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The impact of multinational R&D spending firms on job polarization and mobility

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Abstract

This report analyses the role of multinational R&D intensive firms in job polarization. It also investigates how these firms affect the labour market in terms of wage growth and labour mobility.

Firms appearing on the EU Industrial R&D Investment Scoreboard account for a significant share of economic activity in Denmark measured by employment, innovation activity, and R&D expenditures. Domestic firms listed on the scoreboard are the largest and most innovative, but subsidiaries of foreign scoreboard firms are still larger and more innovative compared to non-scoreboard firms.

Relying on information from register data the report demonstrates that R&D spending among scoreboard firms is a complement to high skill jobs, while it substitutes low skill jobs. Thus, scoreboard firms are more involved in upgrading than polarization. Organisational change has an effect similar to that of R&D, while there is indication that innovation is a complement for low skilled jobs. Labour flows, particularly of high skilled workers, are stronger among scoreboard firms than between scoreboard firms and other firms. Thus, labour flows in networks instead of appearing in labour market pools, and non-scoreboard firms are kept out of the "knowledge spill-over" loops, providing them with fewer opportunities to learn from the scoreboard firms.

Executive summary

A large share of R&D spending is limited to a relative small set of multinational firms, which tend to be among the largest employers in any given economy. Given their role as magnets for (high skilled) labour it is expected that these firms pay an important role in the pattern of polarization in the reorganisation of skills and jobs in the current European context. This report aims to provide new evidence on these major challenges facing Europe, and to formulate some recommendations for policy. The new evidence will come from statistical and econometric analyses on data from the firms retrieved from the EU Industrial R&D Investment Scoreboard (SB firms). This data is merged with registry data covering the entire Danish economy in terms of firms, workplaces and employed persons, and combined with survey data on private sector R&D and innovation. The registry and survey data are administered by Statistics Denmark (DST). The SB firms account for large shares of private sector R&D and innovation, and are world-leaders in these terms. Given their dominant position in the organisational landscape, it is important to understand their role in the reorganisation of skills and jobs within firms and on the labour market. These data will enable a detailed investigation of the impact of multinational R&D spending firms on the current trend of job polarization eroding jobs with middle skill level, and on mobility of employees and innovation in the current global economic context

The report documents that firms listed on the EU Industrial R&D Investment Scoreboard account for a significant share of economic activity in Denmark measured by employment, as well as a major share of innovation activity measure by the propensity to introduce new products and services, and measured by R&D expenditures. The average SB firm or subsidiary is quite different from the average non-SB firm, and within SB firms and subsidiaries there are large differences between the domestic SB firms and their subsidiaries in Denmark, and the subsidiaries in Denmark of foreign SB firms. Highlights from the descriptive analysis of SB firms and subsidiaries in Denmark include:

- SB firms and subsidiaries pay higher average wages across all occupational groups
- SB firms and subsidiaries account for a disproportionate share of employment around the Danish capital region but also in some peripheral regions.
- SB firms exhibit a home bias in the sense that they tend to locate R&D activities and subsidiaries in their home country. Therefore the domestic SB firms R&D activities differ from the foreign SB firms in Denmark
- SB firms are defined as firms with large scale R&D, and their R&D is shown to be high also in relative terms. They are also more innovative, especially regarding the introduction of new products and services.

The general trend in the Danish economy is towards polarization in jobs, where jobs that are middling in terms of skills and wages tend to disappear and High and Low jobs become more abundant. However, the detailed analyses in this report focus specifically on changes in the private sector from 2012 to 2013, which shows general upgrading of jobs, where Low jobs decline in share while High and to a lesser extent Middling jobs become relatively more abundant. This change is particularly strong among the firms that appear on the EU Industrial R&D Investment Scoreboard and their subsidiaries. These few hundred firms account for more than 10 percent of total private sector employment in Denmark and almost two thirds of private sector R&D in Denmark. The main results from the econometric analysis of the role of SB firms in job polarization can be summarized as:

- Depending on perspective, the change in job structure among SB firms can better be described as skill biased or general upgrading rather than polarizing since high wage/skill jobs are created at the expense of lower skill/wage jobs
- SB firms and their subsidiaries R&D expenditures complement High jobs while substituting Low jobs
- For domestic SB firms and their subsidiaries internationalisation (measured by imports and exports) also complement High while substituting Low.
- Innovation among SB firms and subsidiaries in the sense of introducing new products or services, applying new production methods or new marketing approaches have uncertain effects that further analyses must clarify. The results in the present report show no effect or that innovation is a source of inclusive development in that it complements Low jobs.
- Organisational changes within SB firms and subsidiaries have complicated effects on jobs depending on the dimension along which the organisational change is observed. In general, however, organisational changes are a source of general upgrading.

The descriptive statistics show that wages are higher in SB firms and subsidiaries and this is substantiated by the econometric analyses: wage growth is higher in these firms and workers moving to such firms will on average experience a significant increase in wage. In addition, the SB firms and subsidiaries to some degree form a sub labour market within the labour market in the sense that workers exhibit higher mobility within this group of firms than between this group and the rest of the labour market. Highlights from the econometric analysis of the employees at SB firms and subsidiaries include:

- High-skilled workers are more inclined to work for SB firms and subsidiaries, most likely because they also offer considerable better wages.
- (High-Skilled) Labour is inclined to move between SB firms and subsidiaries rather than between these firms and other firms in the economy. This indicates that instead of labour market pools, it is more useful to think more about labour flow networks.
- Non-SB firms are to a larger extent kept out of the "knowledge spill-over" loops, which provides them with fewer opportunities to learn from the SB firms.

1. Introduction

A large share of a R&D spending is limited to a relative small set of firms, which tend to be among the largest in any given economy. Given their role as magnets for (high skilled) labour it is expected that these firms pay an important role in the reorganisation of skills and jobs. However, there is shortage of evidence on how these firms impact in the current European context of relocation of production and distributed research and development (R&D). This report aims to provide new evidence on these major challenges facing Europe, and to formulate some recommendations for policy. The new evidence will come from statistical and econometric analyses on data from the firms that constitute the EU Industrial R&D Investment Scoreboard (SB firms) combined with registry data covering the entire Danish economy in terms of firms, workplaces and employed persons, and combined with survey data on private sector R&D and innovation. The registry and survey data are from Statistics Denmark (DST). The SB firms account for large shares of private sector R&D and innovation, and are world-leaders in these terms. Given their dominant position in the organisational landscape, it is important to understand their role in the reorganisation of skills and jobs. These data will enable a detailed investigation of the impact of multinational R&D spending firms on job polarization, mobility of employees and innovation in the current global economic context

The report has an emphasis on the role played by the SB firms in the Danish economy. SB firms are by definition R&D intensive firms and thus supposed to have a high impact on the economies of the home countries and other countries in which they have subsidiaries. In this report, we make a distinction between three groups of firms: domestic SB firms and their subsidiaries, foreign subsidiaries and non-SB firms.

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1.1 Research questions

The report documents that the firms appearing on the EU Industrial R&D Investment Scoreboard account for a significant share of economic activity in Denmark measured by employment, as well as a major share of innovation activity measure by the propensity to introduce new products and services, and measured by R&D expenditures. The average SB firm or subsidiary is quite different from the average non-SB firm, and within SB firms and subsidiaries there are large differences between the domestic SB firms and their subsidiaries in Denmark, and the subsidiaries in Denmark of foreign SB firms. The difference between subsidiaries in Denmark of domestic and foreign SB firms demonstrates a considerable home bias as domestic SB firms focus their activities disproportionately in Denmark. Thus, a relatively small number of large and innovative firms seem to play a dominating role on the evolution of the Danish economy. Additionally, there is unambiguous evidence of urbanisation and job polarisation trends in Denmark in recent years. These trends are continuations of longer trends and they are intertwined with technological change and globalisation (Keller and Utar, 2016; OECD, 2017), deindustrialisation (Bernard et al., 2016) and the pattern of labour market flows (Eurofound, 2017). But despite that these SB firms

[1] The focus on Denmark entails that all monetary values are converted to Euros using the exchange rate of 7.46 DKK/Euro, which is the central peg in the Exchange Rate Mechanism.

are large employers, with an ability to attract high-skilled labour; the role of SB firms in these trends is unknown. This report focusses on two general research questions:

1. What is the role of SB firms and their subsidiaries in the recent job polarization trend observed in the Danish economy?
2. How do SB firms and subsidiaries affect the Danish labour market in terms of wage growth and labour mobility?

SB firms and their subsidiaries are different from non-SB firms in various ways that ideally should be accounted for when analysing the data. Some differences are observable to researchers while others are not. The observed variables include the frequency of innovation, the level of R&D expenditures, the degree to which the firm is part of a global value chain etc. The effects of these observed factors can be analysed directly, unlike unobserved differences. However, it is also expected that there are such unobserved differences between SB firms and their subsidiaries, and other firms; i.e. difference that the data cannot account for. In such cases, it is necessary to rely on simply distinguishing SB firms and subsidiaries from other firms as proxy for these differences. Similarly, it is expected that there are both observed and unobserved differences between domestic SB firms and their subsidiaries compared to subsidiaries of foreign SB firms. Such differences can be driven by the above mentioned home bias whereby domestic SB firms locate activities in separate firms, which are nonetheless spatially close to the parent firm.

Firms' workforce composition and factors leading to change therein will be analysed econometrically when studying job polarisation. This is elaborated below. When studying SB firms and subsidiaries' effect on the Danish labour market it is necessary to study labour market dynamics among employees of SB firms and subsidiaries relative to employees at other firms. In order for such an analysis to be robust these groups need to be matched. This methodology is explained shortly in connection with the presentation of the analyses in Section 5.5.

The present report is structured as follows. Section 2 describes the relevant overall trends in the Danish economy, while the SB firms and subsidiaries in Denmark are presented in greater detail in Section 3. Section 4 is a descriptive analysis of employment and R&D across Denmark while section 5 presents the econometric analysis of the above research questions. Section 6 concludes the report and sums up.

2 Macro trends in Denmark

As many other developed countries, the Danish economy exhibits trends towards deindustrialisation, urbanisation around the larger university cities and job polarization where middle wage jobs disappear while low and high wage jobs become more abundant. These trends are closely linked: manufacturing tends to locate outside cities and provide middle-wage jobs. The deindustrialisation and job polarization trends for Denmark are recently documented using employer and employee level registry data by Keller and Utar (2016) and Bernard et al. (2016).

2.1 Job polarization

The job polarization literature generally groups jobs into three categories: Low, Middling and High wage/skill jobs, and polarization is then the trend that the share of Middling jobs is decreasing while the shares of Low and High-wage jobs are increasing. Goos et al. (2014) is a recent example of this literature documenting the pervasiveness of job polarization across European countries, including Denmark.

According to Goos and colleagues the share of Middling jobs in Denmark dropped by 10.3 percentage points from 1993 to 2010, while the shares of Low and High jobs increased by 1.73 and 8.56 percentage points respectively.

However, Fernández-Macías (2012) demonstrates that the polarization pattern is sensitive to the grouping of jobs into the three categories. Fernández-Macías (2012) concludes that, among EU15 countries, the polarization trend is limited to West/Continental countries while the opposite trend is observed among Mediterranean countries and the trend in Northern countries, including Denmark, can best be described as general upgrading, where no job categories decline in absolute terms, but High wage jobs grow in relative terms.[2]

Table 1 – Classification of occupations

First digit of ISCO-08	ISCO-08 label	Group	Median hourly wage
1	Managers	High	41.96
2	Professionals	High	31.90
3	Technicians and Associate Professionals	High	29.62
4	Clerical Support Workers	Middling	25.07
5	Services and Sales Workers	Low	22.25
7	Craft and Related Trades Workers	Middling	26.94
8	Plant and Machine Operators and Assemblers	Middling	26.54
9	Elementary Occupations	Low	22.39

Source: Based on table 1 of Goos et al. (2014) combined with own calculations.
Note: Median wages in Euro/hour computed for the entire Danish labour market in 2010 from DST's registry data.

This report will focus on polarization along the lines of the general job polarization literature, here exemplified by Goos et al. (2014). The same categorisation of jobs is applied making the analysis comparable to earlier studies. This entails using the categorization illustrated in Table 1 mapping jobs into High, Middling and Low from the first digit of the jobs' International Standard Classification of Occupations (ISCO-08) code from the International Labor Association.

Skilled agricultural, forestry and fishery workers (ISCO-08: 6) along with armed forces (ISCO-08: 0) are excluded from the analysis because few private sector jobs are classified in these occupational groups. The categorization of occupations in Goos et al. (2014) based solely on a ranking of occupations by median wage at the two-digit ISCO level, but the resulting delimitations of the groups follow the one-digit level. To assess the validity of the ranking it is ascertained that it applies to our data, cf. Table 1.[3] As mentioned, Fernández-Macías (2012) demonstrated the sensitivity of the

[2] The UK and Ireland are partially showing upgrading and partially showing polarization.
[3] An individual's wage in the registry data is the average hourly compensation before taxes including any extra supplement, bonuses etc.

conclusions to applying the pattern of Table 1; a concern that is augmented by the fact that wages are generally higher in SB firms compared to non-SB firms. Therefore, Table 2 shows the median wage for 24 occupational groups: the eight groups included in the categorisation in Table 1, sub-divided into domestic SB, foreign SB and non-SB private sector firms.

Table 2 - Wage hierarchy

Occupation	SB Type	Median hourly wage	Group
1. Managers	Domestic	56.57	
1. Managers	Foreign	52.95	
2. Professionals	Foreign	42.63	
2. Professionals	Domestic	41.02	
1. Managers		40.62	
3. Technicians and Associate Professionals	Foreign	35.92	
3. Technicians and Associate Professionals	Domestic	32.04	
2. Professionals		31.37	
7. Craft and Related Trades Workers	Foreign	30.29	
7. Craft and Related Trades Workers	Domestic	30.16	
3. Technicians and Associate Professionals		29.09	High
8. Plant and Machine Operators and Assemblers	Domestic	28.15	Middling
4. Clerical Support Workers	Domestic	27.61	
7. Craft and Related Trades Workers		26.68	
8. Plant and Machine Operators and Assemblers		26.54	
9. Elementary Occupations	Domestic	26.41	
8. Plant and Machine Operators and Assemblers	Foreign	26.27	
9. Elementary Occupations	Foreign	25.87	
5. Services and Sales Workers	Foreign	25.74	
5. Services and Sales Workers	Domestic	25.74	
4. Clerical Support Workers		24.93	
4. Clerical Support Workers	Foreign	24.66	Middling
5. Services and Sales Workers		22.12	Low
9. Elementary Occupations		22.12	

Source: DST's registry data.
Note: Median wages in 2010 Euro/hour. Blank for SB Type means non-SB private sector

Table 2 shows that median wage is highest for managers at domestic SB firms and their subsidiaries. A potential explanation that these wages are higher compared to foreign SB subsidiaries might be the result of a "home bias" and subsequent

headquarter dominance in the upper echelon of the organization's work force. Applying the threshold between High and Middling jobs implied by Table 1 at around 28-29 euro/hour means that craft related occupations at SB subsidiaries (both domestic and foreign) could be included among High jobs. Craft related occupations at SB subsidiaries have a wage that is comparable to the wage of technicians in non-SB firms, which could - arguably - even be placed in the group of Middling occupations with a median wage of only 29 euro/hour. Furthermore, applying the threshold between Middling and Low jobs at around 23-24 euro/hour (as implied by Table 1) entails that only non-SB jobs in service, sales and elementary occupations should be considered Low jobs. However, in order to make the analysis comparable to other studies, this study relies on the categorisation presented in Table 1.

Figure 1 illustrates the trend for job polarization in Denmark. A clear shift from Middling to Low occupations can be observed with only a minor increase in the share of High occupations in the years leading up to 2013, and even a slight decline from 2012 to 2013 in the share of High. In fact, only one of the three occupational groups classified as High (cf. Table 1) actually increases over the period, namely ISCO-08: 2, Professionals (not shown).

Figure 1 – Job polarization. Share of total employment by occupation

Source: DST's registry data.

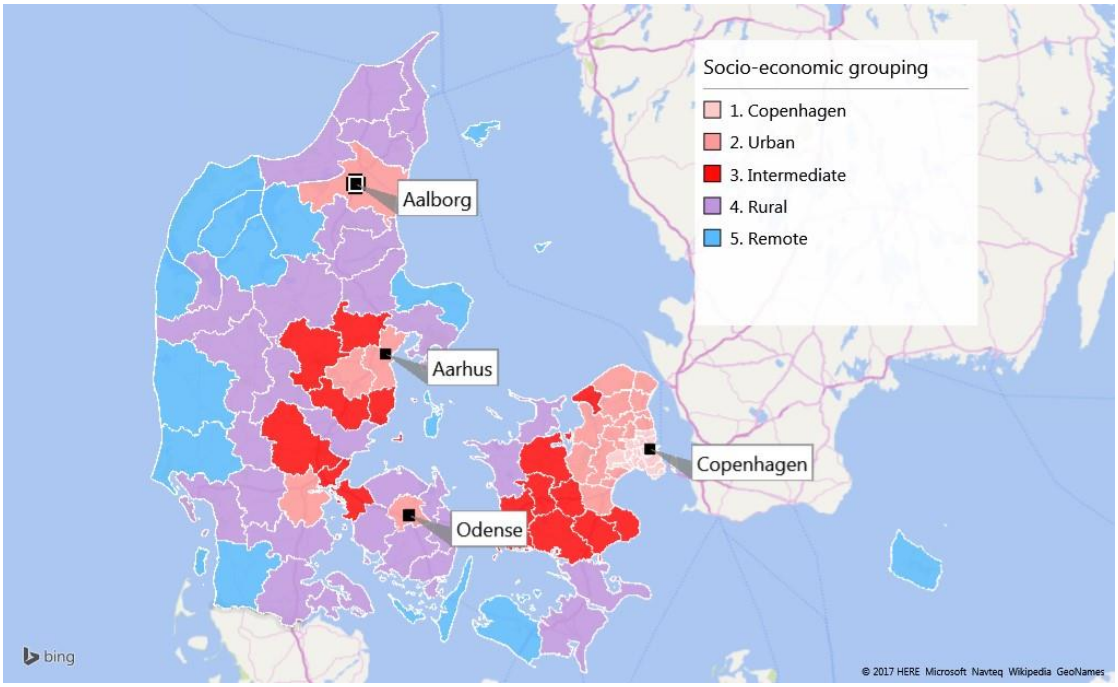
2.2 Urbanisation

Economic activity in Denmark is centred around the four largest Danish cities Aalborg, Odense, Aarhus and Copenhagen or, in terms that are more general: along the eastern coast of the mainland (Jutland) and around Copenhagen, see Figure 2. The figure groups the municipalities of Denmark into four socio-economic groups and Copenhagen. The grouping is taken from the review of Nordic regional definitions given in Damsgaard (2010) and is based on 14 indicators describing the local labour market, infrastructure, income, and demographics.[4] Each urban municipality has a

[4] See p. 4 of Damsgaard (2010) for details.

central urban zone, but Copenhagen presents a special case by being one large urban zone spanning many municipalities. To account for this, Copenhagen is treated separately and it is defined as the NUTS 3 regions 11 and 12 (see below for details on NUTS 3).

Figure 2 - Socio-economic grouping of regions in Denmark



Source: Classification from Damsgaard (2010).

The socio-economic grouping of Figure 2 summarises the economic topography of Denmark giving a general picture of the spatial distribution of economic activity. However, a more internationally recognisable classification is the NUTS 3 classification, which will be used when describing the spatial distribution of SB firms' activities in Denmark. The 11 NUTS 3 regions of Denmark are illustrated in Figure 3, and when comparing to Figure 2 it can be seen which are the economic centres.

Figure 3 - NUTS 3 regions in Denmark

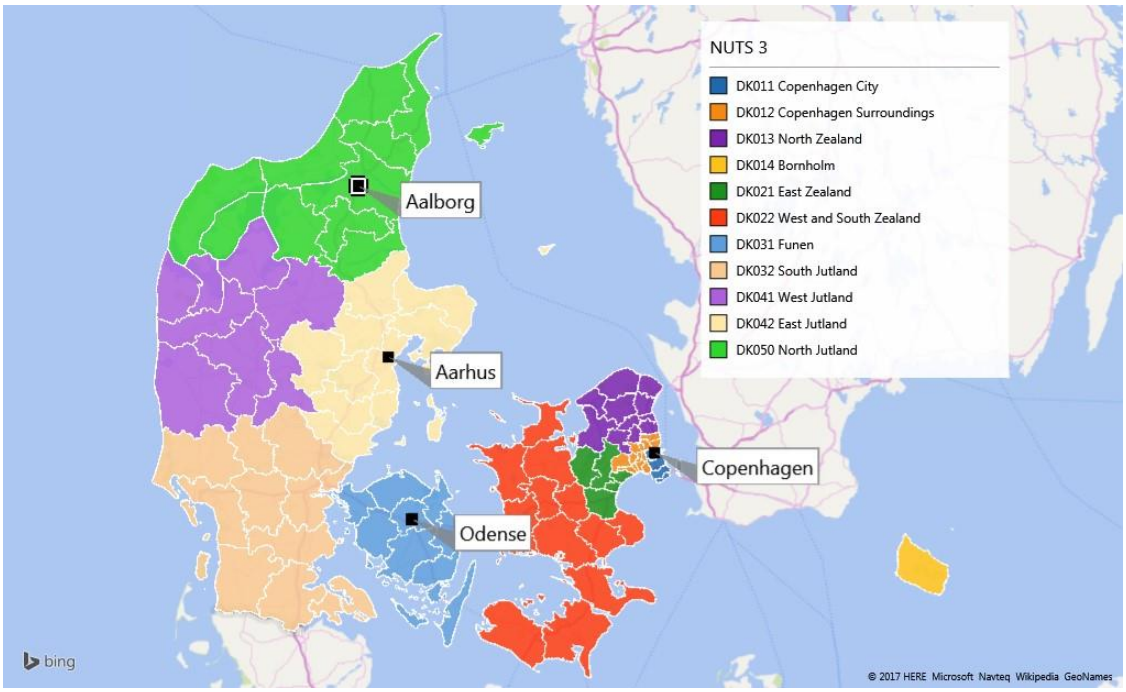


Table 3 shows the geographic distribution of subsidiaries compared to other private firms in the economy in terms of full-time equivalent (FTE) employment.

Table 3 - Regional characteristics

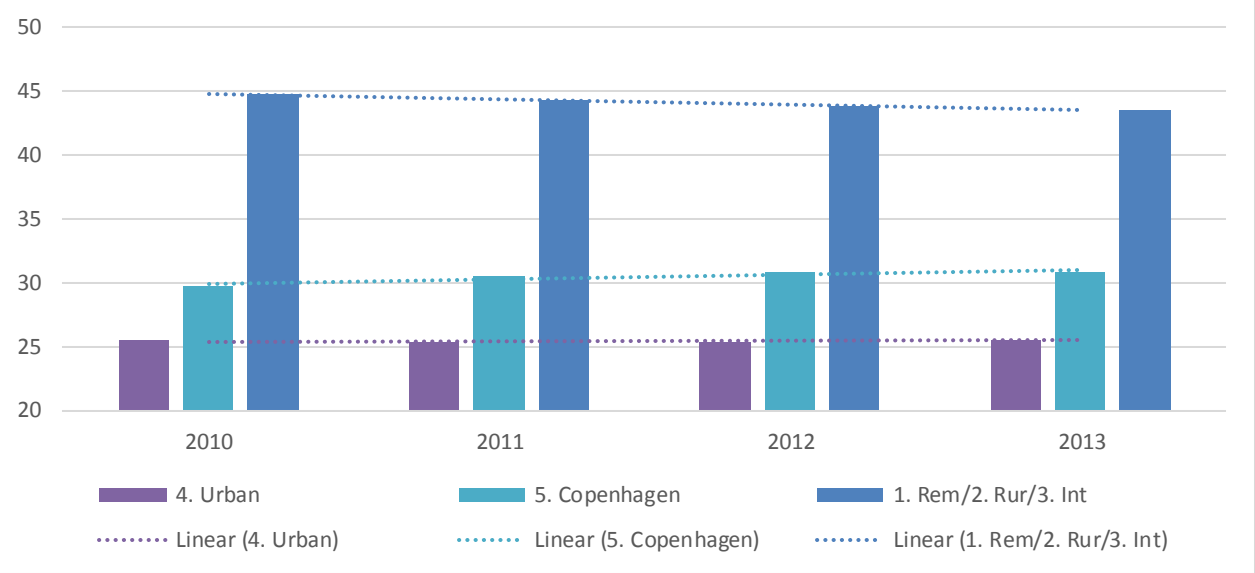
NUTS 3	Subsidiaries of foreign SB firms	Domestic SB firms and their subsidiaries	Other private firms in Denmark
DK011 Copenhagen City	18.15	11.15	16.32
DK012 Copenhagen surroundings	24.49	30.08	12.26
DK013 North Zealand	6.08	8.53	5.97
DK014 Bornholm	0.12	0.08	0.55
DK021 East Zealand	2.57	0.54	3.64
DK022 West and South Zealand	5.01	5.75	7.22
DK031 Funen	4.33	2.61	7.55
DK032 South Jutland	11.80	14.85	13.45
DK041 West Jutland	7.13	12.41	7.88
DK042 East Jutland	11.75	9.58	15.21
DK050 North Jutland	8.57	4.43	9.95
Socio-economic region group			
1. Copenhagen	42.65	41.22	28.57
2. Urban	27.38	21.58	26.57
3. Intermediate	10.1	5.3	12.43
4. Rural	17.28	26.16	24.97
5. Remote	2.58	5.73	7.46

Source: Computed from DST's registries and SB data.

Not surprisingly, a high share of these subsidiaries is located in and around the main economic centre of Denmark, Copenhagen. There also appears to be an overrepresentation of SB subsidiaries in the area north of Copenhagen and sizeable representations of domestic SB subsidiaries in the west and south of Jutland, which are otherwise considered relatively marginal regions, cf. Figure 2. The second panel of Table 3 divides regions in urban, intermediate, rural and remote areas. An interesting observation is again the relative strong presence of domestic SB subsidiaries in rural areas.

Figure 4 shows the urbanization trend in Denmark. Remote, rural and intermediate regions all share a common slightly declining trend and have therefore been grouped together. Despite the declining trend, they still account for more than 40 percent of employment in Denmark. The employment growth trend in urban regions is flat while the share of jobs in the Copenhagen region is increasing.

Figure 4 - Urbanisation. Share of total employment by municipality type



Source: Computed from DST's registry data.

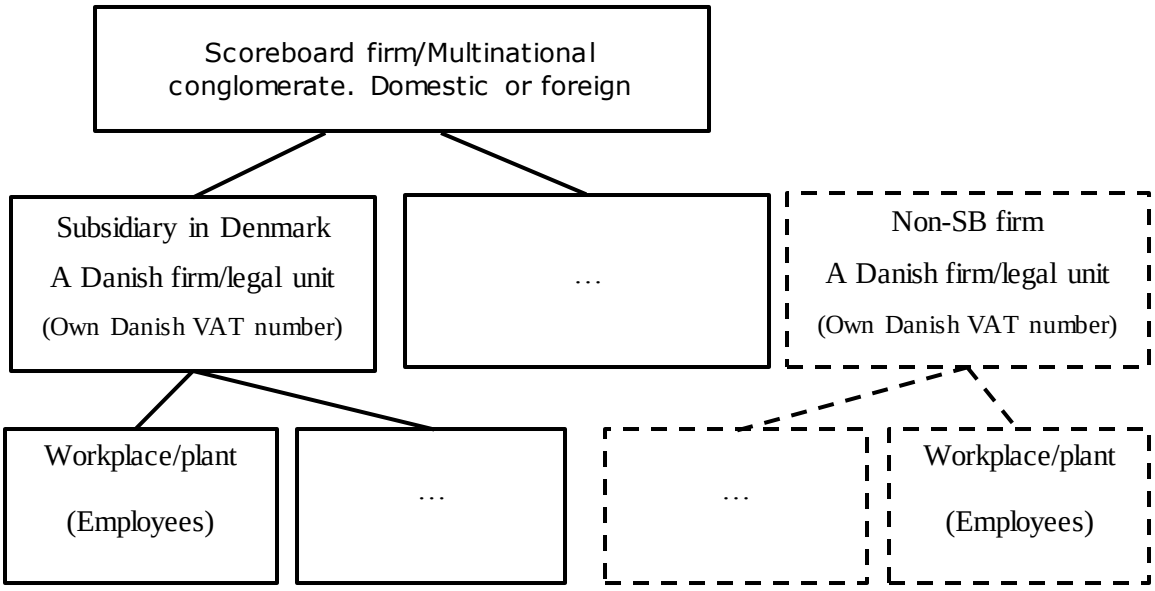
3 The scoreboard firms

The report is studying skills, innovation and reorganization of labour based on Danish data with a specific emphasis on the role played by firms that are part of the EU Industrial R&D Investment Scoreboard. Hence, the data are a combination of data on the SB firms, registry data covering the entire Danish economy in terms of firms, workplaces and workers, and survey data on firms' R&D and innovation related activities. This means that the analysis will be between three different levels as illustrated in Figure 5.

The highest aggregate level is the level of SB firms. The SB firms are identified through the EU Industrial R&D Investment Scoreboard data. Information on the subsidiaries of these top R&D spenders was obtained directly from Bureau Van Dijk, using the corporate structure of the SB firms at the end of 2015. This data connects each SB firm to a number of Danish subsidiaries (i.e. VAT numbers) some of which

exist only one year, have no employees and no economic activity, while others exist for longer timespans and have actual economic activity. Only the latter will appear in our registry data.

Figure 5 - The levels in the data



With the SB data, it is possible to link domestic and foreign SB firms to subsidiaries in Denmark so that the term "SB firm" refers to the conglomerate. The average SB firm/conglomerate consists of three subsidiary firms in Denmark. The domestic SB firms generally have more subsidiaries in Denmark than foreign firms do. However, subsidiaries of domestic SB firms include the SB firms themselves; i.e. the parent firm. This and several other empirical discrepancies between foreign and domestic SB firms entail that we will distinguish between these two groups.

In principle, there are three types of SB firm subsidiaries but the data do not distinguish explicitly between them:

1) The domestic SB firms and their subsidiaries, such as the largest R&D spender in Denmark the pharmaceutical company Novo Nordisk.

2) Firms acquired by a SB firm with either a competence-exploiting motive or a competence-creating motive. These are firms in Denmark that have been acquired by foreign or domestic SB firms for e.g. access to the intellectual property, such as the large Danish ingredients firm Danisco that was acquired by DuPont for 5.4 billion euro in 2011.

3) Greenfield SB subsidiaries. These include competence exploiting subsidiaries set up by foreign SB firms for access to the Danish or EU markets, such as the Norwegian oil and gas company Statoil; competence creating subsidiaries set up in order to have R&D activities present in Denmark, such as Intel.

The third level in the data consists of workplaces. While "SB firms" are conglomerates and "subsidiary firms" are single legal units a "workplace" is the workplace in a

geographical location to which employees are associated.[5] Each subsidiary firm consists of on average 4-5 workplaces with average FTE employment of roughly 50 or 100 for workplaces under foreign subsidiaries and domestic SB firms and their subsidiaries respectively, making them much larger than the average workplace in the remaining private sector, cf. Table 7 below. Workplaces under SB firms and subsidiaries are larger and have almost as high labour turnover as non-SB workplaces (cf. later) suggesting that they can have a substantial impact on mobility and wage determination in the labour market.

The SB ranks the world's top 2,500 firms by R&D spending each year, but does not provide information to what extent the corporate structures of SB firms changes. Consequently, there lacks information on changes in the subsidiary structure of SB firms. The set of Danish SB subsidiaries appears to be rather stable over the time-period studied and we assume that the same is true for subsidiaries of foreign SB firms that have employees.[6] Given the relative stability, it is assumed that by following the set of subsidiaries identified in late 2015, the report analyses a representative sample of SB firms and their subsidiaries in Denmark. However, this assumption loses reliability when expanding the period of study. This issue is amplified by a break in the database prior to 2011. The latest available registry data for this report are for 2013 and, in order to avoid problems with data breaks and to maximize the amount of available data, the analyses therefore focus on changes from 2012 to 2013, unless otherwise stated.

The 2,500 scoreboard firms are multinational companies and it is difficult to assess their impact in a specific country. Table 4 shows an excerpt of the Danish firms in the scoreboard. The full scoreboard is freely accessible at the webpage of the JRC-B3-IRITEC (http://iri.jrc.ec.europa.eu/home).

These 25 Danish SB firms are large in terms of R&D spending, sales, and employment. However, these are worldwide figures and the scoreboard reveals nothing of their impact on the Danish economy, or of the impact of foreign (non-Danish) scoreboard firms on the Danish economy. As can be observed in Table 4, most Danish SB firms grew in R&D spending, sales and employment from 2012 to 2013. But there is no guarantee that any of this expansion was actually taking place in Denmark as most of the Danish firms are also multinational organizations.

The list of 25 Danish scoreboard firms reveals that most firms are active in the pharmaceutical industry or biotech, which is a traditional Danish stronghold. Novo Nordisk is the largest R&D spender with an R&D expenditure of 1,567 million euro, placing it in the Top 10 of the European SB firms. The list shows that Novo Nordisk has a higher R&D spending than the next ten R&D spenders combined. Other Danish stronghold companies are those that produce products related to greening of the economy, such as Vestas, Danfoss, Grundfos, and Rockwool International. Denmark also hosts two of the seven EU top 1,000 scoreboard firms in leisure goods, the toy company LEGO and the high-end consumer electronics firm Bang & Olufsen.

[5] It is possible to work for a firm without being assigned to a specific workplace but this is not common in our data.
[6] Higher levels of volatility of SB ownership are observed among subsidiaries with zero or very few employees.

Table 4 - Danish scoreboard firms.

Name	Industrial sector	R&D	R&D growth (%)	Sales	Sales growth (%)	Employees	Employee growth (%)
ALK-Abelló	Pharmaceuticals & Biotechnology	52.2	48.9	301	-4.3	1,763	-5
Arla Foods	Food Producers	65.9	57.7	9,860	16.6	19,577	8.1
Auriga Industries	Chemicals	45.3	1.2	884	5.4	2,204	2.6
Bang & Olufsen	Leisure Goods	52.3	-18	384	1.8	2,192	4.9
Bavarian Nordic	Pharmaceuticals & Biotechnology	65.6	36	162	19.3	426	-5.3
Chr. Hansen	Pharmaceuticals & Biotechnology	45	-3.4	738	5.7	2,510	3.5
Coloplast	Health Care Equipment & Services	50.8	21.1	1,559	5.6	8,412	6.8
Danfoss	Industrial Engineering	185.3	4.5	4,505	-1.1	22,463	-2.7
Danske Bank	Banks	281.1	-11.3	5,663	-14.3	19,122	-5.8
Dong Energy	Gas, Water & Multi-utilities	15.9	80.3	9,672	9.5	6,692	-0.6
DSV	Industrial Transportation	24	35.6	6,124	1.8	22,021	0.4
FLSmidth	Industrial Engineering	56.1	20.7	3,607	8.3	15,317	-3.7
GN Store Nord	Technology Hardware & Equipment	81.9	10.9	910	8.6	5,050	6.3
Grundfos	Industrial Engineering	138.4	-18.9	761	-2.5	2,790	0.5
H. Lundbeck	Pharmaceuticals & Biotechnology	210.1	-38	2044	3.1	5,518	-0.4
KMD	Software & Computer Services	16.8	-6.6	626	-0.6	3,199	-4.3
Lego	Leisure Goods	72.2	38.2	3,400	8.4	11,755	13
NKT	Electronic & Electrical Equipment	41.1	1.3	2,118	3.6	8,899	0.4
Novo Nordisk	Pharmaceuticals & Biotechnology	1,567.4	12.1	11,196	7.1	37,978	10.8
Novozymes	Pharmaceuticals & Biotechnology	185.1	-4.4	1,574	4.6	6,162	3.6
Rockwool International	Construction & Materials	29.7	-1.8	1,997	1.6	10,066	7
Simcorp	Software & Computer Services	48.2	10	225	7.6	1,093	1.7
TDC	Fixed Line Telecommunications	23.4	29.6	3,296	-5.8	9,007	-3.6
Vestas Wind Systems	Alternative Energy	241	9	6,084	-15.7	15,497	-12.8
William Demant	Health Care Equipment & Services	84.3	2.6	1,234	7.6	9,120	13.6

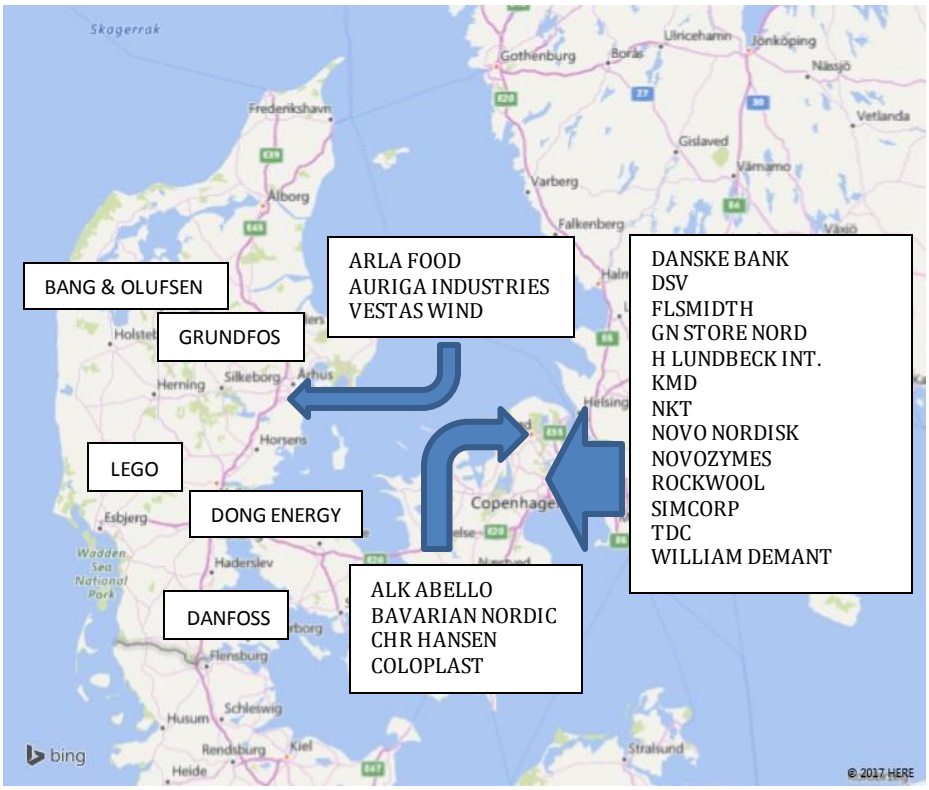
Source: EU Industrial R&D Investment Scoreboard.
Note: 2013 data. R&D and Sales in millions of euro. Growth in percentage since 2012.

Unfortunately, the list provides no information about SB firms R&D spending within the domestic economy, while Danish SB firms generally do spend R&D domestically and there is evidence that some foreign SB firms have extensive R&D spending in Denmark. For example DuPont's R&D spending in ingredients through Danisco, the spending by the large subsidiary of Microsoft with 550 employees in Copenhagen or the many R&D active subsidiaries of foreign SB firms active in alternative energy (e.g. Siemens Wind Power). But for the vast majority of foreign SB firms it is not that clear how much they spend on R&D in Denmark.

The aim is to describe and analyse the impact of SB firms on the Danish economy by identifying the firms in Denmark that belong to a SB firm, and focus on their combined impact. The data builds on a list of firms by their VAT number in Denmark that belong to an SB firm. There are 1,195 firms in Denmark on this list, of which 250 are associated with the Danish SB firms in Table 4 and the remaining firms are associated with foreign SB firms. DST does not allow researchers to report results based on their register data where it is possible to distinguish specific firms. Therefore, it is necessary to be particularly careful since each of the above SB firms is very significant in the Danish economy and would be readily recognizable from its size, industrial sector and/or region.

Figure 6 maps the domestic SB firms' headquarters as listed in the Central Business Register.[7] About half are located in the NUTS 3 regions of West-, East and South Jutland and North Zealand while the other half are located close to Copenhagen.

Figure 6 - Location of Danish SB firms



Source: The Central Business Register.

[7] www.cvr.dk. Accessed April 19, 2017.

The SB firms are concentrated around Copenhagen, but their subsidiaries are more spread out across Denmark, especially when we focus not only on the firm but go down one level of aggregation and focus on the geographical location of the firm's individual workplaces.

3.1 Merging the scoreboard firms with Statistics Denmark's registries

The original data on SB firms can be linked to 1,195 firms in Denmark. These firms are linked to 483 SB parent firms/conglomerates from the SB ranking. Of the 1,195 subsidiary firms, 769 can be identified in the registry data. The 426 missing firms are suspected to be mainly holding firms without employees and potentially even without economic activity. As will be seen below, the 769 firms identified in the registry data account for a significant share of economic activity in Denmark. In addition to the registry data, the sample of firms is also merged to the yearly Danish Research, Development and Innovation (FUI) surveys. The number of firms additionally identified in the survey is 315. The information on the number of firms identified for use in the analyses is reported in Table 5.

Table 5 - Observations

	SB firms/ Conglomerates	Danish firms/ Subsidiaries
SB firms with subsidiaries in Denmark	483	1,195
… of which can be found in the registry data	445	769
… of which are in the Innovation Survey (FUI)	219	315

Source: SB data, DST's registry data and DST's FUI survey

The FUI surveys have a comprehensive coverage but from manual inspection of the merged data it nevertheless seems that several of the 25 Danish SB firms in Table 4 are not covered by the survey. Observing the distribution of the highest R&D spenders in the merged data by region and industry also leads to the suspicion that more than half of the top 20 R&D spenders in Denmark are not SB firms, although they may be subsidiaries of SB firms. Furthermore, it appears that as many as 10 of the SB firms in Table 4 do not appear to be among the high R&D spenders in the FUI surveys meaning that they must necessarily have subsidiaries with high R&D spending. These apparent contradictions are explained by the FUI survey focussing on single legal units (firms) while the SB ranking takes into account all R&D spending across the conglomerate. This is not a problem for our analysis since it reflects that SB firms have complex corporate structures where activities such as logistics or R&D are undertaken by what are legally separate firms, while the parent firm only has a handful of employees. The implication for the analyses presented in this report is that, even if the 25 Danish SB firms could be positively identified in the registry data, it would not impact the analyses if they were excluded. In other words: results are robust to excluding the SB firms themselves.

3.2 The scoreboard subsidiaries compared to other firms

In this section, the subsidiaries of SB firms are compared to other private firms in Denmark. In Table 6, the comparison is based on the industry in which they are active. Clearly, SB firms' subsidiaries are over-represented in manufacturing industries, but foreign SB firms' subsidiaries clearly lead in wholesale activities indicating that foreign SB firms mainly have a competence exploiting or market-seeking motive.

Table 6 - Industry distribution

Industry	Subsidiaries of foreign SB firms	Domestic SB firms and their subsidiaries	Other private firms in Denmark
Agriculture, forestry and fishing	0.21	0	2.6
Manufacturing, mining and quarrying and other industry	32.09	57.75	16.82
Construction	0.88	0.36	8.61
Wholesale and retail trade, transportation and storage, accommodation and food service activities	49.8	5.71	34.25
Information and communication	9.28	13.3	4.86
Financial and insurance activities	2.04	13.9	4.95
Real estate activities	0.35	0	1.39
Professional, scientific, technical, administration and support service activities	5.16	8.65	11.92
Public administration, defence, education, human health and social work activities	0.13	0.26	12.13
Other services	0.07	0	2.39
Unknown activity	0	0	0.08
Total	100	100	100

Source: DST's registries.
Note: Percentage of FTE employment in each industry in 2013

Table 7 compares the number of firms to the number of workplaces in each column and illustrates that the average foreign SB subsidiary has slightly less than three workplaces, while the average domestic SB subsidiary has about eight workplaces and the average in the remaining private sector is close to one workplace per firm. Table 7 also demonstrates that SB subsidiaries have larger workplaces measured by employment size, i.e. foreign SB subsidiaries have on average 47 full time equivalent (FTE) while this number is 106 for domestic SB subsidiaries. SB workplaces are considerably larger compared to other private sector workplaces that have on average 8 FTEs. The total employment of SB subsidiaries in Denmark is about 80,000 FTE for both foreign and domestic firms meaning that they make up roughly 12 percent of private sector employment in total.

Table 7 - Size

		Subsidiaries of foreign SB firms	Domestic SB firms and their subsidiaries	Other private firms in Denmark
Firms		673	96	128,957
Workplaces		1723	783	149,805
FTE Employees per workplace	Mean	47.2	106.2	7.9
	Median	13.3	13.5	2.4
	Sum	81,310	83,148	1,181,305

Source: DST's registries.

Table 8 shows the innovation activities of subsidiaries of SB firms compared to non-SB firms in Denmark where innovation is defined as the introduction of a new product or service. Using this measure, SB subsidiaries are more innovative than other firms, but domestic subsidiaries are more innovative than foreign subsidiaries. A potential reason might be the overrepresentation of wholesale activities among foreign subsidiaries (see Table 6). 24% of other private firms (non-SB firms) are innovative while 39% and 61% of foreign and domestic subsidiary firms are innovative respectively. When instead studying differences in other forms of innovation the differences between the three groups are smaller but the ranking is the same: Domestic SB firms and their subsidiaries are the most innovative while non-SB firms are the least innovative. The reason why the difference is strongest when looking at product innovation is related to the type of activities that the various firms undertake in Denmark, and in as much as innovation is a linear process resulting primarily in new products, the differences are consistent with the observed differences in R&D spending.

By aggregating the R&D expenditures of the subsidiaries and comparing the result to the total international R&D expenditures of the SB firm as reported in the SB data, it is possible to calculate the share of total R&D located in Denmark. The R&D expenditures by foreign SB subsidiaries amounts to 0.5% of the total international SB firm R&D expenditures for foreign SB firms, while the corresponding value for domestic SB subsidiaries is 66%. This highlights that domestic subsidiaries include parent firms and that MNEs often have most of their R&D expenditures in their home country. However, it must be kept in mind that foreign subsidiaries still spend much more than other private sector firms on R&D in Denmark.

Table 8 – R&D and Innovation activities

		Subsidiaries of foreign SB firms	Domestic SB firms and their subsidiaries	Other private firms in Denmark
New product and/or service		38.82%	61.29%	24.49%
New process		30.20%	50.00%	25.14%
New Market		41.18%	54.84%	31.09%
New organisation		45.88%	64.52%	35.50%
R&D expenditures	Mean	2.30	35.98	0.39
	P25	0	0	0
	Median	0	2.25	0
	P75	0.54	28.97	0
	Sum	586.53	2230.60	1736.76
	per FTE	7.96	27.91	3.29
	per Sales	5.82	9.33	0.13
Av. Share of SB firm total international R&D expenditure		0.53%	65.74%	-

Source: SB data, DST's FUI survey and DST's registries.
Note: R&D expenditures in millions of euro in 2013. 'per FTE' is millions per FTE and 'per Sales' is euros of R&D expenditures per millions of euros in sales.

The differences between the foreign SB subsidiaries and domestic SB firms and their subsidiaries cannot be attributed to the latter group including the 25 Danish SB firms themselves, as a large share of the SB firms appear very small in the registry data and are not covered by the FUI survey, cf. earlier. Instead, it indicates a corporate structure among SB firms where activities in the home country are separated into a number of distinct and legally independent firms, e.g. a large domestic SB firms may have a separate R&D subsidiary and not just a R&D department.

Table 9 presents the distribution of the different occupation and education levels. Based on the distribution of occupation codes, it can be observed that domestic subsidiaries employ a larger share of professionals and associated professionals, while foreign SB subsidiaries recruit a relative high share of clerical support workers. The differences in innovation activities (see Table 8) and the differences in the distribution of occupations in Table 9 might reflect the difference in economic activities between domestic and foreign SB subsidiaries; in particular, it may reflect the fact that a relatively large share of foreign SB subsidiaries is represented by wholesalers. SB subsidiaries tend to hire more highly educated workers on average, but domestic SB subsidiaries clearly hire even more educated workers than foreign SB subsidiaries.

Table 9 - Occupation and education

Occupation	Subsidiaries of foreign SB firms	Domestic SB firms and their subsidiaries	Other private firms in Denmark
Managers	7.43	5.6	5.4
Professionals	20.9	36.9	18.7
Technicians and Associate Professionals	19.3	21.6	12.5
Clerical Support Workers	23.2	10.4	8.9
Services and Sales Workers	6.7	1.6	18.9
Skilled Agricultural, Forestry and Fishery Workers	0.1	0.1	1.4
Craft and Related Trades Workers	7.8	9.0	13.4
Plant and Machine Operators and Assemblers	10.3	11.0	7.5
Elementary Occupations	4.3	3.8	13.4
Education			
Primary education	18.0	11.6	25.4
Upper secondary education (General)	6.8	4.0	7.1
Upper secondary education (Specialised)	3.7	2.5	3.4
Post-secondary non-tertiary education	37.9	34.0	38.4
Short-cycle tertiary education	8.6	11.4	5.9
Professional bachelor	10.5	12.0	8.0
Academic bachelor	2.7	3.0	2.4
Master or equivalent	11.0	18.9	8.7
Doctoral or equivalent	0.7	2.5	0.8

Source: DST's registries.

4 Descriptive analyses

The previous sections described the empirical trends in the Danish economy and the SB firms and subsidiaries. This section starts the analysis. It goes deeper into the role of the SB firms in the Danish economy with a relatively descriptive approach. In the following sections econometric techniques are applied to study the role of SB firms in the structural transformation of the Danish job market and their effect on the Danish labour market.

4.1 Scoreboard firm employment

There are at least two ways to count employment using the registries of DST. One way is to use the total labour services employed at a firm or workplace over a year – the FTE employment. This is the preferred variable when comparing size. However, this

variable does not distinguish between different occupational categories. In order to distinguish between different occupational categories, it is necessary to look at the employment relations between employers and employees at a specific point in time (here: November 1st). For employees with multiple employment relations only the primary employment relation is included. This means that employees are not double counted.

Table 10 - Employment by occupational category

Number of employees 2012 (row pct.)

	High		Middling		Low	
Domestic SB	52,833	61%	15,870	18%	17,260	20%
Foreign SB	39,968	45%	25,767	29%	21,980	25%
Non-SB	890,554	38%	328,555	14%	1,071,981	46%

Number of employees 2013 (row pct.)

	High		Middling		Low	
Domestic SB	53,626	63%	16,192	19%	15,512	18%
Foreign SB	39,745	46%	25,791	30%	20,809	24%
Non-SB	897,069	38%	327,900	14%	1,076,141	46%

Change from 2012 to 2013 (pp change)

	High		Middling		Low	
Domestic SB	793	2pp	322	1pp	-1,748	-2pp
Foreign SB	-223	1pp	24	1pp	-1,171	-1pp
Non-SB	6,515	0pp	-655	0pp	4,160	0pp

Source: DST's registries.
Note: Pp: Percentage points.

Using this approach, 52,833 persons were in a type High employment relationship with a domestic SB firm or subsidiary in 2012 (cf. Table 1 for the definition of "High"). 15,870 persons were in Middling occupations and 17,260 in Low. Both domestic SB firms and their subsidiaries and foreign subsidiaries employ a smaller proportion of type Low than non-scoreboard firms and higher proportions of the other two categories. Domestic SB subsidiaries employ a particularly large share of High (61%) while foreign SB subsidiaries employ a particularly large share of Middling.

From 2012 to 2013, the polarizing pattern among jobs is clearly visible for non-SB firms. The number of employment relations classified with a Middling occupation decreases while High and Low increase. SB firms, on the other hand, appear to contribute to a general upgrading rather than polarization. They decrease the number of Low jobs and increase the shares of Middling and High jobs. Domestic SB firms also increase High and Middling in absolute terms. The data show that there is a net increase in jobs of types High and Low, but the growth of type Low jobs is relatively small compared to the growth in High. Therefore, type Low decreases as a share of

total employment. Figure 1 revealed polarization in the Danish labour market at the aggregate level, but this polarization trend is eliminated when only studying private sector firms as seen in Table 10. This means that part of the explanation for polarization is the creation of type Low jobs in the public sector, which fits well with the popular hypothesis that increases in type Low jobs is caused by Baumol's cost disease (Autor 2015, Baumol 1967).[8] Baumol's cost disease would typically afflict jobs that are relatively abundant in industries like health care and education, which are predominantly public sector industries.

The net changes in the bottom panel of Table 10 mask large gross flows. Table 11 reports the gross job creation among firms and it can be seen that 20-30% are new jobs across all three job categories and all three firm types. Labour turnover does appear to be slightly lower in SB firms than in non-SB firms.

Table 11 - Labour turnover

Number of employees in 2013 that are hired in 2013 (in pct.)

	High		Middling		Low	
Domestic SB	11,072	(21%)	3,345	(21%)	3,050	(20%)
Foreign SB	6,686	(17%)	5,929	(23%)	5,429	(26%)
Non-SB	211,188	(24%)	83,342	(25%)	374,920	(35%)

Source: DST's registries.

4.2 Scoreboard firm R&D

Table 8 contained a detailed description of SB firms and subsidiaries' R&D and innovation activities relative to non-SB firms as revealed in the FUI survey. In this section, additional details are added in the description of private sector R&D in Denmark. The FUI survey from 2013 has 4,787 observations while the relevant population for measuring private sector R&D activities in Denmark consist of 18,674 firms according to DST.[9] 61 of the 4,787 firms in the 2013 FUI survey are domestic SB firms and subsidiaries while 254 firms are foreign SB subsidiaries. As already mentioned, manual inspection of the data suggests that at least on third of the actual Danish SB firms (cf. Table 4) are not covered by the FUI survey data.

The total R&D expenditures (costs and investment, not purchase) of the firms in the sample amount to 4,554 million euro and after applying weights, Statistics Denmark infers that the population wide expenditures are 4,867 million euro. This number is reported by DST as the official private sector R&D in Denmark in 2013. Hence, the firms in the sample constitute the bulk of R&D active firms in Denmark. The specific weights used by DST are not available, but they obviously oversample large firms and

[8] Baumol's Cost Disease applies to activities producing output with demand that is relatively income elastic but price inelastic, and where technological progress has a limited or no effect at all on productivity. Demand for such output (e.g. many personal services including some in education, health, etc.) remains more or less fixed in relative terms as income rises meaning that a larger share of the workforce must be engaged in supplying them. However, at the same time, people employed in these industries do not experience productivity growth and hence their wage will often not be able to grow at the same pace as the average wage.

[9] Cf. DST's own analysis of the FUI data. http://www.dst.dk/ext/4364210019/0/serviceit/2013--xlsx. Accessed 4 May 2017.

firms in specific sectors. The survey covers 100% of firms with more than 250 employees and more than 80% of firms in the ICT, pharmaceutical and scientific R&D sectors. The data are thus not representative of the Danish economy as a whole but they are highly representative for firms in Denmark with R&D activities.

As shown in Table 8, 2,231 million euro of the private sector R&D expenditures can be attributed to domestic SB firms and their subsidiaries while 587 million euro can be attributed to the subsidiaries of foreign SB firms. Table 8 also documented the differences in R&D intensity showing that domestic SB firms and their subsidiaries have a particularly high R&D intensity when comparing R&D to employment, while non-SB firms have a particularly low R&D intensity when comparing R&D to sales. These differences are likely to be partially explained by differences in activities in the groups of firms. For SB firms and subsidiaries, however, the activity of the parent firm (as indicated by the industry of the firm), may differ from the activity of the subsidiary which actually has the R&D expenditures. Part of the R&D by SB firms is undertaken by subsidiaries that are active in sectors other than the SB parent firm; this is illustrated in Table 12. The table shows how SB parent firms' subsidiary R&D is distributed across industries. For example, 49 percent of the R&D undertaken by subsidiaries of SB firms in "Food, beverages and tobacco" is undertaken in that same industry, while 51% are undertaken in "Chemicals". As should be expected, a large share of R&D is registered along the diagonal of the table. However, a non-trivial amount of R&D is also undertaken "off the diagonal". In particular, R&D is relatively often undertaken in "computers, electronics and optical", "wholesale" and "research and development" in cases where the SB firm itself has a different industry classification. Domestic SB firms are obviously located along the diagonal while the wholesalers are likely to be subsidiaries of foreign SB firms.

Table 12 - Sectoral distribution of SB firms' R&D

	Industry of SB subsidiary firm performing R&D																						
SB parent firm industry	A	CA	CB	CE	CF	CG	CH	CI	CJ	CK	CL	CM	D	E	G	H	JA	JB	JC	K	MA	MB	N	Sum
A. Agriculture etc															100									100
CA. Food, beverages and tobacco		48.83		51.17																				100
CB. Textiles and leather																						100		100
CE. Chemicals	0.52	4.55		87.76	5.67		0.93								0.57									100
CF. Pharmaceuticals				12.54	85.56										1.71				0.19					100
CG. Plastics, glass and concrete						1.59	1.77								50.41						46.23			100
CH. Metal		24.84						31.5	43.66															100
CI. Computers, electronics and optical				7.45				21.79	3.36	31.62					10.90				1.63			23.24		100
CJ. Electrical equipment								15.79	4.39	36.29		3.68										39.85		100
CK. Machinery							1.57	0.50	0.20	91.93					5.81									100
CL. Transport equipment								95.23		0.39					4.38									100
CM. Furniture and others						46.76		53.22																100
D. Electricity, gas, etc																					3.25	96.75		100
E. Water and waste management																					100			100
G. Wholesale and retail trade								100																100
H. Transportation and storage																								0
JA. Publishing, radio and TV								0.92									5.27		93.81					100
JB. Telecommunication								49.78							24.18			26.04						100
JC. IT and Information services																			100					100
K. Financial and insurance activities											0.28	32.35								67.32	0.05			100
MA. Consulting etc.										27.81						69.08							3.11	100
MB. Research and Development																								0
N. Admin. and support service																							100	100

Source: SB data and DST's FUI survey.

4.3 Geographical distribution of employment

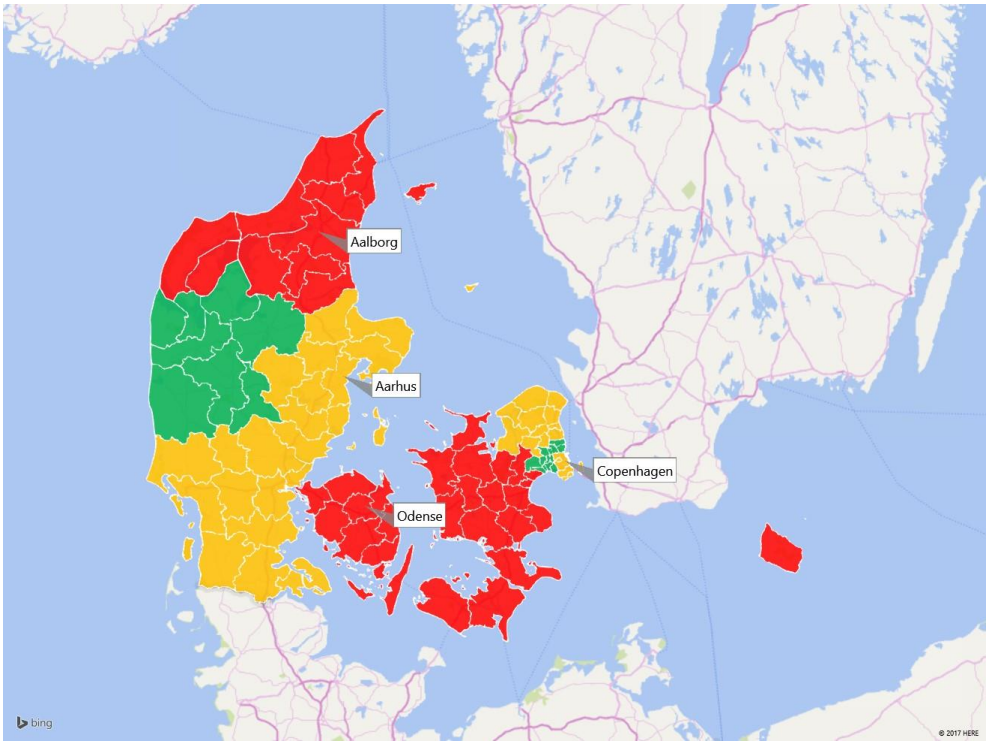
As indicated in Table 3, the scoreboard firms and subsidiaries are not evenly geographical distributed across Denmark. Table 9 showed the geographical distribution across NUTS 3 regions by workplace level full time equivalent employment. This analysis will, however, be firm level since several variables of interest - not least the contents of the FUI surveys - are firm level.[10]

Figure 7 illustrates the location coefficients for the SB firms and subsidiaries at the workplace level while Figure 8 illustrates the location when data are aggregated to the firm level. The location coefficient is defined as the region's share of SB employment relative to its share of total employment:

$$LC_i = \frac{N_i^{SB}/N^{SB}}{N_i/N} \quad (1)$$

N_i is employment in region i and N is national employment. SB indicates that the variable only pertains to SB firms and subsidiaries. The coefficient takes a value higher than 1 if a region is relatively specialised in SB employment in the sense that SB employment constitutes a disproportionately large share of regional employment. NUTS 3 regions specialised in SB employment ($LC_i > 1.25$) are coloured green while regions specialised in non-SB employment ($LC_i < 0.75$) are red. Intermediate regions are coloured yellow. Table 13 explains the colouring of the maps.

Figure 7 – Employment at the workplace level

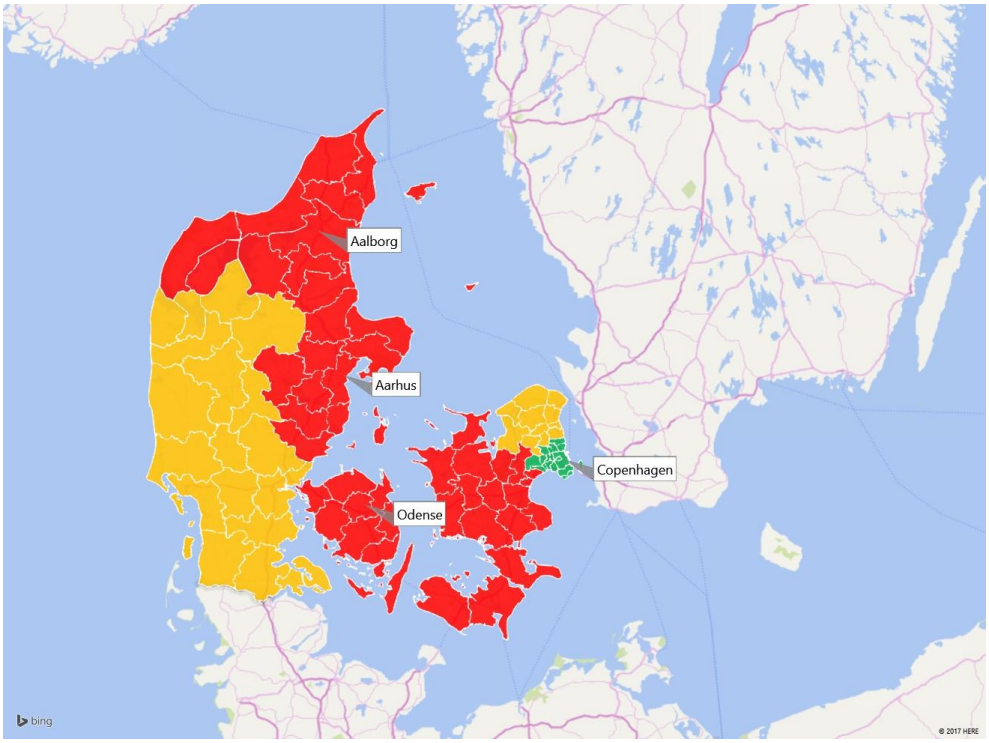


Source: DST's registries.
Note: See Table 13 for legend.

[10] The analysis is based on aggregating individual employment relations to the firm level in order to distinguish between different occupations, which entails that no correction is made for the extent of working hours in each employment relationship

There is no obvious link between a region's specialisation in SB employment and a region's socio-economic classification (cf. Figure 2). Regions that are relatively peripheral as well as regions that are relatively urban can exhibit relative specialisation in SB employment.

Figure 8 - Employment at the firm level



Source: DST's registries.
Note: See Table 13 for legend. No data in NUTS 3 region DK014 Bornholm

Table 13 - Map colours

Value range	0.00-0.75	0.75-1.25	1.25-
Colour	Red	Yellow	Green
Interpretation of figures 7, 8 and 10	Relatively specialised in non-SB	Not Specialised	Relatively specialised in SB
Interpretation of figures 9 and 11	Foreign SB over represented	Relative balance	Domestic SB over represented

There are two regions specialised in SB employment (green in Figure 7), i.e. West Jutland and the large Copenhagen area. The figure illustrates relative specialisation and the fact that these two regions are green does not necessarily entail that most SB employees work in these regions, only that the number is disproportionately large relative to the region's size. If employment is aggregated to the firm level rather than the workplace level the result is Figure 8. There are again two green regions but this time they are Copenhagen surroundings and Copenhagen. This reflects that the firms' addresses tend to be in Copenhagen even though they have workplaces scattered over the country. Studying firm level data may entail a

geographical distortion as all employment, sales, R&D etc. are registered at the firms' central addresses. The one variable where it is possible to gauge the extent of this distortion is employment, as it can be measured at the workplace level. Conclusions reached by comparing Figures 7 and 8 are potentially sensitive to the detail of the figures and the cut-off value deciding whether a region is given one or the other colour. However, the conclusion that firm level data attributes a disproportionate share of economic activity to Copenhagen is robust.

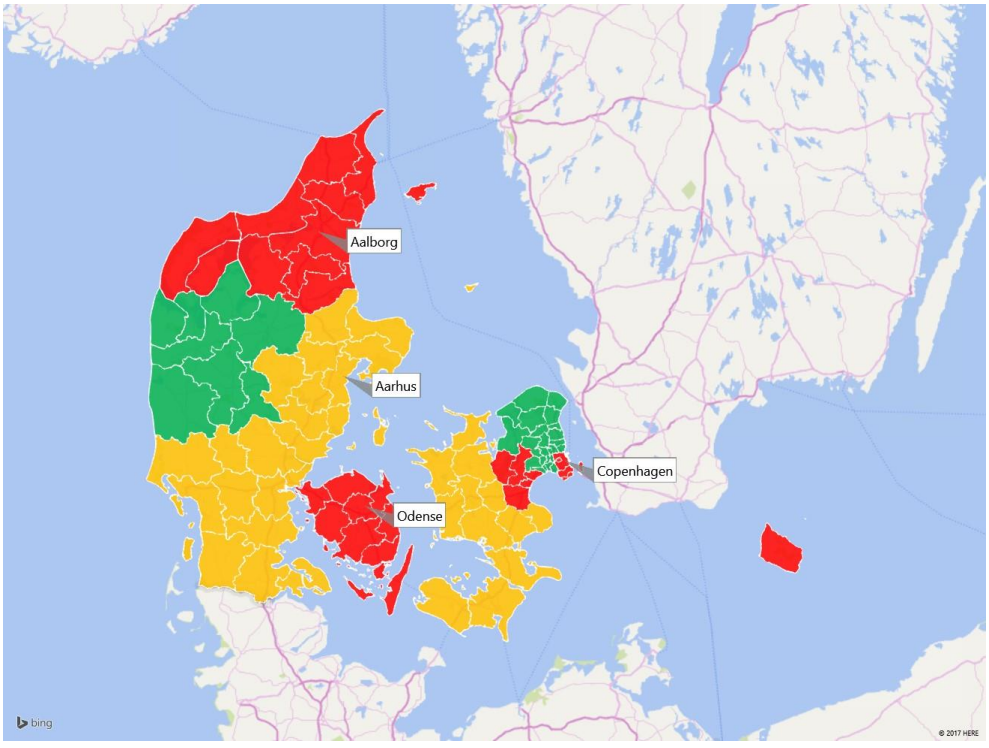
Figures 7 and 8 show the general relative specialisation in SB employment, while Figure 9 illustrates the balance between foreign subsidiaries and domestic SB firms and their subsidiaries using workplace level employment. The figure is coloured according to the ratio of the location coefficients for the two groups (denoted F and D respectively).

$$B_i = \frac{LC_i^D}{LC_i^F} = \frac{N_i^{D.SB}/N^{D.SB}}{N_i^{F.SB}/N^{F.SB}} \quad (2)$$

A balance of 1 ($B_i = 1$) means that the region is equally specialised in foreign and domestic SB employment while a value greater than 1 means that the regions is relatively specialised in domestic SB firms and their subsidiaries, and a value less than 1 means that the region is relatively specialised in foreign SB subsidiaries.

Figure 9 shows that the regions specialised in SB employment (West Jutland and Copenhagen surroundings, cf. Figure 7) are particularly specialised in domestic SB employment, and so is North Zealand. Five regions are relatively specialised in foreign SB employment. These include regions that were shown earlier to host none of the domestic SB firms themselves, but in Copenhagen there is also much more foreign than domestic SB employment.

Figure 9 - Balance for workplace level employment

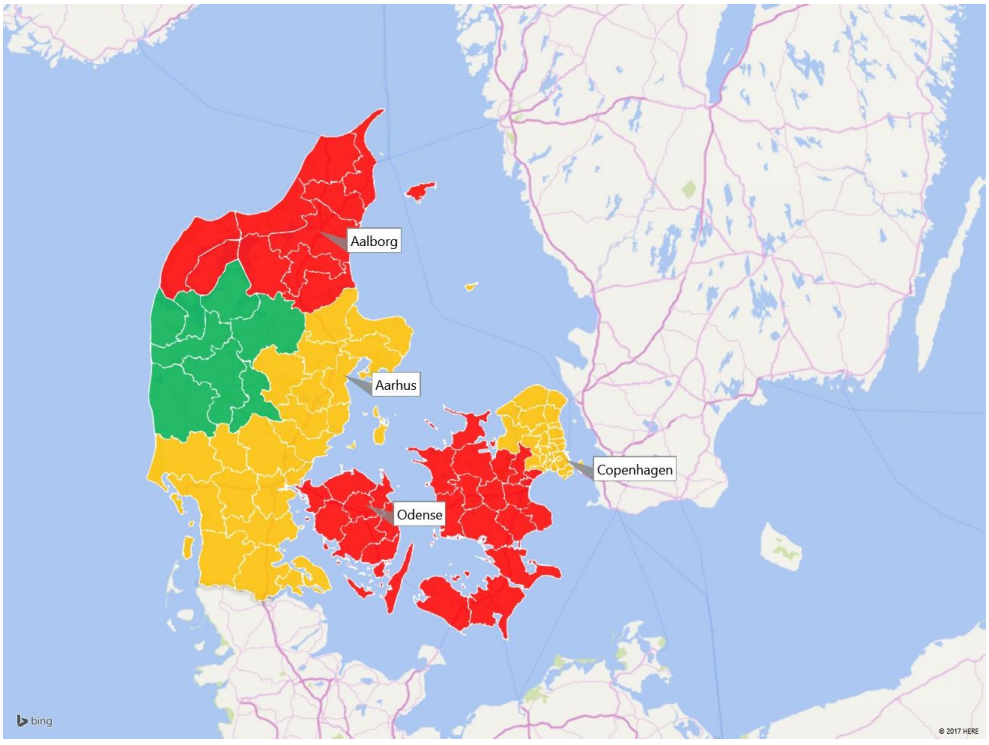


Source: DST's registries.
Note: See Table 13 for legend.

4.4 Geographical distribution of R&D

Figure 10 shows the relative geographical distribution of SB firms' R&D expenditures. The figure shows the relative R&D coefficient defined analogously to the location coefficient in equations 1: the region's share of SB R&D relative to its share of total private sector R&D. The colours of the regions adhere to Table 13. R&D expenditures are measured at the firm level and thus Figure 10 can be compared to the geographical distribution of firm level employment in Figure 8. Thus it is interesting to note that West Jutland is specialised in SB R&D though not in firm level employment. Figure 7 showed that West Jutland is specialised in workplace level employment but R&D expenditures are not measured at the workplace level and hence these two maps are not directly comparable. The two regions Copenhagen and Copenhagen surroundings are not specialised in R&D though they were specialised in terms of employment, indicating that R&D intensity is relatively low in these two regions.

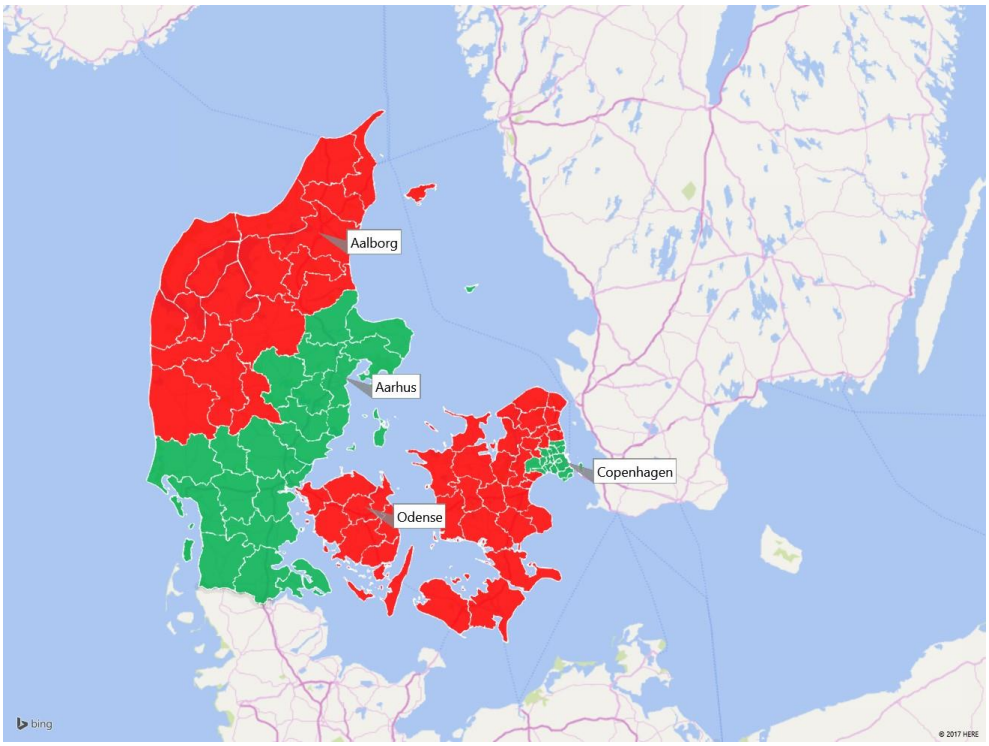
Figure 10 - Domestic SB firm and their subsidiaries' R&D



Source: DST's FUI survey and DST's registries.
Note: See Table 13 for legend. No data in NUTS 3 region DK014 Bornholm

Figure 11 shows the balance for R&D expenditures defined analogously to equation 2. Interestingly, there are no yellow regions: regions are either relatively specialised in foreign SB R&D (red) or in domestic SB R&D (green). The green regions are, not surprisingly, the regions where domestic SB parent firms are located (cf. Figure 6).

Figure 11 - Foreign SB subsidiaries' R&D



Source: DST's FUI survey and DST's registries.
Note: See Table 13 for legend. No data in NUTS 3 region DK014 Bornholm

Domestic SB firm R&D is relatively concentrated in and around Copenhagen, and in the industrial heartland of South/Central Jutland. This is no surprise given the location of the firms that appear on the scoreboard, c.f. earlier but it can also be expected that the concentration in Copenhagen is over-emphasised from nationwide R&D being registered at the firm's main municipality and not at the workplaces spread out across the country. There are relatively high shares of foreign SB R&D undertaken on Zealand outside Copenhagen and in North/West Jutland. It is striking that Funen with the university city of Odense has relatively little scoreboard R&D. It indicates an environment of many smaller firms doing R&D with only a limited role for large multinational firms.

5 Regression analysis

The previous section described the role of SB firms and subsidiaries in Denmark and it is abundantly clear that they have a huge impact on employment and on R&D in the Danish economy. In this section we go into more detail regarding the two more specific questions raised earlier: how do SB firms and subsidiaries contribute to the structural transformation of the Danish economy as evident from labour market data, and how they affect the labour market in terms of wage growth and mobility?

In principle, the factors leading to job polarization are at three distinct levels where the focus of this report is exclusively on the first:

1. Within firms. Changes in technology or organisation leads to change in the types of labour employed.

2. Between firms, but within industries. Competition leads some firms to grow relative to others, and the occupational composition of successful firms thus become more dominant in the economy
3. Between industries. The structural transformation of the economy entails that some industries expand while others contract. In other words, some economic activities and the associated technologies and skills become relatively less important in the economy while others become relatively more important.

Goos et al. (2014) focus on the distinction within vs. between industries and conclude that both elements are important, but they are not able to split the within industry effect into between and within firm components. Heyman (2016) performs two separate decompositions into within and between effects at the firm and industry level respectively and concludes that there are important within and between effects at both levels, though Heyman does not perform a decomposition that takes both levels into account simultaneously and the details of the applied method are not elaborated. However the studies agree that the within firm effects are an important part of the explanation which warrants the approach in this report.

As in earlier studies of job polarization and skill biased technological change based on micro level data, this report will use Seemingly Unrelated Regression models, SUR models (Sanders and ter Weel, 2000; Caroli and Van Reenen, 2001; Piva et al., 2005). The basic SUR model is a system of K equations for the wage cost shares of K types of labour. The rationale for using a SUR model relies on specifying a transcendental logarithmic (translog) functional form for a model of firms' costs. This entails the assumption that the output level is given for firms, and that firms must minimize costs for this output level. The translog model and the SUR method are elaborated in the appendix. For discussions of empirical applications of the translog functional form and SUR models see Greene (2000), and Christensen and Greene (1976) in addition to the above references.

5.1 Results for the sources of job polarization

Equation 14 from the appendix is the general version of the model to be estimated and it is repeated here as equation 3. To reiterate: The dependent variable, Δs_k, is the change in the wage cost share of category k employees at the firm. Employment share is used rather than wage cost share to avoid endogeneity issues with the wage regressors, and as the primary interest is in the shifts in the frequency of labour categories.

The regressors are $\Delta \ln\left(\frac{w_i}{w_j}\right)$: the change in the log of wage for each labour category where category j is used as a numeraire, $\Delta \ln Y$: the change in the log of output, and $\Delta \ln A_n$: the change in the log of each element in the vector of technology variables.

$$\Delta s_k = \sum_{i \neq j} \alpha_{ki} \Delta \ln\left(\frac{w_i}{w_j}\right) + \alpha_{kY} \Delta \ln Y + \sum_n \beta_{kn} \Delta \ln A_n + \Delta u_k \quad (3)$$

There are three equations to estimate: $k = (High, Middling\ (Mid), Low)$ but as explained in the appendix the system of three equations is singular and only two of the equations are estimated in practice while the parameter estimates of the third equation are computed from the first two equations. The system of two equations to estimate is:

$$\Delta s_{High,i} = \beta_{0High} + \alpha_{HighHigh}\Delta \ln\left(\frac{w_{High}}{w_{Low}}\right)_i + \alpha_{HighMid}\Delta \ln\left(\frac{w_{Mid}}{w_{Low}}\right)_i + \alpha_{HighY}\Delta \ln Y_i + \beta_{HighExport}\Delta \ln X_i + \beta_{HighImport}\Delta \ln IM_i + \beta_{HighR\&D}\Delta \ln R\&D_i + \beta_{HighProd}PD_i + \beta_{HighProc}PC_i + \beta_{HighMarket}MK_i + \beta_{HighOrgExt}OE_i + \beta_{HighOrgFor}OF_i + \beta_{HighOrgWrk}OW_i + \gamma_{HighNOSB}NOSB_i + \gamma_{HighFRSB}FRSB_i + \gamma_{HighSize}lnSize_i + \gamma_{HighManuf}Manuf_i + \epsilon_{High,i}$$

(4)

$$\Delta s_{Mid,i} = \beta_{0Mid} + \alpha_{MidHigh}\Delta \ln\left(\frac{w_{High}}{w_{Low}}\right)_i + \alpha_{MidMid}\Delta \ln\left(\frac{w_{Mid}}{w_{Low}}\right)_i + \alpha_{MidY}\Delta \ln Y_i + \beta_{MidExport}\Delta \ln X_i + \beta_{MidImport}\Delta \ln IM_i + \beta_{MidR\&D}\Delta \ln R\&D_i + \beta_{MidProd}PD_i + \beta_{MidProc}PC_i + \beta_{MidMarket}MK_i + \beta_{MidOrgExt}OE_i + \beta_{MidOrgFor}OF_i + \beta_{MidOrgWrk}OW_i + \gamma_{MidNOSB}NOSB_i + \gamma_{MidFRSB}FRSB_i + \gamma_{MidSize}lnSize_i + \gamma_{MidManuf}Manuf_i + \epsilon_{Mid,i}$$

The dependent variable is the change in employment share at firm i from 2012 to 2013 of the relevant occupational type while all explanatory variables are measured prior to these two years. They are either changes from 2011 to 2012, survey questions pertaining to changes 2010-2012 or time invariant dummies.

There are two variables for relative wage: $\Delta \ln\left(\frac{w_{High}}{w_{Low}}\right)_i$ and $\Delta \ln\left(\frac{w_{Mid}}{w_{Low}}\right)_i$. The wage for an occupational group is computed as the average wage income over the year for individuals of the particular occupational group living in the municipality where the firm is based. If a firm consists of only one workplace and this workplace's address is in the municipality "Aalborg" then w_{High} is the average wage income for persons with an occupation in the High group and living in Aalborg. This is intended to reflect the costs of expanding the workforce with this occupation. We do not use the average wage income for employees within the occupation at the firm since several firms have few or even no employees of a particular group even after removing small firms. Our measure of wages furthermore entails that we avoid a common endogeneity problem arising from firm level wages and labour composition being jointly determined. For firms consisting of several workplaces in different municipalities the wage variables are computed as the average over the relevant municipalities weighted by the size of the firm's workplaces.

The estimate for $\alpha_{HighMid}$ can be used to derive the elasticity of substitution between the labour types High and Middling, and the estimate for $\alpha_{HighHigh}$ can be used to derive and own price elasticity for type High. Similar method can be used for the other equations. In short, if $\alpha_{HighMid}$ is zero then the elasticity of substitution is 1 and labour of types High and Mid are substitutes. If the estimate is negative then they are complements.

Output is measured as sales deflated to 2015 values using the consumer price index. Other relevant variables are also deflated in this manner. $\Delta \ln Y_i$ is the change in log sales from 2011 to 2012 and its estimated effect indicates the homogeneity of the cost function. If $\alpha_{HighY} = \alpha_{MidY} = \alpha_{LowY} = 0$ then the cost function is homogenous of degree 1 meaning that a proportional increase in all inputs (types of labour) is associated with a proportional increase in output.

The βs all indicate whether the various technology indicators are complements or substitutes to the types of jobs. If an estimate for a β is positive then there is indication of complementarity. If the estimate for β_{HighRD} is positive, for example, it means that R&D expenditures are complementary to type High employment. If the estimate is negative then they are substitutes. The first three technology variables are $\Delta \ln X_i$, $\Delta \ln IM_i$ and $\Delta \ln R\&D_i$, and are the change 2011-2012 in log exports, imports and R&D expenditures for firm i respectively. The following six variables are binary variables for innovation. PD_i is 1 if the firm introduced a new product or service in 2010-2012 while PC_i and MK_i indicate process and marketing innovation respectively. Since change in occupational composition is likely to be closely linked to

organisational innovation it is exploited that the FUI survey allows us to distinguish between three different forms of organisational innovation. OE_i, OF_i and OW_i are 1 if the firm has undertaken organisational innovation in terms of external linkages, formal structure and work organisation respectively.

Finally, controls for SB firms, firms' size and sector are included. $NOSB_i$ and $FRSB_i$ are 1 if the firm is not a SB firm or a foreign SB subsidiary respectively. I.e. the reference is domestic SB firms and subsidiaries. It would arguably be more coherent to have non-SB as the reference, but in later regressions only SB firms and subsidiaries are used and hence domestic SB is used as the reference for comparability. $lnSize_i$ is the log of employment at the firm in 2012 and $Manuf_i$ is 1 if the firm is in the manufacturing sector. The epsilons are classical errors with the exception that they correlate across equations.

Table 14 – Variables in SUR model

Variable	Definition (change in period 2011-2012. Dependent variables: 2012-2013)
$\Delta s_{High,i}, \Delta s_{Mid,i}, \Delta s_{Low,i}$	Change in the share of type High, Mid and Low respectively in firm i's workforce
$\Delta \ln\left(\frac{w_{High}}{w_{Low}}\right)_i, \Delta \ln\left(\frac{w_{Mid}}{w_{Low}}\right)_i$	Change in log of average wage for type High (Mid) workers relative to the average wage for type Low workers in firm i's home municipality
$\Delta \ln Y_i$	Change in log of firm sales
$\Delta \ln X_i$	Change in log of firm exports
$\Delta \ln IM_i$	Change in log of firm imports
$\Delta \ln R\&D_i$	Change in log of firm total R&D expenditures (costs and investment)
PD_i	1 if firm i introduced new or significantly changed product or service 2010-2012
PC_i	1 if firm i introduced new or significantly changed method for production, logistics or support functions 2010-2012
MK_i	1 if firm i introduced new or significantly changed design, promotion techniques, marketing strategy, sales channels or pricing 2010-2012
OE_i	1 if firm i introduced new methods for organising external linkages (alliances, partnerships, suppliers etc.) 2010-2012
OF_i	1 if firm i introduced new methods for organising formal structure (quality control, knowledge management, supply chain management etc.) 2010-2012
OW_i	1 if firm i introduced new methods for organising work (decentralisation teams, job rotation etc.) 2010-2012
$NOSB_i$	1 if firm i is not a subsidiary of a SB firm
$FRSB_i$	1 if firm i is a subsidiary of a foreign SB firm
$\Delta \ln p.R\&D_i$	Change in log of parent firm R&D expenditures
$\Delta \ln p.Y_i$	Change in log of parent firm sales
$lnSize_i$	Log of firm employment in 2012
$Manuf_i$	Dummy for manufacturing firms

Later models are restricted to only the SB firms and this allows the use of two additional indicators: the change 2011-2012 in log sales and in log R&D for the SB parent company which will be added to the equations as $\beta_{kp.R\&D}\Delta \ln p.R\&D_i$ and $\beta_{kp.Y}\Delta \ln p.Y_i$. I.e. parent sales are

considered as part of the vector of technology related variables. In later models, interaction terms between the variables in the technology vector and the dummies for SB firms will be added. These will take the form of, for example $\beta_{kProdFRSB} PD_i FRSB_i$ .The variables are summarised in Table 14.

5.2 Descriptive statistics

Before reporting the regression analyses, the data will be described in more detail. Since the variables in the regression model only can be identified for firms that are present in 2011-2013, new firms and firms that close down are excluded. Removing these firms and firms where data on output or the regional wage level is missing yields 19,459 observations which can be used in a relatively simple regression where the technology related variables (i.e. the variables with a beta parameter) are omitted. It was noted in connection with Table 10 that removing the public sector from the analysis made the polarization tendency disappear. Instead, the sample reveals general upgrading, where type Low declines while type High and to some degree type Mid increases. General upgrading rather than polarization was also the pattern observed for Denmark by Fernández-Macías (2012). This study of the effect of R&D and innovation on the shifts in the labour market is dependent on FUI surveys, this further decreases the sample to 2,713 firms. In this smaller sample, the trend for general upgrading is even stronger. Finally, the SB firms and subsidiaries are studied in isolation. There are only 228 firms in this sample since the SB firms and subsidiaries must also be on the FUI surveys. In this final sample the tendency towards upgrading is particularly strong with a 1.78 percentage point decrease in Low, and increases of 1.43 and 0.34 percentage points for High and Mid respectively. Table 15 reports the weighted mean of the three dependent variables for the three samples.

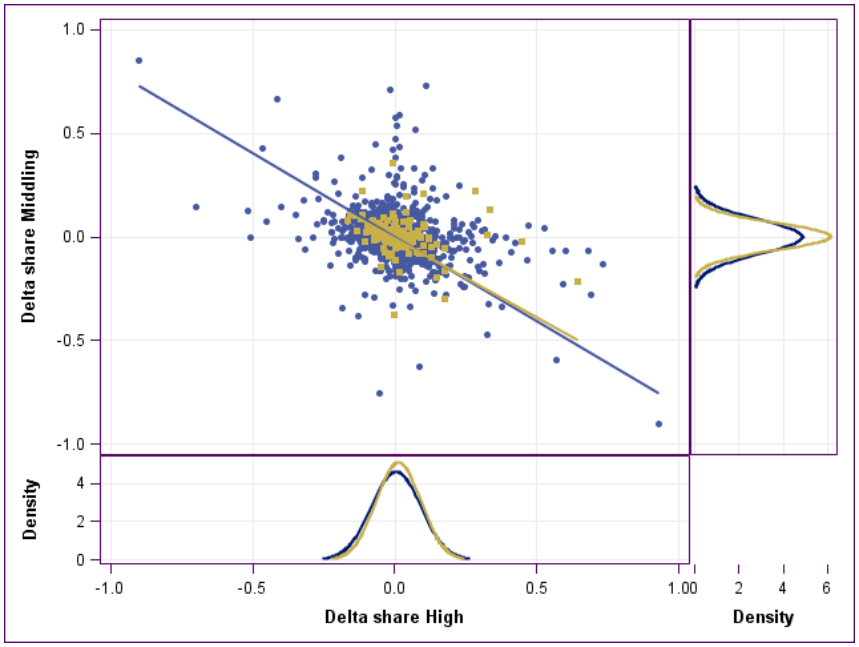
Table 15 - Weighted mean of dependent variables

Sample	$\Delta s_{High,i}$	$\Delta s_{Mid,i}$,	$\Delta s_{Low,i}$,	Sample size
Implied by Table 10	0.0016	-0.0006	-0.0010	
All excluding entry and exit	0.0049	0.0019	-0.0068	19459
FUI survey	0.0069	0.0012	-0.0081	2713
SB only	0.0143	0.0034	-0.0178	228

Source: Own computations from DST's registries

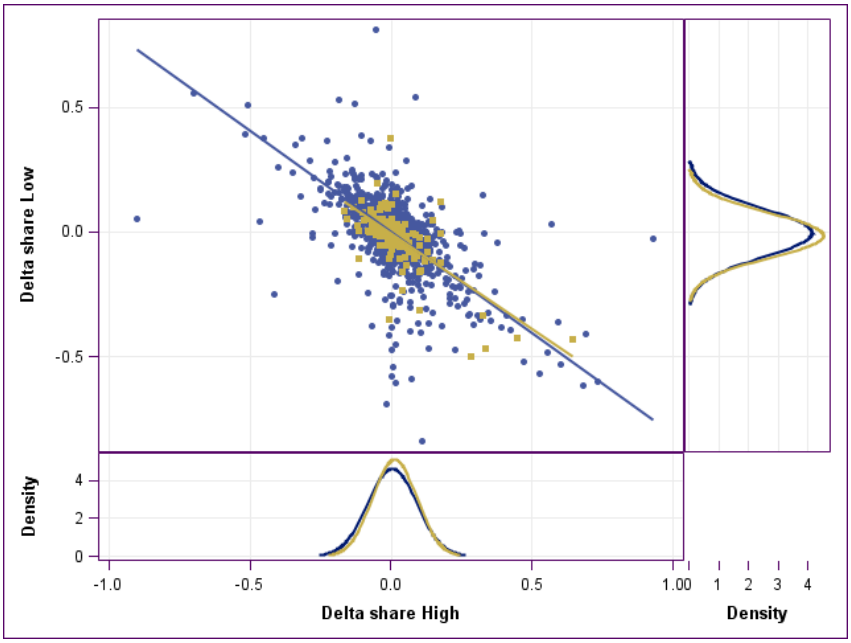
Figures 16 and 17 further describe the joint distribution of the dependent variables. Figure 16 plots the $\Delta s_{High,i}$ against $\Delta s_{Mid,i}$ while figure 17 plots $\Delta s_{High,i}$ against $\Delta s_{Low,i}$. The plots show the 2,713 observations from the FUI survey with SB firms and subsidiaries indicated in yellow. The plots also contain normal density curves for the distributions. There is a large degree of variation around the means with some firms showing positive or negative percentage point changes near 100%. However, most observations cluster near the centre; a tendency, which is perhaps slightly more pronounced for SB firms and subsidiaries than for other firms, but this may be explained by the larger size of these firms.

Table 16 - Distribution of dependent variable: High vs Middling



Source: Own computations from DST's registries
Note: Yellow: SB firms and subsidiaries. Blue: Non-SB firms.

Table 17 - Distribution of dependent variable: High vs Low



Source: Own computations from DST's registries
Note: Yellow: SB firms and subsidiaries. Blue: Non-SB firms.

The plots show that there is a strong negative correlation between the dependent variables, which is necessary since a percentage point change in one type of jobs must be accompanied by an exact opposite change for the other types.

Table 18 contains summary statistics for the independent variables and reports their correlation with the dependent variables. The correlations among the dependent variables correspond to Figures 16 and 17 and their mean values are the same as in Table 17.

Some of the descriptive statistics are unexpected. Both variables for relative real wage change have negative means, which implies that low wage groups have had the highest wage increase in the period. However, given the variables' definition the negative means could also mean that SB firms and subsidiaries have grown relatively most in low wage regions. The table also shows that the average firm did quite well in 2011-2012 with a 7 percent increase in sales, a 10 percent increase in exports, a 16 percent increase in imports and a 5 percent increase in R&D. Again, it must be emphasised that the sample is based on the FUI surveys and are hence representative of firms active in private sector R&D rather than the entire economy.

Table 18 - Descriptive statistics, weighted

			Correlations		
Variable	Mean	Std Dev	$\Delta s_{High,i}$	$\Delta s_{Mid,i}$	$\Delta s_{Low,i}$
$\Delta s_{High,i}$	0.0069	0.7506	1.000	-0.2057***	-0.6556***
$\Delta s_{Mid,i}$	0.0012	0.7110	-0.2057***	1.000	-0.6040***
$\Delta s_{Low,i}$	-0.0081	0.9217	-0.6556***	-0.6040***	1.000
$\Delta \ln\left(\frac{w_{High}}{w_{Low}}\right)_i$	-0.0113	0.1602	0.0340*	0.01785	-0.0414**
$\Delta \ln\left(\frac{w_{Mid}}{w_{Low}}\right)_i$	-0.0043	0.2045	0.0117	0.0561***	-0.0528***
$\Delta \ln Y_i$	0.0727	13.8916	0.0094	0.0279	-0.0292
$\Delta \ln X_i$	0.0957	40.5864	0.0020	0.0222	-0.0187
$\Delta \ln IM_i$	0.1559	37.0101	0.00742	0.0383**	-0.0356*
$\Delta \ln R\&D_i$	0.0460	10.9939	-0.0101	0.0407**	-0.0231
PD_i	0.5057		-0.0119	-0.0227	0.027
PC_i	0.5314		0.0083	0.0179	-0.0205
MK_i	0.4813		-0.0354*	-0.0458**	0.0642***
OE_i	0.3135		0.0262	0.0254	-0.0409**
OF_i	0.5519		0.0333*	-0.0243	-0.0084
OW_i	0.4686		0.0339*	0.0214	-0.0441**
$NOSB_i$	0.7626		-0.0777***	-0.0272	0.0831***
$FRSB_i$	0.1225		-0.0211	0.0581***	-0.0277
$\Delta \ln p.R\&D_i$	0.0209	10.8691	-0.0263	0.0000	0.0232
$\Delta \ln p.Y_i$	0.0648	2.5719	0.2832***	-0.1021	-0.1713***

Source: Own computations from DST's registries.
Note: SUR estimates. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 18 also shows that about 50 percent of firms report the different types of innovation, except for organisational innovation concerning external linkages where the percentage is 31.

The positive and significant correlation between imports and change in share of Mid, and between R&D and the change in share of Mid is unexpected as technology and offshoring are expected to eliminate this type of jobs. However, the regression should clarify the relationships between these variables. The correlations between the dummies for non-SB subsidiaries and for subsidiaries of foreign SB firms suggest that foreign and domestic SB subsidiaries play different roles in the general upgrading of jobs in Denmark, with domestic firms increasing the share of High and foreign subsidiary firms increasing the share of Mid.

5.3 Estimation

Estimation of the equation system in equation 4 is undertaken with the iterated Zellner estimator. This means that the error covariance matrix is initially produced from OLS estimates before the equation parameters are estimated, and these estimates are then used to update the error covariance matrix. The process continues until convergence and is equivalent to maximum likelihood estimation in our case (Berndt, 1990, p. 463). Since we are analysing aggregate job polarization we will use firm size defined as average full time equivalent employment in 2012 and 2013 as weight, and we will disregard firms with 10 or fewer employees on average since such small organisations do not meaningfully have organisational structure or sufficient division of labour to have clear occupational groups. The threshold size of 10 employees is the common threshold between micro enterprises and small- and medium-sized enterprises used by organisations such as Eurostat. The number of observations left after this censoring was reported in the Table 15 for the various samples. After estimating the system in equation 4 we will compute the estimates for the equation for type Low. For example:

$$\widehat{\alpha_{LowHigh}} = -\widehat{\alpha_{HighHigh}} - \widehat{\alpha_{MidHigh}} \tag{5}$$

The variance (and hence standard error) for the estimate computed in equation 5 can be manually computed from the variance-covariance matrix of the estimates arising from estimating equation 4 as (continuing the example):

$$Var\left(\widehat{\alpha_{LowHigh}}\right) = Var\left(\widehat{\alpha_{HighHigh}}\right) + Var\left(\widehat{\alpha_{MidHigh}}\right) + 2Cov\left(\widehat{\alpha_{HighHigh}}, \widehat{\alpha_{MidHigh}}\right) \tag{6}$$

A coefficient of determination for the Low equation can also be computed from the inferred parameters. See Berndt (1990) pp. 469-476 for more details.

5.4 Results

Table 19 shows the result from estimating equation 4 without the variables for technology (i.e. variables with a beta parameter). This allows us to include most private sector firms in Denmark above the size threshold for inclusion in our data. Table 20 shows the results from estimating equation 4 as presented above. Table 20 is thus restricted to the firms that are on the FUI survey. Table 21 shows the result from estimating the model for only the SB firms and subsidiaries. Thus parent R&D and sales are only included in Table 21.

Table 19 - Estimates without technology

Parameter	High	Mid	Low
α_{kHigh}	0.0839**	0.0061	-0.0900**
	(0.0364)	(0.0261)	(0.0366)
α_{kMid}	0.0061	0.0876**	-0.0937***
	(0.0261)	(0.0354)	(0.0359)
α_{kY}	0.0002	0.0010*	-0.0013*
	(0.0005)	(0.0005)	(0.0006)
γ_{kNOSB}	-0.0178***	0.0039*	0.0138***
	(0.0021)	(0.0022)	(0.0025)
γ_{kFRSB}	-0.0179***	0.0104***	0.0075**
	(0.0025)	(0.0026)	(0.0031)
γ_{kSize}	0.0004*	-0.0002	-0.0003
	(0.0002)	(0.0002)	(0.0002)
γ_{kManuf}	0.0028**	-0.0020*	-0.0008
	(0.0011)	(0.0012)	(0.0014)
Constant	0.0195***	-0.0005	-0.0190***
	(0.0027)	(0.0029)	(0.0034)
Observations	19,459	19,459	19,459
R-squared	0.0069	0.0016	0.0035

Note: SUR estimates. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The estimates for $\alpha_{LowHigh}$ and α_{LowMid} in Table 19 are both negative indicating that the elasticities of substitution between Low and High and between Low and Mid are less than 1. Thus, it is only possible to a limited extent to substitute between these types of labour. The estimate for $\alpha_{MidHigh}$, on the contrary, is not significantly different from zero indicating that there is unit elasticity of substitution between Mid and High. The estimates for $\alpha_{HighHigh}$ and α_{MidMid} are both positive and significant indicating relatively low own price elasticity, which naturally follows from limited substitutability. There is no estimate for α_{LowLow} in the model but in terms of magnitude, it is implied to be relatively high.[11] Two of the α_{kY} parameter estimates are significantly different from zero indicating that the production function is not homothetic: the three types of labour do not increase in equal proportions as firms grow. Growing firms shift labour from Low to Mid, which in addition entails that there cannot be constant returns to scale.

The first three columns in Table 20 contain the result from estimating equation 4 while the last three columns contain the result from adding interactions between the technology variables and the dummies for SB firms. As with Table 19, the elasticities of substitution and own price elasticities have not been computed but the estimates in the first part of Table 20 imply unit elasticity of substitution between High and Mid and between High and Low, but less than unit elasticity between Mid and Low. This means that jobs of type High can be substituted with

[11] $\widehat{\alpha_{LowLow}} = 0 - \widehat{\alpha_{LowHigh}} - \widehat{\alpha_{LowMid}} = 0.09 + 0.0937 = 0.1837$

either of the other two types of labour while types Mid and Low are complements and hence can only substitute for each other to a limited degree. Relatedly, the own price elasticity of type High appears to be higher than the own price elasticity of the other types.

Unlike the results in Table 19, the effect of sales growth is zero across all three equations implying that production is homothetic. This means that, as sales change, the use of all three types of labour change in equal proportions, though not necessarily in the same proportion as sales.

Focus now turns to the main parameters of interest: the beta parameters reflecting complementarities between different aspects of technology and the types of jobs. The estimate for imports for type Mid is positive and significant meaning that as firms import more they also employ more type Mid labour. There is no corresponding negative estimate, but when the Mid share goes up others must go down. In as much as importing reflects some degree of offshoring, this result was unexpected as it means that offshoring counteracts polarization in jobs. Organisational innovation involving external relations and organisational innovation involving work organisation are also both complementary to type Mid, while product innovation and organisational change involving formal structure substitutes for type Mid. External linkages were expected to indicate outsourcing and hence expected to lead to polarization instead of counteracting it, as the results indicate. Changes in formal structure appear to contribute to polarization. This means that firms implement practices, such as quality control, knowledge management and supply chain management whereby Mid occupations become superfluous. The results do not indicate whether it is type High or Low that increases in response. Changes in work organisation appear to be part of the explanation for general upgrading. In other words, implementing a team structure and decentralising decision-making upgrades jobs from type Low to type Mid. Finally, the results show that marketing innovation increases the use of Low at the expense of both other types. That is, new marketing initiatives require type Low workers, which thus increase in the share of employment. Summing up, these first results seem to be just as good at explaining polarization as they are at explaining general upgrading, while it is general upgrading, which is observed in the averages of the dependent variables. In addition, the coefficient of determination is quite low for all equations. Therefore, we add interactions between the SB dummies and the technology indicators to better explain the sources of polarization. The result is presented in the last three columns of Table 20.

Table 20 – Estimates for complementarity and substitutability of technology and labour

	Equation 4			Equation 4 w/ interactions		
Parameter	High	Mid	Low	High	Mid	Low
α_{kHigh}	0.0986	-0.0021	-0.0965	-0.0030	0.0434	-0.0404
	(0.0925)	(0.0576)	(0.0927)	(0.0939)	(0.0582)	(0.0941)
α_{kMid}	-0.0021	0.2308***	-0.2287***	0.0434	0.1618**	-0.2052***
	(0.0576)	(0.0694)	(0.0754)	(0.0582)	(0.0701)	(0.0763)
α_{kY}	0.0004	0.0009	-0.0014	0.0000	0.0011	-0.0012
	(0.0011)	(0.0010)	(0.0013)	(0.0011)	(0.0010)	(0.0013)
$\beta_{kExport}$	-0.0001	0.0001	-0.0001	0.0339***	0.0041	-0.0381***
	(0.0004)	(0.0003)	(0.0004)	(0.0084)	(0.0080)	(0.0102)
$\beta_{kImport}$	0.0002	0.0008**	-0.001*	0.0234**	-0.0065	-0.0169
	(0.0004)	(0.0004)	(0.0004)	(0.0104)	(0.0099)	(0.0127)
$\beta_{kR\&D}$	-0.0005	0.0020	-0.0015	0.0089*	0.0013	-0.0103
	(0.0013)	(0.0013)	(0.0016)	(0.0051)	(0.0048)	(0.0062)
β_{kProd}	-0.0033	-0.0043*	0.0076**	-0.0323***	-0.0194**	0.0517***
	(0.0026)	(0.0025)	(0.0032)	(0.0101)	(0.0096)	(0.0123)
β_{kProc}	-0.0013	0.0038	-0.0025	-0.0954***	-0.0356*	0.1309***
	(0.0029)	(0.0028)	(0.0035)	(0.0220)	(0.0209)	(0.0269)
$\beta_{kMarket}$	-0.0061**	-0.0065**	0.0126***	-0.0226**	0.0104	0.0122**
	(0.0027)	(0.0025)	(0.0032)	(0.0113)	(0.0108)	(0.0139)
$\beta_{kOrgExt}$	-0.0021	0.0046*	-0.0025	-0.0253***	0.0489***	-0.0237
	(0.0028)	(0.0027)	(0.0034)	(0.0095)	(0.0091)	(0.0116)
$\beta_{kOrgFor}$	0.0041	-0.0065**	0.0024	0.0562***	-0.0073	-0.0489**
	(0.0031)	(0.0029)	(0.0037)	(0.0186)	(0.0177)	(0.0228)
$\beta_{kOrgWrk}$	0.0029	0.0081***	-0.0111***	0.1003***	-0.0086	-0.0917***
	(0.0031)	(0.0030)	(0.0038)	(0.0201)	(0.0191)	(0.0245)
γ_{kNOSB}	-0.0175***	0.0070**	0.0105**	-0.0987***	-0.0346	0.1332***
	(0.0036)	(0.0034)	(0.0044)	(0.0271)	(0.0258)	(0.0331)
γ_{kFRSB}	-0.0184***	0.0136***	0.0048	-0.0823***	-0.0621**	0.1444***
	(0.0043)	(0.0041)	(0.0053)	(0.0313)	(0.0298)	(0.0383)
γ_{kSize}	0.0006	0.0006	-0.0012	-0.0083**	-0.0023	0.0106**
	(0.0007)	(0.0006)	(0.0008)	(0.0035)	(0.0033)	(0.0042)
γ_{kManuf}	0.0050**	0.0003	-0.0053*	-0.0153**	-0.0055	0.0208**
	(0.0024)	(0.0023)	(0.0029)	(0.0077)	(0.0073)	(0.0094)

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	Equation 4			Equation 4 w/ interactions		
Parameter	High	Mid	Low	High	Mid	Low
Interactions with $NOSB_i$						
$\beta_{kExportNOSB}$				-0.0341***	-0.0039	0.0380***
				(0.0084)	(0.0080)	(0.0102)
$\beta_{kImportNOSB}$				-0.0233**	0.0073	0.0160
				(0.0104)	(0.0099)	(0.0127)
$\beta_{kR\&DNOSB}$				-0.0101*	0.0010	0.0090
				(0.0053)	(0.0051)	(0.0065)
$\beta_{kProdNOSB}$				0.0357***	0.0124	-0.0482***
				(0.0106)	(0.0101)	(0.0129)
$\beta_{kProcNOSB}$				0.0928***	0.0371*	-0.1300***
				(0.0222)	(0.0211)	(0.0272)
$\beta_{kMarketNOSB}$				0.0176	-0.0111	-0.0066
				(0.0118)	(0.0112)	(0.0144)
$\beta_{kOrgExtNOSB}$				0.0254**	-0.0523***	0.0269**
				(0.0100)	(0.0096)	(0.0123)
$\beta_{kOrgForNOSB}$				-0.0571***	0.0058	0.0513**
				(0.0190)	(0.0180)	(0.0231)
$\beta_{kOrgWrkNOSB}$				-0.1004***	0.0173	0.0830***
				(0.0203)	(0.0194)	(0.0249)
$\gamma_{kSizeNOSB}$				0.0092***	0.0021	-0.0114***
				(0.0035)	(0.0034)	(0.0043)
$\gamma_{kManufNOSB}$				0.0209**	0.0070	-0.0279***
				(0.0082)	(0.0078)	(0.0100)
Interactions with $FRSB_i$						
$\beta_{kExportFRSB}$				-0.0341***	-0.0003	0.0344***
				(0.0087)	(0.0083)	(0.0106)
$\beta_{kImportFRSB}$				-0.0207*	0.0074	0.0132
				(0.0107)	(0.0102)	(0.0130)
$\beta_{kR\&DFRSB}$				-0.0030	-0.0080	0.0109
				(0.0061)	(0.0058)	(0.0075)
$\beta_{kProdFRSB}$				0.0324**	0.0131	-0.0455**
				(0.0132)	(0.0126)	(0.0162)

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	Equation 4			Equation 4 w/ interactions		
Parameter	High	Mid	Low	High	Mid	Low
$\beta_{kProcFRSB}$				0.0958***	0.0433*	-0.1391***
				(0.0235)	(0.0224)	(0.0287)
$\beta_{kMarketFRSB}$				0.0153	-0.0349***	0.0196
				(0.0136)	(0.0130)	(0.0167)
$\beta_{kOrgExtFRSB}$				0.0323**	-0.0276**	-0.0047
				(0.0129)	(0.0123)	(0.0157)
$\beta_{kOrgForFRSB}$				-0.0383*	-0.0254	0.0636**
				(0.0207)	(0.0197)	(0.0253)
$\beta_{kOrgWrkFRSB}$				-0.1068***	0.0360*	0.0707***
				(0.0221)	(0.0210)	(0.0270)
$\gamma_{kSizeFRSB}$				0.0051	0.0083**	-0.0134**
				(0.0043)	(0.0041)	(0.0052)
$\gamma_{kManufFRSB}$				0.0181*	0.0136	-0.0318**
				(0.0104)	(0.0099)	(0.0127)
Constant	0.0204***	-0.0075	-0.013*	0.0989***	0.0377	-0.1366***
	(0.0062)	(0.0059)	(0.0075)	(0.0267)	(0.0254)	(0.0326)
Observations	2,713	2,713	2,713	2,713	2,713	2,713
R-squared	0.0223	0.0204	0.0270	0.0617	0.0505	0.0642

Note: SUR estimates. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The estimates for the various alpha parameters are not greatly affected by the inclusion of the interactions. When interpreting the betas, however, an interesting change is observed: the direct effect reported in the top part of Table 20 includes many significant effects describing shifts between types High and Low. The direct effects pertain to the reference category, domestic SB firms and their subsidiaries. For these firms exporting, importing and performing R&D are all complements to type High, thus upgrading the employment structure. Organisational innovation involving the formal structure or involving work organisation are also complements for type High and simultaneously substitutes for Low indicating that these organisational changes are part of the explanation for general upgrading among domestic SB firms and subsidiaries.

The remaining four variables for innovation: product, process, marketing and organisational innovation involving external linkages are all substitutes for High and are found to have differing relationships to types Mid and Low. Thus the regression results show a number of factors leading to general upgrading – declining share of Low, stable share of Mid and an increasing share of High – of the workforce among SB firms and their subsidiaries. But the results also show a number of effects counteracting general upgrading; not least that both product innovation and process innovation decreases the shares of both High and Mid while increasing Low. The estimates for the interaction terms in the rest of Table 20 show the differences in the relationships between the job types and technology variables when considering the other two groups of firms: subsidiaries of foreign SB firms and non-SB firms.

In both cases, the estimates are more or less the exact opposite of the estimated direct effects in the top part of Table 20. This means that the effects identified as leading to a general upgrading rather than polarization among domestic scoreboard firms and their subsidiaries do not pertain to other firms except for an interesting exception: R&D is complementary to type High jobs in foreign SB subsidiaries as well as in domestic SB firms and their subsidiaries, but not in non-SB firms.

In the descriptive statistics it was noted that SB firms and subsidiaries – domestic or foreign – contribute to a general upgrading of the wage level and skill content of jobs from 2012 to 2013, whereas non-SB firms show polarization. This difference is not well explained in Table 20. In addition, the results in Table 20 have quite low R-squared - yet it is still surprising that internationalization, R&D and innovation are not factors that significantly affect polarization or have consistent effects on upgrading across the groups of firms. By using the data from the EU Industrial R&D Investment Scoreboard it may be possible to delve deeper into the unique factors that affect SB subsidiaries, but not firms that are not part of these R&D intensive multinational conglomerates. Specifically, we may add the effects of changes in sales and in R&D at the level of the parent firm. The results are presented in Table 21.

The first three columns of Table 21 report the result of fitting equation 4 to relatively small dataset of only 228 SB firms and subsidiaries for which complete data are available. There are three differences between the model and equation 14: the dummy for non-SB firms is naturally excluded and variables for parent company R&D and parent company sales are added. The first part of the table shows that there is very low substitutability between types High and Low and the production function is not homothetic.

Table 21 - Complementarity and substitutability among SB firms and subsidiaries

	Eq. 4, SB firms only			Eq. 4, SB firms only w/ interactions		
Parameter	High	Mid	Low	High	Mid	Low
α_{kHigh}	0.6320**	-0.0892	-0.5429**	0.4109	0.0487	-0.4597*
	(0.2883)	(0.2136)	(0.2744)	(0.3061)	(0.2406)	(0.2773)
α_{kMid}	-0.0892	-0.0188	0.1080	0.0487	-0.1024	0.0536
	(0.2136)	(0.2928)	(0.2728)	(0.2406)	(0.3333)	(0.2893)
α_{kY}	0.0313**	0.0047	-0.036**	0.0173	0.0097	-0.027*
	(0.0145)	(0.0128)	(0.0165)	(0.0144)	(0.0133)	(0.0162)
$\beta_{kExport}$	-0.0003	0.0034	-0.0032	0.0221**	0.0058	-0.0279**
	(0.0027)	(0.0024)	(0.0031)	(0.0101)	(0.0093)	(0.0112)
$\beta_{kImport}$	0.0042	0.0001	-0.0044	0.0182	-0.0060	-0.0123
	(0.0030)	(0.0027)	(0.0034)	(0.0121)	(0.0112)	(0.0138)
$\beta_{kR\&D}$	0.0075**	-0.0040	-0.0035	0.0118*	-0.0014	-0.0104
	(0.0035)	(0.0032)	(0.004)	(0.0062)	(0.0057)	(0.007)

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	Eq. 4, SB firms only			Eq. 4, SB firms only w/ interactions		
Parameter	High	Mid	Low	High	Mid	Low
β_{kProd}	-0.0102	0.0044	0.0057	-0.0256**	-0.0189*	0.0445***
	(0.0073)	(0.0066)	(0.0082)	(0.0121)	(0.0112)	(0.0133)
β_{kProc}	0.0071	0.0017	-0.0089	-0.1017***	-0.0303	0.1319***
	(0.0087)	(0.0076)	(0.0098)	(0.0247)	(0.0228)	(0.0279)
$\beta_{kMarket}$	-0.0097	-0.0200***	0.0296***	-0.0178	0.0094	0.0084
	(0.0075)	(0.0066)	(0.0085)	(0.0135)	(0.0125)	(0.0152)
$\beta_{kOrgExt}$	-0.0116	0.0290***	-0.0175**	-0.0244**	0.0482***	-0.0238**
	(0.0078)	(0.0068)	(0.0088)	(0.0105)	(0.0097)	(0.0118)
$\beta_{kOrgFor}$	0.0146	-0.0273***	0.0126	0.0473**	-0.0120	-0.0354
	(0.0098)	(0.0087)	(0.0111)	(0.0216)	(0.0201)	(0.0238)
$\beta_{kOrgWrk}$	0.0105	0.0116	-0.0222**	0.1111***	-0.0125	-0.0987***
	(0.0098)	(0.0087)	(0.0112)	(0.0229)	(0.0210)	(0.0258)
$\beta_{kp.R\&D}$	-0.0054	-0.0008	0.0061	0.0072	-0.0021	-0.0052
	(0.0068)	(0.0061)	(0.0079)	(0.0081)	(0.0078)	(0.0094)
$\beta_{kp.Y}$	0.0601**	-0.0384	-0.0217	0.1139**	-0.0729	-0.041
	(0.0280)	(0.0246)	(0.0319)	(0.0504)	(0.0471)	(0.0573)
γ_{kFRSB}	-0.0147**	0.0148**	-0.0002	-0.0833**	-0.0640*	0.1473***
	(0.0067)	(0.0060)	(0.0077)	(0.0359)	(0.0329)	(0.0403)
γ_{kSize}	-0.0029	0.0020	0.0008	-0.0100**	-0.0010	0.011**
	(0.0024)	(0.0021)	(0.0027)	(0.0039)	(0.0036)	(0.0043)
γ_{kManuf}	-0.0023	-0.0022	0.0044	-0.0226**	-0.0014	0.024**
	(0.0061)	(0.0055)	(0.007)	(0.0100)	(0.0095)	(0.0114)
Interactions with $FRSB_i$						
$\beta_{kExportFRSB}$				-0.0225**	-0.0019	0.0243**
				(0.0104)	(0.0095)	(0.0115)
$\beta_{kImportFRSB}$				-0.0152	0.0067	0.0084
				(0.0124)	(0.0115)	(0.0141)
$\beta_{kR\&DFRSB}$				-0.0048	-0.0058	0.0106
				(0.0072)	(0.0066)	(0.0081)
$\beta_{kProdFRSB}$				0.0273*	0.0138	-0.0412**
				(0.0158)	(0.0146)	(0.0176)

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	Eq. 4, SB firms only			Eq. 4, SB firms only w/ interactions		
Parameter	High	Mid	Low	High	Mid	Low
$\beta_{kProcFRSB}$				0.1059***	0.0379	-0.1438***
				(0.0266)	(0.0244)	(0.0301)
$\beta_{kMarketFRSB}$				0.0104	-0.0347**	0.0242
				(0.0160)	(0.0149)	(0.018)
$\beta_{kOrgExtFRSB}$				0.0289*	-0.0223	-0.0066
				(0.0148)	(0.0137)	(0.0166)
$\beta_{kOrgForFRSB}$				-0.0290	-0.0241	0.0531**
				(0.0236)	(0.0219)	(0.0262)
$\beta_{kOrgWrkFRSB}$				-0.1188***	0.0394*	0.0794***
				(0.0252)	(0.0231)	(0.0284)
$\beta_{kp.R\&DFRSB}$				-0.0200	0.0099	0.0100
				(0.0181)	(0.0168)	(0.0205)
$\beta_{kp.YFRSB}$				-0.0833	0.0642	0.0190
				(0.0579)	(0.0542)	(0.0657)
$\gamma_{kSizeFRSB}$				0.0063	0.0074	-0.0138**
				(0.0050)	(0.0045)	(0.0055)
$\gamma_{kManufFRSB}$				0.0225*	0.0125	-0.0351**
				(0.0128)	(0.0118)	(0.0143)
Constant	0.0397**	-0.0138	-0.0259	0.1065***	0.0338	-0.1403***
	(0.0200)	(0.0179)	(0.0234)	(0.0303)	(0.0283)	(0.0344)
Observations	228	228	228	228	228	228
R-squared	0.2315	0.2182	0.2174	0.3829	0.3170	0.3877

Note: SUR estimates. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Only the firm's own R&D expenditures and the parent firm's sales are found to be complementary to type High. However, when adding interactions (right part of Table 21), exports and organisational innovations involving formal structure or work organisation are also complementary to the type High among domestic SB firms and their subsidiaries. Only the effects of own R&D, parent's sales and organisational innovation involving formal structure also pertain to subsidiaries of foreign SB firms.

Organisational innovation involving external linkages or involving work organisation are substitutes for type Low jobs among domestic SB firms and their subsidiaries, thus being part of the explanation for the observed general upgrading of jobs. Organisational innovation involving external linkages are complementary to type Mid for both domestic SB firms and subsidiaries as well as foreign SB subsidiaries, while organisational innovation involving work organisation are complementary for type Mid in foreign SB subsidiaries only. Factors that substitute for type Low and hence contribute to general upgrading are organisational

innovation involving work organisation among domestic SB firms and their subsidiaries and organisational innovation involving external linkages for both groups of subsidiaries.

The results for product innovation and process innovation in tables 20 and 21 are difficult to explain. It appears that the two factors both shift employment towards type Low but only for subsidiaries of domestic SB firms. However, this may be caused by omitted variable bias since the effect of product innovation and, especially, process innovation are likely to go through organisational changes, and as we control for organisational innovations we account for the effect of product and process innovation already. However, it is also possible that the result is valid and that innovation driven growth hence is inclusive in the sense that it not only creates benefits for owners and employees at the top of the wage hierarchy, but also creates benefits in the form of employment possibilities at the lower end of the wage hierarchy (Dutz et al., 2011).

5.5 Scoreboard employees: mobility and wages

In this section of the report we move away from a firm-level analysis and conduct an individual level analysis on workers to investigate in greater detail the extent that workers in SB firms and subsidiaries and non-SB firms differ in terms of propensity to move and destination type of firm. Furthermore, it will be analysed how moving affects workers from these different types of firms. The longitudinal nature of the registry data allows for such a detailed investigation. Since the report relies on the population of private sectors employees in Denmark in 2012 and 2013, it makes it possible to set strict sample requirements to more precisely capture differences that are driven by being employed (and/or moving to) SB firms or subsidiaries.

In creating this sample, private sectors employees in Denmark in 2012 are taken as the starting point and it is investigated where these workers are employed the following year. To assure that mobility events are not driven by the exit of workplaces and firms, workers that work for a workplace and/or firm that closes down during 2013 are removed. Based on this criterion, it is possible to find just over 1.2 million workers where 12 percent work for a SB firm, which corresponds to the SB employment reported in Section 3.

Some differences in labour market status between workers in SB and non-SB firms from 2012 to 2013 can be observed (see Table 22). Non-SB workers are more inclined to change employer (13.4 compared to 8.03 percent); furthermore, a higher percentage of non-SB employees move to unemployment or have left the labour market. Consequently, total turnover among non-SB firm employees is higher.

In the analysis, the sample is limited to those that have a job in the following year i.e. either remain in the firm or change to a new employer. A multinomial logit model is employed to investigate the propensity for a worker to move to a non-SB firm and SB firm contrary to remain in the current firm. These models are presented in Table 23. Model 1 demonstrates that a worker in a SB firm or subsidiary is more likely to stay in a SB firm or subsidiary compared to moving to a non-SB firm. However, this worker is more likely to move to another SB firm or subsidiary when the opportunity arises. This provides evidence that labour market function more like labour flow networks rather than labour market pools (Guerrero and Axtell, 2013) Furthermore, we also see some clear distinction in the human capital characteristics for those workers that are inclined to move to a SB firm or subsidiary. First, higher educated workers, those with more overall work-experience and high skilled occupations are more inclined to move to SB firms or subsidiaries. Less tenure in the previous workplace and age is negatively related to move to a SB firm or subsidiary. Thus based on these results, SB firms and subsidiaries draw on workers that appear to be in a different segment from the labour market.

Table 22 - Labour market attachment in 2013

following year		Non-SB firm	SB firm	Total
Remain in the same firm	#	837,435	121,649	959,084
	%	*76.33*	*85.77*	*77.42*
To another firm	#	147,314	11,389	158,703
	%	*13.43*	*8.03*	*12.81*
Unemployed	#	24,358	2,028	26,386
	%	*2.22*	*1.43*	*2.13*
Outside the labour force	#	80,946	5,488	86,434
	%	*7.38*	*3.87*	*6.98*
dead/missing	#	7,021	1,267	8,288
	%	*0.64*	*0.89*	*0.67*
Unknown	#	31	8	39
	%	*0.00*	*0.01*	*0*
Total	#	**1,097,105**	**141,829**	**1,238,934**
	%	***100***	***100***	***100***

Source: SB data and DST's registries.

This raises concerns as to what extent the workers can be compared. To deal with this problem a matching strategy is applied to overcome some of these problems; more specifically, Coarsened Exact Matching is used (Iacus et al., 2012). This approach allows us to balance covariates between workers that are employed in SB firms or subsidiaries with workers in non-SB firms. Workers are placed in a finite set of bins based on individual level characteristics. Following this method, a new sample is created where SB employees that cannot be matched with non-SB employees and vice versa are discarded. The variables used for matching are gender, age categories, education levels, and wage quartile. To deal with industry and regional variation, industry sectors (NACE-21) and region of work (NUTS 3) are also used.

Following these criteria, a match is found for 95 percent of the SB employees and 62 percent of the non-SB workers, occupying 21,610 strata. Implementing CEM reduces the final sample from 1,169,909 to 835,100 workers. Running the multinomial analysis on this matched sample (Model 3 and Model 4) yield similar results although slightly weaker coefficient estimates.

In models 5 and 6, the SB firms and subsidiaries are divided into domestic and foreign to investigate whether there are differences in the mobility patterns of workers. This analysis shows that both forms of SB employees are more inclined to remain in the firm rather than to move to a non-SB firm and that the likelihood to move is mainly explained by those employed by foreign SB subsidiary. Model 7, Model 8 and Model 9 create an extra category in the dependent variable to measure the relation between the probability to move to a domestic or foreign SB firm or subsidiary. The findings demonstrate that employees in domestic SB firms and subsidiaries are more likely to move to a domestic SB firm or subsidiary, while employees in foreign SB subsidiaries are more likely to move to SB firms and subsidiaries in general, particular to other foreign SB subsidiaries. Thus overall, it shows that mobility is rather cliquish, meaning that SB employees limit their mobility pattern to within the population of SB firms and subsidiaries.

Table 24 takes the analysis one-step further and investigates the effect on wage growth. The dependent variable "Wage growth" is measured as changes in log wage: $log(wage_{t+1}) - log(wage_t)$. Model 1 in Table 24 looks at the wage growth of the full sample. Model 2 measures wage growth in the observations where a match between non-SB employees and SB employees was obtained, while Model 3 is the strongest specification where CEM Strata fixed effects are created, meaning that wage growth differences among matched employees are in focus. All these models show that workers employed at a SB firm or subsidiary experience higher wage growth. In the strongest specification, this wage growth is approximately 2.8 percent, but moving to a scoreboard firm means a wage increase of 12.5 percent or roughly a difference of 1.5 months of salary. Tests for interaction effects of being employed at a SB firm or subsidiary and moving to another SB firm or subsidiary have been undertaken but are not reported as these interaction effects did not show any significant effects, meaning that the overall effect is additive.

Table 23 – Propensities to move to a new job

	1	2	3	4	5	6	7	8	9
VARIABLES	Non-SB firm	SB firm	Non-SB firm	SB firm	Non-SB firm	SB firm	Non-SB firm	foreign SB	Domestic SB
CEM	no	no	sample	sample	sample	sample	sample	sample	sample
industry and region FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Scoreboard firm (any)	-0.1453***	0.4854***	-0.1339***	0.4608***					
	(0.030)	(0.078)	(0.030)	(0.081)					
Scoreboard firm (domestic)					-0.1221*	0.2338	-0.1221*	-0.2421	0.4986**
					(0.054)	(0.146)	(0.054)	(0.174)	(0.181)
Scoreboard firm (foreign)					-0.1405***	0.5835***	-0.1405***	0.7217***	0.3946***
					(0.032)	(0.081)	(0.032)	(0.094)	(0.119)
Gender	-0.0005	-0.1183***	-0.0104	-0.0949**	-0.0104	-0.0951**	-0.0104	-0.1170**	-0.0645
	(0.007)	(0.027)	(0.009)	(0.031)	(0.009)	(0.031)	(0.009)	(0.041)	(0.047)
age	0.0022***	-0.0479***	0.0140***	-0.0435***	0.0140***	-0.0437***	0.0140***	-0.0414***	-0.0470***
	(0.000)	(0.002)	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)	(0.004)	(0.004)
education (yrs)	-0.0034*	0.1220***	-0.0113***	0.1161***	-0.0113***	0.1161***	-0.0113***	0.0938***	0.1405***
	(0.002)	(0.008)	(0.002)	(0.009)	(0.002)	(0.009)	(0.002)	(0.011)	(0.013)
Experience (yrs)	-0.0202***	0.0109***	-0.0328***	0.0061+	-0.0329***	0.0063+	-0.0328***	0.0087+	0.0043
	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)	(0.005)	(0.005)
Tenure (in previous firm)	-0.0646***	-0.0986***	-0.0588***	-0.0949***	-0.0588***	-0.0957***	-0.0588***	-0.1113***	-0.0787***
	(0.002)	(0.006)	(0.002)	(0.006)	(0.002)	(0.006)	(0.002)	(0.007)	(0.008)
wage (log)	-0.4386***	-0.0307	-0.4746***	-0.0298	-0.4746***	-0.0280	-0.4746***	-0.0178	-0.0354
	(0.005)	(0.020)	(0.006)	(0.025)	(0.006)	(0.025)	(0.006)	(0.032)	(0.038)
occuH	-0.1323***	0.4366***	-0.1080***	0.4328***	-0.1079***	0.4254***	-0.1079***	0.3795***	0.4894***
	(0.014)	(0.041)	(0.018)	(0.046)	(0.018)	(0.046)	(0.018)	(0.055)	(0.072)
occuM	-0.0369**	0.1509***	-0.0592***	0.1373**	-0.0591***	0.1377**	-0.0591***	0.0737	0.2288**
	(0.012)	(0.043)	(0.015)	(0.048)	(0.015)	(0.049)	(0.015)	(0.059)	(0.078)
Constant	4.7657***	-3.6690***	5.0281***	-3.7335***	5.0275***	-3.7418***	5.0275***	-4.2538***	-4.6795***
	(0.066)	(0.249)	(0.083)	(0.304)	(0.083)	(0.303)	(0.083)	(0.394)	(0.454)
Observations	1,169,909	1,169,909	835,100	835,100	835,100	835,100	835,100	835,100	835,100
Pseudo-R2	0.116	0.116	0.120	0.120	0.120	0.120	0.119	0.119	0.119
Log Likelihood	-589521	-589521	-404658	-404658	-404636	-404636	-409073	-409073	-409073

Note: Robust standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0.1.

Table 24 - Wage growth upon moving

	(1)	(2)	(3)
VARIABLES	wage_change_log	wage_change_log	wage_change_log
CEM	no	sample	Strata FE
industry and region FE	yes	yes	yes
Move to scoreboard firm	0.1550***	0.1453***	0.1231***
	(0.005)	(0.006)	(0.007)
Scoreboard firm	0.0472***	0.0436***	0.0273**
	(0.008)	(0.009)	(0.009)
Gender	-0.0721***	-0.0737***	
	(0.004)	(0.004)	
Age	-0.0055***	-0.0064***	-0.0133***
	(0.000)	(0.000)	(0.001)
education (yrs)	0.0396***	0.0415***	-0.0005
	(0.001)	(0.001)	(0.003)
Experience (yrs)	0.0121***	0.0130***	0.0137***
	(0.000)	(0.001)	(0.001)
Tenure (in previous firm)	-0.0009***	-0.0009***	-0.0012*
	(0.000)	(0.000)	(0.001)
wage (log)	-0.4452***	-0.4324***	-0.6568***
	(0.003)	(0.004)	(0.006)
occuH	0.1714***	0.1567***	0.0965***
	(0.005)	(0.006)	(0.006)
occuM	0.0329***	0.0231***	0.0187**
	(0.005)	(0.006)	(0.006)
Constant	5.0455***	4.9179***	8.3316***
	(0.034)	(0.041)	(0.079)
Observations	159,355	106,888	106,888
R-squared	0.330	0.322	0.451

Note: Robust standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0.1

6 Conclusions

The general trend in the Danish economy is towards polarization in jobs, where jobs that are middling in terms of skills and wages disappear and High and Low jobs become more abundant. However, the detailed analyses in this report focus specifically on changes in the private sector from 2012 to 2013, which shows general upgrading of jobs, where Low jobs decline in share while High and to a lesser extent Middling jobs become relatively more abundant. This change is particularly strong among the firms that appear on the EU Industrial R&D Investment Scoreboard and their subsidiaries. These few hundred firms account for more than 10 percent of total private sector employment in Denmark and almost two thirds of private sector R&D in Denmark.

The report relies on two sources of data: freely available data from JRC-B3-IRITEC, and registry and survey data from DST with strict confidentiality requirements. The JRC-B3-IRITEC data show the identity of the SB firms and the domestic SB firms in Denmark can be seen to be household names in general. And so are many of the foreign SB firms undoubtedly. 769 subsidiaries of SB firms, probably including most of the domestic SB firms themselves, can be identified in the DST data and the confidentiality requirement entails that it is not possible to be more specific regarding the firms' identities. It is shown, however, that SB firms and their subsidiaries pay high wages, hire relatively skilled employees and locate throughout the country – not just around the economic centres. Thus there are strong indices that SB firms and subsidiaries are desirable.[12]

In the regression analysis of SB firms' role in structural change in the Danish labour market a number of specific factors particular to SB firms and subsidiaries were identified. The subsidiaries' own R&D and the parent firms' sales are both complementary to High skill jobs overall, but organisational innovations also play an important if complicated role. Organisational innovations that affect work organisation are complementary to Middling skill jobs in foreign SB subsidiaries and complementary to High in domestic SB subsidiaries, where it is also a substitute for Low skill jobs. Organisational innovation that affect formal structure is complementary to type High among domestic SB subsidiaries but complementary to type Low among foreign subsidiaries. Finally, organisational innovation affecting external linkages substitutes for type Low and complements type Mid in general and, for subsidiaries of domestic SB firms, also substitutes for type High. These differences are summarised in Table 25.

Table 25 - Effects of organisational change on jobs

SB group	Dimension of organisational change	Job type		
		High	Middling	Low
Domestic	Work Organisation	Complements	-	Substitutes
	Formal structure	Complements	-	-
	External linkages	Substitutes	Complements	Substitutes
Foreign	Work Organisation	-	Complements	-
	Formal structure	-	-	Complements
	External linkages	-	Complements	Substitutes

Note: "Domestic" are domestic SB firms and their subsidiaries. "Foreign" are foreign subsidiaries

While the effects are complicated the pattern is clear: organisational change in SB firms and subsidiaries upgrade jobs in Denmark. When extending the analysis to include also firms that are not subsidiaries of SB firms the results are qualitatively very similar, but it

[12] As far as firms and jobs are created and not just "acquired" by the SB firm or their subsidiaries.

is also apparent that there are a number of effects in addition to our focus on innovation, R&D and internationalisation that must affect the observed shifts in types of jobs.

The econometric analyses substantiates what the descriptive statistics indicates: wages are higher in SB firms and subsidiaries; wage growth is higher in these firms and workers moving to such firms will on average experience a significant increase in wage. In addition, the SB firms and subsidiaries to some degree form a sub labour market within the labour market in the sense that workers exhibit higher mobility within this group of firms than between this group and the rest of the labour market.

A number of interesting effects of organisational change on jobs were identified, while the results for the effects of other forms of innovation were less clear. Further analyses should explore the interaction between these factors since it seems likely that the effects on jobs of introducing new products, new processes or new marketing techniques are intertwined with simultaneous organisational changes. A second promising route for contributing additional details to the results would be to take into account explicitly that the data contain many relatively large firms with multiple workplaces. At such firms the effects e.g. product innovation and R&D are not likely to be observed at the same workplaces. They may even be in different regions.

Polarization in the labour market is an undesirable outcome but since it was not observed in the data available for this report, it is not possible to advise how to avoid it. The data exhibited a general upgrading instead which may be a positive thing, but it may also be negative if framed differently: that jobs requiring a high level of skills are becoming more abundant relative to jobs requiring less skill can also be framed as skill biased change instead. The upgrading trend is particularly strong among SB firms and subsidiaries so assuming that the trend is deemed desirable then attracting and creating such firms is also desirable. The analysis presented in this report does however not deal with attracting or creating such firm but with changes within existing SB firms and subsidiaries. Based on these results domestic SB firms are found to be the primary source of upgrading and, in particular, in cases where they undergo organisational change and have high R&D expenditures.

SB firms and subsidiaries contribute to upgrading of skills and jobs, and therefore it is no surprise that they pay higher wages. However, the wages also grow at a higher rate and employees moving to an SB firm or subsidiary can expect a wage premium from the onset. Such higher wages imply that jobs at SB firms and subsidiaries are relatively knowledge intensive and the mobility within the group of SB firms and subsidiaries suggests that also knowledge flows between these firms. A challenge for policy would be to encourage this knowledge to flow also to the remaining parts of the economy, including encouraging spin-offs from SB firms to ensure that there will be domestic SB firms in the future too.

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Appendix – the SUR model

The starting point of the model is a production function of arbitrary functional form. Output is referred to as Y. No restrictions are placed on returns to scale or substitution among the factors of production. The inputs are different types of labour ($\boldsymbol{L}$) and technologically varying factors ($\boldsymbol{A}$) such as physical capital, organisational structure and external linkages. $\boldsymbol{A}$ and $\boldsymbol{L}$ are therefore vectors. Bold type refers to vectors in the following.

$$Y = f(\boldsymbol{L}, \boldsymbol{A}). \tag{7}$$

The demand for labour of type k depends on output level, on the vector of wages ($\boldsymbol{w}$) and on technology. Total wage costs follow directly from summing over the types of labour.

$$L_k = L_k(Y, \boldsymbol{A}, \boldsymbol{w}), \tag{8}$$

$$C = \sum_k w_k L_k(Y, A, \boldsymbol{w}) = C(Y, \boldsymbol{A}, \boldsymbol{w}). \tag{9}$$

The Taylor polynomial of the cost function of order two at $[Y, \boldsymbol{A}, \boldsymbol{w}] = \mathbf{1}$ is then computed. $[Y, \boldsymbol{A}, \boldsymbol{w}] = \mathbf{1}$ is referred to as the expansion point. This becomes a very tedious expression since it involves all first and second order partial derivatives of the wage cost function evaluated at $[Y, \boldsymbol{A}, \boldsymbol{w}] = \mathbf{1}$. But by ignoring $\boldsymbol{A}$ in this appendix, the derivation becomes much less tedious. Had $\boldsymbol{A}$ been included it should be treated analogously to Y. See e.g. equation 9 in Sanders and ter Weel (2000) for an example of a very long Taylor approximation to a cost function. Equation 10 is the Taylor approximation to the cost function, equation 9, ignoring $\boldsymbol{A}$ for now.

$$\begin{aligned} \mathrm{Ln}\, C(Y, \boldsymbol{w}) \approx C(\mathbf{0}) + \sum_i \frac{\partial C(Y,\boldsymbol{w})}{\partial \ln w_i} \ln w_i + \frac{1}{2} \sum_{i,j} \frac{\partial^2 C(Y,\boldsymbol{w})}{\partial \ln w_i\, \partial \ln w_j} \ln w_i \ln w_j + \frac{\partial C(Y,\boldsymbol{w})}{\partial \ln Y_i} \ln Y + \\ \sum_i \frac{\partial^2 C(Y,\boldsymbol{w})}{\partial \ln w_i\, \partial \ln Y} \ln w_i \ln Y + \frac{1}{2} \frac{\partial^2 C(Y,\boldsymbol{w})}{\partial (\ln Y)^2} (\ln Y)^2. \end{aligned} \tag{10}$$

The derivatives are all constant at the expansion point and so is the function itself. Hence, we can consider them as coefficients and rewrite equation 10 as

$$\ln C(Y, \boldsymbol{w}) = \alpha_0 + \sum_i \alpha_i \ln w_i + \frac{1}{2} \sum_{i,j} \alpha_{ij} \ln w_i \ln w_j + \alpha_Y \ln Y + \sum_i \alpha_{iY} \ln w_i \ln Y + \frac{1}{2} \alpha_{YY} (\ln Y)^2 + \epsilon \tag{11}$$

where ϵ is a classical error and also includes the remainder from the Taylor approximation. If it is assumed that given the output level, a proportional increase in all wages leads to a proportional increase in total wage costs, then the sum of the direct wage effects must equal one, $\sum_i \alpha_i = 1$, and the sums over the interaction effects must equal zero, $\sum_{i,j} \alpha_{ij} = \sum_i \alpha_{iY} = 0$.[13] The aim is to use the cost function to estimate firms' demand for different types of labour and the wage cost share of labour type k can be computed as

$$\frac{\partial \ln C(Y,\boldsymbol{A},\boldsymbol{w})}{\partial \ln w_k} = \frac{w_k L_k}{C} = s_k. \tag{12}$$

Writing equation 11 in terms of wage cost shares, as equation 12, taking the assumed parameter constraints into account and reintroducing the vector $\boldsymbol{A}$ yields:

$$s_k = \alpha_k + \sum_i \alpha_{ki} \ln w_i + \alpha_{kY} \ln Y + \sum_n \beta_{kn} \ln A_n + u_k. \tag{13}$$

With K types of labour and N elements in the vector $\boldsymbol{A}$ indexed by n this is a system of K equations with identical regressors and each equation has $1 + K + 1 + N$ parameters to be estimated. This is a Seemingly Unrelated Regression model where the interdependence among the equations is created from the fact that cost shares must necessarily sum to one and the errors of the equations will be perfectly correlated. This means that the system is singular cannot be estimated. That the wage cost shares must sum to one

[13] I.e. the cost function is homogenous of degree one in wages

means that $\sum_k \alpha_k = 1$ and $\sum_k \alpha_{ki} = \sum_k \alpha_{kY} = \sum_k \alpha_{kn} = 0$. This follows from the fact that a positive effect on one cost share must necessarily be balanced by a negative effect on another cost share. Thus, it is sufficient to estimate $K-1$ equations, which, contrary to estimating the system of K equations, is possible. Therefore, one equation is removed from the system and the remaining $K-1$ equations are estimated with maximum likelihood. It is inconsequential which equation is excluded (Greene, 2000, p. 642). Since it was assumed that the wage cost function is homogenous of degree one in wages, the parameters of equation 13 are restricted by $\sum_i \alpha_{ki} = 0$. In other words: a proportional increase in all wages increases total costs in the same proportion but does not affect the wage cost shares. In order to implement this restriction one of the wage variables is used as numeraire.

In this study of the change in the demand for labour types by occupational category equation 13 will estimated in differenced form (Δ). This is a common approach to eliminate fixed effects such as the business cycle that might affect both wage cost shares and the independent variables (See Piva et al. (2005) and Caroli and Van Reenen (2001) for examples, and Greene (2000) p. 643 for an alternative). Equation 14 is thus the general form of the models that will be estimated. The wage for labour type j is used as numeraire.

$$\Delta s_k = \sum_{i \neq j} \alpha_{ki} \Delta \ln \left(\frac{w_i}{w_j}\right) + \alpha_{kY} \Delta \ln Y + \sum_n \beta_{kn} \Delta \ln A_n + \Delta u_k \qquad (14)$$

Restrictions on returns to scale and elasticities of substitution may be imposed on the parameters (Christensen and Greene, 1976) but we follow and Caroli and Van Reenen (2001) and keep the specification flexible and follow their definition of complementarity between labour and technology: if $\beta_{nk} > 0$ then there is a complementarity between labour type k and the n'th variable in the vector of technology variables. In other words, as technology increases the demand for type k labour increases too, so that its wage cost share increases.[14] However, for consistency the implied elasticities of substitution must be identical across equations meaning that the parameters must be restricted across equations so that $\alpha_{ki} = \alpha_{ik}$. E.g. in the equation for type High the effect of the wage of type Middling must be the same as the effect of the wage of type High in the equation for type Middling.

A final remark about the general model is that there is still a risk of endogeneity in equation 14 since any shock to w_k on the right side will by definition also affect the left-hand side. This can be handled by either instrumenting the wages on the right by region, time and industry dummies (Caroli and Van Reenen, 2001) or by estimating labour shares instead of wage costs shares (Piva et al., 2005). In this report labour shares are estimated rather than wage cost shares in order to analyse polarization specifically.

[14] The elasticity of substitution between two types of labour can be computed as

$$\sigma_{ki} = \frac{\alpha_{ki} + s_k s_i}{s_k s_i}, \qquad (15)$$

while a study of scale economies would require estimating equation 6, the total wage cost function (Christensen and Greene, 1976). The elasticity of substitution should be interpreted as the change in the wage cost share of labour type k relative to type i when the relative wage between the two types of labour changes. A value greater than 1 means that if w_k/w_i increases then the costs share of k decreases as substitution towards i cancels out the effect of the wage increase, and vice versa: if $\sigma_{ki} < 1$ then the two types of labour are complements. Thus if $\alpha_{ik} = 0$ then there is unit elasticity of substitution between labour types i and k. As equation 15 shows the elasticity of substitution is not constrained to be constant when using a translog functional form.

List of abbreviations

CEM – Coarsened Exact Matching

DKK – Danish Kroner

DST – Statistics Denmark

FTE – Full-time equivalent

FUI survey – R&D and Innovation survey

ISCO – International Standard Classification of Occupations

JRC-B3-IRITEC – European Commission Joint Research Centre, Territorial Development Unit, Economics of Industrial Research and Innovation

MNE – Multinational Enterprise

NACE – Statistical Classification of Economic Activities in the European Community

NUTS – Classification of Territorial Units for Statistics

OLS – Ordinary Least Squares

Pp – Percentage point

R&D – Research and Development

SB – Scoreboard

Std Dev – Standard deviation

SUR – Seemingly Unrelated Regression

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