analysis is made for eight Czech regions in the period between 2006 and 2009. Obtained results using different input variables are compared between the regions and the differences are discussed. Besides, the process of construction of regional stocks is described as a useful source for other users.

1 DATA AND METHODOLOGY

The Czech Republic is divided into eight regions: Praha, Střední Čechy, Jihozápad, Severozápad, Severovýchod, Jihovýchod, Střední Morava and Moravskoslezsko. The division is based on the Nomenclature of Territorial Units for Statistics[4] (NUTS) which is used to subdivide the territory of the European Union into regions at 3 different levels. The regions mentioned are at level 2 (NUTS 2).

For an analysis of regional labour productivity and total factor productivity, it is necessary to investigate the most suitable data for the input and output variable. The output variable reflects the goods and services produced by the labour force. This variable is measured either by gross domestic product (GDP) or gross value added (GVA) in constant prices. In the case when both indicators are available, there is a preference towards using value added as taxes are excluded. Since the Czech Statistical Office publishes regional gross value added in constant prices of the previous year and in current prices, the chain linked method was used to calculate the volume index of output:

$$I_{GVA\frac{09}{06}} = \frac{GVA_{\frac{09}{08}}}{GVA_{\frac{08}{08}}} \times \frac{GVA_{\frac{08}{07}}}{GVA_{\frac{07}{07}}} \times \frac{GVA_{\frac{07}{06}}}{GVA_{\frac{06}{06}}} \tag{1}$$

For the measurement of labour input, the dataset from the Average Earnings Information System (hereafter: ISPV)[5] and Czech Statistical Office were used.[6] This dataset includes regional data of hours worked, average wage and number of employees divided by the level of education. The input variable reflects the

[3] ESA 1995 is an European modification of international standard SNA 1993.

[4] This classification is based on the Act of the European Parliament No. 1888/2005.

[5] ISPV = Average Earnings Information System survey is the system of regular inspection of earnings and working hours of the employees in the Czech Republic. The main indicators monitored are hourly wage and gross monthly wage.

time, effort and skills of the labour force. It is the most important factor that influences the measurement of labour productivity. Labour input is measured either by hours worked, total employment or the latest option — labour services. All the possible inputs mentioned have their advantages and disadvantages. According to ESA 95, the hours worked are the most suitable for labour input because a simple headcount of labour force can hide changes in average hours worked, caused by the evolution of part-time work or the effect of variations in overtime, absence from work or shifts in normal hours. On the other hand, total employment is easy to measure but less recommended for not reflecting changes in the average work time per employee and changes in multiple job holdings and the role of self-employed persons. Labour services[7] are the only one input measure which reflects the skills of the labour force. This paper discriminates four levels of education — primary, secondary without A-levels, secondary with A-levels and tertiary. Standard measures of labour input do not take the education differences into account. Labour services respect differences in the amount of services delivered per unit of labour in the output growth. It is assumed that the flow of labour services for each labour type is proportional to hours worked, and workers are paid according to their marginal productivities.[8] Then the index of labour services input *LS* is given by:

$$\Delta \ln LS_t = \sum_l \bar{v}_{l,t} \Delta \ln H_{l,t}\,, \tag{2}$$

where $\Delta \ln H_{l,t}$ indicates the growth of hours worked by labour type l and weights (v) are given by the average share of each type in the values of labour compensation in current prices. Thus, aggregation takes into account the changing composition of the labour force. A shift in the share of hours worked by low-skilled workers to high-skilled workers will lead to a growth of labour services which is larger than the growth in total hours worked. This difference is called the labour composition effect.

The index of labour composition is divided into the index of hours worked and the index of labour services (2):

$$\frac{\mathrm{LC}_1}{\mathrm{LC}_0} = \frac{\left(\frac{\mathrm{LS}_1}{\mathrm{LS}_0}\right)}{\left(\frac{\mathrm{H}_1}{\mathrm{H}_0}\right)}\,. \tag{3}$$

At first, the contribution of the change in labour services to the change in value added is computed; then the contribution of the change in hours worked to the change in value added and the contribution of the change in labour composition to the change in value added are calculated.

The measurement of labour services does not reflect the ability and skills which labour force gains during the work experience. There are several kinds of human capital measurement (Mazouch, Fischer, 2011). Unfortunately, none of them is suitable as a measurement of human capital in production function.

As the capital input for measuring total factor productivity, gross fixed assets or capital services can be used. Even capital services provide comprehensive measures of capital inputs respecting not only changes in the volume of capital but also the quality of services provided. Construction of capital ser-

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[6] ISPV does not cover enterprises with less than 10 employees which is why we use the ratio coefficients employing the data from the Czech Statistical Office. The differences between the data from ISPV and Labour Force Survey are discussed in Čadil et al. (2011).

[7] Analysis of the labour services is discussed by O'Mahony, Timmer, van Ark (2007).

[8] In the analysis average wages are used instead of marginal productivities because one can assume that the average wages are indicators of marginal productivities.

vices on a regional level is very demanding. Capital services[9] show the contribution of capital to the production process and the volume index of capital services is a suitable input indicator to total factor productivity measurement.

General approach to the volume index of capital services is based on the following (OECD, 2001):[10]

$$I_q = \prod_{i=1}^{N} \left(\frac{C_{i,t}}{C_{i,t-1}}\right)^{\bar{v}_i}, \tag{4}$$

$$v_{i,t} = \frac{f_{i,t} C_{i,t}}{\sum_{i=1}^{N} f_{i,t} C_{i,t}}, \tag{5}$$

$$\bar{v}_i = \frac{1}{2}(v_{i,t} + v_{i,t-1}), \tag{6}$$

where C capital stocks in efficiency unit,
f capital services,
v weights derived from operating surplus,
I type of asset,
t time.

The key element of equation 4 is *C*, capital recorded in efficiency units. It means that *C* respects the decreasing quality of services provided by capital due to its usage. Capital services became more known when revised international standard (SNA, 2008) was issued.

As an alternative way, one can decide to use capital stocks, which are easier to estimate on a regional level. Estimates of regional net capital stocks at current prices are based on the balancing method. Original estimates for 2006 were prepared in cooperation with Mr. Jaroslav Kahoun.[11] Data for the total economy at current prices were separated according to regions by institutional sectors and industries. This top-down method allowed to accurately record mainly communications and dwellings. Data for non-financial corporations were split by the shares obtained from statistical surveys on local units' property. Subsequently, this analysis used the balancing method where:

$$C_t = C_{t-1} + I_t - CFC_t + HG_t + O_t, \tag{7}$$

where C_t regional net capital stock on 31st December t,
I_t regional gross fixed capital formation,
CFC_t regional consumption of fixed capital,
HG_t regional holding gain,
O_t regional other changes in volume.

Regional data for consumption of fixed capital, holding gains and other changes in volume are usually not available. Therefore one can estimate them proportionally to the regional capital stock for $t-1$

[9] More information about estimation of capital services for the Czech economy in Sixta, Vltavská, Zbranek (2011).

[10] The methodology of capital services has its own history, recent approaches can be found in (OECD, 2009) but it is less illustrative.

[11] Jaroslav Kahoun is an expert on regional accounts at the Czech Statistical Office.

in different industries. For the total factor productivity measurement, volume indices are required. Therefore, published deflators[12] of capital stocks for industries were used and current prices estimates were recalculated into prices of 2000. The Table 1 shows regional capital stocks at current prices and volume indices.

Table 1 Regional net capital stocks of fixed assets, 2006–2009, current prices (volumes in %)

	2006	2007		2008		2009	
	Current prices	Current prices	Volumes, PY = 100	Current prices	Volumes, PY = 100	Current prices	Volumes, PY = 100
Total	**12 428 799**	**13 151 638**	**102.2**	**13 814 705**	**101.8**	**14 066 661**	**100.4**
Praha	2 839 550	3 119 082	105.9	3 396 821	105.2	3 528 292	102.4
Střední Čechy	1 429 491	1 491 187	100.9	1 537 946	100.1	1 551 534	99.5
Jihozápad	1 366 840	1 429 510	101.1	1 474 615	100.0	1 492 374	99.6
Severozápad	1 133 722	1 190 519	101.6	1 238 335	100.9	1 256 468	100.0
Severovýchod	1 512 825	1 567 781	100.2	1 622 554	100.3	1 629 144	99.1
Jihovýchod	1 859 966	1 963 617	102.0	2 053 138	101.3	2 083 673	100.0
Střední Morava	1 108 458	1 155 841	100.8	1 195 597	100.3	1 215 352	100.3
Moravskoslezsko	1 177 946	1 234 101	101.4	1 295 699	102.0	1 309 823	99.8

Note: PY — previous year.
Source: Czech Statistical Office, own calculation

Measuring productivity is a popular part of economic research. For estimation of total factor productivity, the neo-classic Cobb-Douglas production function and the index number approach are recommended. This method is based on the Törnqvist index number formula which can be used if the function is a member of the class of homogeneous of degree one transcendental logarithmic functions (Lau, 1979). This approach assumes a constant return to scale. Recently, a discussion is in progress about the return to scale (represented by the condition $\alpha_L + \alpha_K = 1$) and about the sustainability of the constant return to scale assumption. This paper can not discuss this assumption by employing econometric methods as the time series are too short. Employing traditional inputs, the index of productivity of two factors (*A1 / A0*) originates from the following decomposition (Jílek, Moravová, 2007):

$$\frac{Y_1}{Y_0} = \frac{A_1}{A_0}\left(\frac{C_1}{C_0}\right)^{1-\alpha}\left(\frac{H_1}{H_0}\right)^{\alpha}, \tag{8}$$

where
- Y_1 / Y_0 is the index of gross value added in constant prices of 2000,
- C_1 / C_0 is the index of net fixed assets in constant prices of 2000,
- H_1 / H_0 is the index of hours worked,
- α is the average share of compensation of employees on gross value added at current prices.[13]

[12] All national accounts data can be found at: *www.czso.cz.*

[13] More information about the estimation of return to scales in Hulten (2000).

Using alternative labour input, the index of productivity of two factors originates from the following:

$$\frac{Y_1}{Y_0} = \frac{A_1^*}{A_0^*}\left(\frac{C_1}{C_0}\right)^{1-\alpha}\left(\frac{LS_1}{LS_0}\right)^{\alpha}, \tag{9}$$

where LS_1 / LS_0 is the index of labour services.

This paper designates the indicators used in its formulas based on the national accounts. Therefore the results presented in the tables are labelled as follows: gross value added *GVA* (instead of *Y* used in the equation), capital input *C*, labour input *L* or *LS* and index of total factor productivity *TFP* instead of *A*.

2 RESULTS

2.1 Regional labour productivity

Firstly, labour productivity using the index of gross value added and index of hours worked by region is estimated.

Table 2 Change in regional labour productivity, 2006–2009, average annual growth (in %)

Region	LP
Praha	2.12
Střední Čechy	1.34
Jihozápad	–1.56
Severozápad	–0.37
Severovýchod	0.73
Jihovýchod	0.77
Střední Morava	1.31
Moravskoslezsko	–1.00

Note: LP — % change in labour productivity using hours worked as input.
Source: Czech Statistical Office, ISPV, own calculation

The Table 3 shows the decomposition of labour productivity to the productivity based on hours worked and a part created by labour composition of the labour force in the Czech regions in the period between 2006 and 2009.

By using the decomposition of contribution of labour services into contribution of hours worked and contribution of labour composition one can find out how a shift in the proportion of hours worked by low-skilled workers to high-skilled workers leads to a growth of labour services. This increase is larger than the growth of hours worked.

The value of contribution of labour composition shows that the average annual growth of the

As seen in the Table 2, the highest average annual growth of regional labour productivity in the period between 2006 and 2009 was achieved in Praha. The second most significant average annual growth in the period in question was reached in the region of Střední Čechy. On the other hand, the largest decrease of labour productivity was recorded in regions Jihozápad and Moravskoslezsko.

In this paper, the influence of human capital on regional labour productivity is measured as well. The question is how significant a part of the labour productivity is caused by the skills of the work force.

Table 3 Change in regional labour productivity using hours worked and labour services as the input, change in labour composition effect, 2006–2009, average annual growth (in %)

Region	LP	LP*	LC
Praha	2.12	1.23	0.88
Střední Čechy	1.34	1.36	–0.02
Jihozápad	–1.56	–1.90	0.35
Severozápad	–0.37	–1.04	0.68
Severovýchod	0.73	0.06	0.67
Jihovýchod	0.77	0.09	0.67
Střední Morava	1.31	1.00	0.31
Moravskoslezsko	–1.00	–1.69	0.70

Note: LP — % change in labour productivity using hours worked as the input, LP* — % change in labour productivity using labour services as the input, LC — % change in labour composition effect.
Source: Czech Statistical Office, ISPV, own calculation

level of education in the period in question was recorded in the following regions: Praha (0.88 %), Moravskoslezsko (0.70 %), Severozápad (0.68 %), Severovýchod and Jihovýchod (0.67 %). The decrease of the level of education was reported only in one region, Střední Čechy (–0.02 %). The part of the increase of the level of education of the work force in the regions of Moravskoslezsko and Jihovýchod is caused by research centres being founded in these areas. Such centres obviously need highly qualified work force.

The increase in education level in Praha was caused to a large extent by the region's positive orientation towards real estate, renting and business activities industry. Companies in the region require their work force to gain tertiary education with a possibility to accomplish this during the first years of their careers. Employers commonly cooperate with universities and companies can even found their own colleges or universities to school their staff (e.g. Unicorn).

The decrease in the level of education in the region of Střední Čechy is an interesting fact. This phenomenon reflects the orientation of the region on manufacturing and the inhabitants' frequent commuting to Praha, which correspondingly raises the level of education in the companies based in the capital city.

2.2 Regional total factor productivity

Total factor productivity reflects both inputs (labour and capital) and it is closer to economic reality. There are several approaches to total factor productivity measurement (e.g. EU-KLEMS project)[14] but this paper focused on two factors. This analysis uses the index number approach. As the input variables, labour services or hours worked and net stock of fixed assets were used; as the output, variable regional gross value added was used.

Table 4 Calculation of regional total factor productivity index, using hours worked and net stock of fixed assets as inputs, total growth from 2006 to 2009 (in %)

Region	GVA	C	H	TFP
Praha	11.37	6.95	2.20	1.89
Střední Čechy	11.10	0.32	2.84	7.69
Jihozápad	–3.83	0.39	0.40	–4.58
Severozápad	–2.11	1.27	–0.49	–2.86
Severovýchod	0.79	–0.22	–0.69	1.71
Jihovýchod	4.44	1.65	1.03	1.70
Střední Morava	4.44	0.74	0.21	3.46
Moravskoslezsko	–0.12	1.64	1.44	–3.12

Note: GVA — change in gross value added in %, H — contribution of change in hours worked to change in GVA, C — contribution of change in net stock of fixed assets to change in GVA, TFP — total factor productivity growth in %.
Source: Czech Statistical Office, ISPV, own calculation

The highest increase of regional gross value added in the period between 2006 and 2009 was achieved in the region of Praha. The main proportion of this growth was constituted by net stock of fixed assets (6.95 %). Hours worked and total factor productivity represents a much lower influence with 2.20 % and 1.89 % respectively. The deepest decrease of regional gross value added was recorded in the region Jihozápad with a decline of 3.83 %. The main proportion of this was constituted by total factor productivity (–4.58 %). The increase of net fixed assets and hours worked was very small. On the other hand, the decrease of gross value added was much more significant.

[14] For more information about the EU-KLEMS project see: *www.euklems.org*.

Table 5 Calculation of regional total factor productivity index, using labour services and net stock of fixed assets as inputs, total growth from 2006 to 2009 (in %)

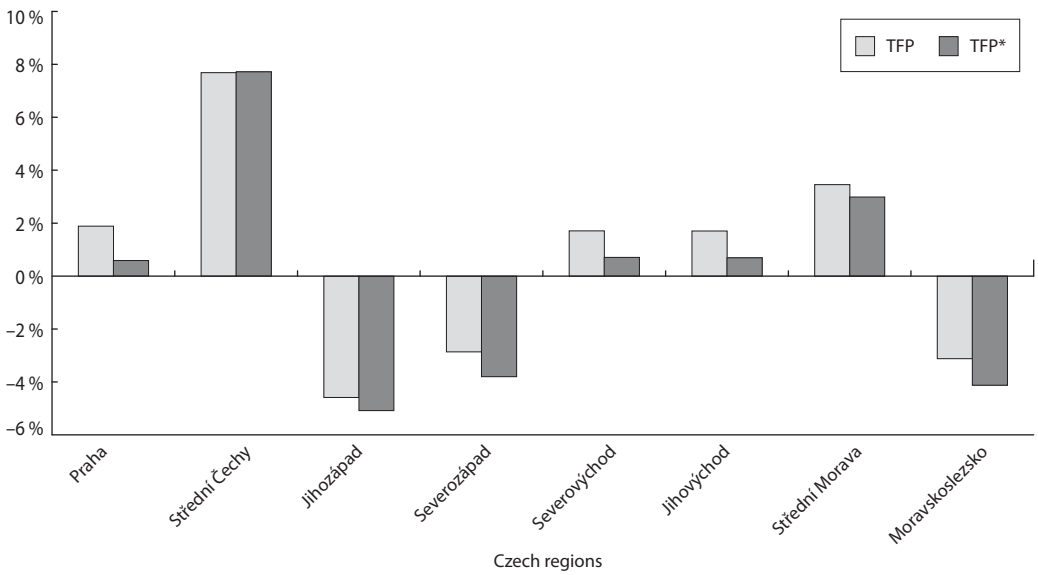
Region	GVA	C	LS	H	LC	TFP*
Praha	11.37	6.95	3.53	2.20	1.30	0.58
Střední Čechy	11.10	0.32	2.81	2.84	–0.03	7.72
Jihozápad	–3.83	0.39	0.93	0.40	0.53	–5.08
Severozápad	–2.11	1.27	0.48	–0.49	0.98	–3.81
Severovýchod	0.79	–0.22	0.30	–0.69	1.00	0.70
Jihovýchod	4.44	1.65	2.04	1.03	1.00	0.69
Střední Morava	4.44	0.74	0.67	0.21	0.46	2.99
Moravskoslezsko	–0.12	1.64	2.50	1.44	1.04	–4.12

Note: GVA — change in value added in %, LS — contribution of change in labour services to change in GVA, H — contribution of change in hours worked to change in GVA, LC — contribution of change in labour composition to change in GVA, C — contribution of change in net stock of fixed assets to change in GVA, TFP* — total factor productivity growth in %, adjusted of labour composition effect.
Source: Czech Statistical Office, ISPV, own calculation

In the case of the pre-crises period between the years 2006 and 2008 the results are quite different. The highest increase of total factor productivity was achieved in the region Střední Čechy (11.80 %). It was caused by a small increase in hours worked (2.53 %) and net fixed assets (0.58 %) and by a much higher increase in gross domestic product (15.30 %).

By using the decomposition of contribution of labour services into contribution of hours worked and contribution of labour composition one can find out how a shift in the proportion of hours worked by low-skilled workers to high-skilled workers leads to a growth of labour services that is larger than the growth of hours worked in the Czech regions.

Figure 1 Comparison of regional TFP using standard and alternative methodology of computation, total growth from 2006 to 2009 (in %)



Source: own calculation

The value of contribution of labour composition shows that the highest growth of the level of education in the period between the years 2006 and 2009 was recorded in regions Praha (1.30 %), Moravskoslezsko (1.04 %), Severovýchod and Jihovýchod (1.00 %). The decrease of the level of education was reported only in one region, Střední Čechy (–0.03 %). The decrease of the level of education in the region Střední Čechy was caused by the daily commuting of the labour force to the capital city of Prague. This caused the increase of the level of education in Prague and the decrease in Střední Čechy at the same time.

Using the labour services as input variable one can see the difference in regional total factor productivity measurement in the given period. The highest difference between standard computation and the alternative computation of *TFP* is within the region Praha (1.3 p.p.). The transformation of the labour input from a stock indicator to a flow indicator which respects the quality of the work force means cutting a part of the residual and giving out more precise results of total factor productivity in the Czech region in the period between the years 2006 and 2009.

CONCLUSION

Productivity measurement is a popular and useful kind of measurement used for economic growth evaluation. Firstly, this paper discussed the availability of the regional data. As the output variable, gross value added at current prices and prices of the previous year was used for the estimation of the index of gross value added. The data from ISPV (hours worked, average wage, number of employees) were used for the estimation of the input variable. Regional capital input was estimated from the data published by the Czech Statistical Office. Net stock of fixed assets was split according to the regions and revaluated into constant prices. The paper focused mainly on finding out what part of labour productivity and total factor productivity the level of education represents. All regions except for Střední Čechy recorded average annual growth in the level of education between the years 2006 and 2009. The growth in the number of work force with completed tertiary education and placement of European Centres of Excellence will undoubtedly raise the labour productivity through the increase in the level of education among the labour force in Czech regions in the upcoming years.

As in other analyses Praha stands out highly. In the period between 2006 and 2009 the capital city achieved the highest increase of education of the labour force, which is larger than the increase of education of the labour force in the Czech Republic in the period in question. The decrease in the level of education was reported in the region Střední Čechy. This interesting fact does not mean that the education decreased among the population of the region in question. In fact, the education increased in the region Střední Čechy but the labour force with the best education was commuting to Praha. Thus, the level of education recorded an increase in the capital city instead of the region.

This paper shows that the regional analysis brings the possibilities to evaluate an economy further.

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