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Digitalization in Nordic manufacturing: Some case-study illustrations

Nordic future of work project 2017–2020: Working paper 3

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Preface

This Working Paper is a genuine "work in progress" output from a study undertaken in the project *"The future of work: Opportunities and challenges for the Nordic models"* (NFoW) funded by the Nordic Council of Ministers and coordinated by Fafo. The overall project analyses 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 forms part of pillar-2 of the NFoW-project, *"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 first phase of pillar-2 focuses on the impact of digitalization in the manufacturing sector, a cornerstone of the labour regimes in the small, open Nordic economies. Here we have interviewed representatives of plant management and trade unions about their experiences with adoption of digital production technology in a number of Nordic machinery industry companies. Although the study is far from completed, we think the preliminary observations collected in this paper for the Nordic ILO conference 4-5 April 2019 might be helpful in conveying a glimpse of what digitalization in Nordic manufacturing is about. In parallel, a working paper about recent changes in the occupational structure of employment, including manufacturing, is made available (Berglund et al. 2019). In fall 2019, these studies will be followed up by an exploratory investigation of the impact of digital change in the services sectors.

We would like to thank members of the NCM reference group for useful input to the work in this pillar of the NFoW-project, and the information unit at Fafo for, as always, their swift professional help in bringing the mimeo into decent shape.

Bertil Rolandsson,
Gothenburg, March 2019

Abstract

Studies, grouped under the heading of Industry 4.0, have predicted that the introduction of advanced robots, networked machines, additive manufacturing, machine learning, internet of things (IIot) etc. will not only propel labour-saving automation, but also alter tasks, content, skill demands and conditions of work. In this brief Working Paper we offer a look into how a set of large-scale Nordic manufacturing companies makes use of digital production technology, and what kind of challenges such technological change implies for the organization of work. Drawing on 49 semi-structured interviews at 7 Nordic manufacturing sites, we describe the aims driving the companies' introduction of new technology and explore how the Nordic managers and unions seek to tackle the impact of digitalization on work, skill requirements, and employment relations at company level. The interviewees all come from comparable sites in advanced machinery industry companies in Denmark, Finland, Norway and Sweden. Accounting for sizeable shares of national production and export in their domains, the selected companies have been using digital equipment and ICT-based production processes for quite a while. As companies with a long history, several of them have also experienced earlier rounds of industrial and technological transformation. According to the interviewees, the development of new digitalized production lines is associated with team-work and other new modes of organizing work, which requires continuous reskilling and upgrading of work at the same time as the boundaries between blue- and white collar labour become more blurred. To succeed in such reorganizations and reaping the benefits of digitalization, the interviewees on both sides emphasised the critical importance of bottom-up involvement from the shop-floor and active support from partnerships between management and unions. Hence, rather than as a barrier, the local pillars of the Nordic model were viewed as a prerequisite for successful digitalization, and for safeguarding jobs in ever more competitive global markets. Even in instances where company level partnerships showed signs of strain, none of the respondents depicted the transition into Industry 4.0 as a challenge to the Nordic tradition of collaborative industrial relations.

Key Words: Manufacturing, Digitalization, Industry 4.0, Nordic model, Upgrading, Skills

Introduction

Drawing on interviews with representatives of plant management and trade unions in a number of Nordic manufacturing companies, the aim of this working paper is to give some illustrations of what technological digitalization of manufacturing is about in concrete settings, and how it may affect work, skill requirements, and employment relations in a core domain of the Nordic work life model.

Manufacturing is in the international literature singled out as one of the areas where digital technology is likely to have pervasive impact on the volume, nature, and relations of work (Fernández-Macías et al. 2018). Often grouped under the heading of Industry 4.0, the introduction of advanced robots, networked machines, additive manufacturing, machine learning, internet of things (IIot) and other digital applications, is foreseen to transform production processes and work organization in manufacturing (ibid., see also Dølvik and Steen 2018; Federal Ministry of Labour and Social Affairs 2017; Barneveld and Jansson, 2017). As seminally illustrated in "The Second Machine Age: Work, Progress and Prosperity in a Time of Brilliant Technologies" of McAfee and Brynjolfsson (2013), the fourth industrial revolution is expected not only to erase industrial jobs at an unprecedented rate but also to alter the tasks, content, and conditions of manufacturing work fundamentally.

While a number of studies have suggested that as much as half of all jobs – and considerably more in manufacturing – can be made redundant by digital processes, robots, and so forth in the coming decades (Fölster 2014; Pajarainen 2015; Frey and Osborne 2017; Böckermann 2018), more recent OECD-estimates based on work tasks suggest that the figures will be substantially lower – around 14 percent in OECD as a whole and 7-10 percent in the Nordic countries (Arntz et al. 2016; OECD, 2018; Nedelkoska and Quitini 2018). A report from World Economic Forum (2018, see also 2016), adopting a short-medium term perspective, even argues that the creation of new jobs needed to accomplish the digital shift is likely to generate increased manufacturing employment in Europe 2018-2023. In the same vein, McKinsey (2018) suggests that the opportunities opening up for pioneer countries in digitalization, mostly found in northern Europe, may unleash a wave of re-industrialization if the right facilitating policies are applied.

Similar prospects are referred to in a report made by the IRIS-group for the Nordic Council of Ministers (2015), but it also points to the barriers to digitalization and automation of manufacturing not least among the majority of small-and medium-sized 'digital followers' in Nordic manufacturing. Obviously, the availability of path-breaking technologies does not automatically imply that the investments in such equipment, and the training and organizational adjustments needed to make it work, are economically viable for the many small producers typical of Nordic manufacturing. Furthermore, as underscored by Fernándes-Marcías et al. (2018:4), the breadth and pace of digital technology diffusion depend on a range of financial, political-institutional, and technological factors, including access to the raw materials and standards needed to make the new means of manufacturing production available and applicable throughout the sector. How path-breaking the digital shift

in Nordic manufacturing will turn out to be therefore remains to be seen, as indicated for instance by surveys showing that only a tiny share of firms in Finnish and Norwegian manufacturing, by 2016-17, had introduced digital equipment beyond the mere PC-handling of information and communication (Alasoini 2018; NHO 2017).

Uncertainties about the pace and employment impact of technological change notwithstanding, there is broad agreement that digitalization of manufacturing production will imply substantial changes in work tasks, work organization, skill requirements, and the occupational structure of the workforce (SOU 2017). Whereas increased use of ICT-technology seems to enhance the productivity of and demand for highly educated personnel, workers performing routine-based, manual and increasingly also cognitive tasks seem more susceptible to be replaced by automated ICT-driven processes (Susskind and Susskind 2015; Elliot 2017; Thilander and Rolandsson 2018). By contrast, workers doing less skill-demanding, non-routine, manual tasks related for instance to ancillary work – on the factory floor or in support functions – are less prone to automation, and may even see increased demand if production expands (Autour 2006; Goos and Manning 2007; Ilsoe 2017). Whether such changes will lead to upgrading of the job/skill structure in manufacturing or polarization – i.e. job growth in the top and bottom, but decline in the middle – is an empirical question, which, amongst others, depends on the industrial structure of manufacturing in the various countries. A new study undertaken in this project by Berglund et al. (2019), based on LFS-data, indicates a tendency towards polarization of the occupational job/wage structure in Danish manufacturing 2000-2014, while a clear upgrading tendency was found in Swedish and Norwegian manufacturing. Through the interviews with actors at plant level, this study sheds more light on the ways in which digitalization of production in the machinery industry influence the job and skills structure in that context.

Besides transforming the organization of production and work within single plants, we are then also considering that the new digital technologies offer opportunities to develop more elaborated value-chains, i.e. networks with suppliers, sub-contractors, and customers as well as reshaping relations between different units within the production chain (Castells 1996; Gawer, 2010; Van Laar et al. 2017). This provides infrastructures for wider knowledge sharing supporting innovation, upskilling and development, enabling companies to manage demands for shorter product life cycles (Benkler 2006, Rolandsson et al. 2011). But, it also enables changes in the division of labour within corporations, nationally and transnationally, making it easier in switching of production tasks to subsidiaries or subcontractors abroad, and may – combined with automation of domestic production – allow reshoring/ home-sourcing of certain tasks (Goos et al. 2014; Oldenski 2014; EU 2015). Such networked linking of production units can facilitate externalization of labour, for instance through digital mediation of labour from sub-contractors, temporary agencies or labour platforms. Whether or not such impetus to development of more complex, networked production and delivery structures will imply a rise in non-standard, flexible work, is also an empirical question where the answer depends on the strategic choices of managements and their labour counterparts (Autor et al. 2003; Emmenegger et al. 2012.) Contrary to the widely predicted casualization of

work, it is principally foreseeable that easier opportunities to switch work tasks within a network of interlinked producers can enable the single units to reduce their dependence on buffers of flexible, casual labour and concentrate on refining the development and use of their internal, core staff (Svenskt Näringsliv 2015). In the same vein, a fresh policy brief from this project (Larsen and Ilsøe 2019) shows that the share of non-standard employment in Nordic working life has remained remarkably stable – accounting for around 30 percent of total employment – and none of the industries with relatively high shares of such jobs belong to manufacturing.

Combined, the two dimensions of digitalization of production organization in manufacturing – i.e. internal automation and digital reshaping of external/internal networks – are likely to propel changes in the industry's workforce composition (Van der Zande et al. 2018). In a trajectory of more high-skilled, white-collar employees and shrinking shares of skilled manual workers – which has in fact been the trend in several decades already in Nordic manufacturing – one can envisage further shifts in the recruitment bases and the numerical size of trade unions affiliated to different confederations (e.g. LO vs TCO/Unionen, SACO in Sweden) (see IF Metall 2017; Rolandsson 2003; Ilsoe and Larsen 2016; Larsen 2019). As perhaps indicated in Sweden, where Unionen (TCO) organizing white-collar manufacturing employees has surpassed IF Metall in members and become the largest national trade union, such shifts can in the longer term imply significant changes in the configuration of actors and power relations shaping industrial relations and collective bargaining, locally as well as nationally.

The purpose of this study is not to give a comprehensive view of the scope and impact of digitalization in Nordic manufacturing, but to offer some illustrations of how, why and with what effects digital production equipment and processes have been introduced in a number of quite advanced companies in the Nordic machine industry. Presenting the aims, views and experiences of the local actors regarding digitalization of production[1], the emphasis is on how such processes have affected the pattern, organization, skill requirements, and environment of work and employment relations in these plants.

Before looking closer these local actor experiences, however, the following section provide a short review of developments in Nordic manufacturing employment and productivity during the past decades of ICT-related technological change and globalization along with some brief references to the Nordic model of company level restructuring and adjustment. Then, the selection of companies and our interview-based data collection are described, followed by an initial, rough review of the main commonalities concerning the use and impact of digital equipment in production on work and work organization that are salient in the material.

[1] By *digitalization* in this text, we refer to the integration of multiple technologies into all aspects of production possible to digitize – i.e. convert into digital information (Gray, J. and Rumpe B. 2015).

Background: Manufacturing employment and the Nordic model

As the leading export sector in the small, open Nordic economies, the manufacturing sector has been a backbone in the Nordic labour market regimes. The organizations of labour in manufacturing and their employer counterparts have been key actors in the Nordic systems of industrial relations, and have acted as pattern-setters in collective bargaining and key interlocutors of the state in working life politics (Andersen et al. 2014; Mueller et al. 2018). The prospect of a fourth industrial revolution bringing large-scale automation and sweeping changes in the structure of manufacturing jobs can therefore be perceived as a particular challenge to the Nordic models. Bluntly put, if the manufacturing working class increasingly is being replaced by robots and digitalized machines, delicate power balances and defining traits of the Nordic models can be disrupted.

In this view, pillar-2 of the NFoW-project – "Digitalization and robotization of traditional work" – starts off with a quantitative study of recent changes in the occupational structure of employment in the Nordic countries, including in manufacturing (Berglund et al. 2019), and an exploratory qualitative study of digitally driven changes in manufacturing work. As underscored in the project's initial report (Dølvik and Steen 2018), technological change is nothing new in Nordic manufacturing, which in the context of high labour costs and strict regulations has thrived precisely by fostering innovation, technological rationalization, and productivity growth through cooperation and employee involvement. This has gone hand in hand with continuous restructuring and internationalization, where labour intensive production to a large extent has been moved abroad, while national headquarters and sites have concentrated on developing advanced, high value-added products. In 1980, manufacturing accounted in Sweden and Finland for more than one of four jobs (25-26 percent) and in Denmark and Norway for one of five (19-20 percent). Since 1980, the value added of Nordic manufacturing production has more than doubled, whereas the number of jobs by 2017 has decreased by around 40 percent (Elliot 2017; nordicstatistics.org). In parallel, job growth in services has by far exceeded the decline in manufacturing – contributing to substantial rises in employment[2] – implying that manufacturing by 2017 only accounted for 13 percent of employment in Finland, 11 percent in Sweden, 10 percent in Denmark, 9 percent in Iceland, and 8 percent in Norway (Nordicstatistics.org; Statistics Iceland[3]).

[2] Since 1995, total employment had in 2017 risen by 12 percent in Denmark, 21 percent in Sweden, 24 percent in Finland, and 32 percent in Norway (nordicstatistics.org), underscoring that job growth is influenced by many other factors than technological change (which supposedly was fairly similar in the countries in this period).

[3] https://statice.is/ publications/news-archive/enterprises/number-of-employers-and-employees-3/

Figure 1. Manufacturing employment 2000-2017 in the Nordic Countries. Source: nordicstatistics.org

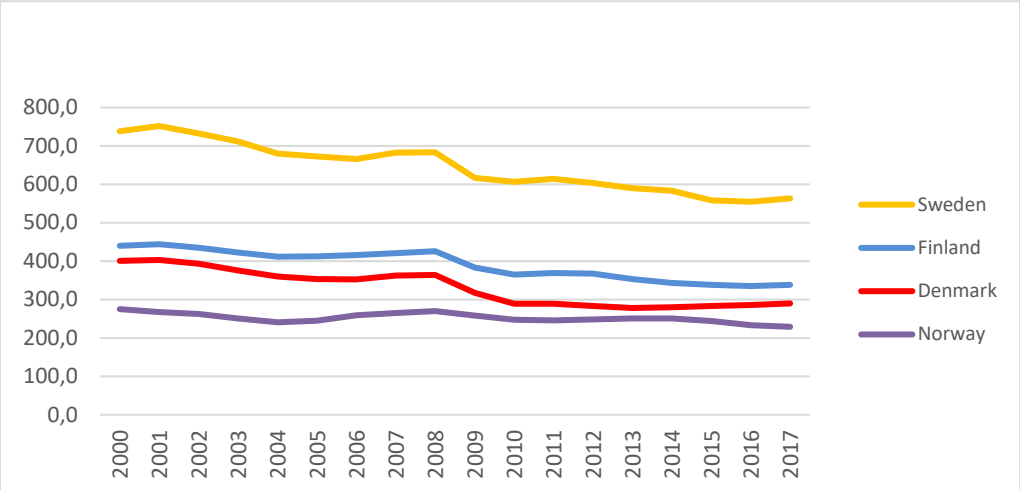
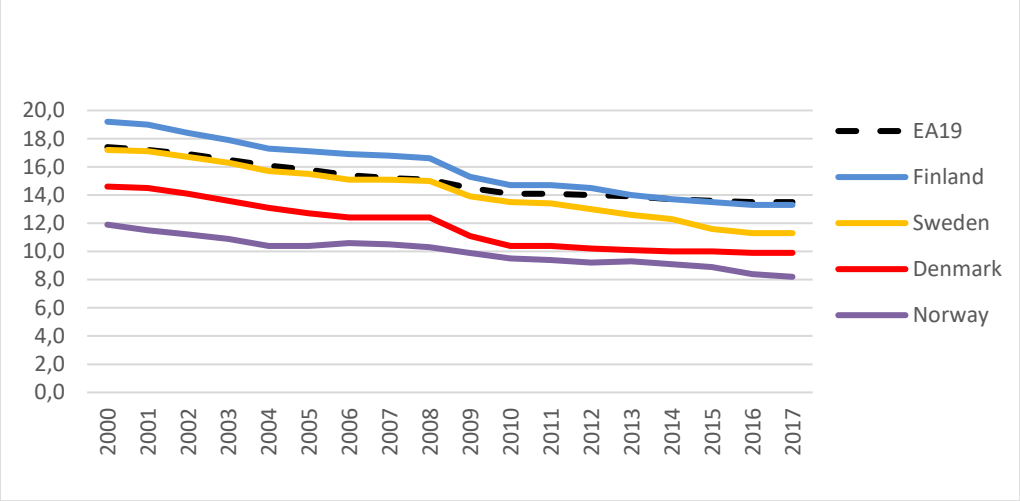


Figure 2. Manufacturing employment as share of total employment 2000-2017 in the Nordic Countries. Source: nordicstatistics.org



The rising gap between manufacturing production growth and employment mirrors vast productivity growth, which after the economic stagnation in the 1980s picked up strongly with the ICT-wave rising in the 1990s, when especially Finland and Sweden experienced an amazing instance of re-industrialization (Erixon 2011; Vartiainen 2011). Developments in the new century have been marked by further technological progress along with the rise of China as the world factory and further restructuring of global value chains. In the wake of the 2008 financial meltdown these developments has been followed by the surge in robotization, artificial intelligence, the internet of things and so forth, claimed to propel the fourth industrial revolution. In this view, it is sobering to look at the trends in productivity growth in manufacturing over the past 25 years, compared with the trends in the economy as a whole (se Figures 3 and 4).

Figure 3. Annual change in gross value added per hour worked, manufacturing, 1994-2017, percent. Source: OECD.stats [4]

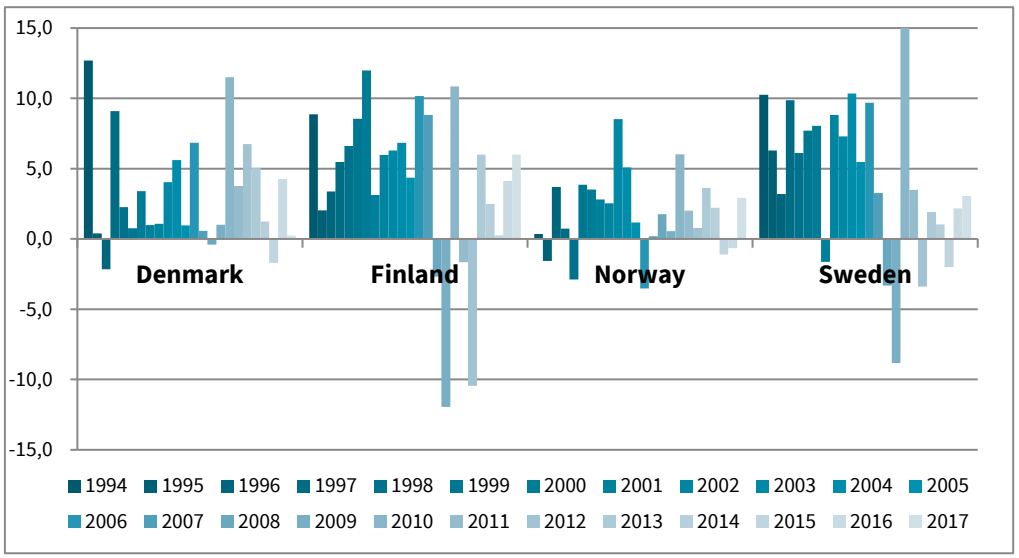
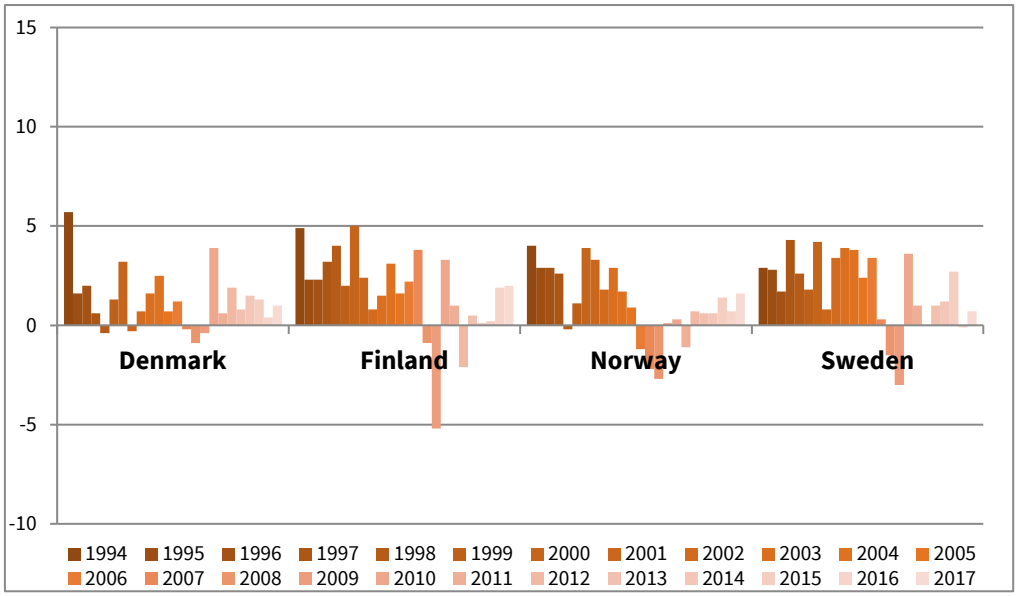


Figure 4. Annual change in gross value added per hour worked, total economy, 1994-2017, percent. Source: OECD.stats}



The above figures highlight three striking tendencies: First, although productivity growth remains much higher in manufacturing than in the other sectors (mirrored in total economy figures), it has been markedly lower after the 2008 crisis than before. Second, there are salient discrepancies in the development of productivity growth in Nordic manufacturing; while Finland and Sweden were way ahead of the other two until the 2008 financial crisis, productivity in Danish manufacturing then caught up strongly and exceeded the others until Finland in 2015 recovered from its prolonged

[4] Unfortunately, figures for Iceland are not available in the OECD data bases.

downturn. Evidently, the ability to reap productivity gains of technological change is highly contingent on fluctuations in market demand. Third, despite the rising use of digital technologies in the post-crisis years, productivity growth in the total economy has shown a marked tendency of decline in all the Nordic countries. Except for the post-crisis Danish rise, this tendency of secular decline in productivity growth is in line with international trends, and seems at odds with the widespread expectation that digitalization is bringing rising productivity growth (Manyika et al. 2017).

Clearly, development in productivity growth – hence also the employment impact of growth – is influenced by many other factors than technology, including, not least, fluctuation in product market demand (Vernon 1966). Given the sluggish demand growth in many sectors during the post-crisis period, a plausible interpretation in such a perspective is that the expected productivity gains from recent years of digitalization in manufacturing have been hampered, or disguised, by the negative impact of deficient demand (Van Welsum et al. 2014). This can imply that the potential efficiency gains and labour saving effects of digitalization in manufacturing will materialize on a later stage, when the staff increases often required in the investment/introduction phase are over and demand eventually picks up. Illustratively, one of the European branches where robotization is supposed to bring substantial labour saving, the automotive industry, has actually seen rising employment in Germany recent years [5] and stable employment in Sweden (Pohl 2017). The relevance of such an interpretation is more questionable when looking at the total economy, where, first, the potential for technological labour saving in many services is far more limited, especially in the provision of intangible services which is often reliant on instant interaction with the customers and hence time-and space-bound (Baumol 2012). Besides the disparate effects of digitalization on productivity and labour demand within different sectors, second, structural shifts in product market demand between sectors – for example from highly productive production of goods and 'technical/distributive services' to more labour intensive intangible or personal services – may in fact imply that the overall job-saving effects of technological advances within single sectors are overruled by shifts in the composition of demand in the economy towards more labour intensive services. Such dynamics are essential in explaining that the Nordic countries, regardless of successive waves of technological renewal in important sectors, have shown steady growth in employment over the past 100 years. A critical precondition for continuation of this virtuous circle is, however, that a sufficient share of the value added arising from productivity growth is channelled into demand-enhancing investment and consumption in the national economy (Dølvik & Steen 2018; Eurofound 2018a; 2018b).

Regardless of the impact on jobs and productivity, the transition to a digital and carbon-neutral international economic is likely to propel increased pressures for industrial restructuring and company adjustment and thereby additional strains on the Nordic model and its local tier of consultation and negotiation at company and

[5] The German automotive industry has shown steady job growth in recent years, increasing by almost 17 percent from 2010 to 2017. See https://www.statista.com/statistics/587576/number-employees-german-car-industry/

community levels. According to the Swedish Labour Minister, Ylva Johansson (14 May 2018), one can identify a specific Nordic model for handling restructuring rooted in the interaction between three pillars: (1) the strong partnership relations at both local and central levels; (2) a range of support schemes available for companies and employees facing restructuring, downsizing or sudden market fall-outs;[6] and (3) the provision of income security and high levels of education in the workforce underwritten by the welfare states (Johansson 2018). Citing that the share of Nordic workforces involved in workplace restructuring and learning new things is the highest in Europe (Hurley et al. 2017), Johansson argues that this type of 'flexicurity' approach to restructuring creates trust and encourages people to test out new opportunities and solutions.

As argued by Dølvik and Steen (2018), this model has in recent years nevertheless been subject to erosion, more in some countries than others, due to decline in unionization and collective agreement coverage especially among the parts of the workforce that are most vulnerable to exclusion during restructuring processes. Although the Nordic economies in the past have been renowned for their flexible adjustment capacity (Katzenstein 1985), it is an open, empirical question whether it is equipped and agile enough to master the unknown challenges arising from the digital and green shifts. A central question in this exploratory study into some Nordic machinery industry companies is thus how and to what extent the company tier of cooperation and dialogue is considered by the parties as a barrier or a resource in resolving the problems arising in processes of digital renewal.

The following study sets out to investigate in what way plant manager and trade union representatives in a number of Nordic manufacturing companies tackle such demands on digital renewal, and whether they consider cooperation and dialogue as barriers or as a resource in resolving the problems arising in this process of digitalization. Complementing the review of Nordic manufacturing developments above, the following text elaborates further on how these manufacturing companies in practice try to master the challenges associated with the digital shifts. So far, studies, grouped under the heading of Industry 4.0, have suggested that the introduction of advanced robots, networked machines, additive manufacturing, machine learning, internet of things (IIot) etc., not only propel labour-saving automation, but also alter tasks, content, skill demands and conditions of work (McAfee and Brynjolfsson 2013; Fernández-Macías et al. 2018). In the following sections, we explore how these Nordic managers and unions make sense of different ways to tackle the digital challenges and the way it affects work, skill requirements, and employment relations at company level.

[6] These include various public benefits, schemes for training and ALMP, temporary lay-offs/short-term work, and other forms of public involvement at local, branch/industry, and central levels. Sweden has, through social partner agreement, also developed 'job security councils' (Trygghetsråd) funded by the employers, helping people subject to downsizing find new jobs. In Stockholm in 2017, 83% of the users found new jobs, 2/3 with the same or better pay (NYT 27.12.2017).

Method and data

We may keep in mind that the industrial structure varies markedly between the Nordic manufacturing sectors. Sweden stands out with its large automotive industry. Together with Finland, Sweden also accommodates paper/pulp and wood industry, as well as a sizeable ICT sector. Denmark is renowned for its advanced production of pharmaceuticals, windmill technology, design, and food industries, while Norwegian manufacturing traditionally has been reliant on natural resources, for instance cheap hydro-power, fisheries, and eventually oil- and gas, but has in recent years developed world-leading aquaculture and offshore industries (Mjøset 2011; Nordic Council of Ministers 2015).

This study draws on interviews with managers and union representatives at comparable sites in Denmark, Finland, Norway and Sweden. They all work in advanced machinery industry companies, ranging from global export production of cars and air-plane engines to advanced pumps and drilling equipment. All the sites are part of multinational corporations, and are mainly involved in business-to-business production. Accounting for sizeable shares of national production and export in their domains, the selected companies have been using digital equipment and ICT-based production processes for quite a while. As companies with a long history, several of them have been central in earlier rounds of industrial and technological transformation. Being early movers in developing and applying new technologies, they are drawing on accumulated knowhow – in some instances stretching back more than a hundred years – in how to manage such paradigmatic shifts in production technology, work organization and skill requirements. More specifically, the companies share certain traits that may enable us to shed light on how core manufacturing firms, developing more and less raw materials or rough parts into sophisticated physical products, utilize digital technologies to renew their organization of production and work, in some instances involving advanced automation and development of digitalized international value-chains.

In doing these interviews, one of the Swedish companies was used as a pilot, enabling an explorative approach where we could try out the interview guide on more than 20 representatives of management and trade unions. We have also drawn on documentation from company web pages, policy documents, and digital presentations. Along with antecedents of the two Norwegian companies, this Swedish site is part of one of the oldest still thriving companies in Nordic manufacturing. The two Danish companies and the second Swedish company have also been around at least since the 1940s, while the Finnish company is of more recent date, established in the 1980s. To enhance comparison, all units belong to the machinery industry. The first Swedish unit produces mechanical components crucial for a variety of machinery, the second Swedish unit and the Finnish one are engaged in manufacturing of vehicles, whereas one of the Norwegian units produce engines for air traffic. Both the Danish and the second Norwegian site produce advanced equipment used in various sorts of extraction, pumping, drilling and so forth. The sample of companies included in the

study thus spawns a range of machinery products that demand a high level and variety of skills and knowledge.

Table 1. Company cases and interviewees (n=49)

Companies and type of production	Approx. share of employees	Number of interviewees	Interviewees and additional empirical material
Swe1: Mechanical components vital for all sorts of machinery	42% blue collar and 58% white collar employees.	22	Managers and union representatives, webpages, policy documents etc.
Swe2: Vehicles and construction equipment	80% blue collar and 20% white collar employees.	5	Specialists, representatives for the local unions, webpages.
Fin1: Vehicles used for professional purposes.	66% blue-collar and 34% white-collar employees.	4	Production manager, supervisor and chief shop steward, HR manager, annual reports, product information, company website.
Dk1: Advanced equipment used in extraction, pumping, and drilling	82% blue-collar workers18% white-collar employees.	7	Managers, employees, representatives for the local unions and shop stewards, plant visits.
Dk2: Advanced equipment used in extraction, pumping, and drilling	82% blue-collar workers18% white-collar employees.	4	Managers, employees, representatives for the local unions and shop stewards, plant visits.
No1: Engines for air planes	24% blue-collar workers and 76% white collar employees.	2	Director of digitalization and blue-collar union representative, Plant visits.
Nor2: Advanced equipment used in extraction, pumping, and drilling	60% blue collar and 40 % white collar employees.	5	Managers, shop steward of blue-collar union, and project leader, company web pages, videos and documents.

The interviews were conducted in accordance with the semi-structured interview guide, organized around a set of core themes and questions that allowed us to follow up flexibly on arising issues. The design of the guide aimed in particular to identify the objectives and drivers behind current digitalization processes, how digital technology was applied and implemented, the role and responsibilities of specific employee groups therein, and the benefits and consequences resulting from such processes in terms of changes in jobs, skills, work content/situation, work environment and employment relations.

Making sense of digitalization – common themes and variation in Nordic manufacturing

Keeping in mind how employment in the industrial sector has declined and the job structure has changed over the years (Berglund et al. 2019), this section summarizes common themes emerging from the interviews in the Nordic manufacturing companies, and how the actors make sense of today's digitalization in practice. We look closer at how they, within their own concrete settings, encounter and apply the ideas about smart manufacturing, so-called industry 4.0, starting by reviewing how management and union representatives describe the purposes for engaging in digitalization of production. We then describe what type of organizational challenges and changes in skill requirements they have to tackle, before looking at how they describe the role of industrial relations and social dialogue in handling digital renewal.

Aims and motives for digitalization

To begin with, the interviewees do in many ways depict digitalization in their companies as a combination of advanced automation and broadened networks of digitalized value-chains and communication, reflecting pretty much what we have referred to as smart manufacturing or industry 4.0 (Brynjolfsson and McAfee 2017). They underscore that the companies are not just interested in the capacity to automate tasks, but also to enhance the capacity to connect to broader digital networks enhancing data collection about and flexibility in relation to customers and units in the delivery chain. In other words, they describe a combination of technical rationalization improving efficiency by letting computerized machines execute manual work tasks, and communication measures enhancing data gathering and analyses regarding in particular the production process and customer preferences important in development of products and services.

Technical rationalization in these cases entails measures by which they computerize different types of more or less conventional assembly lines. As for any rationalization process, minimizing costs is the main goal in this process, which also exposes staff conducting simple tasks to the risk of being substituted by machines. In particular, they refer to how automation makes it possible to replace manual work tasks with digital solutions, which in turn create more tasks for blue-collar staff in monitoring production and quality control.

Describing how they proceed with such technical rationalization, the interviewees differ in the way they emphasise various measures. For instance, Swe1, the company producing mechanical machine components, focuses on total automation of the manufacturing process. Consequently, it has been able to turn four production lines primarily based on manual work, into one line. In combination with natural turnover, retirements etc., this has clearly reduced the total number of blue-collar employees, but also meant that those who remained could work in a safer and better work environment. It became possible to eliminate repetitive or heavy work tasks, while

allowing the remaining blue-collar staff to engage in more cognitively demanding work tasks rather than manual work.

> Why do we have to automate our production facilities? Well it is because we have a cost pressure. In that sense it is very externally driven. Meanwhile, looking at the customer digital experience area we have to become better or they will go to another. So it is very customer driven. In the area of the sensor driven data, I think we are in fact pushing towards our customers' ideas and solutions (Swe1: Group Manager IT).

A similar interest in technical rationalization recurred in most companies, but the fact that this Swedish company produces mechanical machine components that easily lends themselves to large batches, could explain why it, contrary to most other cases, prioritized total automation of the production line. In line with the other companies, however, interviewees in this company also describe how they have started to engage in digitalizing wider value-chains. In particular, they refer to the introduction of sensors in their components, enabling them to stay connected with their products while being in use. In this way, the company can gather and analyse data making it possible to tailor both products and services in accordance with customer needs. Respondents in the other companies elaborated further on what this type of broader networks of digitalized value-chains could mean. They described opportunities to connect their business strategies with a range of production concepts referred to as adaptivity, agility, servitization. More generally, we may understand such moves as measures enabling the plants to solve problems, tailor products, and innovate in response to changing markets. By gathering and analysing a continuous flow of information from various parts of the value chain, the sites improve their ability to develop products matching customer preferences as well as shortening the processes from development to market release of new products. In other words, they enhance their ability to compete with other companies by developing constantly new services and constructing more flexible production lines enabling the plants to adapt to increasingly shorter product-life-cycles:

> In accordance with the ideas of "agile manufacturing", we now do changes in the products underway, aiming to make ever more tailor-made products. If we end up with standardized production, we freeze and can send it all to China. (Nor1: Shop Steward)

In this context, the interviewees were eager to describe how digitalization provides essential solutions for managing, sharing and using information throughout the organization. More precisely, digitalization makes it possible to improve management of communication despite the growing scope of the companies, involving employees at many different sites, globally located in different time zones. For instance, the interviewees from Swe2, producing vehicles, describe how digital systems facilitate information management within the company as a whole, making sure that everyone uses the same data, constituting "one source of truth". Joint information systems also enable the recycling of information and avoid the time costs and quality risks involved in manual documentation and transfer of product data. Furthermore, keeping product information and prints in a digital archive

instead of a physical archive is said to increase accessibility as well as information safety.

By connecting such archives of information directly with the production, the interviewees highlight that digital solutions help them to secure *product quality* and augment the capacity to plan and foresee both process and product adjustments. For instance, interviewees in both Dk1 and Swe2 describe how they use 3D-modeling to assess instructions on early stages of production or visualize the product before it has been manufactured to attain customer feedback enabling final improvements before release. By then connecting with automated robots, several of the informants emphasise that the ability to make products recognized by good quality is significantly improved. For instance, respondents from Nor1, making production systems to the oil and gas industry, argue that even though the best possible man-made result may still be better, they appreciate the way digitalized processes improve general reliability and precision in smooth sequences of production, critical to reduce failures and attain cost efficiency. Furthermore, this way of connecting automated production with broader digital networks is said to reduce safety risks and make it easier to improve work environment.

Re-organizing production and upgrading competence

In combination, the digital capacity to automate procedural tasks in the production, and the improved ability to manage an extensive amount of data, is associated with opportunities to reorganize work in teams, enhance job-rotation or engage in other more inclusive, peer-based forms of collaboration. Furthermore, respondents in the first Danish case (Dk1) describe new digitalized ways of measuring performance and productivity, causing concern primarily amongst white-collar workers for new modes of management control. Some of the respondents also describe how these new ways of organizing and leading work is associated with digital opportunities to outsource parts of production or relieve staff of certain automated tasks, allowing them to focus more on specific, prioritized tasks. Further, a striking common feature emphasised by most interviewees is that the introduction of new digital solutions fosters demands for new skills.

> In fact, that is what the digitalization processes are about, i.e. emancipating skills and capacity for more important, demanding tasks. (Nor1: Blue-collar, Shop Steward)

To a vast extent, digitalization thus emerges as a matter of identifying, prioritizing and developing new tasks and competences. For instance, both managers and union representatives underscore how so-called “smart maintenance”, demands that both white-collar and blue-collar workers acquire the ability to continuously scrutinize data and engage in programming. Blue-collar workers have to broaden their cognitive skills, and perhaps become a bit more engineer minded. This increases demands on employees’ capability to engage in continuous problem solving. Furthermore, to make sure that the process functions smoothly, the automated production also requires that all personnel execute their tasks correctly and thoroughly. For instance, auto trucks will not work if goods are initially misplaced. By referring to demands for

a range of new types of cognitive skills, comprising surveillance, communication, computing, digital problem solving etc., the interviewees depict the introduction of digitalization very much as a matter of upgrading work as well as the responsibilities and skills of the workers.

Yet, the complexity and the qualifications characterizing the new skills cannot be taken for granted; surveying production processes via a panel or an Ipad, demanding that you fill in some information every now and then, does not necessarily entail qualified tasks or challenges. Nevertheless, most respondents regard the changes as a process in which particularly blue-collar workers are upgraded by having to acquire abstract competence to run and adjust digital production systems:

> The role of an operator is increasingly the role of a systems operator. Our operators become increasingly 'light blue', the distinction [between blue collar and white collar workers] is being blurred. Engineers do some operator tasks, while operators do engineering tasks. Cooperation between the different groups of employees has previously been difficult, partly because of resistance from the unions, but this has really changed: Everyone understands that we cannot be fractioned and that we have to work together to be a good and competitive firm. Many operators now do what was considered engineering tasks, it is quite a big shift. (Nor1: Director, Research and Technology)

As implied, the respondents also referred to acquisition of more advanced competence among white-collar employees, but they tended to be less specific about how white-collars were involved in such upgrading processes. They were much more concrete in the case of blue-collar workers, describing how skills upgrading due to digitalization meant that the workers engaged less physically in production and became more involved in managing the digitalized production process. This focus on cognitive skills, in resolving tasks previously undertaken by engineers, also appear to be the reason why many respondents highlight the blurred boundaries between white-collar and blue-collar workers. At the same time, they all stress that digitalization is part of continuous improvements in their production, always underway in their plants. Rather than claiming that digitalization disrupts former boundaries or completely turn previous modes of working upside down, digitalization is thus associated with ongoing rationalization of production constantly requiring renewal of skills, work tasks and work organization. Even if production becomes less dependent on hands-on operations, some also stress the importance of continuity by underscoring that certain hands-on skills are still needed:

> The use of robots is still only something for the future. Many kinds of new digital technical devices are offered to us, but we are sceptical. AI-based solutions might be of some use for us, but we do not know so much about them. (Fin1: Production manager)

We may add that this transformation of skilled manual work not always implies that workers perceive applications of digital skills as upgrading. For instance, in the second Swedish company (Swe2), the interviews revealed that the outcome of automated welding, by some criteria, provided a lower standard compared to the result of manual welding. This pertains for instance to aesthetic aspects, where the

welders' occupational pride is set aside when having to deliver a product that looks 'bad' in their own eyes. The need for manual finish of the automatically welded products also contributed to certain negative attitudes among some of the welders, consolidating a feeling that it is not worthwhile to work with robots. Union representatives from the first Swedish company (Swe1), even described some incidents of sabotage or protests in connection with the introduction of automated trucks.

Updating technology and skills in a Nordic context

The interviews thus reveal that the workforces in these companies face strong pressure to acquire new cognitive competences, and that both management and trade unions see this as an upgrading of work. While both sides have to tackle tensions and concerns among employees who experience that some of their skills become obsolete, they refer to specific Nordic conditions fostering incentives for management and unions to find joint ways to meet the needs for training and re-training. For instance, in the second Norwegian company (Nor2), interviewees emphasize the Nordic labour market model as a crucial source of such motivation. In particular, the high cost of labour acts as an incentive to invest in new technology, automation and reskilling:

> I believe we have come quite far in terms of automation, compared to our competitors. It has to do with the fact that we face a challenge in terms of cost levels, which drives a logic of automation. We [the international parent company] have a similar production site in Sweden, and one in the U.S. The Norwegian and Swedish plants are more or less on the same level in terms of automation, while there is a huge difference compared with the U.S. plant – they simply don't have the same incentives. (Nor2: Director, Research and Technology)

Several respondents also highlight that the local collaboration between the employer and the unions enables them to tackle concerns and tensions arising among the employees when restructuring the production and work organization. For instance, several of the manager and union representatives describe how they together identified needs for long-term educational measures, provided by technical colleges, validation of industrial specific competence, E-learning, or collaboration with local universities etc.

As mentioned, however, these measures primarily granted blue-collar workers new opportunities to upgrade their competence and engage in tasks that engineers and other white-collar staff previously used to do. It was often less obvious how white-collar staff was supposed to update their competences, as it remained unclear how the exigencies for innovation and change affected their work tasks and needs for retraining. In their case, digitalization rather seems to imply demands for being flexible and independently develop skills in relation to a variety of shifting requirements for product development. In accordance, respondents in the first Danish company (Dk1) refer to possible future demands for reskilling among white collar staff, instead of ongoing reskilling measures.

There are also some notable differences between the companies. In particular, the Finnish vehicle producer stands out by having outsourced several blue-collar functions. According to respondents in this case, the company primarily engages in promoting upskilling among white-collar staff engaged in product design. Renewal is largely perceived as a matter of providing white-collar staff with competence to engage in customization and innovation, while remaining blue-collar workers continue conducting tasks similar to those they used to do prior to the latest twist of digitalization.

Hiring, firing and re-allocating staff

In line with previous research, describing how industrial work over the past 30-40 years has shrunk throughout the Nordic countries (Berglund et al. 2019), respondents in the Danish, Swedish and Norwegian cases report that the numbers of blue-collar workers have declined due to long term trends of technological renewal. In the Finnish case reference is also made to recent decline in the number of blue-collar workers due to outsourcing. Nevertheless, in most of these companies, the interviewees tend to dampen any impression of extensive changes, rather depicting continuity in the total numbers of employees and/or referring to challenges in developing and recruiting labour with required skills.

> Our challenge is that we have to become more efficient and sometimes the most efficient way to develop mentally, what we have done is……, at first we are not replacing people because in total we have enough bodies. I am sure of that, but they are just in the wrong places. What we have gotten to now is if someone will leave, I move some people around, and I change a little in what they work with. Two things have come out of it; one, we have become far more efficient, and, two, we have actually blossomed people's careers in doing that. Persons are being challenged and sees something different. (Swe1: Group Manager Sales).

This quotation reflects that the interviewees did not seem to be particularly concerned with decreasing numbers of employees. Many of them appeared confident that they could manage demands for cuts, for instance by retiring some of the staff, and stressed that they rather had difficulties in finding enough staff with the right type of qualifications. Lack of supply of adequately skilled labour did also amplify demand for reskilling and reallocation of labour already present within the firms. They also describe how changes in digitalized modes of production make it more difficult to know exactly what type of skills they should acquire – whom are they supposed to hire and what type of reskilling should they promote? The upgrading of workforce skills emerged both as a difficult and potentially expensive task. One of the managers in the first Swedish case (Swe1) describes how he tackles this uncertainty:

> Sometimes we do a strategic mapping of the competences we believe we need. But to be honest the way recruitment or approvals work here I am constantly being chased on cost. I do not have much freedom to say, I would like to have these competences within the next couple of years. I simply do not have the head-count or the budget to increase that. So it is a very, I wouldn't call it a

> strategic process. It is not ad-hoc, we know where we are going but it is position by position. Because if I would hire the ten people I think I need in two years, if hire them now, then I wouldn't have the budget for it. (Swe1: Group Manager IT).

The interviewees thus describe how their companies have to encourage already hired employees to develop their capacity to adjust and change functions, i.e. each and every employee are expected to invest in their own upskilling. However, this may turn out to be a difficult task, and in some instances staffing is further complicated by the fact that continuous updates in technology and changes in the organization require that they retain some of the old competences with specific expertise, able to maintain production while introducing the new system.

Labour relations and the Nordic model

Enhancing the companies' flexibility and skills, both in terms of numbers and functionality, are in some cases associated by the managers with concern for overly rigid regulations constraining their flexibility in staffing the production. In particular, managers in the Swedish cases appear to be critical towards aspects of national labour law. There are respondents, for instance in the first Danish case, describing a certain increase in the numbers of temporary contracts. However, most of the interviewees remain sceptical towards staffing agencies and short-term contracts, and tend to look at new digital platforms offering independent and dispersed labour as something alien (cf. Larsen and Ilsøe 2019). Thus, despite difficulties in finding enough labour with the right qualifications, most interviewees still prefer managing for instance reskilling by hiring and training the staff they need in-house.

Not surprisingly, the union representatives agree that ordinary employment contracts make it easier to manage adjustments and reskilling. As mentioned, some of them engage with the employer in educational measures addressing primarily in-house staff. They depict what we may refer to as a stable Nordic model, based on good connections between management and the local unions, for instance in discussions about how to re-allocate staff, adjust work organization, and foster new skills.

We do of course find traces of tension between the employer and the unions. For instance, the blue-collar union in the Finnish case criticises the company for maintaining a rather conventional hierarchical structure, and complains that their members lack re-skilling opportunities. A union representative from the second Norwegian company (Nor2) also complained that the company under the previous owner had resorted to outsourcing and expanded use of consultants – many of which previously were employees:

> We fire three workers and *then* contemplate if we should buy a robot! Others do it the other way around… We only bought the bare minimum [of equipment and machinery] required to keep the production running. (Nor2: Blue-collar Shop Steward)

The white-collar unions in the first Swedish case (Swe1) also appear somewhat critical against the employer for not supporting their members' need for retraining to the extent they believe the members regard necessary. Measures meant to support white-collar staff seem to be less explicit, and often individualized, relying on dispersed E-learning initiatives and employees taking responsibility for their own skills. Some of them also complained about an unclear connection between upskilling and salaries.

Despite such tensions, the informants refer to continuous interaction between unions and managers, fostering collaboration and consensus about the need for digital technology and skills upgrading. In accordance, they depict collective bargaining and agreements as self-evident, and in some cases explicitly emphasise that both sides share interests in well-functioning and efficient production. Rather than expressing dystopic complaints about the consequences of new technology, the unions do in several cases also express concern that they have to urge managers to invest more in the skills they believe are necessary for making the most out of the new digital technology and safeguarding job opportunities at the plant.

In other words, both sides tend to underscore the importance of local social partnerships and promoting new technology at work in a way that reminds us of the Nordic model for restructuring and adjustment referred to in the background section. Even if some of these company level partnerships showed signs of strain, none of the key actors in these plants thus perceived the transition into Industry 4.0 as a challenge to the Nordic tradition of collaborative industrial relations.

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