WORKING PAPER

Eurofound

Digitisation in the workplace

# Case study: Internet of Things in Sanmina (Örnsköldsvik)

*Digitisation in the workplace*

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# Case summary

Sanmina Corporation is an international manufacturing company that designs, manufactures and repairs complex and innovative optical, electronic and mechanical products (NACE code C.26, 27, 32.5 predominantly). Sanmina provides end-to-end design, manufacturing and logistics solutions for customers primarily in the medical, defence and aerospace, industrial, automotive, communications and cloud computing sectors.

The current case study explores one of Sanmina's 75 global facilities, namely the Örnsköldsvik plant, located in Sweden. For over 25 years, the Örnsköldsvik plant has offered product design, test development, manufacturing, configure-to-order, product delivery and repair services, specialising in medical devices.

The establishment has always used technological innovations and aims to automate as many production/business processes as possible. Some 15–20 years ago, digital shop floor data collection (SFDC) technology was adopted to improve production processes. However, in 2015 a much more integrated IoT platform, called 42Q, was launched across all Sanmina's factories. 42Q is a system that connects 26,000 pieces of manufacturing equipment, equalling 90% of production-related technologies. Through machine-to-machine communication, the technology enables real-time manufacturing and supply chain visibility in all of Sanmina's factories throughout the world.

The new system has several advantages: it improves traceability of production processes and products, enables a standard process flow, enhances report capabilities, and provides a visual overview of product status for employees as well as for customers. Adoption of 42Q broadened the spectrum of products and services delivered at the Örnsköldsvik plant, leading to an expansion of the customer base and intensification of communication with customers.

The new IoT technology did not transform internal organisation of work between units in the Örnsköldsvik plant, but rather improved organisation of work processes within them. Stricter monitoring of orders and procedures across the value chain enabled better quality control and uniformly high standards of delivered products and services. This came at the cost of some operational freedom of assemblers. Adoption of 42Q has (unavoidably) led to monitoring of activities of employees in the production unit, but improved a sense of job satisfaction in avoiding errors. The range of performed tasks has expanded for all employees – assemblers, engineers and members of the management unit. The new technology increased efficiency and effectiveness of their work, thereby slightly decreasing the workload. Due to 42Q, employees in the engineering and production units developed analytical, IT and quantitative skills, thereby improving their job prospects. However, a lack of easily transferrable skills and a mounting threat from increasing automation posed an initial challenge for employees in the production unit.

# Introduction

## Background and objectives

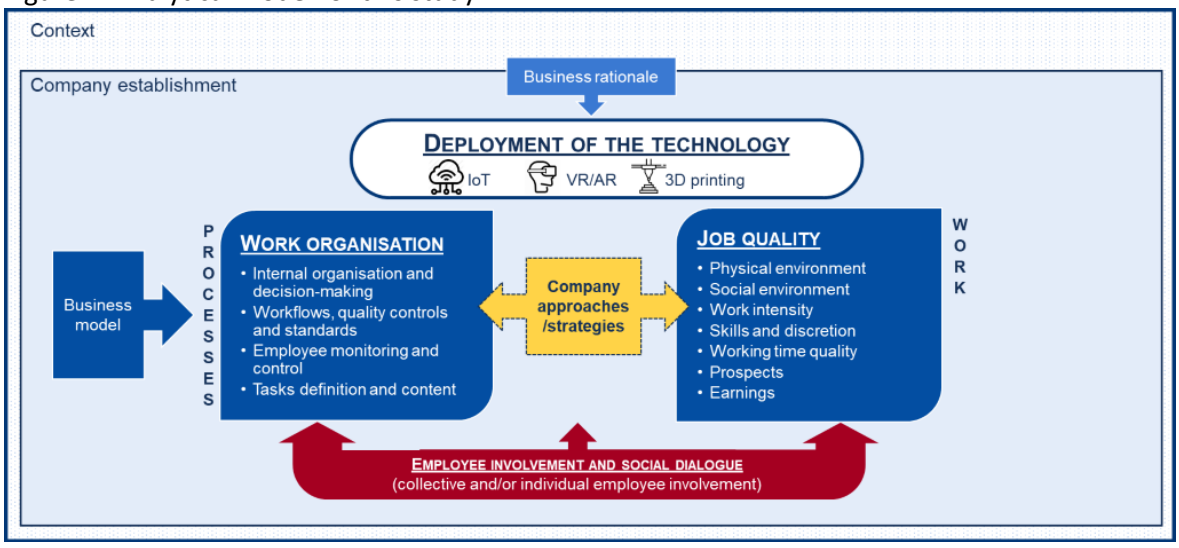
This working paper illustrates the case of Sanmina, the Örnsköldsvik plant (Sweden), in relation to the introduction and deployment of a digital technology. The working paper explores the impact of this digital technology on work organisation and job quality, as well as the extent of the employee involvement in relation to the digitisation process.

This case study has been conducted in the context of a Eurofound research on the impact of digitisation on the nature of work. This research is set against a conceptual framework elaborated by Eurofound (Eurofound, 2018), which differentiates between three vectors of change, of which one is digitisation and is associated with three digital technologies. These are additive manufacturing or 3D printing, the Internet of Things and Virtual and Augmented Reality.

Eurofound's conceptual framework on the digital age (Eurofound, 2018) proposes that the effect of digitisation is most direct on working conditions, as it involves a change in the work environment and nature of work processes. It also involves changes in tasks and occupations and has an indirect effect on employment conditions and industrial relations.

Based on this conceptual framework, Eurofound has developed an analytical model (reproduced in Figure 1) that serves to guide the analysis of nine case studies (including the Sanmina case) conducted for this research. According to this model, the nature of work consists of two core dimensions, namely work organisation and job quality. Employee participation and social dialogue is a cross-cutting dimension as it can both influence and be influenced by the way the technology is deployed in the workplace. Typically, the technology changes the establishment's business model, which in turn affects the work organisation and elements of job quality (partly depending on how the technology is applied in the workplace). Both contextual factors and establishment or company specificities may drive the digitisation efforts. These factors should be taken into account for a better understanding of what has either constrained or facilitated the digitisation process within each establishment.

Figure 1: Analytical model for this study




*Source: Technopolis & Eurofound 2019*

This particular case study provides insights into the introduction of the Internet of Things technology in the Örnsköldsvik plant of Sanmina and illustrates the impact on job quality and work organisation, which is the core of this study. This case study draws primarily from 8 qualitative interviews conducted with the VP plant manager, director NPI and business development, human resource manager, test development engineer who acts in the capacity of a formal employee representative of the works council, and with 4 other employees – assembler, quality engineer, process and project manager at the Örnsköldsvik plant. The interviews were conducted between 17 June and 24 September 2020. In addition to conducted interviews, the current study uses materials provided on the website of Sanmina corporation.

## Reason for selecting this particular case

This case highlights the value of digital technologies for a large corporation that develops highly complex products. It illustrates the impact of an advanced IoT technology on a business model, effectiveness and efficiency of production processes across the value chain and highlights different effects on several groups of employees.

## Set up of the report

In the following chapters more context will be provided by describing the establishment in more detail (chapter 1), the analysis will be illustrated by describing the process of the introduction and implementation of the technologies, including the role of social dialogue and employee involvement throughout the digitisation process (chapter 2), the impact of the two technologies on the business model, work organisation and job quality (chapter 3). The working paper ends with lessons learnt and take-aways.

# 1. Establishment profile

## Type of entity and ownership structure

Sanmina Corporation (Sanmina) is an American company, founded in Silicon Valley in 1980. Currently, Sanmina Corporation is a leading integrated manufacturing solutions provider serving fast-growing segments of the global Electronics Manufacturing Services market. In 2020, its revenue totalled $6.96 bn. (€5.86 bn. at current prices). Thus, Sanmina is one of the 500 largest companies in the United States.

Sanmina Corporation is a public company quoted on the NASDAQ stock exchange with ticker symbol SANM. Throughout the world, Sanmina has a global footprint in 21 countries. This case study explores the impact of digitisation on the Örnsköldsvik plant, located in Sweden. This plant has been operating for over 25 years, and is one of Sanmina's premier medical facilities in Europe.

## Activities and geographic location

Sanmina's plants provide end-to-end manufacturing solutions to original equipment manufacturers in the medical, communications networks, defence and aerospace, industrial, cloud computing and automotive technology sectors. However, the Örnsköldsvik plant specialises in delivery of products in medical, industrial and defence industries. All of Sanmina's plants work in close collaboration, as supply chains for complex products are typically global, with components, sub-assemblies and finished products manufactured in different locations and countries. This results in mutual dependence and interconnection of production processes across Sanmina's factories.

Similar to other plants of Sanmina, the Örnsköldsvik plant produces a wide range of complex technology products. Box 1 provides a few examples of products and services in several industries. As a manufacturer of electronic and optical products, the plant's activities fall predominantly under the NACE code C.26, 27 and 32.5.

**Box1. Examples of Sanmina's services in communication, cloud computing, medical, defense and aerospace, automotive and industrial markets.**

Among the services provided at the Örnsköldsvik plant are listed product design, test development, manufacturing, configure-to-order, product delivery and repair.


Examples of products:

Medical industry: personal use medical devices (blood glucose meters, thermometers), patient monitoring systems (applications include pulse oximetry, telemedicine), ultrasound systems, medical imaging and large systems such as computer tomography scanners, surgical robots, magnetic resonance imaging scanners, X-Ray systems, laboratory diagnostic systems and blood handlers.

Industrial industry: industrial controls, 3D printers, ATMs, kiosks, gaming systems, capital equipment for the semiconductor market, power distribution and management, smart meters and electric car chargers, inverters and enclosures for renewable energy systems, mass transit, elevators and escalators.

Defense industry: electronics for defense applications including avionics, communications, encryption, mission control, guidance, radar and night vision.

*Source: Sanmina's official website*

The Örnsköldsvik plant is located in Västernorrland County in northern Sweden, and is Sanmina's only production facility in the country.

## Size and workforce composition

Of 37,000 Sanmina employees, 275 work in the Örnsköldsvik plant. Employees in the plant can be divided into three groups: those who work in production, in the engineering unit and those who are part of the management team. The production unit predominantly consists of assemblers that are assembling and testing products or components. The engineering unit houses (higher-qualified) engineers, technicians, process and project managers who develop products, monitor their quality and supply chain, and support employees in the production area. The management team is the smallest unit in the establishment. It includes staff who are responsible for the overall business development, innovation, human and physical resources.

The number of staff in the production and engineering units are almost equal, around 125 in each unit. The establishment has a good gender balance with 50% female and male employees. In terms of age distribution and ethnic backgrounds of employees, the Örnsköldsvik plant has significant diversity. Being part of Sanmina Corporation, the Swedish plant is committed to inclusive hiring practices. Therefore, the only basic requirement for recruitment is the ability to speak and read Swedish. Due to complexity of work in the engineering and management units, university education is a must for hiring in those units. In contrast, work in the production unit does not have high educational requirements. As a result, about a half of currently employed personnel in the establishment are university graduates and the other half have only upper secondary school education (ISCED 3). Most employees have permanent employment contracts for full-time work.

Among the central human resource strategies of the Örnsköldsvik plant is the stimulation of employees to develop professionally at the establishment. This opens new career opportunities for some employees and improves their understanding of work processes, resulting in higher quality of performed tasks.

## Form of employee representation

The Örnsköldsvik plant has a workers' council that is chaired by an employee representative who acts as a delegate to the management team. In practice, an employee representative rarely participates in negotiations or consultations, as his/her intervention is requested only in cases where it is difficult to reach a compromise between the parties. His/her role is focused on providing general feedback of employees to the management team when it is requested. As a rule, employees in the establishment directly approach the management if there is an issue. The management team has always cultivated an open organisational culture that minimises distance between the management and the production and engineering teams. According to management, such an approach improves

effectiveness of communication, awareness of the management about present issues, and speeds up the development of solutions.

Sanmina Corporation, as most large establishments, is characterised by a hierarchical, decision-making structure. The corporate management is the central decision-making body, which determines key business strategies and approaches that are implemented at a plant level. The members of the management team from the Örnsköldsvik plant are the main channel to voice concerns and views of employees to corporate level. An employee representative is rarely invited to attend a meeting with the corporate management, therefore he/she passes feedback of employees to the local management. As a result, presentation of a concern directly to the management team increases the possibility that it will be heard at a corporate level.

Based on interviews with employees in the production and engineering units at the Örnsköldsvik plant, they are satisfied with the level of responsiveness of the management team to requests of employees, with the communication and employee involvement approach. The latter represents a balance between the bottom-up and top-down tactics of the management team. The employee involvement approach is better illustrated in the following examples: if a corporate decision is to be implemented in the Swedish plant, then the local management team invites employees to discuss how to better introduce changes. In cases where the local management has full authority they might involve employees in the decision-making process. Nevertheless, employees recognise that their ability to influence decisions that are not directly related to working conditions of employees is relatively small.

# 2. Introducing and deploying digital technologies in Sanmina

In light of the great complexity of production processes, introduction of new digital technologies is strictly monitored on effectiveness and impact on production and business processes in the Örnsköldsvik plant by the local and corporate management teams. According to the director of the Örnsköldsvik plant, the establishment has always used most recent technological achievements and aims to automate as many production/business processes as possible. To better monitor production processes, about 15–20 years ago all Sanmina's plants adopted a digital shop floor data collection (SFDC) technology. It was the first large IoT technology/system that connected several machines in production. Due to SFDC, the Örnsköldsvik plant expanded the range and improved quality of products and services. Over the years, the digital data collection and management platform has been developed and in 2015 a much more integrated IoT platform, called 42Q, was launched across all Sanmina's factories.

The decision to adopt the 42Q system was taken by the corporate management as a next step in the Corporation's technological development. The decision was preceded by multiple company meetings which were attended by directors of each Sanmina plant. The idea of having such a system has been nurtured for decades and a suitable infrastructure was developed prior to the adoption of the technology. The design of 42Q took 4 years prior to its deployment across all Sanmina's factories. Throughout this period, the technology designers together with the ICT (information and communication technology) professionals at Sanmina collected data from Sanmina's plants, including client needs and preferences, developing necessary functionalities and testing success of operations.

The new common platform is hosted in the United States, thereby the system is maintained centrally. 42Q has the same system set-up across all Sanmina's plants, including technology settings, logistical indexes and a protocol that allows control of each machine via the platform. Once the system was developed, it was integrated in each of Sanmina's factories. In the Örnsköldsvik plant, the local ICT professionals set up the system with the assistance of the ICT professionals from the headquarters in the United States. The headquarters developed instructions and provided on-site training on how to set up and use the new technology. To test the effectiveness of operations in the Örnsköldsvik plant, the pilot project has been launched on one product prior to full deployment of the technology in the plant. 42Q was already well developed when implemented in Örnsköldsvik (Technology Readiness Level 8).

42Q is a cloud manufacturing execution system that connects 26,000 pieces of manufacturing equipment, equal to 90% of production-related technologies in Sanmina. Due to machine-to-machine communication, the technology enables real-time manufacturing and supply chain visibility in all of Sanmina's factories throughout the world. 42Q facilitates data collection throughout the entire supply chain in an organised manner, connecting resource and product management systems, data storage, testing of products, reporting, execution and monitoring of processes and of employees who work with specific machines.

The new system has several advantages: it improves traceability of production processes and products, forces a standard process flow, improves quality of products, enhances report capabilities, and provides a visual overview of product status for employees as well as for customers. Due to the adoption of 42Q, the company conducts more tests on products, thereby obtaining more information about a product, and is able to provide advice to customers on use and maintenance of

a product. In addition to better organisation of the production processes, efficiency is achieved via a reduced need to handle paper-based data, as all production-related reports are electronically produced, sent and stored automatically.

Currently, each manufactured product has a DHR (device history record) which specifies how it has been developed. The new IoT technology allows the monitoring of all production-related processes, including performance of the production team. Due to increased analysis of collected data, 42Q enables monitoring of yield, technical capacity, production flow and productivity against predefined targets.

## Motivation for the introduction of the technology

The corporate management team had several reasons for the adoption of 42Q. First, it aimed to improve effectiveness of production process. A greater visibility, traceability and integration of data were expected to provide better analysis of and control over product development across the value chain. Considering interdependencies between different Sanmina factories and a relatively high cost of mistakes in production, availability and remote access to data in real time is critical for a complex production process. Second, the availability of new types of data was expected to improve the quality of products and expand the range of services that Sanmina can provide. Constant monitoring of almost all production-related processes and the ability to conduct more tests of products provided essential information for engineers and managers at Sanmina, as they have learned more about current and potential products. A better analysis of customers products, in parallel with analysis of market and industry specific trends, enabled Sanmina to anticipate needs of customers and adjust 42Q to those needs.

The third motivation behind the adoption of 42Q was an external pressure – increasing customer demand for more advanced technological products and greater access to data, as well as growing competition in the market. The market competition not only put pressure on the quality and novelty of products, but also on cost competitiveness. Increasing efficiency has become the means to save resources and invest them in innovation. In addition, 42Q was expected to enable customers to access data on status of their product development and to receive additional information on how specific materials, components or products can/should be treated.

## Place in the workplace for the technology and its embeddedness

42Q has been set up in the production area of the Örnsköldsvik plant. The technology is highly embedded into all production-related processes not only in the Swedish plant, but also with other Sanmina factories around the world. Almost all manufacturing and test devices in Sanmina are connected to this IoT system. In addition, once 42Q had been developed the ICT professionals in the headquarters of Sanmina designed complementary technologies, programmes that enable statistical analysis of generated data. Such analyses currently serve to gain insight into production and business processes in the Örnsköldsvik plant and in Sanmina globally.

## Timing of the introduction and progress thus far

The new IoT technology was adopted in 2015. The pilot phase in the Örnsköldsvik plant, which included testing the technology with one product, lasted for six months. Testing, analysis and adjustment of the 42Q during the pilot phase was conducted by five local employees. Among key issues that were discussed during that phase was the ease of use for the personnel and suitable training for different categories of employees. Once the pilot phase ended, 42Q was fully deployed and operational.

## Initial expectations of the introduction of the technology

The management team at a corporate level had great hopes related to the capabilities and benefits of the new technology. 42Q had to address all of their key concerns, listed in the section on motivation for the introduction of the technology. Some of Sanmina's clients were aware of the advanced IoT system, as their preferences and suggestions had been considered during the technology design stage. Thus, customers also had high expectations prior to the deployment.

At the Örnsköldsvik plant, the management unit welcomed the technological change, anticipating greater efficiency and effectiveness of production and other business processes. Sweden is a high cost country, therefore the director of the Örnsköldsvik plant expected a gradual reduction of the number of employees following increasing digitisation and automation. Due to previous positive experience in digitisation of the plant, the management team in Sweden did not have serious apprehensions related to the adoption of 42Q. According to the director of the Örnsköldsvik plant, a new digital platform is a natural part of the plant's development and, as in the case of any change, it will be accepted and resisted by some employees. For the local management, the major concern was the safety of data of suppliers and clients, as 42Q stores all data via the Internet in the "cloud".

The employees at the engineering and production units of the Örnsköldsvik plant had more concerns about 42Q than their local management. The common concern was the ease of use of the new complex technology. Employees in production, in particular, were doubting their ability to learn new methods, tasks and processes of work. Another concern, dominant among assemblers, was the possibility of job loss in the case where the new advanced technology would replace human labour. Last, employees in production were aware that 42Q would increase monitoring of their work, and this led to internal discussions on how generated data would be used and what impact it would have on their job.

## Initial strategy for the introduction of the technology and adjustments during its deployment

The introduction of a large IoT system throughout Sanmina's factories is considered a global, corporate issue that has been centrally managed. Thus, most components of the strategy for the introduction and adjustment of 42Q were developed at corporate level. The strategy included the provision of in-house training for employees who work with 42Q, internal and external communication strategy and a detailed technical plan for technology deployment. The latter included instructions on how each plant should set up the technology, the list of settings, protocols and other specifications for uniform use of the system.

When the technology was released, the sales teams communicated to customers about the possibilities and functionalities of the new system. Internal communication between the local management and employees focused on explaining the benefits of the new system. 42Q was presented as a helpful tool that would reduce frustrations at work and make working life easier. The change had been announced during a collective staff meeting. If employees had questions about the new technology, they could approach the management team directly, but, based on conducted interviews, most employees preferred to wait until the system was fully deployed. Such reaction of the employees is attributed to local culture, as employees in Sweden tend to avoid conflict and act in the common interest of the establishment (Matuska, 2013). The director of the Örnsköldsvik plant stated that the process of adoption in the plant went smoothly, as the management team did not experience significant opposition to change. According to him, the technical change is the easy part, while process change strongly depends on local culture – the willingness to accept new circumstances and rules, as well as trust in management by employees.

The management team explained to employees that 42Q would increase the monitoring of work in the production unit. Management clarified that collected data would not be used to assess individual performance, despite that there is a technological capability to monitor that, but rather serve for monitoring production processes and for detecting errors. Considering that Sanmina as a whole is following European General Data Protection Regulation rules and is compliant with national regulations, most employees trusted that collected data would not be used beyond its functional need.

During the process of 42Q adoption, no third-party organisations or additional employees were hired at the Örnsköldsvik plant, although Sanmina's headquarters hired several programmers who are developing the technology and its interface. In the Swedish plant, all technical changes were implemented by the local ICT employees, with the support of technical experts from the headquarters.

As mentioned above, employees in production were afraid that their job would be at risk following deployment of the technology. Nevertheless, there was no immediate downsizing of personnel. In the last 15 years, digitisation and automation of processes led to a gradual replacement of about 45% of all job positions in the plant. Predominantly manual jobs were eliminated, while roughly the same number of engineering and managerial positions was created to conduct in-depth analysis and utilisation of data. Thus, a number of created jobs offsets a number of lost jobs. The local management team did not have an explicit strategy to reduce the number of employees after integration of 42Q. A few positions have been eliminated since 2015, but this has not been attributed purely to adoption of 42Q, but rather to a series of technological transformations at the Örnsköldsvik plant. For example, prior to 42Q, the production unit had assemblers and employees who conducted specific tests. Currently, one employee combines the tasks of assembly and testing.

On the surface, the recruitment strategy of the establishment has not changed, although job requirements have been adjusted to new tasks. For example, among key characteristics of new job profiles in the production unit were basic computer knowledge, ability to learn quickly on the job and flexibility in changing tasks. Hence, the establishment is looking for a slightly different composition of skills among job applicants. The director of the Örnsköldsvik plant believes that Sanmina is only at the beginning of its digital journey and everything that can be automated will be automated. In the view of the management team, absence of innovation poses a much greater risk to the establishment than any change. Thus, a gradual replacement of human labour is deemed unavoidable.

## Role and involvement of employees before, during and after the technological change

The involvement of employees in the discussion of technological change has been quite limited, as the corporate management had already made the decision to introduce a technology and prepared instructions on how the technology should be set up and run. Apart from providing feedback on use of 42Q and sharing their experiences, employees had little influence on the technology development and adjustment process. The works council issued their opinion/advice, but it was non-binding. Their opinion expressed initial worries of employees, presented above (e.g. ease of use, ability to learn how to work with a new technology), and advice to address arising concerns of employees.

Such an approach to employee involvement is typical at the Örnsköldsvik plant, as decisions taken at a corporate level cannot be amended in Sanmina's factories. Where an issue concerns only local challenges it is addressed with the local management team. Based on the conducted interviews, the management team at the Örnsköldsvik plant has shown readiness in hearing and addressing issues

related to working conditions of employees and training needs. Most concerns of employees were related to a lack of habit of working with the new system. According to interviewees, employees do not have concerns about data protection, as Sanmina is compliant with the GDPR.

Due to a relatively flat, non-hierarchical structure in communication between departments and colleagues at the Swedish plant of Sanmina, employees directly approach their immediate manager to discuss issues. Thus, the role of the works council representative seems to be small in the Örnsköldsvik plant in general and during the technological change. An ability to directly approach the management team seems to instill trust, as most employees feel that their opinions are considered by the establishment when it is appropriate.

Prior to the adoption of 42Q, the employee representatives across plants were consulted on what issues employees might face while using the new system. However, during the pilot phase in the Örnsköldsvik plant, a works council representative contributed to the assessment of impact of 42Q only in the capacity of the test development engineer. During that assessment, only technical and business-related processes were analysed, such as quality of products, production processes and efficiency. A lack of consideration of the human side of technological change is typical for profit-oriented organisations, as priority is given to the effective operation of the new technology. Employee representatives did not demand an impact assessment of technology integration on employees, due to continuous dialogue between employees and the management that helps to resolve arising issues.

# 3. Impact of the technology in the workplace

## Changes to the business model

The technological capabilities of 42Q broadened the spectrum of products and services delivered at the Örnsköldsvik plant and improved their quality. For example, the establishment's sales and marketing department offers to analyse the weakest part of the product and suggests how the product could be improved, to advise on spare parts and service requirements of a product, to make forecasts and better control the machine remotely.

Due to 42Q, the list of customers of the plant expanded and the quality of communication with customers improved. Currently, customers can remotely access data on a product status and get various new insights from collected data. For example, 42Q offers detailed information about the production time and potential yield. Currently, the management of the Örnsköldsvik plant discusses how to better incorporate feedback of customers, adding new data and functionalities to 42Q. Thus, the establishment conducts co-creation activities with customers. The platform seems to be an excellent tool for continuous communication between product developers and customers. If a customer provides new input data (e.g. technical requirements of a product) or changes the order, then data is automatically updated in the system and the production process automatically proceeds based on the new information.

New product tests and comprehensive analyses of data provide invaluable information for customers and opens new opportunities for Sanmina. Controlling before something happens, namely predictive maintenance, is a key feature of 42Q. In the future, the management team at the Örnsköldsvik plant expects that the data generated by 42Q will enable more predictive maintenance of products.

Apart from the above listed advantages of 42Q for business activities of Sanmina and its customers, the new system improved control of processes and efficiency, allowing precise calculations of production costs. Some customers of the Örnsköldsvik plant decided to adopt 42Q after realising its benefits. Thus, Sanmina became the supplier of the new technology.

## Impact on the work organisation

### Internal organisation and decision-making

The new IoT technology did not transform internal organisation of work between units in the Örnsköldsvik plant, but rather improved the organisation of work processes within them. Most changes appeared due to changes in work procedures and altered lists of tasks of employees, thereby increasing collaboration between units at the Örnsköldsvik plant. Despite that, the degree of autonomy between units has not been affected, as most collaboration is consultative in nature.

Undoubtedly, the work of the production unit has been affected most by the introduction of 42Q. In the production area, the work is divided between the two teams: PCB (printed circuit board) assembly and system assembly teams. Employees are shifted between teams where they are most needed, as similar skills are required. Prior to the adoption of 42Q, there was less flexibility in re-arrangement of teams, as specific tasks, such as some types of repair activities, could be performed only by a few employees. Once 42Q had been deployed, many repetitive tasks (e.g. specific technical procedures for building particular products, sending of reports) in the production area became

automated. This provided an additional opportunity for the production managers to move employees between different teams (PCB and system assembly teams). An additional advantage of this is a better understanding of production processes by employees, which results in higher effectiveness of their work.

Due to the adoption of 42Q, employees in the production unit spend more time monitoring data displayed on the computer. Due to greater transparency of the production process, assemblers have more knowledge of product characteristics and specificities of their production. As a result, communication between the production, engineering units and customer service teams has intensified, and assemblers are more involved in decision-making on which tests should be conducted on a product, and what are the root causes of errors. Thus, the spirit of teamwork has increased.

Among other changes in the organisation of work between production and engineering units is the reporting process. Prior to deployment of 42Q, employees in production units would provide paper-based reports to the management after a product had been produced. Currently, the system automatically creates, sends and stores reports, thereby reducing the need for handing reports.

42Q provided more data for analysis, leading to greater frequency of communication between the engineering and management units and customers. The management unit, particularly sales, marketing and innovation teams, maintain constant discussions with new and potential customers, presenting new capabilities of 42Q and working on the design of new products. Meanwhile, engineers conduct more analyses of data and, as a result, are engaged in more intense collaboration with colleagues from all units within the Örnsköldsvik plant and in other Sanmina plants.

## Workflows, quality controls and standards

After 42Q was adopted in the Swedish plant, the production process became very systematic: a further production process cannot be started until a previous stage of activities is complete. The degree of autonomy of assemblers has decreased due to stricter procedures of the production process that increases dependency on the work of colleagues. At the same time, 42Q allows to monitor and control all processes and conduct activities in real time and remotely, thereby increasing smoothness of the production. In contrast to employees in production, the work for employees in the management and engineering units has not greatly been affected by the new technology.

The strict order and procedures across the value chain were designed to ensure quality control and uniform high standards of delivered products and services. In light of the complexity of developed products, production procedures and technologies/machines, detailed guidelines have been developed for employees in the production and engineering units and training was provided. If procedures are not followed, then the execution of tasks is blocked by 42Q. For example, 42Q automatically checks whether each process has been performed correctly. In the case of a wrong procedure being launched, or a value being beyond set limits, the system shows an error and an employee has to correct the error before new activities can be performed. Once the system was adopted, the new rules of work posed difficulties for employees, as they had to adjust to them. Nevertheless, later most employees appreciated that the system guidance minimises the possibility of errors. The quality control professionals, product managers and director of the Örnsköldsvik plant are obviously pleased with capabilities of 42Q. Their assessments reveal a positive impact on the quality of products and, consequently, higher satisfaction of Sanmina's customers.

To start work with a particular machine in the production area, employees have to scan their badge, which serves as an electronic signature and verifies access to a machine. Where an employee did not

receive suitable training for operating a machine, access will be denied. The scanning of the badge also serves as a tool to monitor working hours of employees, namely when they start and end work.

## Employee monitoring and control

Adoption of 42Q has unavoidably led to monitoring of activities of individual employees in the production unit. The technology provides visibility on who has been performing a particular task, on which machine, when and how long they were executed, and what results were produced. Such functionalities allow the tracing of mistakes and understanding the reasons behind them, thereby helping to prevent future errors. Where a particular employee incorrectly performs a specific task, the management team can notice this quickly and provide assistance, training or support by another employee.

According to conducted interviews, the performance of employees in the production unit is monitored with only one purpose – high quality of products. Employees' performance in the Örnsköldsvik plant is not measured for calculation of individual productivity. Similarly, salary is not dependent on quality of work, but on the number of working hours. The latter is recorded via 42Q when an employee signs on to a machine in the production area with an electronic badge. Overall, employees do not experience discomfort from constant monitoring of their work. They consider that collected data is used for appropriate business reasons. Moreover, monitoring and automatic correction of activities by the new system help to ensure good performance at work. Employees seem to appreciate that digital technologies highlight the quality of their work. The positive experience with 42Q has increased trust in the management team and appreciation of digital technologies in general.

## Task definition and content

The job profiles in the Örnsköldsvik plant have not been affected by the introduction of 42Q, although the range of tasks has expanded. Many assembly tasks have become digitised and automated, such as tracking of processes, control and reporting. Instead, assemblers monitor the performance of machines, conduct more tests, perform repair work and assemble a greater range of products. In terms of new methods of work, assemblers had to learn how to insert data into computer programs, instead of recording it on paper. Overall, employees seem to appreciate a greater diversity of tasks and an ability to monitor and control various processes remotely.

For employees in the engineering units, the adoption of 42Q led to more analytical, quantitative, reporting and communication-related tasks. The new technology allows development and testing of different production scenarios of new products; therefore engineers are frequently requested to provide various types of product or business-related analyses to (potential) customers. Using 42Q, engineers can better visualise and present data, as well as find new working methods and opportunities to utilise the advanced technology.

The type of tasks that the management team typically conduct did not change following adoption of 42Q. Yet, the management team has intensified the amount of collaboration with customers, focusing on co-creation with customers, monitoring of technology, industry trends and business performance in the Örnsköldsvik plant. Hence, their work has a greater analytical and monitoring component.

# Impact on job quality

## Physical environment

Based on conducted interviews, employees have always felt safe working in the Örnsköldsvik plant, as Sanmina has specific protocols, rules and procedures to safeguard occupational health and safety. The Swedish Work Environment Authority (Arbetsmiljoverket) conducts regular checks of working conditions and working environment. The establishment tries to avoid all possible technical, environmental risks and adapt the workplace for a safe interaction between employees and digital machines. Among adopted measures are listed emergency plans, employee training, fire safety and recovery plans.

A greater transparency of the production process, ability to better monitor, control and prevent human and technological mistakes are additional benefits of 42Q. Installation of new computer monitors in the production area was conducted in line with safety regulations. Once the new IoT technology was adopted, all employees received training in what should be done in emergency situations and how to prevent them. The working environment has become even safer and any potential hazards (e.g. electrical hazards, technical failure) are minimised.

Based on interviews, the gradual digitisation of the Örnsköldsvik plant in the last 15 years has reduced the amount of paper-based reports, leading to lower risk of respiratory diseases.

## Social environment

Employees in the Örnsköldsvik plant are used to new digital technologies and tools, therefore the adoption of 42Q did not cause major distress or lead to conflict between employees. As discussed above, the Swedish culture operates in a community spirit if a change is considered beneficial in general. An additional important factor that stimulated a positive atmosphere at workplace was an enthusiastic local engineer who embraced technological change and helped other employees to learn and appreciate a new way of working. He was involved in introduction of 42Q during a pilot phase and was willing to provide support to other engineers.

In most cases, 42Q has increased the frequency of communication and collaboration between employees. Due to the need to exchange and discuss generated data, employees in the production unit have more direct and frequent contact with other units since adoption of 42Q. In the production unit, a greater flexibility in allocation of teams resulted in more communication between different assemblers. However, assemblers admit that introduction of electronically submitted reports also reduced the need for interaction with other assemblers and engineers.

The communication between engineers and assemblers has increased, since engineers need to obtain new insights from data and discuss whether they interpret results correctly. Similarly, the interaction between and within the engineering and management units has been enhanced, as more decisions are taken in collaboration with engineers.

## Working time and work intensity

Despite a greater diversity of tasks following adoption of 42Q, the speed of work, the number of working hours or any other working time arrangements have not been affected. In the production, automation and digitisation of some tasks time was saved for execution of new, in most cases, data-driven tasks, therefore the pace of work has not changed.

For employees in the engineering and management units, 42Q has been an extremely useful instrument that facilitated access to data, ensured better planning and control of processes across

the value chain, data management, and made their work more interesting. The latter feeling emanates from greater possibilities in data analysis, product design and business development.

The technology has facilitated many processes at work and slightly lowered the workload, thereby improving the overall wellbeing at work. Moreover, a greater ability to trace and control processes, as well as the corrective mechanisms of 42Q reduced the possibilities of mistakes and, to some extent, decreased the stress levels of employees.

## Skills and discretion

Due to the establishment's continuous upgrading of technologies and introduction of new products and services, continuous upskilling of employees is needed. All training in the Örnsköldsvik plant is provided in-house and is focused on work processes, workplace/organisational rules and tasks that an employee should conduct.

When 42Q was introduced, all employees affected by the technology received tailored training. The number and type of training provision depended on a level of knowledge that an employee should possess to perform daily tasks. Thus, training varied even at the level of the establishment's units. For example, training on Internet awareness was provided only to those assemblers who are performing specific tasks on a computer. Information about successfully completed training by an employee is recorded on internal human resource system to which an electronic badge of an employee is connected. Thus, without the required training an employee will not be able to start working on a specific machine. In cases of complex technological and analytical processes, employees need to apply for a certificate to be allowed to work with specific technologies connected to 42Q. All training related to the introduction of 42Q was organised in-house to combine theoretical and practical learning. In addition to training, learning on the job for assemblers and engineers has been facilitated by provision of detailed guidelines on how to work with the new system.

Based on conducted interviews, most employees found the new system easy to use, due to a user-friendly interface. However, a few employees in production still experience difficulties at times while operating the new system. In such cases, their colleagues assist them, or such employees receive training again. Due to automation of many production processes, human input and learning demands are relatively low. For the engineering unit, 42Q offers a broad range of learning opportunities and, depending on the curiosity of an employee, the system can offer a very deep learning curve. During interviews, some engineers from the Örnsköldsvik plant said that they are constantly discovering new features of the technology.

For the production unit, the prerequisites for working with the new system are basic computer skills, while employees from the engineering and management units have to have a moderate level of IT, quantitative and analytical skills. Prior to adoption of 42Q, most employees already possessed the necessary skills to work with the new IoT technology, due to experience with other digital technologies. The assemblers learned how to insert data into the system, instead of on paper, and to conduct various tasks using 42Q and other machines connected to it. As a result, most assemblers either acquired or improved their basic computer skills. However, a lower degree of autonomy, resulting from data-driven work processes and stricter procedures, has partially reduced discretion of employees.

## Prospects and earnings

Most employees work full-time and have a regular/long-term employment contract. The level of salaries in the Örnsköldsvik plant is comparable to companies in the same sector, which implies that the majority of staff receive an average wage according to Swedish standards.

Despite changes in the tasks of assemblers, a large part of their work is still manual. This reduces their fear of being replaced by another digital technology, although it limits their ability to learn new skills on a job that could be easily transferred to a new place of employment. Apart from improvement of basic computer skills that most assemblers acquired, other technical skills that are directly related to execution of tasks via 42Q are difficult to transfer outside Sanmina. In contrast, analytical, quantitative and IT skills, which engineers and employees in the management unit have developed will be useful in any other place of work.

The job prospects within the Örnsköldsvik plant or Samina generally have not been significantly affected by introduction of 42Q. It allowed employees in the production unit to perform more varied tasks and be more easily shifted between teams of assemblers. However, it did not build a bridge to enter jobs in the engineering or management units for which formal qualification and higher level of education is required. Engineers, in contrast, consider that adoption of 42Q may advance their professional development within the establishment, provided that they continue learning and gaining new work experience.

Following adoption of 42Q the salaries of employees have not changed, as they depend on the number of working hours and job profiles. The management of the establishment argues that the process of adjustment to 42Q has been relatively easy for employees and they benefit from acquisition of new skills. Thus, additional financial compensation is not needed.

# Lessons learnt and take-aways

- The introduction of IoT technologies, which are strongly integrated into production, work and business processes, can have a significant impact on the business model, work organisation and job quality of employees, even in establishments that have had prior experience with IoT systems.
- The adoption of digital technologies requires significant preparation and a good strategy, which outlines technical, organisational and process-related aspects. Some resistance to technological change among employees is likely to happen in any establishment; the acceptance of technologies is partly influenced by cultural norms in a country and a culture in the establishment. Thus, the management team should adjust communication approach to their employees and effective address all arising concerns.
- Employee involvement in the decision-making process of the technological change is an effective mechanism for reducing opposition to a change, as it develops trust and infuses the feeling that opinions of employees are taken into account. In Sanmina, an establishment that is characterised by hierarchical organisational structures, employee involvement through the works council and effective dialogue with the closest level of the management has been critical to ensure compliance with new procedures and tasks.
- In the Sanmina establishment, employee monitoring enabled by the IoT based technology did not result in great discomfort or cause resistance. At no stage, did employees question the legitimacy of the data collection and processing via the technology or compliance with data protection regulations. The conditions for these are the following: first, employees should have knowledge and trust that the data is collected for appropriate business purposes and that monitoring will support the work of employees; second, monitoring should not affect salaries of employees; third, employees should have direct communication with the management (at least at a plant level) to openly discuss all issues.
- Introduction of the new digital technology led to diversification and introduction of new data-driven tasks of all employees in the Örnsköldsvik plant. However, it did not result in a higher workload, as the technology facilitated or replaced more repetitive tasks.
- Existence of corrective technology mechanisms that identify or prevent human and technological errors decreases the level of stress for employees. This may compensate the restriction in their operational freedom, due to stricter work protocols.
- Digitisation and automation of tasks may lead to reduction of workforce, placing jobs of employees who perform predominantly manual tasks under threat. In case of Sanmina, acquisition of new technical skills by assemblers for performance of tasks via 42Q is unlikely to expand job prospects, as these skills are closely linked to a specific technology interface. Nevertheless, experience with any digital technology results in development of basic computer skills. In contrast to assemblers, engineers and members of the management team have improved their job and career prospects, as the IoT technology required improvement of analytical, quantitative, IT and reporting skills. Moreover, these categories of employees have higher job satisfaction following adoption of the technology, as they experience the capabilities and potential of the technology for their work and for establishment in general.
- An important factor that stimulated technology adoption was an enthusiastic local engineer who embraced technological change and helped other employees to learn and appreciate a

new way of working. The importance of psychological aspects (e.g. level of trust of employees towards the management) and support between employees should not be underestimated during technological change.

- In large corporations, the introduction of new technologies such as IoT is often introduced as a top-down innovation that serves the purpose of better management insight and new features for corporate customers. The logic of one integrated system across a vast array of production sites imposes stricter procedures across these production sites, thus limiting the operational freedom of employees in local establishments. This may be acceptable to employees if the business logic of improving quality and avoiding errors is explained well. Furthermore, trust in local management and a low-conflict culture have played a role in the acceptance of IoT in this particular case.
- IoT in a production site allows for the expansion of intellectual, data-driven tasks at different levels and the reduction of repetitive administrative tasks. At the operational level, new skills are closely linked to the production process and may not be easily transferred to other jobs. At the engineering and management level, the more abstract analytical skills are seen as a valuable skills asset.
- Digitisation of work and business processes are seen as a strong force of operational excellence by the management. Once deployed, these processes are seen as a temporary competitive advantage that in due time is turned into standard operational practice for all competing businesses. Thus, change is seen as a constant force that both management and employees will have to cope with. The history of Sanmina has shown that digitisation leads to the need for different employee skills and greater monitoring and analysis of business and work process.

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