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Changes in the occupational structure of Nordic employment: Upgrading or polarization?

Nordic future of work project 2017–2020: Working paper 2

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Abstract

This paper studies whether the occupational structure in Nordic labour markets is changing in the direction of upgrading or polarization. Upgrading refers to an increase of employment in highly skilled/paid occupations, while low-skilled/paid jobs decline. Polarization refers to simultaneously growing shares of employment in occupations in the high and low ends, while the share of occupations in the middle declines. According to previous research, there are some indications of polarization in Nordic labour markets in recent decades, although the evidence is not conclusive. The empirical data of this study stem from the Labour Force Surveys in Denmark, Norway and Sweden the period 2000-2015. The results show clear tendencies towards polarization in Denmark, especially after the 2008 crisis, while upgrading is the dominant tendency in Norway in recent years. The tendencies in Sweden lie between these two countries, showing clear upgrading in the public sector and modest signs of polarization in private sector. By studying the occupational changes in more detail, we find some evidence suggesting that technological change is a main driver of change. However, the analysis also indicates that political and economic factors influencing labour demand in the public and private sector respectively are important to take into consideration to understand occupational change in the Nordic region.

Key Words: occupational change, upgrading, polarization, technological change, Nordic model

Preface

This is Working Paper No 1 in the cross-disciplinary project *"The future of work: Opportunities and challenges for the Nordic models"*, which is funded by the Nordic Council of Ministers and coordinated by Fafo. The project studies how ongoing changes in the labour market associated with, amongst other, digitalization, demographic change, and new forms of employment will influence the future of work in the Nordic countries. It is conducted by a team of more than 30 Nordic scholars from universities and research institutes in Denmark, Finland, Iceland, Norway, and Sweden.

This working paper emerges from the project *pillar-2, "Digitalization and robotization of traditional work"*, where the research team comprises Bertil Rolandsson (coordinator), Tomas Berglund, and Anna Hedenius (University of Gothenburg), Anna Ilsøe and Trine Pernille Larsen (FAOS, University of Copenhagen), Stine Rasmussen (CARMA, Aalborg University), Tuomo Alasoini (TTL, Finland), and Johan Røed Steen and Jon Erik Dølvik (Fafo). The work on this paper has partly also drawn on funding from the project "The Challenges of Polarization on the Swedish Labour Market" (Forte Dnr: 2016-07204). As work in progress, the paper will be updated by including analyses of occupational change in Finland later in 2019. In parallel with this initial quantitative study of occupational change, the pillar-2 team has interviewed representatives of plant management and trade unions about their experiences with adoption of digital production technology in a selection of Nordic machinery industry companies (see Rolandsson et al. 2019). In fall 2019, these will be followed up by an exploratory study of digital change in the services sectors.

We would like to thank members of the NCM reference group for useful comments on an earlier presentation of the analyses in this paper, and, the information unit at Fafo for, as always, their swift professional help in bringing the paper into proper shape.

Tomas Berglund,
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Introduction

The Nordic countries have been renowned for their ability to sustain 'high-road" labour markets. This refers to labour markets combining high employment rates with increasing shares of high quality jobs with good work environments and high wages (Regini 2000). Generally, this success has been ascribed to the so-called Nordic model – distinguished by policy coordination between strong labour market partners, and the state providing social security and stable labour demand (see Dølvik et al. 2014). However, during the past decades, the picture of this success has been challenged by instances of increased unemployment, stagnant employment and welfare retrenchments. Still, the Nordic model seems to be resilient and continues to combine relative egalitarian societies with solid growth.

A new challenge to the Nordic high road seems to come with technological changes related to digitalization. This new technology is described to have pervasive impact on labour markets and societies (Brynjolfsson and McAfee 2017). One effect observed in recent decades both in Europe and North America is the so-called polarization of labour markets. Polarization refers to simultaneously growing shares of employment in high- and low-paid occupations, while the share of middle-paid occupations decline. There are some indications that similar tendencies also have reached the Nordic labour markets (Böckerman et al. 2018; Åberg 2015), although the evidence is not conclusive (Eurofound 2017). Still, if labour market polarization is evolving also in the Nordic economies, it challenges some of the core values of the Nordic model, notably an even distribution of good jobs and income opportunities.

The present study analyses changes in the occupational structure in three Nordic countries[1] – Denmark, Norway and Sweden – during the period 2000 to 2015. Using the general wage levels of occupations to divide the workforce in 5 wage quintiles, we study how the number of employed persons have changed in the different wage quintiles. We describe in which occupations main changes have taken place, and analyse socio-demographic factors, e.g. gender, age and origin, as well as education and type of contract, that are related to the placement in the occupational structure. The data used for the comparisons are a combination of national Labour Force Surveys (LFS) and wage-data from the three countries.

The paper starts with some theoretical considerations regarding labour market changes and continues with a presentation of data and methods. Thereafter, the results are presented. First, overall employment growth in the occupational structure for two time periods – 2000-2010 and 2011-2015 – are shown for the three countries, as well as more detailed analyses of developments in major categories of occupations. Second, the distribution of social categories (gender, age, origin etc.) within the occupational structure is described. Finally, a specific analysis of occupational change within manufacturing industry and the private and public sector is presented. The report ends with a discussion of the main results.

[1] In a forthcoming version, also Finland will be included in the analysis.

Labour Markets and Occupational Change

In all labour markets, employers' demand for labour – that is, the number of workers needed as well as their qualifications and skills – is in constant change. In the short-term, demand fluctuations due to shifts in the business cycle create swings in unemployment and employment. However, in the long run, other factors come to the fore. New inventions and rising wealth creating changing preferences, alongside altering needs (e.g. due to demographic changes) in the population, affect the product markets of goods and services. Production systems react to these changes by offering the new products that are in demand and less of those in decline. Such adjustments can change the employers' need for labour, and in particular, the skills and competencies in demand. Usually, such changes mean that new companies and industries grow and old ones decline, prompting between-industry change (see Böckerman et al 2018).

New production methods as well as the organization of business also affect and alter the demand for labour within existing companies. The last decades' digitalization has been described as a new industrial revolution that fundamentally transforms production methods – every routinized work process can in principle be overtaken by robots or computerized applications. Artificial intelligence makes it probable that also more advanced cognitive work tasks can be replaced in the future. Furthermore, information and communication technologies make it possible for businesses to re-organize in time and space. They are now able to coordinate production processes over vast distances, and move essential business activities into virtual realities of platforms and digital networks.

All of these factors gradually, but sometimes rather rapidly, affect the occupational structure. An occupation is usually defined as a bundle of work tasks (Taylor 1968). To perform these tasks, the worker needs skills – sometimes rather basic (communicative skills, physical able), but often these skills are complex (e.g. problem-solving, creativity, esthetical knowledge) (see Acemoglu and Autor 2011: 1075ff). Long-term changes in the occupational structure will therefore reflect shifts in the sets of skills that are in demand in the labour market.

In much research on occupational change, wages of occupations have been used as an indicator for the price of skills in a job or occupation, implying that a higher wage mirrors a higher skill-level (Autor et al 2003; Manning et al 2014). This assumption is certainly a simplification, as wages are a more complicated function of the productivity of jobs, labour supply, monitoring problems related to work tasks, turnover risks, and institutional factors – most importantly the system of industrial relations (e.g. union strength) and collective bargaining. In the current study, however, we will stick to the assumption that wages to a large extent mirror skill-levels. The relative wages of occupations are rather stable over time, that is, the rankings of the wages of occupations do not change much (Eurofound 2018). Consequently, by studying changes in the distribution of employees within the occupational/wage structure, we can track the levels of skills that are in increasing or decreasing demand in the economy. In the present study, as in the vast majority of research in this area, we use the wage-approach to study occupational change.

Upgrading or polarization of labour markets

Many scholars describe the present period of technological progress as a new industrial revolution in which 'digitalisation' has a profound and pervasive effect on the patterns of production and work. The concept refers to computerization, robotization and ICT or, more generally, all processes that can be programmed and operated with computers (Brynjolfsson and McAfee 2017). The new technology is expected to have huge impact on the occupational structure, that is, the work tasks conducted in the production system, and thereby the skills in demand in the labour market.

Economists noticed rather early changes in the occupational structure that they related to digital technological change. In the United States, the demand dropped for low-skilled labour during the period 1970–1990, while the demand for highly skilled employees went in the opposite direction (Berman, Bound and Machin 1998; Katz and Murphy 1992). These changes were explained with the theory of Skill Biased Technological Change (SBTC), which asserts that the new technologies (computers, ICT, robotics) decrease the demand for low-skilled employees by substituting them with new labour-saving technology. The productivity of highly skilled, on the other hand, was enhanced by the new technology. In general, this development was viewed rather positively, described as an upgrading of the occupational structure (Oesch 2013).

However, in recent decades a new pattern of occupational change has been observed. Autor et al. (2006) shows that in the US from 1990 to 2000, not only high paid employment, but also the numbers of the lowest paid jobs grew as well, while jobs in the middle of the occupational/wage structure was stagnating or decreasing. This pattern was described as a polarisation of the US labour market. According to Autor et al. (2003; 2006), the digital technology enhanced the productivity of non-routine cognitive tasks while taking over routine tasks (both cognitive and manual; for example, bookkeeping, clerical work, routine production work) often situated in the middle of the occupational structure. They called this effect Routine-Biased Technological Change (RBTC). However, labour performing non-routine manual tasks (for example, those of hairdressers, waiters, childcare workers) was more or less untouched by computerization and continued to grow. Thus, the substitution of routine workers by computerization decreased the number of jobs in the middle of the occupational structure, while the numbers at both ends of the occupational structure continued to grow.

Several additional explanations of the changing occupational structure in the US have been proposed. According to Oldenski (2014), occupations in the middle of the distribution are sensitive to international cost competition; offshoring production to low-paid countries could therefore also contribute to the decline. However, the evidence of offshoring affecting job polarisation is weak (Autor and Dorn 2013; Goos et al. 2014). Moreover, researchers have explained the growth of jobs at the low-paid end by increased purchasing power in the higher strata, raising the demand for personal services (Mazzolari and Ragusa 2013). Beside technological and economical

factors, the diverse patterns of occupational change in the European area (Fernandez-Macias 2012; Eurofound 2017) have been suggested to be affected by policies and institutions, although conclusive empirical evidence of how these affect tendencies of upgrading or polarization of the occupational structure is still missing.

There is evidence of similar patterns as in the US also in other countries. Goos and Manning (2007) showed that in the United Kingdom, the labour market polarised during the period 1979–1999. In Germany, Dustmann et al. (2007) found similar trends. However, in a European comparative study of the period 1995–2007, Fernández-Macías (2012) found diverging patterns of both upgrading and polarisation. In a recent report studying the period 2011–2016, diverging patterns are again visible among the European countries (Eurofound 2017).

In the Nordic region, there are some studies of changes in the occupational structure. Asplund et al. (2011) compare three Nordic countries (FI, NO, SE) with the US over the years 1995-2006 and find polarization tendencies in all the three countries. The strongest tendency was found in Norway. In three Swedish studies, polarization has been shown. Comparing three time periods, Åberg (2015) found that during the last studied period (2008–2012) polarisation replaced the upgrading initially seen (1997–2002). Adermon and Gustavsson (2015) also discern a pattern of job polarization. They study the period 1975 to 2005 showing an increasingly polarized pattern in the latter years of the period (1990-2005). Heyman (2016) found a polarized occupational structure in Sweden analyzing the period 1996 – 2013, showing that beside between-firm polarization, also within-firm polarization is taking place. In Finland, Böckerman et al. (2018) also find a polarized change of the occupational structure, at least in the latter period of comparison (2002-2008). Moreover, they show that within-company change works in the direction of routine occupations being replaced by abstract non-routine jobs driven by increased use of ICT at the firm level. The growth in service occupations in the lower end of the wage distribution is instead an effect of reallocation between businesses, implying that new demand (for services) drives the change.

The current analysis adds to the few comparative studies that have been conducted in the Nordic region, and both includes more resent years and a longer timespan (2000-2015) than most previous studies. Moreover, we also focus on the significance of private and public employment, which should be an important institutional factor in the Nordic area, and to our knowledge previously not included in these kind of analyses.

Data and Methods

The present study on occupational change in Denmark, Norway and Sweden is based on the Labour Force Survey (LFS) in the three countries, which includes detailed data of the labour market status of the adult population. In particular, the LFS includes data on occupation in accordance with the international ISCO classification. The basic rationale of the study is to calculate the occupational distribution the first year of the study, and compare with changes in the distribution in later years. We focus our comparisons of occupational changes on the period 2000-2015. However, in both Denmark and Norway there is a break in the occupational classification the years 2010/11, when an updated version of ISCO was introduced. This means that the comparisons have to be conducted for two different periods in those countries. In Sweden, there is no brake in the series between 2000 and 2015, but the analysis of the Swedish data will be adapted to the breaks in the other countries for the purpose of comparisons.

The focus of analysis is not on occupation per se, but the so called Occupational-Wage Structure (OW-Structure). The basis for the OW-Structure is, firstly, occupation. In Sweden, occupation is in the whole period classified according to SSYK-96 on 3-digit level (very similar to ISCO-88), including 113 different occupations in the data. In Denmark, occupation is based on DISCO-88 the period 2000-2010 and DISCO-08 from 2011 and onwards. DISCO-88 and DISCO-08 are the Danish versions of ISCO-88 and ISCO-08 and comparable with the international classification down to 4-digit level. In the Danish LFS, occupation is available on 3 digit level with around 125 different occupations in the data. In Norway, occupation is classified according to STYRK for the period 2000-2010 and according to STYRK 08 from 2011 and onwards. STYRK and STYRK-08 are the Norwegian versions of ISCO-88 and ISCO-08, compatible with the international classification down to 4-digit level, albeit with some modifications. Occupation is studied at 3-digit level, with 121 occupations in the data.

Secondly, to each occupation is linked the full-time mean or median wage. These wages are based on different sources. In Sweden, the so-called Wage Structure Statistics are used (lönestrukturstatistiken). This register collects wages recalculated to full-time monthly equivalents, reported as median wage, and include individuals 18-64 years (66 years since 2014). SCB excludes some individuals from the statistics, e.g. persons with less than 5 percent employment (of full time), or being in active labour market measures. All public organizations are included, as well as private companies with more than 500 employees. For private businesses with a fewer number of employees, the information is collected by a survey addressed to companies. About 50 percent of all employees in the private sector are thereby included in the statistics.

In Denmark, the Wage Structure Statistics (lønstrukturstatistikken) is used for the period 2011-2015. The register collects a number of different wage components. All wage-earners are included, except those employed by companies within the sector 'agriculture, forestry and fishing' and private companies with less than 10 full-time employees. In both the public and the private sector, persons who work very short

hours, who are not employed on ordinary terms, and persons for whom it is not possible to decide the number of hours worked are excluded. For the analyses we have used the wage component called 'standardberegnet månedsfortjeneste'. It is equivalent to a full-time monthly wage and includes a number of different wage components (basic pay, various pay supplements, bonuses and pension).

In Norway, data from the Wage Statistics (lønnsstatistikken) is used. From 2015, this statistic is based on register data of monthly wages for all employees from compulsory tax reports (a-ordningen). For years before 2015, the data is based on surveys covering a representative sample of all employees. For the purpose of this study, we include individuals 18-64, with more than 5 percent employment and a monthly wage above 44 percent of the median wage. Monthly wages are then recalculated to full-time equivalents, before the median monthly wage is calculated for each occupation.

In the present study, we use the wage distribution across occupations for the latest year as a basis for ranking occupations from lowest to highest pay. There is no real consensus in research about which wages over a time period that should be the basis for ranking occupations. In some studies, wages in an arbitrary single year during a time-period are used, mainly due to data availability (see Eurofound 2017). Others use the median wage over a whole time-period (Åberg 2015). In the present study, we use the latest available year in the time series. One argument for this choice is that the processes in focus here are expected to influence relative wages over time, in particular in the two tails of the distribution (Acemoglu and Autor 2011). On the other hand, the ranking of the OW-structure is expected to be rather stable over time. Testing this assumption in Sweden, correlating the rank of occupations year 2000 with 2013, the r^2 value is 0.92 indicating a very strong correlation (i.e. the ranking 2000 explains 92 percent of the ranking 2013).

Due to the changes in the occupational classification in Denmark and Norway, different comparison periods will be used. The most complete and comparable data refer to the period 2011-2015. In Sweden, year 2013 is the latest available year with wages according to the SSYK-96 and is used as a basis to calculate the OW-structure during this period (2011-15). In Denmark, it is possible to connect wages (standardberegnet månedsfortjeneste) to DISCO-08 from 2011 and onwards, and 2015 is used as a basis to define the OW-structure. In Norway, the wage statistics are available according to STYRK 08 from 2011 and 2016 is used as the reference year[2] for the 2011-2015 period.

For the period 2000-2010, the same sources as above are used in Norway and Sweden and the basis for the definition of the OW-structure are wages year 2010. In Denmark, however, it is not possible to use the Wage Structure Registry to define wages, as 'standardberegnet månedsfortjeneste' cannot be connected to DISCO-88, as it was first implemented in 2011, and no similar calculations did, to our knowledge, exist before. Because of this unfortunate fact, we decided to use the Swedish wage-structure as a proxy for the ranking of occupational wages also in Denmark. This is not a particularly satisfying solution, but similar ways of making comparisons between countries have been conducted in other studies. In Goos et al. (2009), British wage

[2] Year 2016 is chosen over 2015 (the end year of the analysis) due to accuracy issues with the 2015 wage data, linked to the introduction of the new data source (a-ordningen).

data were used to estimate the OW-structure in other European countries (criticized by Fernadéz-Macía 2012). In the Nordic context, we can assume that the relative ranking of occupations on wages should be rather similar (due to similar institutions, industrial relation systems, cultures etc.). As Swedish data do not have any breaks in the occupational classification the whole period 2000-2015, we also include Swedish figures of occupational change for the entire period (with 2013 as basis for occupational wages).

When the OW-structure is defined, the occupations are arranged from the ones with the lowest mean/median wage to the ones with the highest. Thereafter, we include the individuals working in these occupations and calculate at which wages the occupation-wage distribution breaks into five quintiles of (a more or less) equal size in number of individuals. This procedure is done for year 2011, when studying the 2011-15 period, and year 2000, when studying the earlier period. The cut-points in the structure are then held constant, which makes it possible to study changes between years in the OW-structure.

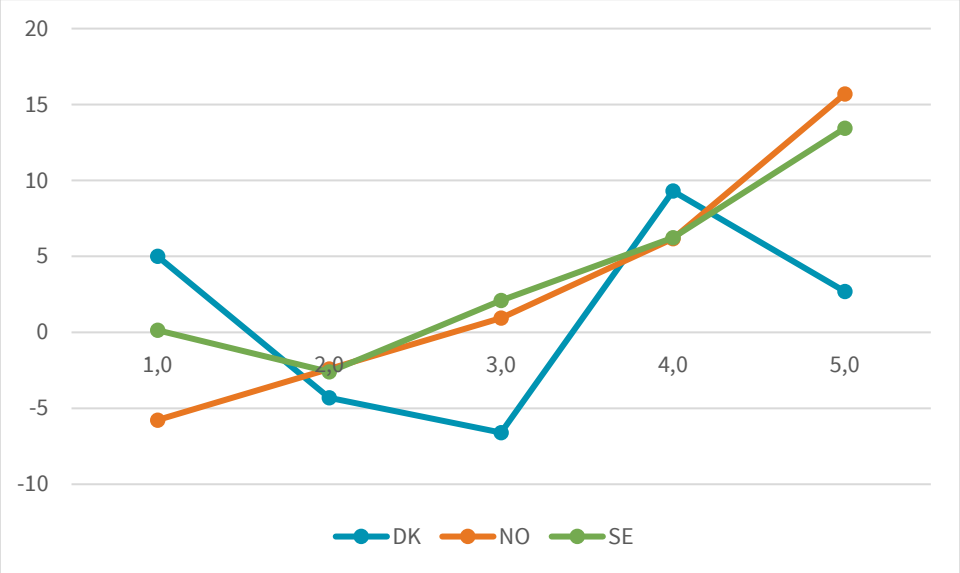
Below, we start with a descriptive analyses of the changes in the number of employees within the quintiles of the baseline years' cut-points. Thereafter, we study changes within major occupational categories on 3-digit level. Then we analyse the social categories present within each quintile, focusing on the last year, 2015. We use the distribution of sex, age, origin, education, type of contract and working time within the first quintile (lowest mean full-time wages), the third, and the fifth quintile (highest wages). Lastly, we compare developments in sectors of the economy. First, we focus on changes in manufacturing, defined as the categories 10-33 according to NACE Rev. 2, during the period 2011-15. Second, we make separate analyses of the private and public sectors. However, due to missing data on sector in Denmark, the latter analysis is only conducted in Norway and Sweden.

In all the analyses, we use weighted LFS-data. These weights are provided by the Statistic authorities in the three countries, and used to adjust for demographic representability, and to upscale the LFS surveys to absolute numbers.

Results

We start by analysing the overall change in the occupational structure the period 2011-15 (see figure 1 and table 1), as these figures are most reliable to compare. The three countries show rather diverging patterns in this period. A clearly polarized pattern is found in Denmark, with a high decrease in the number of employed in quintile 2 and 3 (measured as percent change), while both the highest and the lowest paid quintiles show increases in the numbers of employed. A peculiarity in Denmark is that growth in the highest paid quintile is less than in the second highest paid quintile. Moreover, comparing the development in quintile 5 with Norway and Sweden, we find a much stronger growth in the latter two countries. The Norwegian pattern is unequivocally one of upgrading, with a decline in the lowest paid quintile, and gradually stronger growth in the higher paid quintiles. The Swedish pattern is similar to the Norwegian concerning the upper three quintiles. In quintile 2, there is a decline, while the lowest paid quintile shows stability in employment. There are thus signs in Sweden of a weak polarization – but far from clear as in Denmark – although the overall pattern is more in the direction of upgrading during the period.

Figure 1: Percent Change in Occupational Wage Quintiles, 2011-2015. LFS, 16-64 years. Weighted data.



To understand the patterns in Figure 1 it is important to notice that it shows percent change in the number of employed within the quintiles. These changes are to a large extent also an effect of the overall growth of employment and labour demand. In parallel, it is therefore also important to study changes in the relative distribution of the quintiles between 2011-15 (table 1). In Denmark, this confirms the rather strong polarized pattern in this period. Both quintile 2 and 3 have decreased their overall share of employment with more than 1 percentage point each, while the lowest paid quintile has increased its share with close to 1 percentage point. Increases are also found

in quintiles 4 and 5. Concerning Norway, these figures confirm an overall upgrading pattern: We find a consistent shift from the lower to higher quintiles, with a decline in the bottom two quintiles, stability in the third quintile and growth in the upper two. The highest paid quintile has increased its share with more than 2 percentage points, while the lowest paid quintile has decreased with nearly the same amount. In Sweden, quintile 2 has decreased with more than 1 percentage point and quintile 5 increased with close to 2 percentage points. While the number of employed in quintile 1 is more or less stable (0.2 percent increase), the share working in the quintile has decreased with 0.6 percentage points.

This exercise highlights that the change (in percent) of persons working in an occupational quintile, must be assessed in view of the overall development in employment. For example, in Denmark, with modest growth in the period, we find a 6.6 percent decrease in quintile 3 but a sizeable share is still working within the quintile – a decline from 19.8 to 18.3 percentage share.

Table 1 Changes in the Occupational Wage Structure between 2011 and 2015 of persons in employment 16-64 years, weighted data.

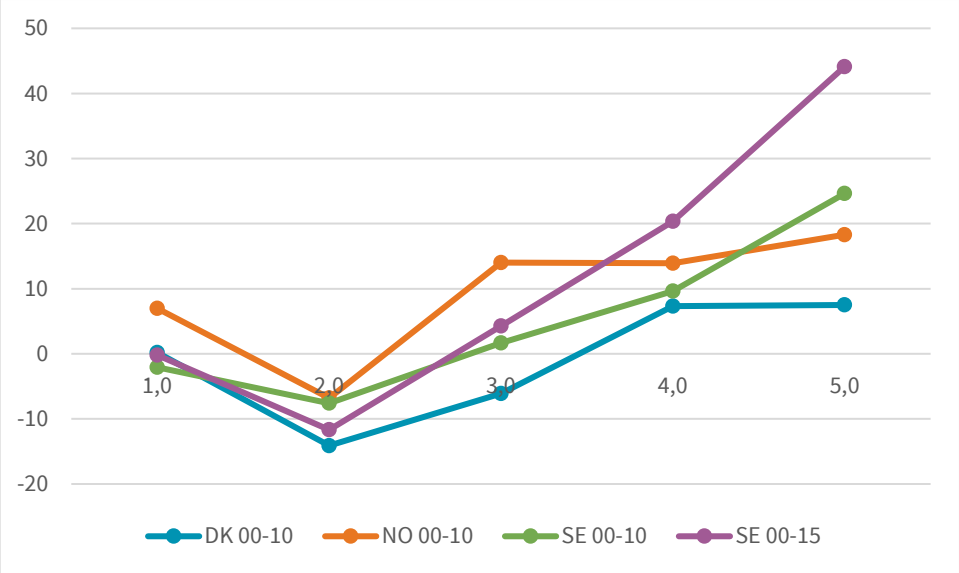
Total Employment 16-64 years	**2011 Percent**	**2015 Percent**	**Percentage point Difference 2011-2015**	**Percent Change (numbers) 2011-2015**	**Change in numbers (1000s) 2011-2015**
Denmark					
1st quintile (lowest)	20.0	20.8	+0.8	5	25.8
2nd quintile	20.7	19.6	-1.1	-4.3	-22.9
3rd quintile	19.8	18.3	-1.5	-6.6	-33.7
4th quintile	19.6	21.2	1,6	9.3	47.4
5th quintile (highest)	19.9	20.2	+0.3	2.7	14.1
Total	100	100			
N (in thousand)	2 599	2 630		1.2	31.0
Norway					
1st quintile (lowest)	21,5	19,6	-1.8	-5.8	- 30.3
2nd quintile	17,5	17,0	-0.9	-2.4	1.0
3rd quintile	19,3	18,8	-0.4	0.9	4.5
4th quintile	21,7	22,2	0.7	6.2	33.0
5th quintile (highest)	20,0	22,4	2.5	15.7	77.8
Total	100	100			
N (in thousand)	2 446	2 521		3.1	74.9
Sweden					
1st quintile (lowest)	20.5	19.9	-0.6	0.2	1.3
2nd quintile	22.2	20.9	-1.3	-2.6	-25.9
3rd quintile	18.4	18.2	-0.2	2.1	17.4
4th quintile	21.0	21.5	0.5	6.2	58.6
5th quintile (highest)	17.9	19.6	1.7	13.4	107.8
Total	100	100			
N (in thousand)	4 482	4 641		3.5	159.0

Figure 2 shows the period 2000 to 2010. As discussed in the method section, we use the Swedish ranking of the OW-structure as a proxy for the Danish OW-structure. In

Denmark, this way of calculating produces a similar pattern as in figure 1, with growth in the upper quintiles and marked declines in quintile 2 and 3, although in 2000-2010 no increase in the lowest paid quintile is found. In Norway, this period shows signs of polarization, with strong growth in the upper three quintiles, decline in quintile 2 and growth in the lower end (quintile 1). All three countries thus show a marked decline in quintile 2 over the two periods (2000-2010 and 2011-14), persistent growth in the top, whereas growth patterns in quintile 1 vary between the countries.

In the Swedish case, where the figures for both periods are directly comparable, the data for the entire period 2000-2015 display a very strong increase of employment in the highest paid quintile, where 44 percent growth correspond to an absolute increase of more than 350 000 employees. The overall pattern is very similar to figure 1 (2011-2015), with more or less stable employment in quintile 1, but a strong decline of almost 100,000 jobs lost in quintile 2 (2000-2015).

Figure 2: Percent Change in Occupational Wage Quintiles, 2000-2010 and 2000-2015 (SE). LFS, 16-64 years. Weighted data.



Employment change within occupational-wage quintiles

In table 2, changes in major occupational categories the period 2011-15 are shown (see also appendix, table 1A-3A). As discussed in the method section, Denmark and Norway changed occupational classification to national variants of ISCO-08, while Sweden has kept the older classification (until 2016 in LFS). Despite these difficulties for comparisons, some patterns are possible to discern.

Growth in the top

In all three countries, we find salient growth in the highest paid quintile. Checking more closely on quintile 5, we find a very strong increase of so called Software and Application Developers and Analysts in both Denmark and Norway (22.6 respectively 63.5 percent increase). In Sweden, an increase is found in the similar category Computing Professional, but not that strong (9.9 percent). The share classified as Software etc. constitute about 10-11 percent of quintile 5 in Denmark and Norway, and about 16 percent in Sweden (Computing Professionals). The largest occupational category in quintile 5 is Sales and Purchasing Agents and Brokers in Denmark (18 percent with 4 percent increase), Physical and Engineering Science Technicians in Norway (16 respective 20 percent increase), and Business Professionals in Sweden (19 respective 27 percent increase). In Denmark we find a conspicuous decline related to Finance Professionals (-19 percent), possibly an effect of the deep Danish financial crisis and related rationalizations in banking. In quintile 4, the largest increases are found for Physical and Engineering Science Technicians in Denmark (38 percent) and Sweden (26 percent), and Sales and Purchasing Agents and Brokers in Norway (28 percent).

In short, we can conclude that the increases of occupations in quintile 4 and 5 are very similar between the three countries. Occupations directly related to the new technology have a strong increase, as well as occupations complemented by the digital technology (Technicians). Moreover, we also find occupations mediating between companies and organizations as categories favoured by the last years development of the economy.

Decline in middle and lower occupations

There have also been declines in some of the quintiles during the period 2011-15: In Sweden, this pertained to quintile 2, and in Denmark to quintile 2 and 3, while in Norway these quintiles had a weak increase. In quintile 2, we find a strong decline of the occupational category “Material-recording and transport clerks” in Denmark (-49 percent) and a less strong decline in Norway (-10 percent). The tasks performed within this category have to do with clerical work within production and transports (e.g. keep records on goods, stock etc.) and should be a typical category affected by digitalization. Similarly, office clerks declined in Norway (-9 percent). In Denmark, only, we also see a decrease of heavy bus and truck drivers (-8 percent). In Sweden,

Agricultural and mobile-plant operators (for example crane and lifting-truck operators) had a strong decline. Encompassing 23 occupations, 16 of quintile 2 occupations in Sweden saw declines, for example, Assemblers (-16 percent) and Office secretaries (-19 percent). In Denmark, also quintile 3 showed a marked decline. These years, typical occupations hit were Primary school and early childhood teachers (-15 percent), Building frame and related workers (-11 percent), and Blacksmiths, toolmakers and related trades (8 percent).

Looking at these declining jobs, several of them are in line with the expectations of the Routine Bias Technological Change theory. Assemblers, clerks and operators of machines all have routine-components in their work tasks that are possible to substitute with new technology. There are also some diverging examples, for instance, bus and truck drivers in Denmark are not an obvious example (yet) of an occupation that should be subjected to replacement. Other processes may be going on, for example, competition from abroad concerning truck drivers in Denmark, combined with the recession in the Danish economy.

Table 2: Percent change in employment. Major occupational categories, within quintiles (%)

Denmark			**Norway**			**Sweden**		
Occupation	**Percent Change**	**Share 2015**	**Occupation**	**Percent Change**	**Share 2015**	**Occupation**	**Percent Change**	**Share 2015**
1st quintile								
522 Shop salespersons	-9.0	19.3	522 Shop salespersons	-8.5	32.2	513 Personal care and related workers	-2.0	50.2
531 Child care workers and teachers' aides	-8.4	16.2	531 Child care workers and teachers' aides	-4.7	18.7	912 Helpers and cleaners	-1.2	9.3
911 Cleaners and helpers	2.5	12.8	911 Cleaners and help	2.6	10.7	512 Housekeeping, rest	18.7	9.6
941 Food preparation assistants	11.0	9.2	422 Client information clerks	-1.4	5.9	913 Helpers in restaurants	1.9	6.0
523 Cashiers, ticket clerks	43.7	11	612 Animal producers	-17.6	4.2	422 Client info clerks	6.2	5.8
2nd quintile								
532 Personal care workers	0.2	23.6	711 Building frame and related trades workers	2.9	15.0	522 Shop and stall salespersons etc	-2.4	23.8
933 Transport and storage labourers	-2.0	11.3	411 General office clerks	-8.5	10.4	832 Motor-vehicle drivers	6.4	12.9
432 Material-recording and transport clerks	-49.0	4.3	432 Material-recording and transport clerks	-10.9	9.9	713 Building finishers etc	2.3	12.1
833 Heavy truck and bus drivers	-8.3	7.4	833 Heavy truck and bus drivers	3.1	9.0	833 Agricultural and other mobile-plant operators	-8.5	6.9
422 Client information workers	7.2	6.8	325 Other health associate professionals	-2.4	6.1	419 Other office clerks	-0.6	6.6

3rd quintile								
234 Primary school and early childhood teachers	-14.8	23.1	532 Personal care workers	-7.7	26.4	343 Administrative associate professional	15.9	14.2
411 General office clerks	5.5	17.2	723 Machinery mechanics and repairers	3.0	9.8	331 Pre-primary education teaching etc	3.1	11.8
711 Building frame workers etc	-11.5	11.3	741 Electrical equipment installers etc	16.6	10.2	233 Primary education teaching professionals	10.5	11.0
722 Blacksmiths, toolmakers etc.	-8.2	7.7	834 Mobile plant operators	-15.6	5.7	412 Numerical clerks	11.3	8.4
723 Machinery mechanics and repairers	4.8	7.3	335 Regulatory government ass. prof.	17.4	6.9	723 Machinery mechanics and fitters	-6.1	7.0
4th quintile								
311 Physical and engineering science tech	37.6	18.0	234 Primary school and early childhood teachers	4.8	20.8	341 Finance and sales associate prof.	5.1	23.9
222 Health professionals	2.9	10.2	222 Health professionals	-4.8	17.7	311 Physical and engineering science tech	26.1	17.0
331 Financial and mathematical associ prof	-3.0	9.3	242 Administration professionals	20.8	12.8	712 Building frame and related trades workers	-4.8	12.2
235 Other teaching professionals	29.0	10.8	332 Sales and purchasing agents etc	27.9	12.7	323 Nursing associate professionals	-6.5	6.3
334 Administrative and specialised secretaries	-1.3	8.3	331 Physical and engineering science tech	15.5	10.6	232 Secondary education teaching prof.	-1.4	6.2
5th quintile								
332 Sales and purchasing agents and brokers	4.1	17.6	311 Physical and engineering science technicians	19.7	15.7	241 Business professionals	26.8	19.1
242 Administration professionals	16.0	11.9	241 Finance professionals	24.6	7.8	213 Computing professionals	9.9	15.9
241 Finance professionals	-19.4	7.4	251 Software,applications develop and analysts	63.1	9.8	122 Production and operations managers	8.0	10.3
251 Software, applications developers and analysts	22.5	10.8	132 Manufac, mining, construc, distrib manager	35.0	7.9	214 Architects, engineers professionals	18.6	10.4
214 Engineering professionals	8.2	6.7	134 Professional services managers	19.5	7.0	123 Other specialist managers	-5.7	7.7

Similarly, the decrease in primary school teachers may be related to cutbacks in public budgets, while the decrease in construction workers steams from the building and

houses crises that hit Denmark in connection to the financial crisis 2008 (Arnholtz et al. 2018).

The mixed patterns of the lowest paid quintile

The lowest paid quintile shows different national patterns the period 2011-2015. In Denmark, we see a rather strong increase in the numbers of workers. In Norway, by contrast, there is a strong decline, while in Sweden, the numbers remain on more or less the same level. In Denmark, there has been a massive increase in Cashier and ticket clerks (43 percent) and a strong increase in Food preparation assistants (11 percent). Decreases are found in Shop salespersons (-9 percent) and Child care workers (-8 percent). As in Denmark, Norway has seen decrease especially among Shop salespersons (-9 percent), but also among Animal producers (-18 percent). A small increase is noted for Cleaners and helpers (4 percent). In Sweden, the strongest increase is found for Housekeeping and restaurant services workers (19 percent) and Client information clerks (6 percent). However, the largest category workers, by far, is Personal care and related workers. Here we find a small decrease of 2 percent, although rending rather large numbers.

What lessons can we draw from these differences? According to the RBTC hypothesis, non-routine service and manual jobs in the lowest paid quintile is expected to be largely untouched by the new technology. In both Denmark and Sweden, we find rather large increases in occupations related to restaurants services, which are in line with the expectations. In Norway, despite an overall decline in the bottom quintiles, the same pattern is evident with increases among Food preparation assistants (22 percent) and Waiters and bartenders (8 percent). Moreover, in Denmark and Norway, in line with theory, we find some increases in Cleaners and helpers (although not in Sweden). However, contrary to theory, we do not see any increase in Personal care workers (SE) or Child care workers (DK, NO). In the Nordic countries, to a large extent are these kind of services organized by the public sector and growth dependent on political decision-making. Expansions and retrenchments are therefore not only influenced by market, but also by political priorities and budget constraints. This emphasises that, besides technological change, we also have to take other considerations into account to understand occupational change, including cyclical variations in the economies. The large increase in Cashier and ticket clerks in Denmark is perhaps neither in line with the RBTC hypothesis, although these are jobs that may be replaced by new technology, Instead, the increase probably reflects a change in regulations concerning working hours in Denmark in 2012, allowing shops and stores to have longer opening hours, including on Sundays and holidays, requiring more staff.

The distribution of demographic and socio-economic characteristics within quintiles

Table 3 shows distributions of individual characteristics within the lowest, mid-, and highest paid quintiles in the year 2015. Several of the patterns are rather similar between the three countries. In all the countries, a distinct gender-pattern is found, with women dominating in quintile 1, while men are in majority in the highest paid quintile. Especially, in Sweden we find a very large share of women in the lowest paid quintile (72 percent), while Norwegian men showed the strongest majority in quintile 5 (69 percent). In Denmark and Norway, there is a pronounced age pattern where the 16-24 category is strongly overrepresented in quintile 1. This is not the case in Sweden where the age-categories are more of equal size. In all three countries, the middle aged category (35-44) is the largest in quintile 5. Concerning country of birth, we can only compare Denmark and Sweden, where the latter shows higher figures of foreign born. In particular, persons with non-European origin account for a higher share in the lowest paid quintile (22 percent) in Sweden than in Denmark (14 percent).

The educational composition within the quintiles is also rather similar between the countries. As expected, primary educated are largely overrepresented in quintile 1, and tertiary educated in quintile 5. However, Sweden stands out with a much lower share of primary educated, and a substantial share of tertiary educated in quintile 1. This may be an effect of the large influx of relatively highly educated immigrants during the period studied. Moreover, in quintile 5, Sweden has a higher share of tertiary educated than in the other two countries.

The shares in so called "non-standard employment" differ considerably between the quintiles. In Denmark and Norway, there are large shares of part-time employment within the lowest paid quintile. In Denmark approximately 25 percent within quintile 1 work short part-time (1-14 hours), while the share is only 9 percent in Sweden. In all countries, part-time jobs are very rare in the highest paid quintile. Concerning temporary contracts, the pattern of variation is also similar between the countries, with decreasing shares of temporary employed the higher in the OW-distribution. Sweden stands out, however, with much larger shares of temporary employed than the other two countries. In quintile 1, over 28 percent of all in employment have a temporary contract, while the shares are only 10 and 12 percent in Denmark and Norway, respectively.

Table 3: Distribution within selected quintiles in 2015. Persons in employment, weighted data. Percent.

	Denmark			Norway			Sweden		
	1st	**3rd**	**5th**	**1st**	**3rd**	**5th**	**1st**	**3rd**	**5th**
Sex									
Male	42.0	56.8	64.1	36.5	53,3	69,3	28.0	43.6	58.0
Female	58.0	43.2	35.9	63.5	46,7	30,7	72.0	56.4	42.0
Age									
16-24	33.6	11.0	3.0	30,3	13.6	1.7	20.2	8.7	2.2
25-34	19.6	20.9	22.5	21,9	22.3	20.1	21.0	22.7	22.5
35-44	17.3	25.4	31.1	17,1	22.1	30.0	18.2	24.5	30.9
45-54	18.2	24.7	28.4	17,5	23.9	28.8	21.6	24.9	27.7
55-64	11.3	18.0	15.0	13,3	18.2	20.0	18.9	19.2	16.9
Origin									
Native	80.1	92.7	88.1	-	-	-	72.2	85.5	83.8
EU-28	5.6	3.0	5.0	-	-	-	6.1	5.5	6.9
Non-EU	14.3	4.3	6.9	-	-	-	21.7	9.0	9.3
Education									
Primary	36.7	14.0	4.3	36.3	18.3	4.7	15.7	6.7	2.3
Secondary	49.3	51.3	24.1	50.5	57.7	29.4	62.4	39.2	17.9
Tertiary	11.3	34.0	71.0	12.4	23.8	65.9	21.9	54.1	79.8
No answer	2.7	0.7	0.6	0.8	0.1	0			
Working time									
1-14	24.5	5.0	2.1	19.9	5.8	1.4	8.6	3.7	1.5
15-29	14.7	7.3	3.3	21.0	13.8	2.8	15.7	6.9	3.4
30+	60.8	87.7	94.6	59.1	80.4	95.9	75.7	89.5	95.1
Contract									
Temporary	10.1	8.8	6.5	12.1	8.7	4.2	28.5	12.7	8.0
Non-temp	89.9	91.2	93.5	87.1	90.9	95.7	71.5	87.3	92.0

Occupational change in Nordic manufacturing

Polarization or upgrading of national occupational/wage structures can be split into within-industry and between-industry components. Polarization both within and between industries has been linked to routine-biased technological change (Goos et al. 2014). Manufacturing, with its historically high share of medium-skilled routine jobs and a long history of continuous technological change may be viewed as a critical case[3] in this regard, insofar as the RBTC hypothesis would lead us to expect both an overall decline in manufacturing due to the share of routine jobs, as well as a relative decline of routine jobs within manufacturing. As shown below, this seems to largely be the case in all three countries in the 2011-2015 period, with a significant decline in overall employment in manufacturing and job reductions concentrated in the middle of the occupation/wage structure within the industry.

In this section, we take a closer look at how the recent years – marked by increased digitalization, globalization, and sweeping restructuring – have influenced the occupational structure in manufacturing. In a parallel working paper, this mapping is complemented by case study illustrations of how processes of digitalization affect the pattern of employment, work organization, and skill requirements in a selection of plants in Nordic manufacturing sector (see Rolandsson et al. 2019).

As the leading export sector in the small, open Nordic economies, the manufacturing industry has been seen as a backbone of the Nordic labour market regimes. In this view, the prospect of a fourth industrial revolution bringing large-scale automation and polarization of manufacturing jobs can be perceived as a particular challenge to the Nordic models. The organizations of skilled manual workers and their employer counterparts in manufacturing have been key actors in the Nordic systems of industrial relations and vocational training, and have served as power-brokers in collective bargaining and labour politics (Dølvik and Marginson 2018).

Production and added value in Nordic manufacturing have many-doubled since the 1970s, whereas employment has steadily decreased (Iris Group 2015). As underscored in the initial report from the NFoW project (Dølvik & Steen 2018), technological change has been a long-term trend in manufacturing, which in the Nordic context of high labour costs and strict regulations has thrived precisely by fostering innovation and technological rationalization through cooperation and employee involvement, while labour intensive production has been moved abroad. Technological progress, China's rise as the world's factory, and further restructuring of global value chains have brought significant changes in the pattern of jobs, occupations, and skills in manufacturing. Since the 1970s, there has, despite the emphasis on "flatter organizations", been a steady decrease in the share of blue-collar workers in manufacturing and a rise in the share of white-collar and managerial employees.

In the 1970s, manufacturing accounted for almost 1/3 of Nordic employment. Since 1980, Nordic manufacturing employment has declined by approximately 40

[3] A critical case is a case of particular interest and with strategic content in relation to the research questions investigated (Flyvbjerg 1991).

percent. By 2017, manufacturing accounted for around 8 percent of total employment in Norway, 9 percent in Iceland, 10 percent in Denmark, 11 percent in Sweden and 13 percent in Finland (Rolandsson et al. 2019, OECD.stat, Iris Group 2015).

Below we briefly look at how the occupational structure of employment in manufacturing has evolved in the years after 2010, when a combination of post-crisis recovery and digitalization expectedly has propelled restructuring. The data and methods used are the same as above, but due to the breaks in the data series we show tables for the last period 2011-2015 only. For this initial mapping purpose we have also simplified the occupational groupings by only distinguishing between three categories, i.e. occupations with low, medium, and high median wages in 2011. The groups are constructed using wage data as described in the data and methods section above to construct three categories of equal size in terms of the number employed in 2011.

In the period 2011-2015, manufacturing in Sweden experienced a substantial drop in activity (-8.5 %), while there was a rise in Denmark (7.8%) and Norway (5.4%). Also Finnish manufacturing (for which data will be included later) saw a decline (-8.5%) in these years.[4]

Despite the divergent activity developments, Table 4 (below) shows that all three countries (DK, NO, SE) experienced significant decline in overall manufacturing employment 2011-2015 (1-2 percent per year). In Sweden, the job decreases largely corresponds to the drop in production, while in Denmark and Norway employment decreased markedly (-3.8 and -5.6 percent, respectively) despite solid growth in production (7.8 percent). This indicates significant rationalization and technological renewal in all three countries, while the decline in Sweden probably also had a cyclical element.

Table 4: Percentage change in the number of employed persons in occupations with low, high and medium wages in manufacturing, 2011-2015, Sweden, Denmark and Norway.

	Sweden	Denmark	Norway
Low wage third	-16.2%	2.1%	-15,4%
Medium wage third	-23.4%	-17.3%	-11,7%
High wage third	8.3%	4.7%	10,1%
Total manufacturing	-9.9% (2011: N=547') (2015: N=493')	-3.8% (2011: N=336') (2015: N=320')	-5.6% (2011: N=231') (2015: N=218')

With respect to changes in the occupational distribution of employment, we see in Table 4 that there was a strong, unequivocal tendency towards within-industry occupational upgrading of the pattern of employment in Swedish and Norwegian manufacturing. While the low and medium wage occupational categories saw substantial decline in employment – much larger than the declines in production – there was in parallel strong job growth in the highest occupational/wage tiers in both countries.

In Danish manufacturing, by contrast, the changes in employment show a distinctly polarized pattern during these years of recovery. Alongside steady job growth

[4] OECD *Main Economic Indicators: Production and sales*, available at stats.oecd.org/viewhtml.aspx?datasetcode=MEI_REAL&lang=en

in the top – lower than in Sweden and Norway though – the expansion in Danish manufacturing production came with a strong job decline in the middle but a certain growth in occupations in the low end. A look into the changes in specific low-wage occupations reveals that the most significant job growth appeared in the occupational groups "Manufacturing laborers", "Shop salespersons" and "Food and related machine operators". Occupations typically viewed as prone to digitalization showed, as expected, declining employment, e.g. "Assemblers" and "Transport and storage labourers".

By comparison, the sharp drops in the *low wage* categories in Sweden and Norway were associated with shrinking employment in occupations such as "Agricultural and other mobile plant operators", "Assemblers" and "Metal and mineral products machine operators". In Norway, large declines were also seen in "Material recording and transport clerks and "General office clerks" (-28 percent).

The shrinking of the *middle wage categories* observed in all countries was most salient in the strong job decline in for instance "Material-recording and transport clerks" [5], and "Machinery mechanics". "Blacksmiths, toolmakers and related trades" declined most steeply in Norway, though declines are evident in Sweden and to some extent in Denmark. In Sweden, another middle category decreasing markedly was "Metal moulders, welders, sheet-metal workers, structural-metal preparers and related trades workers" which, by contrast, grew strongly in Norway (possibly due to the developments in the shipyard and petroleum services industry). "Mining & mineral processing plant operators" also grew in Norway.

In the *higher end* of manufacturing, job growth in the three countries was particularly pronounced in large occupational groups that include engineers, science technicians and related professionals. The number of various manager positions also increased markedly in all three countries. Conversely, the number of "Sales and purchasing agents and brokers" declined in Norway and Denmark.

In short, the main direction of change fits well with the upgrading thesis arising from the theories of respectively Skill-Biased and Routine-Biased Technological Change, the first mirrored in strong job growth in the top and the second in the strong decline in the medium/middle part of the occupational ladder in all three cases. Low-wage occupations associated with routine work saw substantial decline in all three countries, typical examples being "Assemblers", "Transport and storage labourers" and "Material recording and transport clerks". The only deviation from this pattern is the slight rise in employment in the lower end of the occupational structure in Denmark, contributing to a more polarized pattern of manufacturing employment there. This may be an example that even in highly productive Nordic manufacturing, there is in some industries a certain amount of non-routine simple jobs that lend themselves poorly to technological rationalization.

In a study covering only a period of four years, one must be cautious not to ascribe all findings of change to factors driven by technology especially because the three national manufacturing industries were facing quite different cyclical conditions

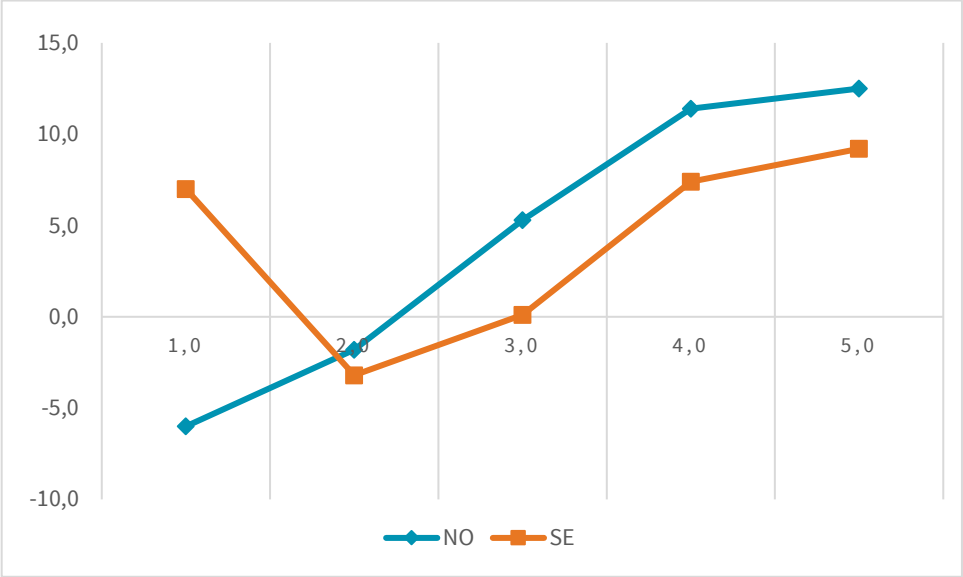
[5] We find similar declines in this occupation in all three countries. While this occupation falls into the middle wage category in Denmark and Sweden, it is classified as a low-wage occupation in Norway.

2011-2015. The contrast between the modest rise in demand for low-wage/skilled work in Danish manufacturing and the decline in Sweden and Norway, may to some extent reflect differences in employer needs for ancillary labour in downturn and upturn, and can to some extent also be attributed to differences in the industry structure of the countries. It is not unlikely that the differing development in Danish manufacturing is partly due to certain well-performing industries that are more reliant on simple, non-routine manual labour than its Swedish and Norwegian counterparts. To draw safe inferences about the longer term impact of present technological changes in manufacturing, one needs to study longer time series. We intend to do this in a revised version of this paper, to be published later in 2019.

Change in private and public sector

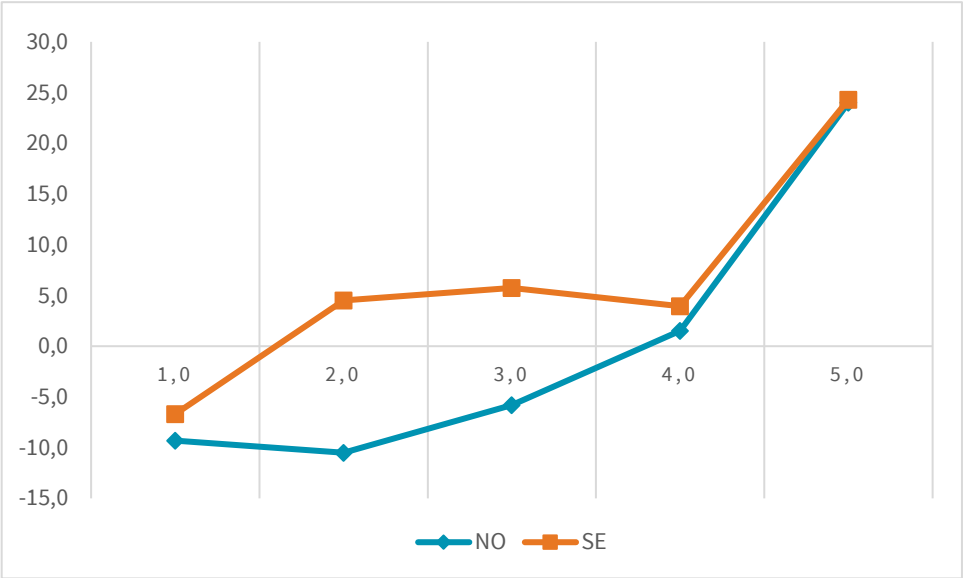
In the introductory part of this paper, we referred to possible other factors than technology affecting the patterns of occupational change. Besides shifting demand in the economy, institutionalized regulations, policy changes and political decisions also influence demand and supply of labour, thereby affecting the occupational distribution of employment. In particular, the Nordic countries are characterized by relatively large public sectors. Expansions and reductions within this sector affect the overall employment structure, and especially, privatization and outsourcing of public activities to private providers can increase activities in the private sector. Of the three Nordic countries compared here, Sweden has during the 2000-2015 period restructured several areas of the public sector, for example the health sector and the educational system, by allowing private providers (Berglund and Esser 2014).

Figure 3: Percent Change in Occupational Wage Quintiles of the Private Sector in Norway and Sweden, 2011-2015. LFS, 16-64 years. Weighted data.



Displaying percentage change in the occupational-wage quintiles of the private sector (Denmark excluded due to missing data), Figure 3 shows that Norway displays an unambiguous up-grading trajectory. The private sector in Sweden, by contrast, clearly moves in the direction of polarization. The lowest paid quintile has grown with 7 percent, more or less on the same level as the highest paid quintiles, while quintile 2 declines, and 3 shows no growth.

Figure 4: Percent Change in Occupational Wage Quintiles of the Public Sector in Norway and Sweden, 2011-2015. LFS, 16-64 years. Weighted data.



The public sectors in Norway and Sweden (figure 4) both show a clearer pattern in the direction of upgrading – most pronouncedly in Norway. In particular, there has been a very strong growth in occupations within the highest paid quintile, while the number of employed in the lowest paid quintile has decreased. In Norway, that pertains also to quintiles 2 and 3.

Figure 5 and 6 show the trends for the preceding period 2006-10 in Norway (covering the 2008-09 downturn) and 2000-2010 in Sweden, as well as the trend for the whole 2000-15 period for Sweden. These figures reveal that in the private sector in Norway, employment growth in this period was rather weak in all quintiles, except for the highest paid one. In contrast, the public sector – benefitting from countercyclical policies during the crisis – showed more persistent growth (except for the first quintile). The overall growth of employment in Norway the period 2006-10 was 3.9 percent in the private and 8.6 percent in the public sector. In the Swedish case, a clear pattern of polarization is shown in the private sector, and is very distinct when studying the whole period 2000-2015. In the upgrading trajectory of the Swedish public sector, the profound decline in quintile 2 for the whole 2000-2015 period is striking and contributes to a somewhat polarized profile of the overall upgrading tendency.

Figure 5: Percent Change in Occupational Wage Quintiles of the Private Sector in Norway 2006-2010, and Sweden 2000-2010 and 2000-2015. LFS, 16-64 years. Weighted data.

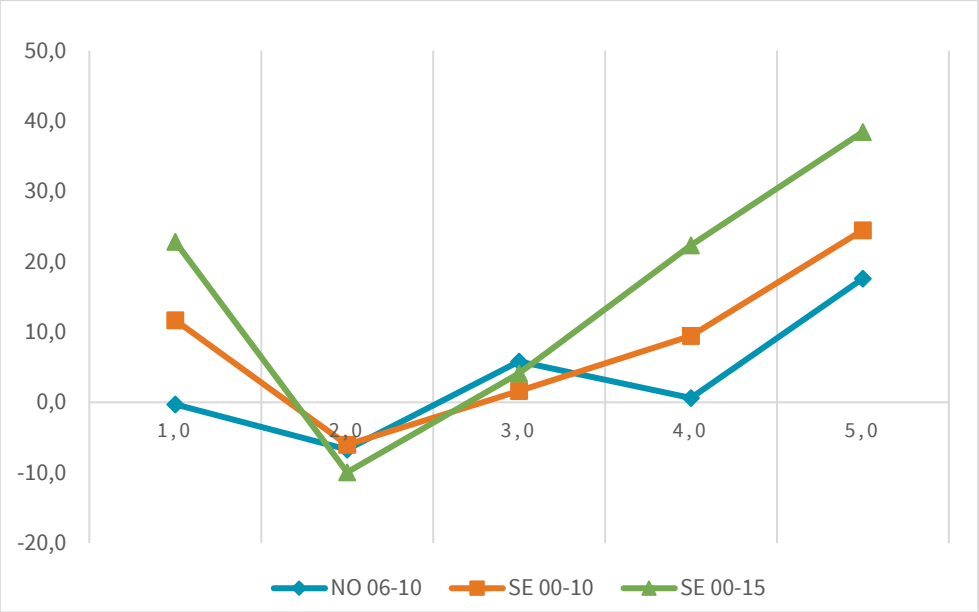
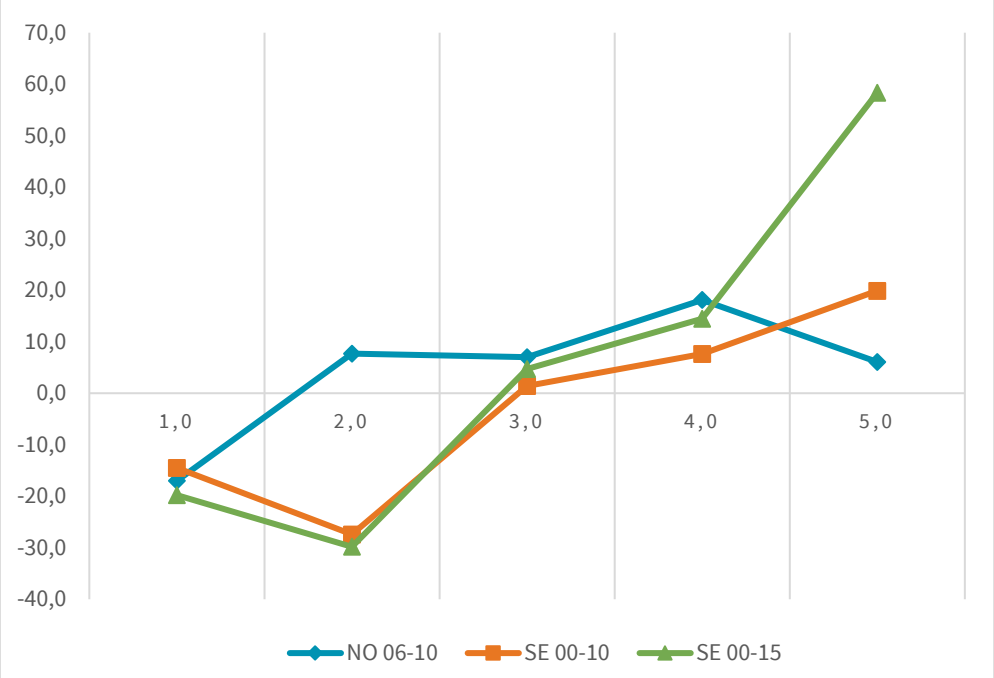


Figure 6: Percent Change in Occupational Wage Quintiles of the Public Sector in Norway 2006-2010, and Sweden 2000-2010 and 2000-2015. LFS, 16-64 years. Weighted data.



The Swedish case is thus illustrative for the impact of other processes taking place, having little to do with technological change. As shown in figure 5, a strong polarized pattern of employment change has appeared in the private sector in Sweden during

the period 2000-2015. Looking closer on the private sector occupations that have increased in the lowest paid quintile, "Personal care and related workers" (SSYK 513) is conspicuous. The category includes child-care workers, assistant nurses, home-based personal care workers, attendants in psychiatric care and dental nurses. The rise in these categories is estimated to 79 000 persons, corresponding to a 170 percent increase. In parallel, however, the public sector lost close to 100 000 workers in quintile 1; "personal care and related workers" account for 68 000 of this decline, i.e. roughly as much as this occupation increased in the private sector.

These patterns indicate that the polarization in the Swedish private sector is partly an effect of privatizations and outsourcing of public activities since the 1990s (Berglund and Esser 2014). In parallel, the close to 60 percent growth during the same period found in the highest paid quintile in the public sector is largely an effect of increases in "Production and operation managers" (SSYK 122) and "Public service administrative professionals" (SSYK 247), with 87 respectively 80 percent growth (the second and third largest occupational categories in the public sector within this quintile in 2015). Combined, these tendencies are indicative of a public sector that during the period has become more influenced by a New Public Management system, where large resources are needed to administrate "buy and sell"-systems and public procurement.

Concluding discussion

Technological change and digitalization affect societies and labour markets. In this report, we have focused on the Nordic region during the period 2000-2015, trying to discover traces of these changes in the occupational structure. According to theory, the new technology affects which skills that are in demand in the labour market: The work of high skilled workers with non-routine jobs, for example, technicians, researchers, analysts, are said to be complemented by the new technology, augmenting the productivity of their work. Many medium and low skilled workers, on the other hand, conducting routine tasks, for example, clerical work and repetitive production, are susceptible to be substituted by new technology. These effects of the new technology imply that the former categories will expand, while the latter will decrease in the number of employed. The market for high skilled labour will expand, developing and using new advanced applications of the digital technology, for example, new ways of reducing work-intensive routine work, while the medium- and low-skilled will see their labour market shrinking. According to this scenario, the latter are bound to reskill and find new jobs in the growing industries, or become unemployed.

However, there is also a third alternative left for workers in declining occupations. The new technology does, according to theory, not affect many low-skilled non-routine jobs, for example, food preparation and serving, cleaning, or personal care work, which are not, yet, possible to replace with automatic digital processes and services. This fact, however, does not mean that there are any direct rationale for these jobs to expand in numbers (above a natural increase in demand due to general population increases). For this to happen, the demand for these services need to grow, which can happen if their price is lowered, or that demand increase of other reasons, for example, that rising affluence among more well-paid strata increase their use of these kind of services, or alternatively, that the tax-based public sector expand because of political priorities.

The first part of the argument above, usually called Skill-Biased Technological Change (SBTC), is commonly regarded with a rather positive view and described as an upgrading of the occupational structure. The second part of the argument, that is, demand-driven growth of low-skilled and low paid occupations more or less untouched by technological change, is usually explained with the theory of Routine-Biased Technological Change (RBTC). However, if RBTC is the best prediction of the effects of technological change, the consequences in terms of further labour market polarization are regarded as rather pale.

Which patterns have been most salient in the labour markets of the three Nordic countries in recent years? The results of the current study show diverging patterns of occupational change. In Norway, the direction of change is clearly towards upgrading in recent years, whereas a certain polarization was seen 2000-2010. Employment in the highest paid occupations has grown strongly, while the numbers in the lower ends have declined over the past decade. Such decline has been strongest and most persistent in the medium-low category (quintile 2), which might lend support both to the SBTC and RBTC hypotheses. In contrast, the job growth in the Danish labour

market has especially since 2010 showed a more polarized pattern with growth in both ends of the distribution, while the numbers employed in middle-wage occupations have decreased. The Swedish labour market has shown a less clear development 2000-2015. On the one hand, a strong upgrading has taken place with large increases in the two upper quintiles of the occupational distribution. On the other hand, employment in the quintile with the lowest wages has remained more or less unchanged and not declined, while quintile 2 has declined strongly. This pattern does result in a more polarized occupational structure, but the changes are not as distinct as in Denmark.

To what extent can these patterns be accounted for by the SBTC and RBTC hypotheses of technological change? Examining which occupations that have increased and declined in more detail gives some clues of the explanations. In all three countries, there is strong growth in the occupations that are directly related to the new digital technology (e.g. Software and Application Developers) or whose productivity are augmented by the technology (e.g. Technicians). This is in line with both hypotheses. The decline in occupations such as Assemblers, Clerks and Operators of machines fits both hypotheses, but particularly support the RBTC theory, which stresses that jobs with routine tasks are prone to replacement by automatic processes. Moreover, in the lowest paid quintile, the increases in occupations like Housekeeping and Restaurant services workers, and Cleaners and Helpers, accord with the RBTC hypothesis. The development within manufacturing also seems to lend support to these hypotheses. The overall decline in manufacturing, with its large share of middle-skilled routine jobs, contributes to between-industry polarization. Within manufacturing, job reductions are concentrated in the middle of the occupation/wage structure of the industry, while the number of employees in the highest paid occupations has increased.

However, we also find contradictory tendencies. In Denmark, with the most clear indications of polarization, the strongest decline is found among Primary school and Early childhood teachers. This highlights that other factors than technological change are important to take into account. In the Nordic region, politically determined expansions and retrenchments in the public sector are definitively important along with other economic factors.

We therefore also made separate analyses of changes in employment in the private and public sector in Norway and Sweden (LFS in DK misses a good indicator for private/public employment). In Norway, both the private and the public sector show similar tendencies of upgrading. In Sweden, the patterns diverge strongly between the private and the public sector. The private sector shows a strongly polarized pattern, while the public sector is upgrading. This divergence is apparently explained by a transfer of low-paid public jobs into the private sector, in particular “personal care and related workers”, which declined and increased with more or less the same amount in the respective sectors. We interpret these changes as an effect of large-scale privatizations and outsourcing of public sector activities during the period. Again, other processes than technological development are evidently important to take into account to understand occupational change.

Moreover, our study confirms that different social categories are unevenly positioned in the occupational structure. There are some variations between the countries, but the main pattern is the same: Women, young, foreign-born and low educated are over-represented in the low wage quintile; men, natives and higher educated, together with the age-category 35-44 years, are over-represented in the highest paid quintile.

Finally, we find that "non-standard employment", that is, part-time (DK and NO) and temporary employment (SE), is more common in the lowest paid quintile. These findings highlight that changes in the occupational structure of employment impact on individuals' job quality and living conditions. In the current study, we have used full-time wages as a proxy for the skill-levels of occupations. However, this is not an indicator of the earnings and incomes of individuals' in different occupations, which to a large extent also depend on their number of working hours, and employment uninterrupted by spells of unemployment. The concentration of part-time jobs and temporary employment in the lowest paid quintile is in this regard particularly problematic.

All in all, this study shows that the distribution of employment in the occupational structure in Denmark, Norway and Sweden is changing. The patterns vary between the countries, with clear examples of upgrading (especially in public sector) as well as polarization (mostly in private sector). Some of these changes can certainly be explained by the development of new (digital) technology – evidence pro this explanation is the increase and decrease of particular occupations. However, our study also reminds us that other explanations have to be considered as well. Changes in public sector organization and employment as well as transfers from public to private employment, affect the overall employment structure as well as the occupational structure within each sector. Finally, our study indicates that also economic shocks, such as the financial crisis in Denmark 2008, and changes in labour supply, for example due to immigration, may have consequences for occupational change.

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Appendix

Table 1A: Change in employment in major occupational groups within OW-quintiles in 2011-2015. Weighted data. Denmark.

	Occupation	Number 2011	Share 2011	Number 2015	Share 2015	Percent point Difference	Percent Change (numbers)	Change in Numbers
1st quintile	522 Shop salespersons	115639	22,2	105287	19,3	-2,9	-8,95	-10352
	531 Child care workers and teachers' aides	96383	18,5	88286	16,2	-2,3	-8,40	-8097
	911 Cleaners and helpers	67905	13,1	69632	12,8	-0,3	2,54	1727
	941 Food preparation assistants	45339	8,7	50317	9,2	0,5	10,98	4978
	523 Cashiers and ticket clerks	41959	8,1	60287	11	2,9	43,68	18328
2nd quintile	532 Personal care workers in health services	121790	22,6	121982	23,6	1	0,16	192
	933 Transport and storage labourers	59512	11	58296	11,3	0,3	-2,04	-1216
	432 Material-recording and transport clerks	43248	8	22077	4,3	-3,7	-48,95	-21171
	833 Heavy truck and bus drivers	41532	7,7	38104	7,4	-0,3	-8,25	-3428
	422 Client information workers	32930	6,1	35291	6,8	0,7	7,17	2361
3rd quintile	234 Primary school and early childhood teachers	130195	25,3	110876	23,1	-2,2	-14,84	-19319
	411 General office clerks	78410	15,2	82707	17,2	2	5,48	4297
	711 Building frame and related trades workers	61504	12	54446	11,3	-0,7	-11,48	-7058
	722 Blacksmiths, toolmakers and related trades workers	40084	7,8	36813	7,7	-0,1	-8,16	-3271
	723 Machinery mechanics and repairers	33652	6,5	35275	7,3	0,8	4,82	1623
4th quintile	311 Physical and engineering science technicians	72875	14,3	100304	18	3,7	37,64	27429
	222 Health professionals	54978	10,8	56545	10,2	-0,6	2,85	1567
	331 Financial and mathematical associate professionals	53252	10,5	51660	9,3	-1,2	-2,99	-1592
	235 Other teaching professionals	46613	9,2	60125	10,8	1,6	28,99	13512
	334 Administrative and specialised secretaries	46903	9,2	46281	8,3	-0,9	-1,33	-622
5th quintile	332 Sales and purchasing agents and brokers	89654	17,4	93309	17,6	0,2	4,08	3655
	242 Administration professionals	54437	10,5	63120	11,9	1,4	15,95	8683
	241 Finance professionals	48497	9,4	39070	7,4	-2	-19,44	-9427
	251 Software and applications developers and analysts	46725	9	57275	10,8	1,8	22,58	10550
	214 Engineering professionals (excluding electrotechnology)	33018	6,4	35719	6,7	0,3	8,18	2701

Table 2A: Change in employment in major occupational groups within OW-quintiles in 2011-2015. Weighted data. Norway.

	Occupation	Number 2011	Share 2011	Number 2015	Share 2015	Percent point Difference	Percent Change (numbers)	Change in Numbers
1st quintile	522 Shop salespersons	174350	33,2	159475	32,2	-1,0	-8,5	-14876
	531 Child care workers and teachers' aides	97213	18,5	92640	18,7	0,2	-4,7	-4573
	911 Cleaners and helpers	51367	9,8	52710	10,7	0,9	2,6	1343
	422 Client information clerks	29389	5,6	28978	5,9	0,3	-1,4	-412
	612 Animal producers	25352	4,8	20902	4,2	-0,6	-17,6	-4451
2nd quintile	711 Building frame and related trades workers	59359	14,3	61068	15,0	0,8	2,9	1709
	411 General office clerks	46241	11,1	42295	10,4	-0,7	-8,5	-3946
	432 Material-recording and transport clerks	45290	10,9	40334	9,9	-1,0	-10,9	-4957
	833 Heavy truck and bus drivers	35358	8,5	36459	9,0	0,5	3,1	1101
	325 Other health associate professionals	25321	6,1	24703	6,1	0,0	-2,4	-618
3rd quintile	532 Personal care workers in health services	136587	28,8	126100	26,4	-2,5	-7,7	-10487
	723 Machinery mechanics and repairers	45693	9,6	47071	9,8	0,2	3,0	1378
	741 Electrical equipment installers and repairers	41798	8,8	48732	10,2	1,4	16,6	6934
	834 Mobile plant operators	32018	6,8	27026	5,7	-1,1	-15,6	-4991
	335 Regulatory government associate professionals	28262	6,0	33185	6,9	1,0	17,4	4923
4th quintile	234 Primary school and early childhood teachers	112813	21,1	118198	20,8	-0,3	4,8	5385
	222 Health professionals	105447	19,7	100346	17,7	-2,0	-4,8	-5100
	242 Administration professionals	60286	11,3	72853	12,8	1,6	20,8	12566
	332 Sales and purchasing agents and brokers	56393	10,5	72136	12,7	2,2	27,9	15743
	331 Physical and engineering science technicians	52342	9,8	60440	10,6	0,9	15,5	8098
5th quintile	311 Physical and engineering science technicians	75182	15,2	89980	15,7	0,5	19,7	14798
	241 Finance professionals	35938	7,2	44785	7,8	0,6	24,6	8847
	251 Software and applications developers and analysts	34425	6,9	56136	9,8	2,8	63,1	21711
	132 Manufacturing, mining, construction and distribution managers	33705	6,8	45486	7,9	1,1	35,0	11782
	134 Professional services managers	33474	6,8	40000	7,0	0,2	19,5	6526

Table 3A: Change in employment in major occupational groups within OW-quintiles in 2011-2015. Weighted data. Sweden.

	Occupation	Number 2011	Share 2011	Number 2015	Share 2015	Percent point Difference	Percent Change (numbers)	Change in Numbers
1st quintile	513 Personal care and related workers	471705	51,3	462317	50,2	-1,1	-2,0	-9389
	912 Helpers and cleaners	86738	9,4	85657	9,3	-0,1	-1,2	-1081
	512 Housekeeping and restaurant services workers	74860	8,1	88838	9,6	1,5	18,7	13978
	913 Helpers in restaurants	54115	5,9	55116	6,0	0,1	1,9	1001
	422 Client information clerks	50341	5,5	53447	5,8	0,3	6,2	3106
2nd quintile	522 Shop and stall salespersons and demonstrators	236017	23,7	230272	23,8	0,0	-2,4	-5745
	832 Motor-vehicle drivers	117677	11,8	125154	12,9	1,1	6,4	7477
	713 Building finishers and related trades workers	114733	11,5	117394	12,1	0,6	2,3	2661
	833 Agricultural and other mobile-plant operators	72864	7,3	66662	6,9	-0,4	-8,5	-6202
	419 Other office clerks	64163	6,5	63766	6,6	0,1	-0,6	-397
3rd quintile	343 Administrative associate professionals	103127	12,5	119499	14,2	1,7	15,9	16372
	331 Pre-primary education teaching associate professionals	96648	11,7	99617	11,8	0,1	3,1	2970
	233 Primary education teaching professionals	83610	10,1	92411	11,0	0,8	10,5	8801
	412 Numerical clerks	63285	7,7	70405	8,4	0,7	11,3	7120
	723 Machinery mechanics and fitters	63262	7,7	59397	7,0	-0,6	-6,1	-3865
4th quintile	341 Finance and sales associate professionals	227099	24,2	238640	23,9	-0,3	5,1	11540
	311 Physical and engineering science technicians	134323	14,3	169334	17,0	2,7	26,1	35011
	712 Building frame and related trades workers	128405	13,7	122239	12,2	-1,4	-4,8	-6166
	323 Nursing associate professionals	67445	7,2	63034	6,3	-0,9	-6,5	-4412
	232 Secondary education teaching professionals	63119	6,7	62215	6,2	-0,5	-1,4	-905
5th quintile	241 Business professionals	137308	17,1	174150	19,1	2,0	26,8	36843
	213 Computing professionals	131611	16,4	144664	15,9	-0,5	9,9	13054
	122 Production and operations managers	86835	10,8	93762	10,3	-0,5	8,0	6927
	214 Architects, engineers and related professionals	80020	10,0	94922	10,4	0,5	18,6	14902
	123 Other specialist managers	74774	9,3	70528	7,7	-1,6	-5,7	-4246