

Offshoring and the Skill Structure of Labour Demand in Belgium

May 2012

Bart Hertveldt, bh@plan.be

Bernhard Michel, bm@plan.be

Federal Planning Bureau

The Federal Planning Bureau (FPB) is a public agency.

The FPB performs research on economic, social-economic and environmental policy issues. For that purpose, the FPB gathers and analyses data, examines plausible future scenarios, identifies alternatives, assesses the impact of policy measures and formulates proposals.

The government, the parliament, the social partners and national and international institutions appeal to the FPB's scientific expertise. The FPB provides a large diffusion of its activities. The community is informed on the results of its research activities, which contributes to the democratic debate.

The Federal Planning Bureau is EMAS-certified and was awarded the Ecodynamic Enterprise label (three stars) for its environmental policy

url: <http://www.plan.be>

e-mail: contact@plan.be

Publications

Recurrent publications:

Forecasts

Short Term Update

Planning Papers (last publication):

The aim of the Planning Papers is to diffuse the FPB's analysis and research activities.

110 Les charges administratives en Belgique pour l'année 2010 / De administratieve lasten in België voor het jaar 2010
Chantal Kegels - February 2012

Working Papers (last publication):

6-12 Supply and Use Tables and Input-Output Tables 1995-2007 for Belgium - Methodology of Compilation
Luc Avonds, Geert Bryon, Caroline Hambjé, Bart Hertveldt, Bernhard Michel, Bart Van den Cruyce - May 2012

With acknowledgement of the source, reproduction of all or part of the publication is authorized, except for commercial purposes.

Responsible publisher: Henri Bogaert

Legal Deposit: D/2012/7433/15

Federal Planning Bureau

Avenue des Arts 47-49, 1000 Bruxelles

Phone : +32-2-5077311

Fax : +32-2-5077373

e-mail : contact@plan.be

<http://www.plan.be>

Offshoring and the Skill Structure of Labour Demand in Belgium

May 2012

Bart Hertveldt, bh@plan.be

Bernhard Michel, bm@plan.be

Abstract - A major concern regarding the consequences of offshoring is about the labour market position of low-skilled workers. This paper provides evidence for Belgium that offshoring has had a negative impact on the employment share of low-skilled workers in the manufacturing sector between 1995 and 2007. The main contribution to the fall in the low-skilled employment share came from materials offshoring to Central and Eastern Europe (21%), followed by business services offshoring (8%). In manufacturing industries with a higher ICT capital intensity the impact of offshoring is smaller. For market services industries, no robust conclusions regarding the impact of offshoring on low-skilled employment could be drawn.

Jel Classification – F16, J24

Keywords - Offshoring, employment, skill upgrading, educational attainment, ICT capital intensity

Table of contents

Executive summary	1
Synthèse	2
Synthese	3
1. Introduction	4
2. Relevant empirical literature	6
3. Stylised facts	9
3.1. Skill upgrading	9
3.2. Offshoring	11
4. Econometric analysis	14
4.1. Model specification	14
4.2. Results	16
4.2.1. Results for manufacturing	16
4.2.2. Results for market services	23
5. Conclusion	25
References	27
Appendix	30
Appendix 1 - The translog cost function	30
Appendix 2 - Industry classification	32
Appendix 3 - Data sources and descriptive statistics	35
Appendix 4 - GMM estimations and own-price elasticities	36

List of tables

Table 1	Employment by skill level	10
Table 2	Industry decomposition of the fall in the low-skilled employment share.....	11
Table 3	Materials and business services offshoring, total and split by region of origin	13
Table 4	Current and constant price materials and business services offshoring.....	13
Table 5	Endogeneity tests for relative wage, materials offshoring and business services offshoring in manufacturing	17
Table 6	Estimation results with total offshoring intensities in manufacturing.....	18
Table 7	Endogeneity tests for regional materials offshoring intensities in manufacturing	21
Table 8	Estimation results with regional materials offshoring intensities in manufacturing	22
Table 9	Endogeneity tests for relative wage, materials offshoring and business services offshoring in market services	23
Table 10	Estimation results with total offshoring intensities in market services	24
Table 11	List of manufacturing industries, NACE-SUT-code and description.....	32
Table 12	List of market services industries, NACE-SUT-code and description	34
Table 13	Data sources	35
Table 14	Descriptive statistics	35
Table 15	GMM estimation results with total offshoring intensities in manufacturing	36
Table 16	Own-price elasticities for low-skilled and high-skilled workers for estimations with total offshoring intensities in manufacturing	37

List of figures

Graph 1	Employment shares by skill level.....	9
---------	---------------------------------------	---

Executive summary

Over the past couple of decades, production processes have become increasingly fragmented, and inputs are being purchased in a growing number of countries. In this context, it has become common to speak of offshoring when inputs, corresponding to activities relocated abroad, are sourced from foreign suppliers. Offshoring encompasses both manufacturing and service activities. A typical example for the former is the sourcing of materials from abroad, e.g. parts and components for car assembly. While offshoring of manufacturing activities has been occurring since very long, offshoring of service activities such as the provision of accounting or call centre services is a more recent phenomenon that has been fostered by the increased tradability of such services.

A major concern regarding the consequences of offshoring is about the labour market position of low-skilled workers. According to the traditional idea underlying offshoring, firms relocate low-skilled intensive stages of production to low-skilled abundant countries, thereby reducing the number of low-skilled workers in their workforce.

Skill upgrading, measured by educational attainment, has been substantial in both manufacturing and market service industries in Belgium. Over the years 1995-2009, the share of workers with primary or lower secondary education has fallen from 53% to 31% in the former and from 36% to 22% in the latter. Besides that, there is also evidence of increased offshoring where this is measured as the share of intermediates sourced from abroad. It is overall business services offshoring as well as materials offshoring to CEE (Central and Eastern European) and Asian countries that have been increasing at the fastest pace. This paper provides evidence on the impact of offshoring on the skill structure of employment in Belgium between 1995 and 2007.

According to the estimation results, offshoring has a significant and sizeable effect on the skill composition of employment in manufacturing industries, whereas no robust conclusions regarding this impact can be drawn for market service industries. In manufacturing industries, the contribution of offshoring to the fall in the employment share of low-skilled workers amounted to roughly 35% between 1995 and 2007, largely exceeding the contribution of technological change (17%). The contribution of offshoring mainly came from materials offshoring to CEE countries (21%). Business services offshoring accounted for 8% of the fall in the employment share of low-skilled workers. Moreover, in manufacturing industries with a higher ICT capital intensity this impact of offshoring on the low-skilled employment share is smaller. This finding also implies that even if ICT capital facilitates or even fosters offshoring, especially of business services, this does not lead to faster skill upgrading in industries with a high ICT capital intensity.

Synthèse

Aux cours des deux dernières décennies, les entreprises ont profondément modifié leurs processus de production en les divisant dans un nombre croissant d'activités distinctes et en multipliant le nombre de pays d'approvisionnement de leurs inputs. Dans ce contexte, on parle de délocalisation lorsque les inputs dans le processus de production générés par une activité sont achetés auprès de fournisseurs étrangers. Cela concerne aussi bien des activités manufacturières que des activités de services. Un exemple classique pour le premier cas est l'importation de composants pour l'assemblage automobile. Alors que des activités manufacturières sont délocalisées depuis longtemps, les délocalisations d'activités de services tels que les centres d'appel et les services de comptabilité sont un phénomène plus récent favorisé par la disparition de barrières techniques et institutionnelles au commerce de services.

Une des principales sources d'inquiétude liées aux délocalisations est l'effet sur l'emploi de travailleurs peu qualifiés. En effet, on considère traditionnellement que ce sont les parties du processus de production les plus intensives en travail peu qualifié qui sont délocalisées vers des pays avec une main d'oeuvre peu qualifiée abondante, contribuant ainsi à réduire l'emploi peu qualifié dans le pays d'origine.

En Belgique, il y a eu, depuis le milieu des années 90, une hausse importante du niveau de qualification des travailleurs mesuré par le diplôme obtenu. Concrètement, entre 1995 et 2009, la part des travailleurs avec un diplôme d'enseignement primaire ou secondaire inférieur a chuté de 53% à 31% dans l'industrie manufacturière et de 36% à 22% dans les services marchands. Par ailleurs, en prenant la part des inputs intermédiaires qui sont importés comme mesure de l'ampleur des délocalisations, on constate un recours accru aux délocalisations au cours de la même période, surtout pour les activités de services aux entreprises. Pour les activités manufacturières, ce sont les délocalisations vers les PECO (Pays d'Europe centrale et orientale) et l'Asie qui connaissent la plus forte croissance. Cette étude contient une analyse empirique de l'impact des délocalisations sur la structure de l'emploi par qualification en Belgique pour les années 1995 à 2007.

Selon les résultats économétriques, les délocalisations ont un impact significatif sur la structure de l'emploi par niveau de qualification dans l'industrie manufacturière, tandis que dans les services marchands les estimations ne permettent pas de tirer de conclusions stables sur cet impact. Dans l'industrie manufacturière, la contribution des délocalisations à la baisse de la part des travailleurs peu qualifiés dans l'emploi était d'environ 35% entre 1995 et 2007 – largement supérieure à celle du progrès technique (17%). Cette contribution provient principalement de la délocalisation d'activités manufacturières vers les PECO (21%). Les délocalisations d'activités de services aux entreprises ont contribué pour 8% à la baisse de la part des peu qualifiés dans l'emploi dans l'industrie manufacturière. De plus, l'impact des délocalisations sur l'emploi peu qualifié est moindre dans les branches d'activité avec une intensité en capital TIC plus élevée. Ce résultat implique, par ailleurs, que même si le capital TIC facilite les délocalisations, en particulier de services aux entreprises, cela n'entraîne pas une baisse plus rapide de l'emploi peu qualifié dans les branches avec une intensité en capital TIC plus élevée.

Synthese

De voorbije decennia hebben ondernemingen hun productieprocessen in toenemende mate gefragmenteerd. Zo vinden inputs uit een steeds groter wordend aantal landen hun weg naar binnenlandse waardeketens. Het verhuizen van activiteiten naar de rest van de wereld, waarna de betrokken producten vervolgens bij buitenlandse leveranciers worden ingekocht, wordt gangbaar aangeduid met de term 'offshoring'. Offshoring kan zowel slaan op industriële als op dienstenactiviteiten. Een typisch voorbeeld van de eerste is de invoer van onderdelen voor de assemblage van voertuigen. Terwijl offshoring van industriële activiteiten reeds lange tijd gebeurt, is offshoring van zakelijke diensten (zoals het uitbesteden van de boekhouding of call center diensten) een meer recent fenomeen, dat in de hand is gewerkt door de toegenomen verhandelbaarheid van dergelijke diensten.

Als we kijken naar de gevolgen van offshoring, is een belangrijke bekommernis de arbeidsmarktsituatie van laaggeschoolde werknemers. De traditionele visie op offshoring houdt immers in dat ondernemingen segmenten van het productieproces die intensief gebruik maken van laaggeschoolden, zullen verplaatsen naar landen waar die arbeidskrachten overvloedig aanwezig zijn, waardoor het aandeel van laaggeschoolden in hun personeelsbestand afneemt.

In België heeft zich, zowel in de verwerkende nijverheid als in de sector van de marktdiensten, een opmerkelijk toename van het opleidingsniveau voorgedaan (gemeten aan de hand van het hoogst behaalde diploma). Over de periode 1995-2009 is het aandeel van arbeidskrachten met een diploma van lager onderwijs of lager secundair onderwijs teruggevallen van 53% naar 31% in de verwerkende nijverheid en van 36% naar 22% in de sector marktdiensten. Daarnaast stelt men ook vast dat offshoring aan belang wint, op basis van de stijging van het aandeel van ingevoerde intermediaire inputs. Vooral offshoring van zakelijke diensten en goederenoffshoring naar Centraal- en Oost-Europa en Azië kenden over de beschouwde periode een snelle opgang. In deze paper wordt empirisch nagegaan hoe sterk in België over de periode 1995-2007 de impact geweest is van offshoring op de kwalificatiestructuur van de vraag naar arbeid.

Uit de schattingsresultaten blijkt dat offshoring een significant en sterk effect heeft gehad op de kwalificatiestructuur van de vraag naar arbeid in de verwerkende nijverheid, terwijl voor de sector van de marktdiensten hierover geen robuuste conclusies kunnen getrokken worden. Tussen 1995 en 2007 was offshoring verantwoordelijk voor ongeveer 35% van de daling van het aandeel van laaggeschoolden in de verwerkende nijverheid, hiermee de bijdrage van de technologische vooruitgang (17%) ruimschoots overtreffend. De bijdrage van offshoring kwam vooral op rekening van goederenoffshoring naar Centraal- en Oost-Europa (21%). Offshoring van zakelijke diensten stond gedurende de betrokken periode in voor 8% van de afname van het werkgelegenheidsaandeel van laaggeschoolden. Uit de schattingsresultaten blijkt verder dat in industriële bedrijfstakken met een hogere ICT-kapitaalsintensiteit de impact van offshoring op laaggeschoolden lager uitvalt. Die vaststelling impliceert dat ondanks het feit dat ICT-kapitaal offshoring vergemakkelijkt en zelfs bevordert, dit niet leidt tot een snellere upgrading van de kwalificatiestructuur in bedrijfstakken met hoge ICT-kapitaalsintensiteit.

1. Introduction

Over the past couple of decades, production processes have become increasingly fragmented: they are divided into ever smaller parts considered as separate activities, which are then spread over various locations in different countries. Hence, inputs into the production process are sourced not only from local but also from foreign suppliers. The latter mode of sourcing is commonly referred to as offshoring. It encompasses both manufacturing and service activities. A typical example for the former is the sourcing of materials from abroad, e.g. parts and components for car assembly. While the offshoring of manufacturing activities has been occurring since very long, the offshoring of service activities such as the provision of accounting or call centre services is a more recent phenomenon that has been fostered by the increased tradability of such services.

One of the main concerns in developed countries regarding the consequences of offshoring is about the worsening of the labour market position of low-skilled workers. Indeed, according to the traditional idea underlying offshoring, firms shift low-skilled intensive stages of production to low-skilled abundant countries, thereby influencing the within-industry skill composition of labour demand. In other words, just like technological change, offshoring is generally believed to be skill-biased, shifting labour demand from low-skilled to high-skilled workers.

The issue of the changes in the skill structure of labour demand induced by offshoring has generally been addressed at the industry-level within the framework of a flexible cost function from which a system of cost or employment share equations by skill level is derived. Early papers for the US (in particular Feenstra and Hanson, 1996 and 1999) as well as subsequent ones for European countries (e.g. Strauss-Kahn, 2003, for France; Hijzen et al., 2005, for the UK; Ekholm and Hakkala, 2006, for Sweden) have found that offshoring harms the relative position of low-skilled workers. Moreover, it is offshoring to low-wage countries in particular that leads to a worsening of the labour market position of low-skilled workers (Anderton and Brenton, 1999; Egger and Egger, 2003; Hsieh and Woo, 2005; Dumont, 2006; Geishecker, 2006).

The aim of this paper is to address the issue of the impact of offshoring on the skill structure of labour demand for Belgium. Measuring skills by educational attainment, industry-level data show that there has been considerable skill upgrading of employment in both manufacturing and market services in Belgium over the past 15 years. Besides that, there is also industry-level evidence for Belgium of increased offshoring where this is measured as the share of imported intermediates in total non-energy inputs. In order to determine to what extent offshoring has influenced the skill structure of labour demand in Belgium, we estimate an employment share equation for the low-skilled that includes offshoring and is derived from a translog cost function. Filling a gap in the existing literature, we take not only materials offshoring, but also business services offshoring into account. Moreover, while previous papers have focused exclusively on manufacturing industries, we extend the analysis to market services industries. In the econometric analysis, technological change is controlled for through the inclusion of the R&D intensity and a split of the capital stock into ICT and non-ICT capital. Last but not least, we investigate whether the impact of offshoring on the employment share of low-skilled workers differs between industries according to the technological content of their activity.

The core of this paper is divided into four chapters. The relevant empirical literature is reviewed in Chapter 2, while Chapter 3 contains stylised facts regarding skill upgrading and offshoring in Belgium. In Chapter 4, the model, the estimation strategy and the results are presented. Finally, concluding remarks are made in Chapter 5.

2. Relevant empirical literature

Within the vast body of academic literature on the consequences of globalisation for developed economies, a growing number of contributions have been looking specifically at offshoring measured by the share of imported intermediates in total intermediates. Among the possible consequences, the impact of offshoring on the skill structure of labour demand has been a major issue. It has become standard to investigate this issue within the framework of a flexible cost function – mostly translog – from which expressions for the input cost shares or factor demand shares are derived. Estimations of these expressions are almost exclusively based on industry-level data.

Feenstra and Hanson (1996) are the first to measure offshoring by the share of imported intermediates in total intermediates and to consider explicitly its impact on low-skilled and high-skilled labour proxied by production and non-production workers. Although they do not refer to a cost function, their approach is comparable as they regress the average annual growth in the wage share of non-production workers on that of materials offshoring plus controls for 435 US manufacturing industries. They find that offshoring has a significant positive impact for the period 1979-1990. A subsequent paper by the same authors – Feenstra and Hanson (1999) – distinguishes between narrow and broad offshoring¹ and extends the framework to include several alternative specifications of high-tech and computer capital. This lowers the contribution of materials offshoring to the rise in the non-production workers' wage share considerably.

In the wake of these two studies for the US, several papers have analysed this issue for – mostly large – European economies. Most of these papers explicitly define a cost function framework. Anderton and Brenton (1999) look at the effect of offshoring to low-wage countries on the wage bill and employment share of manual workers in six textile and five non-electrical machinery industries in the UK for the years 1970-1986. Their estimations in first differences indicate that this effect is negative.² Falk and Koebel (2002) specify a Box-Cox cost function from which they derive a system of seven variable input demands including imported materials and three skill levels for labour measured by educational attainment. Estimating the parameters of this system with non-linear SUR (seemingly unrelated regression) for 26 German manufacturing industries over 1978-1990, they find that the cross-price elasticities of the three skill levels with respect to imported materials are non-significant. However, in one of their specifications the elasticity of the demand for unskilled labour with respect to the volume of imported materials is significant negative. For France, Strauss-Kahn (2003) examines the impact of materials offshoring on the employment share of low-skilled workers in 50 manufacturing industries between 1977 and 1993. The distinction between high-skilled and low-skilled is defined in terms of occupations. Her estimation strategy is based on annual average changes just like in Feenstra and Hanson (1996). The results point to a significant negative impact of narrow offshoring to both OECD and non-OECD countries on the low-skilled employment share.

¹ For broad offshoring, all imports of intermediates are taken into account for each industry, while for narrow offshoring, only intermediates from the same industry are considered.

² It is, however, not entirely clear in this paper whether the authors replicate the standard offshoring measure of Feenstra and Hanson (1996) or just use total imports for the products corresponding to the industries in the sample.

The fall of the iron curtain leads to an increased focus on offshoring to Central and Eastern European countries (CEEC). Egger and Egger (2003) look at Austrian manufacturing. Their sample covers 20 industries over 1990-1998 and skill levels are based on occupations. They regress the relative employment of high-skilled on narrow materials offshoring to CEEC using two-stage and three-stage least squares. According to the results, offshoring to CEEC has a significant positive impact, explaining about a quarter of the rise in this share. Geishecker (2006) investigates the same question for Germany, i.e. the threat of offshoring to CEEC for the low-skilled in manufacturing in the 90's. He estimates a cost share equation for production workers by generalised method moments with data for 22 industries over 1991-2000 and finds a significant and sizeable negative effect of both narrow and broad offshoring to CEEC. A radical liberalisation similar to the one experienced by CEEC in the wake of the fall of the iron curtain is analysed in Hsieh and Woo (2005). Their paper is the exception to the rule of papers on European countries and looks at offshoring from Hong Kong to China triggered by China's opening up to foreign investment in 1980. Based on first difference and instrumental variable regressions, they find that this offshoring has had a significant downward effect on the production workers' wage bill share in Hong Kong's manufacturing industry over the years 1981 to 1996.

Furthermore, Hijzen et al. (2005) present evidence for the UK with skill levels based on occupations. They include narrow offshoring as an explanatory variable in systems of either cost shares or employment shares and apply fixed effects ISUR (iterated SUR) to estimate these with data for 50 manufacturing industries over 1982-1998. The results point to a strong negative impact of offshoring on the demand for unskilled labour. The approach chosen in Ekholm and Hakkala (2006) is similar. These authors also estimate systems of either cost shares or employment shares, but use pooled ISUR, for 20 Swedish manufacturing industries between 1995 and 2002. In terms of results, they report a significant positive impact of offshoring to low-wage countries on labour demand for workers with tertiary education and the opposite for workers with upper secondary education.

Dumont (2006) tests two flexible cost functions (generalised Leontief and minflex Laurent generalised Leontief) to show that the choice of functional form may alter the impact of offshoring on the cost shares by skill level. He estimates a system of cost share equations by iterated three-stage least squares separately for 12 manufacturing industries with data for the years 1985-1996 pooled over 5 EU countries (Belgium, Denmark, France, Germany and the UK). Low-skilled labour is proxied by manual workers. The results show that offshoring to high-skill abundant and low-skill abundant countries has, respectively, a positive and a negative impact on the cost share of low-skilled labour. Finally, Kratena (2010) treats offshoring as a direct substitution process between imported intermediate inputs on the one hand and labour of different skill levels and domestic inputs on the other hand. He estimates a set of cost share equations separately for three small open economies (Austria, Denmark and the Netherlands) by fixed effects ISUR for 13 manufacturing industries over the period 1995-2004 and finds positive cross-price elasticities for (almost) all skill levels.

Firm-level evidence on the impact of offshoring on the skill structure of labour demand is scarce. Head and Ries (2002) investigate the issue for what they call "offshore production" with a firm-level dataset for Japan. They define offshore production as the share of employment in foreign affiliates and find that it raises a firm's share of non production workers. Nonetheless, this offshoring measure is different from the one based on imported intermediates. Using data for French manufacturing firms, Biscourp

and Kramarz (2007) distinguish between imports of finished goods defined as goods that belong to same classification code as the importing firm, and imports of intermediate inputs that include all other goods imported by the firm. In line with the idea of narrow offshoring, they consider the share of imports of finished goods in total sales as an indicator of offshoring, and find that it has a significant negative effect on the share of production workers. Mion et al. (2010) replicate this measure with Belgian firm-level data. But it turns out that its impact on the skill intensity measured in terms of both occupations and educational attainment is either small or non-significant.

To sum up, several salient features of this literature should be highlighted. First, mostly large economies have been examined. Second, there has been an exclusive focus on the manufacturing sector, while service industries have not yet been analysed. Third, analogous to the previous point, the offshoring of business services has been largely neglected in this literature. Finally, in terms of the results, the large consensus regarding the negative impact of offshoring on the demand for low-skilled labour stands out, especially for offshoring to low-wage countries.

3. Stylised facts

The stylised facts presented in this chapter illustrate trends in employment by skill level and in offshoring intensities. The industry-level data presented here cover 103 industries, which are listed in Appendix 2. A systematic split is made between manufacturing including construction (63 industries) and market services (40 industries). Data sources are indicated in Appendix 3.

3.1. Skill upgrading

In Belgium, like in other European countries, there has been considerable skill upgrading of employment in terms of educational attainment over the past 15 years. Graph 1 shows that this upgrading has occurred in both manufacturing and market service industries over the period 1995-2009. Distinguishing three levels of educational attainment, it can be seen that the share of workers with ‘tertiary long’ and ‘tertiary short and higher secondary’ education has increased at the expense of workers with ‘primary and lower secondary’ education. We will henceforth refer to the latter as low-skilled workers. The analysis that follows will be mainly focused on their labour market position. The other levels of educational attainment are grouped together in one category referred to as high-skilled workers.³ Between 1995 and 2009, the share of low-skilled workers has fallen from 53% to 31% in manufacturing and from 36% to 22% in market services.

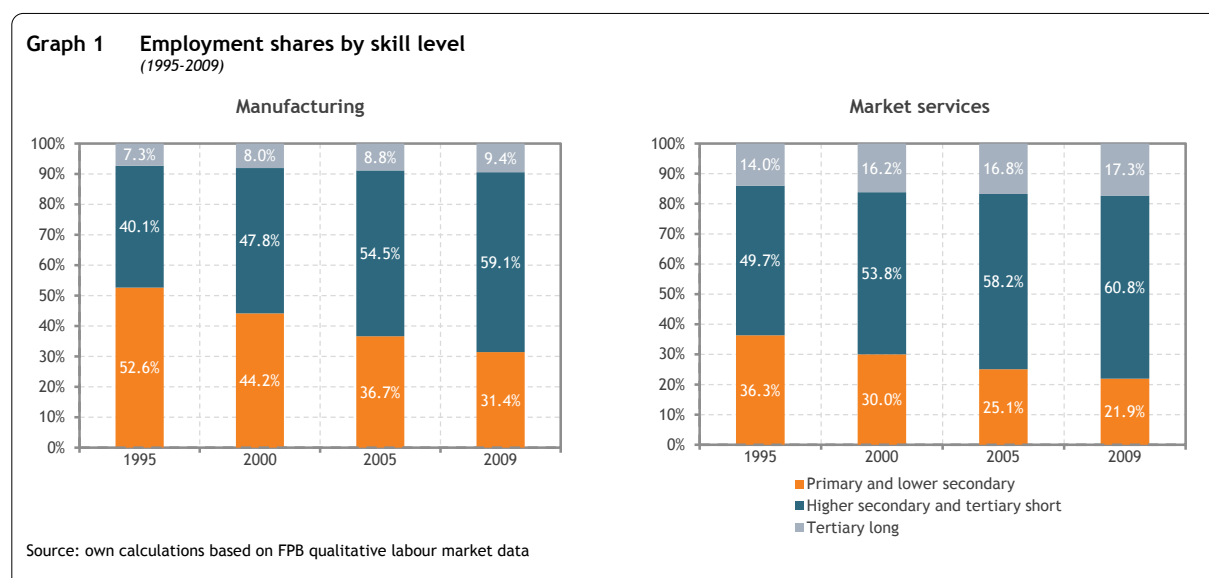


Table 1 highlights that not only the share of low-skilled workers decreased dramatically, but also their absolute number. Between 1995 and 2009, employment of low-skilled workers in Belgian manufacturing dropped by more than 45% from 487 000 to 261 000. This fall was partially offset by an increase in high-skilled workers. Overall, manufacturing employment decreased by 10%, from 926 000 to 830 000. In market services, the fall in low-skilled employment was also substantial, but relatively less than in manufacturing (-22% between 1995 and 2009, from 738 000 to 574 000), and it was more than

³ Despite the large differences in educational attainment within this second category, we have chosen to use the term high-skilled workers.

compensated for by a rise in high-skilled workers, resulting in an increase in total employment by 29%, from 2 032 000 to 2 617 000. Comparing the two sub-periods 1995-2002 and 2002-2009 in Table 1, we can see that the skill upgrading of Belgian employment slowed down somewhat, but remained substantial over the years 2002-2009.

Table 1 Employment by skill level
1995-2009, growth rates

	1995-2002	2002-2009	1995-2009
<i>Manufacturing</i>	-4%	-7%	-10%
Primary and lower secondary	-26%	-28%	-46%
Higher secondary and tertiary short	22%	9%	32%
Tertiary long	10%	5%	15%
<i>Market services</i>	15%	12%	29%
Primary and lower secondary	-13%	-11%	-22%
Higher secondary and tertiary short	28%	23%	57%
Tertiary long	37%	16%	59%

Source: own calculations based on FPB qualitative labour market data

Limiting the time span to 1995-2007⁴, two further stylised facts about skill upgrading deserve to be illustrated here. First, we examine to what extent the decline in the employment share of low-skilled workers comes from changes in the allocation of employment *between* industries or *within* industries. Following Berman et al. (1994), the change in the aggregate share of low-skilled workers (ΔE^L) can be decomposed into two components:

$$\Delta E^L = \sum_{i=1}^n \bar{E}_i^L \Delta E_i + \sum_{i=1}^n \bar{E}_i \Delta E_i^L$$

for $i = 1, \dots, n$ industries; E_i^L is the share of low-skilled workers in employment of industry i , E_i is the share of employment of industry i in total employment, and a bar over a term denotes a mean over time. The first term on the right-hand side is the *between* industries component; the second term is the *within* industries component.

Table 2 presents the results of the decomposition specified above for the period 1995-2007. Decomposing separately for manufacturing and market services shows that the fall in the overall employment share of low-skilled workers overwhelmingly occurred within industries in both sectors. In other words, between 1995 and 2007, shifts of employment away from industries with high shares of low-skilled workers (the *between* component) made almost no contribution to the observed overall skill upgrading. This finding is in line with empirical evidence for many other OECD-countries. According to the bottom row of Table 2, the *between* component is higher in a common decomposition for all 103 industries, which reflects the fact that part of the skill upgrading is due to a shift of activities from manufacturing to market services. However, *within* industry skill upgrading still largely dominates.

⁴ This matches the period covered by the econometric analysis in chapter 4.

Table 2 Industry decomposition of the fall in the low-skilled employment share 1995-2007

	Between	Within
Manufacturing	0.7%	99.3%
Market services	4.6%	95.4%
Total	8.6%	91.4%

Source: own calculations based on FPB qualitative labour market data

Second, it proves interesting to compare changes in the employment share of the low-skilled with changes in their wage bill share. Between 1995 and 2007, the wage bill share of low-skilled workers in both manufacturing and market services fell by roughly 40%. Decomposing this change shows that in manufacturing about 90% was due to a decrease in relative employment of low-skilled workers and only 10% can be attributed to a fall in relative wages. In market services, the share of the fall due to a decrease in relative low-skilled employment was smaller but still above 70%. These shares reflect that Belgium, like other continental European countries, has a less flexible labour market than for instance the US or the UK.

3.2. Offshoring

The scarcity of direct evidence regarding the transfer abroad of economic activities has prompted most authors in the field of offshoring to make use of the indirect measure suggested in Feenstra and Hanson (1996).⁵ It consists in measuring the industry-level intensity of offshoring by the share of imported intermediates in total non-energy inputs.⁶ A distinction can be made according to the type of intermediates that are sourced from abroad. It can be parts and components entering manufacturing processes, e.g. integrated electronic circuits used in computer assembly or lenses used in the production of optical instruments. When such materials are sourced from abroad, we call this materials offshoring. But offshoring may also concern business services, which encompass amongst others bookkeeping services, payroll services or legal advice. During the last couple of decades, such business services have become increasingly tradable due to developments in information and communications technology and service trade liberalisation. This has made it easier to source them from abroad. When such services are provided by foreign suppliers, we call this business services offshoring. Hence, following Amiti and Wei (2005), we define materials offshoring (*OM*) and business services offshoring (*OS*) as:

$$OM_i = \frac{\sum_m IIM_{mi}}{I_i} \quad OS_i = \frac{\sum_s IIS_{si}}{I_i}$$

where *IIM* stands for imported intermediate materials, *IIS* for imported intermediate business services and *I* for total non-energy inputs, *i* is the industry index, *m* the index for materials and *s* the index for business services.

⁵ The shortcomings of this indirect measure are summarised in Michel and Rycx (2012, p.230): "..., it ignores cases of offshoring that do not give rise to imports and includes imports that are not due to offshoring. Moreover, focusing on intermediates implies leaving out cases where the final stage of the production process is offshored." Nonetheless, in the absence of direct evidence on the transfer abroad of economic activities, it can reasonably be taken to be the best indirect measure of offshoring.

⁶ Some authors divide by output, e.g. Ekholm and Hakkala (2006) or Geishecker (2006), and some even by value added, e.g. Hijzen et al. (2005).

These offshoring intensities can be computed from input-output tables (IOT) or supply-and-use tables (SUT) and more specifically from the use table of imports, which contains information on imported intermediates by industry.⁷ Furthermore, the imported intermediates can be split according to the country of origin of the imports so as to distinguish between offshoring to different countries, in particular between high-wage and low-wage countries. Such splits are computed by a proportional method since use tables of imports by country of origin do not exist. The proportional computation of the amount of imported intermediates from country c for industry i implies multiplying the amount of imported intermediates for each product by the share of country c in total imports of that product. Hence, write:

$$OM_{_c i} = \frac{\sum_m \frac{M_{mc}}{M_m} IIM_{mi}}{I_i} \quad OS_{_c i} = \frac{\sum_s \frac{M_{sc}}{M_s} IIS_{si}}{I_i}$$

where $OM_{_c}$ and $OS_{_c}$ stand for materials and business services offshoring intensities to country c , M_m or M_s is total imports of material m or business service s and M_{mc} or M_{sc} is imports of material m or business service s from country c .

For Belgium, total materials and business services offshoring can be computed with data from a series of constant price SUT for the years 1995 to 2007 that is described in Avonds et al. (2012).⁸ Use tables of imports are contained in this database. Their construction is based on the original method described in Van den Cruyce (2004) for the input-output reference years 1995, 2000 and 2005. This method makes use of cross-tabulated import data by firm and product so as to allow for identification of intermediates that have been imported. For non reference years, the shares of imported intermediates by industry and product have been first interpolated and then multiplied with total intermediates by industry and product in order to obtain a table of imported intermediates. A balancing procedure is then used to adapt this table so as to respect import totals by product. Materials and business services are defined here in terms of product categories of the CPA⁹ by products 15-37 (except for energy products) and 72-74 respectively. Using detailed import data by country of origin and product¹⁰, we calculate offshoring intensities for three regions: OECD, which includes 22 OECD member states¹¹, CEEC, which corresponds to ten Central and Eastern European countries¹², and ASIA, which includes eight newly industrialised economies of Asia as well as China and India¹³.

⁷ In line with the initial approach in Feenstra and Hanson (1996), some authors, e.g. Egger and Egger (2003) or Ekholm and Hakkala (2006), compute the offshoring intensity for industry i by multiplying the amount of intermediates of each product by the share of imports in total supply for that product. This so-called 'proportional method' is applied when use tables of imports are not available.

⁸ These tables are deflated using a separate price index for imports and domestic production for each product.

⁹ Standard Classification of Products by Activity in the European Community (CPA2002 version).

¹⁰ The data on the geographic distribution of imports come from Intrastat and Extrastat for goods (the 8-digit Combined Nomenclature data are aggregated to the level of the product classification in our SUT) and from the balance of payments for services (categories 'Computer and information services' (7) and 'Miscellaneous business, professional and technical services' (9.3)).

¹¹ Austria, Australia, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxemburg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the UK and the US. These countries plus Turkey were the OECD member states by the middle of the 1970's.

¹² Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia.

¹³ China, Hong Kong, India, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Thailand and Taiwan.

Trends in offshoring are shown in Table 3 separately for manufacturing and market services. Starting from a high level of 35.7% in 1995, the intensity of materials offshoring in manufacturing grows relatively slowly to reach 38.3% in 2007. Business services offshoring in manufacturing is at a much lower level, but grows relatively fast from 0.7% in 1995 to 1.9% in 2007. In market services, materials offshoring also stands at a higher level than business services offshoring, and the latter again grows at a faster pace. The figures for the regional offshoring intensities show that offshoring to OECD countries largely dominates for both materials and business services. Especially for the latter, offshoring to CEE and Asian countries is still very small during the period considered here. Nonetheless, it stands out from Table 3 that between 1995 and 2007 offshoring to Asian and CEE countries grows fastest with average annual growth rates mostly above or close to 10% for both materials and business services.

Table 3 Materials and business services offshoring, total and split by region of origin

	Materials offshoring			Business services offshoring		
	1995	2007	avg grt	1995	2007	avg grt
<i>Manufacturing</i>						
Total	35.68%	38.33%	0.6%	0.71%	1.94%	8.7%
OECD	32.57%	32.13%	-0.1%	0.68%	1.77%	8.4%
CEEC	0.55%	1.95%	11.2%	0.02%	0.06%	11.9%
ASIA	0.88%	1.82%	6.2%	0.01%	0.03%	16.5%
<i>Market services</i>						
Total	4.88%	7.50%	3.6%	3.20%	5.71%	4.9%
OECD	4.51%	6.42%	3.0%	3.05%	5.23%	4.6%
CEEC	0.05%	0.31%	17.3%	0.07%	0.19%	8.9%
ASIA	0.19%	0.48%	8.0%	0.03%	0.09%	11.0%

Source: own calculations

The possibility of computing volume measures of offshoring is particularly important since value measures tend to underestimate the extent of offshoring. Indeed, activities are generally being offshored in order to make cost savings, i.e. because imported intermediates are cheaper than domestically produced intermediates. Then, the growth in the offshoring intensity in value terms can be expected to be biased downwards. This is exactly what we find when computing offshoring intensities in current and constant prices from the corresponding SUT as illustrated by their average growth rates shown in Table 4.

Table 4 Current and constant price materials and business services offshoring 1995-2007, average annual growth rates

	Materials offshoring		Business offshoring	
	Value	Volume	Value	Volume
Manufacturing	0.30%	0.60%	7.85%	8.71%
Market services	2.89%	3.64%	3.77%	4.94%

Source: own calculations

4. Econometric analysis

4.1. Model specification

In line with most empirical literature in this field, we specify a model based on the translog cost function to analyse the impact of offshoring on the skill structure of labour demand. Translog cost functions are frequently used for empirical analyses. Belonging to the category of flexible functional forms, one attractive feature of the translog cost function is that it puts no a priori restrictions on elasticities. Instead of estimating the translog cost function directly, it is more convenient to estimate a system of cost share equations derived from it.

The translog cost function is presented in its most general form in Appendix 1. The model estimated below departs in a number of ways from the general outline given in equation (A.4) in Appendix 1. First of all, on the left-hand side, we replace cost shares by employment shares. As argued above, Belgium has, like other continental European countries, a rather rigid labour market compared with the UK or the US. Hence, the deterioration of the relative position of low-skilled workers is primarily reflected in the structure of (un)employment and less by a growing wage gap between low-skilled and higher-skilled workers. Therefore, it is not surprising that employment share specifications are also the preferred model choice for France in Strauss-Kahn (2003) and for Austria in Egger and Egger (2003).¹⁴ Moreover, replacing wage bill shares by employment shares reduces the potential endogeneity problem¹⁵ stemming from the presence of wages on the right-hand side of the system of equations. In the case of a cost share model, endogeneity is highly likely given the relationship between the dependent variable, i.e. the cost share of labour, and the (relative) wage term.¹⁶ But even in an employment share model, there is a potential problem of simultaneity between the employment share and the relative wage. Finally, contrary to cost share specifications, employment share specifications are based on labour expressed in numbers of persons or hours worked¹⁷ and hence they necessarily exclude input factors other than labour.

As in most other studies, capital is taken to be a quasi-fixed factor. By treating capital as exogenous in the short-term, we assume that adjustment costs exist and prevent capital to attain its long-term equilibrium level. In line with theory, we include the capital stock rather than capital-intensity.¹⁸ Furthermore, the capital stock is split into ICT and non-ICT capital (see Table 13 on data sources in Appendix 3).

We extend the standard translog cost framework by including two types of demand shifters. The first is offshoring, both materials and business services offshoring. Furthermore, we include the R&D inten-

¹⁴ It has also been tested as an alternative specification or robustness check by other authors, e.g. Anderton and Brenton (1999), Hijzen et al. (2005) and Ekholm and Hakkala (2006).

¹⁵ Endogeneity leads to inconsistent estimators.

¹⁶ However, in a test with data for Germany, Geishecker (2006) fails to reject the exogeneity of the relative wage in a regression for the cost share of low-skilled workers.

¹⁷ Hours worked by skill level are not available for Belgium. Hence, just like all other paper in this literature, we use data on the number of persons.

¹⁸ In several papers, the capital intensity is used as a regressor instead of capital stock, e.g. Feenstra and Hanson (1996, 1999), Hsieh and Woo (2005) and Geishecker (2006).

sity, which – together with the ICT capital stock – controls for skill-biased technological change.¹⁹ Accordingly, our model takes the following form:

$$E_{it}^L = \beta_L + \delta_{LL} \ln W_{it}^L + \delta_{LH} \ln W_{it}^H + \delta_{LY} \ln Y_{it} + \delta_{LK} \ln K_{it} + \gamma_{LR} RD_{it} + \gamma_{LM} OM_{it} + \gamma_{LS} OS_{it} \quad (1)$$

$$E_{it}^H = \beta_H + \delta_{HL} \ln W_{it}^L + \delta_{HH} \ln W_{it}^H + \delta_{HY} \ln Y_{it} + \delta_{HK} \ln K_{it} + \gamma_{HR} RD_{it} + \gamma_{HM} OM_{it} + \gamma_{HS} OS_{it} \quad (2)$$

where E_i^L and E_i^H denote industry i 's employment share of the low-skilled (L) and high-skilled (H) workers, W_i^L and W_i^H denote the corresponding industry specific wage rates²⁰, Y is value added, K is capital stock, RD is R&D intensity, OM is materials offshoring and OS is business services offshoring.

As explained in Appendix 1, we can now apply, without loss of generality, the symmetry condition $\delta_{LH} = \delta_{HL}$. Moreover, a 'well-behaved' cost function should be homogeneous of degree 1 in prices, which imposes restrictions (A.2) given in Appendix 1. Applying all these restrictions to the model above, it follows that:

$$\beta_L + \beta_H = 1$$

$$\delta_{LL} = \delta_{HH} = -\delta_{LH} = -\delta_{HL} \quad \delta_{LY} = -\delta_{HY} \quad \delta_{LK} = -\delta_{HK} \quad (3)$$

$$\gamma_{LR} = -\gamma_{HR} \quad \gamma_{LM} = -\gamma_{HM} \quad \gamma_{LS} = -\gamma_{HS}$$

Given restrictions (3), our model is reduced to one single equation. Adding industry dummies D_i and a stochastic error term u_{it} , the specification to be estimated is as follows:

$$E_{it}^L = \beta_L + \delta_{LL} \ln \left(\frac{W_{it}^L}{W_{it}^H} \right) + \delta_{LY} \ln Y_{it} + \delta_{LK} \ln K_{it} + \gamma_{LR} RD_{it} + \gamma_{LM} OM_{it} + \gamma_{LS} OS_{it} + \theta_i D_i + u_{it} \quad (4)$$

In (4), the impact of materials and business services offshoring on the employment share of low-skilled workers is given by the coefficients γ_{LM} and γ_{LS} . The own-price elasticities of low-skilled and high-skilled workers can be calculated using the estimated coefficient $\hat{\delta}_{LL}$ and the fitted value \hat{E}^L :

$$\varepsilon_{LL} = \frac{\hat{\delta}_{LL}}{\hat{E}^L} - (1 - \hat{E}^L) \quad \varepsilon_{HH} = \frac{\hat{\delta}_{LL}}{(1 - \hat{E}^L)} - \hat{E}^L \quad (5)$$

Modelling a set of industry equations implicitly limits the analysis to within industry skill upgrading. In our case, however, this is not really a limiting factor, as during the period considered here almost all skill upgrading occurred within and not across industries.

¹⁹ We explicitly refrain from including variables that may indirectly also account for technological progress such as a time trend. Baltagi and Rich (2005) is an example of the use of the latter for modelling technological progress.

²⁰ The wage rate is expressed here as the wage cost per employee.

4.2. Results

In this section, estimation results for equation (4) are discussed. As this implies constraining all β , δ and γ parameters to be the same for all industries, we have split the sample into manufacturing (63 industries) and market services (40 industries) to account for their different nature and production technology. Data sources and descriptive statistics for the variables that have not been discussed in the previous chapter are reported in Appendix 3 (Tables 13 and 14).²¹

A number of studies, e.g. Feenstra and Hanson (1996), Anderton and Brenton (1999), Strauss-Kahn (2003) and Egger and Egger (2003), estimate the model by taking first differences in order to control for industry specific time-invariant effects. However, according to Griliches and Hausman (1986) using first differences tends to exacerbate potential problems of measurement error in the data. For this reason, we prefer to estimate equation (4) in levels by fixed effects, as is also done in Hijzen et al. (2005) and Kratena (2010). Given that we focus on a single employment share equation our model is closest to that of Geishecker (2006).

4.2.1. Results for manufacturing

a. Impact of total offshoring

For manufacturing, we start by estimating equation (4) by fixed effects (fe). The results are shown in column (a) of Table 6. R&D intensities are only available at a higher level of aggregation than the other variables.²² Therefore, standard errors are corrected for clustering in the estimations including the R&D intensity variable so as to avoid the bias discussed in Moulton (1990).

However, as mentioned earlier, there is a potential endogeneity issue regarding the relative wage as explanatory variable in equation (4) since industry-level wages and employment by skill-level may be determined simultaneously. The same argument may hold for the offshoring intensities, which may be chosen together with the low-skilled employment share thereby leading to an endogeneity problem. Failure to take these endogeneity problems into account entails inconsistent coefficient estimates for all variables. This is traditionally addressed through instrumental variable regression even though the estimation becomes less efficient.²³ We instrument the relative wage and the offshoring intensities using their one-year and two-year lags. As a first step, we conduct separate endogeneity tests for these variables.²⁴ The results are reported in Table 5. The null hypothesis of exogeneity is only rejected for the relative wage. Hence, we estimate equation (4) by two-stage least squares (2sls) with fixed effects instrumenting the relative wage by its one-year and two-year lags while taking the offshoring intensities

²¹ We have also added descriptive statistics for the dependent variable, i.e. the low-skilled employment share, so as to show the variation for the period covered by the estimations (1995-2007).

²² The R&D-intensity is defined as the industry-level R&D stock divided by output. Its level of aggregation is 2-digit Nace Rev.1.1 (16 industries for manufacturing) instead of the more detailed SUT classification in the Appendix.

²³ The stata module `xtivreg2` (Schaffer, 2010) is used for all instrumental variables and GMM regressions in this paper. For more details on this module, see Baum et al. (2003 and 2007).

²⁴ It is in fact an exogeneity test, i.e. "under the null hypothesis the specified endogenous regressor can actually be treated as exogenous" (Baum et al., 2007, p.482). The test reported in Table 5 is equivalent to a C or GMM distance test where the test statistic is distributed as a χ^2 with a number of degrees of freedom equal to the number of potentially endogenous regressors, and, with homoskedastic errors, it is identical to the Wu-Hausman F-test for endogeneity (Baum et al., 2003, pp.23-25). In our case, it is necessary to account for clustered standard errors due to the higher level of aggregation of the R&D intensity variable.

as exogenous. The main change compared with the fixed effects regression occurs for the instrumented variable (see columns (a) and (b) of Table 6). Furthermore, we have also estimated this model with endogenous relative wage by generalised method of moments (gmm).²⁵ The differences in the results (reported in column (a) of Appendix 4 Table 15) compared with the 2sls estimation are very small in terms of both magnitude and significance of the coefficients.

Table 5 Endogeneity tests for relative wage, materials offshoring and business services offshoring in manufacturing

	ln(relative wage)	Materials offshoring	Services offshoring
Test stat [$\chi^2(1)$]	4.687	0.510	1.094
p-value	[0.030]	[0.475]	[0.296]

Source: own calculations

Remarks: GMM distance test based on one-year and two-year lags of potentially endogenous regressor; clustered standard errors; H0: regressor can be treated as exogenous; computed with xtivreg2 (Schaffer, 2010)

According to the results of the 2sls regression in column (b) of Table 6, both materials and business services offshoring have a statistically significant negative impact on the employment share of low-skilled workers, i.e. they contribute to reducing the relative demand for low-skilled labour in a setting where relative wage trends and skill-biased technological change are controlled for. Regarding the relative wage in this specification, its negative and significant coefficient is broadly in line with what may be expected based on theory and empirical results for other countries. Own-price elasticities for low-skilled and higher-skilled workers calculated according to (5) based on estimates in Table 6 are reported in Appendix 4 Table 16.²⁶ Both are negative and strongly significant (column (b) of Table 16). Furthermore, neither of the two variables measuring skill-biased technological change (the R&D intensity²⁷ and the ICT capital stock) has a significant impact on the low-skilled employment share²⁸, whereas the non-ICT capital stock has a strongly significant negative impact. Our interpretation of this finding is that it is investment in specialised machinery and equipment for manufacturing rather than investment in computers and other ICT-equipment that puts pressure on low-skilled employment in manufacturing.²⁹ Finally, we find no effect of value added on the low-skilled employment share.

Contributions to the change in the low-skilled employment share can be calculated for the offshoring intensities and the non-ICT capital stock based on their coefficients in column (b). Materials offshoring and business services offshoring rise by respectively 2.65 and 1.23 percentage points between 1995 and 2007, accounting for respectively 2% and 10% of the fall in the low-skilled employment share during that period. The contribution of the increase in the non-ICT capital stock to the observed fall in the low-skilled employment share amounts to 24% between 1995 and 2007.

²⁵ As explained in Baum et al. (2003, p.11), estimation by gmm is generally more efficient than 2sls estimation due to the use of the optimal weighting matrix. However, the estimation of this matrix requires a large sample size and the properties of the gmm estimator may therefore be poor in small samples, notably leading to over-rejection of the null hypothesis in Wald tests.

²⁶ The values and standard errors of the elasticities reported in Appendix 4 Table 16 are based on the fitted employment shares for the last year of the dataset (i.e. 2007). The columns of Table 16 correspond to those of Table 6.

²⁷ The p-value of the R&D intensity amounts to 0.11 for the estimation in column (b). Without the cluster correction, it would be significant at the 5%-level. However, it should be noted that in our case the R&D intensity would contribute to raising the low-skilled employment share given the overall fall in the R&D intensity in manufacturing between 1995 and 2007 (see Appendix 3 Table 14). But this would be smaller than 0.5%. Moreover, we have also tested alternative calculations of the R&D intensity, but the coefficient remains non-significant.

²⁸ The two variables are not jointly significant either: the p-value of a joint Wald test for the R&D intensity and the ICT capital stock is 0.1719.

²⁹ This runs counter to the findings for US manufacturing in the 1980's reported in Feenstra and Hanson (1999).

Table 6 Estimation results with total offshoring intensities in manufacturing

Dependent variable:	(a)	(b)	(c)	(d)	(e)
low-skilled employment share	fe	2sls	2sls	2sls	2sls
ln(relative wage)	-0.065 (0.107)	-0.278*** (0.065)	-0.292*** (0.068)	-0.276*** (0.062)	-0.285*** (0.068)
ln(value added)	0.000 (0.019)	-0.006 (0.017)	-0.006 (0.017)	-0.000 (0.015)	0.015 (0.014)
ln(non-ICT capital stock)	-0.190*** (0.043)	-0.188*** (0.045)	-0.195*** (0.046)	-0.167*** (0.042)	-0.169*** (0.043)
ln(ICT capital stock)	0.002 (0.024)	-0.005 (0.021)	-0.004 (0.021)	-0.006 (0.019)	-0.037** (0.018)
R&D-intensity	-0.078 (0.114)	-0.212 (0.133)	-0.230 (0.146)	-0.160 (0.126)	-0.145 (0.125)
Materials offshoring	-0.180** (0.082)	-0.143** (0.068)		-0.234*** (0.071)	-0.192*** (0.066)
Services offshoring	-1.763*** (0.454)	-1.531*** (0.370)		-2.093*** (0.495)	-1.544*** (0.484)
Materials offshoring (current prices)			-0.087 (0.071)		
Services offshoring (current prices)			-1.398*** (0.337)		
Hitech * Materials offshoring				0.292** (0.115)	
Hitech * Services offshoring				1.045* (0.549)	
ICTcapital intensity * Materials offshoring					0.263*** (0.058)
ICTcapital intensity * Services offshoring					0.211 (0.293)
Observations	819	693	693	693	693
R-squared	0.447	0.424	0.387	0.463	0.454
Number of nace_num	63	63	63	63	63
Hansen J stat [$\chi^2(1)$]		3.136	3.511	2.333	2.538
p-value		[0.077]	[0.061]	[0.127]	[0.111]

Source: own calculations

Remarks: 63 manufacturing industries covered; standard errors with correction for clustering reported in parentheses; fe: fixed effects; 2sls: two-stage least squares (fe estimations in both stages, estimations with xtivreg2 module in stata (Schaffer, 2010)); Hansen J stat and p-value: test of validity of over-identifying restrictions (H_0 : overidentifying restrictions valid); reported significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

We have produced three extensions to the analysis of the specification with the total offshoring intensities. All three imply 2sls regressions with fixed effects using one-year and two-year lags as instruments for the relative wage and results are reported in columns (c) - (e) of Table 6.³⁰

First, given the differences in the growth rates of the offshoring intensities in value and volume terms shown in Table 4, we estimate equation (4) replacing the offshoring intensities in constant prices by their current price counterparts. This is of particular interest as most of the papers reviewed in section 2

³⁰ Own-price elasticities for high-skilled and low-skilled labour for these regressions can be found in columns (c) - (e) of Appendix 4 Table 16. They are very close in terms of size to those for the standard specification in column (b). To complete the results, we have also run gmm estimations for the specifications in columns (c) - (e) of Table 6 (see columns (b) - (d) of Appendix 4 Table 15). There are no substantial differences compared with the 2sls estimations.

use non-deflated SUT or IOT to compute the offshoring intensities that enter into the estimated equations.³¹ The results are reported in column (c) of Table 6. Comparing them with results in column (b) shows that using current price offshoring intensities leads to an underestimation of the impact on the low-skilled employment share. The coefficients for both materials and business services offshoring are smaller in current prices than in constant prices and the one for materials offshoring even becomes non-significant in current prices. Moreover, the R^2 of the estimation with current price offshoring intensities is lower. This confirms the theoretical belief that deflated SUT should be preferred for computing the offshoring intensities.

Second, in order to enhance our understanding of the relationship between offshoring and the technological content of the activities of an industry, we test for differences in the impact of offshoring on low-skilled employment between high-tech and low-tech industries. In high-tech industries, production processes are less standardised, have a higher knowledge content and require more sophisticated inputs, which makes offshoring more difficult and less profitable – especially for very specific materials inputs. As a consequence, the impact of offshoring on the low-skilled employment share may be expected to be weaker in high-tech industries. A classification of high-tech and low-tech industries is put forward in OECD (2005, pp.181-183). Based on this classification we create a high-tech dummy (Hitech).³² While the fall in the low-skilled employment share between 1995 and 2007 is almost identical in high-tech and low-tech industries (respectively 18 and 19 percentage points), materials offshoring stagnates in the former and grows moderately by 4 percentage points in the latter. Moreover, business services offshoring rises faster in high-tech industries (2 percentage points) than in low-tech industries (1 percentage point). Estimating equation (4) with interaction terms between the high-tech dummy and respectively materials and business services offshoring confirms the reasoning above (column (d) in Table 6). For both materials and business services offshoring, the coefficients of the offshoring variable and the respective interaction term with the high-tech dummy are individually and jointly significant.³³ Materials offshoring has a stronger impact in low-tech industries (-0.234), and its coefficient for high-tech industries (0.058) is not significant. In low-tech industries, the contribution to the fall in the employment share of low-skilled workers is close to 5% for the average increase in materials offshoring in these industries. Business services offshoring has a significant negative effect on the low-skilled employment share in both low-tech and high-tech industries. The effect is again weaker in the latter (-1.048 compared with -2.093), but, due to the difference in the average increase in business services offshoring, the contribution to the fall in the low-skilled employment share amounts to approximately 10% for both.³⁴

Third, instead of interacting the offshoring intensities with a rough and arbitrarily defined high-tech dummy, we interact materials and business services offshoring with the ICT capital intensity (ICT_VA) measured as the ICT capital stock normalised by value added. The expected effect of including these interaction terms into equation (4) is less clear than in the case of the high-tech dummy. On the one

³¹ Only, Falk and Koebel (2002), Geishecker (2006) and Kratena (2010) explicitly mention the deflation of their intermediate input data.

³² Industries 24A-24G and 29A-35B from the code list in Appendix 2 Table 11 are considered high-tech.

³³ Wald test for joint significance of:

- OM and OM*Hitech: test-stat [$\chi^2(1)$] = 10.67, p-value = 0.004

- OS and OS*Hitech: test-stat [$\chi^2(1)$] = 34.51, p-value = 0.005

³⁴ We have also interacted the R&D intensity with the high-tech dummy, but this did not produce significant results.

hand, the ICT capital intensity may be seen as an alternative indicator of the technological content of an industry's activity and the same reasoning as for the distinction between high-tech and low-tech industries should hold, i.e. offshoring is more difficult to put into practice in industries with a higher ICT capital intensity and, as a consequence, the impact of offshoring on the low-skilled employment share is expected to be weaker in these industries. On the other hand, ICT capital is a potential driver for offshoring decisions, especially for business services that have become tradable through developments in information and communication technology. Indeed, ICT capital enables business services offshoring, and, in general, makes it easier to coordinate activities in different locations. Hence, if ICT capital promotes offshoring, then we would expect the negative impact of offshoring on the low-skilled employment share to be stronger in industries with a higher ICT capital intensity. The results of the estimation of equation (4) with these interaction terms are reported in column (e) of Table 6. For both materials and business services offshoring, the coefficients of the offshoring variable and the respective interaction term with the capital intensity are jointly significant.³⁵ The results show that for materials offshoring it is the former of the two described effects that dominates since the impact of the materials offshoring intensity on the employment share of low-skilled workers is greater for industries with a lower ICT capital intensity. For business services offshoring, there is no significant difference in the impact on the low-skilled employment share between industries with high and low ICT-capital intensities as the interaction term is not individually significant. Contributions to the fall in the low-skilled employment share can again be computed based on the average increase in materials and business services offshoring. For the average ICT capital intensity, the contributions are in line with the standard specification: 2.2% for materials offshoring, and to 10.1% for business services offshoring.³⁶

³⁵ Wald test for joint significance of:

- OM and OM*ICT_VA: test-stat [$\chi^2(1)$] = 20.62, p-value = 0.000
- OS and OS*ICT_VA: test-stat [$\chi^2(1)$] = 44.04, p-value = 0.000

³⁶ As the impact of materials offshoring varies significantly according to the ICT capital intensity, we have also computed the interval of contributions (for the average absolute change in materials offshoring) between the last and the first decile of the ICT capital intensity distribution (p90 and p10 since the impact of OM decreases with ICT_VA). It extends over [1.9%; 2.6%].

b. Impact of regional offshoring intensities

The possibility of splitting the offshoring intensities by region has been discussed above. We include regional offshoring intensities for materials offshoring in equation (4).³⁷ A first estimation is done by fixed effects (fe). Results are presented in column (a) of Table 8. We also test for endogeneity of the regional materials offshoring intensities – separately for each of the regional variables using their one-year and two-year lags as instruments. According to the results for the tests reported in Table 7, none of them is endogenous. Hence, we only instrument for the relative wage and estimate the model by 2sls with fixed effects (column (b) of Table 8). As before, the main difference compared with the fixed effects estimation concerns the relative wage.³⁸ However, there is also a noteworthy fall in the coefficient of materials offshoring to CEE countries. Finally, the gmm-estimation results in column (c) are very similar to the 2sls-estimation results.

Table 7 Endogeneity tests for regional materials offshoring intensities in manufacturing

	Materials offshoring to OECD	Materials offshoring to CEEC	Materials offshoring to ASIA	Materials offshoring to OTHER
Test stat [$\chi^2(1)$]	0.864	0.517	0.769	0.020
p-value	[0.353]	[0.472]	[0.380]	[0.888]

Source: own calculations

Remarks: GMM distance test based on one-year and two-year lags of potentially endogenous regressor; clustered standard errors; H0: regressor can be treated as exogenous; computed with xtivreg2 (Schaffer, 2010).

According to the results in column (b) of Table 8, materials offshoring to CEE and Asian countries as well as to the rest of the world (OTHER) has a significant negative impact on the low-skilled employment share, whereas materials offshoring to OECD countries does not influence this share. In other words, it is mainly offshoring to the typical offshoring destinations in Central and Eastern Europe and Asia that affects the relative demand for low-skilled workers. Moreover, comparing these results with the previous ones obtained with total materials offshoring, it stands out that composition matters for the magnitude of the impact of materials offshoring. Aggregating offshoring to CEE and Asian countries with offshoring OECD countries contributes to masking the real size of their effect. Regarding the coefficients for the other variables, those for the relative wage, the non-ICT capital stock and services offshoring are negative significant as in the specification with total materials offshoring in Table 6 (column (b)). The main change in these coefficients is that the impact of the latter two variables has become smaller (in absolute value).

As previously, contributions to the overall fall in the employment share of low-skilled workers can be calculated. For the three significant regional materials offshoring intensities – to CEEC, ASIA and OTHER – they amount to respectively 21%, 2% and 4%. Hence, the total contribution of materials offshoring is 27%. Given the 8% contribution of business services offshoring in this specification, the overall fall in the low-skilled employment share that is due to offshoring adds up to 35%. The accumulation of non-ICT capital accounts for a contribution of 17% to this fall. The difference with the

³⁷ We have included offshoring intensities for the three above-mentioned regions as well as the rest of the world (OTHER) in the equation. Moreover, we have decided not to split business services offshoring by region since it is almost entirely limited to the OECD region.

³⁸ The own-price elasticities for low-skilled and high-skilled labour are very close to those reported in Appendix 4 Table 16 and all significant at the 1%-level: respectively -0.785 (standard error = 0.264) and -0.407 (0.132) for the fe estimation, and respectively -1.387 (0.167) and -0.697 (0.0767) for the 2sls estimation.

contributions in the specification with total materials offshoring is striking. The contribution of offshoring is now three times as big and is no longer driven by business services offshoring, but by materials offshoring – overall and to CEE countries in particular.

Table 8 Estimation results with regional materials offshoring intensities in manufacturing

Dependent variable: low-skilled employment share	(a) Fe	(b) 2sls	(c) gmm
ln(relative wage)	-0.099 (0.098)	-0.268*** (0.057)	-0.250*** (0.053)
ln(value added)	-0.011 (0.016)	-0.019 (0.014)	-0.016 (0.014)
ln(non-ICT capital stock)	-0.134*** (0.039)	-0.132*** (0.044)	-0.149*** (0.040)
ln(ICT capital stock)	0.006 (0.020)	0.003 (0.018)	-0.003 (0.017)
R&D-intensity	-0.108 (0.084)	-0.092 (0.072)	-0.093 (0.072)
Materials offshoring to OECD	-0.028 (0.078)	0.013 (0.064)	0.022 (0.063)
Materials offshoring to CEEC	-3.354*** (0.659)	-2.828*** (0.581)	-2.586*** (0.509)
Materials offshoring to ASIA	-0.485** (0.213)	-0.422** (0.194)	-0.417** (0.194)
Materials offshoring to OTHER	-0.765 (0.464)	-0.886* (0.485)	-0.777* (0.468)
Services offshoring	-1.386*** (0.362)	-1.195*** (0.282)	-1.228*** (0.279)
Observations	819	693	693
R-squared	0.632	0.614	0.610
Number of nace_num	63	63	63
Hansen J stat [$\chi^2(1)$]		0.749	0.749
p-value		[0.387]	[0.387]

Source: own calculations

Remarks: 63 manufacturing industries covered; standard errors with correction for clustering reported in parentheses; fe: fixed effects; 2sls: two-stage least squares; gmm: generalised method of moments (estimations with xtivreg2 module in stata (Schaffer, 2010)); Hansen J stat and p-value: test of validity of over-identifying restrictions (H_0 : overidentifying restrictions valid); reported significance levels: * p<0.1, ** p<0.05, *** p<0.01.

4.2.2. Results for market services

The estimation strategy for market services mirrors the one for manufacturing. We start by estimating equation (4) by fixed effects (fe). Again, the higher level of aggregation of the R&D intensity variable requires a correction of the standard errors for clustering. Since there are only six industry groups in the higher level of aggregation, this correction imposes a rather strong penalty. In particular, testing for endogeneity and instrumenting for endogenous variables – as described above for manufacturing – is only possible by partialling out several explanatory variables and results become less trustworthy. Moreover, the coefficient of the R&D intensity is non-significant. Given this result and the absence of more disaggregated data on R&D intensities in market services, we prefer to exclude the R&D intensity variable from the estimation and avoid the correction for clustering.³⁹

Results of a fixed effects estimation of equation (4) without the R&D intensity can be found in column (a) of Table 10. According to the endogeneity tests in Table 9, the offshoring intensities can be treated as exogenous, while the relative wage is endogenous. Using one-year and two-year lags as instruments for the relative wage, we estimate the same specification by 2sls and report results in column (b) of Table 10. Neither materials nor business services offshoring has a significant impact on the low-skilled employment share, whereas both ICT and non-ICT capital have a significant negative influence. Their respective contributions to the overall fall in this share amount to 21% and 6%. Moreover, the coefficient of value added is positive significant. The last column of Table 10 contains results for the corresponding gmm estimation.

Table 9 Endogeneity tests for relative wage, materials offshoring and business services offshoring in market services

	ln(relative wage)	Materials offshoring	Services offshoring
Test stat [$\chi^2(1)$]	5.503	0.088	0.864
p-value	[0.019]	[0.767]	[0.353]

Source: own calculations

Remarks: GMM distance test based on one-year and two-year lags of potentially endogenous regressor; H0: regressor can be treated as exogenous; computed with xtivreg2 (Schaffer, 2010)

However, two further results cast doubt on the relevance of this specification. First, the significant positive effect of the relative wage runs counter to expectations based on intuition and theory.⁴⁰ Second, the Hansen J-test strongly rejects the validity of the over-identifying restrictions. This leads us to believe that the model in this form is not appropriate for explaining changes in the low-skilled employment share in the market services sector.⁴¹

³⁹ As alternative means of taking technological progress into account while avoiding the correction for clustering, we have tested specifications with respectively a linear time trend and the overall R&D intensity for market services (which is basically equivalent to introducing time dummies) instead of the industry-level R&D intensity. According to the results of the respective estimations (available from the authors upon request), the time trend as well as the total R&D intensity have a very significant and very strong downward impact on the low-skilled employment share. However, the magnitude of the impact suggests that these variables account for a lot more than just technological progress. Moreover, none of the other explanatory variables is significant in these specifications.

⁴⁰ Note that the own-price elasticities are positive for both high-skilled and low-skilled workers.

⁴¹ Estimation of an extended specification, where interaction terms between the ICT capital intensity and respectively materials and business services offshoring are included, does not change the results in a substantial way, i.e. the Hansen J test still strongly rejects the validity of the overidentifying restrictions and an rise in the relative wage contributes to increasing the employment share of low-skilled workers. Moreover, we have refrained from running estimations with materials business services offshoring split by region since both are almost entirely limited to the OECD region.

Table 10 Estimation results with total offshoring intensities in market services

Dependent variable: low-skilled employment share	(a) fe	(b) 2sls	(c) gmm
ln(relative wage)	0.267*** (0.076)	0.538*** (0.100)	0.430*** (0.098)
ln(value added)	0.022 (0.038)	0.037** (0.015)	0.023 (0.015)
ln(non-ICT capital stock)	-0.010 (0.025)	-0.031** (0.012)	-0.015 (0.012)
ln(ICT capital stock)	-0.061*** (0.020)	-0.044*** (0.010)	-0.056*** (0.010)
Materials offshoring	-0.115 (0.130)	-0.021 (0.067)	-0.085 (0.066)
Services offshoring	-0.076 (0.122)	0.102 (0.071)	0.032 (0.070)
Observations	520	440	440
R-squared	0.492	0.400	0.432
Number of nace_num	40	40	40
Hansen J stat [$\chi^2(1)$]		23.685	23.685
p-value		[0.000]	[0.000]

Source: own calculations

Remarks: 40 market services industries; heteroskedasticity and autocorrelation robust standard errors reported in parentheses; fe: fixed effects; 2sls: two-stage least squares; gmm: generalised method of moments (estimations with xtivreg2 module in stata (Schaffer, 2010)); Hansen J stat and p-value: test of validity of over-identifying restrictions (H_0 : overidentifying restrictions valid); reported significance levels: * p<0.1, ** p<0.05, *** p<0.01.

5. Conclusion

Offshoring has become a major element of globalisation. It changes production processes and industrial structures with potentially far-reaching consequences for developed economies. Among these consequences, a major concern for policy makers is that offshoring may be skill-biased. In other words, it may contribute to worsening the labour market position of low-skilled workers, either by putting pressure on their wages or by reducing their relative employment. While Dumont et al. (2012) show that in Belgium offshoring has indeed weakened the bargaining power of low-skilled workers, this paper provides evidence on the impact of offshoring on the skill structure of employment in Belgium over the period 1995-2007.

Skill upgrading has been substantial in both manufacturing and market service industries in Belgium. Over the years 1995-2009, the share of workers with primary or lower secondary education has fallen from 53% to 31% in the former and from 36% to 22% in the latter. Regarding offshoring, three major trends can be identified for Belgium: first, materials offshoring had already reached a high level in 1995 and keeps on growing slowly; second, business services offshoring is only at its beginnings in the wake of service trade liberalisation and communication technology developments, but has started to grow fast; third, it is offshoring to CEE and Asian countries that has been increasing at the fastest pace.

Estimations of the impact of offshoring on skill upgrading in this paper are based on a low-skilled employment share equation that can be derived from a translog cost function. It has been augmented to take into account offshoring – through the share of imported intermediates in total non-energy intermediates – as well as skill-biased technological change – through the R&D intensity and the capital stock variables. According to the results of the estimations for manufacturing, the contribution of offshoring to the fall in the employment share of low-skilled workers amounted to roughly 35% between 1995 and 2007. It largely exceeded the joint contribution of the technological change variables (17%). The impact of offshoring on the low-skilled employment share mainly came from materials offshoring to CEE countries (contribution of 21%), while offshoring to OECD countries had no effect. Business services offshoring accounted for 8% of the fall in the employment share of low-skilled workers. Hence, these results imply that offshoring has a significant and sizeable effect on the skill composition of employment in manufacturing industries. In this respect, they are an important complement to the previous finding that neither materials nor business services offshoring have had a significant impact on overall industry-level employment in Belgium between 1995 and 2003 (Michel and Rycx, 2011).

We have provided three further extensions compared with the existing literature. First, we have shown that a current price offshoring intensity measure underestimates the growth in offshoring, which is consistent with the idea that intermediates sourced from abroad are cheaper than domestically sourced intermediates. As a consequence, the impact of offshoring on the low-skilled employment share is also underestimated when using a current price measure as is done in most of the literature. Second, we have tested whether the impact of offshoring on low-skilled employment differs between high-tech and low-tech industries. It turns out that this impact is smaller in the former. Third, we have repeated this test ordering industries according to their ICT capital intensity. The previous results are confirmed, i.e. in industries with a higher ICT capital intensity the effect of offshoring on low-skilled employment

is smaller. Moreover, this finding also implies that even if ICT capital facilitates or even fosters offshoring, especially of business services, this does not lead to faster skill upgrading in industries with a high ICT capital intensity.

Finally, we have also investigated whether offshoring can explain skill upgrading in market services. However, the results of our estimations rather contribute to calling into question the validity of the cost function framework for market services. Further research should investigate the issue of the impact of offshoring on low-skilled employment in market services.

References

- Amiti, M. and Wei, S. (2005), "Fear of service outsourcing: is it justified?", *Economic Policy*, April 2005, vol. 20 (42), pp. 308-347
- Anderton, B. and Brenton, P. (1999), "Outsourcing and low-skilled workers in the UK", *Bulletin of Economic Research*, vol. 51 (4), pp. 267-285
- Avonds, L., Bryon, G., Hambj e, C., Hertveldt, B., Michel, B. and Van den Cruyce, B. (2012), "Supply and Use Tables and Input-Output Tables 1995-2007 for Belgium: Methodology of Compilation", Federal Planning Bureau, Working Paper 6-12, Brussels
- Baltagi, B. and Rich, D. (2005), "Skill-biased technical change in US manufacturing: a general index approach", *Journal of Econometrics* 126, pp. 549-570
- Baum, C., Schaffer, M., and Stillman, S. (2003), "Instrumental Variables and GMM: Estimation and Testing", *The Stata Journal*, vol. 3 (1), pp. 1-31
- Baum, C., Schaffer, M., and Stillman, S. (2007), "Enhanced routines for instrumental variables/ GMM estimation and testing", *The Stata Journal*, vol. 7 (4), pp. 465-506
- Berman, E., Bound, J. and Griliches, Z. (1994), "Changes in the Demand for Skilled Labor within U.S. Manufacturing: Evidence from the Annual Survey of Manufactures", *The Quarterly Journal of Economics*, vol. 109 (2), pp. 367-397
- Berndt, E. (1991), *The Practice of Econometrics: Classics and Contemporary*, Reading, MA, Addison-Wesley
- Berndt, E. and Wood, D. (1975), "Technology, Prices, and the Derived Demand for Energy", *The Review of Economics and Statistics*, vol. 57 (3), pp. 259-268
- Biatour, B., Bryon, G. and Kegels, C. (2007), "Capital services and total factor productivity measurements: impact of various methodologies for Belgium", Federal Planning Bureau, Working Paper 3-07, Brussels
- Biatour, B., Dumont, M. and Kegels, C. (2011), "The determinants of industry-level total factor productivity in Belgium", Federal Planning Bureau, Working Paper 7-11, Brussels
- Biscourp, P. and Kramarz F. (2007), "Employment, skill structure and international trade: Firm-level evidence for France", *Journal of International Economics*, vol. 72 (1), pp. 22-51
- Bresseleers, V., Hendrickx, K., Hertveldt, B., Van den Cruyce, B. and Wera, J. (2007), "Kwalitatieve werkgelegenheidsdata voor België, een SAM-aanpak voor de periode 1999-2005", Federal Planning Bureau, Working Paper 2-07, Brussels
- Christensen, L., Jorgenson, D. and Lau, L. (1971), "Conjugate Duality and the Transcendental Logarithmic Production Function", *Econometrica*, vol. 39 (4), pp. 255-256
- Coucke, K. and Sleuwaegen, L. (2008), "Offshoring as a survival strategy: evidence from manufacturing firms in Belgium", *Journal of International Business Studies* 39 (8), pp. 1261-1277

- Crino, R. (2009), "Offshoring, multinationals and the labour market: a review of the empirical literature", *Journal of Economic Surveys*, vol. 23 (2), pp. 197-249
- Deardorff, A. (2006), "Comment on Mankiw and Swagel, 'The politics and economics of offshore outsourcing'", *Journal of Monetary Economics*, vol. 53, pp. 1057-1061
- Dumont, M. (2006), "Foreign outsourcing, labour demand and the choice of functional form", *Journal of Applied Economics*, vol. IX (2), pp. 255-273
- Dumont, M. (2008), "Wages and employment by level of education and occupation in Belgium", Federal Planning Bureau, Working Paper 22-08, Brussels
- Dumont, M., Rayp, G. and Willemé, P. (2012), "The bargaining position of low-skilled and high-skilled workers in a globalising world", *Labour Economics*, vol. 19, pp. 312-319
- Egger, H. and Egger, P. (2003), "Outsourcing and skill-specific employment in a small economy: Austria after the fall of the Iron Curtain", *Oxford Economic Papers*, vol. 55 (4), pp. 625-643
- Egger, P., Pfaffermayr, M. and Wolfmayr-Schnitzer, Y. (2001), "The international fragmentation of Austrian manufacturing: The effects of outsourcing on productivity and wages", *North American Journal of Economics and Finance*, vol. 12, pp. 257-272
- Ekholm, K. and Hakkala, K. (2006), "The Effect of Offshoring on Labor Demand: Evidence from Sweden", Research Institute of Industrial Economics, Working Paper n°654, Stockholm, Sweden
- Falk, M. and Koebel, B. (2002), "Outsourcing, Imports and Labour Demand", *Scandinavian Journal of Economics*, vol. 104 (4), pp. 567-586
- Feenstra, R. and Hanson, G. (1996), "Globalisation, Outsourcing, and Wage Inequality", *American Economic Review*, vol. 86 (2), pp. 240-245
- Feenstra, R. and Hanson, G. (1999), "The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States, 1979-1990", *The Quarterly Journal of Economics*, vol. 114 (3), pp. 907-940
- Geishecker, I. (2006), "Does Outsourcing to Central and Eastern Europe Really Threaten Manual Workers' jobs in Germany?", *The World Economy*, vol. 29, pp. 559-583
- Greene, W. (2000), *Econometric Analysis*, Fourth Edition, Prentice Hall, New Jersey
- Griliches, Z. and Hausman, J. (1986), "Errors in Variables in Panel Data", *Journal of Econometrics*, vol. 31 (1), pp. 93-118
- Head, K. and Ries, J. (2002), "Offshore production and skill upgrading by Japanese manufacturing firms", *Journal of International Economics*, vol. 58 (1), pp. 81-105
- Heathfield, D. and Wibe, S. (1987), *An Introduction to Cost and Production Functions*, Humanities Press International, Atlantic Highlands, New Jersey
- Hijzen, A. (2005), "A bird's eye view of international outsourcing: data, measurement and labour demand", *Economie Internationale* 104, pp. 45-63

- Hijzen, A., Görg, H. and Hine, R. (2005), "International outsourcing and the skill structure of labour demand in the United Kingdom", *The Economic Journal*, vol. 115, pp. 860-878
- Hsieh, C. and Woo, T. (2005), "The Impact of Outsourcing to China on Hong Kong's Labor Market", *American Economic Review*, vol. 95 (5), pp. 1673-1687
- Kratena, K. (2010), "International Outsourcing and the Demand for Skills", *Empirica*, vol. 37, pp. 65-85
- Michel, B. (2011a), "Stock de capital par branche SUT 1995-2004", unpublished, internal document, Federal Planning Bureau, Brussels
- Michel, B. (2011b), "Productivity gains and spillovers from offshoring", Federal Planning Bureau, Working Paper 6-11, Brussels
- Michel, B. and Rycx, F. (2012), "Does offshoring of materials and business services affect employment? Evidence for a small open economy", *Applied Economics*, vol. 44 (2), pp. 229-251
- Mion, G., Vandenbussche H. and Zhu L. (2010), "Trade with China and skill upgrading: evidence from Belgian firm level data", National Bank of Belgium, Working Paper Research, n° 194, Brussels
- Moulton, B. (1990), "An illustration of a pitfall in estimating the effects of aggregate variables on micro units", *The Review of Economics and Statistics*, vol. 72 (2), pp. 334-338
- OECD (2005), *Science and Technology Scoreboard 2005*, Paris
- Schaffer, M. (2010), "xtivreg2: Stata module to perform extended IV/2SLS, GMM and AC/HAC, LIML and k-class regression for panel data models"
- Strauss-Kahn, V. (2003), "The role of globalisation in the within-industry shift away from unskilled workers in France", NBER Working Paper n° 9716
- Van den Cruyce, B. (2004), "Use Tables for Imported Goods and Valuation Matrices for Trade Margins - an Integrated Approach for the Compilation of the Belgian 1995 Input-Output Tables", *Economic Systems Research*, vol. 16 (1), pp. 33-61

Appendix

Appendix 1 - The translog cost function

Transcendental logarithmic⁴² or translog production and cost functions were introduced in the first half of the seventies in a number of papers, e.g. Christensen et al. (1971) and Berndt and Wood (1975), and have been frequently used in empirical work since then. They belong to the category of the so-called flexible functional forms that were developed in an attempt to impose as little a priori restrictions as possible.⁴³ More precisely, translog cost functions allow substitution elasticities to be unrestricted – they must not even be constant – and they are nonhomothetic, meaning that cost-minimizing relative input demands may depend on the level of output⁴⁴, hence allowing for U-shaped average cost functions.

Denoting total variable costs C , the prices of N variable input factors P_j and output Y , the general formulation of the translog cost function is as follows:⁴⁵

$$\ln C = \beta_0 + \sum_{j=1}^N \beta_j \ln P_j + \frac{1}{2} \sum_{j=1}^N \sum_{k=1}^N \delta_{jk} \ln P_j \ln P_k + \beta_Y \ln Y + \frac{1}{2} \delta_{YY} (\ln Y)^2 + \sum_{j=1}^N \delta_{jY} \ln P_j \ln Y \quad (\text{A.1})$$

In a classic KLEMS framework, equation (A.1) represents a five-factor model ($N=5$), with capital (K), labour (L) and three intermediate inputs (energy (E), materials (M) and services (S)) as variable factors of production. Labour can further be divided into different skill levels, augmenting the number of production factors N . It is standard to take into account capital as a quasi-fixed factor (at least in the short-run). In this case the number of variable input factors N is reduced by one, capital costs are excluded from C , and capital enters the cost function in the same way as output.

In equation (A.1), $N(N-1)/2$ symmetry conditions ($\delta_{jk} = \delta_{kj}$) can be imposed without loss of generality. Moreover, a ‘well-behaved’ cost function should be homogeneous of degree 1 in prices, meaning that a proportional increase in all variable input prices should shift total variable costs by the same proportion. This implies the following restrictions:

$$\sum_{j=1}^N \beta_j = 1 \quad ; \quad \sum_{j=1}^N \delta_{jk} = \sum_{k=1}^N \delta_{jk} = \sum_{j=1}^N \delta_{jY} = 0 \quad (\text{A.2})$$

⁴² Transcendental means non-algebraic and a logarithmic function is one form of non-algebraic function.

⁴³ Another popular flexible functional form is the Generalised Leontief function.

⁴⁴ Implying returns to scale of the dual production function are not constrained a priori, not even constant (see Berndt (1991), p.469-470).

⁴⁵ For ease of presentation, time and industry subscripts have been omitted.

According to Shephard's lemma, the cost-minimizing input quantities X_j can be derived by differentiating total costs with respect to the prices of the input factors:

$$\frac{\partial C}{\partial P_j} = X_j \quad (\text{A.3})$$

Differentiating the translog cost function (A.1) with respect to input prices and applying Shephard's lemma (A.3), one obtains a set of N cost share equations of the form:

$$S_j = \beta_j + \sum_{k=1}^N \delta_{jk} \ln P_k + \delta_{jY} \ln Y \quad (\text{A.4})$$

with the following adding-up condition:

$$\sum_{j=1}^N S_j = \sum_{j=1}^N \frac{P_j X_j}{C} = 1 \quad (\text{A.5})$$

In the empirical literature, instead of estimating the translog cost function (A.1) directly, most authors estimate the system of cost share equations (A.4).⁴⁶

As pointed out above, one attractive feature of flexible functional forms like translog cost functions is that they put no a priori restrictions on elasticities. The own price elasticities ε_{jj} and cross price elasticities ε_{jk} , and the elasticities of substitution σ_{jk} are given by the formulas below:

$$\varepsilon_{jj} = \frac{\delta_{jj}}{S_j} - (1 - S_j) \quad (\text{A.6})$$

$$\varepsilon_{jk} = \frac{\delta_{jk}}{S_j} + S_k \quad j \neq k \quad (\text{A.7})$$

$$\sigma_{jk} = \frac{\varepsilon_{jk}}{S_k} = \frac{\delta_{jk}}{S_j S_k} + 1 \quad j \neq k \quad (\text{A.8})$$

These elasticities are not constant, but differ at every data point. It is common practice to compute them either at the means of the data, or for the first, central or last year of the sample. When computing estimates of these elasticities, fitted cost shares should be used rather than observed cost shares.⁴⁷

⁴⁶ This implies efficiency gains, notably because the number of parameters to be estimated is lower. It is also noteworthy that some authors, e.g. Baltagi and Rich (2005), simultaneously estimate the cost function and the system of cost share equations.

⁴⁷ Then, given that the elasticities are nonlinear functions of the estimated parameters, the standard errors of the elasticities must be computed by the 'delta method'. This is done automatically by the command *predictnl* in Stata.

Appendix 2 - Industry classification

Table 11 List of manufacturing industries, NACE-SUT-code and description

NACE-SUT	Description
14A	Mining and quarrying of stone, sand, clay and chemical and fertilizer materials, production of salt, and other mining and quarrying n.e.c.
15A	Production, processing and preserving of meat and meat products
15B	Processing and preserving of fish and fish products
15C	Processing and preserving of fruit and vegetables
15D	Manufacture of vegetable and animal oils and fats
15E	Manufacture of dairy products
15F	Manufacture of grain mill products, starches and starch products
15G	Manufacture of prepared animal feeds
15H	Manufacture of bread, fresh pastry goods, rusks and biscuits
15I	Manufacture of sugar, chocolate and sugar confectionery
15J	Manufacture of noodles and similar farinaceous products, processing of tea, coffee and food products n.e.c.
15K	Manufacture of beverages except mineral waters and soft drinks
15L	Production of mineral waters and soft drinks
16A	Manufacture of tobacco products
17A	Preparation and spinning of textile fibres, weaving and finishing of textiles
17B	Manufacture of made-up textile articles, except apparel, other textiles, and knitted and crocheted fabrics
18A	Manufacture of wearing apparel; dressing and dyeing of fur
19A	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20A	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw
21A	Manufacture of pulp, paper and paper products
22A	Publishing
22B	Printing and service activities related to printing, reproduction of recorded media
23A	Manufacture of coke, refined petroleum products and nuclear fuel
24A	Manufacture of basic chemicals
24B	Manufacture of pesticides and other agro-chemical products
24C	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
24D	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
24E	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
24F	Manufacture of other chemical products
24G	Manufacture of man-made fibres
25A	Manufacture of rubber products
25B	Manufacture of plastic products
26A	Manufacture of glass and glass products
26B	Manufacture of ceramic products
26C	Manufacture of cement, lime and plaster
26D	Manufacture of articles of concrete, plaster and cement; cutting, shaping and finishing of stone; manufacture of other non-metallic mineral products
27A	Manufacture of basic iron and steel and of ferro-alloys and tubes
27B	Other first processing of iron and steel; manufacture of non-ferrous metals; casting of metals

NACE-SUT	Description
28A	Manufacture of structural metal products, tanks, reservoirs, containers of metal, central heating radiators, boilers and steam generators; forging, pressing, stamping and roll forming of metal
28B	Treatment and coating of metals; general mechanical engineering
28C	Manufacture of cutlery, tools, general hardware and other fabricated metal products
29A	Manufacture of machinery for the production and use of mechanical power, except aircraft and vehicle engines
29B	Manufacture of other general purpose machinery
29C	Manufacture of agricultural and forestry machinery and of machine tools
29D	Manufacture of domestic appliances
30A	Manufacture of office machinery and computers
31A	Manufacture of electric motors, generators and transformers, of electricity distribution and control apparatus, and of insulated wire and cable
31B	Manufacture of accumulators, batteries, lamps, lighting equipment and electrical equipment
32A	Manufacture of radio, television and communication equipment and apparatus
33A	Manufacture of medical, precision and optical instruments, watches and clocks
34A	Manufacture of motor vehicles
34B	Manufacture of bodies (coachwork) for motor vehicles, of trailers and parts and accessories for motor vehicles
35A	Building and repairing of ships and boats; manufacture of locomotives and rolling stock, and of aircraft
35B	Manufacture of motorcycles and bicycles and other transport equipment n.e.c.
36A	Manufacture of furniture
36B	Manufacture of jewellery and related articles
36C	Manufacture of musical instruments, sports goods, games and toys; miscellaneous manufacturing
37A	Recycling
45A	Site preparation
45B	General construction of buildings and civil engineer works; erection of roof covering and frames
45C	Construction of motorways, roads, airfields, sports facilities and water projects; other construction work
45D	Building installation
45E	Building completion; renting of construction or demolition equipment with operator

NACE-SUT based on Nace Rev. 1.1.

Table 12 List of market services industries, NACE-SUT-code and description

NACE-SUT	Description
50A	Sale, maintenance and repair of motor vehicles and motorcycles, parts and accessories
50B	Retail sale of automotive fuel
51A	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52A	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
55A	Hotels and other provision of short-stay accommodation
55B	Restaurants, bars, canteens and catering
60A	Transport via railways
60B	Other scheduled passenger land transport; taxi operation; other land passenger transport
60C	Freight transport by road; transport via pipelines
61A	Sea and coastal water transport
61B	Inland water transport
62A	Air transport
63A	Activities of travel agencies and tour operators; tourist assistance activities n.e.c.
63B	Cargo handling and storage, other supporting transport activities; activities of other transport agencies
64A	Post and courier activities
64B	Telecommunications
65A	Financial intermediation, except insurance and pension funding
66A	Insurance and pension funding, except compulsory social security
67A	Activities auxiliary to financial intermediation
70A	Real estate activities
71A	Renting of automobiles and other transport equipment
71B	Renting of machinery and equipment and personal and household goods
72A	Computer and related activities
73A	Research and development
74A	Legal activities, accounting activities; market research and public opinion polling
74B	Business and management consultancy activities; management activities of holding companies
74C	Architectural and engineering activities and related technical consultancy
74D	Advertising
74E	Labour recruitment and provision of personnel
74F	Investigation and security activities; industrial cleaning; miscellaneous business activities n.e.c.
80A	Education (market sector)
85A	Human health activities
85B	Veterinary activities
85C	Social work activities
91A	Activities of membership organisations
92A	Motion picture and video activities; radio and television activities
92B	Other entertainment activities
92C	News agency activities and other cultural activities
92D	Sporting and other recreational activities
93A	Other service activities n.e.c.

NACE-SUT based on Nace Rev. 1.1.

Appendix 3 - Data sources and descriptive statistics

Table 13 Data sources

Variable	Name	Data source	Splits	References
Y	Output	Harmonised SUT (FPB ¹) based on data from NAI ²		Avonds et al. (2012)
VA	Value added	Harmonised SUT (FPB ¹) based on data from NAI ²		Avonds et al. (2012)
IIM, IIS	Intermediates	Harmonised SUT (FPB ¹) based on data from NAI ²	Imported (by region based on detailed trade data from NBB ³)	Van den Cruyce (2004), Avonds et al. (2012), Michel and Rycx (2012)
K	Capital stock	Own calculations based on detailed investment data from NBB ³	ICT and non-ICT	Biatour et al. (2007), Michel (2011a)
L	Labour (number of workers)	Social Accounting matrix (SAM - FPB ¹) based on NAI ² data	By level of education	Bresseleers et al. (2007)
W	Labour compensation	Own calculation based harmonised SUT (FPB ¹) and on NAI ² data	By level of education	Avonds et al. (2012), Dumont (2008)
R&D	R&D stock	Own calculations based on R&D expenditure data from BSP ⁴		Biatour, Dumont and Kegels (2011)

Remarks: 1 Federal Planning Bureau
 2 National Accounts Institute
 3 National Bank of Belgium
 4 Belgian Science Policy (belspo)

Table 14 Descriptive statistics

	1995	2007	abs change	avg grt
<i>Manufacturing</i>				
Low-skilled employment share	0.53	0.34	-0.19	-3.6%
Relative wage of low-skilled	0.73	0.74	0.01	0.2%
Value added (bn of 2005 €)	51.72	62.68	10.96	1.6%
ICT capital (bn of 2005 €)	5.48	7.03	1.55	2.1%
Non-ICT capital (bn of 2005 €)	90.37	114.30	23.93	2.0%
R&D intensity	0.076	0.072	-0.004	-0.4%
<i>Market services</i>				
Low-skilled employment share	0.36	0.24	-0.13	-3.5%
Relative wage of low-skilled	0.67	0.60	-0.07	-1.0%
Value added (bn of 2005 €)	168.54	234.45	65.91	2.8%
ICT capital (bn of 2005 €)	29.50	53.88	24.38	5.1%
Non-ICT capital (bn of 2005 €)	289.98	368.69	78.71	2.0%
R&D intensity	0.009	0.020	0.01	7.0%

Source: see Table 13; own calculations

Appendix 4 - GMM estimations and own-price elasticities

Table 15 GMM estimation results with total offshoring intensities in manufacturing

Dependent variable: low-skilled employment share	(a) Gmm	(b) gmm	(c) gmm	(d) gmm
ln(relative wage)	-0.233*** (0.060)	-0.239*** (0.062)	-0.237*** (0.057)	-0.230*** (0.059)
ln(value added)	0.001 (0.016)	-0.001 (0.017)	0.006 (0.014)	0.003 (0.015)
ln(non-ICT capital stock)	-0.215*** (0.042)	-0.227*** (0.043)	-0.189*** (0.040)	-0.211*** (0.042)
ln(ICT capital stock)	-0.012 (0.021)	-0.009 (0.020)	-0.010 (0.019)	-0.029 (0.025)
R&D-intensity	-0.218 (0.133)	-0.238 (0.146)	-0.146 (0.126)	-0.192 (0.141)
Materials offshoring	-0.140** (0.068)		-0.221*** (0.071)	-0.267 (0.179)
Services offshoring	-1.652*** (0.363)		-2.032*** (0.493)	-2.704*** (0.584)
Materials offshoring (current prices)		-0.083 (0.071)		
Services offshoring (current prices)		-1.542*** (0.328)		
Hitech * Materials offshoring			0.292** (0.115)	
Hitech * Services offshoring			0.854 (0.535)	
ICT capital * Materials offshoring				0.041 (0.052)
ICT capital * Services offshoring				0.243*** (0.084)
Observations	693	693	693	693
R-squared	0.418	0.380	0.459	0.431
Number of nace_num	63	63	63	63
Hansen J stat [$\chi^2(1)$]	3.136	3.511	2.333	3.000
p-value	[0.077]	[0.061]	[0.127]	[0.083]

Remarks: 63 manufacturing industries covered; standard errors with correction for clustering reported in parentheses; gmm: generalised method of moments (estimations with xtivreg2 module in stata (Schaffer, 2010)); Hansen J stat and p-value: test of validity of over-identifying restrictions (H_0 : overidentifying restrictions valid); reported significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 16 Own-price elasticities for low-skilled and high-skilled workers for estimations with total offshoring intensities in manufacturing

	(a) fe	(b) 2sls	(c) 2sls	(d) 2sls	(e) 2sls
Own-price elasticity of low-skilled labour	-0.820*** (0.305)	-1.452*** (0.192)	-1.482*** (0.200)	-1.450*** (0.184)	-1.474*** (0.179)
Own-price elasticity of high-skilled labour	-0.461*** (0.162)	-0.773*** (0.0975)	-0.802*** (0.103)	-0.769*** (0.0934)	-0.735*** (0.0811)

Source: own calculations

Remarks: elasticities computed according to equation (5) based on estimates of δ_{11} in Table 6 and fitted values for 2007; standard errors in parentheses calculated with delta method; columns correspond to those in Table 6; reported significance levels: * p<0.1, ** p<0.05, *** p<0.01.