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CENTROPE Regional Development Report

Technical Report on Forecasting for the CENTROPE Region

Peter Huber (WIFO), Martin Labaj (EU SAV)

October 2012

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Austrian Institute of Economic Research, Institute of Economic Research Slovak Academy of Sciences

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Abstract

This report surveys the forecasting quality of the Cambridge Econometrics forecasts used in the CENTROPE Regional Development Report project and derives first estimates of total factor productivity for the CENTROPE regions. While forecasts from Cambridge Econometrics for the CENTROPE aggregate seem to be informative of future growth developments, forecasts for individual regions and sectors must be interpreted with much greater care in all cases except for those of the Austrian CENTROPE and service sector development. Furthermore the report confirms the large productivity differences among CENTROPE regions. These differences are, however, smaller when accounting for total factor productivity than when considering labour productivity. In addition the economic recession of 2009 led to a decline in productivity growth across the CENTROPE regions. In this recession the service sector seems to have played a stabilising role. This highlights the importance of the service sector during economic declines.

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CENTROPE Regional Development Report – Technical report on forecasting for the CENTROPE region

Peter Huber (WIFO), Martin Labaj (EU SAV)

Table of contents

List of tables

List of figures

CENTROPE Regional Development Report – Technical report on forecasting for the CENTROPE region

1. Introduction

In the course of the CENTROPE regional development report project one issue that repeatedly arose was what existing forecasts predicted on the likely future development of the region. For this purpose the project team used the forecasts derived by Cambridge Econometrics. These forecasts are based on an econometric forecasting model (described in Gardiner, 2001) for NUTS 3 regions based on a unique data set constructed by Cambridge Econometrics (see www.cameecon.com/Europe/Regional_local_Cities for a description) and are regularly updated. For the regional development reports in the CENTROPE regional development report project the spring 2010 and autumn 2010 versions of these forecasts were used. A natural question that arises is, how reliable these estimates are. In this report we, therefore, assess the reliability of the current forecasts, by focusing, on the forecasting quality of previous forecasts for the CENTROPE region.

A more detailed analysis of forecasting quality – which shows that the model can be expected to provide reliable estimates of EU-wide regional development except for in years where substantial unforeseen events, such as the financial and economic crisis of 2008 occur – has previously been conducted by Cambridge Economics (see www.cameecon.com/Europe/Regional_local_Cities) our contribution in this report therefore is to assess the quality of forecasts to a particular set of NUTS 3 regions in the EU namely the CENTROPE regions.

A second issue of data quality that has repeatedly arisen in the CENTROPE regional development report project was that throughout the project – due to serious data constraints – labour productivity (i.e. GVA per worker) was used as a measure to discuss productivity in CENTROPE, although from a economic theoretical perspective total factor productivity would be a more convincing concept to focus on. For this reason despite substantial data constraints own estimates of total factor productivity based on a growth accounting framework were developed by the CENTROPE regional development report project. Although our results – on account of the difficult data situation[1] – are preliminary and might be subject to revision in later research, this report presents these estimates – which are currently available for the time period 2008 to 2009 and compares both the level of total factor productivity as well as total factor productivity growth over this admittedly still short time period, as an additional robustness check to our previous findings based on labour productivity measures.

In the next section of the technical report we therefore focus on the forecasting quality of the Cambridge Econometrics forecasts, we find that while existing forecasts seem to predict the CENTROPE aggregate with some precision, forecasts for individual regions and sectors must be interpreted with great care in all cases except for those of the Austrian CENTROPE and service sector development. In the third chapter, by contrast, we then focus on total factor productivity estimates, here we show that first of all there are still rather large differences in total factor productivity among CENTROPE regions that largely mirror those found for labour productivity, while second of all also the scarce evidence on changes in total factor productivity growth indicate a decline during the crisis. Chapter 3 finally summarizes the major findings of this report.

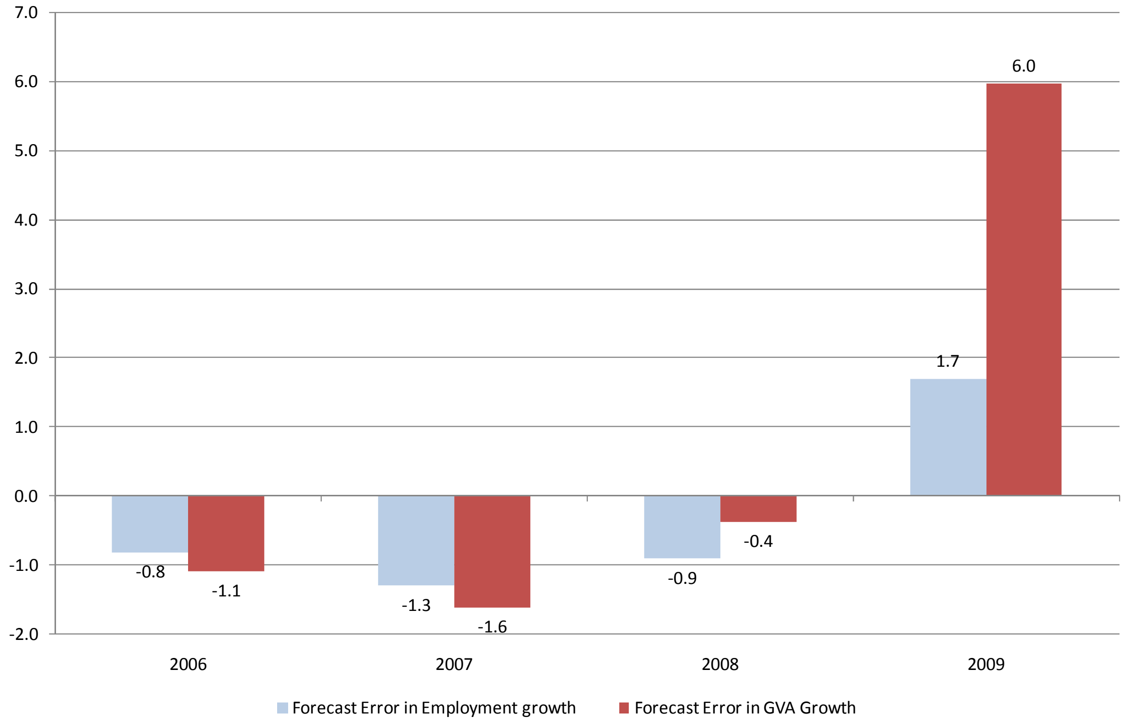
2. The Forecasting Quality of the Cambridge Econometrics Model

To assess the quality of the Cambridge Econometrics forecasts we use the one year forecasts (i.e. the forecast made for 2009 in the year 2008, for 2007 in 2006 and soon) of the years 2006 to 2009 and compare them to their realization in 2010.[2] To visually inspect the forecasting quality we follow the approach of previous evaluations of the forecast quality of this data and focus on the difference between the predicted growth rate in employment or GVA and the actual value in percentage points. This is referred to as the forecast error. A negative value of the forecast error indicates that the forecast of the respective aggregate was too low relative to the realization, while a positive value indicates that the forecast was too high relative to the actual value.

[1] This arises from patchy and not very recent data on GVA and employment as well as unreliable estimates of the capital stock and lacking data on skills of the workforce, hours worked, wages received, capital stock vintages and many other data one would like to have available for such an estimate.

[2] Note that due to the data constraints on official data this implies that these forecasts are made with a two year lead on official data (i.e. for the forecast of 2007 in 2006 only official data for the year 2005 was available and so on).

Figure 1: Forecast error of GVA and Employment growth rates for the years 2006 to 2009 in CENTROPE Total

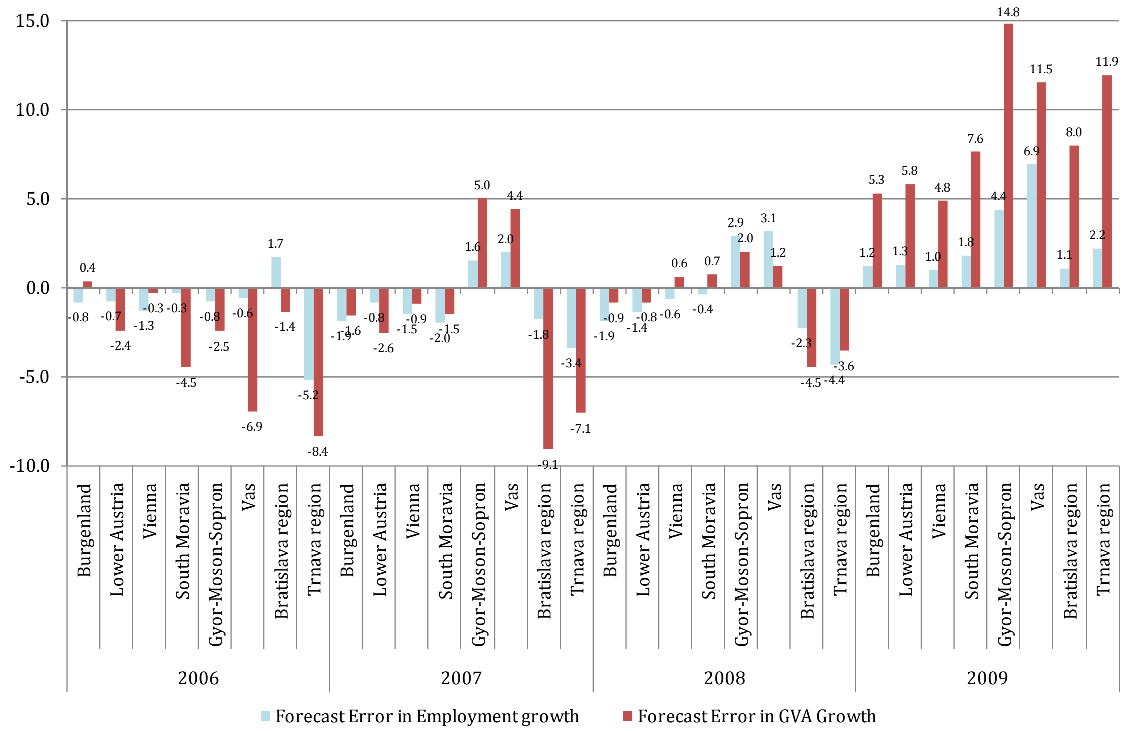


Source: Cambridge Econometrics, own calculations. Note: Forecast error = Difference between predicted and actual growth rates.

As can be seen from figure 1, which displays the forecast error for the total CENTROPE for individual years, on the level of the total CENTROPE the used forecasts seem to provide a satisfactory forecasting quality. The forecasts for the total CENTROPE both with respect to employment as well as with respect to GVA growth were too pessimistic for the years 2006 to 2008, but in general the forecast error is around one percentage point, which can be considered a sufficient reliability, given that the forecast – due to data constraints – is a two year forecast of actual developments. The same does, however, not apply to the year 2009. Clearly here the Cambridge Econometric forecasts in 2008 were much too optimistic. The 2008 forecast for employment growth was 1.7 percentage points higher than the actual growth and the forecast for GVA growth was 6.0 percentage points higher than in reality. These large forecast errors, however, reflect the unexpected nature of the deep recession in 2009 and actually are comparable to many forecasts of national economies.[3]

Thus, in terms of forecasts for the CENTROPE total, it seems that the forecasting quality of the forecasts used, although not perfect, has an acceptable forecast error. The same does, however, not apply to the forecasts for individual regions. Here the forecast errors (displayed in Figure 2) suggest that first of all forecasts were almost always too pessimistic for almost all regions over the 2006 to 2008 period, except for the Hungarian CENTROPE in 2007 and 2008 and Vienna and South Moravia in 2008, while – for the reasons already explained above – they were much too optimistic in 2009.

Figure 2: Forecast error of GVA and Employment growth rates for the years 2006 to 2009 in the individual CENTROPE regions



Source: Cambridge Econometrics, own calculations. Note: Forecast error = Difference between predicted and actual growth rates.

[3] Thus for instance the forecasting errors of many national summer forecasts for the year 2009 in 2008 were comparable to these errors.

Furthermore the results also suggest that forecasting quality differs substantially between different regions. Thus – leaving the year 2009 aside – forecasting errors amounted to between 1 to 2 percentage points in the 2006 to 2008 period in the Austrian CENTROPE and were of similar quality in South Moravia. For the Slovak CENTROPE and the Hungarian CENTROPE by contrast forecasting quality is much lower. Here forecasts were much too pessimistic for Trnava region for all of the pre-crisis period (with forecast errors amounting to up to –7.1 percentage points for GVA) and also for most years in Bratislava region (where the forecast underestimated actual GVA growth by 9.1 percentage points in 2007). For the Hungarian CENTROPE, by contrast, estimates were overly optimistic both in 2007 and 2008.

Table 1: Average bias in forecasts of employment and GVA growth 2006 to 2009 in total and by sector

	Total	Agriculture	Industry	Services
		Employment		
Burgenland	–0.8	1.0	–1.4	–1.2
Lower Austria	–0.4	0.7	–0.5	–0.7
Vienna	–0.6	0.1	0.6	–0.8
South Moravia	–0.2	–1.3	0.4	–0.5
Gyor-Moson-Sopron	2.0	5.4	0.7	2.4
Vas	2.9	1.9	4.4	–0.6
Bratislava region	–0.3	8.6	0.5	–0.8
Trnava region	–2.7	6.2	–5.2	–2.6
TOTAL	–0.3	2.0	–0.2	–0.7
		GVA		
Burgenland	0.8	–2.5	1.1	1.0
Lower Austria	0.0	–3.5	–0.1	0.3
Vienna	1.1	–0.9	–0.7	1.4
South Moravia	0.6	–7.8	2.1	0.1
Gyor-Moson-Sopron	2.8	–1.1	3.5	4.9
Vas	2.5	–5.3	1.4	4.5
Bratislava region	–1.7	–9.0	4.2	–3.9
Trnava region	–4.8	4.2	–6.2	–4.2
TOTAL	0.7	–2.3	–0.1	0.7

Source: Cambridge Econometrics, own calculations.

This varying forecast quality is also reflected in average statistics of forecasting quality over the whole observation period such as the bias of the estimate (i.e. the average forecast error) reported in table 1 and the standard deviation of the forecast error reported in table 2. Thus the average bias of the forecast for the aggregate CENTROPE region was –0.3 percentage points for employment growth and 0.7 percentage points for GVA growth for the time period 2006 to 2009, suggesting a slight underestimation of employment growth but a slight overestimation of GVA growth (on account of the overestimation in 2009). Similarly the standard deviation of the forecast error for the CENTROPE region is 1.2 % for employment growth and 1.6 percentage points for GVA growth. This therefore suggests that the forecast's 10% confidence interval is between +/–1.5 percentage points for the forecast. For the Hungarian CENTROPE, by contrast, both the bias of the forecast exceeds 2 percentage points both for employment and GVA growth and the standard error of the forecast even exceeds the 3 percentage point mark. Similarly, for the Slovak CENTROPE – in particular Trnava region – the bias exceeds 2.0 percentage points and the standard deviation of the forecast error again is much higher, in particular for GVA growth forecasts.

Table 2: Standard deviation of the forecast error of forecasts of employment and GVA growth 2006 to 2009 in total and by sector

	Total	Agriculture	Industry	Services
		Employment		
Burgenland	0.8	0.8	1.6	0.8
Lower Austria	0.6	0.6	1.2	0.5
Vienna	0.6	0.5	1.0	0.6
South Moravia	0.7	1.5	1.3	0.6
Gyor-Moson-Sopron	1.4	4.2	3.0	1.2
Vas	2.0	1.0	4.1	1.9
Bratislava region	0.9	10.4	2.5	0.6
Trnava region	2.0	5.6	4.3	1.4
TOTAL	1.2	1.5	1.6	0.4
		GVA		
Burgenland	1.4	1.8	2.6	0.9
Lower Austria	1.7	3.5	3.0	1.0
Vienna	1.2	1.9	3.4	1.0
South Moravia	2.2	8.6	4.2	2.1
Gyor-Moson-Sopron	4.0	9.7	5.9	2.7
Vas	3.5	9.0	4.8	3.2
Bratislava region	3.2	8.2	4.9	3.6
Trnava region	5.2	7.9	6.5	3.8
TOTAL	1.6	2.8	3.4	1.0

Source: Cambridge Econometrics, own calculations.

The reason for this poor forecast performance in the case of the Hungarian and Slovak CENTROPE may be that the forecasts are based on an econometric model that cannot foresee structural breaks. This implies that the substantial FDI inflows into in particular Trnava region, which – as shown in previous regional development reports – have contributed to the region's spectacular growth performance in the last decade, could not be adequately predicted by the model used for forecasting. Similarly, also in the Hungarian

CENTROPE the evident structural break in relative growth performance in the second half of the 2000’s also – documented in previous regional development reports – could not be predicted by the model. This implies that the forecast performance is best in rather stable economic environments such as that of Austria, while in cases of more dynamic environments as in the Hungarian and Slovak CENTROPE forecast quality is likely to suffer.

Finally tables 1 and 2 also present some evidence on the forecasting quality of individual sectors. Here the results indicate a tolerable forecast error for the service sector development – which is also the largest economic sector in the region – for the whole CENTROPE, while in particular the standard deviations of the forecast errors for the other sectors are rather large even in the case of CENTROPE aggregates. The sector developments of individual CENTROPE regions, by contrast, seem to be rather poorly predicted in all regions except for the Austrian CENTROPE.

In sum therefore, these considerations suggest that while forecasts from Cambridge Econometrics for the CENTROPE aggregate seem to be informative of future growth developments forecasts for individual regions and sectors must be interpreted with much greater care in all cases except for those of the Austrian CENTROPE and service sector development.

3. Total factor productivity developments in CENTROPE

A second issue of data quality that has repeatedly arisen in the CENTROPE regional development report project was that throughout the project – due to serious data constraints – labour productivity measures (i.e. GVA per worker) was used to measure productivity in CENTROPE. This is unsatisfactory from a theoretical perspective, since it is easy to show that labour productivity will be – all else equal – higher in regions with a higher abundance of capital, since workers that have more machines are also likely to be more productive. Therefore – given the rather different specialization of individual CENTROPE regions with many of the Hungarian, Czech and Slovak CENTROPE regions specializing on capital intensive manufacturing – a focus on labour productivity may be misleading in terms of both comparisons of productivity between different regions, and second of all in comparisons of productivity over time.

Total factor productivity would be a more convincing concept to focus on. For this reason own estimates of total factor productivity were developed in the CENTROPE regional development report project (see the Annex for a short methodological description). These estimates – although burdened with a number of methodological caveats – allow us to add to existing knowledge by first off enabling us to compare total factor productivity among the CENTROPE regions and second of all allowing us to decompose the contribution of capital accumulation, employment growth and of total factor productivity growth (Barro – Sala-i-Martin, 2004; Weil, 2008) to overall growth over time.

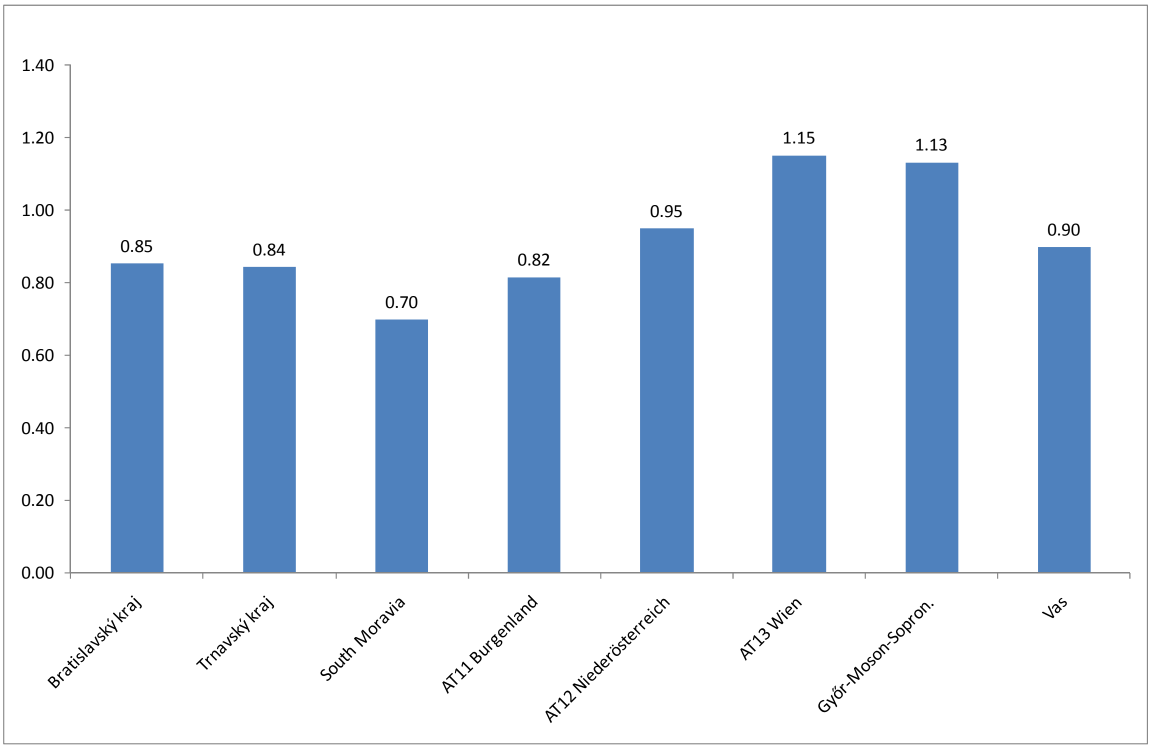
3.1. Comparing total factor productivity over regions

Thus focusing first on a comparison of relative total factor productivity levels of CENTROPE in aggregate as well as in the primary, secondary and tertiary sector separately sectors, we find that productivity levels still differ substantially in the region (see figure 3). Thus for instance overall total factor productivity in Vienna is by 15% higher than in the CENTROPE average, while it is 30% below the average in South Moravia.

By and large, however, these productivity differences accord with the differentials in labour productivity reported in Frank et al (2012): Vienna and Lower Austria are regions with a high total factor productivity, while total factor productivity is lower in The Slovak and Czech parts of CENTROPE and in Burgenland. The only differences are that first of all the differences in total factor productivity between the Czech, Slovak and Hungarian CENTROPE parts are substantially lower than in the differences in labour productivity and that second of all the Hungarian regions perform substantially better than when looking at labour productivity differences.

The first of these can be explained by the high share of manufacturing in the Czech, Slovak and Hungarian parts of CENTROPE (documented in Rozmahel et al, 2011), since the higher capital intensity of industry also leads to an underestimation of productivity in these regions, when labour productivity is used as an indicator of productivity. The second of these differences can probably be explained by methodological differences. While labour productivity estimates were calculated based on exchange rates between the Euro and the Hungarian Forint, total factor productivities were calculated at purchasing power parities (PPPs). Since the Hungarian Forint was undervalued relative to PPP total factor productivity estimates are substantially higher, than labour productivity estimates. This therefore implies that once the undervaluation of the Hungarian Forint in 2009 is accounted for productivity levels in Hungary seem to already be of a level comparable to that of the Austrian CENTROPE. While part of this finding is due to the high share of industry in the Hungarian CENTROPE relative to say the city of Vienna, it once more highlights the substantial catching–up – also documented in many other parts of the CENTROPE development report project – that has taken place in CENTROPE in the last decade.

Figure 3: Estimates of total factor productivity in the CENTROPE regions (Averages 2008 and 2009, CENTROPE Total = 1)



Source: Authors´ computations.

3.2. Total factor productivity growth over time

In sum therefore our total factor productivity estimates in accordance to those of labour productivity suggest that – while substantial differences remain in the region – productivity convergence within CENTROPE has been rather rapid in this region. When considering the growth of total factor productivity in the years 2008 and 2009, by contrast, we find a

Table 3: GVA, Employment growth, capital accumulation and total factor productivity growth in the CENTROPE regions (%)

		GVA Growth			Employment growth			Capital accumulation			Total factor Productivity Growth		
	Sector	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Bratislava region	Primary	11.4	18.6	-24.6	-12.1	27.8	-4.1	-3.5	-2.3	-3.2	20.6	0.7	-20.8
	Secondary	12.8	8.2	-10.4	0.4	-1.9	0.3	13.0	5.9	2.5	8.3	7.5	-11.4
	Tertiary	10.8	3.4	3.4	5.2	3.5	4.1	1.6	1.7	1.6	6.9	0.4	0.2
	Total	11.5	5.2	-1.3	4.0	2.7	3.3	4.1	2.6	1.7	7.5	2.5	-4.1
Trnava region	Primary	16.0	4.5	-32.1	-5.0	-12.5	-26.6	-2.9	-1.3	-3.0	20.3	13.3	-13.3
	Secondary	9.2	1.1	-7.7	5.8	2.3	-7.1	5.4	3.9	1.2	3.5	-1.7	-3.3
	Tertiary	9.2	5.8	-2.6	4.2	2.6	1.7	1.5	3.1	1.7	5.9	3.0	-4.3
	Total	9.5	2.8	-6.9	4.3	1.8	-2.9	2.6	2.9	0.9	5.7	0.6	-5.3
South Moravia	Primary	-25.2	20.2	-0.1	-	-26.1	-12.3	6.0	5.8	4.1	-	35.7	6.8
	Secondary	11.3	20.7	-9.9	-	4.3	-11.7	6.7	5.2	1.9	-	16.1	-2.7
	Tertiary	5.1	-1.8	-3.0	-	0.1	5.9	1.7	2.2	1.3	-	-2.6	-7.4
	Total	6.8	8.8	-6.1	-	0.9	-1.5	2.9	2.9	1.5	-	7.2	-5.6
Burgenland	Primary		-5.4	-5.4		-0.7	-2.8		-1.9	-1.5		-4.3	-3.0
	Secondary		1.4	-6.3		2.2	-2.5		1.7	0.9		-0.6	-5.0
	Tertiary		2.2	-0.2		1.1	1.5		1.3	0.5		1.0	-1.4
	Total		1.6	-2.3		1.3	-0.1		1.0	0.4		0.4	-2.4
Lower Austria	Primary		9.6	-7.2		-1.3	-2.1		-0.6	-0.5		10.6	-5.7
	Secondary		0.3	-14.4		1.6	-3.2		3.4	1.4		-1.9	-12.7
	Tertiary		3.7	-1.6		2.9	0.0		1.4	1.0		1.3	-1.9
	Total		2.7	-6.2		2.2	-1.0		1.6	1.0		0.7	-5.8
Vienna	Primary		7.9	-10.7		-7.4	7.4		-4.3	-4.4		14.3	-14.2
	Secondary		2.8	-10.3		1.8	-2.4		0.4	-0.1		1.5	-8.7
	Tertiary		1.2	-2.7		2.4	-0.2		0.6	-0.3		-0.6	-2.5
	Total		1.5	-4.1		2.3	-0.5		0.6	-0.3		-0.2	-3.7
Gyor-Moson-Sopron	Primary		-3.1	-11.3		-1.1	-3.5	-2.5	-2.0	0.3		-1.7	-9.0
	Secondary		3.6	-13.4		2.2	-7.5	-0.5	0.3	-0.5		2.1	-8.2
	Tertiary		9.9	-5.1		-1.2	-2.0	-3.2	-2.6	-3.2		11.6	-2.8
	Total		6.3	-9.4		0.1	-4.1	-2.3	-1.6	-2.1		6.8	-5.9
Vas	Primary		-23.4	-21.9		0.7	-5.2	-3.3	-3.2	-2.2		-22.8	-17.7
	Secondary		2.7	-10.3		-4.2	-4.5	0.3	1.5	-1.3		5.0	-6.8
	Tertiary		2.9	-9.4		-1.6	-3.0	-3.5	-3.0	-3.0		5.0	-6.4
	Total		0.9	-10.6		-2.6	-3.8	-2.5	-1.9	-2.5		3.2	-7.2

Source: Authors´ computations.

noticeable decline in total factor productivity growth during the crisis that largely mirrors the decline in labour productivity found in Frank et al (2012). Thus as can be seen from table 3, the steep decline in value added in Bratislava and Trnava regions, which was preceded by a substantial growth in 2008, was associated with a marked decline in total factor productivity growth. While the capital stock still expanded in 2009 in both Slovak CENTROPE regions and employment still grew in Bratislava region, productivity which had been growing by 2.5% in 2008 in Bratislava region, decreased by –4.1% in 2009 and by 5.3% in Tranva region. In addition this productivity decline was most pronounced in the primary and secondary sectors, while in the tertiary sector productivity still increased in Bratislava but decreased by –4.3% in Trnava in 2009.

Similar observations also apply to South Moravia. Here productivity with a growth rate of 7.2% was the fastest growing component of GVA growth in 2008, but also shrunk the fastest in 2009. In contrast to the developments in the Slovak CENTROPE here, however, the fastest decline in productivity was found in the tertiary sector, while productivity still increased in the primary sector.

In the Austrian CENTROPE, by contrast, productivity – together with GVA – had already been growing rather modestly in 2008 and was even declining in Vienna, so that in all Austrian CENTROPE regions productivity was growing less rapidly than either capital or employment. This thus suggests a primarily extensive growth already before 2009. As in the rest of the CENTROPE regions productivity, however, started to decline in the Austrian CENTROPE in 2009. These declines were, however, in general somewhat more modest than in the other parts of CENTROPE, with only Lower Austria (–5.8%) experiencing similar declines in total factor productivity as the other parts of CENTROPE.

From the point of view of sector contribution, by contrast, the largest declines in productivity were experienced in the manufacturing sector in the Austrian CENTROPE in 2009, while the tertiary sector proofed to be rather resilient to the crisis. The only exception to this is Vienna. Here – although productivity decline in services was also rather low – productivity in the primary sector reduced somewhat more rapidly than that in the secondary sector. This sector is, however, not very important in Vienna.

Finally, in the Hungarian CENTROPE, patterns of productivity growth follow those of the Slovak and Czech CENTROPE. Despite the somewhat slower GVA growth in Vas already in 2008 productivity still grew at a rather rapid rate in both regions (Vas 3.2.%, Györ-Moson-Sopron 6.8%) of the Hungarian CENTROPE. In 2009, however, a deep decline by

–5.9% in Gyor-Moson-Sopron and by –7.2% in Vas followed, with the declines being most pronounced in the primary sector, followed by the secondary sector and with the tertiary sector experiencing the lowest decline.

In sum therefore we can conclude that the economic recession in 2009, which led to decline in economic activity, also reduced productivity across the CENTROPE and its sectors. Although our evidence shows large differences among the regions, one general tendency seems to have been that the service sector played a stabilizing role in general. This highlights the importance of the service sector during the economic declines.

3.3. Summary

In this report we survey the forecasting quality of the Cambridge Econometrics forecasts used in the CENTROPE regional development report project and derive first estimates of total factor productivity for the CENTROPE regions. The results suggest that while forecasts from Cambridge Econometrics for the CENTROPE aggregate seem to be informative of future growth developments, forecasts for individual regions and sectors must be interpreted with much greater care in all cases except for those of the Austrian CENTROPE and service sector development.

Furthermore our results while confirming the finding of large productivity differences among CENTROPE regions add to existing knowledge by showing that these differences are somewhat smaller when accounting for total factor productivity than when considering labour productivity. In addition they also indicate that the economic recession of 2009, also led to a decline in productivity growth across the CENTROPE regions and its sectors. Although our evidence shows large differences among the regions, one general tendency seems to have been that the service sector played a stabilizing role in general. This highlights the importance of the service sector during economic declines.

4. Technical annex – Deriving Total Factor Productivity estimates

Long-term economic growth is determined by supply-side factor inputs such as labour, capital and technological progress. Growth accounting is an empirical methodology that allows for the breakdown of observed growth of GDP into components associated with changes in factor inputs and in production technologies (Barro – Sala-i-Martin, 2004, p. 433). In this approach, growth rate of technology is measured indirectly as the growth rate in GDP that cannot be accounted for by the growth of the observable inputs.

The analysis starts from a standard neoclassical production function

$$Y = AK^{\alpha}L^{(1-\alpha)} \qquad (1)$$

where *Y* is the total output (GDP or gross value added), A is the level of technology, *K* is the capital stock and *L* is the quantity of labour. The specification of production function makes it clear that output can grow only if there is growth in productive inputs or the level of technology (total factor productivity growth). The growth rate of output can be decomposed into the contribution associated with factor accumulation and into the contribution of technological progress. Taking logarithms of equation (1) and derivatives with respect to time leads to

$$\dot{Y} / Y = \dot{A} / A + \alpha\dot{K} / K + (1-\alpha)\dot{L} / L \qquad (2)$$

where $\dot{Z} / Z$ represents the growth rate of respective variable, α is the fraction of output used to rent capital (a fraction also known as the capital share) and $(1-\alpha)$ is the fraction of GDP used to pay wages (labour share). In this specification (Cobb-Douglas case), the factor shares are constant over time (and corresponds to the exponents in the production function specified in (1). The estimation of the rate of technological progress can be then rewritten as

$$\dot{A} / A = \dot{Y} / Y - \alpha\dot{K} / K - (1-\alpha)\dot{L} / L \qquad (3)$$

All the right-hand side variables could be directly measured and obtained from national and regional statistics and allow us to indirectly estimate the total factor productivity growth $(\dot{A} / A)$. Economic growth in (2) is thus decomposed into the contribution of total factor productivity growth, the contribution of weighted growth of capital stock and the contribution of weighted growth of labour (where capital share and labour share represents the weights).

4.1. Database for growth accounting

The empirical implementation of the growth accounting requires measuring the growth rate of inputs as well as the shares of capital and labour.

Gross value added at NUTS III level in NACE Rev. 2 classification was obtained from national statistics in national currency and current prices. Price index of value added according to branches for CENTROPE countries was obtained from EUROSTAT and used to convert the current prices into the constant prices of 2000. Value added in constant prices was then aggregated into primary, secondary and tertiary sector and used for computation of value added growth.

Growth rate of labour was computed from data on total employment (in persons) in NACE Rev. 2 classification.

Measures of the stock of physical capital come from cumulating of figures on gross fixed capital formation along with estimates of depreciation of existing capital stock. This approach is termed the *perpetual-inventory method (PIM)* and considers that the capital stock available in period *t+1* is the sum of the capital stock left over from period *t* minus depreciation, plus the capital purchased during the period or investment I_t

$$K_{t+1} = K_t + I_t - \delta K_t \qquad (4)$$

where δ is the constant depreciation rate (we have assumed that $\delta = 0.05$, that is 5% of capital stock is depreciated during the period *t*). For computation of capital growth rates we need data for initial capital stock in period *t=1* and data for gross fixed capital formation in subsequent periods. Data for initial capital stock for the NUTS 2 regions (for the year 2006) in 2000 prices (mil. EUR) were obtained from European Regional Database 2010 constructed by Cambridge Econometrics, UK. Based on the share of value added generated by particular NUTS III region on total value added generated by corresponding NUTS II region, we have estimated the initial stock of capital in 2006 in CENTROPE on NUTS III level in primary, secondary and tertiary sector. Then, we have used data for gross fixed capital formation obtained from national statistics in current prices and deflated them to 2000 constant prices with total fixed assets price index (Slovak data were deflated to 2005 prices on industry level and then converted into 2000 constant prices using gross fixed capital formation price index for the whole economy, because price index of total fixed assets on industry level was not available). Gross fixed capital formation data by sector were based on NACE Rev. 2 industry classification while data on initial capital stock by sector obtained from Cambridge Econometrics Database are based on NACE Rev. 1 industry classification, but still we consider them as the best estimates of initial capital stock in CENTROPE. For further information on estimating the capital stock for the NUTS II regions of the EU-27 see recent working paper published by DG Regional Policy (Derbyshire – Gardiner – Waights, 2011). Because the initial capital stock was available in million € and all the other data were in national currencies, we have converted them into national currency using the average annual exchange rate before we applied PIM.

There are several ways how factor shares can be computed but we have adopted a standard estimation for α used in economic growth literature and we have assumed that $\alpha = 1/3$. Therefore the capital share on value added is assumed to equal 0,33 and labour share equals 0,66 (for further discussion on factor shares and their computation see Barro – Sala-i-Martin, 2004; Weil, 2008).

5. References

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