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Job Polarisation in Denmark?

Changes in Employment Structure and Work Organisation, 2006-2010

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1. Introduction

Over the last several decades a voluminous literature has developed on the effects of technical change on occupational and wage structure. One of the starting points of this literature has been the evidence that the returns to skills as measured by the relative wages of persons with a higher-level education has increased despite the secular increase in the supply of highly educated labour.[1] The main technology centred hypothesis developed to explain this until recently was the skill-biased technical change (SBTC) hypothesis, which focused on the effects of computerisation and automation in the so-called third industrial revolution on the demand for skills. The basic hypothesis supported by a variety of survey-based and case study research was that computerisation and related capital investments would have both a substitution effect and a complementarity effect favouring the employment of skilled labour. The substitution effect comes from the observation that simple repetitive tasks characteristic of production and clerical workers have proven more amenable to computerisation and automation than the relatively complex tasks of managers and professionals requiring judgment and interaction. The complementarity effect emphasized in the work of authors like Bresnahan (1997) and Bresnahan, Bynjolfsson, and Hitt (2002) refers to the way computerisation changes data use and information processing within the firm leading to greater decentralisation of decision making and an increase in the need for worker flexibility and discretion in coordinating work processes, both of which increase the demand for skilled labour.

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[1] See Acemoglu and Autor (2011) for a survey of the voluminous literature on the returns to skills.

A more recent literature, while not questioning the basic hypothesis in the SBTC literature that technical change has led to an increase in the demand for skilled labour, has argued that there is a need for a more nuanced view taking into account how the tasks and skills of the lowest skilled groups (mainly service workers and the elementary trades) differ from those of the middling groups composed of clerks and skilled and semi-skilled manual workers. This has been motivated by the observation that while the employment shares of the upper occupational categories composed of technicians, professionals and managers has increased, this has also been the case for the lowest occupational groups, leading to a job polarisation trend with the hollowing out of the middling categories. (Autor, Katz and Kearney 2006; Goos and Manning 2007; Goos, Manning and Salomons, 2014).

For reasons which we elaborate on below in our methodological section, while the recent empirical literature on job polarisation has estimated the relative importance of technical change and globalisation as key drivers of the process, the role of organisational change has remained unexplored. Our contribution to the analysis of structural change as observed in the occupation and wage distribution of jobs is to add an unparalleled level of detail to the analysis of organisational changes that contribute to job polarization, and, as a consequence, to distinguish between organisational changes that create polarization on their own and organisational changes that contribute to polarization by moderating the effects of technological change or globalisation. In order to do this we draw on a unique data set consisting of a panel of 601 Danish firms created by merging two surveys. The surveys provide information on the firms' organisational practices including HRM practices, on outcomes of their innovation activities and on the impact of the 2008 financial crisis. By merging this panel with registry data for the entire Danish economy we add detailed data on the composition of firms' workforce in terms of occupations. The registry data also contain information on the form of contract distinguishing between full time and six levels of part time work. This information is used to transform the firm level occupational groups into full-time equivalent and hence to compute the total employment of the firm. The sample displays a strong polarization tendency with the low group employment share increasing by 2.72 percent, the middle group share declining by 5.78 percent and the high group share increasing by 3.04 percent.

2. **Organizational Change, technology and Job Polarization**

The effect of technological change on the structure of wages and the occupational structure as a perspective on structural transformation taking the labour market as the point of departure. Structural change is traditionally operationalised as a change in the distribution of economic

activity over industries measured by employment or production, which of course yield quite different results. More recently there has also been focus on the change in export portfolio, which is argued to proxy changes in the activities and available capabilities within a country (Hidalgo et al. 2007, Hausmann and Hidalgo 2011), and focus on studying structural change as a change in the distribution of wages (Férandez-Macia 2012, Autor 2015). The wage distribution is interpreted as a proxy for the skill distribution and a general result is that a polarizing pattern is observed over time, where the highest and lowest skill/wage jobs are expanding at the expense of middling wage/skill jobs, as described in the introduction.

There are in principle four different channels of job polarization (Autor et al. 2003, Goos et al. 2014, Heyman 2016): 1) For a given occupational composition within industries polarization is the relative growth of industries where high and/or low skill occupations are relatively common at the expense of industries where medium level occupations are relatively common. 2) For a given occupational composition within firms, interfirm competition leading to differences in firm growth rates may similarly cause polarization. 3) Changes within the firm such as technological change, outsourcing or organisational change may cause a polarizing change in the firm's occupational composition and finally 4) such changes may entail that the definition or task-wise content of occupations change. Empirical results imply that processes at all four levels are important for the aggregate polarization pattern (Autor et al. 2003, Goos et al. 2014, Heyman 2016), and focus has to a large extent been at the aggregate polarization resulting from changes at all four levels. Our analysis explicitly focuses on changes within firms but this does not mean that our paper focusses on a polarization in the quality of jobs. There is no question that the quality of a job depends on many other factors than just the wage level (Greenan et al. 2014).

Our analysis focusses on the changes within firms that contribute to structural change as observed in the wage distribution. A permanent feature of structural change, since at least Adam Smith's famous example of the pin factory, is increasing division of labour and hence increasing specialisation through routinisation, and more routinized activities are more susceptible to automation (Bresnahan et al, 2002). Automation means codification of the skills – or more generally: the knowledge – applied in the routine, and commodification of this knowledge by mechanisation or computerisation if sufficient incentives are in place. The RBTC hypothesis for explaining structural transformation in the wage distribution is based on the assumption that routine jobs are also low skill and low wage jobs, and these jobs tend to be automated (Autor 2015, Goos et al 2014, Autor et al. 2003). In a relatively high wage economy there is also an incentive to outsource such jobs and offshore outsourcing has also been studied as a driver of changes in the wage distribution (Goos et al. 2014). Both technological change and outsourcing

thus contribute to a general increase in average wage, as observed in some countries, while the polarizing tendency is arguably caused by technological change and outsourcing together with a share of the economy suffering from Baumol's Cost Disease. (Autor 2015, Férandez-Macia 2012, Baumol 1967).

The effects of technological change and outsourcing are thus relatively clear, while it is not clear how organisational changes contribute to the changes in the wage distribution. Earlier studies focusing on skill biased effects of organisational change tend to use relatively crude measures and do not offer detailed explanations of the hypothesised effects (Caroli and Van Reenen 2001, Piva et al. 2005). An important exception is Bresnahan et al. (2002) who argue that changes in IT capital, work organisation and products tend to co-occur within firms. Such change decreases routine tasks and increases the use of discretion and autonomy among workers. It also increases the availability of data and faced with potential problems of data overload one response is to decentralise decision-making meaning that workers are faced with more problem solving, which often takes place in groups, and that managers hence must rely more on people skills than formal monitoring for assessing the merits of individual workers. Thus, the hierarchy is arguably flattened. It may also be argued that the increased use of quantitative data associated with increased computerization can lead to increased use of standards, norms and formal requirements to facilitate quantification. Bresnahan et al. (2002) still apply a relatively crude approach by summing a number of work organisation indicators into a single factor in their analyses, and they do not study the effect on the composition of employment but instead focus on potential skill bias.

According to Green (2012) organizational change and new management practices should not be considered solely as an intermediary link between technology change and task distribution. Organizational change may have independent effects on development of the distribution between non-routine and routine tasks and thus on polarization tendencies. Among the new management practices a main track has abandoned the Taylorist principles of tight vertical control of narrow routine tasks and delegated autonomy to the operational employee level, promoting discretion and functional flexibility in the organization. This development has been known as high-involvement or high-commitment practices. It often implies horizontal collaboration and integration of functions. This has supported problem solving and discretionary learning practices (Lorenz 2014) on operational level, which also is important for innovative capabilities in the organization. Green (op. cit. 2012) argues that the practices enhancing involvement and horizontal integrative collaboration should be regarded as "potential independent sources of change in the

content of tasks" and his results indicate strong effects of employee involvement and task discretion on generic skills in job requirements.

Technological change and outsourcing necessarily entail simultaneous organisational changes within firms, and the effects of organisational change on the firm's use of different categories of labour as previously identified in empirical studies, may be a consequence of insufficient controls for technological change and outsourcing. In our analysis, we strive to control for both technological change and outsourcing as the data allow, and we use a battery of indicators of work organisation to measure organisational change. This means that we identify relationships between changes in the composition of the workforce and specific changes in the organisation, which should allow us to suggest a model distinguishing between the effects of different organisational changes and complementarities with technological change and with outsourcing. It also means that we should be able to distinguish between organisational changes associated with increased specialisation and routinisation within the organisation, readying it for automation of such tasks, and other organisational changes.

A useful distinction may be made between manual tasks and analytic/interactive tasks. The latter may involve complex communication. Both of these categories can be divided into routine and non-routine task. An example of a routine analytic task is record keeping. Medical diagnosis or managing others are examples of non-routine analytic/interactive task. Many low-skilled manual tasks are non-routine and rely on perceptual and motor skills that have proven hard to automate. Examples include janitorial services and waitressing. An example of routine manual work is repetitive auto assembly-line work, one of the main areas today of investment in industrial robots. Autor et al. (2003) argue that routine jobs will tend to be eliminated by automation while the higher skilled non-routine analytic and interactive jobs will be complemented by computerization and hence they will become more abundant (assuming that the different tasks are not perfect substitutes). The reason why a polarizing pattern is observed is because of Baumol's cost disease leading to an increase in the non-routine manual jobs.

In the original exposition Baumol (1967) referred to sectors and not to tasks or occupations and he distinguished between progressive sectors and stagnant sectors. In progressive sectors, technological change will decrease the demand for low-middle skill workers while complementing high skill workers. In stagnant sectors, there is no technological change by definition but in as much as their output is income elastic and price inelastic employment in these sectors will expand as average income rises from technological progress in progressive sectors. Traditional examples of stagnant sectors are classical music and hairdressers (Autor 2015, Baumol 1967). While

Baumol's analysis focused on these inter-firm and inter industry effects, an analogous reasoning may be applied to low skilled 'stagnant' occupations within firms such as janitorial services that prove relatively impervious to automation. While our firm level approach focusing on changes within the firm will not be able to account for the contribution to the aggregate change in the distribution of occupations and wages from inter firm and inter industry effects, it will be able to identify any relation between organisational changes and the relative employment share of the low-skill groups.

3. Data sources and variable construction

3.1 Trends in the labour market

A labour market is a set of employment relations between employers and employees and these employment relations may be characterised in a number of ways, but regardless of the perspective taken when describing employment relations they will also be found to be evolving. One way of describing the tasks and hence skills and more generally knowledge involved in an employment relation is by its occupation such as "School inspector", "Secretary" or "Automated-assembly-line operator". Internationally standardised taxonomies are used when classifying occupations but even such classification schemes need to be updated continuously (which caused problems for the analysis presented in the present paper, as elaborated below), such as the expansion in the number of occupations when moving from ISCO-88 to ISCO-08 in order to reflect the new occupations reflecting the increased use of information and communication technology. Thus when relying on occupations to describe the structural transformation of an economy from the perspective of the labour market it is thus a good idea to limit the study to a period where there is no change in the taxonomy. In this paper we employ two surveys from 2006 and 2010 respectively which means that our study necessarily spans the break between ISCO-88 and ISCO-08, which we handle as explained below. First, however, the trend in the structural changes in the labour market for the period leading up to the break in occupation taxonomy is described. The break is between 2009 and 2010 when ISCO-08 was implemented in the Danish data.

**Figure 1. Employment relations in the Danish labour market**
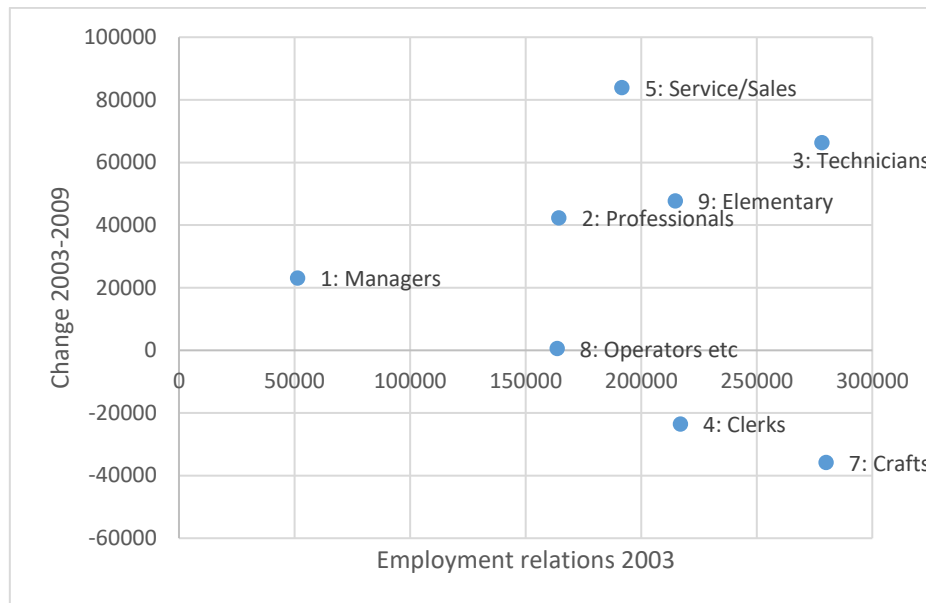
When excluding the sectors for public administration, health and education, allowing each person to have only one employment relation, removing the employment relations in occupations in agriculture (ISCO-88=6) and armed forces (ISCO-88=0), and removing employment relations with unknown occupation there were 1,560,666 employment relations in Denmark in early November 2003. Their distribution across the remaining eight ISCO-88 groups is shown on the horizontal axis of figure 1. The vertical axis shows the net change in the number of employment relations within each category over the ensuing six years. The aggregate net change was a growth of 204,340 employment relations.

The smallest group in 2003 was "1: Managers" of which there were about 50,000 but the group grew by more than 20,000 over the ensuing six years. The two largest groups in 2003 were "3: Technicians" and "7: Crafts" but while the former expanded even more over the period, the number of employment relations classified as "7: Crafts" decreased by about 35,000.

Figure 1 already hints at a structural transformation where some occupations become less abundant and hence some skills and knowledge become less used but to see this transformation clearly it is useful to observe the changes in relative terms. Figure 2 shows the evolution in each of the eight occupation categories when their share of total employment in 2003 is standardised to 1. Both "1: Managers" and "5: Service/Sales" expand by almost 30 percent. For managers this is from 3.48 percent of employment to 4.21 percent while service/sales grow from 12.28 to 15.61 percent. "8: Operators etc" decline by about 10 percent even though they do not decrease in absolute terms (cf. figure 1).

Figure 2. Structural change in the Danish labour market
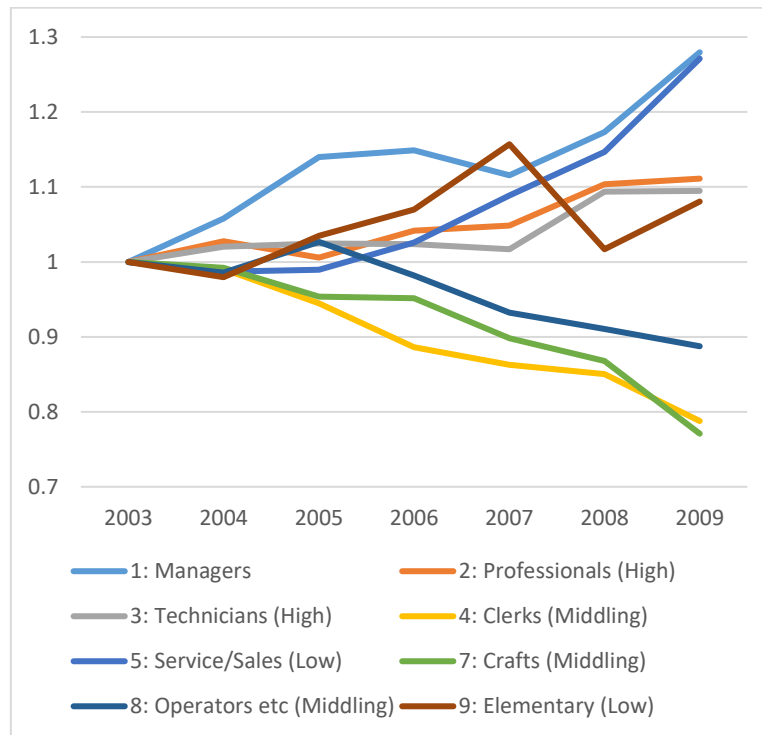
The pattern observed in figure 2 corresponds very well to the general pattern of polarization for many developed economies, cf. Goos et al. (2014): The highest and lowest skill level (and wage level) occupations expand while the Middling occupations contract. However figure 2 also shows some interesting nuances: the relative share of managers goes up sharply 2003-05 and then goes down slightly 2006-07; i.e. it goes up in the early years of the expansion, and then goes down in later years of the expansion when also other types of jobs are created. When the expansion ended in the 2008 financial crisis "9: Elementary" goes down steeply and other occupations hence grow in relative shares, however as elementary occupations bounce back already the following year only clerks and crafts go down, indicating that there is also job creation among the remaining occupations. In short, figure 2 shows how the trends for the different occupation categories are affected differently by the economic conjuncture but also that the trends in our data are very similar to the trends documented by other researchers, which suggests employing the common grouping of occupations into Low, Middling and High. The exception is that Managers seem to evolve in a relatively unique manner suggesting that growth in the relative share of managers is not determined by the same factors as growth among the remaining occupations.

3.2 Data

The trends in the Danish labour market described in the previous section were based on registry data available to researchers on servers at Statistics Denmark (DST). However to estimate the econometric models in this paper we primarily rely on survey data. We thus utilize three different sources of data for the analyses in this paper. The primary source is the GOPA survey from 2010 and the DISKO4 survey from 2006. GOPA is a multilevel study, designed to investigate the effects of external exposure and internal firm practices on psychosocial work environment (GOPA-projektgruppen 2013). The data used in the study are the DISKO4 survey, which was launched in 2006 and collected information from private sector employers on innovation, organisational change and -practices, employee relations and collaboration. This survey resulted in a research sample of 1775 employer responses. The research sample was used as a basic sample for the GOPA survey, which is a matched survey collected among employers and employees in the survived DISKO4 firms in 2010, thus establishing a panel to the DISKO4 survey. Twenty out of forty seven questions from DISKO4 was used in the GOPA employer level survey and supplemented with twenty seven questions specific to GOPA inquiries. This survey resulted in 601 usable firm responses, establishing the panel between the two surveys. The matched employer-employee research sample is 3392 employees in the 601 firms, which returned completed questionnaires. 6627 employees were drawn in three waves of up to 12 employees in each of the 601 firms and 3392 employees responded after three reminders. In the current paper we only use the employer level questionnaire of GOPA (Ibid.).

In order to construct the indicators for organisational practices we exploit the fact that the GOPA sample was intentionally structured to create a panel with the sample from the 2006 DISKO4 survey, with parallel and identical questions. We use only the 601 panel firms that are on both the GOPA survey and the DISKO4 survey, and construct weights to mend the selection bias created thereby. The panel consists of 601 firms before censoring by sectors and size. This panel is then merged with registry data from DST covering the entire Danish economy in terms of firms, workplaces and employed persons. The registry data are used to assess the representativeness of the DISKO4-GOPA sample, to create the weights to rectify selection bias and to create the dependent variables, which are the shares of firms' employees within four different occupational categories. While the registry data contain a wide range of information about firms our covariates are all based on the data from the two surveys, as our sample is relatively small and would get even smaller if we were to use data on sales, productivity, imports etc from the registries.

3.2.1 Weights

Table 1 shows the representativeness of the firms in our data compared to the entire economy. The table documents the distribution of employment, not firms, across sectors and firm size groups. As can be seen "Manufacturing etc." and very large firms are overrepresented in our data while "Other services" and small firms are underrepresented. This is corrected by weighting the data when performing regressions. Public sector including education and health are excluded since they were not included in DISKO4 and GOPA. Firms with less than 10 employees are excluded as our focus is on organisational practices which require a minimum firm size to be meaningful and hence the data available for regressions includes 531 firms.

Table 1. size and sector distribution

Sector	NACE 2	DISKO4-GOPA	Danish economy
1: Primary, manufacturing and utilities	ABCDE	46.74	25.81
2: Construction	F	5.57	7.25
3: Other services	GHILNRS	22.39	44.49
4: KIBS	JKM	25.3	22.45
Size			
1: 10-49 employees		7.45	29.48
2: 50-249 employees		23.92	25.58
3: 250-1000 employees		23.15	19.95
4: 1000+ employees		45.49	24.99

Source: Computed from IDA registry data for 2010. Pct. of total employment

The weights applied in the analyses are the product of three intermediate weights: two constructed from the information in table 1 intended to make the data representative by the sector and size groups, while the third intermediate weight is firm employment. The reason for including firm employment as a weight is that our analyses focusses on patterns of aggregate change in the Danish economy and hence an observation's impact in our data should be proportional to its impact on the aggregate changes in Denmark.

3.2.2 Dependent variable

Our dependent variables represent structural change as it impacts the distribution of jobs by occupation. Following recent contributions and in accordance with the trends illustrated in figures 1 and 2, we classify the workforce of each firm into Managers and the three categories defined by

Goos et al. (2014): High-paid, Middling and Low-paid occupations. For comparability with other studies and as a robustness check we also estimate models where Managers are included in High. The analysis by Goos and colleagues is undertaken at the sub-major group (2 digit) level but the result perfectly separates occupations at the major group (1 digit) level in the following pattern (keeping managers separate):

- Managerial occupations
    - ISCO-88 = 1: Managers
- High-paid occupations
    - ISCO-88 = 2: Professionals
    - ISCO-88 = 3: Technicians and associate professionals
- Middling occupations
    - ISCO-88 = 4: Clerks
    - ISCO-88 = 7: Craft and related trades workers
    - ISCO-88 = 8: Plant and machine operators and assemblers
- Low-paid occupations
    - ISCO-88 = 5: Service workers and shop and market sales workers
    - ISCO-88 = 9: Elementary occupations

ISCO-88 = 6 "Skilled agricultural and fishery workers" and ISCO-88 = 0 "Armed forces" are very small occupational groups that are not included in the study by Goos and colleagues, and are not observed in our data. As a control for validity we have confirmed that the wage level for each occupation corresponds to the hierarchy established by Goos et al. (2014).

For each firm we compute the share of the workforce in each occupational group in 2006 and 2010. If a worker has is missing occupational code for 2006 and works at the same firm in 2005 he/she is given the occupation from 2005. If this is also missing the 2007 occupation is used. In the Danish data ISCO-88 is used until 2009 while ISCO-08 is used from 2010. Thus all workers in 2010 receive the 2009 occupation code if they worked at the same firm. 2008 is used if 2009 is missing. Finally, the average wage for Managers, High, Middling and Low occupations is computed for the entire sample and workers who are still missing their occupational code is grouped into high, middling or low depending on their own wage level. This is done separately for 2006 and 2010.

After all employees at each firm in 2006 and 2010 are thus classified as Manager, High, Middling or Low we compute employment shares for each of the four categories as full time equivalent employment. The registry data contains information on the form of contract distinguishing between full time and six levels of part time work. This information is used to transform the firm

level occupational groups into full-time equivalent and hence to compute the total employment of the firm.

Goos et al. (2014) document labour market polarization over a range of European countries, including Denmark, for the period 1993-2010. In their data the share of Low goes up by 1.73 percentage points and the share of High goes up by 8.56 percentage points, while the share of Middling goes down by 10.30 percentage points. This is based on the European Union Labour Force Survey but corresponds closely to the changes observed in the registry data as documented in figures 1 and 2. The figures showed how largest increases where among Managers and Service/Sales personal which both grew by almost 30 percent. The change are as could be expected based on the data reported by Goos and colleagues. The share in Low-paid occupations increases from 26.04 to 30.48 percent, the share in high-paying occupations increases from 28.35 to 31.22 percent and the share in Middling occupations decreases from 42.32 to 34.09 percent.

In the raw DISKO4-GOPA sample there is also a strong polarization tendency although the shares of workers in the four categories is somewhat different from the aggregate picture even after applying the weights for sector and size representativeness. The result is presented in table 2.

Table 2. Polarization in our sample

	Shares in 2010	Change 2006-2010
Managers	5.83	0.40
High	34.18	2.66
Middling	35.24	-5.78
Low	24.75	2.72

Pct of employees in each category in the 531 firms used in the analysis. The combined employment of the firms is 104048.3 full-time equivalents in 2010

3.2.3 Organisational practices

Our regressions are to explain the firm level changes associated with the observed labour market trends. Previous studies have in particular emphasised technological change and off-shoring as the factors responsible for the disappearance of middling occupations and growth of high- and low-paid occupations. Relatively few studies have focussed on the effect of organisational change, which is our primary focus. To this end we exploit that firms were asked a number of identical questions on the DISKO4 and GOPA surveys: "Does the firm make use of some of the following ways of organizing the work?".

1. Autonomous groups
2. Systems for collecting proposals from employees
3. Quality circles/groups (Formal delegation of quality control)
4. Delegation of responsibility
5. Interdisciplinary workgroups
6. Integration of functions (e.g. sales, production)

For each question the respondent was asked to assess the share of employees involved and we thus have seven categorical variables taking four values: 1) No/None/Don't know, 2) Less than 25%, 3) 25-50%, 4) over 50%. We pool both surveys and run a principle components analysis on the resulting 1064 observations.

Table 3: Frequencies for work organisation variables

Extent of use among employees	Auton. groups	Systems for proposals	Quality circles	Delegation	Interd. workgroups	Integration
No/None/Don't know	35.34	33.36	39.29	27.82	36.09	6.39
Less than 25%	24.34	28.01	23.97	29.04	26.97	14.1
25-50%	19.36	13.72	16.07	20.86	19.83	24.81
over 50%	20.96	24.91	20.68	22.27	17.11	54.7
Total	100	100	100	100	100	100

Source: GOPA and DISKO4. N=1064.

Table 3 shows the frequencies for the four different responses for each of the six variables describing organisational practices. The distributions are quite similar with the exception that integration of functions appears to be a very widespread practice. When giving the six variables values from 1 to 4 (4 = "over 50%") they are all correlated with $p<0.0001$ and correlation coefficients ranging from 0.265 to 0.503 so it is no surprise that when applying a principle components analysis only one principle component has eigenvalue greater than one. However this first principle component only explains 44.85 percent of the combined variation in the six variables and therefore we retain the second principle component too. The eigenvalues of the first two principle components are 2.69 and 0.89 respectively jointly they explain 59.73 percent of the variation. We then apply oblique oblimin rotation and the resulting correlation between the factors and the original variables is shown in table 4.

Table 4: Correlations after rotation

	Factor1	Factor2
Auton. groups	0.507	0.591
Systems for proposals	0.324	0.784
Quality circles	0.351	0.822
Delegation	0.828	0.364

Label	Horizontalization	Involvement
Interd. workgroups	0.803	0.298
Integration	0.720	0.444

The first factor is positively delegation of responsibility, interdisciplinary workgroups and integration of functions. Firms scoring high on this factor have a relatively flat organisational structure where employees have own responsibility and do not have narrowly set functions, but rather participate in a range of functions across the organisation. The second factor captures employee involvement in the sense that employees have influence on management of their own tasks in autonomous groups and quality circles, and more directly on management through systems for collecting proposals from employees.

The interfactor correlation is 0.455 meaning that firms will tend to score high or low on both factors which, given their partially overlapping definitions, is no surprise. In our regressions it is not the factor score but the change 2006-2010 in each factor that will be used as explanatory variables. These changes are plotted for our 532 observations in figure 3 and not surprisingly they are also positively correlated. What is more surprising is the number of observations that are exceptions to the positive correlation. I.e. firms that become more horizontalized but with less employee involvement and vice versa.

Figure 3: Changes in work organisation
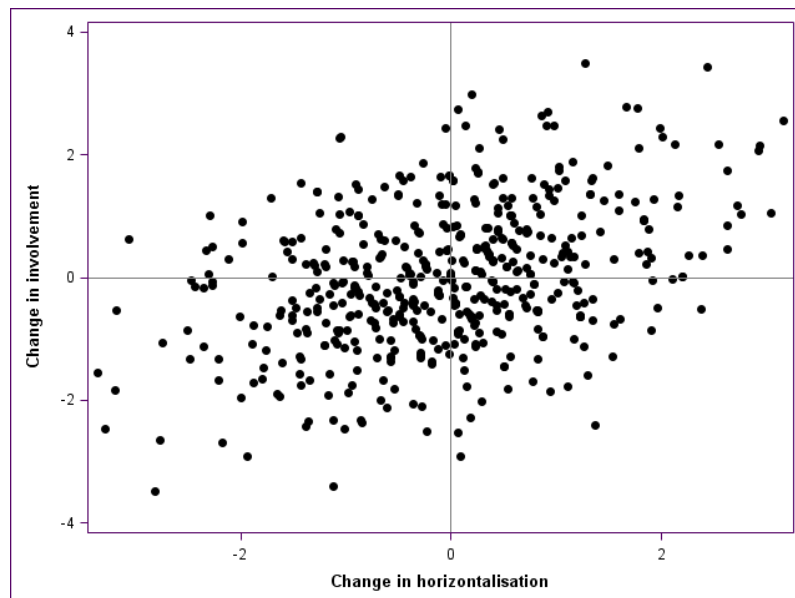
3.2.4 Other covariates

In addition to the principle components for changes in organisational practices and the size and sector controls we included variables for off-shoring, technological change and the effect of the 2008 financial crisis.

Both the DISKO4 and GOPA surveys include detailed questions on off-shoring behaviour but the questions are not identical. Hence we can only construct binary indicators for whether the firms uses off-shoring or not in each year, and then include variables in the regressions for whether the firm has begun or ceased to off-shore in the period between the surveys. In DISKO4 firms are asked whether and to where they have outsourced a number of activities. If a firm indicates to have outsourced any activity to a country other than Denmark then it is registered as having engaged in off-shoring in 2006 in our data. The corresponding question in GOPA contains a different range of activities and has a different range of possible responses so the binary indicator for whether off-shoring was used in 2010 is 1 if the firm has outsourced internationally or not.

We do not have a direct indicator of technological change within firms for the 2006-2010 period. Instead we construct an indicator for the firm's innovation effort. In GOPA firms are asked to indicate the priority given in the innovation effort to five different areas over 2007-2009, one of which is technological change, on a five-level Likert scale. We distinguish between firms that have prioritised technological change or not. If the firm has responded High or Very High it has prioritised technological change.[2]

GOPA includes six questions regarding the effect of the 2008 financial crisis on the firm. We use two: the effects on national sales and on liquidity. We do not use international sales since this is irrelevant to a large share of the firms, we do not use financing since it is almost perfectly correlated with liquidity and purchase of raw materials and intermediates since only few firms have registered an effect. The effects on national sales and liquidity are two dummies taking the value 1 for some/high deterioration.

The registry data contains detailed financial data on firms including sales, profits, wage costs, imports, exports etc. but these are not available for all industries and the decrease in the number of available observations in our case has been deemed unacceptable.

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[2] We also tried using the Likert scale as continuous and tried using it as a relative priority where it was standardised relative to the mean of all 5 questions pertaining to priorities in the innovation effort but these more complicated variables showed the same result as the binary variable that we use.

3.3 Descriptive statistics

Table 5 presents correlations and summary data for the variables used in the regressions. The same weights as used in the regressions have been applied. The means of the four dependent variables show the familiar pattern of polarization: Middling jobs decrease by about 6 percent while Managers, High and Low all increase. These numbers were also reported in table 2. The dependent variables are naturally correlated since an increase in one share must be matched by a decrease in one of the other.

Changes in the shares of Managers and of Low do not correlate with the explanatory variables except for a few cases but changes in the shares of High and Middling do. In particular, changes in the frequencies of type High and type Middling jobs correlate with prioritizing technological change, organisational change and with the effects of the financial crisis. However while changes in the occupational structure of firms' workforces do not correlate with removing or adding offshoring, offshoring does correlate with organisational change while technological change surprisingly does not. Organisational change along the two factors Horizontalisation and Involvement has positive correlation, as was also seen in figure 3, but while the average firm did move towards increased Involvement it simultaneously moved towards decreased Horizontalisation. These average changes are relatively close to zero (compare to figure 3) and since the factors have mean zero by construction, this indicates that there is no trend in organisational change over the period. Rather, firms change in idiosyncratic ways. All this underlines the importance of testing hypotheses regarding the confoundedness of the effects of these variables.

Many more firms experiences a sales constraint than a liquidity constraint from the financial crisis (two thirds versus one third), while more than a third of firms report that sales grew over the period. It almost looks like the all firms that did not experience significant sales growth blame it on the financial crisis, but the correlations between the dummies for growth and decline of sales, and the dummy for experiencing a sales constraint from the financial crisis are not particularly strong, although they are significant and have the expected signs. Quite few firms added or removed offshoring (eight and six percent), and more than 40 percent prioritized technological change over the period.

Table 5: Correlations, means and standard deviations

	ΔS_{Mana}	ΔS_{High}	ΔS_{Mid}	ΔS_{Low}	Sales_up	Sales_down	Add_offs	Rmv_offs	Tech_Prio	$\Delta Horizon$	$\Delta Involve$	Fc_sales	Fc_liqui
ΔS_{High}	**-0.13**	1.00											
ΔS_{Mid}	**-0.12**	**-0.65**	1.00										
ΔS_{Low}	-0.05	**-0.38**	**-0.40**	1.00									
Sales_up	0.00	**-0.15**	**0.10**	0.07	1.00								
Sales_down	**0.11**	**-0.14**	0.08	0.03	**-0.61**	1.00							
Add_offs	0.02	-0.03	-0.03	0.07	**0.12**	-0.08	1.00						
Rmv_offs	-0.01	0.00	0.00	0.00	-0.06	0.04	-0.08	1.00					
Tech_Prio	0.01	**0.22**	**-0.16**	-0.08	**0.11**	**-0.13**	-0.02	0.02	1.00				
$\Delta Horizon$	0.01	**0.23**	**-0.23**	-0.01	**-0.09**	0.00	-0.02	**-0.10**	0.06	1.00			
$\Delta Involve$	0.01	**-0.10**	0.01	**0.11**	0.02	-0.02	**0.16**	-0.06	-0.08	**0.31**	1.00		
Fc_sales	-0.01	**-0.15**	**0.18**	-0.04	**-0.14**	**0.28**	**0.14**	0.00	**-0.19**	-0.03	**0.14**	1.00	
Fc_liqui	0.04	**-0.18**	0.07	**0.12**	-0.05	**0.26**	0.06	-0.01	-0.07	0.01	0.02	**0.28**	1.00
Mean	0.004	0.027	-0.058	0.027	0.376	0.384	0.080	0.061	0.412	-0.050	0.068	0.643	0.316
Std. Dev.	0.047	0.158	0.159	0.126						1.140	1.164		

Bold indicates significant at the 5% level

4. Econometric specification and results

Our econometric specification fits within the framework based on the translog firm cost function framework. This is a relative traditional economic framework but also a very flexible framework as there are no restrictions on the homogeneity (returns to scale), homotheticity (factors of production do not need to change proportionally) or the substitutability of the factors of production in the production function. The framework means starting from a short run production function taking only different types of labour and technology as inputs. Technology should here be understood in a broad sense including not just knowledge and skills but also human capital more broadly, organisation and, in e.g. Caroli and Van Reenen (2001), also physical capital. Given the output level firms' task is to minimise wage costs:

$$C = \sum_{f=1}^{F} w_f L_f(Y, \vec{A}, \vec{w}) = C(Y, \vec{A}, \vec{w}). \tag{1}$$

Total wage costs C is the sum of wage times employment, $w_f L_f(\cdot)$, over the F different types of labour. The demand for each type of labour depends on output Y, technology $\vec{A}$, and the wage structure $\vec{w}$. Arrows denote vectors. By differentiating equation 1 with respect to the F types of labour a system of F equations for the cost shares of each type of labour is obtained. The wage variables among the regressors entail a range of econometric problems which do have standard solutions, but since the wage regressors are instrumented these problems will not be elaborated as in e.g. Holm et al. (2017). Specifying the equations in cost shares and in differences to eliminate fixed effects yields equation 2, where a lower case c_f is used to denote a cost share:[3]

$$\Delta c_f = \sum_g \alpha_{fg} \Delta \ln(w_g) + \alpha_{fY} \Delta \ln Y + \sum_n \alpha_{fn} \Delta \ln A_n + \Delta u_f. \tag{2}$$

g is used as a second index of labour categories and n indexes technology. The F equations of the type in equation 2 all have identical regressors. This means that there is no difference between estimating each equation separately with ordinary least squares and estimating them jointly using Seeming Unrelated Regression (SUR, or the Zellner estimator. See Berndt (1990) chapter 9 for details)[4], unless data is available on wages in which case there must be cross equation restrictions of the form $\alpha_{fg} = \alpha_{gf}$ to ensure consistent estimates for

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[3] I.e. $c_f = \frac{w_f L_f}{C(Y, \vec{A}, \vec{w})}$. Getting from equation 1 to equation 2 involves expanding equation 1 as the Taylor approximation at $C(\vec{1})$ and assuming that the cost function is homogenous in wages; i.e. that doubling all wages doubles total wage costs. See e.g. Holm et al. (2017) for a more detailed derivation.

[4] In practice we use the iterated Zellner estimator which in our case is equivalent to Maximum Likelihood.

elasticities of substitution between the categories of labour, and thus SUR must be employed. However not all studies use wage data even when it is available since there is an endogeneity problem from having wages as regressors when estimating wage cost shares. Instead, instruments in the form of dummies for e.g. region and sector are used. An alternative approach is to use labour shares rather than wage cost shares as the dependent variable. We combine both strategies for separate reasons. Our interest is strictly in the changes in shares of types of jobs and hence we do not want our dependent variable confounded by wage. Hence we estimate labour shares. In addition, since we are not interested in the properties of the production function, we instrument wages with dummies for region and sector, and hence simplify the analysis so that we may use ordinary least squares rather than SUR. The registry data contain financial data on most firms but we do not use it since it is missing for an unacceptable share of the sample. Instead we use a question of the GOPA survey for output. The questions asks whether the firms total revenue has increased, decreased or been constant (within a +/- 5% margin) in the years 2007-2009. The vector of variables for technology includes organisational change, technological change and the use of offshore outsourcing. We also include variables describing the impact of the 2008 financial crisis as conceptually part of the technology vector.

As in Caroli and Van Reenen (2001) and Piva et al. (2003) we use the long differences form thus eliminating firm's fixed effects and regressing the change in an occupational group's employment share between 2006 and 2010 on variables measuring the degree of change (positive or negative) over the same period in two dimensions of organizational practices based on the factor analysis, ($\Delta Horizon_i$ and $\Delta Involve_i$), the binary variable measuring the degree to which the firm has prioritized technological change over the period 2007-2009 ($Tech\_prio_i$) , the binary variables indicating whether or not the firm has begun (Add_offs_i) or ceased (Rmv_offs_i) offshoring during the period, and the binary variables measuring the effect of the financial crisis on the firm's liquidity (Fc_liqui_i) and sales (Fc_sales_i). The binary variables for increases or decreases in output are $Sales\_up_i$ and $Sales\_down_i$ respectively. We include dummies for the sector ($Brch$) and NUTS 3 region, of which there are 11 in Denmark ($NUTS$).

Our basic occupational share equation is:

$$\Delta S_{fi} = \beta_{of} + \alpha_{fHorizon}\Delta Horizon_i + \alpha_{fInvolve}\Delta Involve_i + \alpha_{fTech\_prio}Tech\_Prio_i$$
$$+ \alpha_{fAdd\_offs}Add\_offs_i + \alpha_{fRmd\_offs}Rmv\_offs_i + \alpha_{fFc\_liqui}Fc\_liqui_i$$
$$+ \alpha_{fFc\_sales}Fc\_sales_i + \alpha_{fSales\_up}Sales\_up_i + \alpha_{fSales\_down}Sales\_down_i$$
$$+ \sum_{j=1}^{3}\beta_{fBrch_j}Brch_{ji} + \sum_{k=1}^{10}\beta_{fNUTS_k}NUTS_{ki} + \epsilon_{fi}$$

(3)

Where f indexes the skill/occupational group, i the enterprise, j the sector and k the NUTS3 region of the firm's main address. ϵ_{fi} are classical errors.

4.1 Results

Table 6 presents the results for the basic specification for the 4 occupational groups: managers, high, medium and low. Table 7 includes interaction effects between the technology priority variable and the two organizational change variables, and between the two organizational variables and the variables measuring the initiation and cessation of off-shoring. Both table 6 and 7 also include a fifth column where managers are included in the group of high occupations. This column is included for comparability with other studies but will not be focused on. Focusing in on the organisational change variables in the Table 6 results, a first observation is that organisational change clearly has a statistically significant effect on the relative employment shares of the high, middle and low skill groups. With respect to changes in horizontalization, the results show a positive and statistically significant effect on the share of the high category and a negative and statistically significant effect on the share of the middle category. For the variable measuring changes in employee involvement, there is a relatively weak negative effect on the share of the high group and a positive effect on the share of low group. The results show, other things equal, that a unit increase in both types of organizational change (a plausible event, cf. figure 3) would contribute to the polarization in the labour market as the positive effect of an increase in horizontalization on the share of the high skill group would more than compensate for the negative effect of an increase in employee involvement. Another interesting result is that management is effected differently from the other relatively high skill/wage composed on technicians and professionals as the coefficients in case of management are relatively weak and insignificant.

These results point to the uneven effects of organization change viewed from the perspective of their impact on the relative employment shares of different occupational

groups. In particular we see a difference between the management group, whose share is unaffected by an increase in horizontalization, and technicians and professionals, whose employment share increases with greater horizontalization. With respect to the latter categories, as work on adhocracies has shown, the horizontalization process, often involving the introduction of interdisciplinary groups and greater integration of functions in order to cut across entrenched silos, tends to shift the locus of decision-making power towards those persons with key expertise and competences. As vertical lines of control are eliminated there is greater need for what Mintzberg (1987) refers to as 'mutual adjustment'. The winners in this process in terms of employment shares are likely to be those with technical and professional expertise.

Increasing employee involvement based on autonomous teams and the use of quality circles, on the other hand, may well have an opposite effect acting to reduce the role of technicians and professionals while reinforcing the position of those lower down on the occupational hierarchy, whose skills and expertise may be increasingly needed in order to coordinate daily work activity. The regression results are consistent with this in the sense that the impact on the employment share of technicians and professionals is negative. However the positive effects on the middle and low skill groups is only observed in the case of low group composed of sales and service worker and the elementary trades.

The results show that technological change can contribute to polarisation as there is a significant positive effect on the shares of the upper group composed of technicians and professionals. However the coefficients for the management and low skills groups are both positive, though not significant. Turning to the other covariates, somewhat surprisingly none of the coefficients on the variables measuring the initiation or cessation of off-shoring are statistically significant suggesting that in the Danish case globalization is not an important force driving the polarization trend. The direction of the affects are consistent with polarization with negative coefficients for both the initiation and cessation of off-shoring in the case of the regression explaining the share of the middle group and positive coefficients for both the high and low groups.

The effects for the two variables for changes in sales are surprisingly very similar. When there is a change in sales in excess of 5%, whether up or down, the share of high jobs decreases while the other categories increase. For growing sales the increase is significant for managers and for low while for declining sales the increase is only significant for

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managers. The standard interpretation of the effect of sales in the translog functional form pertains to the homotheticity of the production function: if sales does not affect the occupational shares then the shares are constant when the firm scales up or down and it becomes relevant to also study the homogeneity (returns to scale) of the production function. This is not the case on our results. We cannot precisely say whether our results indicate that growth and decline lead to similar changes or different changes with similar effects. It may be that a large change in sales is an opportunity for breaking organisational inertia and reorganising the firm, in which case the same new principles are adopted regardless of whether the firm grows or declines. It may also be that growth entails expanding sales, production and management in order to meet the larger scale of activity and simultaneously the scale of knowledge intensive functions such as law or R&D do not change, while decline entails cost cutting and shedding the most expensive workers (high) in the relatively short run of our analysis. These are only hypotheses and require further analysis and development since they are to some degree at odds with our other results.

In a number of cases the financial crisis variables have statistically significant effects that seem to counteract polarization. Firms that experienced a liquidity constraint decreased the share of high and increased the shares of the other types, particularly low. However firms that experienced a sales constraint shifted from low to middling. This is consistent with a liquidity constraint being a severe problem necessitating short run cost-cutting and laying off the most expensive workers, while a sales constraint is not a problem in the short run and just entails laying off superfluous sales workers.

Table 6: Model 1 results

VARIABLES	Managers	High	Model 1 Middling	Low	Man+High
$\Delta Horizon$	0.0001	0.0282**	-0.0236*	-0.0046	0.0282**
	(0.0021)	(0.0116)	(0.0124)	(0.0078)	(0.0115)
$\Delta Involve$	0.0019	-0.0133*	-0.0028	0.0143*	-0.0114
	(0.0022)	(0.0077)	(0.0091)	(0.0076)	(0.0077)
$Tech\_Prio$	-0.0008	0.0427***	-0.0213	-0.0206	0.0419***
	(0.0052)	(0.0164)	(0.0161)	(0.0129)	(0.0160)
Add_offs	0.0015	0.0207	-0.0426	0.0204	0.0222
	(0.0086)	(0.0247)	(0.0451)	(0.0530)	(0.0277)
Rmv_offs	0.0014	0.0127	-0.0230	0.0088	0.0142
	(0.0069)	(0.0204)	(0.0233)	(0.0151)	(0.0219)
Fc_liqui	0.0012	-0.0366**	0.0010	0.0344*	-0.0354**
	(0.0050)	(0.0154)	(0.0186)	(0.0193)	(0.0158)
Fc_sales	-0.0047	-0.0044	0.0392*	-0.0300*	-0.0092

		(0.0056)	(0.0221)	(0.0229)	(0.0154)	(0.0219)
Sales_up		0.0125*	-0.1050***	0.0620	0.0304*	-0.0925**
		(0.0065)	(0.0364)	(0.0419)	(0.0184)	(0.0362)
Sales_down		0.0193***	-0.0711***	0.0313	0.0206	-0.0518*
		(0.0071)	(0.0272)	(0.0347)	(0.0199)	(0.0277)
Wage Instruments						
Sector		YES	YES	YES	YES	YES
Region		YES	YES	YES	YES	YES
Constant		YES	YES	YES	YES	YES
Observations		531	531	531	531	531
R-squared		0.0668	0.2806	0.2114	0.0657	0.2764

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In Table 7 the results for the interaction effects between technology and organisational change show that organisational change strongly moderates the effect of technology in the cases of the impact on the shares of the high and middle skill/wage groups. Thus the positive effect of technology on the share of the high group is reinforced by increases in horizontalisation, and the negative effect on the share of the middle group is enhanced. In the case of employee autonomy and involvement, a positive effect on the middle group's share becomes possible if the change coincides with prioritizing technological change. There are no significant interaction effects in the case of the low skill group which is consistent with idea that most of the tasks and skills of this group are impervious to the effects of automation.

After introducing the interaction effects the direct effect of organisational change along either dimension are insignificant showing that organisational change has no impact of employment shares conditional a total absence of technical change and a lack of changes in off-shoring Technology, however, remains highly significant for the share of the high group. This provides strong support for the view that technical change has an up-grading effect on organizations, increasing their demand for more highly skilled labor.

Table 7: Model 2 results

| | | | Model 2 | | |
VARIABLES	Managers	High	Middling	Low	Man+High
ΔHorizon	-0.0039	0.0112	-0.0091	0.0018	0.0073
	(0.0029)	(0.0093)	(0.0108)	(0.0114)	(0.0096)
ΔInvolve	0.0017	-0.0062	-0.0119	0.0164	-0.0045
	(0.0027)	(0.0082)	(0.0120)	(0.0103)	(0.0082)
Tech_Prio	0.0000	0.0469***	-0.0261	-0.0208	0.0469***

	(1)	(2)	(3)	(4)	(5)
	(0.0052)	(0.0168)	(0.0168)	(0.0130)	(0.0163)
Add_offs	0.0079	-0.0057	-0.0168	0.0146	0.0022
	(0.0112)	(0.0229)	(0.0351)	(0.0277)	(0.0276)
Rmv_offs	0.0038	-0.0068	-0.0094	0.0125	-0.0030
	(0.0070)	(0.0192)	(0.0243)	(0.0151)	(0.0209)
$Tech\_Prio * \Delta Horizon$	0.0065	0.0400**	-0.0417**	-0.0049	0.0465**
	(0.0046)	(0.0192)	(0.0204)	(0.0164)	(0.0189)
$Add\_offs * \Delta Horizon$	0.0075	0.0004	0.0418	-0.0497	0.0080
	(0.0068)	(0.0196)	(0.0383)	(0.0465)	(0.0232)
$Rmv\_offs * \Delta Horizon$	0.0013	-0.0501**	0.0355	0.0132	-0.0487*
	(0.0063)	(0.0251)	(0.0257)	(0.0135)	(0.0252)
$Tech\_Prio * \Delta Involve$	0.0022	-0.0228	0.0286*	-0.0080	-0.0206
	(0.0051)	(0.0153)	(0.0161)	(0.0145)	(0.0151)
$Add\_offs * \Delta Involve$	-0.0093	0.0383	-0.0299	0.0009	0.0290
	(0.0097)	(0.0258)	(0.0344)	(0.0386)	(0.0300)
$Rmv\_offs * \Delta Involve$	0.0117*	0.0425*	-0.0281	-0.0261	0.0542**
	(0.0070)	(0.0232)	(0.0289)	(0.0185)	(0.0249)
Fc_liqui	0.0023	-0.0374**	0.0048	0.0303*	-0.0351**
	(0.0049)	(0.0153)	(0.0168)	(0.0168)	(0.0156)
Fc_sales	-0.0045	-0.0049	0.0391*	-0.0297**	-0.0094
	(0.0054)	(0.0209)	(0.0221)	(0.0151)	(0.0206)
$Sales\_up$	0.0126*	-0.0978***	0.0516	0.0336*	-0.0852***
	(0.0067)	(0.0311)	(0.0381)	(0.0197)	(0.0309)
$Sales\_down$	0.0187**	-0.0623***	0.0185	0.0252	-0.0436*
	(0.0072)	(0.0230)	(0.0320)	(0.0205)	(0.0239)
Wage Instruments					
Sector	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES
Observations	531	531	531	531	531
R-squared	0.0829	0.3062	0.2411	0.0853	0.3054

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

No effects of offshoring where found in model 1, cf. table 6, and the direct effects estimated in model 2, table 7, are still not significant. However there a number of significant interaction effects for the variable indicating whether firms have ceased to offshore. Ceasing to offshore coupled with increases in horizontalisation leads to a decrease in high, which is consistent with an expansion of managers and the types of jobs that are potentially offshored (middling and low) in absolute terms. On the other hand, ceasing to offshore and simultaneously increasing involvement leads to an increase in high.

4.1.1 Marginal effects

In Figures 4 and 5 below we take a closer look at the interactions between technology and organisational change by estimating the marginal effects of technology conditional on

organisational change. Figure 4 shows the effects for high while figure 5 shows the effects for middling. There are no significant effects for managers or low so these are not shown.

Figure 4: Marginal effect of technological change on High conditional on organisational change
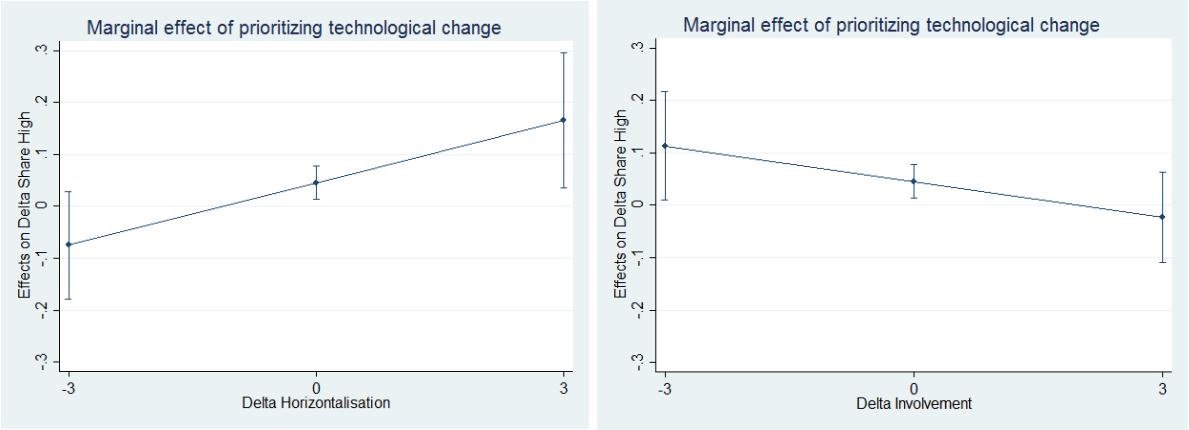
The left panel in figure 4 show that the effect of technological change increases with organisational change towards more horizontalisation. However the marginal effect is only significant when the change in horizontalisation is positive. The right panel shows that the effect of technological change is positive only when it coincides with a move away from the use of employee involvement. That is, new technology has a positive effect on the share of high only when employee involvement is reduced or when there is change towards more horizontalisation.[5] Figure 5 shows more or less the opposite of figure 4: Technological change only has a negative effect on the share of middling when it coincides with a decrease in involvement or an increase in horizontalisation. As was seen in tables 6 and 7 the positive effects for high tend to be highly significant while there is no corresponding highly significant negative change in any of the other shares. In accordance with this, the conditional marginal effects in figure 5 are barely significant. However the conclusion is clear: new technology may complement high skill type jobs and substitute middling type jobs, but it is also possible that technological change does not affect the share of the occupational groups. Whether a polarizing effect is observed depends on the organisational changes that accompany the adoption of the new technology.

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[5] The plots in figures 4 and 5 are average effects meaning that, for example, the left panel in figure 4 is the marginal effect conditional on a change in horizontalisation when the change in involvement is zero.

Figure 5: Marginal effect of technological change on Middling conditional on organisational change
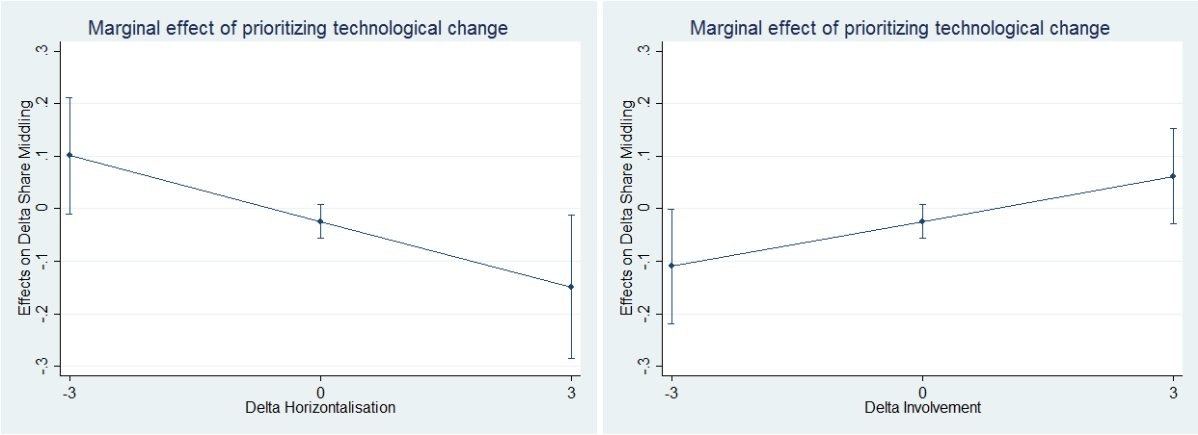
5. Conclusions

Job polarization is central in policy discussions at the EU and national levels because it contributes to earnings inequality and poses challenges to education and training systems to respond to problems of skills gaps and skills mismatches. In this context it is important to have a better understanding of the drivers of polarization including those which are internal to organizations and managerial decision-making. Our results suggest that polarization, rather than being an inevitable consequence of exogenous technical forces or the pressures of globalization is shaped in part by managerial decision making on technology adoption and work organization.

Our analysis shows that the effects of technical change on the relative shares of the occupational groups are moderated by the direction of the firm's organizational change. The positive impact of technical change on the share of the high group is greater for bigger changes in the direction of horizontalization of hierarchies. Further, the results show that technical change has a significant negative effect on the employment share of the middling groups conditional on organizational change in the direction of horizontalization. Changes in the direction of greater employee involvement, however, appear to mitigate to some extent the negative impact on the share of the middling group, though the positive effect is of borderline statistical significance.

Our data are limited in terms of characterizing technical change in Denmark and we cannot identify the importance of such Industry 4.0 processes as robotics and AI. Nonetheless, our

results show that there exists considerable latitude at the workplace level in how technology is implemented. This suggests that policies focusing on the workplace level and designed to encourage the use of skill enhancing forms of work organization as well as related vocational training investments may contribute to mitigating some of the most negative consequences of the current wave of technical change. In a further extension of this research we propose to use linked employee level data to focus in on the effects of technical and organization change on employee outcomes.

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