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Mathilde PAK* et Aurélien POISSONNIER**

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Une décomposition comptable des évolutions de l'emploi selon la technologie, le commerce et la consommation finale

Résumé

Quels sont les déterminants de l'évolution de l'emploi en France au cours des trente dernières années et comment peut-on expliquer la proportion croissante d'emplois qualifiés ? Nous proposons dans cette étude une décomposition comptable des évolutions de l'emploi suivant les contributions de trois facteurs : la technologie, le commerce extérieur et la consommation finale. L'objet de l'étude est d'observer leurs contributions aux évolutions d'emploi par niveau de qualification sur la période 1982-2010. Notre décomposition repose sur des méthodes classiques, mais des données novatrices : des tableaux d'entrée-sortie symétriques des comptes nationaux de l'Insee, en valeur et en prix de l'année précédente, basés sur les nouveaux concepts SEC2010. D'après notre analyse, la hausse des emplois qualifiés apparaît essentiellement portée par la technologie. Cet effet est surtout expliqué par le développement du secteur manufacturier de haute technologie et de la R&D au cours des trente dernières années. Le commerce extérieur aurait positivement contribué sur l'emploi et la production, et ce quel que soit le niveau de qualification.

Mots-clés : analyse entrée-sortie, décomposition structurelle, emploi, qualification, technologie, commerce extérieur, consommation finale

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Accounting for technology, trade and final consumption in employment: an Input-Output decomposition

Abstract

What are the driving forces of changes in employment in France over the last thirty years and how can we explain skill-biased changes in employment? Based on Input-Output analysis we provide a decomposition of changes in employment between the contributions of three channels : technology, trade and final consumption. Our goal is to assess these contributions to employment changes by skill level over the period 1982-2010. Our analysis builds on textbook methodologies of structural decomposition, but innovative data: INSEE's Input-Output tables both in current and previous year prices, based on the new ESA2010 concepts. Our main findings are that technology shows marked skill-bias, whereas trade and final consumption have limited skill-bias effects. The development of high-technology manufacturing and R&D over the last thirty years mainly contributes to this skill-biased change in employment. We find a positive contribution of trade to employment at every skill level.

Keywords: Input-Output analysis, structural decomposition, employment, skill-bias, technology, trade, final consumption

Classification JEL : C67, D57, F66, J23, J24, O33

Contents

1 Introduction

The increasing share of high-skill employment is a widespread phenomenon across advanced economies. While France displays skill-biased changes in employment, there is evidence for labour market polarization in other countries, i.e. increase in both high-skilled and low-skilled employment at the expense of middle-skilled one[1]. In a context of marked technological change and increasing globalisation, there are ongoing debates over the relative influence of trade and technology on employment in advanced economies, and more specifically their contributions to the structure of employment. More recent studies also underline the importance of consumer preferences to explain either skill-biased changes or labour market polarization.

The goal of this paper is to understand the nature of employment changes in France over the period 1982-2010. More specifically, we try to acknowledge whether France experienced only skill-biased changes in employment or if there is evidence of polarization effects that are offset by other effects. Based on Input-Output analysis, we provide a breakdown of changes in employment by skill and production between the contributions of final consumption, trade and technology (defined here as the use of production factors).

Our main findings are that on a yearly basis, technology shows marked skill-bias, whereas trade and final consumption have limited skill-bias effects. We find no evidence of polarization effects of technology, trade or final consumption. The development of high-technology manufacturing and R&D over the last thirty years mainly contributes to this skill-biased change in employment. Final consumption has an important contribution regardless of the skill level and explained by the development of services at the expense of agriculture and low-technology manufacturing products. Finally, unlike other papers based on Input-Output analysis, we find a positive contribution of trade to employment at every skill level, as the positive contribution of higher exports thanks to globalisation offsets the negative contribution of offshore outsourcing.

Our analysis builds on textbook methodologies of structural decomposition (Miller and Blair, 2009, Chapter 13)[2] but innovative data: time series of Input-Output tables from 1980 to 2010, based on the new European System of Account (ESA2010) and both in current and previous year prices. The price effects in the data we built are specific to each use (consumption, investment, exports...) and account for the price differential between domestic and imported supplies.

Within the limitations of the structural decomposition methodology, our evaluation allows for a comparison of the three contributions to employment (of technology, trade and consumption). As such it

[1] See Harrison *et al.* (2010) for a detailed review of literature on the subject

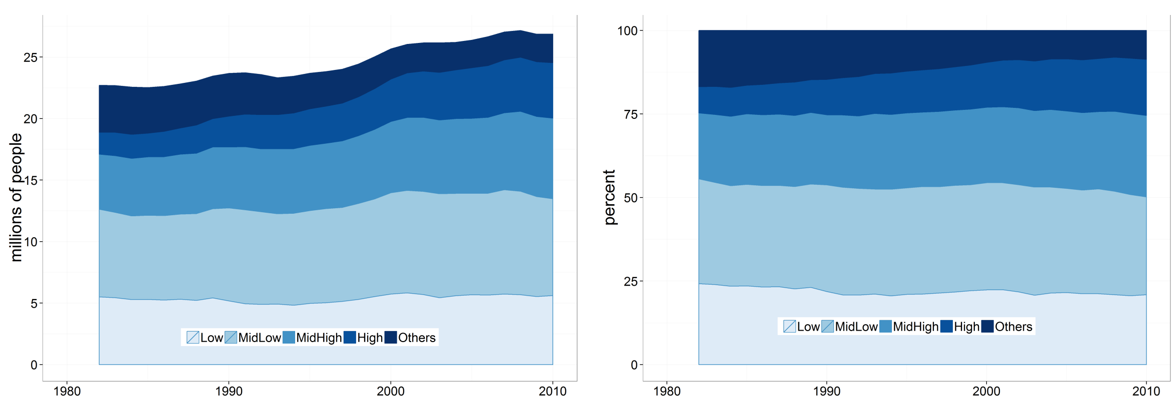
[2] See Rose and Casler (1998); Dietzenbacher and Los (1998) for a general overview of the literature

can be used as a benchmark for econometric approaches trying to capture also the long-term effect of technology, trade and final consumption on employment.

In the remainder of this paper, section 2 reviews the stylized facts and literature behind the present debate, section 3 analyses the labour content of final demand (the framework on which our decomposition is built), section 4 exposes the method we use to decompose changes in employment and section 5 provides an analysis of our results. The construction of the datasets, both Input-Output tables and employment are documented in appendix A and B.

2 Driving forces of employment changes

We identify five skill levels for employment: high skill, middle-high skill, middle-low skill, low skill and others (including in particular farmers and self-employed). Over 1982-2010, the share of higher skilled jobs[3] steadily increased, especially for the highest skilled group: its share markedly increased from 8% to 17% (Figure 1). The share of low-skilled jobs slightly decreased over the same period from 24% to 21%. As for the skill group *others*, their share in the total employment dramatically dropped from 17% to 9%, in line with the decline of the agricultural industry.



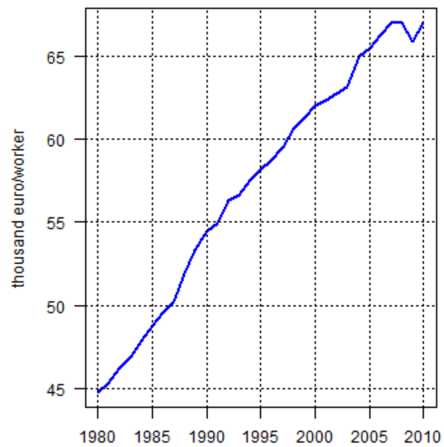
Source: Insee, LFS and national accounts; authors' calculations.

Figure 1: Employment by skill level

Like in many advanced economies, this skill-bias in French employment occurs in a context of steady labour productivity gains (+52% in real terms between 1980 and 2010, Figure 2), increasing openness (+5 points since 1980, Figure 3) and preferences of consumers for services (Figure 4). Hence technology,

[3]See Appendix B for details about how we define skill levels.

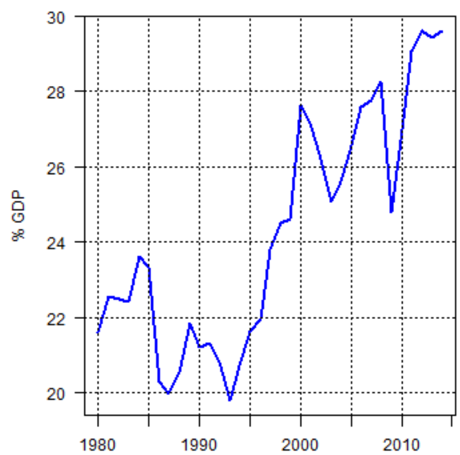
trade and final consumption are traditionally examined to explain employment changes and particularly changes by skill levels.



Source: Insee, national accounts.

Note: Labour productivity is defined as the ratio of real value added on total domestic employment (in number of persons).

Figure 2: Labour productivity in France



Source: Insee, national accounts.

Note: Trade openness is defined as the sum of total exports and imports on GDP times two.

Figure 3: Trade openness ratio in France

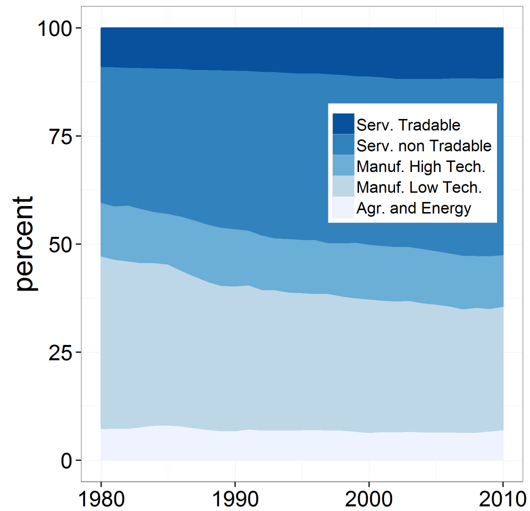


Figure 4: Consumption structure

Source: Insee, national accounts; authors' calculations

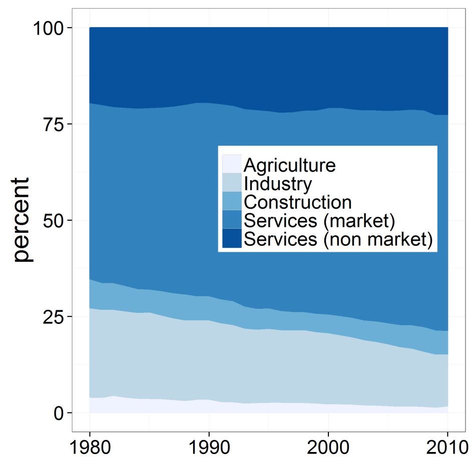
2.1 Technology development

The theoretical impact of technology on aggregate employment is ambiguous. A labour saving innovation can be either used to address higher demand – and hence increase employment – or reduce payroll. Using micro-data on American firms in the concrete industry, Morin (2015) analyses the effects of electricity, a labour saving technology, during the Great Depression and finds that firms have taken advantage of the development of electrical power to reduce employment and payroll.

Technological change can also influence job composition and can imply important reallocation of labour along with sectoral development, for instance development of services at the expense of the manufacturing sector (Figure 5). In this sense, changes in technology and in consumer preferences go hand in hand (Autor and Dorn, 2013). There is evidence of technological skill-biased effects on employment, i.e. it can be associated with an increasing demand for high- relative to low-skilled jobs (Autor *et al.*, 1998, 2003; Maurin and Thesmar, 2004; Los *et al.*, 2014; Charnoz and Orand, 2016). This skill-bias relies on the *routinization hypothesis* of Autor *et al.* (2003): new technologies such as computers are substitute for routine tasks – accomplished by following explicit rules or step-by-step procedures – and complementary to nonroutine cognitive ones[4].

[4] Maurin and Thesmar (2004) rely on a similar hypothesis to explain skill-biased technological change in France: new technologies increase the demand for jobs that require constant adaptation to change, while decreasing the demand for jobs that can be programmed in advance.

One particular aspect of skill-biased technological change is labour market polarization, i.e. a decline in middle skill labour relative both to skilled and unskilled one. Goos and Manning (2007) argue that routinization as described by Autor *et al.* (2003) is the main factor of job polarization, as routine jobs tend to be concentrated in the middle of the skill distribution, and nonroutine cognitive and manual ones in respectively the higher and lower part. On both theoretical and empirical grounds, this labour market polarization is mainly highlighted in the US (Autor and Dorn, 2013; Autor *et al.*, 2013; Morin, 2014), but also in the UK (Goos and Manning, 2007) and Western European countries (Goos *et al.*, 2009, 2011, 2014; Michaels *et al.*, 2014).



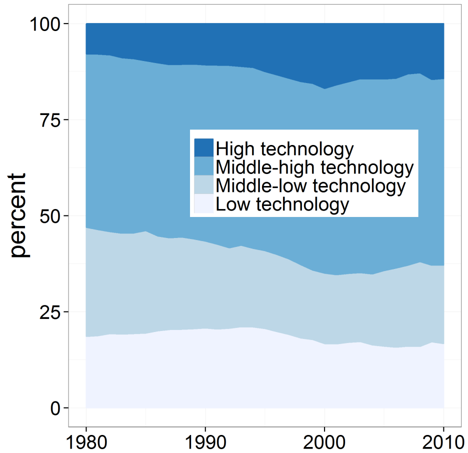
Source: INSEE, national accounts.

Note: Non market services comprise public administration, education, human health and social work activities. Market services comprise the remaining services.

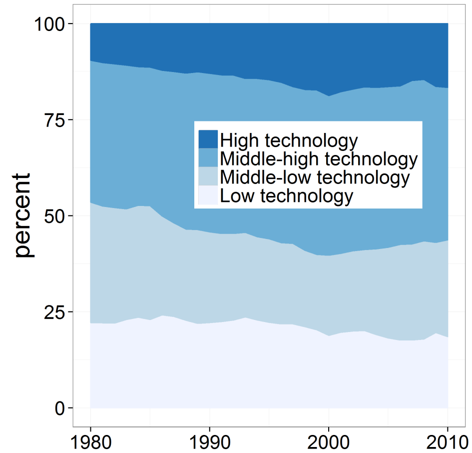
Figure 5: Value added by industry in France

2.2 Trade openness and offshoring

Like technology, trade has opposite effects on aggregate employment. On the one hand, foreign demand can foster domestic employment through exports. On the other hand foreign economies can reduce domestic market shares – and hence employment – by supplying final and intermediate demand. The latter case has raised particular interest. As information and communication technology develop, and transportation costs and trade barriers are reduced, firms have more opportunities to subcontract to foreign lower-cost firms. This phenomenon is known as offshoring (production and jobs of a given firm are moved abroad (Blinder, 2009)) or offshore outsourcing (moved to a different firm abroad).



(a) Exports



(b) Imports

Source: Insee, national accounts; authors' calculations

Note: High technology comprises pharmaceutical, computer, electronic and optical, air and spacecraft. Middle-high technology comprises cheminals, electrical equipment and machinery, motor vehicles. Middle-low technology comprises rubber, plastic, coke and refined petroleum products,ships and boats. Low technology comprises food, beverage, textile, furniture.

Figure 6: Level of technology in manufactured exports and imports in France,1980-2010

Trade can also foster reallocation of workers and production to other industries through relative competitiveness. Being more exposed to international competition, a more open economy can specialize in less exposed sectors (e.g. personal services) or where it has a comparative advantage (for instance in terms of production inputs as predicted by the Heckscher-Ohlin theorem). Trade can thus reallocate labour to sectors using skills in different proportions. For instance, the structure of trade in France – especially manufactured exports – has gradually incorporated more technological content (Figure 6). The share of exports in high-technology manufactured goods raised from 7.9% to 14.3% between 1980 and 2010, the share of imports in such goods from 9.5% to 16.6%. As high-technology requires more skilled jobs, this upgrade in manufactured exports could imply skill-biased changes in employment.

Trade effects on skill demand is usually considered as small (Feenstra and Hanson, 1999; Gregory *et al.*, 2001; Goos and Manning, 2007), or not significant (Blinder, 2009; Goos *et al.*, 2009, 2014; Michaels *et al.*, 2014). However some empirical analyses assess a significant negative impact of trade on employment changes in developed economies (Autor *et al.*, 2013) and even a job polarization effects of trade (Zeddies, 2013) and offshoring (Goos *et al.*, 2011; Foster *et al.*, 2012), since routine jobs – and hence middle-skilled jobs – tend to be more offshorable.

2.3 Final consumption

Conversely to the two previous channels, final consumption is expected to have a positive contribution to employment change. Gregory *et al.* (2001) and Los *et al.* (2014) even show that changes in final consumption are the main determinant of changes in employment.

In addition, structural effects may be at play. The rationale for this structural effect is twofold. First there can be changes in relative prices to which demand reacts. Second consumers can have different preferences as explained by *Engel curves*: as incomes grow, relative demand tends to shift to superior goods and services whose labour content may differ. This mechanism is used to explain labour market polarization in Autor and Dorn (2013) and Goos and Manning (2007). For instance, as displayed in figure 4, the share of services in the household consumption has dramatically increased between 1982 and 2010 (from 31 to 41% for non-tradable services and from 9 to 11% for tradable ones), at the expense of low-technology manufactured products (from 40 to 29%).

2.4 Our approach

The aforementioned papers mainly focus on either one or two out of these three channels to explain employment changes, based on theoretical or econometric models. But Input-Output analysis can take into account and disentangle these three effects altogether. It is also a comprehensive framework that covers all sectors of the economy and captures the increasing complexity of the value chain due to outsourcing. A classic example of this phenomenon is Apple's iPod (Linden *et al.*, 2007). China exports iPods to the US for $150. But its national value added for assembling the electronic inputs represents a few dollars at most, as most expensive electronic inputs are provided by Japan. Hence the overall contribution of exporting iPods to Chinese employment is rather small.

Our analysis belongs to this strand of the literature. It builds on textbook methodologies of structural decomposition (Miller and Blair, 2009, Chapter 13) but innovative data. Conversely to previous papers relying on Input-Output analysis to analyse employment changes (Gregory *et al.*, 2001; Los *et al.*, 2014), we work with time series of Input-Output tables from 1980 to 2010, based on the new European System of Account (ESA2010) and both in current and previous year prices. The price effect in the data we built are specific to each use (consumption, investment, exports...) and account for the price differential between domestic and imported supplies[5].

However there are some limitation. First, the Input-Output analysis cannot reveal the underlying causal links between employment and its determinants in the long run (Martin and Evans, 1981). In-

[5]See Appendix A for further details

deed, this approach captures what we may call first round, short-term or partial equilibrium effects. It does not take into account long-term closure effects. Trade openness can introduce new varieties of goods in the consumption basket, a structural change we identify in the final consumption effect. It can also induce opportunities to adopt new technologies as a "defensive innovation" strategy (Acemoglu, 2003) or increase the productivity of factors (both offshored and not offshored ones) (Grossman and Rossi-Hansberg, 2008) for instance through imported technology. We identify this indirect contribution of trade as technology. Like trade, final consumption cannot be considered exogenous to technology. By enhancing apparent productivity, technology can also increase wages and hence households' purchasing power, which in turn raises final consumption and employment.

Second, we do not isolate the effect of relative prices either. This accounting approach cannot disentangle changes in the relative use of production inputs stemming from changes in relative prices and from changes in the underlying function of production. Likewise our approach cannot disentangle the relative demands for different products or for imported/domestic products stemming from changes in relative prices and from changes in preferences. In other terms, we do not differentiate changes along the demand curves from change of the demand curves.

Within the limitations of our Input-Output decomposition, our evaluation allows for a comparison of the three channels – technology, trade and consumption – on employment. As such it can be used as a benchmark for econometric approaches trying to capture also the long-term effect of technology, trade and final consumption on employment. Our methodology complements these econometric approaches by providing a benchmark evaluation for the effects at play altogether. In addition, in the case of technology, we can solve in part the latter issue by identifying the contribution of purchasing power gains to employment changes (See equation 4.10 in section 4). Finally overlooking long-term closure effects in our analysis does not stand as an issue, since our analysis is restricted to short-term effects of technology, trade and final consumption. Even if long-term effects offset negative effects on employment at time t, employment destruction did occur and should be accounted for at time t (Barlet *et al.*, 2009).

3 A preliminary investigation: the labour content of final demand

As underlined in the previous section, the skill structure of employment has changed over the last 30 years. In this preliminary investigation, we introduce the first Input-Output elements to analyse employment changes by skill level [6].

[6] Employment changes are expressed in terms of headcounts (see Appendix B).

3.1 Defining the labour content of final demand

From the Input-Output framework, we have for every year[7] the following equilibrium and division between domestic ($IC^d + FD^d$) and imported shares ($IC^m + FD^m$):

$$P + M = IC + FD \quad \Rightarrow \quad \begin{cases} P = IC^d + FD^d \\ M = IC^m + FD^m \end{cases} \tag{3.1}$$

with P, M, IC, FD respectively the vectors of production, imports, intermediate consumption, and final demand (vectors of length p, with p the number of products).

We denote $\mathbf{A}$ the matrix of technical coefficients, such that $IC = \mathbf{A}P$ (hence $\mathbf{A}$ is the matrix of intermediate consumption of each product (in lines) for the production of all products (in columns) divided in columns by the production of these products).

The (diagonal) matrix of domestic shares for each demand is denoted $\mathbf{S}^z$ with z the corresponding demand, such that $FD^d = \mathbf{S}^{FD}FD$ is the final demand[8] supplied by domestic production (and $I - \mathbf{S}^z$ is the imported share).[9]

Since $P = IC^d + FD^d = \mathbf{S}^{IC}\mathbf{A}P + \mathbf{S}^{FD}FD$, we can then write:

$$P = (I - \mathbf{S}^{IC}\mathbf{A})^{-1}\mathbf{S}^{FD}FD = \mathbf{R}\mathbf{S}^{FD}FD \tag{3.2}$$

Let N denote a vector of domestic employment corresponding to the domestic employment required for domestic production detailed by product and employment's skill level. Hence N is a vector of length $q \times p$, with p the number of products and q the number of skill groups. We define a matrix T such that:

$$N = \mathbf{T}.VA \tag{3.3}$$

with VA the vector of value added for each product. $\mathbf{T}$ is a matrix of skill-use coefficients. More precisely, it is a concatenation of diagonal matrices for each skill where the diagonal elements are the level of employment of the corresponding skill used for each production divided by the corresponding value added.

[7] The time index is omitted for simplification.

[8] Final demand is the sum of final consumption, gross fixed capital formation (GFCF) and exports.

[9] Due to aggregation effects, these shares differ across operations at the A38 level we work with. They are however based on homogenous assumptions at the underlying level used for retropolation of Input-Output tables (F48).

For each product k, the value added of k is equal to the production of k minus the intermediate consumption used to produce it.

$$VA_k = P_k - \sum_{i=1}^{p} a_{i,k} P_k \tag{3.4}$$

with $a_{i,k}$ the intermediate consumption of a product i required for the production of k, divided by the production of k, i.e. the coefficients of matrix ${}^t\mathbf{A}$.

So VA is related to P through the following relation:

$$VA = diag((I - {}^t\mathbf{A})\mathbf{1})P = \mathbf{M}P \tag{3.5}$$

with $\mathbf{1}$ a vector of ones and of length p. $\mathbf{M}$ is a diagonal matrix of size $p \times p$ which allows us to subtract the share of intermediate consumption required to produce each product[10].

Equations (3.2), (3.3) and (3.5) combined provide an initial framework to measure the domestic labour content of final demand by skill and product.

$$N = \mathbf{TMRS}^{FD} FD \tag{3.6}$$

Under this form, we can identify the product of matrices $\mathbf{TMRS}^{FD}$ as the domestic employment content of final demand. It is a $pq \times p$ matrix. For each product in column, it corresponds to the number of jobs of each skill level and for each product (lines) required to provide 1 € of this product (in column) to the final consumers.

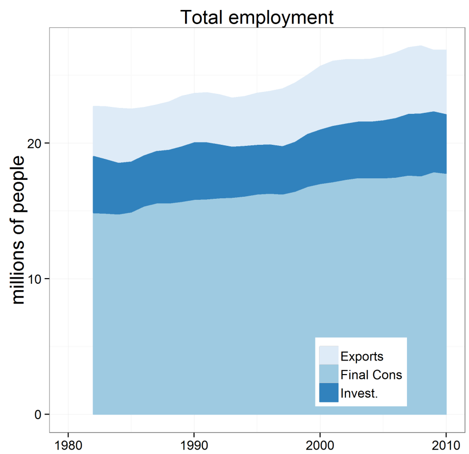
3.2 How many jobs are required to address final domestic demand and exports?

Noting that $\mathbf{S}^{FD} FD$ is the sum of several uses, we can further decompose total employment and employment by skill level into the shares used to address final consumption (including changes in inventories), investment and exports (Figures 7 and 8).

Final consumption requires the largest share of employment: on average two thirds of employment serve it. From 1982 to 2010 the labour force required to address final demand has been steadily increas-

[10] Intermediate consumption defined in Equation 3.2 is different to the one defined in Equation 3.5. In the first case, it represents the use of a product p as an intermediate consumption in the production of all products. In the second case, it represents all intermediate consumptions used to produce p. Hence we cannot write $VA = (I - A)P$.

ing (Figure 7). This increase (+0.7% per year on average) is however less than the increase in the three components of final demand (+3.3% per year on average, in volume). This differential is a consequence of the labour productivity gains. The labour content of final demand measured in employment per € (corrected for inflation) has thus decreased.

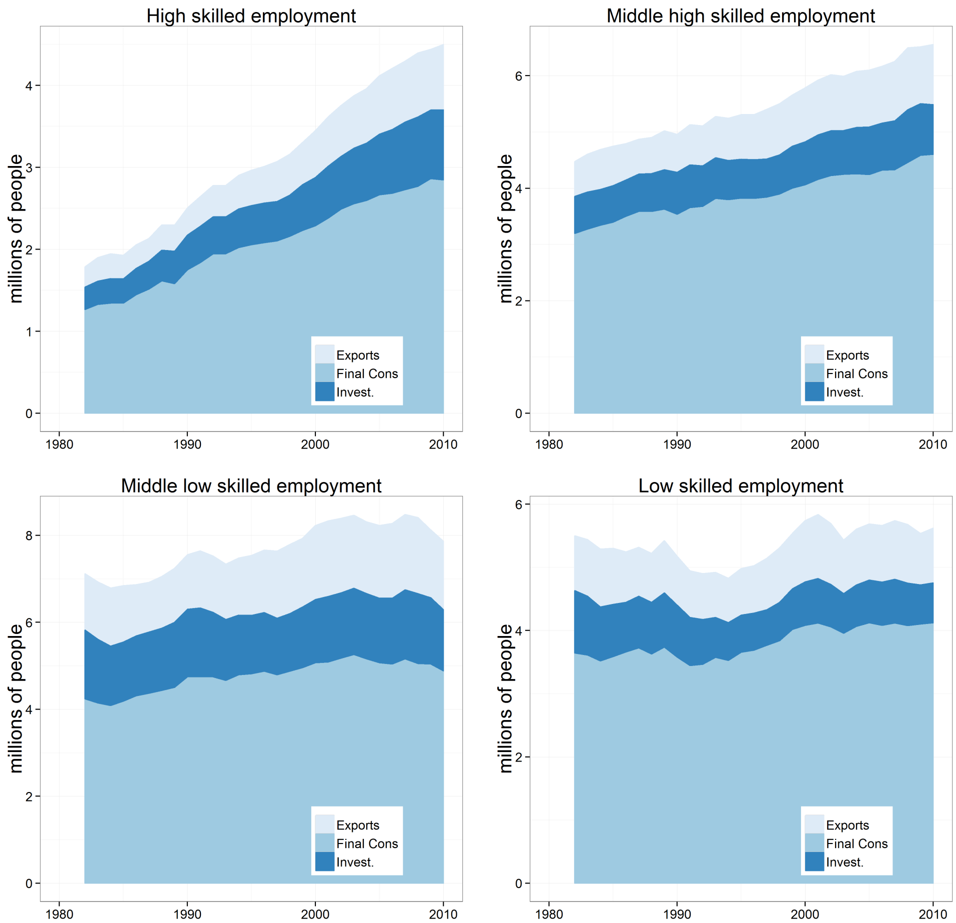


Source: Insee, national accounts; authors' calculations.

Note: In 2010, 18, 4 and 5 millions of people are required to address respectively final consumption, investment and exports.

Figure 7: Labour content of final domestic demand and exports

While the increase in employment is more sizeable for higher skilled jobs (+5.4% and +1.7% per year for high- and middle high-skill), it is virtually null for low-skilled jobs (Figure 8). More precisely buoyancy in high-skilled employment reflects the increasing need of investment and exports for high-skilled labour content, as R&D develops and manufactured exports are more specialised in high-technology. The share of high-skilled employment dedicated to investment increased from 17% in 1982 to 23% in 2010, while it increased from 17% to 20% in the case of exports. Conversely, the share of low-skilled jobs dedicated to investment dropped over the same period (from 18% to 11%), while the share dedicated to consumption dramatically increased (from 66% to 77%).



Source: Insee, LFS and national accounts; authors' calculations.

Note: In 2010, 3, 0.9 and 0.8 millions of high-skilled jobs are required to address respectively final consumption, investment and exports.

Figure 8: Labour content of final domestic demand and exports, by skill level

3.3 Skilled and unskilled, direct and indirect labour content

Table 1 provides a comparison of the labour content of final domestic demand by product between 1982 and 2010.[11] This analysis confirms the overall decrease in the labour content: fewer jobs are required to produce each good and service, in line with productivity gains. In 1982, 17.8 jobs are required to produce 1 million € of 2010 of final domestic demand products. They are 12.7 in 2010. This decrease in the labour content of final domestic demand is effective for all products but more sizeable for goods

[11] A table for 17 products and complementary figures are available in a separate appendix.

than services. For instance, one million euro of high-technology manufactured goods requires 24.6 jobs in 1982 and only 7.3 in 2010, while labour content in non-tradable services decreases only from 17 to 13.7 jobs per million euro. This sizeable decrease in the labour content of manufactured products is consistent with the routinization hypothesis of Autor *et al.* (2003): new technologies replace human labour in routine tasks in industrial sectors while low-skilled jobs in services, engaged in more interactive and social tasks (sales, catering, house care...) are less impacted.

In thirty years, the share of higher skilled labour content increased for all products, conversely to the other skill levels. This increase is particularly important in tradable services and more specifically in information and communication and in business services where R&D is accounted.[12] As for high-technology manufactured products, high-skilled jobs represent 7.3% of the labour content in 1982, against 19.9% in 2010. As underlined by Autor *et al.* (1998), computer-intensive industries in developed economies – and by extension new technology-intensive industries – require higher skilled jobs. The skill level *Others* includes farmers together with other self-employed workers; the content of agriculture (grouped with energy) but also low technology manufactured goods (incl. food products) in this kind of employment has dramatically decreased, reflecting the decline of employment in the agricultural sector.

The direct labour content of a product is defined as the labour involved in the production of final demand within the corresponding sector, whereas the indirect labour content is the labour content of intermediate consumption used to address final demand [13]. For instance, to produce cars, jobs on a car assembly line – direct labour content – will be required, as well as indirect labour content such as jobs in a tire factory, advertising, power plants. Vertical specialization would imply an increasing share of indirect labour content both or either domestic or imported. Looking only at the domestic labour content, this is the case only for high-technology manufactured goods and more specifically transport equipment.

[12]A table for 17 products is available in a separate appendix.

[13]More simply, the direct labour content is the one reported in the LFS in proportion of the final use in each production. More technically, the direct labour content of a product is estimated through **TM** and the indirect labour content through **TMR-TM**.

	Product	High	Mid-high	Mid-low	Low	Others	Total	Direct	Indirect
		Skill level							
1982	Manuf. High Tech.	1.8	5.1	9.4	6.5	1.8	24.6	10.3	14.2
		7.3	20.7	38.1	26.4	7.5	100	42	58
	Manuf. Low Tech.	0.9	2.4	5.5	5.9	6.6	21.2	8.4	12.8
		4.2	11.2	25.9	27.6	31.2	100	39.5	60.5
	Serv. non Tradable	1.4	3.8	5.2	4.2	2.3	17	12.7	4.3
		8.4	22.4	30.4	25	13.8	100	74.7	25.3
	Serv. Tradable	2.4	4	7.4	3.2	1.5	18.5	10.9	7.6
		13	21.6	40	17.3	8.1	100	59	41
	Agr. Energy	0.6	1.8	2.4	2.4	8.9	16	9.8	6.2
		3.5	11	15.2	14.9	55.4	100	61.4	38.6
	Total	1.4	3.6	5.4	4.3	3	17.8	11.8	6
		8.1	20.3	30.6	24.4	16.6	100	66.4	33.6
2010	Manuf HighTech	1.5	1.9	2.4	1.1	0.4	7.3	2.5	4.8
		19.9	26.4	32.4	15.4	5.8	100	34.8	65.2
	Manuf LowTech	1.3	2.2	3.3	2.5	2	11.2	4.8	6.4
		11.4	19.3	29.4	22	17.8	100	42.6	57.4
	Serv. non Tradable	2	3.5	3.9	3.2	1	13.7	10.5	3.2
		14.7	25.7	28.7	23.3	7.6	100	76.6	23.4
	Serv. Tradable	3.4	2.4	2.9	1.2	0.6	10.5	5.9	4.6
		31.9	23.1	27.8	11.8	5.4	100	56.4	43.6
	Agr. Energy	1.2	1.9	1.9	1.8	2.5	9.3	4.6	4.7
		12.9	20.5	20.8	19.3	26.6	100	49.7	50.3
	Total	2.1	3.2	3.6	2.7	1.1	12.7	9	3.7
		16.8	24.8	28.5	21.5	8.4	100	70.7	29.3

Source: Insee, LFS and national accounts; authors' calculations.

Note: In 1982, for the total economy, the labour content of final domestic demand (defined by $\mathbf{TMRS}^{FD}$) is 17.8 jobs per million € of 2010, including 5.4 middle low-skilled wokers who represent 30.6% of the total labour content. This content is down to 12.7 in 2010. In 1982 for high technology manufactured goods, 58% of the labour content is indirect, i.e. due to intermediate consumption while in 2010 it is 65%, reflecting vertical specialisation in this sector.

Table 1: Labour content of final domestic demand by product (in employment per million euro of 2010)

4 Decomposition methodology of employment changes

4.1 From changes in production to changes in employment

Changes in production Between two periods t and τ, changes in production can be related to changes in final demand (domestic or foreign), changes in openness ($\mathbf{S}^z$) and changes in technology ($\mathbf{A}$). From the previous structural decomposition, we built on (Miller and Blair, 2009, Chapter 13) and (Gregory *et al.*, 2001) to identify the contribution of each effect to changes in production. We apply the following methodology to changes in Input-Output data in prices of the previous year at time t and in current prices at time $t-1$, following in that sense the concept of chain linked volumes applied in national accounts. The retropolation of Input-Output is detailed in Appendix A. Note however, that deflation of each operation is based on its specific price index (consumption, investment...) and that the relative prices of domestic and imported shares of a specific operation reflects the relative prices of production and imports.

$$\Delta P_{t,\tau} = P_t - P_\tau = \mathbf{R}_t(\Delta \mathbf{S}^{FD} FD_t + \mathbf{S}^{FD}_\tau \Delta FD) + \Delta \mathbf{R}(\mathbf{S}^{FD}_\tau FD_\tau) \tag{4.1}$$

We can rearrange the terms

$$\Delta \mathbf{R}(\mathbf{S}^{FD}_\tau FD_\tau) = \mathbf{R}_t(\mathbf{S}^{FD}_\tau FD_\tau) - \mathbf{R}_\tau(\mathbf{S}^{FD}_\tau FD_\tau) = (\mathbf{R}_t \mathbf{R}^{-1}_\tau - I)P_\tau \tag{4.2}$$

$$= \mathbf{R}_t(\mathbf{R}^{-1}_\tau - \mathbf{R}^{-1}_t)P_\tau = \mathbf{R}_t(\mathbf{S}^{IC}_t \mathbf{A}_t - \mathbf{S}^{IC}_\tau \mathbf{A}_\tau)P_\tau \tag{4.3}$$

and

$$\mathbf{S}^{IC}_t \mathbf{A}_t - \mathbf{S}^{IC}_\tau \mathbf{A}_\tau = \Delta \mathbf{S}^{IC} \mathbf{A}_t + \mathbf{S}^{IC}_\tau \Delta \mathbf{A} \tag{4.4}$$

It follows that changes in production can be decomposed as :

$$\Delta P_{t,\tau} = \mathbf{R}_t(\Delta \mathbf{S}^{FD} FD_t + \mathbf{S}^{FD}_\tau \Delta FD) + \mathbf{R}_t(\Delta \mathbf{S}^{IC} \mathbf{A}_t + \mathbf{S}^{IC}_\tau \Delta \mathbf{A})P_\tau \tag{4.5}$$

with $FD = FDD + X$ (FDD is the final domestic demand and X are the exports).

Eventually, we can decompose changes in production in three terms:

$$\Delta P_{t,\tau} = \underbrace{\mathbf{R}_t \mathbf{S}^{FDD}_\tau \Delta FDD}_{\text{Changes in final domestic demand}} + \underbrace{\mathbf{R}_t(\Delta \mathbf{S}^{FDD} FDD_t + \Delta(\mathbf{S}^X X)) + \mathbf{R}_t \Delta \mathbf{S}^{IC} \mathbf{A}_t P_\tau}_{\text{Changes in exports and imports}} + \underbrace{\mathbf{R}_t \mathbf{S}^{IC}_\tau \Delta \mathbf{A} P_\tau}_{\text{Changes in technology}} \tag{4.6}$$

Is GFCF demand or technology? In the former decomposition in section 3, we take a standard accounting approach and consider gross fixed capital formation (GFCF) as final domestic demand along with final consumption. However, changes in GFCF can also be related to capital and hence future changes in production factors, i.e. technology. Hence in this paper, we consider GFCF changes as technological changes.

We then write in a slightly different fashion:

$$\begin{aligned}\Delta P_{t,\tau} = \quad & \underbrace{\mathbf{R}_t \mathbf{S}_\tau^{FC} \Delta FC}_{\text{Changes in final consumption}} \\ & + \underbrace{\mathbf{R}_t(\Delta \mathbf{S}^{FC} FC_t + \Delta \mathbf{S}^{GFCF} GFCF_t + \Delta(\mathbf{S}^X X)) + \mathbf{R}_t \Delta \mathbf{S}^{IC} \mathbf{A}_t P_\tau}_{\text{Changes in exports and imports}} \\ & + \underbrace{\mathbf{R}_t \mathbf{S}_\tau^{IC} \Delta \mathbf{A} P_\tau + \mathbf{R}_t \mathbf{S}_\tau^{GFCF} \Delta GFCF}_{\text{Changes in technology}}\end{aligned} \tag{4.7}$$

Changes in employment Changes in production can be related to changes in employment through equations (3.3) and (3.5). Employment changes can then be decomposed between a production, an intermediate consumption and a skill-use effect:

$$\Delta N_{t,\tau} = \mathbf{T}_t \mathbf{M}_t \Delta P + \mathbf{T}_t \Delta \mathbf{M} P_\tau + \Delta \mathbf{T} \mathbf{M}_\tau P_\tau \tag{4.8}$$

Replacing changes in production by its expression (4.7) we can relate the changes in employment by skill level to changes in final domestic consumption, changes in foreign trade and changes in technology:[14]

$$\begin{aligned}\Delta N_{t,\tau} = \quad & \underbrace{\mathbf{T}_t \mathbf{M}_t \mathbf{R}_t \mathbf{S}_\tau^{FC} \Delta FC}_{\text{Changes in final consumption}} \\ & + \underbrace{\mathbf{T}_t \mathbf{M}_t \mathbf{R}_t(\Delta \mathbf{S}^{FC} FC_t + \Delta \mathbf{S}^{GFCF} GFCF_t + \Delta(\mathbf{S}^X X)) + \mathbf{T}_t \mathbf{M}_t \mathbf{R}_t \Delta \mathbf{S}^{IC} \mathbf{A}_t P_\tau}_{\text{Changes in exports and imports}} \\ & + \underbrace{\mathbf{T}_t \mathbf{M}_t \mathbf{R}_t \mathbf{S}_\tau^{IC} \Delta \mathbf{A} P_\tau + \mathbf{T}_t \mathbf{M}_t \mathbf{R}_t \mathbf{S}_\tau^{GFCF} \Delta GFCF + \mathbf{T}_t \Delta \mathbf{M} P_\tau + \Delta \mathbf{T} \mathbf{M}_\tau P_\tau}_{\text{Changes in technology}}\end{aligned} \tag{4.9}$$

4.2 Interpreting the decomposition

Final consumption The first term measures the contribution of changes in final consumption to employment, given the skill-use coefficients **T**, the technology (**R**, **M**) and domestic shares **S**. To provide

[14] By multiplying this decomposition by a diagonal matrix of the inverse of the elements of N, decomposition (4.9) becomes a decomposition of the growth rate of each level of employment per production and skill.

further insights on the effect of changes in consumption we further decompose ΔFC into household consumption and other final consumptions (including changes in inventories). Households' consumption is then decomposed into a composition effect (weight of each product in the consumption basket), population size (measured in consumption units), the purchasing power of gross domestic income (GDI[15]) per consumption unit[16] and the consumption to GDI ratio:

$$FC_{val} = P^{tot} \frac{FC_{val}}{FC_{val}^{tot}} cu \; PP^{GDI/cu} \frac{FC_{val}^{tot}}{GDI} \tag{4.10}$$

with P^{tot}, cu, $PP^{GDI/cu}$ respectively the price index for aggregate households consumption, the number of consumption units and the purchasing power of GDI per consumption unit. FC_{val}^{tot} is the aggregate households' consumption as opposed to the vector of households' consumptions FC_{val}.

With this decomposition, it is possible to directly relate the increase in purchasing power with the increase in labour productivity, two factors which are related in the long run but dissociated in our decomposition. The sociodemographic effect cu can be seen as a pure demand effect. The composition effect $\frac{FC_{val}}{FC_{val}^{tot}}$ is ambiguous, as we do not disentangle changes in the consumption basket composition linked to changes in relative prices from those linked to households' preferences. As for the contribution of changes in $\frac{FC^{tot}}{GDI}$, it can be directly interpreted in terms of savings ratio. Apart from the development of financial savings in the late eighties early nineties, the savings ratio has been stable in France. Its contribution to changes in employment should be only transitory (akin to the long-term imbalances correction in an error correction model for consumption) and null on average in our analysis.

Trade The second term combines the effect of foreign demand addressed to France ($\Delta(\mathbf{S}^X X)$) and changes in openness (ΔS).][17] In this term, the part related to changes in the domestic share of intermediate consumption ($\Delta \mathbf{S}^{IC}\mathbf{A}$) can be interpreted as the effect of *offshore outsourcing* (also referred to as international vertical specialisation) in the *broad sense* (Strauss-Kahn, 2004; Foster *et al.*, 2012). Isolating the diagonal elements (imports of the same product) provides a measure of the offshore-outsourcing effect in the *narrow sense* (Feenstra and Hanson, 1999; Strauss-Kahn, 2004; Foster *et al.*, 2012). According to Feenstra and Hanson (1999), the narrow measure best captures the essence of fragmentation which

[15]The GDI has been modified to be valued at basic prices like the rest of the Input-Output Table, instead of being valued at purchasing price.

[16]Purchasing power per consumption unit takes into account not only population growth, but also changes in household size and composition. An increase in consumption units reflects population growth or social changes such as divorces or youngsters leaving with their parents. According to the OECD-modified scale, the household head is assigned 1 CU, then each additional person older than 14 and each child younger than 14 respectively represents 0.5 and 0.3 CU. Compared to the mere purchasing power, this indicator is more relevant to assess changes in the average standard living of households.

[17]Considering the imported share rather than the imported level in this decomposition avoids the issue of dependency exposed by Dietzenbacher and Los (2000).

occurs within the industry. We focus on offshore outsourcing in the broad sense, so that all contributions sum to employment changes, but nonetheless assess the effect of narrow offshore outsourcing.

In this decomposition, the contribution of trade is related to domestic employment only, i.e. we do not report the global labour content of the trade balance [18]. If imported consumption increases in the same proportion as domestically produced consumption, there is no negative contribution of trade but a positive contribution of consumption. However, if imports increase faster than domestically produced consumption, the decrease in the share of domestic production generates a negative contribution of trade. Overall, the trade effect combines the positive contribution on employment of increasing exports and the negative contribution on domestic employment of imports increasing faster than domestic production.

Technology The third term gathers changes in technology, not only through changes in skill-use coefficients (ΔT, labour-saving effect) and in future capital ($\Delta GFCF$), but also through changes in the production process like outsourcing (captured by ΔA and ΔM)[19]. Here we define technology as the observed use of production factors, i.e. effective technology rather than potential technology (as postulated by a CES, Cobb-Douglas or translog cost function for instance). As a consequence, we also capture under technology effects the reallocation of production factors following changes in their relatives prices.

Due to the overall increase in labour productivity, the contribution of changes in matrix **T** will be largely labour saving. This effect, as we have mentioned, can be interpreted in parallel with the increase in income per capita, which also reflects the increase in productivity but with a positive effect on employment through consumption. We may also expect changes in the indirect labour content of output (GFCF and intermediate consumption) to have positive effect on labour. For intermediate consumption this contribution would reflect vertical specialisation (although our preliminary analysis suggest it is very limited). For GFCF it would reflect an upgrade in the technology of production.

4.3 $n!$ decompositions

When decomposing the variation of the product of n terms into the contribution of each term's changes, there are $n!$ equally valid decompositions. The choice of a particular decomposition corresponds to the choice of reference years to weight each term's variation, i.e. t or τ in the previous equations can switch

[18] See Bohn *et al.* (2016) for such an analysis

[19] These two contributions both depend on matrix A. This could raise the issue of full dependency of determinants raised by Dietzenbacher and Los (2000). But since we aggregate these two contributions into one ("IC effects"), we are not confronted to this full dependency issue.

places. This can be compared, in the context of prices and volumes, to a choice between Paasche and Laspeyre indices.

In our case, there are up to 9! ways to compile each element of Equation (4.9), once the decomposition of households consumption is accounted for. More precisely, we apply the principle of nested or hierarchical decompositions (Dietzenbacher and Los, 1998): we first restrict our analysis to the 4! decompositions of $\mathbf{TMR}FD^d$[20] and then we breakdown the components of final consumption (Equation 4.10) into 5! more ways. Hence we end up with up to 2 880 (= 5! $\times$ 4!) potential decompositions.

We compute and average all these decompositions to measure each effect on the changes in employment by skill[21]. To address criticisms associated with these numerous decompositions (Martin and Evans, 1981; Dietzenbacher and Los, 1998), we show that the choice of a particular decomposition would have a relatively small impact on our analysis in a separate appendix: the methodological uncertainty associated with these decompositions is small relative to the differences between two contributions.

5 What are the main channels of employment changes?

Results from the decomposition (4.9) are displayed both graphically and in tables and are expressed in terms of average annual changes in the following tables and figures. Table 2 displays the general decomposition by skill level, while Tables 3, 4 and 5 focus on final consumption, trade and technology effects respectively. Table 6 (and 8, 9 and 11 in Appendix D) extend the decompositions of these tables by distinguishing the contributions for five main products (a more detailed decomposition for 17 products is available in a separate appendix). Figures 9 to 13 in Appendix E display these decompositions over the whole period.

As displayed in Table 2, between 1982 and 2010, the overall employment increases on average by 0.6 % each year (i.e. approximately 150 000 jobs per year). The main driver of this increase is final consumption (average contribution of +1.2 percentage point per year to employment growth) along with trade growth (+0.3 pp), while technology has a labour-saving effect (-0.9 pp). More precisely, on a short-term basis, technology has a direct labour saving effect through changes in skill-use coefficients (-1.2 pp, Table 5). However in the long run, these gains imply real wage increase and hence contribute to the increase in households' purchasing power (+0.4 pp, Table 3). They also imply competitiveness gains which contribute to foster exports.

[20] The product $S^{FD}FD$ is equal to FD^d and is hence considered as one single aggregate.

[21] Also see Dietzenbacher and Los (1998) for a discussion on alternate solutions to decompose a product of n terms.

Compared to final consumption and technology, trade has a more limited impact on employment, in line with other works based on Input-Output analysis (Gregory *et al.*, 2001; Los *et al.*, 2014). However, unlike these works it has a positive short-term impact: foreign demand has an employment-enhancing effect (+0.7) that offsets the negative effect of offshoring and lost market shares (-0.4, i.e. 99 000 jobs on average per year). This result also implies that with French technology, producing products domestically instead of importing them would not have created a sizeable number of jobs compared to jobs created by exports.

By comparison, Barlet *et al.* (2009) find that imports eliminated 340 000 jobs on average each year over the period 2000-2005, compensated by 281 000 creations attribued to additionnal exports. In our decomposition the contribution of imports over the same period is only -129 000. One explanation for the gap is the way they cleared their decomposition from price effects, using unit value indexes for manufactured products (dollar per kilogram) and computing contributions directly in value for service sectors where unit value indexes are not available[22].

5.1 Sources of skill-bias in employment changes

As previously mentioned, higher skilled employment dramatically increased over the last decades, conversely to lower skilled one. In this section we examine the short-term implications of final consumption, trade and technology on this skill-biased change in employment. We also investigate whether one of these three channels implies jobs polarization. As displayed in Table 2, on average employment of higher skilled jobs increases substantially over the period 1982-2010 (respectively +3.4 % for high- and +1.4 % for middle high-skilled jobs on average per year). In comparison the increase in lower skilled categories is rather small. Employment destructions are mainly focused on farmers, craft jobs and chief executives (-1.7 % per year), in line with the decline of agriculture.

The overall effect of final consumption displays neither a polarization effect on employment nor a skill-biased one. It is driven by household purchasing power gains and the growth in public consumption (Table 3). However changes in the consumption structure is slightly skill-biased. These changes benefit to high-skilled jobs (+0.1 percentage point per year), while they are detrimental to other skill groups (-0.2 for the low-skilled group). The negative effect is even stronger for other skills (including farmers), a result in line with the prediction of Engel curves theory for food products.

[22] Besides this methodological point, the purpose of their study was also somewhat different from ours, their idea being to approximate a notion of "effective" gross destructions. They did so by netting-out positive and negative factors at the within-branch level. For instance, where the decomposition says that a branch "loses" Y jobs because of increasing imports but "gains" X other ones because of increasing global demand or other offsetting factors, their assumption has been to consider only max(0, $Y - X$) effective losses. Under this assumption their final evaluation of yearly destructions was reduced to 36 000 only instead of 340 000, for branches losing jobs, compensated by 41 000 export-driven creations in other branches.

Like final consumption, the skill-bias of trade is also limited[23] (Table 4). However offshore outsourcing has been slightly more detrimental to lower skills (including in the narrow sense, see Table 10). This bias remains quantitatively very low compared to technology. Furthermore, on a short-term basis, the impact of vertical specialisation on lower skilled jobs is stronger: narrow offshore outsourcing represents 48% of broad offshore outsourcing for low-skilled jobs, while it represents 41% for high-skilled ones. Our results relate to other works: Goos *et al.* (2009, 2014); Michaels *et al.* (2014) find no significant effect of offshoring on job polarization in Europe. Likewise, Blinder (2009) finds a weak correlation between educational attainment and offshorability (+0.08). However other works show evidence of a skill-bias, as trade's negative impact on employment is stronger for lower-skilled jobs (Gregory *et al.* (2001) for UK and Autor *et al.* (2013) for the US). Goos *et al.* (2011); Foster *et al.* (2012); Zeddies (2013) even find a polarization effect of offshoring.

The most skill-biased determinant is technology. While technological change is largely labour saving on a short-term basis, this shows mainly on the lowest skilled jobs (Table 5). Only high-skilled jobs benefit from changes in technology (+1.4 percentage point on average per year). According to Autor *et al.* (2003), this skill-biased technological change rose as the price of computer capital dramatically declined over the last decades. The main driver of this skill-bias is the direct labour saving effect. However, there is also a small skill-bias from GFCF, in line with the development of ICT and R&D. Conversely to the US (Autor and Dorn, 2013; Michaels *et al.*, 2014) and to some European countries (Goos and Manning, 2007; Goos *et al.*, 2011, 2014), there is no evidence of employment polarisation because of technological change. The skill-bias seems monotonous in France and favours high-skilled jobs the most (Maurin and Thesmar, 2004). Only by using a more detailed occupational level does Ast (2015) find a slight job polarization in some services, as employment of low-skilled jobs (caregivers, home help, caretakers, nanny, salesclerk, employees in the accommodation and food industry...) has been particularly dynamic.

[23] The skill-bias of trade is by construction only driven by a composition effect. There is no information of the specific labour content of exported products compared to domestically consumed products, least about its change with time.

Average contribution (in % per year)	**Total**	**Skill level**				
		High	Middle higher	Middle lower	Low	Other
Jobs creation	0.6	3.4	1.4	0.4	0.1	-1.7
Final consumption	1.2	1.3	1.3	1.2	1.3	0.9
Trade	0.3	0.3	0.3	0.4	0.3	0.4
Technology	-0.9	1.7	-0.3	-1.2	-1.5	-3

Source: INSEE, LFS and national accounts; authors' calculations.

Note: The first row of the table represents the average annual growth rate of total employment and employment by skill level. The remaining rows represent the average annual contributions that sum to the employment growth rate.

Table 2: Broad contributions to employment change by skill level. 1983-2010

Average contribution (in % per year)	**Total**	**Skill level**				
		High	Middle higher	Middle lower	Low	Other
Final consumption effects	1.2	1.3	1.3	1.2	1.3	0.9
Consumption structure	-0.1	0.1	0	-0.1	-0.2	-0.3
Purchasing power	0.4	0.4	0.4	0.4	0.5	0.6
Sociodemographic effects	0.3	0.2	0.2	0.3	0.3	0.4
Household saving	0	0	0	0	0	0.1
Gov. and NPISH consumption	0.5	0.6	0.7	0.5	0.6	0.2

Source: INSEE, LFS and national accounts; authors' calculations.

Note: The first row represents the average annual contribution of final consumption to employment growth also displayed in Table 2. It is equal to the sum of the remaining rows.

Table 3: Breakdown of final consumption contributions to employment change by skill level. 1983-2010

Average contribution (in % per year)	**Total**	**Skill level**				
		High	Middle higher	Middle lower	Low	Other
Trade effects	0.3	0.3	0.3	0.4	0.3	0.4
Exports	0.7	0.7	0.7	0.8	0.7	0.8
Offshore outsourcing	-0.3	-0.2	-0.2	-0.3	-0.3	-0.3
Home share in FC	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Home share in GFCF	0	0	0	0	0	0

Note: See Table 3.

Table 4: Breakdown of trade contributions to employment change by skill level. 1983-2010

Average contribution (in % per year)	**Total**	**Skill level**				
		High	Middle		Low	Other
			higher	lower		
Technology effects	-0.9	1.7	-0.3	-1.2	-1.5	-3
Direct labour saving	-1.2	1.4	-0.4	-1.5	-1.5	-3.2
IC effects	-0.1	-0.1	-0.1	0	-0.2	0
GFCF effects	0.3	0.5	0.3	0.3	0.2	0.2

Note: See Table 3.

Table 5: Breakdown of technology contributions to employment change by skill level. 1983-2010

5.2 Are skill-biased changes a consequence of sectoral developments?

Autor *et al.* (1998) underline the correlation between the skill-bias and computer-intensive industries. In France, services flourished over the last decades at the expense of industrial and agricultural sectors, and high-skilled jobs are mainly gathered in services (more than 80% in 2010). The previously underlined skill-biased changes could in fact reflect sector-biased developments.

In order to assess the effect of sectoral development on skill-biased change, we focus on five broad groups of products:

(1) High technology manufacturing: chemicals, pharmaceutical, computer, electronic and optical products, electrical and machinery equipment (air and spacecraft, ships, boats...);

(2) Low technology manufacturing: other industrial products such as rubber, plastic, food, beverage, textile, etc.;

(3) Non-tradable services[24]: construction, accommodation and food services, finance and insurance, real estate, public and personal services;

(4) Tradable services: trade, transportation, information and communication, business services;

(5) Other: agriculture, energy and utilities.

Table 6 and tables 8, 9 and 11 break down the previous decompositions according to these five groups of products[25].

Regardless of the skill level, development of services accounts for a substantial part of employment change[26] (+0.5 percentage point per year on average in both non-tradable and tradable services), while

[24]These sectors are defined as non-tradable on the basis of an insignificant contribution of trade to the total changes in the jobs required to produce the final output. See Table C in Appendix C for more details

[25]These tables are also available for 17 products in a separate appendix.

[26]Sectoral employment is measured in terms of jobs required to produce its final output, and does not represent the employment within the sector.

changes are negative in the other industries. The growth in the total labour content of services is mainly driven by consumption, especially purchasing power and population growth. As expected in the case of non-tradable services, public spending like public services is a more important determinant of the increase in total labour content (Table 8).

The skill-bias effect of changes in consumption structure reflects the shift in the consumption of services at the expense of agriculture and low-technology manufactured products. As the latter require more low-skilled labour content (see Table 1), low-skilled jobs suffer more from changes in consumption structure. However this negative contribution to the growth of low-skill is offset by income and population effects. More specifically, the income effect is stronger in the lowest skilled content of non-tradable services. This implies that low-skilled jobs benefit greater demand from richer workers for services replacing their household production, e.g. child care, domestic work, food service (Michaels *et al.*, 2014).

On the trade side, the more favourable contribution of foreign demand to lower skilled jobs is driven by low-technology manufactured products and tradable services (mainly trade, transportation and business services). Nevertheless, offshore outsourcing (broad and narrow) weighs the most on lower skilled content of these goods and services. Focusing on manufacturing, importing finished goods (for final consumption and GFCF) is more detrimental to low-skilled jobs in low-technology manufacturing (average annual contribution of -0.07 point against -0.02 in high-technology manufacturing).

Finally, the skill-bias effect of technological change is at play for all industries, manufacturing or services, although we note a small polarization effect from technology on tradable services. More precisely, the direct labour saving effect weighs more on lower skilled workers in low-technology manufacturing and tradable services (trade and transportation). In the framework of the labour-technology literature, these jobs are more substitutable with capital. The skill-bias effect of GFCF can also be explained as a consequence of sectoral development, as it is more sizeable for tradable services, and more precisely for R&D, included in the business services, and for information and communication.

Average contribution (in % per year)	Total	Products in: Manufacturing high-tech	Manufacturing low-tech	Services non-tradable	Services tradable	Agr. and energy
				Total		
Jobs creation	0.61	-0.08	-0.2	0.52	0.48	-0.12
Final consumption	1.21	0.02	0.05	0.7	0.4	0.04
Trade	0.34	0.05	0.01	0.03	0.23	0.03
Technology	-0.95	-0.15	-0.25	-0.21	-0.15	-0.19
				High skill		
Jobs creation	3.37	0.12	0.08	1.47	1.63	0.07
Final consumption	1.32	0.04	0.02	0.81	0.42	0.02
Trade	0.32	0.06	0.01	0.05	0.2	0.01
Technology	1.73	0.02	0.05	0.61	1	0.04
				Middle skill (higher)		
Jobs creation	1.38	-0.05	0.01	0.75	0.62	0.04
Final consumption	1.34	0.03	0.03	0.86	0.38	0.03
Trade	0.32	0.06	0.01	0.04	0.2	0.01
Technology	-0.28	-0.14	-0.03	-0.15	0.04	0
				Middle skill (lower)		
Jobs creation	0.38	-0.13	-0.17	0.38	0.28	0.01
Final consumption	1.18	0.02	0.05	0.63	0.45	0.02
Trade	0.37	0.06	0.01	0.03	0.26	0.01
Technology	-1.17	-0.21	-0.23	-0.28	-0.43	-0.02
				Low skill		
Jobs creation	0.11	-0.18	-0.54	0.49	0.34	0
Final consumption	1.27	0.02	0.06	0.8	0.37	0.03
Trade	0.3	0.04	-0.01	0.02	0.23	0.01
Technology	-1.46	-0.23	-0.6	-0.33	-0.26	-0.05
				Other skill		
Jobs creation	-1.7	-0.02	-0.31	-0.24	-0.07	-1.06
Final consumption	0.94	0	0.07	0.36	0.35	0.16
Trade	0.38	0.01	0.01	0.03	0.21	0.12
Technology	-3.02	-0.04	-0.39	-0.62	-0.63	-1.35

Source: INSEE, LFS and national accounts; authors' calculations.

Note: Column "Total" is equal to the sum of the remaining columns by products and displays the same figures as Table 2. In each panel, the first row is equal to the sum of the remaining rows.

Table 6: Broad contributions to employment change by skill and product. 1983-2010

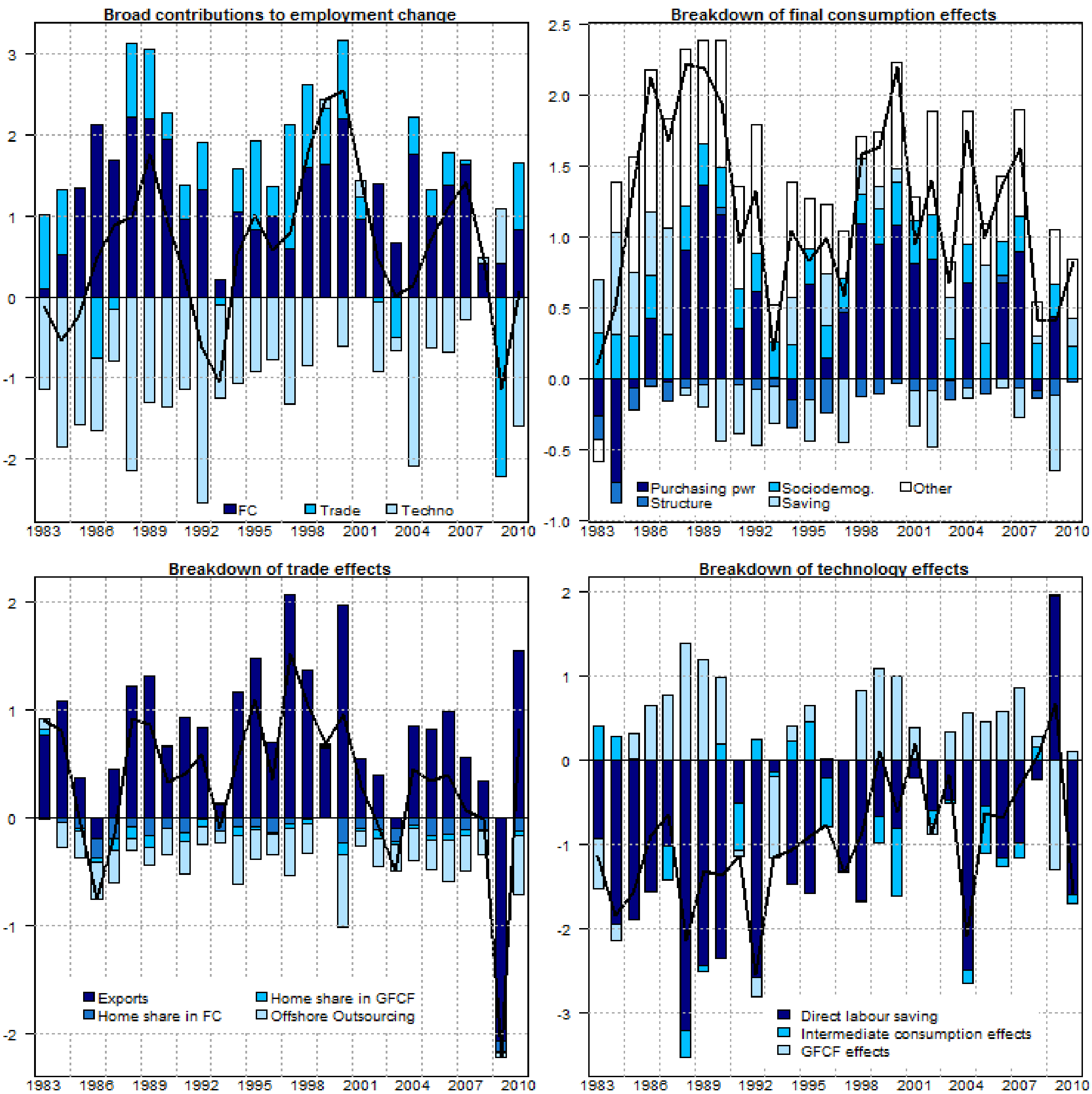
5.3 Are skill-biased changes driven by external shocks?

Apart from sectoral development, skill-biased changes can also result from external determinants, such as crises, labour policies, international environment... Depending on these external shocks, the average annual effects of final consumption, trade and technology on employment changes could be driven by a single year or a specific period. For instance, as displayed in Figure 9, final consumption effects are closely related to the business cycle, with a decreasing impact during years of crises (1993, 2003 and 2009). Trade and technology effects have particularly irregular profiles in 2009 and 2010, as direct consequence of the 2008-2009 economic and financial crisis.

More specifically in the case of trade, the period of the 90's is of great interest since it is linked to the rise of globalization. Hence the effect of both exports and imports on employment changes dramatically increased during this period. Exports effects for tradable services are almost twice as important in the period 1994-2000 than in 1987-1992 and in 2001-2008.[27] In addition, with the development of high-technology manufacturing over the same period, exports also benefit to higher skilled jobs required for this kind of products. Within these three periods, the effect of offshore outsourcing remains relatively similar.

Finally in the case of technology, its decreasing effect on employment changes over time is related to fading productivity gains, as underlined by Schreiber and Vicard (2011). This concerns more specifically low-skilled jobs in manufacturing in the period 1998-2008, in line with a reduction of employer costs implemented from 1995 and also the negative impact in this sector of the switch to the 35-hour working week (Biscourp and Kramarz, 2007; Schreiber and Vicard, 2011).

[27] 1986, 1993 and 2009-2010 are excluded from the following estimates, as they represent years of crisis. Tables are made available in a separate appendix.



Source: INSEE, LFS and national accounts; authors' calculations.

Figure 9: Contributions to total employment changes (in %). 1983-2010

6 Conclusion

To investigate changes in employment in France over the period 1982-2010, we provide a structural decomposition analysis based on time series of Input-Output Tables. This approach allows us to take into account the effects on employment changes of technology, trade and final consumption altogether, conversely to most previous studies on the same subject. Our decomposition is based on textbook methodologies but uses innovative data. More precisely we convert INSEE's Supply and Use tables in the new European System of Acccount (ESA2010) into Input-Output tables, both in current and in previous year price (using specific deflator for consumption, investment...). We then use the Labour Force Survey to measure the skill level from the occupation classification.

The main determinant to skill-biased changes in employment is technology which benefits to high-skilled jobs, especially to those required to produce services (e.g. R&D and information and communication), but is detrimental to lower skilled jobs (especially those required for low-technology manufactured products). The important contribution of final consumption is explained by the development of services at the expense of agriculture and low-technology manufactured products. And finally trade has a small but nonetheless positive effect regardless of the skill level.

The approach chosen in this article could be subject to further research. First, since our approach cannot reveal underlying causal links between employment and its determinants in the long-run, our results are to be interpreted as short-term effects. Adopting the temporal inverse analysis introduced by Sonnis and Hewings (1998) would shed light on structural changes in an economy over time and highlight trends of changes in indirect temporal impacts of final demand on output (Okuyama *et al.*, 2006). Second, we could investigate the contribution of relative prices to further disentangle the contributions of technology, trade and consumption. Third, the approach of Bohn *et al.* (2016) could bring additional insights on trade contribution to employment. By comparing labor footprints with domestic labor force, they can estimate if a country can produce every goods and services alone or if it needs foreign labor force.

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A The retropolation of Input-Output Tables

National accounts and in particular the Supply and Use Table (SUT) are produced in compliance with ESA2010 and Naf Rev2 since 2013. From the 2010 accounts, the SUT is converted by the national accountants into a symmetric Input-Output Table (IOT) based on detailed information (138 products and industries) (Rodriguez, 2014). From 1980 to the reference year (2010), we have replicated the methodology of the national accounts at a less detailed level based on the available information in order to produce IOT with the same concepts and nomenclature as the current national accounts. *This is the first advantage of our dataset: covering thirty years in compliance with the most up to date official accounts.* In particular, two consecutive changes in the reference year (2005 and 2010) have introduced important changes in nomenclature and concepts which have markedly impacted the frontier between goods and services, the definition of investment and intermediate consumption and the measure of foreign exchanges.

The IOT differs from the standard SUT (Eurostat, 2008, Chapter 11). First in the IOT, uses are valued at basic prices, that is excluding trade and transportation margins as well as taxes and subsidies on products (first of which VAT). Second, the computation of the IOT requires a treatment for CIF-FOB (cost insurance freight-free on board) of imports to value them at the frontier of the exporting country (FOB) to match the concept for exports. Third, the concept of industry is converted to a concept of product[28] consistent with the rows of the SUT. This is done through the matrix of transfers, recording the production of each industry (mainly non market and agricultural) in secondary products. With this conversion for instance, the intermediate input table records the consumption of intermediate inputs for the production of each output rather than each industry. Fourth, uses must be split between those addressed by domestic production and by imports. In the absence of additional information, this division is based on hypothesis (both in our retropolation and the official compilation of the IOT). Note that in theory there are no imports re-exported recorded in the national accounts and in practice very few.

An analysis on the year 2010, for which data at the detailed level (138 products) are also available, shows that transposing the *symmetrisation* methodology to a SUT with only 48 products and industries generates only small discrepancies (Poissonnier, 2015b). Some adjustments were made to correct the largest discrepancies, stemming from the ventilation of taxes and subsidies on products other than VAT. In retropolation, missing information on VAT on intermediate consumption by industry and transportation margin by uses were built from the ventilation structure in 2010 and adjusted to match the totals known for each year. As for the partition between imported and domestic demands, an analysis with even more detailed information (332 products) in 2010 showed that there is a 10% uncertainty on this partition for each component of demand (excluding exports) but the official IOT and ours concur at 2%

[28] A symetric choice can also be made for instance in the World Input-Output Database (Dietzenbacher *et al.*, 2013).

for 2010.

Compared to other datasets, we have benefited from detailed information allowing us to conduct the first three operations with greater precision than done for instance in the WIOD (Dietzenbacher *et al.*, 2013) or by the OECD (Yamano and Ahmad, 2006). Our dataset is nevertheless limited to France. As for the separation between imported and domestic uses, we replicate the methodology from the official IOT while the WIOD in particular uses a bilateral trade database to refine this last step.

To be cleared from price effects, decomposition (4.9) must be computed between an IOT in volume (previous year prices) and the IOT of the previous year in value, consistent with changes in chained linked volumes. To do so we have extended the compilation of IOT in values developed by the national accountants to IOT in previous year prices. *This is the second advantage of our dataset: estimates in previous year prices based on detailed price information.* For the most part prices and volumes are inherited from the SUT. However, for some treatments (CIF-FOB, transportation margins by uses) the same weights are used in previous year prices and values which maintain prices specific to the operation and are not affected by the price of use. For other specific operations (VAT on intermediate consumption by industry, other taxes and subsidies), as much as possible the volume growth is based on that of the use, to be in line with national accounting concepts. For domestic and imported demands (excluding exports), prices are such that the relative price index of an imported and domestic use is the relative price index of imports and production while the relative price of two imported (resp. domestically produced) uses is the relative price of these uses. As for exports, the small share of re-exported imports are assumed to follow the same prices as imports.

B Employment by skill level

How skill is measured Several indicators provide information about the skill level of employment. The main indicators found in the literature are the average hourly wage, the educational attainment and the occupation. Measuring skill level according to the average hourly wage is rather simple to implement. But it leaves out self-employed workers and does not control for structural determinants (age, gender, experience, seniority...). Education level – either defined as the highest level of diploma or the years of studying – is an alternative used in some papers (Los *et al.*, 2014; Ludwig and Brautzsch, 2014; Michaels *et al.*, 2014). But it can also bias our analysis. While the level of diploma can be a hiring condition, training and experience make it possible for workers to get more skilled jobs. Further, educational attainment has increased within jobs over the last decades (Goos and Manning, 2007).

The French occupational classification (PCS) classifies workers (employees and self-employed) based on the job they do. As such, it takes into account educational attainment, as well as experience and other specific features related to a given job (e.g. supervising other workers). Therefore, like Gregory *et al.* (2001), we consider the occupational classification as a relevant measure of skill level. The PCS classifies workers into nine major groups:

- Group 1: Farmers
- Group 2: Craft and related trades workers and chief executives
- Group 3: Managers (includes liberal professions)
- Group 4: Intermediate occupations (professionals and technicians)
- Group 5: Skilled service and sales workers
- Group 6: Unskilled service and sales workers [29]
- Group 7: Skilled machine operators and elementary occupations
- Group 8: Unskilled machine operators and elementary occupations
- Group 9: Other (Military contingents, unknown)

We then aggregate these nine groups into five broad skill levels. The "high-skill" group comprises Group 3 and the "low-skill" group comprises Groups 6 and 8. The "middle-skill" level is divided into a higher part (Groups 4) and a lower part (Groups 5 and 7). Groups 1, 2 and 9 are aggregated into "other".

Autor and Dorn (2013) propose another classification to focus on technology effects on employment. It also relies on the occupational classification but takes into account the tasks associated to each job. Three levels are then identified: abstract, routine and manual tasks. Blinder (2009) suggests another classification specifically designed to measure *offshorability*, based on an index he builds. However, these classifications require a more detailed occupational classification, which is not available over a long period in the PCS classification[30].

Using the French Labour Force Survey Employment data by skill level and activity are taken from the Labour Force Survey (LFS) over the period 1982-2010. The main advantage of this data is its exhaustive coverage: both employees and self-employed are surveyed, regardless of the activity they are working in. These data are on headcounts basis. We could convert them into of full-time equivalent (FTE) by using a correction coefficient defined as the ratio of usual weekly hours of work for part-time workers

[29] Groups 5 and 6 are based on (Amossé and Chardon, 2006) classification. Group 6 includes home help, caretakers, salesclerk...

[30] These nine groups are built up from more detailed sub-groups. We stick to these nine groups, since we need long series for our analysis and long series are not available for a more detailed level over the period 1982-2010.

on that of full-time workers (by occupation and by activity). This FTE conversion could be done only from 1990. Hence we favour employment in terms of headcounts. Converting into FTE would however not imply dramatic changes to our main results. First part-time is mainly focused on services. Second it is "involuntary" part-timers who have low usual weekly hours of work and lower skilled workers are mainly concerned by this kind of part-time jobs (Pak, 2013). All in all, we expect the FTE conversion to increase technological skill-bias in services.

Other caveats need to be addressed to combine the LFS with national accounts data. First, from 1982 to 2010 LFS underwent several breaks:

- transition to the new occupational classification in 2003 (PCS-1982 to PCS-2003);
- transitions to different activity classifications (NAP to NAF in 1993, NAF to NAF Rev.1 in 2003, and NAF Rev.1 to NAF Rev.2 in 2008);
- changes in the survey questionnaire and in data collection, especially in 2003 (transition from annual to continuous survey)

Second, employment as defined by the International Labour Office (ILO) with LFS data slightly differ from those as defined in the national accounts. As the LFS cover households living in France, foreigners who live abroad but work in France are excluded from employment, while people living in France but working abroad are included. It is the opposite with the national accounts: only domestic employment is estimated. Another explanation for the discrepancies relies on the estimation of small part-time jobs and borderline jobs (partial or gradual retirement, students, limited activity...). Since estimations from LFS rely on spontaneous answers of the respondent, this kind of small jobs could be under-reported. In the case of limited activity, if respondents are unemployed the week they are surveyed but worked several hours during the previous months, they will be counted as active workers in the national accounts, but not in the LFS estimates.

To correct the former issues, we first address changes in the activity classifications by building transition matrices. In the case of the NAP-NAF transition in 1993 and the NAF Rev.1-NAF Rev.2 transition in 2008, we use the LFS dual coding available at the most highly disaggregated level (650 in NAP, 696 in NAF, 712 in NAF Rev.1, and 732 in NAF Rev.2). There is no dual coding in the LFS for the transition from NAF to NAF Rev. 1 in 2003 but, since very little changes were made between these classifications, we use a theoretical transition matrix. We also use a transition matrix to convert activities (in NAF Rev.2) into industries (national accounts classification at the level A38).

In a second step, we correct remaining breaks by benchmarking our employment matrices according to their skill levels and industries on two sets of series published by INSEE: long series by occupation based on LFS data and long series by industries estimated by the national accounts.[31] Finally, we convert industries into products to fit the IOT concept.

The following figure illustrates the case involving the most numerous steps to correct LFS data, i.e. for activities defined in the NAP classification.

$$N^{activity}_{NAP,650} \Rightarrow N^{activity}_{NAF,696} \Rightarrow N^{activity}_{NAFrev1,712} \Rightarrow N^{activity}_{NAFrev2,732} \Rightarrow N^{activity}_{NAFrev2,129} \Rightarrow$$
$$N^{industry}_{NAFrev2,129} \Rightarrow N^{industry}_{NAFrev2,38} \xrightarrow{benchmarking} N^{industry}_{NAFrev2,38} \Rightarrow N^{product}_{NAFrev2,38}$$

[31]This benchmarking is based on a minimisation framework exposed in (Poissonnier, 2015a)

C Sectoral aggregation

Aggregated sector	Description	Average contribution (in % per year)			
		FC	Exports	Imports	Tech.
Manuf. High Tech.	CE - Chemicals	0.4	2.8	-2.1	-3.2
	CF - Pharmaceuticals	3.3	4.0	-2.5	-4.5
	C3 - Electrical equip.	2.4	8.2	-6.1	-9.8
	CL - Transport equip.	-0.1	2.2	-1.2	-3.3
Manuf. Low Tech.	C1 - Food & drink	0.9	0.7	-0.5	-1.5
	CB - Textile & leather	-0.3	0.7	-4	-2.5
	CC - Wood & paper	0.8	1.2	-0.8	-2.8
	C2 - Coke & refined petroleum	0.7	1.0	-1.2	-2.8
	CG - Rubber & plastic	0.5	1.6	-1.3	-2.2
	CH - Metals	0	1.4	-1.3	-1.8
	CM - Other manuf.	0.1	1.4	-0.9	-1.8
Serv. non Tradable	FZ - Construction	0.2	0.1	0.0	-0.2
	IZ - Accomodation & food serv.	1.2	0.2	-0.1	0.6
	KZ - Finance	2.2	0.5	-0.1	-2.1
	LZ - Real estate	2.0	0.2	-0.1	-0.7
	OQ - Public adm.	7.1	0.1	-0.1	-1.7
	RU - Other serv.	6.0	0.7	-0.2	2.2
Serv. Tradable	GZ - Trade	1.4	1.0	-0.2	-1.5
	HZ - Transportation	1.1	1.1	-0.4	-1.2
	JZ - Info. & comm.	6.4	1.9	-0.8	-2.3
	MN - Business serv.	3.5	3.7	-1.7	3.8
Other	AZ - Agriculture	0.9	0.9	-0.6	-4.3
	DE - Energy & utilities	3.3	2.7	-3.7	-4.7

Source: INSEE, national accounts; authors' calculations.

Note: For each row of the table, the contributions of final consumption, exports, imports and technology sum to the total change in the jobs required to produce each kind of product. The sectoral employment is measured in terms of jobs required to produce its final output, and does not represent the employment within the sector.

Table 7: Sectoral aggregation into 5 broad categories

D Breakdown of final consumption, trade and technology contributions to employment changes by skill and product

Average contribution (in % per year)	**Total**	**Products in:** Manufacturing high-tech	Manufacturing low-tech	Services non-tradable	Services tradable	Agr. and energy
				Total		
Final consumption effects	1.21	0.02	0.05	0.7	0.4	0.04
Consumption structure	-0.08	0	-0.06	-0.02	0.02	-0.03
Purchasing power	0.44	0.01	0.05	0.16	0.18	0.04
Sociodemographic effects	0.27	0.01	0.04	0.09	0.11	0.03
Household saving	0.04	0	0.01	0.01	0.01	0.01
Gov. and NPISH consumption	0.55	0	0.01	0.46	0.08	0
				High skill		
Final Consumption effects	1.32	0.04	0.02	0.81	0.42	0.02
Consumption structure	0.07	0.01	-0.04	0.05	0.04	0
Purchasing power	0.38	0.01	0.03	0.15	0.18	0.01
Sociodemographic effects	0.23	0.01	0.02	0.09	0.11	0.01
Household saving	0.03	0	0	0.01	0.01	0
Gov. and NPISH Consumption	0.61	0.01	0.01	0.5	0.08	0
				Middle skill (higher)		
Final Consumption effects	1.34	0.03	0.03	0.86	0.38	0.03
Consumption structure	0.01	0.01	-0.04	0.01	0.03	0
Purchasing power	0.38	0.01	0.03	0.15	0.17	0.02
Sociodemographic effects	0.23	0.01	0.02	0.09	0.1	0.01
Household saving	0.03	0	0	0.01	0.01	0
Gov. and NPISH Consumption	0.69	0.01	0.01	0.6	0.07	0.01
				Middle skill (lower)		
Final Consumption effects	1.18	0.02	0.05	0.63	0.45	0.02
Consumption structure	-0.05	0	-0.07	0	0.01	0
Purchasing power	0.42	0.01	0.06	0.13	0.21	0.01
Sociodemographic effects	0.25	0.01	0.04	0.08	0.12	0.01
Household saving	0.04	0	0.01	0.01	0.02	0
Gov. and NPISH Consumption	0.53	0	0.02	0.42	0.09	0
				Low skill		
Final Consumption effects	1.27	0.02	0.06	0.8	0.37	0.03
Consumption structure	-0.19	0	-0.09	-0.07	0	-0.02
Purchasing power	0.5	0.01	0.07	0.21	0.18	0.03
Sociodemographic effects	0.3	0.01	0.05	0.12	0.1	0.02
Household saving	0.04	0	0.01	0.01	0.01	0
Gov. and NPISH Consumption	0.62	0	0.02	0.53	0.08	0
				Other skill		
Final Consumption effects	0.94	0	0.07	0.36	0.35	0.16
Consumption structure	-0.29	0	-0.06	-0.07	-0.01	-0.15
Purchasing power	0.59	0	0.07	0.15	0.18	0.18
Sociodemographic effects	0.36	0	0.05	0.09	0.11	0.12
Household saving	0.06	0	0.01	0.01	0.01	0.03
Gov. and NPISH Consumption	0.22	0	0	0.18	0.07	-0.02

Source: INSEE, LFS and national accounts; authors' calculations.

Note: Column "Total" is equal to the sum of the remaining columns by product and displays the same figures as Table 3. In each panel, the first row is equal to the sum of the remaining rows.

Table 8: Breakdown of final consumption contributions to employment change by skill and product. 1983-2010

Average contribution (in % per year)	Total	Products in:				
		Manufacturing		Services		Agr. and
		high-tech	low-tech	non-tradable	tradable	energy
				Total		
Trade effects	0.34	0.05	0.01	0.03	0.23	0.03
Exports	0.74	0.12	0.15	0.05	0.36	0.06
Offshore outsourcing	-0.26	-0.05	-0.09	-0.01	-0.09	-0.02
Home share in FC	-0.1	-0.02	-0.04	-0.01	-0.03	-0.01
Home share in GFCF	-0.04	-0.01	-0.01	0	-0.01	0
				High skill		
Trade effects	0.32	0.06	0.01	0.05	0.2	0.01
Exports	0.67	0.15	0.08	0.08	0.34	0.02
Offshore outsourcing	-0.22	-0.06	-0.05	-0.02	-0.08	-0.01
Home share in FC	-0.08	-0.02	-0.02	-0.01	-0.03	0
Home share in GFCF	-0.04	-0.01	-0.01	0	-0.02	0
				Middle skill (higher)		
Trade effects	0.32	0.06	0.01	0.04	0.2	0.01
Exports	0.67	0.16	0.12	0.06	0.32	0.02
Offshore outsourcing	-0.23	-0.06	-0.07	-0.01	-0.08	-0.01
Home share in FC	-0.09	-0.02	-0.03	-0.01	-0.03	0
Home share in GFCF	-0.04	-0.01	-0.01	0	-0.01	0
				Middle skill (lower)		
Trade effects	0.37	0.06	0.01	0.03	0.26	0.01
Exports	0.81	0.14	0.18	0.05	0.42	0.02
Offshore outsourcing	-0.29	-0.05	-0.11	-0.01	-0.11	-0.01
Home share in FC	-0.11	-0.02	-0.05	0	-0.04	0
Home share in GFCF	-0.05	-0.01	-0.01	0	-0.01	0
				Low skill		
Trade effects	0.3	0.04	-0.01	0.02	0.23	0.01
Exports	0.72	0.1	0.18	0.04	0.37	0.04
Offshore outsourcing	-0.27	-0.04	-0.11	-0.01	-0.1	-0.02
Home share in FC	-0.11	-0.01	-0.06	0	-0.03	-0.01
Home share in GFCF	-0.03	-0.01	-0.01	0	-0.01	0
				Other skill		
Trade effects	0.38	0.01	0.01	0.03	0.21	0.12
Exports	0.78	0.02	0.11	0.05	0.31	0.28
Offshore outsourcing	-0.25	-0.01	-0.06	-0.01	-0.07	-0.11
Home share in FC	-0.12	0	-0.04	-0.01	-0.02	-0.05
Home share in GFCF	-0.02	0	-0.01	0	-0.01	0

Source: INSEE, LFS and national accounts; authors' calculations.

Note: Column "Total" is equal to the sum of the remaining columns by product and displays the same figures as Table 4. In each panel, the first row is equal to the sum of the remaining rows.

Table 9: Breakdown of trade contributions to employment change by skill and product. 1983-2010

Average contribution (in % per year)	Total	Products in: Manufacturing high-tech	Manufacturing low-tech	Services non-tradable	Services tradable	Agr. and energy
				Total		
Offshore outsourcing	-0.26	-0.05	-0.09	-0.01	-0.09	-0.02
Narrow offshore outsourcing	-0.12	-0.01	-0.03	-0.01	-0.06	-0.01
				High skill		
Offshore outsourcing	-0.22	-0.06	-0.05	-0.02	-0.08	-0.01
Narrow offshore outsourcing	-0.09	-0.01	-0.02	-0.01	-0.05	0
				Middle skill (higher)		
Offshore outsourcing	-0.23	-0.06	-0.07	-0.01	-0.08	-0.01
Narrow offshore outsourcing	-0.1	-0.01	-0.02	-0.01	-0.05	0
				Middle skill (lower)		
Offshore outsourcing	-0.29	-0.05	-0.11	-0.01	-0.11	-0.01
Narrow offshore outsourcing	-0.13	-0.01	-0.04	-0.01	-0.07	0
				Low skill		
Offshore outsourcing	-0.27	-0.04	-0.11	-0.01	-0.1	-0.02
Narrow offshore outsourcing	-0.13	-0.01	-0.04	0	-0.07	0
				Other skill		
Offshore outsourcing	-0.25	-0.01	-0.06	-0.01	-0.07	-0.11
Narrow offshore outsourcing	-0.13	0	-0.02	-0.01	-0.07	-0.03

Source: INSEE, LFS and national accounts; authors' calculations.

Note: Column "Total" is equal to the sum of the remaining columns by product.
Offshore outsourcing in the broad sense is defined as imported intermediate inputs from all productions, while narrow offshore outsourcing is restricted to those from the same product.

Table 10: Breakdown of trade effects to employment change by skill and product (focus on offshore outsourcing effects. 1983-2010

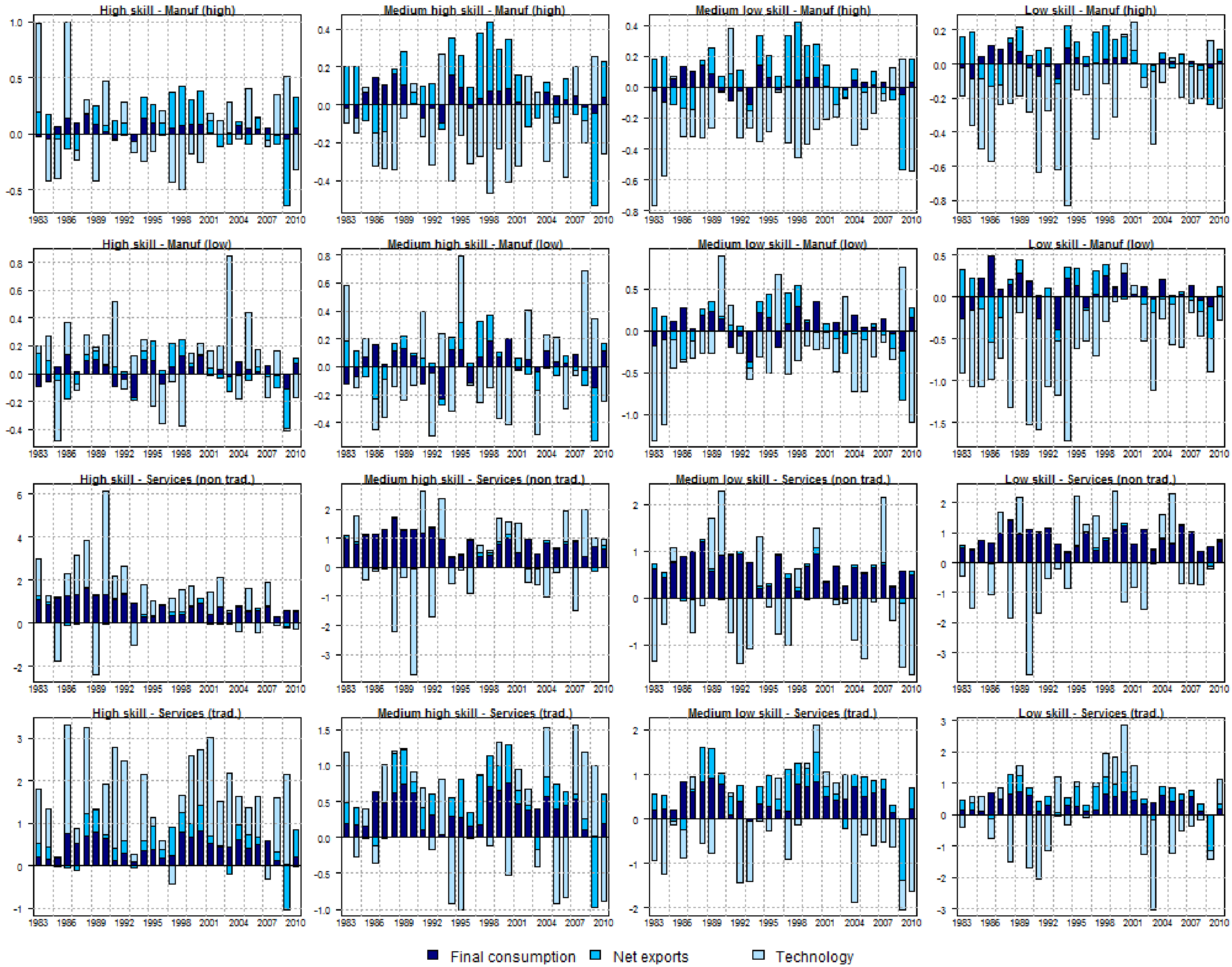
Average contribution (in % per year)	**Total**	**Products in:** Manufacturing high-tech	Manufacturing low-tech	Services non-tradable	Services tradable	Agr. and energy
				Total		
Technology effects	-0.95	-0.15	-0.25	-0.21	-0.15	-0.19
Direct labour saving	-1.16	-0.18	-0.3	-0.1	-0.38	-0.21
IC effects	-0.08	0.01	0.01	-0.18	0.06	0.02
GFCF effects	0.3	0.02	0.04	0.06	0.18	0
				High skill		
Technology effects	1.73	0.02	0.05	0.61	1	0.04
Direct labour saving	1.35	-0.02	0.01	0.73	0.58	0.04
IC effects	-0.07	0.02	0.01	-0.17	0.07	0
GFCF effects	0.45	0.02	0.03	0.04	0.36	0
				Middle skill (higher)		
Technology effects	-0.28	-0.14	-0.03	-0.15	0.04	0
Direct labour saving	-0.44	-0.18	-0.08	0.03	-0.21	0
IC effects	-0.13	0.01	0.02	-0.22	0.07	0
GFCF effects	0.29	0.02	0.04	0.04	0.18	0
				Middle skill (lower)		
Technology effects	-1.17	-0.21	-0.23	-0.28	-0.43	-0.02
Direct labour saving	-1.49	-0.23	-0.3	-0.2	-0.73	-0.03
IC effects	0.01	0.01	0.02	-0.16	0.13	0.01
GFCF effects	0.32	0.02	0.05	0.08	0.16	0
				Low skill		
Technology effects	-1.46	-0.23	-0.6	-0.33	-0.26	-0.05
Direct labour saving	-1.46	-0.25	-0.63	-0.17	-0.34	-0.07
IC effects	-0.24	0.01	-0.01	-0.21	-0.04	0.02
GFCF effects	0.23	0.01	0.04	0.05	0.13	0
				Other skill		
Technology effects	-3.02	-0.04	-0.39	-0.62	-0.63	-1.35
Direct labour saving	-3.23	-0.04	-0.41	-0.61	-0.73	-1.44
IC effects	-0.03	0	-0.01	-0.12	-0.01	0.09
GFCF effects	0.24	0	0.03	0.1	0.11	0

Source: INSEE, LFS and national accounts; authors' calculations.

Note: Column "Total" is equal to the sum of the remaining columns by product and displays the same figures as Table 5. In each panel, the first row is equal to the sum of the remaining rows.

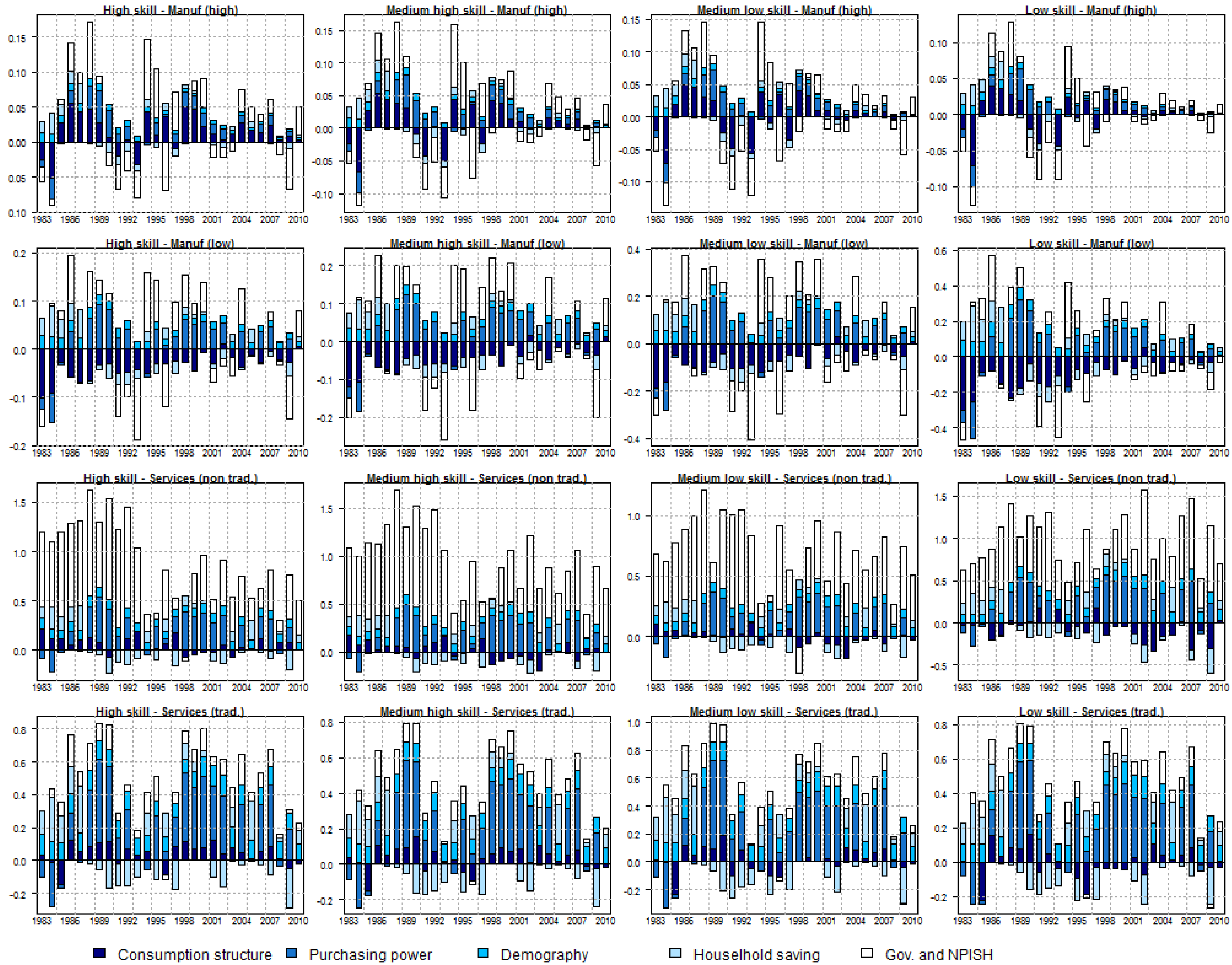
Table 11: Breakdown of technology contributions to employment change by skill and product. 1983-2010

E Evolution of contribution to jobs creation by skill and sector



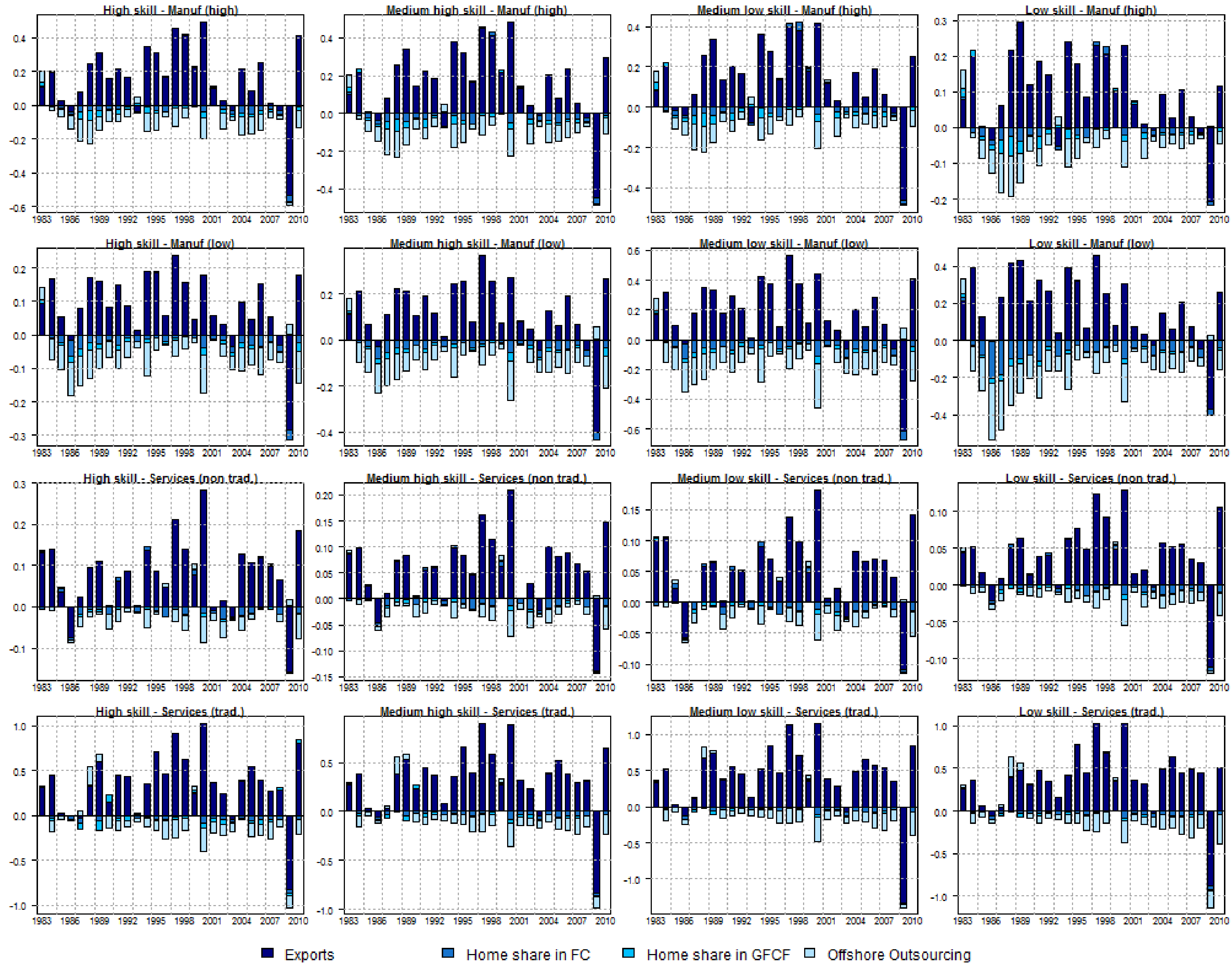
Source: INSEE, LFS and national accounts; authors' calculations.

Figure 10: Final consumption, trade, and technology contributions to employment change, by skill level and product (in %). 1983-2010



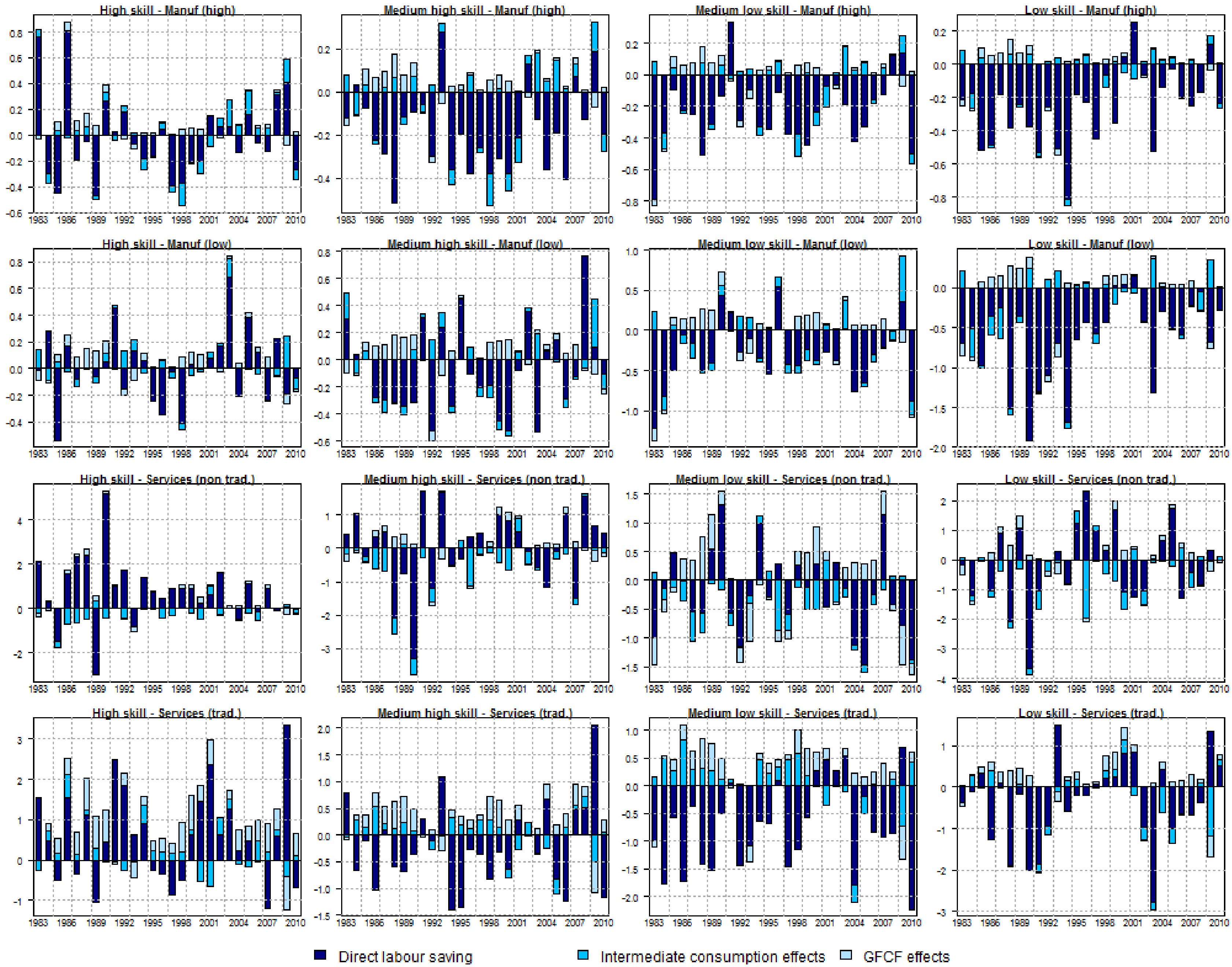
Source: INSEE, LFS and national accounts; authors' calculations.

Figure 11: Breakdown of final consumption effects on employment change, by skill level and product (in %). 1983-2010



Source: INSEE, LFS and national accounts; authors' calculations.

Figure 12: Breakdown of trade contributions to employment change, by skill level and product (in %). 1983-2010



Source: INSEE, LFS and national accounts; authors' calculations.

Figure 13: Breakdown of technology contributions to employment change, by skill level and product (in %). 1983-2010

Accounting for technology, trade and final consumption in employment: an Input-Output decomposition
APPENDIX

Mathilde Pak Aurélien Poissonnier

1 Input data analysis

Animated Figures 1 and 2 depict the technology matrices from 1980 to 2010. These matrices are employment and intermediate consumption engaged in each production (in columns) divided by this production. The darker is a cell in a particular column the more it contributes to the inputs of the corresponding production.

These graphs exemplify the increasing uses of services *business services* (MN) as intermediate consumption (Figure 2) and the increasing investment in R&D (as part of *business services*) for industrial productions.

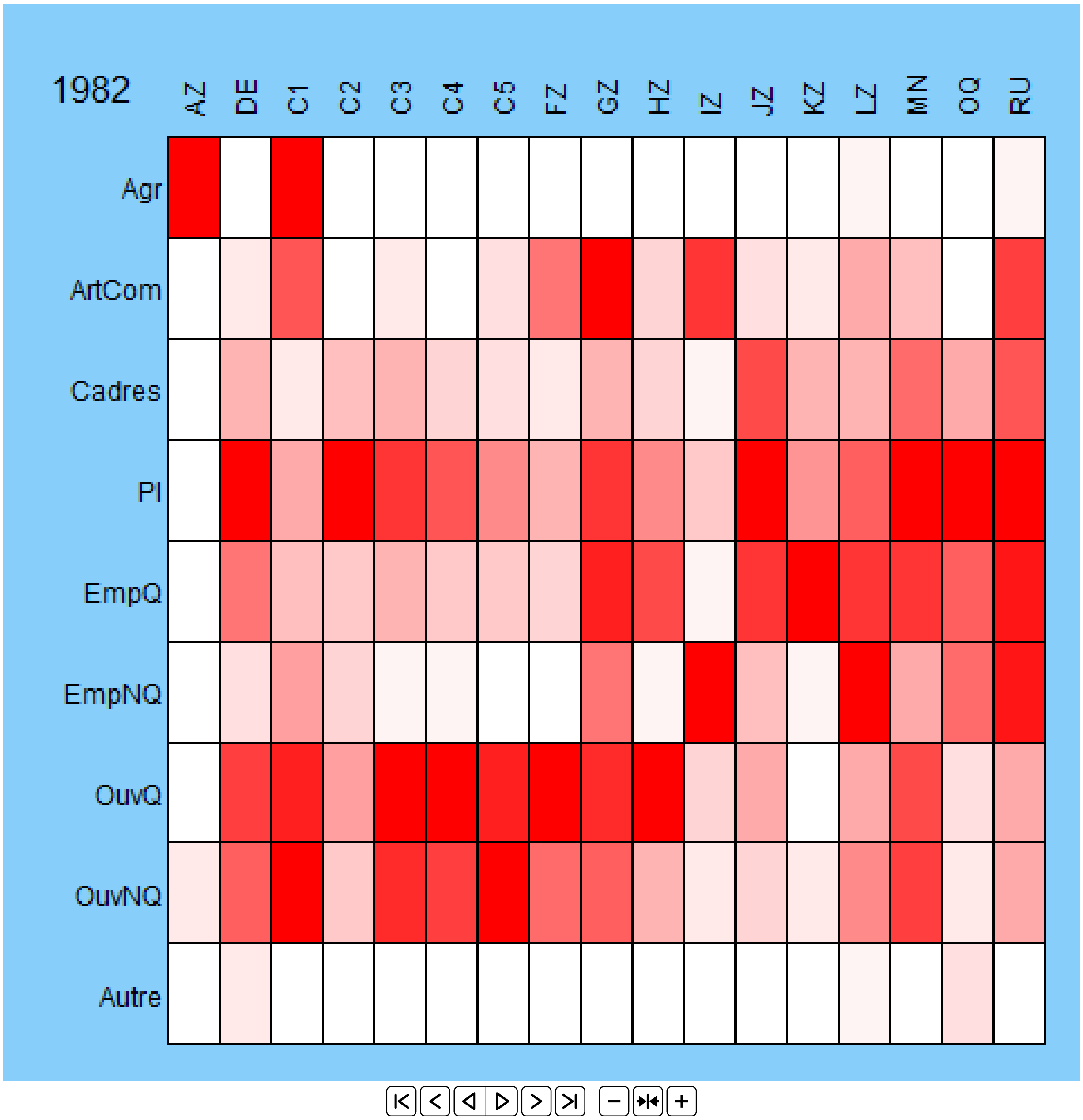


Figure 1: Employment per output (A17 aggregation level)

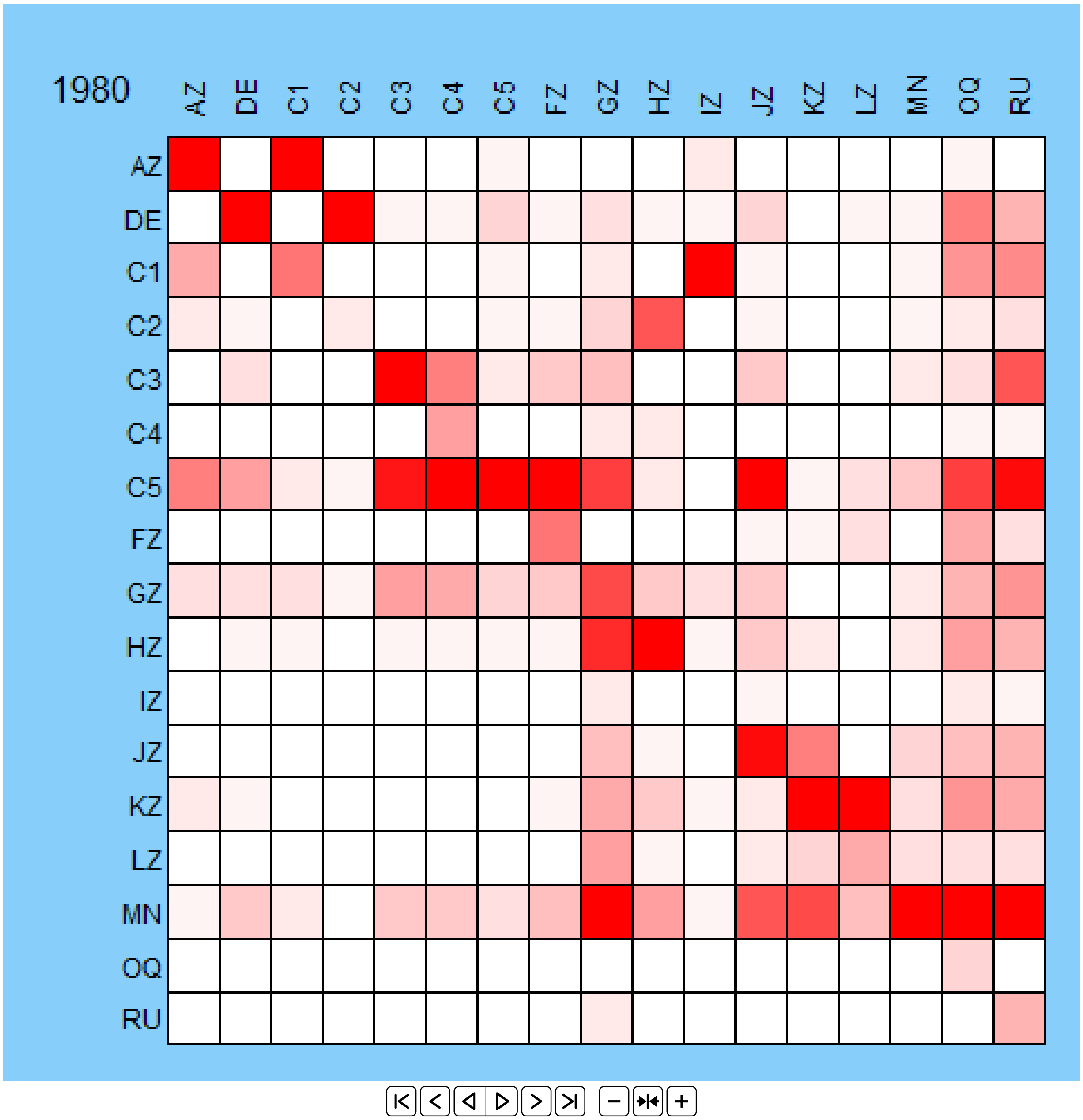


Figure 2: Technical coefficient of intermediate consumption (A17 aggregation level)

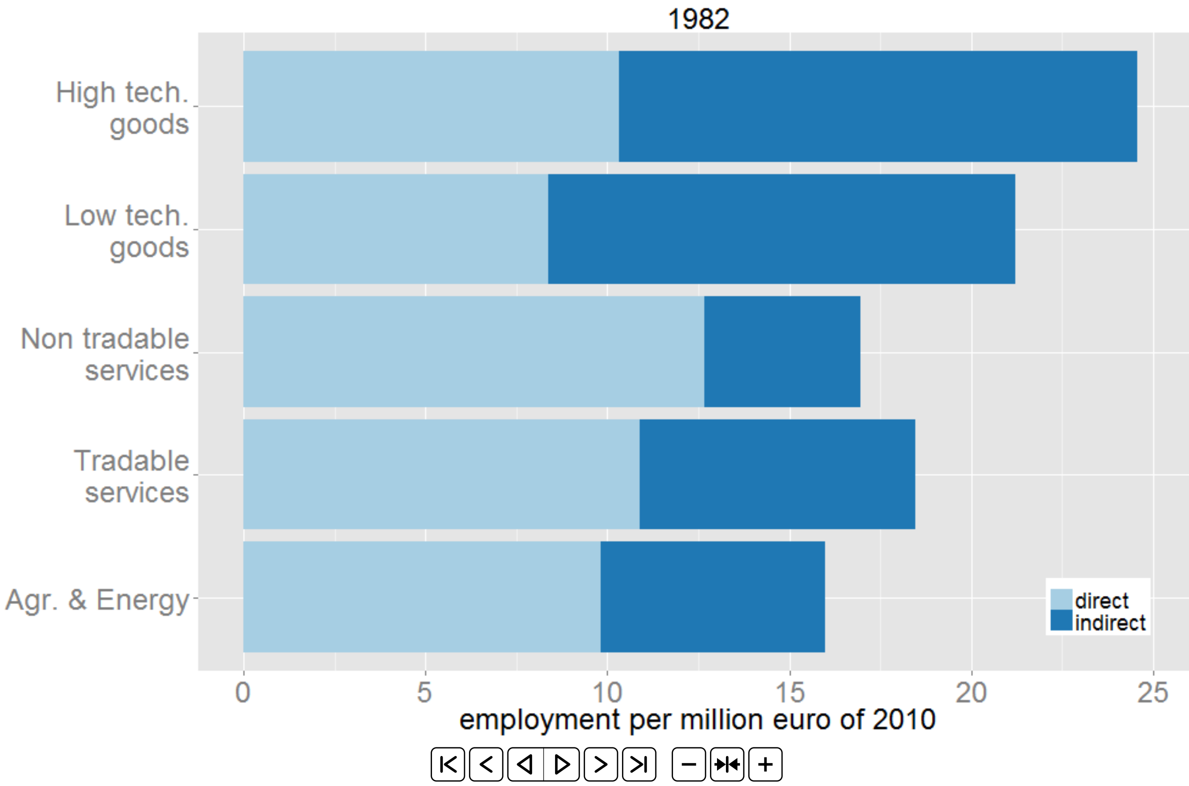


Figure 3: Direct and indirect labour content of final domestic demand (A5 aggregation level)

2 Labour content by product, qualification...

From our framework we can compute by product the labour content of each final good. We display in Figures 3 to 10 the labour content of final domestic demand (considering final demand would only marginally modify the outcome due to the change in ponderation from the introduction of exports).

The direct labour content corresponds to the labour involved in the production process of a particular product in proportion of final demand in total production of this product. Indirect production is all other labour indirectly involved in the production process through intermediate consumptions (Figures 3 to 6).

We can identify the labour content of each product in any qualification and product (e.g. the content of food products in highly qualified labour in business services). It is informative to look at the labour content by qualification (Figures 7 to 10).

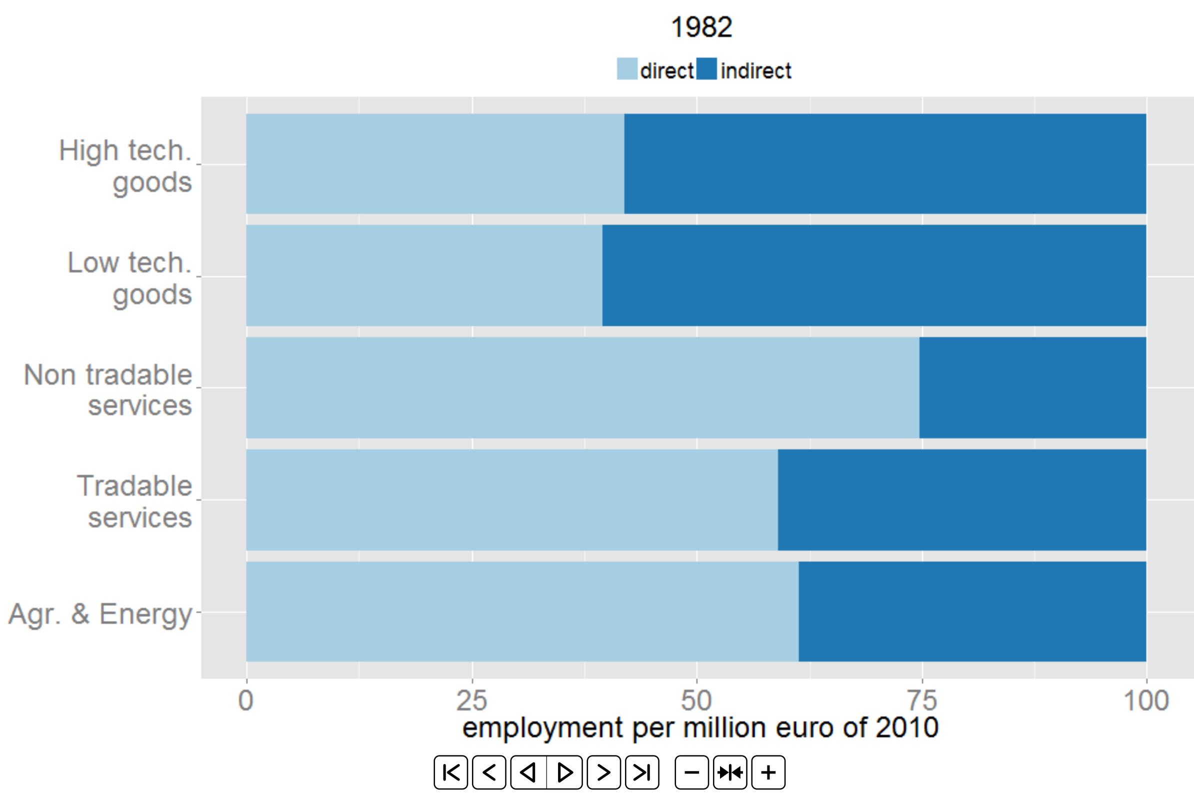


Figure 4: Direct and indirect labour content of final domestic demand (A5 aggregation level, in percentage of total labour content)

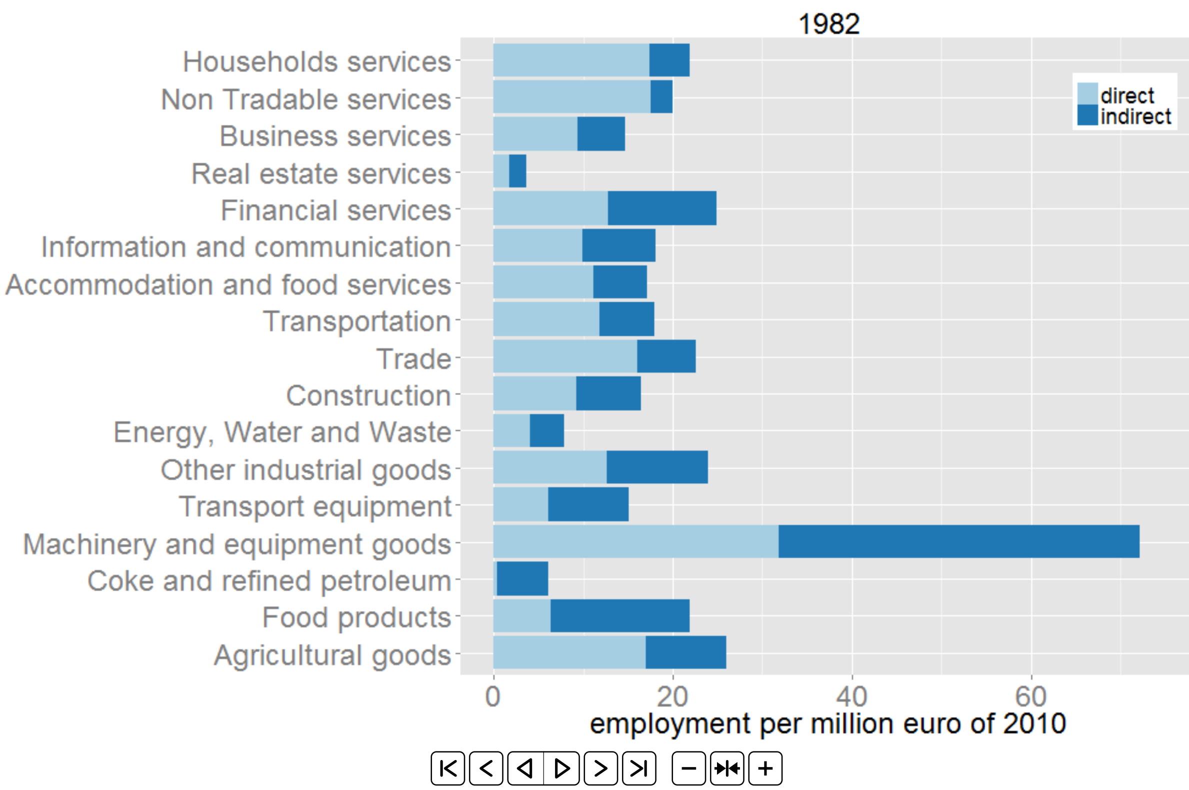


Figure 5: Direct and indirect labour content of final domestic demand (A17 aggregation level)

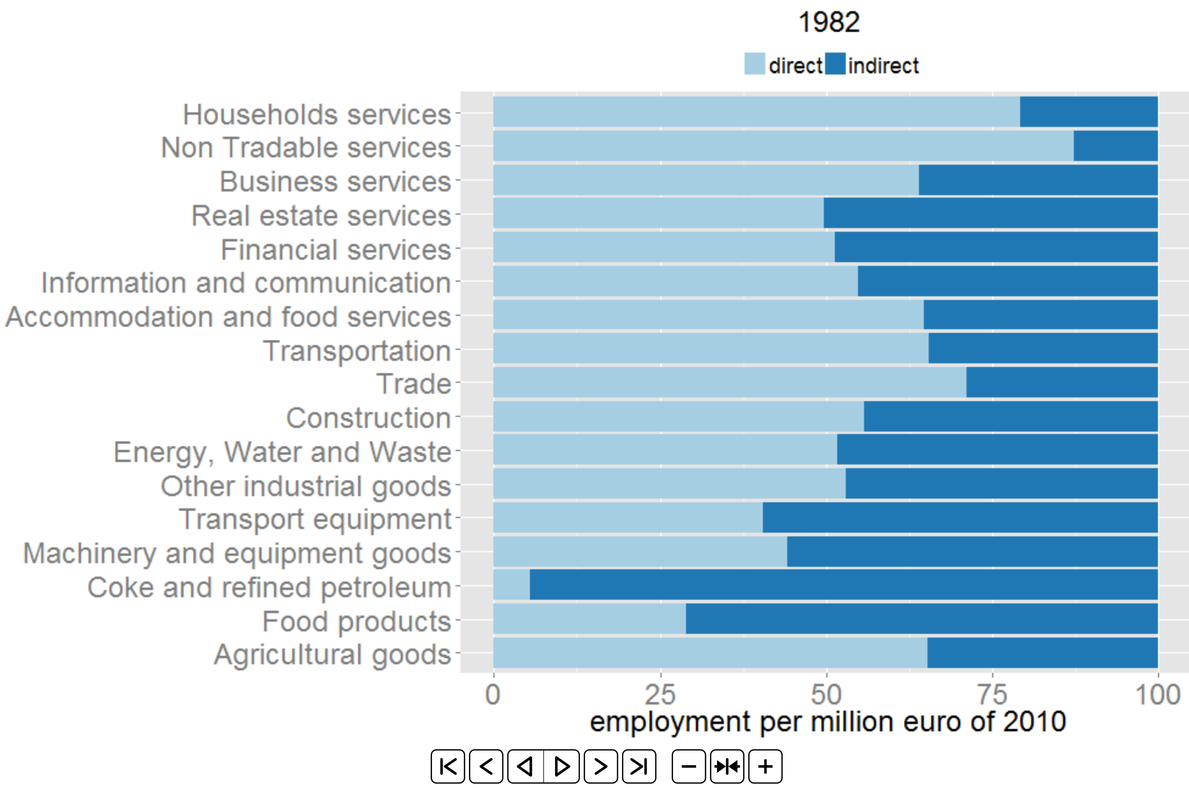


Figure 6: Direct and indirect labour content of final domestic demand (A17 aggregation level, in percentage of total labour content)

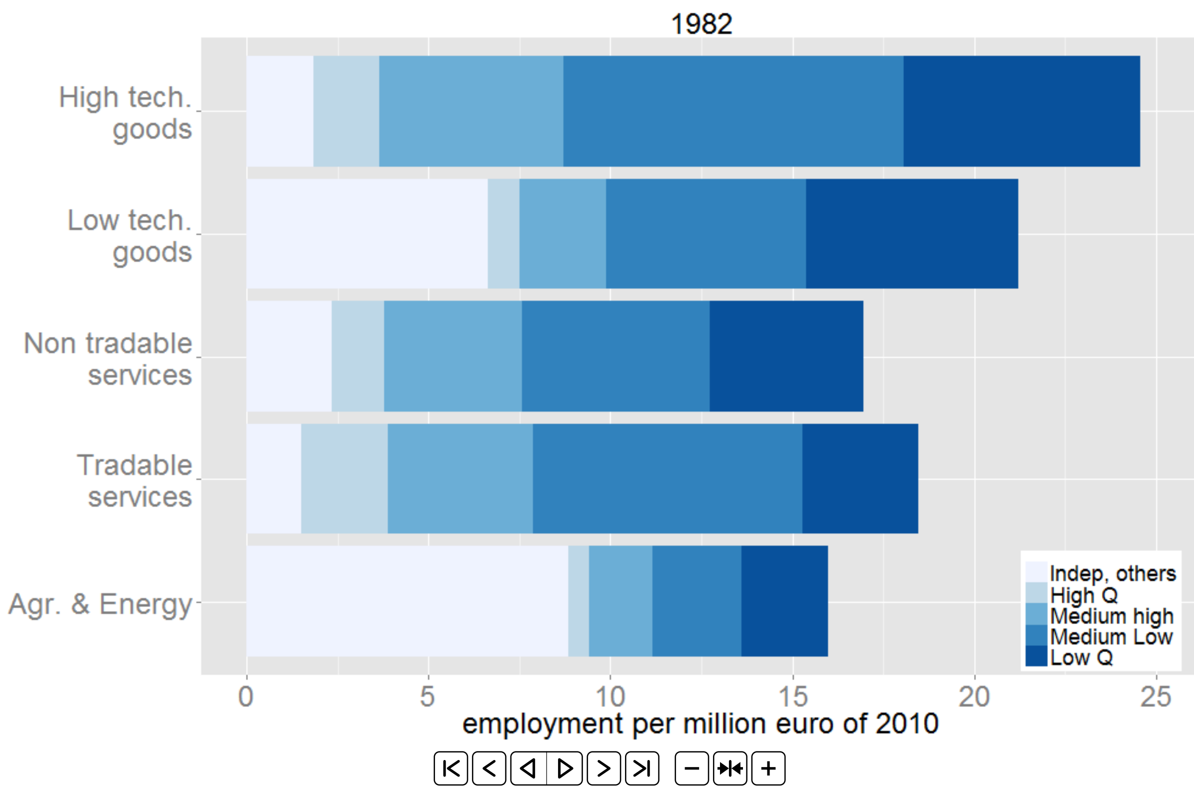


Figure 7: Labour content by qualification content of final domestic demand (A5 aggregation level)

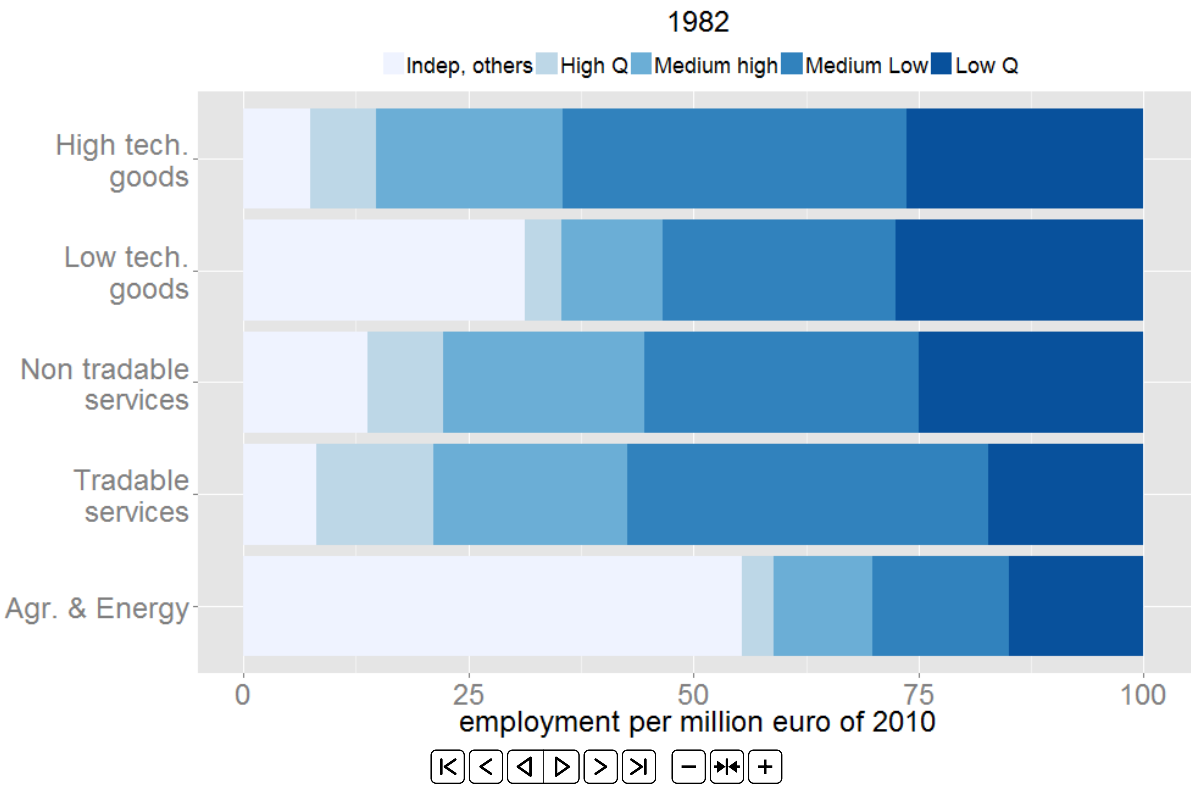


Figure 8: Labour content by qualification of final domestic demand (A5 aggregation level, in percentage of total labour content)

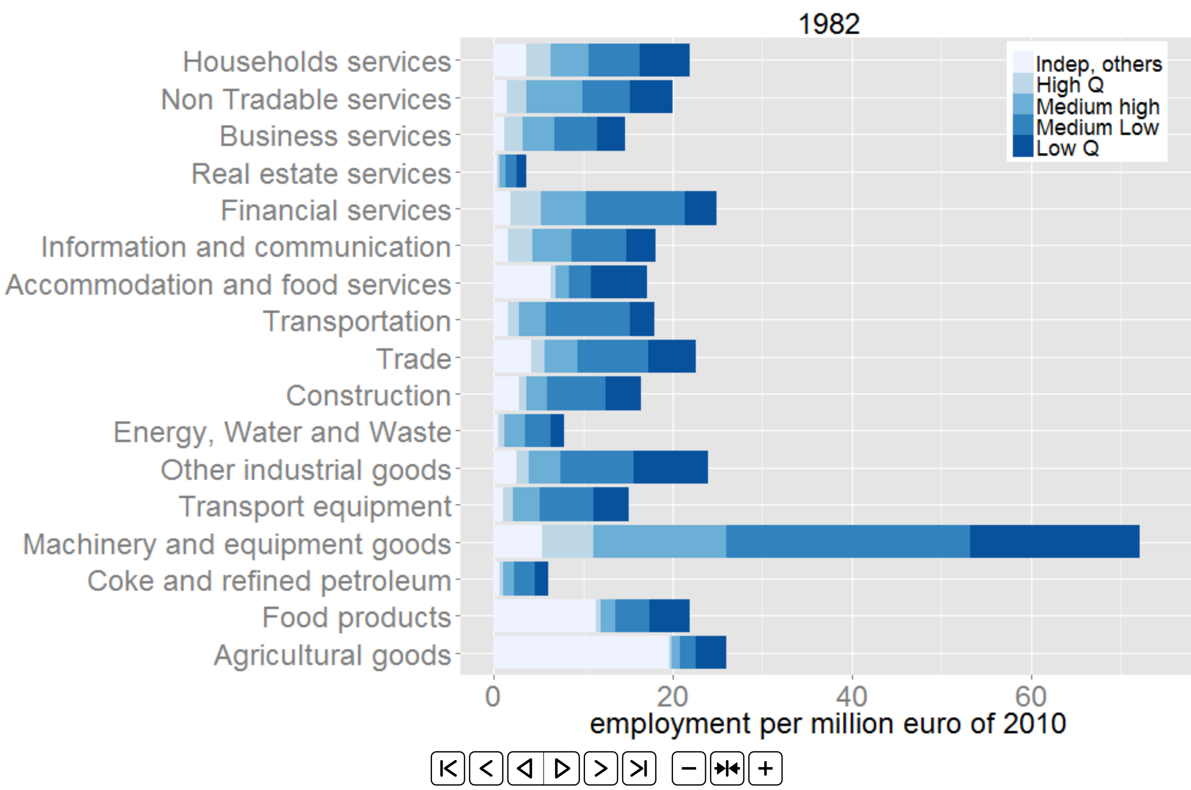


Figure 9: Labour content by qualification of final domestic demand (A17 aggregation level)

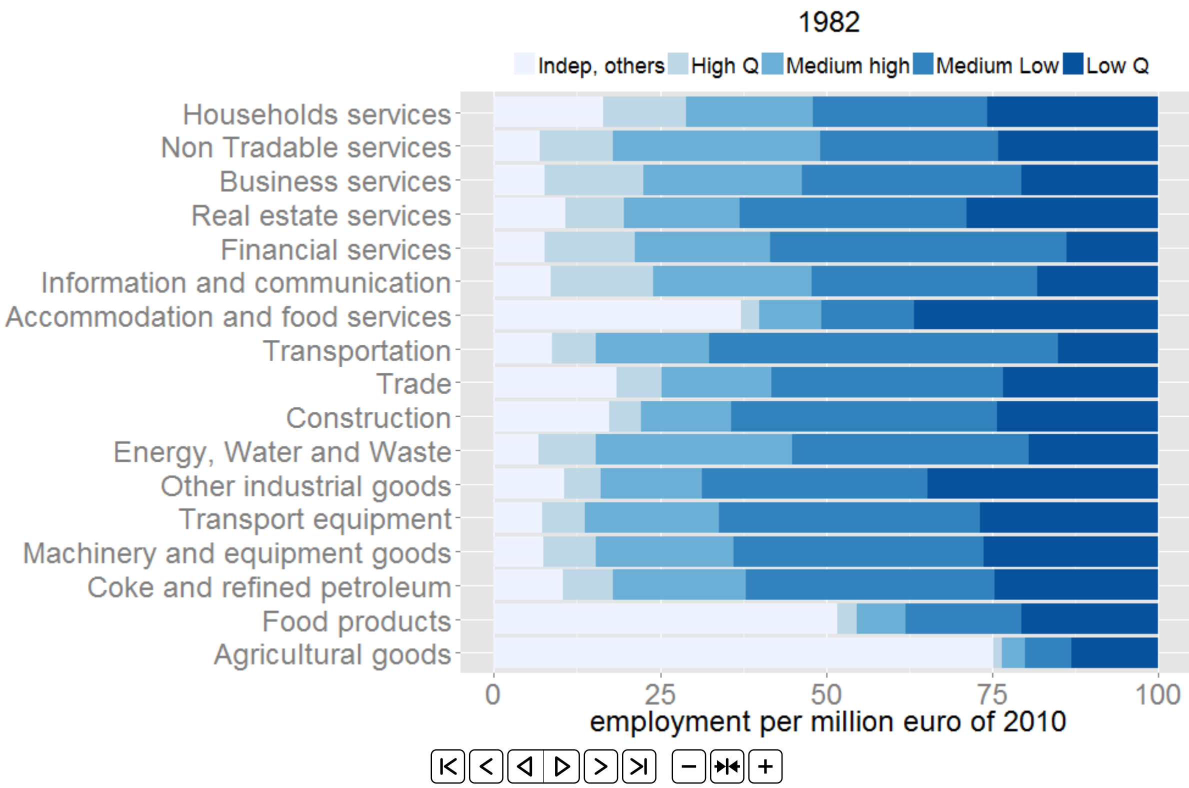


Figure 10: Labour content by qualification of final domestic demand (A17 aggregation level, in percentage of total labour content)

	Product	Qualification					Total	Direct	Indirect
		High	Mid-high	Mid-low	Low	Others			
1982	Agricultural goods	0.3	0.9	1.8	3.4	19.6	26	17	9
	Energy, Water and Waste	0.7	2.3	2.8	1.5	0.5	7.9	4.1	3.8
	Food products	0.6	1.6	3.8	4.5	11.4	21.9	6.3	15.6
	Coke and refined petroleum	0.5	1.2	2.3	1.5	0.6	6.1	0.3	5.8
	Machinery and equipment goods	5.8	14.9	27.2	19	5.4	72.3	31.9	40.4
	Transport equipment	1	3.1	5.9	4.1	1.1	15.1	6.1	9
	Other industrial goods	1.3	3.6	8.1	8.3	2.5	23.9	12.7	11.2
	Construction	0.8	2.2	6.6	4	2.9	16.5	9.2	7.3
	Trade	1.5	3.7	7.9	5.2	4.2	22.6	16	6.5
	Transportation	1.2	3.1	9.4	2.7	1.6	18	11.8	6.2
	Accommodation and food services	0.5	1.6	2.4	6.3	6.4	17.1	11.1	6
	Information and communication	2.8	4.3	6.1	3.3	1.5	18	9.9	8.2
	Financial services	3.4	5.1	11.1	3.4	1.9	24.8	12.8	12.1
	Real estate services	0.3	0.6	1.2	1	0.4	3.6	1.8	1.8
	Business services	2.2	3.5	4.8	3	1.1	14.6	9.3	5.3
	Non Tradable services	2.2	6.2	5.4	4.8	1.4	20	17.5	2.5
	Households services	2.7	4.2	5.8	5.6	3.6	21.9	17.4	4.5
	Total	1.4	3.6	5.4	4.3	3	17.8	11.8	6
2010	Agricultural goods	0.8	1.3	1.7	3.6	7.9	15.3	9.7	5.5
	Energy, Water and Waste	1.4	2.1	2.1	1.1	0.3	7	2.6	4.4
	Food products	1.2	1.9	3.3	3.3	3	12.6	4.7	7.9
	Coke and refined petroleum	0.7	0.9	1.3	0.6	0.3	3.8	0.2	3.6
	Machinery and equipment goods	2	2.2	2.8	1.3	0.4	8.8	4.3	4.5
	Transport equipment	1.3	1.9	2.4	1.1	0.4	7.2	2.1	5.1
	Other industrial goods	1.6	2.8	3.7	1.6	0.8	10.5	5.8	4.7
	Construction	1.3	2.2	4.9	2.1	2.1	12.5	7	5.5
	Trade	2	3.4	4.7	3.1	1.7	14.8	10.1	4.8
	Transportation	1.6	2.3	6.6	1.3	0.7	12.6	7.8	4.8
	Accommodation and food services	1.3	2.4	3.8	6.6	3.1	17.1	12.3	4.8
	Information and communication	3.5	2.1	1.8	1	0.5	9	4.7	4.3
	Financial services	2.8	2.1	2.6	0.9	0.4	8.8	3.8	5
	Real estate services	0.6	0.7	0.8	0.6	0.3	2.9	1.4	1.5
	Business services	4.2	3	2.8	1.7	0.6	12.3	7.6	4.6
	Non Tradable services	2.9	5.4	4.5	4.2	0.2	17.2	15.2	2
	Households services	3.5	4.8	5	4.9	2.1	20.4	16.4	3.9
	Total	2.1	3.2	3.6	2.7	1.1	12.7	9	3.7

Table 1: Labour content by product (in employment per million euro of 2010)

3 Sources of employment change by skill level and product

3.1 Decomposition for 17 products

Average contribution (in % per year)	**Tot.**	AZ	DE	C1	C2	C3	C4	C5	FZ	GZ	HZ	IZ	JZ	KZ	LZ	MN	OQ	RU
									Total									
Jobs creation	0.61	-0.13	0.01	-0.01	0	-0.03	-0.03	-0.2	-0.01	0.09	0.03	0.07	0.05	0.01	0.02	0.31	0.32	0.1
Final consumption	1.21	0.02	0.02	0.03	0	0.01	0	0.03	0.01	0.18	0.06	0.04	0.05	0.06	0.03	0.11	0.46	0.09
Trade	0.34	0.02	0	0.01	0	0.02	0.02	0.01	0	0.11	0.04	0	0.01	0.01	0	0.07	0	0.01
Technology	-0.95	-0.18	-0.01	-0.05	0	-0.07	-0.05	-0.23	-0.02	-0.21	-0.06	0.02	0	-0.06	-0.01	0.13	-0.14	0
									High skill									
Jobs creation	3.37	0.01	0.06	0.02	0	0.06	0.03	0.09	0.06	0.28	0.08	0.05	0.4	0.22	0.06	0.87	0.9	0.18
Final consumption	1.32	0	0.02	0.01	0	0.03	0	0.03	0.01	0.13	0.04	0.01	0.11	0.13	0.03	0.15	0.52	0.12
Trade	0.32	0	0	0	0	0.03	0.01	0.02	0	0.08	0.02	0	0.03	0.03	0	0.08	0.01	0.01
Technology	1.73	0.01	0.04	0.01	0	0.01	0.01	0.04	0.05	0.07	0.02	0.04	0.26	0.07	0.03	0.64	0.38	0.04
									Middle skill (higher)									
Jobs creation	1.38	0.01	0.03	0.02	0	-0.02	-0.02	-0.01	0.04	0.24	0.04	0.05	0.05	0.04	0.04	0.3	0.46	0.13
Final consumption	1.34	0	0.03	0.01	0	0.02	0	0.03	0.01	0.15	0.05	0.02	0.08	0.07	0.03	0.11	0.65	0.09
Trade	0.32	0	0.01	0	0	0.03	0.02	0.02	0	0.09	0.03	0	0.01	0.01	0	0.06	0.01	0.01
Technology	-0.28	0.01	-0.01	0.01	0	-0.07	-0.04	-0.07	0.03	-0.01	-0.04	0.03	-0.04	-0.04	0.01	0.13	-0.2	0.03
									Middle skill (lower)									
Jobs creation	0.38	0.01	0	0.01	0	-0.05	-0.05	-0.21	0	0.04	0.08	0.07	-0.02	-0.05	0.01	0.18	0.27	0.08
Final consumption	1.18	0	0.02	0.02	0	0.01	0	0.04	0.02	0.19	0.11	0.02	0.04	0.08	0.03	0.11	0.41	0.07
Trade	0.37	0	0	0.01	0	0.02	0.02	0.01	0	0.11	0.07	0	0.01	0.02	0	0.07	0	0.01
Technology	-1.17	0	-0.02	-0.01	0	-0.09	-0.07	-0.25	-0.02	-0.26	-0.11	0.05	-0.06	-0.15	-0.02	0	-0.14	0
									Low skill									
Jobs creation	0.11	0.01	-0.01	0	0	-0.08	-0.06	-0.57	-0.1	0.06	-0.03	0.14	-0.01	-0.02	0	0.33	0.38	0.1
Final consumption	1.27	0.02	0.01	0.04	0	0.01	0	0.03	0.01	0.2	0.02	0.09	0.01	0.01	0.04	0.13	0.55	0.1
Trade	0.3	0.01	0	0.01	0	0.02	0.01	-0.01	0	0.13	0.02	0.01	0	0	0	0.08	0	0.01
Technology	-1.46	-0.02	-0.03	-0.05	0	-0.11	-0.08	-0.59	-0.11	-0.27	-0.07	0.04	-0.03	-0.03	-0.05	0.12	-0.17	-0.01
									Other skill									
Jobs creation	-1.7	-1.05	-0.01	-0.21	0	-0.01	-0.01	-0.11	0.07	-0.18	-0.02	-0.01	0.02	-0.01	0.01	0.11	-0.35	0.05
Final consumption	0.94	0.16	0	0.06	0	0	0	0.01	0.02	0.25	0.03	0.1	0.01	0.02	0.02	0.06	0.1	0.09
Trade	0.38	0.12	0	0.01	0	0	0	0	0	0.15	0.02	0.01	0	0	0	0.03	0	0.01
Technology	-3.02	-1.33	-0.02	-0.28	0	-0.02	-0.01	-0.12	0.04	-0.58	-0.08	-0.12	0	-0.04	-0.01	0.02	-0.44	-0.05

Table 2: Broad contributions to employment change by skill levels and for 17 products. 1983-2010

Average contribution (in % per year)	**Tot.**	AZ	DE	C1	C2	C3	C4	C5	FZ	GZ	HZ	IZ	JZ	KZ	LZ	MN	OQ	RU
										Total								
Final consumption effects	1.21	0.02	0.02	0.03	0	0.01	0	0.03	0.01	0.18	0.06	0.04	0.05	0.06	0.03	0.11	0.46	0.09
Consumption structure	-0.08	-0.02	0	-0.02	0	0.01	0	-0.05	0	-0.01	0	-0.02	0.02	0.02	0	0.01	0	-0.01
Purchasing power	0.44	0.03	0.01	0.03	0	0	0	0.03	0.01	0.09	0.03	0.04	0.01	0.02	0.02	0.05	0.05	0.03
Sociodemographic effects	0.27	0.02	0.01	0.02	0	0	0	0.02	0	0.06	0.02	0.02	0.01	0.01	0.01	0.03	0.03	0.02
Household saving	0.04	0.01	0	0	0	0	0	0.01	0	0.01	0	0	0	0	0	0	0	0
Gov. and NPISH consumption	0.55	-0.01	0	0	0	0	-0.01	0.02	0	0.03	0.01	0	0	0.01	0	0.03	0.38	0.06
										High skill								
Final Consumption effects	1.32	0	0.02	0.01	0	0.03	0	0.03	0.01	0.13	0.04	0.01	0.11	0.13	0.03	0.15	0.52	0.12
Consumption structure	0.07	0	0	-0.01	0	0.02	0	-0.03	0	-0.01	0	-0.01	0.04	0.04	0	0.01	0.03	-0.01
Purchasing power	0.38	0	0.01	0.01	0	0	0	0.02	0	0.06	0.02	0.01	0.03	0.05	0.01	0.06	0.05	0.03
Sociodemographic effects	0.23	0	0.01	0.01	0	0	0	0.01	0	0.04	0.01	0.01	0.02	0.03	0.01	0.04	0.03	0.02
Household saving	0.03	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0
Gov. and NPISH Consumption	0.61	0	0	0	0	0	0	0.02	0	0.02	0.01	0	0.01	0.01	0	0.05	0.41	0.08
										Middle skill (higher)								
Final Consumption effects	1.34	0	0.03	0.01	0	0.02	0	0.03	0.01	0.15	0.05	0.02	0.08	0.07	0.03	0.11	0.65	0.09
Consumption structure	0.01	0	0	-0.01	0	0.01	0	-0.04	0	-0.01	0	-0.01	0.04	0.02	0	0.01	0.02	-0.01
Purchasing power	0.38	0	0.01	0.01	0	0	0	0.03	0	0.08	0.02	0.02	0.02	0.03	0.01	0.04	0.07	0.03
Sociodemographic effects	0.23	0	0.01	0.01	0	0	0	0.02	0	0.05	0.01	0.01	0.01	0.02	0.01	0.03	0.04	0.02
Household saving	0.03	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0
Gov. and NPISH Consumption	0.69	0	0.01	0	0	0	-0.01	0.02	0	0.03	0.01	0	0.01	0.01	0	0.03	0.52	0.06
										Middle skill (lower)								
Final Consumption effects	1.18	0	0.02	0.02	0	0.01	0	0.04	0.02	0.19	0.11	0.02	0.04	0.08	0.03	0.11	0.41	0.07
Consumption structure	-0.05	0	0	-0.01	0	0.01	0	-0.06	0	-0.01	0	-0.01	0.02	0.02	0	0.01	0.01	-0.02
Purchasing power	0.42	0	0.01	0.02	0	0	0	0.04	0.01	0.1	0.05	0.02	0.01	0.03	0.01	0.05	0.03	0.02
Sociodemographic effects	0.25	0	0.01	0.01	0	0	0	0.03	0.01	0.06	0.03	0.01	0.01	0.02	0.01	0.03	0.02	0.01
Household saving	0.04	0	0	0	0	0	0	0.01	0	0.01	0	0	0	0	0	0	0	0
Gov. and NPISH Consumption	0.53	0	0	0	0	0	-0.01	0.02	0	0.03	0.02	0	0	0.01	0	0.03	0.35	0.05
										Low skill								
Final Consumption effects	1.27	0.02	0.01	0.04	0	0.01	0	0.03	0.01	0.2	0.02	0.09	0.01	0.01	0.04	0.13	0.55	0.1
Consumption structure	-0.19	-0.02	0	-0.02	0	0	0	-0.07	0	-0.01	0	-0.05	0.01	0	0	0.01	-0.02	-0.01
Purchasing power	0.5	0.02	0.01	0.04	0	0	0	0.04	0.01	0.11	0.01	0.08	0	0	0.02	0.06	0.07	0.04
Sociodemographic effects	0.3	0.01	0	0.02	0	0	0	0.03	0	0.06	0.01	0.04	0	0	0.01	0.03	0.04	0.02
Household saving	0.04	0	0	0	0	0	0	0.01	0	0.01	0	0	0	0	0	0	0	0
Gov. and NPISH Consumption	0.62	0	0	0	0	0	0	0.02	0	0.04	0	0.01	0	0	0	0.03	0.46	0.05
										Other skill								
Final Consumption effects	0.94	0.16	0	0.06	0	0	0	0.01	0.02	0.25	0.03	0.1	0.01	0.02	0.02	0.06	0.1	0.09
Consumption structure	-0.29	-0.15	0	-0.03	0	0	0	-0.03	0	-0.02	0	-0.05	0.01	0.01	0	0	0	-0.02
Purchasing power	0.59	0.18	0	0.06	0	0	0	0.02	0.01	0.13	0.02	0.08	0	0.01	0.01	0.03	0	0.03
Sociodemographic effects	0.36	0.12	0	0.03	0	0	0	0.01	0.01	0.08	0.01	0.05	0	0.01	0.01	0.01	0	0.02
Household saving	0.06	0.03	0	0.01	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0
Gov. and NPISH Consumption	0.22	-0.02	0	-0.01	0	0	0	0.01	0.01	0.04	0.01	0.01	0	0	0	0.01	0.09	0.07

Table 3: Breakdown of final consumption effects to employment change by skill levels and for 17 products. 1983-2010

Average contribution (in % per year)	**Tot.**	AZ	DE	C1	C2	C3	C4	C5	FZ	GZ	HZ	IZ	JZ	KZ	LZ	MN	OQ	RU
Total																		
Trade effects	0.34	0.02	0	0.01	0	0.02	0.02	0.01	0	0.11	0.04	0	0.01	0.01	0	0.07	0	0.01
Exports	0.74	0.05	0.01	0.02	0	0.06	0.03	0.15	0	0.14	0.06	0.01	0.02	0.02	0	0.14	0.01	0.02
Offshore outsourcing	-0.26	-0.02	-0.01	-0.01	0	-0.03	0	-0.09	0	-0.02	-0.02	0	0	0	0	-0.05	0	0
Home share in FC	-0.1	-0.01	0	-0.01	0	-0.01	0	-0.04	0	-0.01	-0.01	0	0	0	0	-0.01	0	0
Home share in GFCF	-0.04	0	0	0	0	-0.01	0	-0.01	0	0	0	0	0	0	0	-0.01	0	0
High skill																		
Trade effects	0.32	0	0	0	0	0.03	0.01	0.02	0	0.08	0.02	0	0.03	0.03	0	0.08	0.01	0.01
Exports	0.67	0	0.02	0.01	0	0.09	0.03	0.12	0	0.1	0.04	0	0.05	0.03	0	0.15	0.02	0.02
Offshore outsourcing	-0.22	0	-0.01	0	0	-0.04	0	-0.06	0	-0.01	-0.01	0	-0.01	-0.01	0	-0.05	-0.01	0
Home share in FC	-0.08	0	0	0	0	-0.01	0	-0.03	0	-0.01	0	0	0	0	0	-0.02	0	0
Home share in GFCF	-0.04	0	0	0	0	-0.01	0	-0.01	0	0	0	0	0	0	0	-0.01	0	0
Middle skill (higher)																		
Trade effects	0.32	0	0.01	0	0	0.03	0.02	0.02	0	0.09	0.03	0	0.01	0.01	0	0.06	0.01	0.01
Exports	0.67	0	0.02	0.01	0	0.08	0.04	0.15	0	0.12	0.05	0	0.02	0.02	0	0.12	0.02	0.02
Offshore outsourcing	-0.23	0	-0.01	0	0	-0.03	-0.01	-0.08	0	-0.02	-0.01	0	-0.01	0	0	-0.04	0	0
Home share in FC	-0.09	0	0	0	0	-0.01	-0.01	-0.03	0	-0.01	-0.01	0	0	0	0	-0.01	0	0
Home share in GFCF	-0.04	0	0	0	0	-0.01	0	-0.01	0	0	0	0	0	0	0	-0.01	0	0
Middle skill (lower)																		
Trade effects	0.37	0	0	0.01	0	0.02	0.02	0.01	0	0.11	0.07	0	0.01	0.02	0	0.07	0	0.01
Exports	0.81	0	0.02	0.02	0	0.07	0.04	0.19	0.01	0.15	0.12	0	0.01	0.02	0	0.14	0	0.01
Offshore outsourcing	-0.29	0	-0.01	-0.01	0	-0.03	-0.01	-0.12	0	-0.02	-0.03	0	0	0	0	-0.05	0	0
Home share in FC	-0.11	0	0	-0.01	0	-0.01	-0.01	-0.05	0	-0.01	-0.01	0	0	0	0	-0.01	0	0
Home share in GFCF	-0.05	0	0	0	0	-0.01	0	-0.01	0	0	0	0	0	0	0	-0.01	0	0
Low skill																		
Trade effects	0.3	0.01	0	0.01	0	0.02	0.01	-0.01	0	0.13	0.02	0.01	0	0	0	0.08	0	0.01
Exports	0.72	0.03	0.01	0.03	0	0.05	0.03	0.16	0	0.16	0.03	0.01	0.01	0	0	0.18	0.01	0.01
Offshore outsourcing	-0.27	-0.01	-0.01	-0.01	0	-0.02	0	-0.11	0	-0.02	-0.01	0	0	0	0	-0.07	0	0
Home share in FC	-0.11	-0.01	0	-0.01	0	0	0	-0.05	0	-0.01	0	0	0	0	0	-0.01	0	0
Home share in GFCF	-0.03	0	0	0	0	-0.01	0	-0.01	0	0	0	0	0	0	0	-0.01	0	0
Other skill																		
Trade effects	0.38	0.12	0	0.01	0	0	0	0	0	0.15	0.02	0.01	0	0	0	0.03	0	0.01
Exports	0.78	0.28	0	0.05	0	0.01	0	0.06	0.01	0.2	0.03	0.01	0.01	0.01	0	0.07	0	0.02
Offshore outsourcing	-0.25	-0.11	0	-0.02	0	-0.01	0	-0.04	0	-0.03	-0.01	0	0	0	0	-0.03	0	0
Home share in FC	-0.12	-0.05	0	-0.02	0	0	0	-0.02	0	-0.01	0	0	0	0	0	-0.01	0	0
Home share in GFCF	-0.02	0	0	0	0	0	0	-0.01	0	-0.01	0	0	0	0	0	0	0	0

Table 4: Breakdown of trade effects to employment change by skill levels and for 17 products. 1983-2010

Average contribution (in % per year)	**Tot.**	AZ	DE	C1	C2	C3	C4	C5	FZ	GZ	HZ	IZ	JZ	KZ	LZ	MN	OQ	RU
									Total									
Technology effects	-0.95	-0.18	-0.01	-0.05	0	-0.07	-0.05	-0.23	-0.02	-0.21	-0.06	0.02	0	-0.06	-0.01	0.13	-0.14	0
Direct labour saving	-1.16	-0.2	-0.02	-0.04	0	-0.09	-0.05	-0.29	-0.03	-0.22	-0.16	0.03	-0.06	-0.06	-0.01	0.06	-0.02	-0.01
IC effects	-0.08	0.02	0	-0.01	0	0.01	0	0.02	-0.03	-0.03	0.09	-0.01	0.01	-0.01	-0.01	-0.01	-0.12	0
GFCF effects	0.3	0	0	0	0	0.01	0	0.04	0.04	0.04	0.01	0	0.05	0.01	0	0.08	0	0.01
									High skill									
Technology effects	1.73	0.01	0.04	0.01	0	0.01	0.01	0.04	0.05	0.07	0.02	0.04	0.26	0.07	0.03	0.64	0.38	0.04
Direct labour saving	1.35	0.01	0.04	0.02	0	-0.03	0.01	-0.01	0.05	0.06	-0.04	0.04	0.12	0.08	0.04	0.43	0.51	0.02
IC effects	-0.07	0	0	0	0	0.02	0	0.02	-0.01	-0.02	0.05	0	0	-0.02	0	0.04	-0.14	0.01
GFCF effects	0.45	0	0	0	0	0.01	0	0.03	0.02	0.03	0.01	0	0.15	0.01	0	0.17	0	0.01
									Middle skill (higher)									
Technology effects	-0.28	0.01	-0.01	0.01	0	-0.07	-0.04	-0.07	0.03	-0.01	-0.04	0.03	-0.04	-0.04	0.01	0.13	-0.2	0.03
Direct labour saving	-0.44	0.01	-0.01	0.01	0	-0.1	-0.04	-0.13	0.03	-0.02	-0.12	0.03	-0.11	-0.04	0.01	0.03	-0.02	0.02
IC effects	-0.13	0	0	0	0	0.02	-0.01	0.03	-0.02	-0.03	0.07	0	0.02	-0.01	0	0	-0.19	0
GFCF effects	0.29	0	0	0	0	0.01	0.01	0.04	0.02	0.03	0.01	0	0.05	0.01	0	0.09	0	0.01
									Middle skill (lower)									
Technology effects	-1.17	0	-0.02	-0.01	0	-0.09	-0.07	-0.25	-0.02	-0.26	-0.11	0.05	-0.06	-0.15	-0.02	0	-0.14	0
Direct labour saving	-1.49	0	-0.03	-0.01	0	-0.11	-0.07	-0.34	-0.04	-0.27	-0.29	0.05	-0.1	-0.14	-0.01	-0.06	-0.05	-0.01
IC effects	0.01	0	0.01	-0.01	0	0.01	-0.01	0.03	-0.04	-0.03	0.17	-0.01	0.01	-0.01	-0.01	-0.01	-0.09	0
GFCF effects	0.32	0	0	0	0	0.01	0.01	0.05	0.06	0.04	0.02	0	0.03	0.01	0	0.07	0	0.01
									Low skill									
Technology effects	-1.46	-0.02	-0.03	-0.05	0	-0.11	-0.08	-0.59	-0.11	-0.27	-0.07	0.04	-0.03	-0.03	-0.05	0.12	-0.17	-0.01
Direct labour saving	-1.46	-0.03	-0.04	-0.04	0	-0.13	-0.08	-0.64	-0.12	-0.28	-0.12	0.06	-0.05	-0.03	-0.04	0.11	-0.01	-0.02
IC effects	-0.24	0.01	0.01	-0.01	0	0.01	0	0.01	-0.02	-0.03	0.04	-0.02	0	0	-0.01	-0.06	-0.16	0
GFCF effects	0.23	0	0	0	0	0.01	0	0.04	0.03	0.05	0	0.01	0.02	0	0	0.06	0	0.01
									Other skill									
Technology effects	-3.02	-1.33	-0.02	-0.28	0	-0.02	-0.01	-0.12	0.04	-0.58	-0.08	-0.12	0	-0.04	-0.01	0.02	-0.44	-0.05
Direct labour saving	-3.23	-1.42	-0.02	-0.26	0	-0.03	-0.01	-0.16	0.02	-0.59	-0.13	-0.1	-0.02	-0.04	-0.01	0	-0.42	-0.06
IC effects	-0.03	0.09	0	-0.02	0	0	0	0.02	-0.06	-0.04	0.05	-0.02	0	0	0	-0.01	-0.02	0
GFCF effects	0.24	0	0	0	0	0	0	0.02	0.08	0.05	0.01	0.01	0.02	0	0	0.03	0	0.01

Table 5: Breakdown of technology effects to employment change by skill levels and for 17 products. 1983-2010

3.2 Breakdown of trade effects by sub-period, skill and product

Average contribution (in % per year)	Total	Products in: Manufacturing high-tech	Manufacturing low-tech	Services non-tradable	Services tradable	Other
			Total			
Trade effects	0.49	0.04	0.03	0.02	0.34	0.05
Exports	0.9	0.17	0.22	0.04	0.38	0.1
Offshore outsourcing	-0.22	-0.07	-0.12	-0.01	0	-0.03
Home share in FC	-0.11	-0.02	-0.06	0	-0.02	-0.01
Home share in GFCF	-0.07	-0.03	-0.02	0	-0.02	0
			High skill			
Trade effects	0.38	0.05	0.02	0.03	0.27	0.01
Exports	0.72	0.19	0.12	0.06	0.32	0.02
Offshore outsourcing	-0.17	-0.09	-0.06	-0.02	0	-0.01
Home share in FC	-0.09	-0.03	-0.03	-0.01	-0.03	0
Home share in GFCF	-0.08	-0.03	-0.01	0	-0.03	0
			Intermediate skill (higher)			
Trade effects	0.42	0.05	0.03	0.03	0.3	0.01
Exports	0.77	0.2	0.16	0.05	0.33	0.03
Offshore outsourcing	-0.19	-0.09	-0.09	-0.01	0.01	-0.01
Home share in FC	-0.09	-0.03	-0.03	0	-0.02	0
Home share in GFCF	-0.08	-0.03	-0.02	0	-0.02	0
			Intermediate skill (lower)			
Trade effects	0.55	0.05	0.04	0.02	0.43	0.01
Exports	1	0.19	0.26	0.04	0.49	0.02
Offshore outsourcing	-0.25	-0.08	-0.14	-0.01	-0.01	-0.01
Home share in FC	-0.11	-0.03	-0.06	0	-0.03	0
Home share in GFCF	-0.09	-0.04	-0.02	0	-0.02	0
			Low skill			
Trade effects	0.43	0.05	0.02	0.02	0.33	0.02
Exports	0.9	0.17	0.31	0.04	0.34	0.04
Offshore outsourcing	-0.24	-0.07	-0.17	-0.01	0.02	-0.01
Home share in FC	-0.15	-0.02	-0.1	0	-0.02	-0.01
Home share in GFCF	-0.08	-0.03	-0.02	0	-0.02	0
			Other skill			
Trade effects	0.64	0.01	0.05	0.02	0.29	0.27
Exports	0.98	0.03	0.15	0.03	0.31	0.45
Offshore outsourcing	-0.19	-0.01	-0.06	-0.01	0	-0.11
Home share in FC	-0.12	0	-0.04	0	-0.01	-0.07
Home share in GFCF	-0.04	-0.01	-0.01	0	-0.01	0

Table 6: Breakdown of trade effects to employment change by skill and product. 1987-1992

Average contribution (in % per year)	Total	Products in:				
		Manufacturing		Services		Other
		high-tech	low-tech	non-tradable	tradable	
				Total		
Trade effects	0.88	0.18	0.12	0.08	0.48	0.03
Exports	1.34	0.26	0.26	0.1	0.65	0.07
Offshore outsourcing	-0.33	-0.06	-0.09	-0.02	-0.13	-0.03
Home share in FC	-0.09	-0.01	-0.04	-0.01	-0.03	-0.01
Home share in GFCF	-0.04	-0.01	-0.01	0	-0.01	0
				High skill		
Trade effects	0.86	0.23	0.08	0.11	0.43	0.01
Exports	1.28	0.34	0.15	0.14	0.62	0.03
Offshore outsourcing	-0.3	-0.08	-0.05	-0.02	-0.14	-0.01
Home share in FC	-0.07	-0.02	-0.01	-0.01	-0.03	0
Home share in GFCF	-0.05	-0.02	-0.01	0	-0.02	0
				Intermediate skill (higher)		
Trade effects	0.87	0.24	0.11	0.08	0.42	0.02
Exports	1.29	0.35	0.22	0.11	0.58	0.04
Offshore outsourcing	-0.31	-0.08	-0.07	-0.02	-0.12	-0.02
Home share in FC	-0.07	-0.02	-0.02	-0.01	-0.02	0
Home share in GFCF	-0.04	-0.02	-0.01	0	-0.01	0
				Intermediate skill (lower)		
Trade effects	1	0.22	0.15	0.07	0.55	0.01
Exports	1.52	0.31	0.34	0.09	0.74	0.03
Offshore outsourcing	-0.38	-0.07	-0.13	-0.02	-0.15	-0.02
Home share in FC	-0.09	-0.01	-0.05	-0.01	-0.03	0
Home share in GFCF	-0.05	-0.02	-0.01	0	-0.01	0
				Low skill		
Trade effects	0.82	0.13	0.1	0.06	0.5	0.03
Exports	1.27	0.18	0.27	0.08	0.67	0.06
Offshore outsourcing	-0.32	-0.04	-0.11	-0.02	-0.14	-0.02
Home share in FC	-0.09	-0.01	-0.05	-0.01	-0.02	-0.01
Home share in GFCF	-0.03	-0.01	-0.01	0	-0.01	0
				Other skill		
Trade effects	0.76	0.03	0.09	0.07	0.43	0.13
Exports	1.16	0.05	0.19	0.1	0.55	0.26
Offshore outsourcing	-0.27	-0.01	-0.06	-0.02	-0.09	-0.08
Home share in FC	-0.11	0	-0.03	-0.01	-0.02	-0.05
Home share in GFCF	-0.03	0	-0.01	0	-0.01	0

Table 7: Breakdown of trade effects to employment change by skill and product. 1994-2000

Average contribution (in % per year)	Total	Products in: Manufacturing high-tech	Manufacturing low-tech	Services non-tradable	Services tradable	Other
				Total		
Trade effects	0.12	-0.01	-0.05	0.02	0.17	-0.01
Exports	0.55	0.07	0.07	0.05	0.35	0.02
Offshore outsourcing	-0.27	-0.04	-0.07	-0.01	-0.13	-0.02
Home share in FC	-0.12	-0.02	-0.04	-0.01	-0.04	0
Home share in GFCF	-0.04	-0.01	-0.01	0	-0.02	0
				High skill		
Trade effects	0.11	-0.02	-0.03	0.03	0.13	0
Exports	0.5	0.08	0.05	0.06	0.3	0.01
Offshore outsourcing	-0.24	-0.06	-0.04	-0.01	-0.11	-0.01
Home share in FC	-0.1	-0.03	-0.02	-0.01	-0.04	0
Home share in GFCF	-0.05	-0.01	-0.01	0	-0.02	0
				Intermediate skill (higher)		
Trade effects	0.12	-0.01	-0.04	0.02	0.14	0
Exports	0.52	0.09	0.06	0.05	0.3	0.02
Offshore outsourcing	-0.25	-0.06	-0.06	-0.01	-0.1	-0.01
Home share in FC	-0.11	-0.03	-0.03	-0.01	-0.04	0
Home share in GFCF	-0.04	-0.01	-0.01	0	-0.01	0
				Intermediate skill (lower)		
Trade effects	0.15	0	-0.07	0.02	0.19	0
Exports	0.63	0.07	0.09	0.04	0.4	0.02
Offshore outsourcing	-0.3	-0.04	-0.1	-0.01	-0.14	-0.01
Home share in FC	-0.13	-0.02	-0.05	-0.01	-0.05	0
Home share in GFCF	-0.04	-0.01	-0.01	0	-0.02	0
				Low skill		
Trade effects	0.13	0	-0.06	0.01	0.19	-0.01
Exports	0.55	0.04	0.07	0.03	0.4	0.01
Offshore outsourcing	-0.28	-0.02	-0.07	-0.01	-0.15	-0.02
Home share in FC	-0.11	-0.01	-0.05	-0.01	-0.04	-0.01
Home share in GFCF	-0.03	-0.01	-0.01	0	-0.01	0
				Other skill		
Trade effects	0.04	0	-0.05	0.02	0.17	-0.1
Exports	0.47	0.02	0.06	0.05	0.32	0.03
Offshore outsourcing	-0.29	-0.01	-0.06	-0.02	-0.1	-0.11
Home share in FC	-0.11	0	-0.04	-0.01	-0.04	-0.01
Home share in GFCF	-0.03	0	-0.01	0	-0.01	0

Table 8: Breakdown of trade effects to employment change by skill and product. 2001-2008

3.3 Breakdown of technology effects by sub-period, skill and product

Average contribution (in % per year)	Total	Products in: Manufacturing high-tech	Manufacturing low-tech	Services non-tradable	Services tradable	Other
				Total		
Technology effects	-1.36	-0.18	-0.37	-0.29	-0.19	-0.33
Direct labour saving	-1.85	-0.23	-0.4	-0.22	-0.65	-0.36
IC effects	-0.01	0.01	-0.05	-0.21	0.22	0.02
GFCF effects	0.5	0.04	0.08	0.14	0.24	0
				High skill		
Technology effects	1.55	0.08	0.02	0.42	1.03	0
Direct labour saving	0.99	0.01	-0.03	0.61	0.4	-0.01
IC effects	-0.08	0.01	0	-0.28	0.18	0
GFCF effects	0.64	0.05	0.06	0.08	0.44	0
				Intermediate skill (higher)		
Technology effects	-0.4	-0.13	-0.06	-0.3	0.15	-0.05
Direct labour saving	-0.79	-0.19	-0.13	-0.1	-0.31	-0.07
IC effects	-0.08	0.01	-0.01	-0.29	0.2	0.01
GFCF effects	0.47	0.05	0.07	0.09	0.26	0.01
				Intermediate skill (lower)		
Technology effects	-1.59	-0.31	-0.46	-0.2	-0.57	-0.05
Direct labour saving	-2.33	-0.36	-0.52	-0.18	-1.2	-0.06
IC effects	0.15	0.01	-0.04	-0.2	0.38	0.01
GFCF effects	0.59	0.05	0.1	0.18	0.25	0.01
				Low skill		
Technology effects	-1.86	-0.26	-0.7	-0.42	-0.18	-0.3
Direct labour saving	-2.15	-0.31	-0.67	-0.37	-0.48	-0.32
IC effects	-0.16	0.01	-0.13	-0.16	0.11	0.01
GFCF effects	0.45	0.04	0.1	0.11	0.19	0
				Other skill		
Technology effects	-2.92	-0.01	-0.3	-0.58	-0.57	-1.46
Direct labour saving	-3.28	-0.02	-0.31	-0.62	-0.82	-1.51
IC effects	-0.01	0	-0.03	-0.14	0.11	0.06
GFCF effects	0.36	0.01	0.04	0.18	0.14	-0.01

Table 9: Breakdown of technology effects to employment change by skill and product. 1983-1989

Average contribution (in % per year)	**Total**	Products in: Manufacturing high-tech	Manufacturing low-tech	Services non-tradable	Services tradable	Other
				Total		
Technology effects	-1.28	-0.18	-0.28	-0.3	-0.28	-0.25
Direct labour saving	-1.26	-0.19	-0.32	0	-0.47	-0.28
IC effects	-0.01	0.01	0.04	-0.21	0.1	0.04
GFCF effects	-0.01	0	0	-0.1	0.08	0
				High skill		
Technology effects	2.09	-0.03	0.03	1.1	0.9	0.09
Direct labour saving	1.97	-0.04	-0.01	1.33	0.61	0.08
IC effects	-0.08	0	0.04	-0.2	0.07	0.01
GFCF effects	0.2	0.01	0	-0.03	0.22	0
				Intermediate skill (higher)		
Technology effects	-0.75	-0.15	-0.02	-0.47	-0.11	0.01
Direct labour saving	-0.68	-0.17	-0.06	-0.14	-0.31	0
IC effects	-0.12	0.01	0.04	-0.28	0.1	0.01
GFCF effects	0.05	0	0	-0.05	0.09	0
				Intermediate skill (lower)		
Technology effects	-0.92	-0.14	0	-0.35	-0.44	0.01
Direct labour saving	-0.97	-0.17	-0.06	-0.03	-0.7	0
IC effects	0.11	0.02	0.06	-0.17	0.2	0.01
GFCF effects	-0.07	0	0	-0.14	0.07	0
				Low skill		
Technology effects	-2.17	-0.4	-0.99	-0.5	-0.49	0.21
Direct labour saving	-1.9	-0.42	-1.05	-0.1	-0.52	0.19
IC effects	-0.24	0.02	0.05	-0.33	-0.01	0.03
GFCF effects	-0.03	0	0	-0.07	0.04	0
				Other skill		
Technology effects	-4.17	-0.05	-0.43	-0.64	-0.76	-2.29
Direct labour saving	-4.35	-0.05	-0.43	-0.51	-0.89	-2.48
IC effects	0.29	0	-0.01	0.03	0.08	0.18
GFCF effects	-0.11	0	0.01	-0.16	0.04	0.01

Table 10: Breakdown of technology effects to employment change by skill and product. 1990-1997

Average contribution (in % per year)	Total	Products in:				
		Manufacturing		Services		Other
		high-tech	low-tech	non-tradable	tradable	
				Total		
Technology effects	-0.53	-0.13	-0.18	-0.07	-0.05	-0.1
Direct labour saving	-0.89	-0.15	-0.23	-0.11	-0.3	-0.11
IC effects	-0.19	0.01	-0.01	-0.17	-0.02	0
GFCF effects	0.56	0.02	0.06	0.2	0.27	0.01
				High skill		
Technology effects	1.72	0.01	0.12	0.51	1.06	0.02
Direct labour saving	1.11	-0.03	0.08	0.51	0.54	0.02
IC effects	-0.05	0.03	0	-0.11	0.03	0
GFCF effects	0.66	0.02	0.04	0.11	0.49	0
				Intermediate skill (higher)		
Technology effects	0.03	-0.17	-0.02	0.12	0.07	0.04
Direct labour saving	-0.31	-0.21	-0.08	0.14	-0.2	0.04
IC effects	-0.15	0.02	-0.01	-0.16	0.01	-0.01
GFCF effects	0.48	0.02	0.06	0.13	0.27	0.01
				Intermediate skill (lower)		
Technology effects	-0.73	-0.19	-0.25	-0.07	-0.21	-0.02
Direct labour saving	-1.18	-0.21	-0.33	-0.18	-0.44	-0.03
IC effects	-0.18	0	-0.01	-0.15	-0.02	0
GFCF effects	0.62	0.02	0.08	0.27	0.25	0.01
				Low skill		
Technology effects	-0.88	-0.13	-0.29	-0.19	-0.23	-0.04
Direct labour saving	-1	-0.14	-0.33	-0.14	-0.35	-0.05
IC effects	-0.3	0	-0.02	-0.2	-0.08	0.01
GFCF effects	0.42	0.01	0.05	0.15	0.2	0
				Other skill		
Technology effects	-3.51	-0.04	-0.46	-1.01	-1.01	-0.98
Direct labour saving	-3.79	-0.05	-0.47	-1.16	-1.13	-0.98
IC effects	-0.36	0	-0.03	-0.24	-0.08	-0.01
GFCF effects	0.64	0	0.04	0.39	0.19	0.01

Table 11: Breakdown of technology effects to employment change by skill and product. 1998-2008

4 $n!$ possible breakdowns

Writing $N = \mathbf{TMR}FD^d$, there are 24 ways to compute the contribution of each element to changes in employment, more when we decompose changes in **R** and FD^d into subcomponents. Boxplot of these different decompositions are displayed on Figure 11. Each component's contribution may be several times as large as the total change in employment. But the methodological uncertainty on a contribution is small, each contribution can be clearly differentiated from the others.

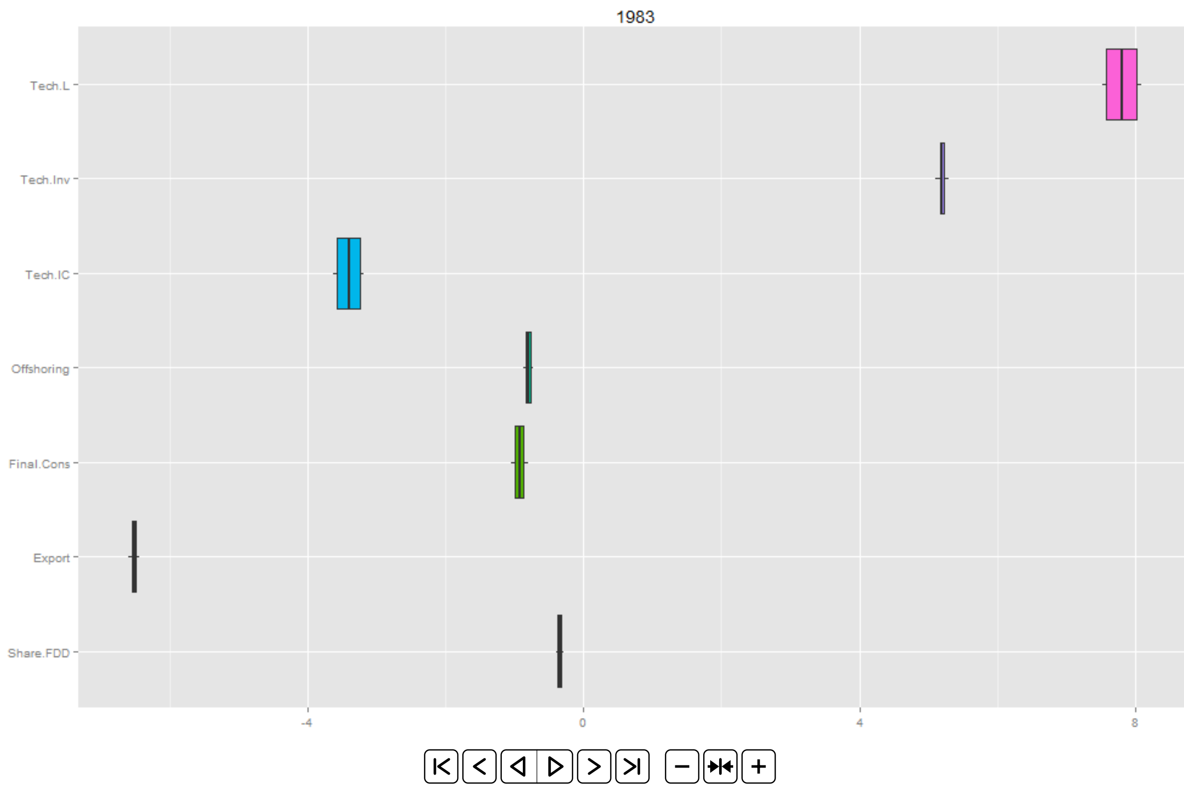


Figure 11: Box plot of changes in total employment contributions

Note: We represent for each year, each contribution to the total change in employment. For each contribution, a box (centered on the average value of the numerous decomposition possiblities used in the paper) represents the dispersion of the contribution. The larger is the box, the more its value depends on a particular choice of reference years for the decomposition. This representation shows that each year, each contribution can be well distinguished from the others.

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