

On the competitiveness of the Flemish economy

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Abstract

Productivity and labour costs are key indicators in the assessment of the economic performance of countries, regions and industries. This paper discusses the evolution of different wage and productivity measures of the Flemish Region compared to the other Belgian regions and the neighbouring countries. Through a growth accounting analysis the main drivers of the labour productivity evolution during the period 1980-2007 are determined.

Keywords: growth accounting, TFP, regional economics

JEL: O40, O47, R11

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1. Introduction

Productivity and labour costs are key indicators in the assessment of the economic performance of countries, regions and industries and as such they have been and still are an important research theme. A first objective of this paper is to give an overview of the evolution of different measures of the labour costs and labour productivity during the period 1980-2007 in the Flemish Region. A comparison will be made with the two other Belgian regions, i.e. the Walloon Region and the Brussels Capital Region. Also the neighbouring countries Germany, France and the Netherlands and the EU-15 are involved in the comparative analysis. The macro-economic labour productivity, the nominal wage per employee and the real wage per employee will be discussed, followed by the wage per unity of value added. Next also the sectoral evolution of the nominal wage per employee will be considered.

The paper continues by firstly repeating some basic growth accounting equations and then applying this growth accounting analysis on the three Belgian regions on a sectoral level. An important parameter in this context is total factor productivity. Total factor productivity is defined as an output measure divided by an aggregate input measure, thus not only considering labour but also other production factors. Total factor productivity growth is the difference between output growth and input growth. Although not strictly necessary, total factor productivity is most of the times defined in a production function framework thereby imposing some neo-classical assumptions, more in particular it is assumed that the production process is subject to constant returns to scale and that there is perfect competition. In this paper the growth accounting technique will mainly be used to disentangle between the different drivers of labour productivity growth in a production function framework.

Section 2 starts with a descriptive analysis of the labour productivity evolution during the period 1980-2007 in the Belgian regions compared to the neighbouring countries and the EU-15 as a whole. Section 2 also discusses in length the macro-economic and sectoral wage evolutions, thereby using the nominal wage per employee, the real wage per employee and the wage per unity of value added. In what follows the goal is to disentangle the different drivers of labour productivity growth in a production function framework. Section 3 contains some technical notes on growth accounting analysis and in Section 4 the results of a growth accounting analysis for the three Belgian regions on a sectoral level are presented. Section 5 concludes.

2. Labour productivity and wages

2.1. Labour productivity

Table 1 contains an overview of the evolution of labour productivity per employee in Belgium and its regions (the Brussels Capital Region, the Flemish Region and the Walloon Region) since 1980. Its neighbouring countries (France, Germany and the Netherlands) and the EU15 are added to make a comparative analysis.

Table 1: Labour productivity, level and annual average growth rate

		1980	1985	1990	1995	2000	2005	2007
EU15	level	21609	27486	34420	43512	46855	51750	53766
	growth	-	4.9	4.6	4.8	1.5	2.0	1.9
France	level	17864	30249	40418	47074	53046	61641	66085
	growth	-	11.1	6.0	3.1	2.4	3.0	1.4
Germany	level	22941	28517	34295	44462	47420	52115	54792
	growth	-	4.4	3.8	5.3	1.3	1.9	1.0
Netherlands	level	25698	31545	33429	48373	46013	55284	58411
	growth	-	4.2	1.2	7.7	-1.0	3.7	1.1
Belgium	level	21796	31473	39318	48373	54630	63374	68171
	growth	-	7.6	4.6	4.2	2.5	3.0	1.5
Brussels Capital Region	level	26556	38200	47462	58320	66669	78031	83699
	growth	-	7.5	4.4	4.2	2.7	3.2	1.4
Flemish Region	level	21740	31387	39472	48159	54373	63142	68186
	growth	-	7.6	4.7	4.1	2.5	3.0	1.5
Walloon Region	level	19071	27544	34088	42997	48149	55369	59305
	growth	-	7.6	4.4	4.8	2.3	2.8	1.4

Source: EUKLEMS and HERMREG

In 1980 the Flemish Region had a labour productivity which was comparable to the EU15 average productivity level (21609 euro in the EU15 compared to 21740 euro in the Flemish Region). The labour productivity levels in both Germany and the Netherlands were somewhat higher compared to the Flemish labour productivity (respectively 22941 euro and 25698 euro). The labour productivity in France was only about 17864 euro in 1980, and by far the lowest value of the countries and regions presented here.

The five following years labour productivity grew relatively rapid in the Flemish Region, with an average annual growth rate of 7,6%. Only in France, starting from a lower level, the labour productivity growth was higher, amounting to 11,1% on average per year. In 1985 the Flemish labour productivity (31387 euro) is only lower than the productivity levels in the Brussels Capital Region (38200 euro) and, marginally, the Netherlands (31545 euro).

In the period 1985-1990 productivity growth remains relatively high, although it slows down somewhat compared to the previous subperiod. In the Flemish Region productivity growth amounted to 4,4% on average per year, comparable with the growth rate of the EU15 (4,6%) but lower than the productivity growth in France (6,0%). In Germany (3,8%) and certainly in the Netherlands (1,2%) labour productivity grew less fast during these years. Now France jumped over the Flemish Region (40418 euro vs 39472 euro), and also the Brussels Capital Region remains to have a higher labour productivity (47462 euro); the other countries and regions have lower labour productivity levels. The lowest level is recorded in the Walloon Region (34088 euro), closely followed by Germany (34295 euro) and the EU15 (34420 euro).

Also the five following years are characterized with relatively high labour productivity levels, see e.g. the annual average growth rate of 7,7% in the

Netherlands during 1990-1995. The Flemish labour productivity grew by 4,1% on average per year and amounted to 48159 euro in 1995. Only the Brussels Capital Region performs better (58320 euro).

In the three most recent subperiods labour productivity growth slowed down considerably. In the periode 2000-2007 labour productivity growth amounted to only 1,5% on average per year in the Flemish Region, in the two previous subperiods the annual average growth rates were respectively 2,5% and 3,0%. The Netherlands even recorded a negative growth of the labour productivity in period 1995-2000 (-1,0%), most probably due to the increased popularity of part time jobs.

In 2007 the highest labour productivity is recorded in the Brussels Capital Region (83699 euro), followed by the Flemish Region (68186 euro) and France (66085 euro). The lowest productivity levels can be observed in the EU15 (53766 euro) and Germany (54792 euro).

A last thing to notice is that the relative positions of the Belgian regions concerning labour productivity does not change during the period 1980-2007, nor does the relative gap between them. In 1980 the gap between the Brussels Capital Region and the Flemish Region was about 18%, it still was about the same in 2007 (18,5%). The same holds for the labour productivity difference between the Flemish Region and the Walloon Region: 14% in 1980 and 15% in 2007.

2.2 Wages

In Belgium the macro-economic wage policy is based on the law of July 25 of 1996 'to promote employment and to the preventative safeguarding of the competition power'². The law clearly states the margins in which the social partners can negotiate with respect to the nominal wage growth, the so-called wage norm. The maximum nominal wage growth, calculated per working hour, is determined on the basis of the average expected wage evolution in the three most important trading partners (i.e. Germany, The Netherlands and France).

In the light of this law, section 2.2.1 starts with looking at the macro-economic evolution of the nominal wage per employee from 1980 onwards in the Belgian regions. Their evolution is compared with the evolution in France, Germany, the Netherlands and the EU-15. Also the real wage per employee and the wage per unity of value added are discussed. Section 2.2.2 then analyses the evolution of the nominal wage per employee at a more detailed level, i.e. the sectoral level, in the earlier mentioned regions and countries.

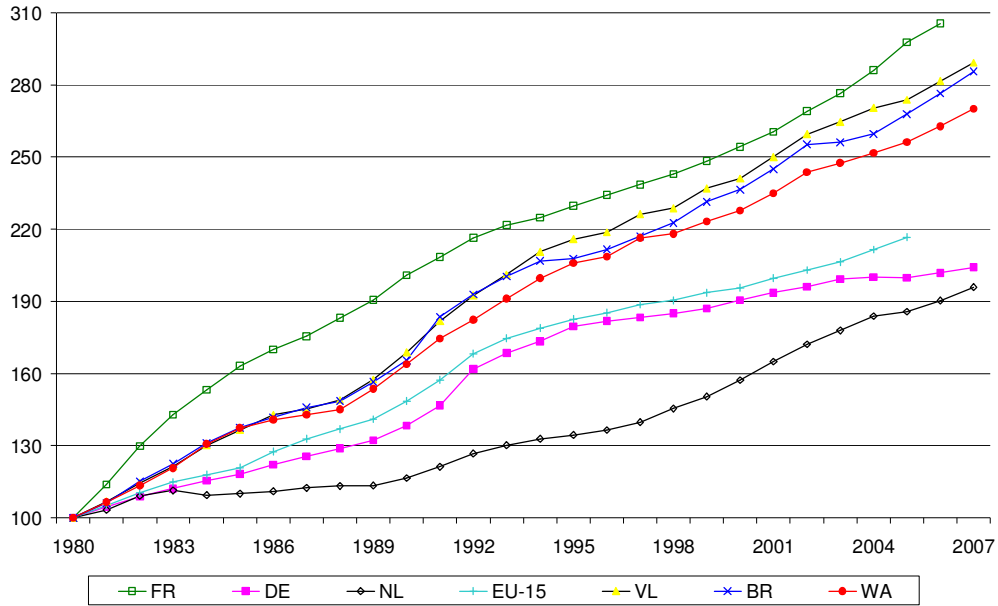
2.2.1. Macro-economic wage evolution

The nominal wage evolution from 1980 onwards differs significantly between the studied countries/regions. Figure 1 considers the evolution of the nominal wage per head (employee) in index form. For each country/region the basis year equals 1980. In France wages increased obviously the most: the average wage per employee in 2006 is more than three times the wage per head in 1980 (2006: 306%). On the other side of the spectrum we find the Netherlands. In 2007, the wage per head in the Netherlands is only 90% higher than in 1980. That said, one

² In Dutch: 'ter bevordering van de werkgelegenheid en tot de preventieve vrijwaring van het concurrentievermogen'. This law builds upon an earlier law from 1989.

should put into perspective this number, given the increased importance of part time labour in the Netherlands.

Figure 1: Evolution of the nominal wage per employee (1980=100)



Source: EUKLEMS, EUROSTAT, HERMREG, SVR.

When considering average yearly growth rates, these evolutions boil down to a nominal wage growth of 4,4% in France versus 2,5% in the Netherlands. The Netherlands is also the only country (in this paper) which shows a temporary decrease of the nominale wage per employee (more precisely in 1984). Since the early nineties Germany follows a strict policy of wage cost moderation, and this can be seen in Figure 1.

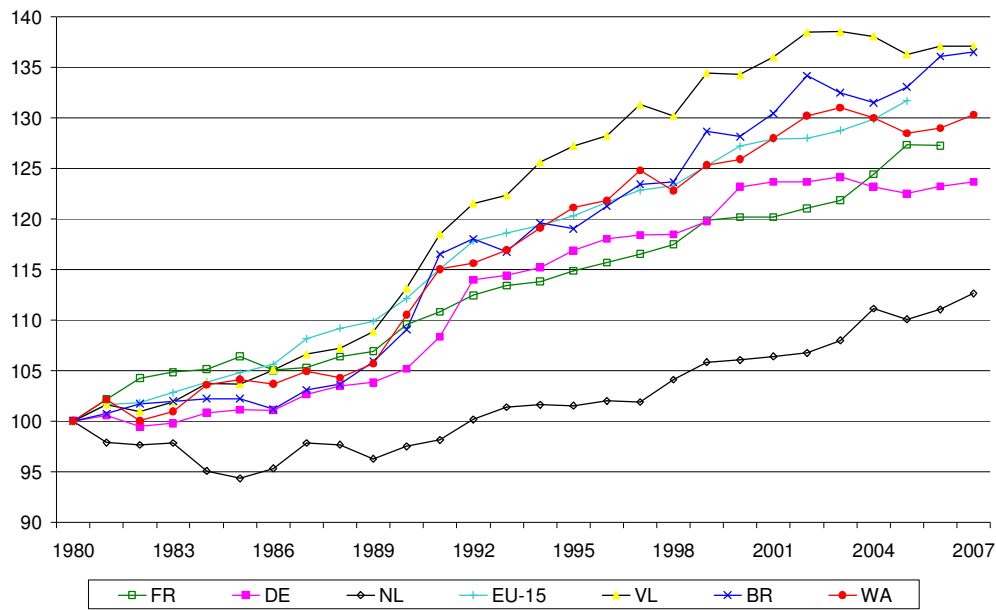
The Belgian regions are situated just below France. The nominal wage per employee grew the most in the Flemish Region. In Flanders the nominal wage per employee increased by more or less 182% in the period 1980-2007. This is equivalent to a average growth of 4,0% per year. In the Walloon Region the nominal wage per employee rose by 163% and in the Brussels Capital Region by

176% (respectively 4,0% and 3,7% average per year). In Germany the nominal wage per head doubled compared to the level in 1980. Also in the EU-15 the wage increase (2005: 117%) was lower than in the Flemish Region.

In the subperiod 1980-1990 the evolution of the nominal wage per employee was relatively comparable between the Brussels Capital Region and the Walloon Region (respectively +65% and +64%). In the Flemish Region on the other hand the nominal wage per employee rose somewhat faster (+69%). In the subperiod 1990-2000 the growth of the nominal wage per employee was considerably lower, analogous to the lower inflation. The nominal wage per employee in the Walloon Region rose by 39%, whereas the increase in the Brussels Capital Region and the Flemish Region amounted to more or less 43%. Also during the last seven years the evolution of the nominal per wage per employee was roughly equal in Brussels and Flanders (+17%); in Wallonia the increase amounted to 15%. During the period 1980-2007, the average per year growth rate of the nominal wage per employee in the Belgian regions more or less halved (e.g. Flemish Region: from 5,4% in 1980-1990 to 2,6% in 2000-2007).

Although ultimately it are the nominal wages which are paid by firms, and which are important in an international context in which not only the domestic price level is of concern (competitiveness), we also compare the regions/countries with respect to the real wage per employee, thereby excluding differences in (domestic) price evolutions. Figure 2 presents the evolution of the real wage per employee (1980=100).

Figure 2: Evolution of the real wage per employee (1980=100)



Source: EUKLEMS, EUROSTAT, HERMREG, SVR.

Whereas in the neighbouring countries the growth of the real wage per employee was limited during 1980-2007, the real wage per employee rose particularly rapid in the Flemish Region. It was about 37% higher in 2007 compared to 1980 in Flanders. From 2005 onwards the real wage per employee stabilized in the Flemish Region. Also in the Brussels Capital Region the real wage per employee increased more than in the neighbouring countries (+36%). Concerning the EU-15, more recent numbers are lacking, but in 2005 the increase amounted to 32%, and with that the EU-15 is located between Brussels and Wallonia. In the latter region the growth of real wager per employee was more modest (2007: +30%) compared to the other Belgian regions.

In nominal terms France registered the biggest increase over the period 1980-2006, while in real terms France is located in the middle. The bigger increase of the nominal wage per employee in France is mainly due to inflation, comparatively more than in the other countries/regions. The nominal wage per

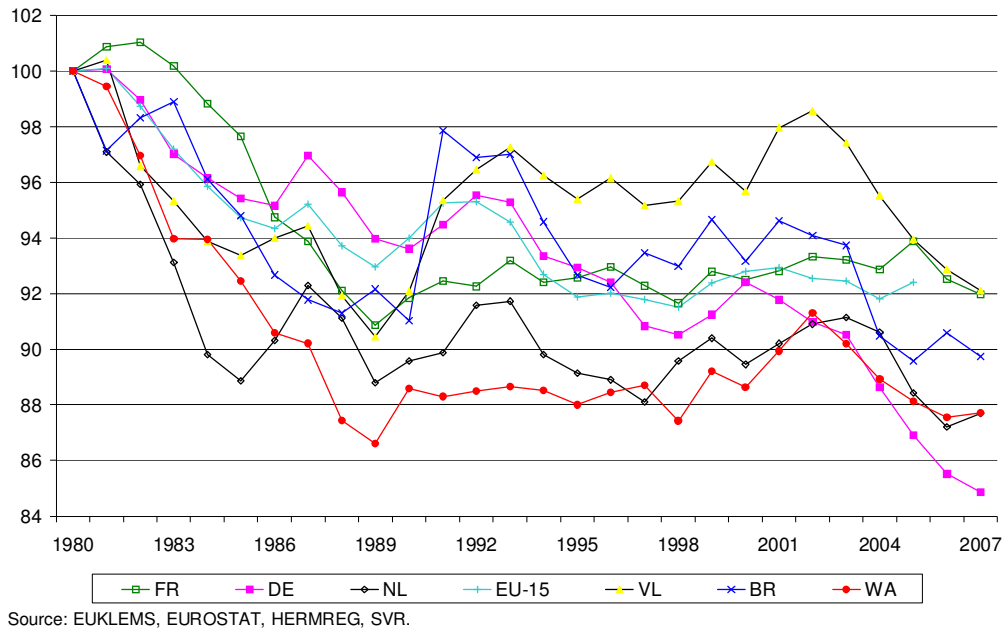
employee rose there by 206%, whereas the real wage per employee only increased by 27% (1980-2006). Besides that it is also striking that the real wage per employee in the Netherlands during the eighties and begin nineties was lower than in 1980. In 2007 the real wage per employee was only 13% higher than in 1980 (of course this is related to the evolution of part time labour). In Germany the increase of the real wage per employee amounted to 24% (2007). In short, the real wage per employee in the three neighbouring countries increased considerably less than in the three Belgian regions.

Since it is possible that the measure 'wage per employee' is biased by differences in the evolution of e.g. part time labour³, it is worth the effort to take a quick glance at another measure, namely the wage per unity of value added. This measure equals the ratio of the wage per employee and the productivity per employee, and as such it compares the evolution of both parameters. Another name for this measure is the wage share (in gross value added).

Figure 3 contains the evolution of the wage per unity value added since 1980 for each of the studied countries/regions. Again, the evolution is presented by using an index with 1980 the base year (1980 = 100). Although this figure is less clear-cut than previous ones, it is still possible to gather some information from the graph.

³ In the official regional accounts of the Institute of National Accounts, the series 'number of hours worked' is not available (the series is available only at the national level).

Figure 3: Evolution of the wage per unity of value added (1980 = 100)



Firstly, the differences in this graph are significantly smaller than in the previous graphs. So, despite a divergent evolution of the wage per employee, the differences between the countries/regions in terms of wage per unity of value added remain limited. A number of factors explain this. As quoted already earlier differences in the evolution of part time jobs do not count here. This measure also takes into account differences in the evolution of labour productivity: as such a wage increase can be neutralised by an increase in labour productivity (or a wage increase is easier to accept if it is accompanied by an increase in labour productivity). A third factor can be found in the fact that the nominal wage per employee is expressed in current prices, whereas the wage per unity of value added is expressed, by construction, in real terms and so the latter measure excludes differences in price evolutions.

Despite the increasing (nominal and real) wage per head, the wage per unity of value added decreased globally in all of the included regions and countries. In

Germany the decrease was most pronounced (decrease of about 15%), in the Flemish Region and France less (decrease of about 8%). In the beginning of this century Germany was located in the middle of the group, but from then on the wage per unity of value added dropped sharply. This is true the last years in most of the countries and regions, except France. The evolution of the wage per employee in the Netherlands clearly displays the influence of an increasing importance of part time jobs. Although the Netherlands are still at the bottom of the graph concerning the wage per unity of value added, this is less the case than in the graph with respect to the (nominal or real) wage per employee.

Regarding the Belgian regions the less good evolution in the Flemish Region is remarkable. The increase of the wage per unity of value added in the early nineties is only partially wiped out afterwards. Around the turn of the century the wage per unity of value added increased again (just like in Wallonia), and then decreased substantially since 2003 so as to compensate partially for the incurred handicap. In the Walloon Region on the other hand the wage per unity of value added decreased strongly in the eighties and afterwards it remained fairly stable (aside an increase around the turn of the century and an equally big decrease afterwards): the wage per unity of value added in 2007 is situated around the same level as in 1980.

Table 2 and Table 3 contain the nominal wage per employee and the wage per unit of value added⁴. The wage per employee (Table 3) in the Flemish Region in 1980 (15295 euro) was a little lower than the EU-15 average (15694 euro), it was also lower than the wage per employee in Germany (16414 euro) and considerably lower compared to the Netherlands (19275 euro). Both in the Walloon Region (14980 euro) and France (13305 euro) the wage per employee were lower in 1980.

⁴ For the wage of the independents the average wage of the employees is used.

Table 2: Nominal wage per employee, level and annual average growth rate

		1980	1985	1990	1995	2000	2005	2007
EU15	level	15694	19002	23388	28735	30829	33579	34473
	growth	-	3.9	4.2	4.2	1.4	1.7	1.3
France	level	13305	21701	26721	30558	33828	39279	41714
	growth	-	10.3	4.2	2.7	2.1	3.0	1.2
Germany	level	16414	19402	22715	29476	31271	32797	33451
	growth	-	3.4	3.2	5.3	1.2	1.0	0.4
Netherlands	level	19275	21222	22459	25912	30309	35828	37751
	growth	-	1.9	1.1	2.9	3.2	3.4	1.1
Belgium	level	15901	21790	26485	33552	37646	42838	45903
	growth	-	6.5	4.0	4.8	2.3	2.6	1.4
Brussels Capital Region	level	18948	25614	31285	39259	44972	51303	55520
	growth	-	6.2	4.1	4.6	2.8	2.7	1.6
Flemish Region	level	15295	21004	25767	32948	36918	42148	45217
	growth	-	6.5	4.2	5.0	2.3	2.7	1.4
Walloon Region	level	14980	20675	24677	31037	34404	38879	41388
	growth	-	6.7	3.6	4.7	2.1	2.5	1.3

Source: EUKLEMS and HERMREG

More recently, in 2007, the wage per employee was only higher in the Brussels Capital Region (55520 euro) compared to the Flemish Region (45217 euro). Whereas in 1980 the Flemish wage per employee was comparable with the EU-15 average and the wage per employee in Germany, this is not longer the case, since in the EU-15 the average wage per employee now amounts to 34473 euro and in Germany it is only 33451 euro. The wage per employee still is the highest in the Brussels Capital Region.

In 1980 the Flemish Region was the cheapest in terms of wage per unit value added (0.70). In 2007, however, this is not the case anymore. In most of the other countries the wage per unit of value added dropped more than this was the case

in Flanders. The decrease was most outspoken in Germany and France, where the wage per unit value added amount to respectively 0.61 and 0.63 (whereas it was 0.72 and 0.74 respectively in 1980). In the Flemish Region the wage per unit of value added equals 0.66 in 2007.

Table 3: Wage per unit of value added, level and annual average growth rate

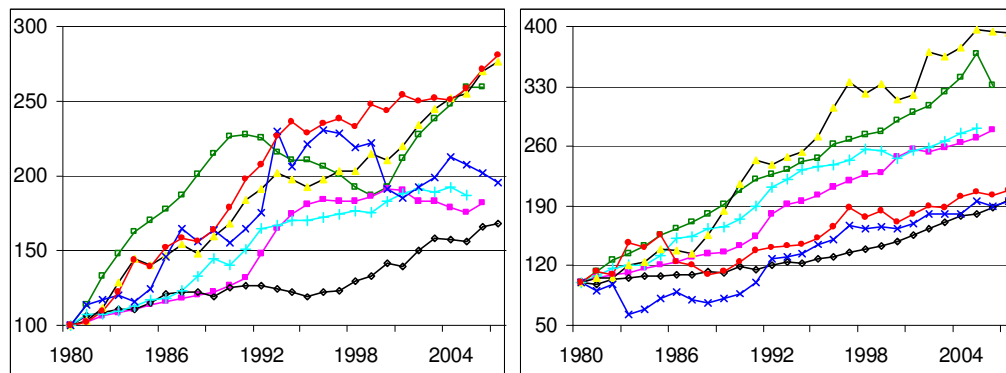
		1980	1985	1990	1995	2000	2005	2007
EU15	level	0.73	0.69	0.68	0.66	0.66	0.65	0.64
	growth	-	-0.98	-0.34	-0.57	-0.07	-0.28	-0.60
France	level	0.74	0.72	0.66	0.65	0.64	0.64	0.63
	growth	-	-0.75	-1.62	-0.37	-0.35	-0.02	-0.19
Germany	level	0.72	0.68	0.66	0.66	0.66	0.63	0.61
	growth	-	-1.00	-0.54	0.02	-0.11	-0.93	-0.60
Netherlands	level	0.75	0.67	0.67	0.67	0.66	0.65	0.65
	growth	-	-2.15	-0.03	0.02	-0.41	-0.33	-0.05
Belgium	level	0.73	0.69	0.67	0.69	0.69	0.67	0.67
	growth	-	-1.04	-0.57	0.57	-0.16	-0.43	-0.04
Brussels Capital Region	level	0.71	0.67	0.66	0.67	0.67	0.66	0.66
	growth	-	-1.24	-0.36	0.40	0.01	-0.55	0.22
Flemish Region	level	0.70	0.67	0.65	0.68	0.68	0.67	0.66
	growth	-	-1.00	-0.51	0.92	-0.18	-0.38	-0.09
Walloon Region	level	0.79	0.75	0.72	0.72	0.71	0.70	0.70
	growth	-	-0.91	-0.74	-0.08	-0.23	-0.39	-0.08

Source: EUKLEMS and HERMREG

2.2.2. Sectoral wage evolution

In the following paragraphs the evolution of the nominal wage per employee in 13 broad sectors will be discussed. The definition of the branches can be found in Appendix 1. To be more exact, only 12 sectors will be presented. The branch 'domestic services' is regarded to be of minor importance. As before, the evolution is presented in index form with base year 1980. For the colour scheme used throughout the following paragraphs, see e.g. Figure 3.

Figure 4: Nominal wage per employee in a) agriculture and b) energy



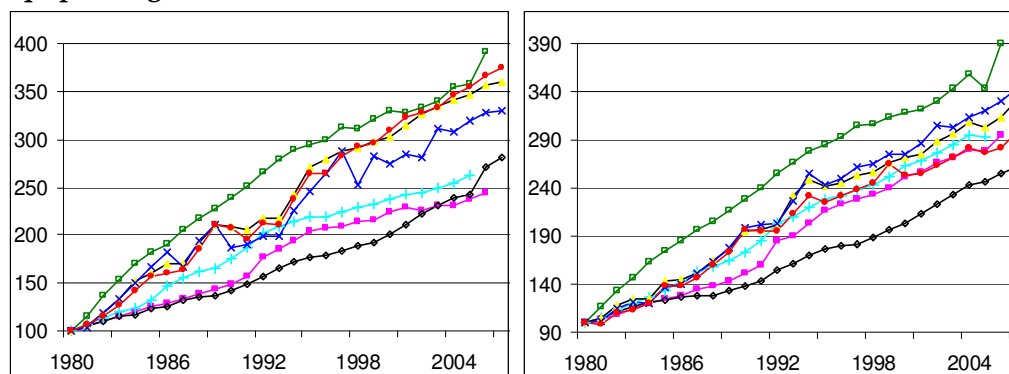
Source: EUKLEMS, HERMREG, SVR.

In 'agriculture' the nominal wage per employee rose fastest in the Walloon and Flemish Regions, followed closely by France. The increase of the nominal wage per employee in 2006 comes to roughly 170% in Wallonia and Flanders against 160% in France (see Figure 4). The increase was most limited in the Netherlands (65% in 2006) and Germany (82% in 2006).

In the 'energy' branch the Flemish Region registered the highest increase. The nominal wage per employee in 2006 is almost four times the wage of 1980 (+295%). Also in France, the nominal wage per employee rose fast (+230% in

2006). The Netherlands and the Brussels Capital Region recorded the lowest increase in that branch (respectively +88% and +90% in 2006).

Figure 5: Nominal wage per employee in a) intermediate goods and b) equipment goods



Source: EUKLEMS, HERMREG, SVR.

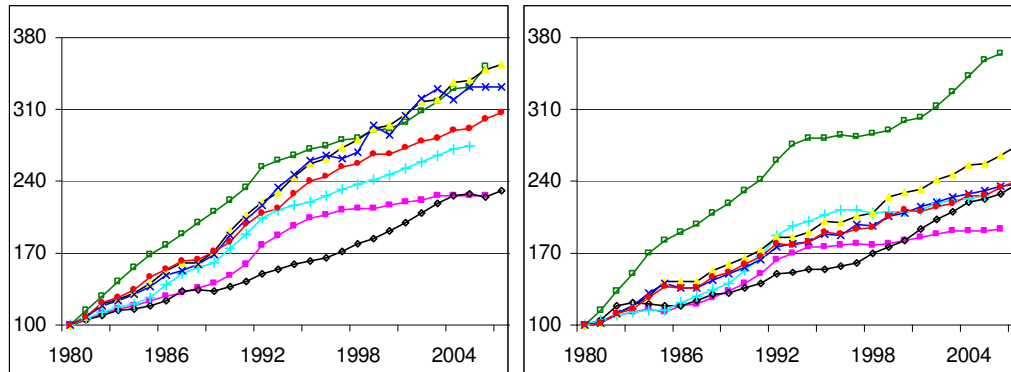
Unsurprisingly, both in the ‘intermediate goods’ and the ‘equipment goods’ it is France who recorded the highest increases in the nominal wage per employee (more or less +290% in 2006, see Figure 5). In the ‘intermediate goods’ France is followed by the Walloon Region and the Flemish Region (respectively +265% and +255% in 2006). Concerning the ‘equipment goods’, the Brussels Capital Region booked a slightly less high increment than France (+230% in 2006).

The growth of the nominal wage per employee in the branch ‘intermediate goods’ was most limited in Germany and the Netherlands (respectively +144% and +172% in 2006), despite a high increase in 2006 in the latter country. Also in the ‘equipment goods’ the evolution of the Netherlands was most competitive (+154% in 2006).

Concerning the ‘consumption goods’ the biggest increment of the nominal wage per employee is booked by France (+251% in 2006, Figure 6), the Flemish Region

(+248% in 2006) and the Brussels Capital Region (+232% in 2006). The smallest increase took place in the Netherlands and Germany (roughly +125% in 2006).

Figure 6: Nominal wage per employee in a) consumption goods and b) construction



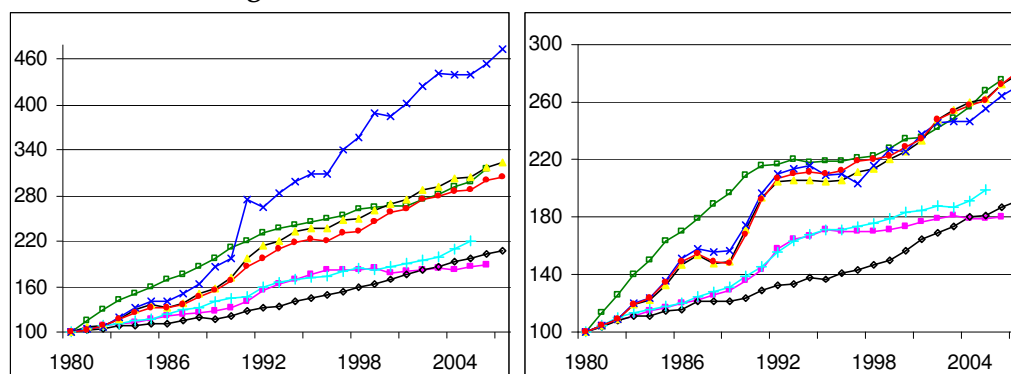
Source: EUKLEMS, HERMREG, SVR.

In the 'construction' branch the nominal wage per employee in France exploded compared to the neighbouring countries (+264% in 2006). The second highest increase is recorded by the Flemish Region, but at a great distance (+165% in 2006). Also in this branch the wage increase was most limited in Germany (+93% in 2006). In Figure 6 (both branches) one clearly observes a stabilisation of the nominal wage per employee in Germany at the end of the period, whereas it still increased in the other countries and regions.

The growth of the nominal wage per employee in the 'transport and communication' branch was by far the highest in the Brussels Capital Region (+355% in 2006, see Figure 7). Brussels is followed by France and the Flemish Region, but there the increase was much more modest (roughly +216% in 2006). The Netherlands and Germany registered the lowest growth in the branch 'transport and communication' (+103% and +88% in 2006).

In 'trade and catering' the spread of wage increases is less (see Figure 7). Here France, Wallonia, Flanders and Brussels had the largest increments of their nominal wages per employee (respectively +176%, +172%, +172% and +164% in 2006). Both in Germany and the Netherlands the growth was smallest (+80% and +86% in 2006).

Figure 7: Nominal wage per employee in a) transport and communication and b) trade and catering

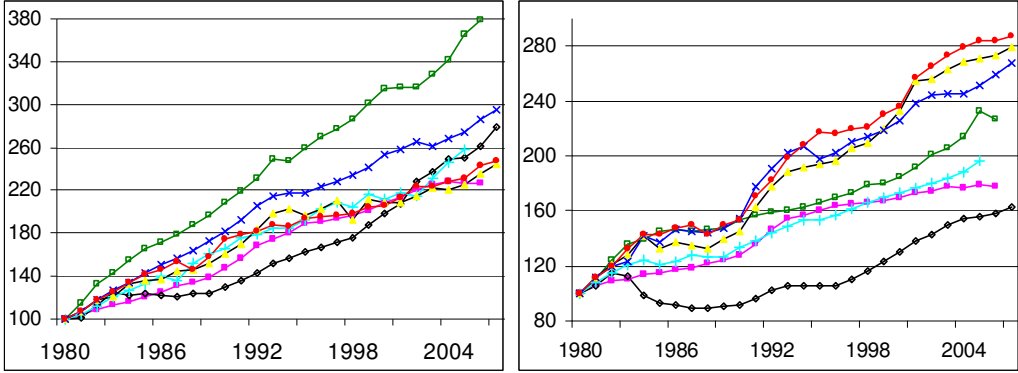


Source: EUKLEMS, HERMREG, SVR.

The nominal wage per employee in 'credit and insurances' rose the most in France (more or less +280% in 2006, see Figure 8). In the Brussels Capital Region and the Netherlands the increase was somewhat smaller (respectively +186% and +161% in 2006). On the bottom of the graph Germany and the Flemish Region are located (respectively +127% and +136% in 2006).

The branch 'other market services' shows quite a different picture. Here France is located in the middle of the graph (+127% in 2006), whereas it are now the Belgian regions which are on top (Wallonia: +184%, Flanders: +173% and Brussels: +160% in 2006). Germany and the Netherlands established the lowest increases in this branch (respectively +78% and +58% in 2006).

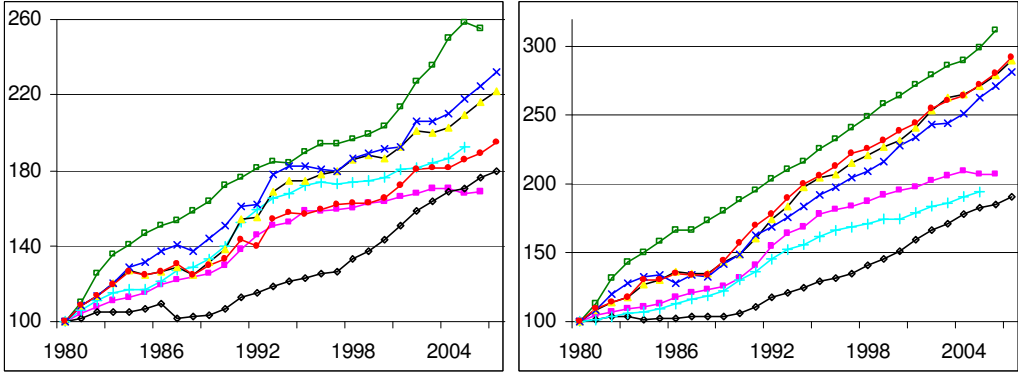
Figure 8: Nominal wage per employee in a) credit and insurances and b) other market services



Source: EUKLEMS, HERMREG, SVR.

In the branches 'health care' and 'public administration and education' it is again France which registers the highest increase over the period 1980-2006 (respectively +155% and +212%, see Figure 9). In the former branch the nominal wages in Brussels and Flanders also rose strongly (respectively +124% and 116% in 2006). Germany and the Netherlands limited the wage increase in 'health care' (respectively + 68% and 76% in 2006). In 'public administration and education' France is followed by the Belgian regions (Wallonia: +181%, Flanders: +179% and

Figure 9: Nominal wage per employee in a) health care and b) public administration and education



Source: EUKLEMS, HERMREG, SVR.

Brussels: +171% in 2006). The growth of the nominal wage per employee was smaller in Germany, the Netherlands and the EU-15 (respectively +106% (2006), +85% (2006) and +96% (2005)).

Considering all branches the highest increases of the nominal wage per employee were recorded in 'transport and communications' (Brussels: +355% in 2006) and some industrial branches, in particular 'energy' (Flanders: +295% in 2006), 'intermediate goods' (France: +291% in 2006), 'equipment goods' (France: +290%) and 'consumption goods' (France: +251% and Flanders: +248%). The lowest increments are found in the branches 'other market services' (the Netherlands: +58% and Germany: +78% in 2006), 'health care' (Germany: +68% and the Netherlands: +75% in 2006) and 'agriculture' (the Netherlands: +66% and Germany: +82%). The presence of some service branches in the lowest wage growth branches is possibly due to the fact that in these branches the number of part time jobs probably increased more.

3. Growth accounting

3.1. Definition en remarks

Total factor productivity growth is the difference between the growth of output in volume and the growth of the combined inputs in volume. So, total factor productivity growth measures the increase in the output that can be produced with a given quantity of the different inputs. Total factor productivity growth measures disembodied technical change under neo-classical assumptions.

Aside from the assumption that there exists a production function linking inputs and outputs, the main assumption is that the production factors are rewarded by their marginal product. This is the neo-classical assumption of perfect competition. It permits a representation of output growth as a weighted sum of the growth rates of the inputs. The weights for the input growth rates are the respective shares in total input payments.

Among the outputs of the growth accounting calculation the one to receive most attention is usually the difference between output growth and input growth. Although this measure has a interesting interpretation, it is also fraught with some difficulties, as underscored by the multitude of phrases used to refer to this difference: besides total factor productivity growth, multi-factor productivity growth, Solow residual, measure of ignorance, rate of technical change, ... Basically total factor productivity growth is a residual measure, and as such it may also include a variety of other effects, as is explained in Timmer (2010) .

Firstly, since total factor productivity growth is calculated under the assumptions of neo-classical theory, it takes along any deviations from these assumptions.

Secondly, total factor productivity growth does not only include technological change, but also e.g. organisational innovation. In the long run, the latter will lead in general to higher total factor productivity growth. In the short run, however, it might lead to lower measured total factor productivity growth rates since some of the inputs are used for the reorganisation process itself. More generally, total factor productivity comprises the effects from changes in unmeasured inputs, such as R&D. Thirdly, total factor productivity is calculated at the sectoral level, not at the firm level. Since productivity levels can differ greatly between firms, changes in total factor productivity on the industry level can also be caused by reallocation of market shares across firms. Lastly, total factor productivity growth is also influenced by measurement errors in inputs and outputs.

3.2. Methodology

To explain the technique of growth accounting in some more detail, consider the following production function defined in terms of:

- capital (K),
- labour (L),
- energy inputs (E),
- other intermediate inputs (M), and
- an index of the level of technological progress (A),

in function of time and hereby using a general form:

$$(1) \quad Y_{it} = f(A_{it}, K_{it}, L_{it}, E_{it}, M_{it}),$$

where Y_{it} is the output from branch i on time t . In the following the subscripts i and t will be dropped as much as possible for reasons of simplification.

Differentiating (1) with respect to time results in

$$(2) \quad \dot{Y} = \frac{\partial f}{\partial A} \dot{A} + \frac{\partial f}{\partial K} \dot{K} + \frac{\partial f}{\partial L} \dot{L} + \frac{\partial f}{\partial E} \dot{E} + \frac{\partial f}{\partial M} \dot{M},$$

where

$$(3) \quad \dot{X} = \frac{dX}{dt},$$

or, \dot{X} is the continuous time representation of ΔX , the first difference of X :

$$(4) \quad \Delta X_t = X_t - X_{t-1}.$$

Take λ_x to be

$$(5) \quad \lambda_x = \frac{dX/dt}{X} = \frac{d \ln X}{dt},$$

the (continuous) growth rate of X , with its discrete counterpart:

$$(6) \quad \frac{X_t - X_{t-1}}{X_{t-1}} = \frac{\Delta X}{X},$$

Now, dividing the equation for the rate of change of Y , i.e. equation (2), by Y and hereby using (5), this becomes

$$(7) \quad \lambda_Y = \frac{\partial f}{\partial A} \frac{A}{Y} \lambda_A + \frac{\partial f}{\partial K} \frac{K}{Y} \lambda_K + \frac{\partial f}{\partial L} \frac{L}{Y} \lambda_L + \frac{\partial f}{\partial E} \frac{E}{Y} \lambda_E + \frac{\partial f}{\partial M} \frac{M}{Y} \lambda_M.$$

So, output growth is equal to a function of the growth rates of capital, labour, energy, other intermediate inputs and the remaining term, giving the effect of proportional changes in A , or the effect of productivity improvements on output, is defined as the Solow residual or total factor productivity growth. In the following this term is denoted by Ω (where the subscripts i and t are dropped).

Equation (7) can be simplified and made more useful for calculation in practice by adopting the neo-classical assumption of perfect competition. By assuming that the production factors are traded in competitive markets, it follows that the production factors are paid their respective marginal products. For example, the marginal product of labour equals the real wage, here denoted by σ_L . So, for the four production factors it holds then that

$$(8) \quad \frac{\partial F}{\partial X} = \sigma_X,$$

with $X = K, L, E, M$.

Substituting the marginal products in (7) by equation (8), it follows that

$$(9) \quad \lambda_Y = \Omega + \frac{\sigma_K K}{Y} \lambda_K + \frac{\sigma_L L}{Y} \lambda_L + \frac{\sigma_E E}{Y} \lambda_E + \frac{\sigma_M M}{Y} \lambda_M.$$

Again, this equation can be simplified by noting that

$$(10) \quad \Sigma_X = \frac{\sigma_X X}{Y},$$

with $X = K, L, E, M$, corresponds to the share of total income spent on payments to the production factor X . For example, $\Sigma_L = (\sigma_L L)/Y$ is the share of total income spent by the economy on payments to the production factor labour and hence is called the labour share of income. Equation (9) is modified into

$$(11) \quad \lambda_Y = \Omega + \Sigma_K \lambda_K + \Sigma_L \lambda_L + \Sigma_E \lambda_E + \Sigma_M \lambda_M,$$

which leads to a simplified expression for the total factor productivity growth or Solow residual Ω :

$$(12) \quad \Omega = \lambda_Y - (\Sigma_K \lambda_K + \Sigma_L \lambda_L + \Sigma_E \lambda_E + \Sigma_M \lambda_M).$$

The Solow residual equals thus the difference between the output growth rate and the weighted sum of factor growth rates, with the weights given by the factor income shares. Or, the Solow residual equals the growth of output that can not be attributed to the growth of the input of capital, labour, energy or other intermediate inputs.

A further simplification arises by assuming that the production function is constant returns to scale, in which case the sum of the factor income shares equals one, i.e.

$$(13) \quad \Sigma_K + \Sigma_L + \Sigma_E + \Sigma_M = 1.$$

Total factor productivity growth can be written then as follows

$$(14) \quad \Omega = \lambda_Y - (\Sigma_K \lambda_K + \Sigma_L \lambda_L + \Sigma_E \lambda_E + (1 - \Sigma_K - \Sigma_L - \Sigma_E) \lambda_M).$$

This is the equation which will be used in the calculations further on in the paper, thereby using both standard neo-classical assumption of perfect competition and constant returns to scale.

An interesting analysis instrument arises when equation (14) is derived in per capita terms. To that end, the following notations are used:

$$(15) \quad \lambda_x = \frac{d(X/L)/dt}{X/L} = \frac{d \ln(X/L)}{dt},$$

where $X = Y, K, E, M$ and $x = y, k, e, m$. Or, k, e, m are the factor intensities with respect to the production factor labour L , e.g. e is energy intensity or the amount of energy per unit of labour (E/L) and k capital intensity or the amount of capital per unit of labour (K/L). y of course represents labour productivity, i.e. output per unit of labour (Y/L).

Rewriting equation (14) in per capita terms results in:

$$(16) \quad \Omega = \lambda_y - \Sigma_K \lambda_k - \Sigma_E \lambda_e - \Sigma_M \lambda_m.$$

This equation can be rearranged to decompose the labour productivity growth into the contributions from the growth of respectively capital intensity, energy intensity and intermediate inputs intensity on the one hand and the contribution of the growth of total factor productivity on the other hand:

$$(17) \quad \lambda_y = \Sigma_K \lambda_k + \Sigma_E \lambda_e + \Sigma_M \lambda_m + \Omega.$$

A production function which is often used in the context of growth accounting is the Cobb-Douglas function, which is written as follows:

$$(18) \quad Y_{it} = A_{it} K_{it}^\alpha L_{it}^\beta E_{it}^\chi M_{it}^\delta.$$

In the case of a Cobb-Douglas production function, equation (7) simplifies to

$$(7') \quad \lambda_Y = \lambda_A + \alpha \lambda_K + \beta \lambda_L + \chi \lambda_E + \delta \lambda_M,$$

such that total factor productivity growth $\Omega = \lambda_A$ is written as follows:

$$(12') \quad \Omega = \lambda_A = \lambda_Y - (\alpha \lambda_K + \beta \lambda_L + \chi \lambda_E + \delta \lambda_M).$$

By assuming perfect competition and constant returns to scale, the parameters $\alpha, \beta, \chi, \delta$ equal the respective factor income shares and they furthermore sum to one:

$$(10') \quad \alpha = \frac{\sigma_L L}{Y}, \beta = \frac{\sigma_K K}{Y}, \chi = \frac{\sigma_E E}{Y} \text{ and } \delta = \frac{\sigma_M M}{Y},$$

and

$$(13') \quad \alpha + \beta + \chi + \delta = 1.$$

4. A sectoral growth accounting exercise for the Belgian regions

4.1. Data

The data used in this paper are sourced from the HERMREG database and run from 1980 to 2007 and include series with respect to production, labour volume and number of persons, capital stock, energy input, other intermediate inputs, wages, capital cost and prices of energy and intermediate inputs; and this for the three Belgian regions in 11 different sectors. The sectors which are considered in this paper are the following:

- agriculture,
- energy,
- intermediate goods,
- equipment goods,
- consumption goods,
- construction,
- transport and communication,
- trade and catering,
- credit and insurances,
- health care and social service, and
- other market services.

In HERMREG there are in total 13 sectors, but the sectors 'domestic services' and 'public administration and education' are not taken into account here. This database is build for the construction and further development of a regional sectoral econometric model HERMREG, in a cooperation between the Studiedienst van de Vlaamse Regering (SVR), the Federaal Planbureau (FPB), the Brussels

Instituut voor Statistiek en Analyse (BISA) and l'Institut Wallon de l'Evaluation, de la Prospective et de la Statistique (IWEPS).

The calculations are done under the assumptions of the two standard hypotheses of perfect competition and constant returns of scale, which was already clear from the previous section. As a consequence of these assumptions the weights are equal to the factor shares in total income en their sum equals one. The factor income shares are estimated as the median values over the entire period 1980-2007.

4.2. Results

In what follows the contributions of the different production factors and total factor productivity growth to labour productivity growth are considered. Figures 10-20 contain the contributions of the production factors capital, energy and other intermediate inputs and the contribution of total factor productivity growth to the labour productivity growth for each of the eleven sectors.

The first sector, agriculture, is presented in Figure 10. Apart from the atypical Brussels Capital Region, it are the production factors capital and other intermediate inputs which contributed the most to the labour productivity growth in that sector during the period 1980-2007. Moreover, the growth of the capital intensity and the intensity of other intermediate inputs seem to be more or less equally important.

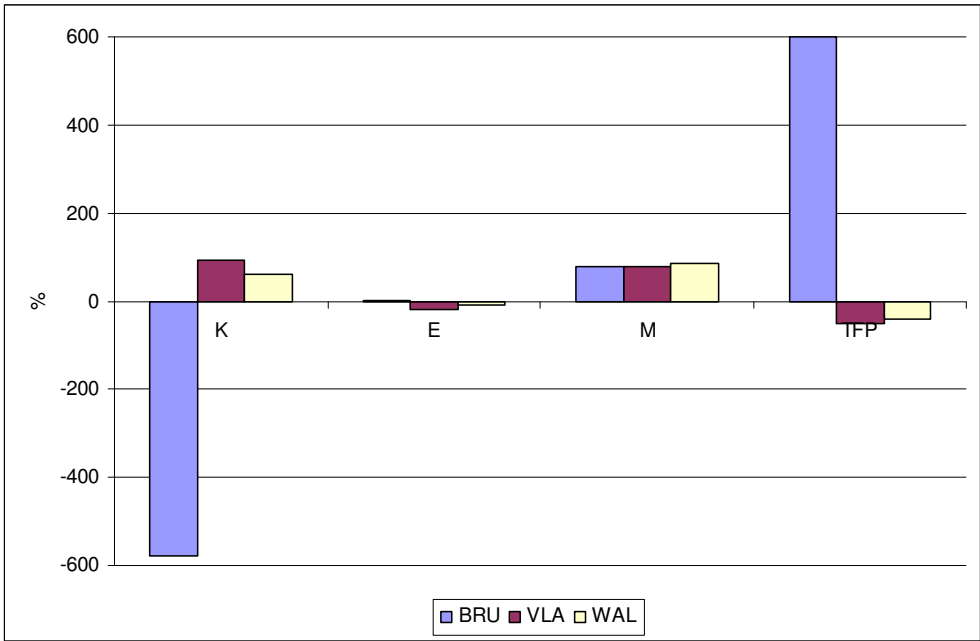
In the construction sector (Figure 11) it are again the production factors capital and other intermediate inputs which supported the labour productivity growth in that branch, although also total factor productivity growth supplied a relatively high contribution in the Brussels Capital Region.

Total factor productivity played a minor role in the consumption goods (Figure 12) sector in both the Flemish Region and the Walloon Region during the period 1980-2007. With a contribution of about 60% it is the production factor other intermediate inputs which contributed most to the growth of labour productivity. Also in the branches equipment goods, intermediate goods and energy (Figures 13, 14 and 15) it is mostly the production factor intermediate inputs which contributed to the labour productivity growth, amounting to contributions of about 60% in all three regions. To a lesser extent, also the production factor capital and total factor productivity growth supported labour productivity growth in these branches. The production factor energy seems less important.

In global one can conclude that for the secondary branches (i.e. consumption goods, equipment goods, intermediate goods, energy and construction) it is the production factor intermediate inputs, or more precisely the growth of its intensity with respect to labour, which contributed most to the labour productivity growth.

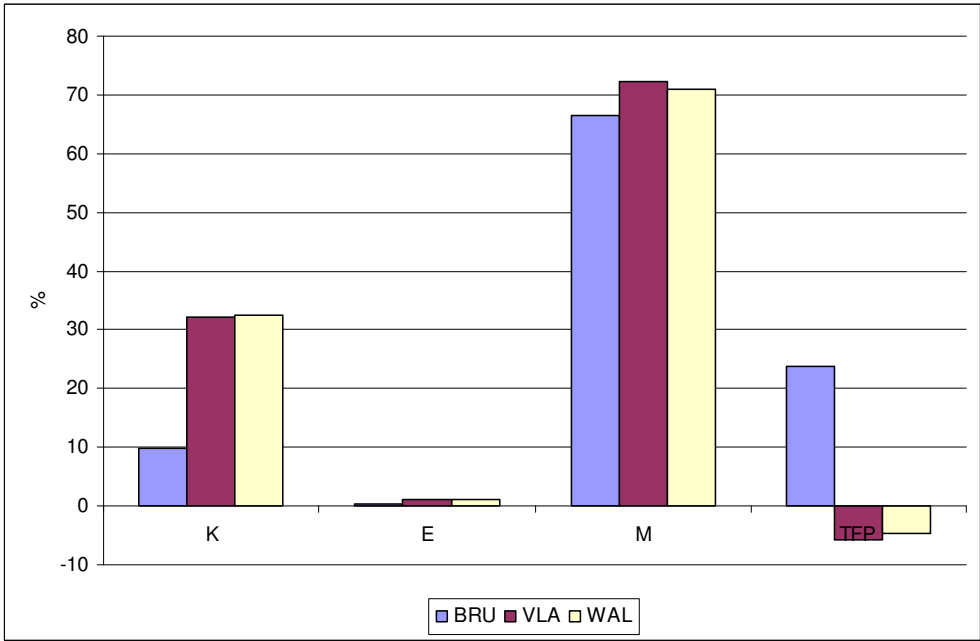
In the tertiary branches a more differentiated pattern seems to be present. As a first example in Figure 16 the growth contributions for the branch credit and insurances are given. For the three regions the biggest contribution is delivered by total factor productivity growth. In the branches trade and catering (Figure 17) and other market services (Figure 18) it are the production factors other intermediate inputs and capital which contributed most to the labour productivity growth. In the branch transport and communication it is again total factor productivity growth which had the highest contribution in all three regions during the period 1980-2007, although also the production factors capital and other intermediate inputs are relatively important.

Figure 10: Contributions to the labour productivity growth in 'agriculture' (1980-2007)



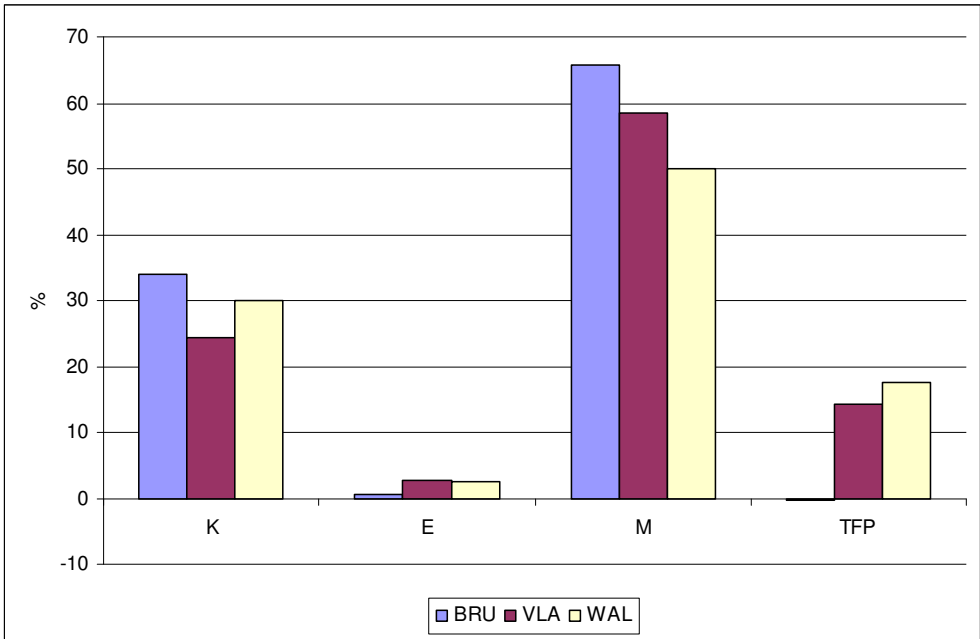
Source: HERMREG, SVR.

Figure 11: Contributions to the labour productivity growth in 'construction' (1980-2007)



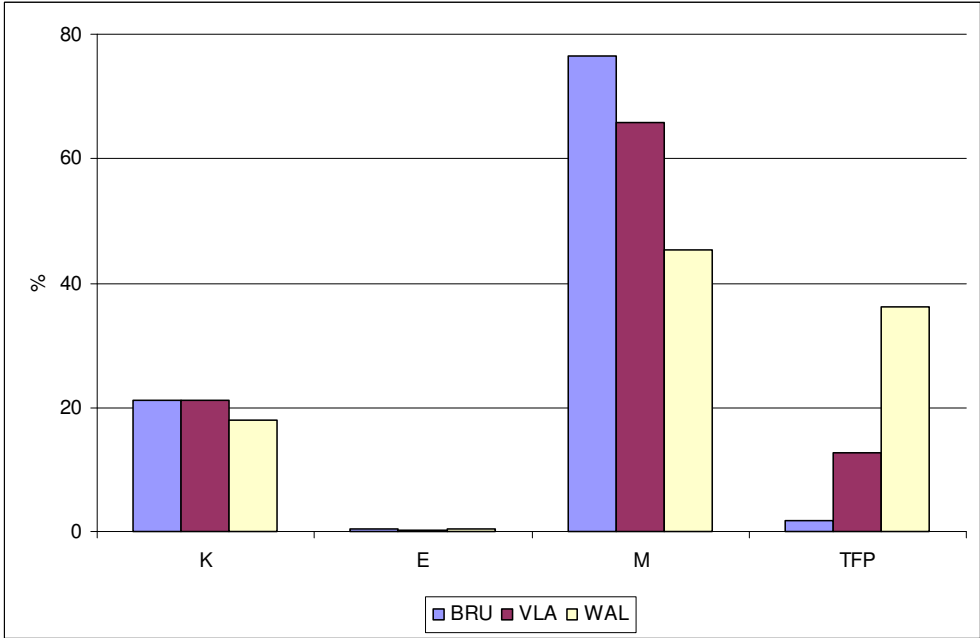
Source: HERMREG, SVR.

Figure 12: Contributions to the labour productivity growth in 'consumption goods' (1980-2007)



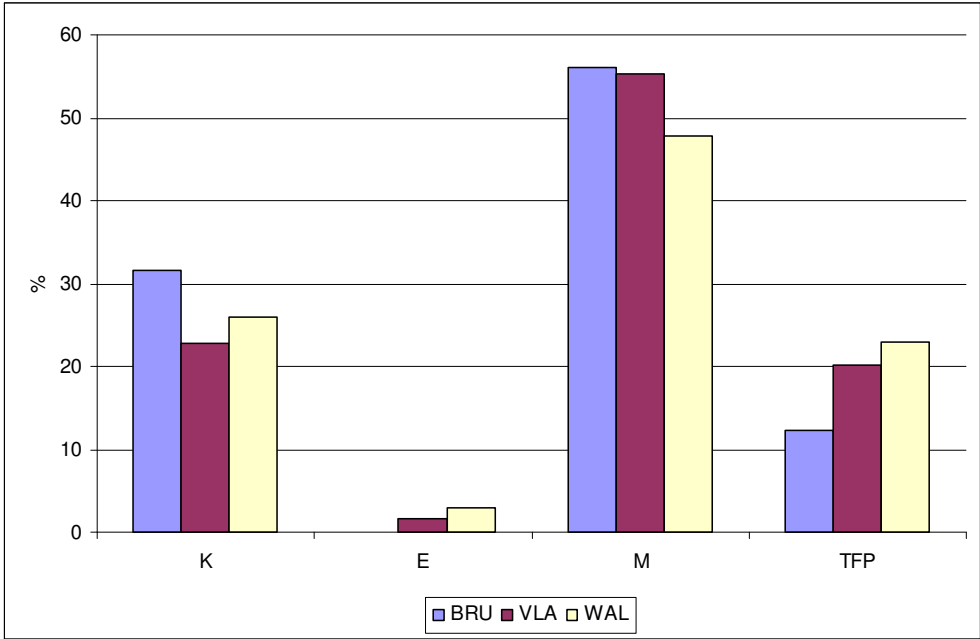
Source: HERMREG, SVR.

Figure 13: Contributions to the labour productivity growth in 'equipment goods' (1980-2007)



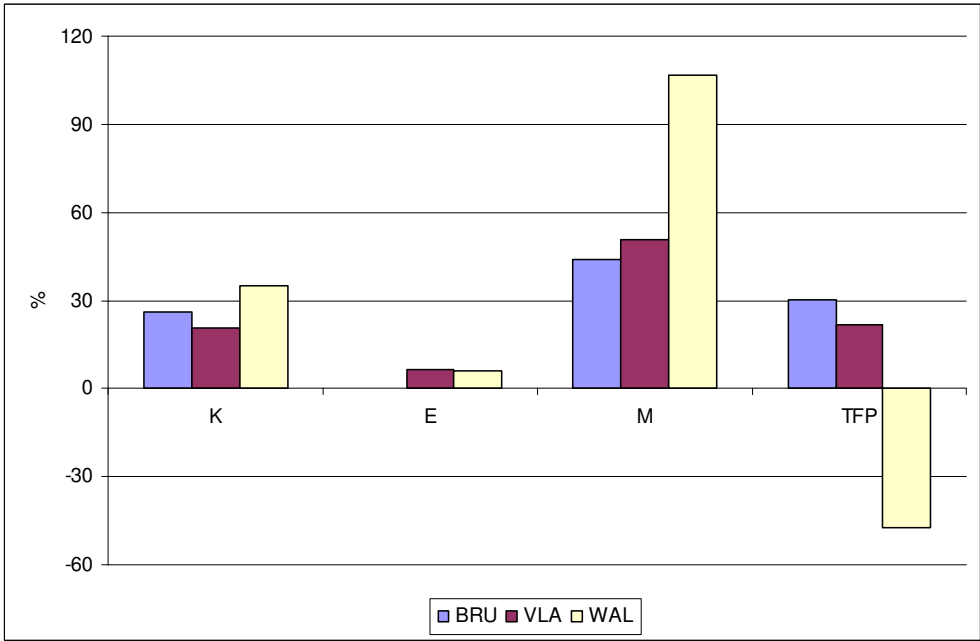
Source: HERMREG, SVR.

Figure 14: Contributions to the labour productivity growth in 'intermediate goods' (1980-2007)



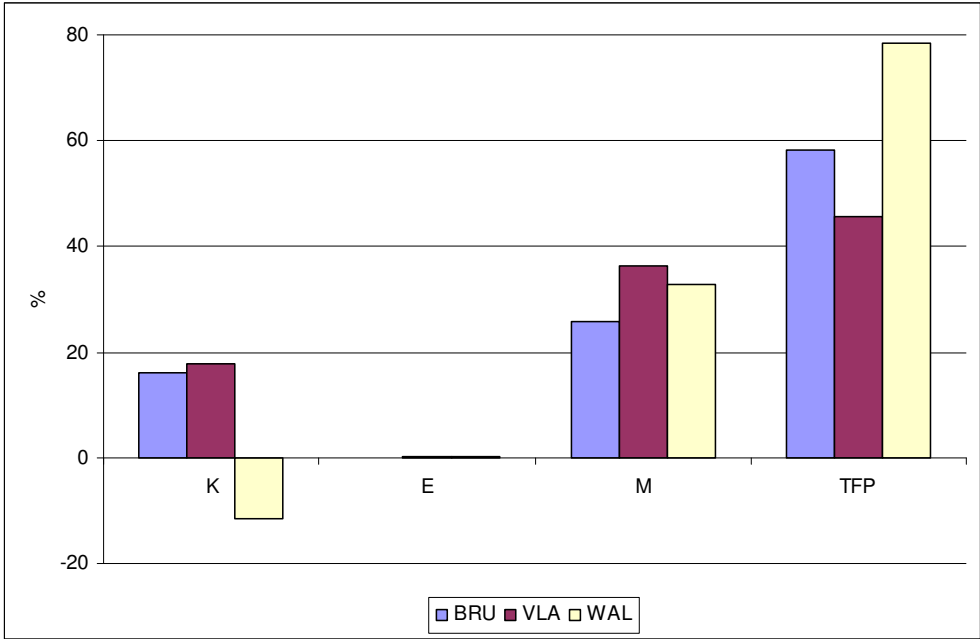
Source: HERMREG, SVR.

Figure 15: Contributions to the labour productivity growth in 'energy' (1980-2007)



Source: HERMREG, SVR.

Figure 16: Contributions to the labour productivity growth in 'credit and insurances' (1980-2007)



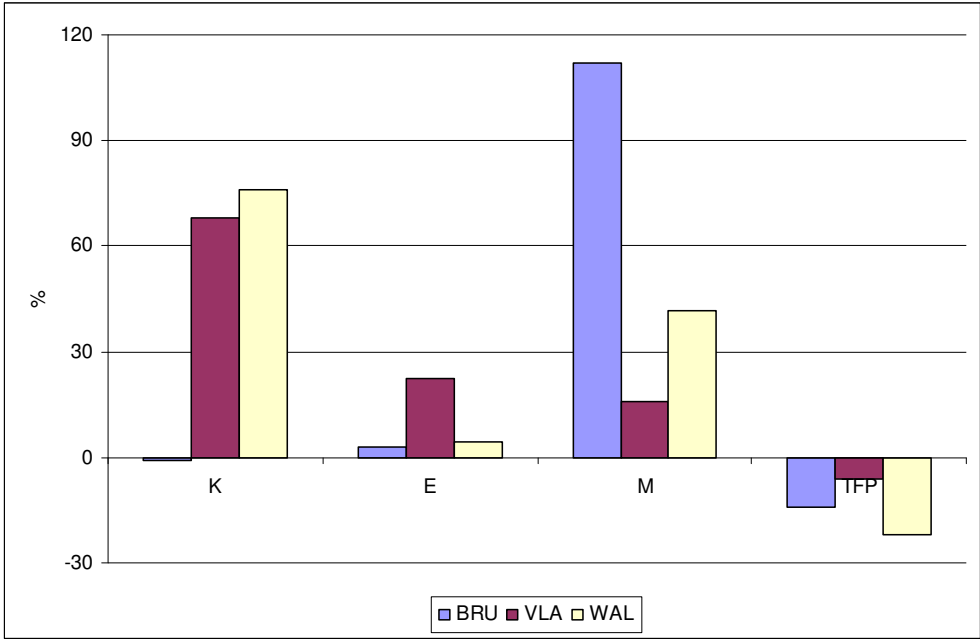
Source: HERMREG, SVR.

Figure 17: Contributions to the labour productivity growth in 'trade and catering' (1980-2007)



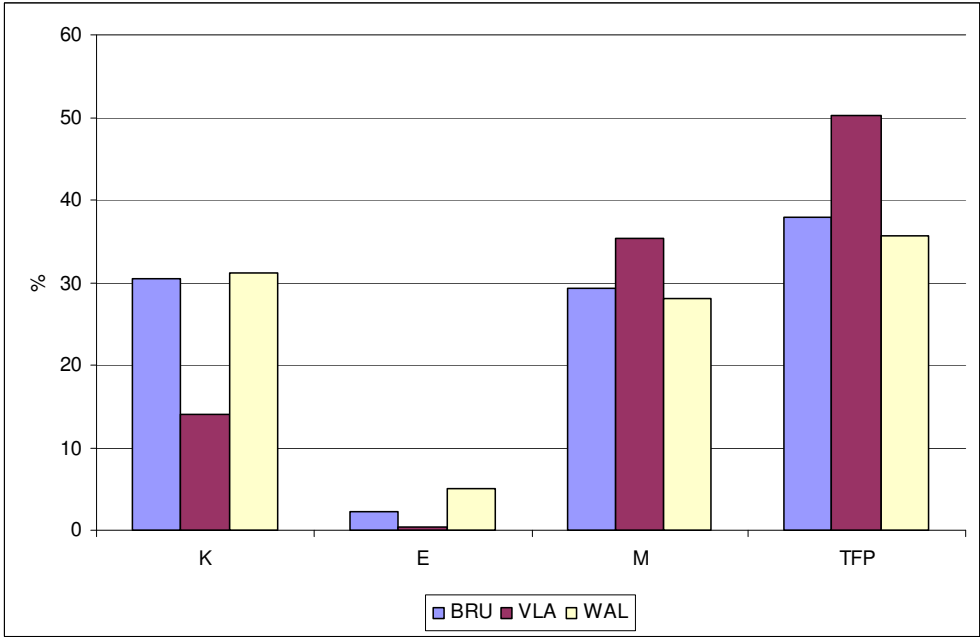
Source: HERMREG, SVR.

Figure 18: Contributions to the labour productivity growth in 'other market services' (1980-2007)



Source: HERMREG, SVR.

Figure 19: Contributions to the labour productivity growth in 'transport and communication' (1980-2007)



Source: HERMREG, SVR.

Figure 20: Contributions to the labour productivity growth in 'health care and social service' (1980-2007)



Source: HERMREG, SVR.

5. Conclusion

From the descriptive analysis of the evolution of labour productivity it was clear that labour productivity evolved relatively good in the Flemish Region: in 1980 it was comparable to the EU-15 average, whereas in 2007 it was significantly higher than the EU-15 average. Only in the Brussels Capital Region the labour productivity per employee is higher, mainly due to its specific characteristics as a capital region.

The evolution of the nominal wage per employee was less favourable in the Flemish Region. Again, in 1980 the nominal wage per employee was more or less the same as in the EU-15; in 2007, however, the Flemish wages were considerably higher than the EU-15 average. In fact, apart from the Brussels Capital Region, the nominal wage per employee was nowhere higher in 2007. Although the wage per unity of value added decreased in all the countries and regions of the analysis, it decreased less in the Flemish Region. And so, whereas in 1980 the wage per unity of value added was lower than in the EU-15, in 2007 it was higher in the Flemish Region compared to the EU-15 average.

A growth accounting analysis was used to determine the main drivers of labour productivity growth during the period 1980-2007. For the three Belgian regions the results were rather similar. With respect to the secondary branches in general the production factor other intermediate inputs seemed to have the highest contribution to the labour productivity growth during the analysed period. In the tertiary branches the pattern was more differentiated and, although in some branches other intermediate inputs were important, total factor productivity growth and the production factor capital delivered high contributions to the labour productivity growth.

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