Skills for Digitalization: Employer Strategies for Competence Management in Manufacturing[1]

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ABSTRACT

Digitalization and the transition toward Industry 4.0 in manufacturing involve changing organizational needs for skills and competences, which, in turn, necessitate strategies for digital competence management. Based on qualitative interviews in four manufacturing companies in Norway and Sweden, this study shows how the transition to digitalized production involves several key decisions regarding staffing strategies, job design, and competence development. Moreover, it illustrates how various contextual conditions influence these decisions. Recognizing these strategic choices as partly interdependent, two contrasting paths are presented: the enabling path vs. the pragmatic flexibility path. While institutional factors in Sweden and Norway mainly push toward the enabling path, company-specific factors push instead toward the pragmatic flexibility path.

KEYWORDS

competences / competence development / digitalization / digital competence management / Industry 4.0 / job design / manufacturing / skills / staffing strategies

Introduction

Digitalization in manufacturing, commonly referred to as 'Industry 4.0.' or 'smart manufacturing', has the potential to radically transform both the organization of work and the content of work tasks. Consequently, companies' needs for skills and competences are changing (van Laar et al. 2020). Furthermore, the development of a digitally competent workforce demands strategies to recruit, train, and retain workers in line with these requirements.

While the literature on recruitment and competence management is vast, often discussing digital competences from the perspective of competence-based recruitment or from a resource-based view of companies (Praest Knudsen 2005), relatively few studies specifically address how digitalization affects competence management strategies (e.g., Ghobakhloo 2020; Hansen et al. 2024; Shwarzmüller et al. 2018). The availability of highly skilled employees is presented as one of the competitive advantages for the Nordic labor market model and as essential for successful implementation of Industry 4.0 (Thun et al. 2019). Studies of digital competence management within Nordic manufacturing can thus be motivated by the ambition to retain and attain such advantages. This

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study contributes to this effort by investigating the practical challenges and strategic decisions involved in digital competence management.

The aim of this study is to explore the competence management strategies applied in companies striving to supply a workforce adapted to digitalized production and to investigate how organizational and contextual factors influence these strategies. Using qualitative data from plant-level case studies, the analysis first investigates how competence and skill needs are changed when digital technologies are introduced. Further, it explores the strategic choices about competence management that these companies face due to digitalization. In the discussion, the findings are further examined in relation to factors influencing the strategic choices.

Previous research and theory

This section outlines key insights from the literature on how digitalization and Industry 4.0 affect (1) the organization of work, (2) competence needs, and (3) competence management strategies.

Digitalization and the organization of work

Digitalization in organizations can be defined as 'changes in ways of working, roles, and business offering caused by adoption of digital technologies in an organisation' (Parviainen 2017, p. 64). Digital technologies may be applied in various forms and to varying extents, with both positive and negative potential outcomes (Liu et al. 2024; Vial 2019). Moreover, technologies with similar properties may be dissimilarly implemented, and with dissimilar outcomes, due to various organizational differences, including type of production, available resources, competence among the staff, employer motivations, or competence management strategies (Krzywdzinski 2022; Ohlert et al. 2022). Consequently, digitalization is closely interconnected with other organizational changes that facilitate, or follow, its implementation (c.f. Hedenus & Nordlander 2024).

In manufacturing, digitalization is often conceptualized as 'Industry 4.0', which describes the increasing digitalization of the value chain and the resulting interconnection of people, objects, and systems through real-time data exchange (Schwab 2016). This facilitates new work practices that use smart equipment and systems, such as collaborative robots, the internet of things (IoT), cyber physical systems, big data analytics, and AI (Fatorachian & Kazemi 2018). It also involves new production processes such as 3D printing and hybrid manufacturing. Organizationally, Industry 4.0 is characterized by decentralized decision-making and planning, worker autonomy, and horizontal communication. Jobs should thus be designed with broad task profiles and organized in a way that facilitates teamwork and collaboration, for example, using job rotation and flexible assignments of tasks (Shamim et al. 2016).

Theories of skill-biased and routine-biased technological change (Autor et al. 2003; Berman et al. 1998) hold that digitalization results in changes to the occupational structure and/or in a general upskilling of the labor force: low-skilled or routine jobs are substituted while upskilling is needed in remaining jobs. These processes have been found to occur both within and between sectors and firms (Goos et al. 2014; Heyman 2016).

Deskilling is another possible outcome (Schaupp 2022), albeit with more limited empirical support. Structural occupational changes in the Nordic manufacturing sector seem to be largely consistent with the upskilling dynamic associated with skill-biased technological change (Berglund 2024; Rolandsson 2020). Within the Swedish companies investigated in this study, digitalization has involved some rationalization, yet the main dynamic is one of upskilling (Hedenus & Nordlander 2024). In this article, the focus will therefore not be on the substituting effects of digitalization but on its consequences for work tasks and competences.

Manufacturing firms also face an increasing need for both numerical and functional flexibility to be able to adapt quickly to developments in technology, mismatch in labor markets, competition in product markets, and fluctuating capital markets (Hedenus & Nordlander 2024). This transition toward both digitalized and flexible organizations requires strategies to recruit and train workers with the necessary competences, as well as to ensure numerical and functional flexibility.

Competences for Industry 4.0

Several theoretical studies on Industry 4.0 attempt to predict which competences will be in increased demand. Literature reviews show that most studies expect growing complexity in task profiles and cross-functional work organization (e.g., Chaka 2020; Muduli & Choudhury 2024; Shamim et al. 2016). There is an anticipated increased need not only for 'hard skills' related to technology, for example, programming competence, but also 'soft skills' related to task performance, for example, agility, coordination, strategic communication, creativity, and problem solving (Benešová & Tupa 2017; Fitsilis et al. 2018). Such projections align with the notion of an ongoing upskilling of labor, pushed by a decrease in routine low-skill work and an increase in high-skill activities, especially involving IT, planning, and control (Fatorachian & Kazemi 2018). Studying workers' resilience to digital transformation, Liu et al. (2024) argue that good opportunities for learning and development provide an 'enabling path' that facilitates high resilience among employees.

A meta-study by Hecklau et al. (2017) distinguished four categories of key competences for Industry 4.0, which will be used as theoretical concepts in the analysis:

(1) *social skills* relating to communication and cooperation;
(2) *personal competences* of creativity, willingness to learn and flexibility, needed for innovation and work-task rotation;
(3) *methodological competences*, including analytical skills related to understanding complex processes and large data; complex problem solving; and leadership in flattened hierarchies;
(4) domain-related *technical competences* relating to digital technology itself, for example, competence on digital networks, digital security, and coding.

Another conceptual distinction to be made is between *firm-specific competences* and *generic competences* which are highly transferable between jobs and occupational roles (Delamare le Deist et al. 2005). Applying the categories of Hecklau et al. (2017), firm-specific competences tend to be domain-related technical competences.

A growing number of studies have also sought to empirically investigate changes in competence needs. Studying Danish manufacturing companies, Hansen et al. (2024, p. 12) stress the need for 'competences related to system integration and digital competences related to data utilization', namely technical and methodological competences (c.f. Hecklau et al. 2017). In a study of Italian manufacturing companies, Freddi (2018) finds increased skill demands, in particular for service provision, software development, and big data collection and analysis, namely all four of the competences categorized by Hecklau et al. (2017). However, another Italian study pointed to a polarized experience of either upskilling – to interact with advanced technology – or deskilling as manual and craft skills become abundant (Da Roit & Iannuzzi 2023). Based on interviews and a survey of Swedish manufacturing companies, Holm, (2018, p. 40) argues that the role of the shop-floor operator is evolving from 'low knowledge level and single tasks' to 'high knowledge level and extensive tasks'. This requires operators with broad abilities and knowledge, including technical, methodological, and personal competences. As implicated by a study of Norwegian manufacturing companies, it seems, however, that 'production managers find digitalization to be more useful, available, and beneficial compared with operators' (Thun et al. 2019, p. 51). The results further indicate that perceived benefits are predicted by the individual's competence in information and communication technology, and the authors argue that 'offering [employees] the opportunity to grow and develop could be regarded as critical success factors in the pursuit of becoming a "smart factory" and fulfilling the visions of Industry 4.0' (Thun et al. 2019, p. 44).

Moreover, empirical studies find that it is increasingly difficult for companies to attain the right competences. Consequently, managers expect toughening competition in attracting the right workers (Holm 2018), which raises questions about the competence management strategies that are applied in organizations.

Competence management strategies

Although there are growing fields of research on 'digital employee management', 'e-HRM', and 'critical management studies' (Fregnan et al. 2020), the bulk of the literature on competence management is not primarily concerned with digitalization or Industry 4.0. Still, it provides useful tools for describing the strategic choices that managers face in competence management for digitalized production.

To begin with, this literature underscores the importance of the organizational context and history. For instance, companies' competence management is influenced not only by the technology introduced but also by other changes in the society (e.g., demography, social, and cultural diversity of work force) and business models (e.g., Lean or agile organizations) (Ganz et al. 2018). Previous choices made in the organization, the 'path on which it arrived at the present position', further affect the available options for competence management (Praest Knudsen 2005, p. 1078).

Second, the present study draws upon the 'collective approach' to competence management which attends to the systematic identification, acquisition, development, and retention of talented employees used to provide competitive advantages for companies in an efficient and long-term way (Delamare et al. 2005; Langenegger et al. 2011). This is a broad concept, also involving competence inventory, validation, and competence profiling of employees. In this study, competence management will be analyzed with a focus on recruitment and staffing, allocation and organization of work tasks, and competence development.

Previous studies looking specifically at the issue of digital competence management argue that digitalization and the shift toward Industry 4.0 exacerbate the need for effective and directed strategies. Schwarsmüller et al. (2018, p. 127) claim that work in today's digital world involves both 'enhanced uncertainty and complexity' and higher expectations for employees to be agile and to 'constantly change and develop themselves'. Consequently, leaders need to manage this new reality by actively initiating, promoting, and allowing for such changes to take place. Similarly, Ghobakhloo (2020, p. 2397) argues that supportive attitudes and policies, along with financial resources and a 'strategic roadmap', need to precede efforts to develop employees' skills. Hansen et al. (2024) show that the lack of such strategic roadmaps hinders further digitalization in many companies. Although companies may have identified their needs for specific competences, few prioritize upskilling and training beyond ad hoc peer-to-peer training (cf. Da Roit & Iannuzzi 2023). The authors conclude that '[t]echnology investments are not enough for digitalisation. Competence development strategies should be developed in parallel with operational technology implementation, preferably through structured facilitation' (Hansen et al. 2024, p. 17). In sum, these studies point to the need for further studies on issues of digital competence management.

Finally, the current study draws upon Rothwell's (2011) work on 'technical talent management', defined as a practice related to securing the right technical competences for technological change processes, and his distinction between buying (external hiring); borrowing (i.e., using contingent labor); and building (developing internal competence) as different ways of attaining the required competence.

Method and material

This study applies a qualitative case study approach – focusing on a small sample of one Norwegian and three Swedish companies – which allows for in-depth study of organizational practices and strategies, and close attention to the influence of different contexts (Silverman 2014). The selection of cases was guided by previous research on what factors influence the digitalization process and, in addition, on informant interviews with sectoral level union representatives who also provided recommendations of relevant companies and production sites. Drawing upon this information, the sampled manufacturing companies were selected based on a combination of similarity and difference. Using a similar-case approach – that is, by studying only companies within mechanical and vehicle manufacturing – it is possible to make comparisons between the companies regarding what digital solutions are available for their production process, and how they use and develop digital competencies. However, by also including cases that differ from each other – that is, in terms of production processes, labor force, and the form and extent of their digital transformation processes – the sample provides the opportunity to discern how organizational and contextual differences affect, and are influenced by, digitalization.

Next, either union representatives or site managers were approached and asked to participate. In all four cases, the sites that were approached first accepted this request. In Norway, additional companies were approached but declined to participate – mainly due to toughening market conditions following the Covid-pandemic – which is why only one Norwegian company is included in the dataset. For this reason, analysis of the potential effects of the national context has also been delimited.

Description of case companies

The studied cases include three production sites within the machine and vehicle industry and one mechanical workshop (see Table 1). Case 2 (Sweden) and case 3 (Norway) belong to the same global corporation but with different specialties and production structures.

The companies represent differences in terms of *products and production* (i.e., the level of customization, numbers, and sizes of production series) and *labor force* (i.e., white- or blue-collar domination). Noteworthy, the companies also represent some variation in the need for flexibility: stable or shifting production levels and use of non-standard employment contracts. Temporary agency workers (TAWs) are used mostly in case 1, where shifting production levels are a concern, making up about a quarter of the total staff. TAWs are also used to some extent in cases 2 and 4, whereas case 3 relies almost exclusively on permanent employees.

Finally, the cases differ regarding levels and forms of *digitalization*, with case 1 being the 'least' digital company and case 4 being the 'most' digitalized. Case 1 is a traditional manufacturing company that uses digital tools primarily for quality monitoring and assembly instructions. At the other end of the spectrum, case 4 is a frontrunner in implementation of Industry 4.0 and has automated large parts of its production, which has markedly reduced the total number of blue-collar employees. In cases 2 and 3, digitalization revolves around connectivity, sensors, and digital systems aimed at monitoring, supporting, and optimizing production processes. Yet further substitution is constrained by legal requirements and high-quality demands.

Table 1 Characteristics of the cases

	Case 1	Case 2	Case 3	Case 4
Industry	Vehicle industry	Vehicle industry	Vehicle industry	Mechanical workshop
Products & production	Manual production with small, custom-made series	Automated production of small, custom-made series Product with high-quality demands Product development	Automated production of small, custom-made series Product with high-quality demands	Automated production of large series of many similar products
Labor force	Domination of blue-collar workers	Domination of engineers	No dominant group	Domination of blue-collar workers
Digitalization	Modest digitalization, used primarily for assembly instructions and quality monitoring	Highly digitalized, but manual monitoring necessary because of high-quality demands	Highly digitalized, but manual monitoring necessary because of high-quality demands	On the forefront of digitalization

In all cases, digitalization processes are closely linked to an increased need for functional flexibility in a team-based organization of work. In the more digitalized companies (cases 2–4), work is also organized, to a different extent, according to the principles

of Lean manufacturing. Changing production methods have increased the need for flexibly organized teams, where operators can handle different machines/stations simultaneously and rotate in between them. This functional flexibility requires that competences be widely distributed among all employees in the production teams.

Description of interviews and interviewees

The selection and recruitment of interviewees was conducted using snowball sampling. Initiated by the first interviewee at each case company, all subsequent interviewees were recommended by a previous interviewee based on their specific knowledge of, experience with or insights into the company's approach to digitalization and/or competence management. The final sample contains 21 interviewees, including managers, specialists, and union representatives.

The data collection was conducted through semi-structured interviews containing a wide range of questions on the topics of digitalization: competence needs, training and education, staffing, and organization of work. The interview guide was tailored to the specific interviewee's area of expertise. The interviews, which lasted for 60–90 minutes, were conducted either face-to-face or using different video conferencing tools. The conversations were transcribed in detail, excluding names and information that could reveal the identity of the company or the interviewees. Quotes from the interviews have been translated from Swedish and Norwegian by the authors and edited for readability.

The interviewer(s)[3] summarized each conversation and sent these to the interviewees with encouragement to add to or correct the text if needed. This not only provided a validation of the researchers' initial interpretation but also ensured that no information that could jeopardize confidentiality was revealed. Moreover, it stressed the voluntary character of participation since it offered the interviewees the opportunity to withdraw statements made during the interview.

Analytical approach

Transcriptions of the interviews were initially analyzed using open coding of a small sample of the interviews (Flick 2022). This coding provided an overview of the various themes in the data. In a second step, our focus was directed at statements about competence, developing categories on competence needs, existing competence, competence development, and so forth. Applying the competence categories conceptualized by Hecklau et al. (2017), we conducted a theoretically informed analysis, attending specifically to the categories and codes on competence needs, which are presented in the first section of the analysis below. As we scrutinized the categories related to competence development, a pattern of *strategic options and choices* emerged. Developing the analysis further, the focus was, therefore, shifted toward some of the choices that managers face considering digitalization, which are presented and discussed in the second part of the analysis.

[3] Interviews in Sweden were conducted by Anna Davidsson, Erica Nordlander, and Kristina Håkansson, while the interviews in Norway were conducted by Johan Røed Steen.

Analysis

First, the analysis responds to the question of how companies' needs for competence are changed by the new organization of production. Second, it responds to the questions of what strategic choices companies face to secure the necessary competence and what contextual factors influence these choices.

Changing competence demands

The case companies have all experienced changes in work tasks and increased demand for certain competencies, pushing them toward reskilling and upskilling of the existing workforce. The strength of this effect appears, unsurprisingly, to be linked to the degree and ambition of digitalization: changes in competence demands are greater in companies that are highly digitalized.

The competences described as increasingly important span technical, methodological, social, and personal competences (c.f. Hecklau et al. 2017). In terms of *technical competence* – related to the use of digital technologies – there is a broad need for skills related to the use and maintenance of digitally controlled machinery and for IT skills, including knowing how to use mobile devices, computers, and specific software (c.f. Hansen et al. 2024). Skills related to managing data are also in demand, as operators and technicians must increasingly be familiar with programming languages to operate digitalized machinery.

Certain *methodological competences* are becoming more important, including analytical skills, process- and system development, and problem solving. There is an increasing need to not just operate but also to monitor, repair, and optimize digitalized machinery, production processes, and communication systems. Utilizing collected data often demands more competence than producing it, as illustrated in the following quote:

> *Group manager, case 4*: What we are able to do, with the competence we have today, and this equipment… We aim to…continuously, we learn how to pick up signals from the machines and the equipment, but then we also need to manage all that data. And I think that's where we are not… we don't have enough competence at the factory. So, we can't really see the whole picture, or draw the map ahead.

A challenge for competence management is thus the uncertainty about what methodological competences are needed. An inability to 'draw the map ahead' (c.f. Ghobakhloo 2020; Hansen et al. 2024), as formulated by the above-cited group manager, can partly be managed by recruiting employees with the right personal and social competence. Interviewees stressed the need for *personal competencies* involving flexibility and self-leadership; motivation to learn and the ability to adapt to new work processes. *Social competencies* highlighted by the informants include cooperation and communication skills, leadership, information sharing, and learning ability,

allowing for work organization with multi-disciplinary, agile teams, and work-task rotation.

Many of the competences that the studied companies report an increased need for are transferrable and *generic competences* (Delamare le Deist et al. 2005). Problem-solving and digital data management, for instance, are competences that could be developed and utilized at almost any manufacturing company. Formal education, including vocational certificates and higher education degrees, also constitutes mainly generic competences. However, the findings also show that there is a striking need for employees with *firm-specific competences* (Delamare le Deist et al. 2005). While this need, and the continued valuation of 'craftsmanship', was especially emphasized in the least digitalized company (case 1), interviewees from the other case companies similarly expressed the need to keep 'old competence' – namely a tacit vocational knowledge attained through long experience – within the organizations.

Having multiple technical and methodological competences involves the ability to perform different tasks depending on the company's needs. Jobs can thus be designed with broad task profiles, enabling functional flexibility. While manual and low-skill work tasks still exist in the companies we studied, these tasks are integrated into jobs that also require broader competence. As indicated by the following quotes, interviewees from cases 2–4 – the 'more' digitalized companies – emphasize that digitalization tends to involve a reduction of 'simple' or manual jobs:

Project coordinator, case 2:	Today, our equipment contains more IT than before, so that is what we need to look for, recruiting people who know IT rather than someone who can hold a monkey wrench.
Technology director, case 3:	[Automation] entails that you reduce the need for the classic vocational competence.
Group manager, case 4:	I believe that increasing numbers of these simple jobs will disappear. We'll have increasingly more monitoring jobs, aiming to let the machines operate more and more independently. [...] The more manual tasks we remove – tasks that actually require of you to stand and watch a machine – the more you can do other things instead.

Here, the interviewees express the understanding that upskilling is the preferred, or indeed inevitable, outcome. This is consistent with a general upskilling dynamic within the Nordic manufacturing sector (Berglund 2024; Rolandsson 2020).

The interviews do not provide any examples of outright deskilling linked to technology-driven loss of jobs at the plant level. Digitalization in these companies has nevertheless had an ambivalent effect on task profiles, in the sense that it makes jobs both 'easier' and 'harder', creating pressures toward both deskilling and upskilling (cf. Da Roit & Iannuzzi 2023). Several core work processes are simplified, reducing the need for previously required manual skills and vocational experience. However, work simultaneously becomes more difficult, requiring the operator to be able to identify and solve problems that may occur. This is illustrated by the following extract:

Chief negotiator, case 4:	[The job today] requires a much deeper competence, at the same time as only a basic competence – or whatever to call it – is required. Anyone can keep production up and running, but the challenge is that – really, what we're saying is that those who previously worked as operators, those tasks are disappearing. Now, we want people who can do repairs, or who previously worked as production technicians, and who can optimize our new, digital process.
	[…]
Interviewer:	You spoke a little about [the fact] that there are no 'simple' jobs left and that tasks are becoming more specialized, but are there any examples of digitalization simplifying tasks and thereby making them easier to perform?
Chief negotiator, case 4:	That's a very good question. Thinking about how production once looked in this place, it was very… it required extensive experience. […] In that sense, the job was more advanced then, than it is today. And that is a bit contradictory. But it's like using a photocopier. You may think that anyone of us could manage that, but when it starts to act up…

The chief negotiator quoted above also stressed that even though digitalized production requires new and higher-level competences, the execution of tasks may potentially be less complex. Whereas it took many years to become fully proficient in managing the old machines, the learning period is now shorter.

Strategies for competence management

One of the companies' strategies for ensuring that they have correct and sufficient competencies is to project what competences they will need in the future, which has been explored in the previous section. However, it also involves prioritizing various competence needs and organizational decisions on how competences and tasks can be distributed. Moreover, companies need to assess where the required competences can be acquired: through competence development of the existing staff or hiring new personnel for the short or long term. This collective approach to competence management (cf. Langenegger et al. 2011; Delamare et al. 2005) involves responding to the questions of *what*, *who*, and *how,* which can be related to the notion of building, borrowing, or buying competence (c.f. Rothwell 2011). However, there are also additional choices raised by the questions of *when* and by *whom*.

This section presents a series of strategic choices that were discerned from the interviewees' discussions of digitalization and competence management. First, overarching strategies for attaining competence are discussed, namely related to the questions of what, who, and how. Thereafter, the focus becomes strategies for competence development, and more specifically the issues of when and by whom this can be accomplished.

Note that the order in which these choices are presented should not be understood as a chronological order. These choices are continuous and – as elaborated in the subsequent discussion – often feed into each other.

Acquiring competence: Building, buying, or borrowing

To address the increased need for certain competences, companies have a fundamental choice between 'building' needed competences internally by training the existing staff, or 'buying' or 'borrowing' these competences from outside of the organization (cf. Rothwell 2011). These options are weighed against each other but are not mutually exclusive; the companies studied use them simultaneously for different ends and types of competence.

The preferred strategy of the case companies when facing digitalization processes is to prioritize *building competence*: to further train and educate existing staff. Competence development was upheld by our interviewees as a natural first choice when addressing new competence needs – though it is contingent on available time, resources, and the motivation of current employees. This can be understood as strategically motivated (i.e., keeping existing competence in the company), as necessary in relation to legislation, and as an empathic way to manage human resources. The latter account is illustrated by the production manager at company 1 who emphasized the need to be flexible and understanding when managing people:

> *Production manager, case 1*: Even in really time-pressured situations, we've never compromised with the quality of competence development. That is, to give everyone the prerequisites to [...] So even if we need to be very flexible, very fast, we maintain a high understanding… For, as I said, it is people, humans, that we talk about and that we manage.

The HR manager representing company 1 stated that their primary ambition is to develop competence that already exists in the company. In a similar fashion, the manager for learning and development at company 2 stressed the notion of life-long learning, and of peer-to-peer training as essential to keeping up with the technological development and resulting competence needs:

> *Manager, Learning & Development, case 2*: It is no longer enough, getting a university diploma and then to move on through your career, maybe with some refilling on the way. I believe that we need to be much more active, continuously adding knowledge. And that is partly because the development is so rapid as it is. So, I would say 'both': we need to work with further training of our co-workers and to utilize the existing competence. But it may also become relevant to recruit new people, absolutely.

This citation illustrates the strategic motives for competence development as well as for recruiting new competences to the company. An awareness that the current staff do not possess sufficient competence in all key areas, nor the time or capacity to acquire it, prompts looking outside the organization. When acquiring competences from outside the organization, companies may either (1) recruit new employees on open-ended contracts (buying competence) or (2) rely on temporary and atypical forms of employment, including fixed-term contracts, TAWs, and external consultants (borrowing competence).

A strategy geared toward *buying competence* relies on recruiting new employees with key competence, through strategic recruitment. In addition to identifying competence needs through mapping and conducting recruitment, the case companies employ long-term strategies to be able to recruit the candidates they need, like working to influence the curriculum at local colleges, running upper secondary schools with a profile orienting toward future work at the company, or working with employer branding to attract the 'right' kind of job seekers. Strategic recruitment can be done in haste but is more often talked about as a long-term effort. For instance, at company 1 (vehicle industry), strategic competence management is primarily structured around anticipated future adaptations to the electrification of their products:

> *Production manager, case 1*: What we need to do is to identify future core competence within this segment and develop a strategy for how to attract that competence. But also, what kind of education can we provide in-house?

Interviewees described building or buying competence by recruiting employees on open-ended contracts as the preferred long-term options, but also as enabling an overall strategy focused on functional flexibility, with multi-skilled teams and task rotation. In case 3, this was presented as a comprehensive policy, with the use of open-ended contracts as complementary to investment in training, aiming to both attract and retain key competence in-house. The following quote, from a technology director in case 3, illustrates this preference for permanent employment when competencies need to be developed over time and there is limited availability in the local labor market, for example, due to low turnover and competition between firms:

> *Technology director, case 3*: I believe we will [continue to] go with permanent staff and there are a couple of reasons for that. One is that this industry is… there are high demands for integrity and reliability and safety: it is a very controlled industry. So, we have to have people that have the right competences to do those tasks […] And there are not that many [firms] in this industry in Norway, so there is not that much circulation of people between firms either. There is often an extensive training period for new employees. And that obviously means that you want to keep people as long as possible when you have made that investment and built them up. The other [reason] is that locally in [the region], traditionally, there are quite a few technology companies, so there is relatively tough competition for the best people. So, if the neighboring firm offers a permanent position, it is not so easy to offer a temporary position here.

The third strategy is to rely more heavily on 'borrowed' competence, using atypical employment, including fixed-term contracts, TAWs, and external consultants. This is often motivated by fluctuating production levels and the need for numerical flexibility, and sometimes managed by specific agreements with staffing agencies that ensure immediate availability. External consultants are often used when digitalization processes

demand specialized competences since permanently acquiring such competence is not always perceived as possible or as the optimal use of resources. As the following quote from the chief negotiator at case 4 highlights, this calls for prioritization between short-term and long-term needs:

> *Chief negotiator, case 4*: We need to have that [technological] knowledge in-house, for sure. But it is also a question of how specialized you are within certain areas. Maybe you can't keep that knowledge up to date by having it in-house, and you may need to buy it from consultants.

Similarly, the channel group manager from the same company proposed that consultants could be especially useful when a need for specialist competence arises quickly, for example, when deploying digital technologies that are new or unfamiliar to the company:

> *Interviewer*: [In the company's future], will there be more consultants as well, more of such short-term jobs?
>
> *Channel group manager, case 4*: Yes, that…we've already had a lot of that during the start-up phase here: technical consultants who have been hired to install various systems and who possess those competencies that we've previously been lacking in-house. I can imagine that. Because it takes some time to build that competence, and it also becomes out-of-date relatively quickly within this field of process and system development.

As illustrated by both these quotes, the rapid development of digitalized processes and systems makes it difficult to have sufficient competence in-house, which motivates the use of borrowed competence.

Several informants, especially workers' representatives, were nonetheless critical of this heavy reliance on such 'borrowed' competence. Aside from the costs involved, extensive use of consultants and TAWs also entails a significant risk of losing essential competence. This concern was raised by, for instance, the union club chairman at company 1:

> *Union club chairman, case 1*: We grew tired of the fact that we have so many temporary agency workers here. Partly because it's an encumbrance as we don't own the competence ourselves. So, we are living quite dangerously. They [temporary agency workers] are not tied to the company, which means that it is very easy for one of these operators, with that competence, to attain another job somewhere else.

Broad vs. narrow task profiles

The second strategic choice relates to job design: how work tasks are organized into jobs with different profiles. Changes in tasks that arise from digitalization can be managed

by adjusting the work content of jobs, typically by either broadening or narrowing task profiles.

The first strategy of broadening task profiles tends to be coupled with a team-based organization of production, wherein high functional flexibility is attained by distributing competencies so that each team always covers all key competencies. As presented in the first part of the analysis, digitalization has spurred this development, as it has allowed for fewer stationary workers (especially machine operators) and increased work rotation (cf. Hedenus & Nordlander 2024). It can also be interpreted in relation to expectations of agile employees (Schwarzmüller et al. 2018). In companies adopting this strategy of broadened task profiles, the interviewees pointed to a reduction of 'simple', 'manual', or 'vocational' jobs and a subsequent need for upskilling. This is especially true for the operators, who are expected to be able to take on a wider range of tasks involving both lower and higher complexity. As illustrated in the following quote, the strategy of broadened competencies also facilitates reallocation of tasks when production levels fluctuate:

> *HR manager, case 1*: When we are fully occupied, we have three assembly lines running. When volumes drop, these are closed, one at a time. Now we have one line running. This means that people that have been working on these other lines, they are redundant now, so to speak. And then there are the assembly workers: they may have been working in logistics, in pre-assembly, tasks that are a bit easier. Then it is our work to ensure that the assembly workers, performing core tasks, that they also have the competence to reallocate to these easier tasks. In that way, when production goes down and lines are closed, tasks are redistributed. And then our co-workers get to step in to perform easier tasks, that we would otherwise have used temporary workers for.

However, as the chief negotiator at case 4 – the company with the most extensive digitalization – explained, it is difficult to make a distinction between 'basic or developmental tasks' since all tasks are executed within a more complex production system. While this can be interpreted in line with the strategy of broadened task profiles and a blurred distinction between technicians and operators, it also involves higher specialization:

> *Chief negotiator, case 4*: Today, you adjust almost every day, and you have more complex tasks that are to be performed continuously within our systems. So, it is really difficult to describe our work tasks in terms of basic or developmental tasks, or similar. Today, it is more about having individuals specialized within different areas.

This leads us to the second strategy of narrowing task profiles: splitting fewer and more complex tasks into different jobs. Specialization and narrowed task profiles can, as illustrated in the quote above, be necessary because of higher complexity due to digitalization. However, whereas the first strategy is focused on developing broad competencies, with the reduction of simpler jobs being merely a consequence, the second strategy is also used to target the identification of low-skilled tasks that can be consolidated into specific jobs. A main aim is to create jobs suitable for newly hired or temporary

employees to avoid long initial training periods. As the union representative at company 1, quoted below, argued, this also ensures that core competences always exist in-house while preserving the possibility of using temporary workers when production increases:

> *Union club chairman, case 1*: And we have raised this with the company on several occasions, that what we are doing is extremely dangerous. Because, competence-wise, we do not possess that competence. So, we have looked at this, specifically regarding the production lines, perhaps not using temps to the extent we have done but instead looking at other places where we have shorter training times, where it is less sensitive, so to speak, to replace people. If we get a production dip or something, the personnel who are redundant in the production line can then move to those positions. For example, driving a forklift or working on some preparation tasks, where the training time is shorter. They can stay there temporarily, and then when the wheels start turning again, they can return to production, and then we can use contingent labor.

As mentioned in some interviews, these jobs with narrow task profiles can also be created to provide tasks for employees that have troubles upskilling.

Competence development in-house vs. externally

For companies that invest in competence development, there is a choice to make between (1) external education and (2) in-house training. All four case companies work with competence development in different forms and offer both in-house training and external education.

The strategy of using external education is contingent on these actors' ability to offer relevant courses. For instance, operators may receive training related to new machinery provided by the manufacturer. The companies also cooperate with educational providers, namely local schools, technical colleges, and universities, to create tailored courses and educations that fulfil the needs of the company. Three of the case companies (cases 2–4) have affiliated vocational schools which provide a recruitment base and ensure that apprentices develop relevant, firm-specific skills. Cooperation with educational providers is also key to upskilling existing staff, developing the general competences needed for digital transformation, as described in the following quote:

> *Manager, case 3*: Here at [industrial cluster], we are lucky enough to have our own vocational school owned by several companies, including us. So, we have a very high degree of influence, and a very good dialog on this among the companies and with [the school]. In addition, we have the technical college that we also work closely with. About two years ago, the technical college created a course on digitalization and Industry 4.0 that we had several employees attend […] because we see that we need to build competence in digitalization.

Still, much competence development is carried out as in-house training. Such education can be conducted flexibly and on demand, through learning-by-doing or as peer-to-peer training. In-house training is framed as more efficient when the skills needed require relatively little training, or when developing employees' general and firm-specific familiarity with software tools, and their ability to troubleshoot and to optimize processes. Although firm-specific competences can be developed using external educational providers with a clear assignment, skills and competences developed through in-house training are guaranteed to be relevant to the company.

Ad hoc vs. structured competence development

Finally, the organization and allocation of resources for competence development involves a strategic choice: to organize training and education as (1) a structured, continuous effort or (2) ad hoc.

The first strategy, continuous and structured competence development, tends to be upheld as an ideal, and the importance of investing in competence development was underscored by interviewees in all four case companies. This aligns with previous research stressing the need for 'strategic roadmaps' for digital competence management (Ghobakhloo 2020; Hansen et al. 2024). Highly structured approaches typically involve regular competence inventories, projections of competence needs, measures and objectives for competence development, and stable funding and time allocated to training (Rothwell 2011).

Case 4 displayed the most structured approach, including a formal agreement on competence development with the union, under which the two parties both set aside resources in a fund for competence development. As emphasized by a local union chairman, the speed of technological development and digitalization makes structured competence development efforts simultaneously more important and increasingly difficult to find time for:

> *Union club chairman, case 4*: It is going to develop rapidly from now on. We know what we need to get in place, and to be able to accomplish that while simultaneously managing ups and downs in production levels. Reallocation of people, competence development of people; I believe these things are only going to get harder. […] It is nothing we won't handle, but the speed… It requires that you ensure both [a good] work environment and [opportunities for] competence development.

However, as noted by this interviewee, this strategy is resource intensive and harder to sustain when the speed of transformation intensifies.

As a result, managers often choose not to prioritize continuous competence development, relying instead on the second strategy of ad hoc competence development, which is a previously identified tendency among companies (Da Roit & Iannuzzi 2023). In all the case companies, lack of time seemed to constitute the main obstacle for competence development. Periods of low production were thus typically used to intensify training. Case 1 had the clearest ad hoc training strategy, exploiting time flexibility in the form

of 'stop days' in production to provide additional training for the staff. However, in case 4, also, the use of 'learning centers' at the production site provided opportunities for training when production was low, reinforcing the ad hoc strategy. For instance, the Covid-19 pandemic was said to have freed up time for competence development, further aided by available governmental support mechanisms.

Discussion

The analysis shows how the case companies experience competence needs associated with digitalization processes and how they seek to meet these needs by applying diverse competence management strategies. Thus far, the identified strategic choices have been presented as separate, although dependent on various contextual factors. However, the available options for each of the strategic choices described in the analysis are not mutually exclusive, nor entirely independent of each other. They may influence each other and produce some path dependency for future strategic choices as employers weigh concerns within constraints partly set by previous choices (c.f. Praest Knudsen 2005). Thinking in terms of ideal types, the authors therefore suggest that there are two main – conceptual – 'paths' of competence management in digitalization processes. This section first presents these two paths and, second, how the different strategic choices, and the inclination to follow a certain path, are influenced by contextual factors.

Paths of competence management

First, there is the 'enabling path' (cf. Liu 2024). This is a strategy which emphasizes functional flexibility and long-term investment in technology, paired with upskilling. This entails designing jobs with broad task profiles, enabling functional flexibility, flat organizational structure, and a high degree of worker autonomy. Retention of core staff is a priority, accomplished by mainly using permanent employment contracts. Training and upskilling of core staff are preferred, though complemented by strategic recruitment when necessary. Companies following this strategy have incentives to invest heavily and continuously in competence development, both as in-house training and in close collaboration with educational providers.

Second, there is the 'pragmatic flexibility path'. This revolves around the need for numerical flexibility and quick adaptation when new digital technology is introduced. To acquire competencies quickly, recruitment can be prioritized over competence development in the short term. Especially when competence needs are short-term or fluctuating, the use of temporary employment contracts and external consultants further pushes these companies to depend on borrowed competence. To accommodate newly hired and contingent labor, and to avoid long training periods and/or to take advantage of specialized skills, certain jobs can be designed with narrow task profiles. This path is more viable if the company can make use of general competencies that are readily available on the labor market. In turn, this can lower the need for in-house competence development programs and allow the use of external educational providers loosely affiliated with the company. This entails a more opportunistic approach where competence development is provided when time and resources are available.

The two outlined paths are ideal types insofar, as none of the sampled companies have implemented all facets of one model. Rather, they seem to balance between them and to reconcile organizational and technological ideals with economic and structural realities. The enabling path, as described above, is closely related to ideals associated both with the concept of Industry 4.0 (e.g., Shamim et al. 2016; Fatorachian & Kazemi 2018) and with the Nordic labor market model. Nevertheless, despite the widespread aspiration among the interviewees to implement these ideals, various contextual factors often require organizations to instead follow the pragmatic flexibility path.

Context matters

Company-specific factors, such as existing work organization, type of product and production, financial resources and competitive position, time constraints, and availability or lack human capital, condition which strategies to apply (c.f. Ganz et al. 2018; Praest Knudsen 2005). The analysis provided several examples of how the companies' different conditions influenced which strategies they chose to apply. For instance, having relatively stable production levels allowed cases 2–4 to hire staff on open-ended contracts, while case 1 needed to depend more on borrowed competence in the form of TAWs. The quality demands and long training periods of cases 2 and 3 also hindered a more extensive use of borrowed competence and, instead, encouraged efforts directed at broadening tasks and building competence among already employed workers. The strategic choice of broadening tasks and upskilling was further encouraged by a team-based organization of work (as in cases 2 and 4), promoting functional flexibility in production.

In addition, the forms and extent of technology adoption are central for the companies' competence needs (Krzywdzinski 2022; Ohlert et al. 2022). For instance, the introduction of digital tablets for reading assembly instructions, used in case 1, influenced competence requirements differently than the introduction of fully digitalized production channels in case 4, which required competence in monitoring and problem solving in digital control systems. A more continuous process of digitalization, involving changing competence needs for many workers, calls for continuous and structured competence management along the enabling path. However, if these changes are introduced in a hurry, or without a 'strategic roadmap' (c.f. Hansen et al. 2024; Ghobakhloo 2020), the companies may still be pushed into the pragmatic flexibility path, solving their competence needs with opportunistic or temporary solutions.

In addition to company-specific factors, contextual factors external to the organization also influence competence management strategies (c.f. Ganz et al. 2018). As explored in the analysis, availability of competences in the local labor market is a key factor. A greater supply of workers with the necessary skills can, as in case 1, enable a strategy geared toward recruitment, following the pragmatic flexibility path. In contrast, a scarcity of competent labor may, as in case 3, push toward competence development. Moreover, competition for competent labor may incentivize companies to opt for additional strategies that make them attractive to jobseekers, including offering open-ended contracts. Both these circumstances would encourage companies to follow the enabling path.

The availability of skilled labor is, in turn, contingent on national and institutional variations, such as local demographics, unemployment rate, and industrial relations. Both Norway and Sweden belong to the Nordic labor market model and share many

similarities when it comes to labor market regulation, which would incentivize the case companies to choose the enabling path. For instance, the trade unions' strength and influence, and a tradition of social dialog in the workplace, strongly influence competence management strategies toward upskilling and the use of open-ended contracts, which is also illustrated in the analysis.

Another key institutional factor is the quality and relevance of the educational system in general, and the vocational education system in particular. In coordinated market economies like Norway and Sweden, collaboration between firms and educational institutions is common, and VET is tailored to local industry, enabling firms to rely on labor with high industry- or firm-specific skills (cf. Hall & Soskice 2001). As exemplified in the analysis, companies that partner with local schools and training institutions influence the development of training programs to meet their specific needs. This creates opportunities for building and buying competence, making companies less dependent on the strategy of borrowing. The national educational systems in Norway and Sweden thus further encourage companies to follow the enabling path.

Conclusion

The empirical contribution of this article is twofold. First, the analysis has explored how digitalization and Industry 4.0 require new digital skills as well as competences conducive to more flexible organization. The findings corroborate previous empirical studies (Freddi 2018; Hansen et al. 2024; Holm 2018) as well as anticipated changes (e.g., Benešová & Tupa 2017; Fitsilis et al. 2018). To operate complex digital systems, solve problems, and work effectively in multidisciplinary teams, workers must possess not only advanced technical skills, such as programming and data analysis, but also methodological, social, and personal competences. The findings also corroborate previous research on a general upskilling of labor (e.g., Berglund 2024; Goos et al. 2014; Heyman 2016; Rolandsson 2020), indicating that traditional manual tasks are increasingly automated, shifting the focus toward roles that demand higher cognitive abilities and continuous learning. While much of this constitutes generic competence, many firm-specific competences are also required.

Second, the analysis highlights how the changed competence needs present new challenges for strategic competence management in digitalized organizations. To manage these challenges, companies navigate between building competences internally, borrowing them temporarily via contingent labor or buying them by recruiting new employees. These choices are interrelated with other decisions regarding job design and how competence development is organized and conducted. While these choices and options are not different from those available to non-digitalized organizations, the justifications for which choice to make – and the factors influencing those choices – are different. This article points to several of these contextual aspects.

In addition, the theoretical contribution of this article lies in presenting two contrasting paths in competence management: the 'enabling path' and the 'pragmatic flexibility path'. The former focuses on building competences internally and fostering a stable, skilled workforce. The latter, in contrast, emphasizes the use of contingent labor and external consultants to quickly adapt to market demands and access specialized skills as needed.

While the institutional context of the Nordic labor market pushes toward the enabling path, many company-specific factors push instead toward the pragmatic flexibility path.

Some limitations of this study should be noted. First, the sample is limited in terms of number, industry, and national context. Results may reflect unique characteristics and practices of these companies and/or the manufacturing industry. Additionally, the geographical focus on companies in Norway and Sweden affects the generalizability of the findings. Future research could incorporate a more diverse sample to test the applicability of the findings, as well as to further investigate the role of contextual factors. A third limitation relates to the different levels of implementation of digital technologies in the sampled companies. More generalizable evidence could emerge from studying a larger number of companies at various stages of digitalization processes or from longitudinal studies.

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