13

Industry 4.0 and SMEs in the Northern Jutland Region

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Introduction

Being located in the Northern periphery, the economic structure of the Northern part of the Jutland Peninsula in Denmark is characterized by a relatively large proportion of firms operating in diverse industrial sectors. A minor proportion of those are high growth companies with a significant presence on international markets. Local firms operate in a diversity of industrial sectors, which are characterized by medium to high technological intensity. According to the Danish government, Danish firms cannot compete with foreign competitors based on low salaries alone because they will be undercut by international competitors who enjoy a lower cost base. In parallel, since the last financial crisis, Danish firms have struggled with the issue of low productivity, which does not justify

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the relatively high levels of salary. Because Northern Jutland, being part of Denmark, falls into the category of a knowledge-based society with a good educational infrastructure, Industry 4.0-related opportunities can provide a significant boost to the local economy if tackled in the right way and contribute to market development and international expansion. However, a variety of factors, such as relative distance to important markets and potential industrial partners, can pose a challenge.

Historical Background

The term Industry 4.0 refers to the previous steps of industrialization, which have up to now taken place. Synonyms for depicting the term Industry 4.0 are Internet of things or Industrial Internet, which are more commonly used in the English speaking world. At the end of 18th century, the process of industrialization was initialized by a proliferation of steam and hydro power mechanization that gradually replaced human powered production and traditional muscle-driven agricultural production. With coal as the main means to power mechanical production, craftsman workshop production started to be driven out by new process innovations (for example, the industrial weaving loom for textile production). Steamships and railways opened up new modes of organizing logistics over large geographical distances. Then, during the second wave of industrial processes starting at the end of the 19th century, coal based mechanization was replaced by electrification. This resulted in a push towards intensified industrialization, characterized by mass production and new forms of organization. Innovation in increased efficiency in production (pioneered by early management thinkers like Frederick Taylor), exemplified by the conveyor that Henry Ford pioneered, resulted in a profound social change, including the rise of a middle class and an increase of the general standard of living. In the after-war period, during the 1960s–70s, the third wave of industrialization set in with the introduction of semiconductors and proliferation of electronics. Computers became increasingly more ubiquitous, facilitating the transformation towards the information based society. Innovations in electronics and information technology let to new modes of industrial production, innovative materials, and the organization of global value chains.

There is an emerging consensus that we are now about to enter a new period of industrialization, thus the term Industry 4.0 has been introduced. The fourth wave is a consequent continuation of the third wave of industrialization. For increasing efficiency in increasing manufacturing operations, traditional concepts have mainly reached their limits in terms of further room for improvements. Techniques like lean production, just-in-time production, and flexible or agile manufacturing are already established and implemented in the organization of competitive firms. Yet, in comparison to the changes, which are expected to arrive in the wake of Industry 4.0, the state of the art of production technology has up to this point only reached intermediary development. Just as the three previous waves, where each wave led to fundamental changes in industry structure, the fourth wave which is now settling, has the potential to cause fundamental shifts in industry structure, yet again leading to significant increases in efficiency. Industry 4.0 is the promise of further increases in efficiency that need to tackle upcoming challenges like population growth, scarcity of resources, and overuse of the environment.

What Distinguishes Industry 4.0 from the Previous Wave?

At present, we are experiencing a period in which information technology (IT) is increasingly transferred and integrated into manufacturing technologies. Within the Industry 4.0 framework, manufacturing equipment will be enabled to act intelligently and autonomously, including the ability to transfer information between machines without human intervention. Innovative technologies like wireless sensor networks, cloud computing, or embedded systems create room for product, process, and service innovations (Wang et al. 2016). While the automation of production processes constituted the dominating paradigm in the previous stages of industrialization, with Industry 4.0 the focus is now shifting towards integration of the network into production processes by leveraging IT and network technologies. Within this new and emerging paradigm, physical systems are merging with cyber systems. Tangible systems are starting to become one with the virtual sphere. The promise is

the ability to provide more value oriented and customer-centric products and services with a higher degree of efficiency.

One of the main distinctive characteristics of Industry 4.0 production processes is the conversion from linear towards networked structures. As opposed to mere automation of stand-alone manufacturing equipment with rigid interfaces and linear chains of consecutive and static workflows, the implementation of new types of network structures has new and far-reaching consequences. The expected result is an increased capacity to flexibly react to changes in the external environment and to accommodate volatile market conditions. By establishing network interconnectivity, it is becoming possible to flexibly connect production processes across large geographical distances and many national boundaries. Three drivers for Industry 4.0 have been identified: a first driver leading to implementation of Industry 4.0 is the perspective of an improved and more efficient governance of vertical and horizontal value chains and value networks. A second driver is the expected benefits resulting from network connectivity that can be implemented into products and related services. Such innovations create opportunities for new product categories and improved customer benefit. A third driver is the opportunities for business model innovations based on Industry 4.0. Successful new business models can serve as a transmitter for new technologies and in new markets.

Related Technologies

Cloud computing: this technology involves the ability to access and process large amounts of data in real time. It also gives access to software-based functionalities on an ad-hoc basis, comparable to application programs (apps) that can be uploaded on a smart-phone when needed. This accelerates the trend towards software as a service, not a product, which is bought for a long-term use. In this way, implementation of cloud computing facilitates the exchange of data and services as needed. The next expected step in the evolutionary process is the establishment of networked connectivity between humans, machines, and other objects. This process will lead to a fusion of real world and cyberspace resulting in a new type of Internet of things. One direct result will be a very

significant rise in the amount of exchanged data, resulting in the need for increased storage capacity for data and a robust, wide, bandwidth network infrastructure to support the data traffic that will be generated.

Cyber physical systems: a system of physical entities controlled by computational elements. Hardware devices are equipped with computational intelligence that enables them to communicate and cooperate with the external environment. A multitude of such elements constitutes cyber physical systems. Smart manufacturing equipment and resulting products are enabled to act flexibly and autonomously, including the ability to anticipate events, for example, when they will be needed. To incorporate advanced functionality, smart products need to be equipped with actuators and sensors that enable them to communicate with the outside world and through the network. Cyber physical systems are becoming visible in areas such as health care, aerospace, energy, or traffic management.

Applications in the automotive sector: network technologies are becoming increasingly ubiquitous and are now used in a variety of settings. In the automotive industry we are currently experiencing a convergence of the physical world and the cyber sphere. The mobile telephone as a central hardware device is becoming more intelligent as a result of the implementation of diverse software and multiple network interfaces. Vehicle drivers can use their mobile telephones for navigation by downloading road maps on their devices. Some of the software-based maps are created by voluntary users in a collaborative networked effort (for example, Open Street Map). Through their GPS-enabled telephone devices, traffic participants can determine their own location and that of other drivers through the network cloud. These technical solutions help to find the best way to their destination. They contribute to avoiding traffic congestions and provide information about critical situations, for example, traffic incidents. The new technology enables drivers to coordinate mutually, which contributes to an improved overall traffic flow. The more drivers that participate in the network, the more attractive it becomes for outsiders to join and participate. It is thus anticipated that motor vehicles will communicate autonomously, without driver intervention. Being part of a wide-spanning network, vehicles as autonomous machines could coordinate on a mutual basis. In this way, network effects can be created (Iacobucci and Hoeffler 2016; Gaudeul and Giannetti 2013).

These technologies are currently developed by firms in the automotive sector, but the potential is also to attract players that are newcomers in this sector. Interestingly, established players in the IT industry have started to develop their own automotive solutions. Such efforts indicate that firms in the IT sector will emerge as new competitors to established vehicle manufacturing firms. Presently, we are still in the early development stages of these new technologies. Early stages of fermentation are usually characterized by trial and error in which not all innovations will survive and some proposed solutions will be discarded again (Abernathy and Utterback 1978). A large number of users enhance the value of the network and creates positive network effects. Network-based innovations are expected to be more frequent in the future, and in applications beyond the automotive sector. Through added network capabilities, objects which up to now have been of a passive nature can adopt proactive and independent properties through integration of new technologies like micro-controllers, sensors, or actuators. Currently, the automotive industry appears to be one of the industrial sectors where these scenarios are becoming reality in the mid-term future. With regards to production process and the smart factory, it is not yet clear how production processes will look like in the more distant future, but changes will eventually take place there as well. Current expectations are that networked product and related services will become entirely autonomous which will have revolutionary value-in-use in processes of production and value creation.

Smart factory: intelligent industrial networks connecting machines which are based on plug and produce technologies, low cost automation and virtualization of production. Smart factories include innovative interfaces between humans and machines. The result will be information that can be automatically exchanged between machines or machine components. Smart factories handle relevant information during the entire lifespan of a product, including after delivery to the customer. At this stage, smart products continue to transfer relevant information to the producer for quality control. Data transferred back to the producer can be valuable as useful input for developing the next product generation. For example, taxi drivers accumulate more mileage than the average user, so they will also be the first to experience quality problems which

may occur during the lifetime of the vehicle. Such information can be of significant value to the manufacturer, so that uncovered defects can be corrected and corrective measures can be taken even in the ongoing production process. Process-related information which is collected during the purchasing phase can be used and updated during the fulfilment phase.

Technological advances like artificial intelligence, robotics, or nanotechnology provide the necessary preconditions for innovations such as 3D printing or drones. These innovations, in turn, have the potential to revolutionize the production processes. They are potentially exponential technologies which initially develop rather slowly and gradually over a period of time, but at some point they may lead to dramatic improvements in performance. From an investment perspective, the potential of such technologies is difficult to estimate since it is difficult to foresee if and when they would enter into the acceleration process.

Within the organization, a system of knowledge management supports the integration of diverse sources of information through open standards. For example, a crew that sets out to repair an off-site device has access to all relevant and necessary information so that they can take the correct spare parts with them. With regards to machine-to-machine interactions, an exemplary smart factory can be composed of back-end servers for background data storage, unifying structures for connectivity of sensors and actuary networks, control devices, intermediary application for communication, and firm-wide data networks. Furthermore, there are interactions at the human-to-machine level. The user interface of the machine should enable human actors, while shielding them from the complexity of the underlying structures and operations. Humans need to be enabled to understand the smart factory operations and to control them. The interfaces could be controlled, for example, by touch-screens, voice controls, or gestures so that human operators will experience their work rather as a positive collaboration with the system. Another application where the physical and virtual realms are coming together is the virtual or augmented reality. The diversity which Industry 4.0 allows for offers an attractive setting for new developments and opens up the potential for value creation through new business model innovations.

Vertical and Horizontal Integration

Vertical integration: intensification of digitalization has the potential to change the way vertical integration is organized. Smart factories as cyber-physical production sys-tems flexibly adapt to changing conditions through rapid reconfiguration of the value chain. As a result of intensifying digitalization, manufacturing equipment will no longer be operated and controlled by human intervention. Instead of being operated by humans, intelligent and social machines interact in a flexible manner. Connectivity to other machines is created through sensors and actuators. By forming a network, they become the communication hard- and software to enable machines in a smart factory to communicate without human intervention. Smart factories can autonomously reconfigure, increasing competitiveness and serving customers more rapidly and individually with customized products. The network of mutually connected manufacturing machines controls the availability of resources and pre-empts bottlenecks. In this way, storage-related costs can be minimized. Upcoming problems, as well as wear and tear, can be detected in time, and for subsequent analysis the system provides logging functionality. Such a system will be more resource efficient and therefore more sustainable than traditional factories because material, energy, and human resource can be employed in a significantly more efficient manner.

Horizontal integration: Horizontal integration results in the expansion of the value chain in a horizontal direction. Through Industry 4.0, substantial changes can be expected to take place at the level of horizontal integration. This aspect of Industry 4.0 merits considerable consideration and attention since the future developments can be a source of new opportunities and innovative business models, but they can also present substantial strategic risks to firms. With regards to horizontal integration within the Industry 4.0 context, expectations are that an array of upcoming issues will need to be solved, for example in the legal sphere, as firms engage in new ways to compete and collaborate. Trust and governance-related issues are expected to result in new and innovative management techniques to handle future modes of organizing

the value creation process. In terms of firms' internationalization pattern and behaviour, new modes of horizontal and vertical integration can result in new forms of international exchanges with an expected change in patterns of international exchange and increased international integration.

In the prevailing literature, the term horizontal integration is associated with the pooling of different firms that at the same stage of production are under one and the same management. By pooling resources, a firm can benefit, for example, by creating economies of scale at the organizational level in market management. Increased horizontal integration creates the potential to optimize the flow of production and information.

Within Industry 4.0, horizontal integration of the value chain is expected to take new forms and shapes. As new technologies blend traditional hardware with computational intelligence into technologies like wireless networks and cloud computing, a new generation of global value chain structures is expected to emerge. The benefit will be an increased capability to serve customer requests not just with regards to the end product, but also at earlier stages of the value creation process. Affected activities will be new product development, planning, flexible adaption of production at the level of volume management and production variety, and so on (Schlaepfer et al. 2015).

Data collection and sampling: Industry 4.0 holds the promise of upcoming business opportunities and the potential to create new types of business models that innovative firms and entrepreneurial start-ups can profit from. Of similar significance are expected to be the consequences for traditional firms, which will find themselves in situations where they will be exposed to substantial opportunities but also challenges and risks. For example, with increased transparency and decreasing costs of conducting transactions, traditional producers may become exposed to the risk of commoditization, which has the potential to drive down product prices in a significant manner, putting the existence of the firm in question at risk. To mitigate these types of risk, firms need to be able to identify innovative mechanisms for mitigating the risks, for example by introducing new type of services to complement the existing product offerings.

Degree of Readiness for Industry 4.0 of SMEs in the Metal Processing Sector of Northern Jutland

In this chapter, we gauge the degree of readiness for Industry 4.0 of SMEs in the metal processing sector of Northern Jutland. By accessing a public database, we chose a random sample of firms in the selected sector. The database returned 78 companies from this sector. Out of these companies, we chose every 12th firm, to obtain a sample of six companies.[1] We also ensured that all companies are owned by investors based in Denmark. In the first sample, one company turned out to be a subsidiary of a Singapore-based company.[2] We excluded this company and instead chose the one which came immediately after on the list returned by the database. Therefore, we shall discuss six companies, which are located in Northern Jutland. The data we rely on were exclusively collected through means of desktop research. To find additional information, we visited the websites of the respective firms and other openly available sources. On their websites, all firms we investigated gave a sufficient overview of their product portfolio, which allowed us to draw conclusions about the technology involved. We also considered visiting the firms for interviews, but refrained from doing so for several reasons. Firstly, the Industry 4.0 related developments are still in the initial phase. The concept is now beginning to be intensively debated, in particular at the level of academia, different institutional actors, political decision makers, and individual firms. In some cases, potential interview partners in firms may not yet have heard about Industry 4.0, or have misunderstood the concept. In other cases – and this is a point of discussion in this study – Industry 4.0 may not be relevant in the immediate future.

[1] We searched in the category with the Code 280000, which represents those companies that manufacture machines and related equipment. We also limited our search to the area of Northern Jutland; thus we only discuss firms from this region (in Danish: Fremstilling af maskiner og udstyr i.a.n).

[2] The Singapore-controlled subsidiary Den-Jet Nordic A/S was replaced by Reo-Pack A/S.

Case Studies

Case 1: Fransgard Maskinfabrik A/S

General characteristics: Fransgard Maskinfabrik A/S is a machine-building company located in the rural Western part of Northern Jutland. The company produces a range of forest machines for towing, mowing, and transporting harvested tree logs. The company also produces harvesting equipment which can be used as an add-on for mounting on tractors. Additionally, the company produces machinery for road building and maintenance equipment, for example, levellers, spreaders, or snow blowers and machines for removing snow. All products are mounted on tractors and powered by electric motors or by hydraulic technology with electricity supplied from the carrying tractor. Enhancing the functionalities of tractors, the product range is of a reliable, rugged, and durable quality. IT intelligence is not implemented, as all items basically serve as add-ons, which are mechanically mounted on tractors. The company employs 40 people, and has in the last five years shown a solid and stable income situation and a positive balance sheet.

Internationalization: Fransgard Maskinfabrik A/S has no foreign subsidiaries, but about 90 % of production is exported to a large variety of foreign markets (Table 13.1).

Vertical integration: as material input, Fransgard Maskinfabrik A/S sources standard input such as pre-processed steel, electrical and hydraulic components, as well as supplementary input. In the future, suppliers may change their modes of operation, which could also affect the way in which the company sources input to the production processes. Products are processed by manually operated production equipment, and apart from these there is little automation in the production process. The production floor is mostly operated manually, apart from IT office equipment.

Table 13.1 Fransgard Maskinfabrik A/S

Number of employees	Gross income (in mln euro)	Equity (in mln euro)	Balance (in mln euro)
40	2.5	2	5

Source: Based on data from NNErhverv (2015)

Finished products are then shipped to intermediary dealers which are, as we mentioned, mostly located abroad. In terms of vertical integration, we see little immediate scope for implementing cyber physical production processes, either at the level of the upstream supply chain or in manufacturing processes, as the company's products apparently have no or few IT-related components. With regards to the downstream supply chain, international distribution may be affected by general changes in the way international distribution is organized.

Horizontal integration: Fransgard Maskinfabrik A/S produces rugged and solid dedicated equipment sold to customers in the primary sector in agriculture and forestry through a network of internationally and geographically distributed dealers who act as intermediaries. The company is embedded in the agricultural and rural area of Western Denmark and rooted in the local community. The company could expand horizontally through collaboration with external partners who have the same position in the global value chain as it has, or by mergers and acquisition. It is doubtful if there would be any immediate apparent strategical logic in expanding horizontally. With quite a diverse product range, the company's internal processes are not highly automated. It is therefore unlikely that economies of scale or scope could be achieved. Since IT is mostly absent, there is apparently little potential for the inclusion of digital technologies into physical components.

Major findings: due to the nature of the value chain where Fransgard Maskinfabrik A/S is active, both from the vertical and horizontal perspective, the prospect for the implementation of Industry 4.0-related practices is limited in the short- and medium-term future. Depending on future initiatives of suppliers and subsequent changes in business practices towards the upstream direction of the global value chain, the company may have to adapt its modes of operation. Looking at the downstream direction of the value chain, for the time being customers will probably keep their conservative stance, so changes can only be expected in the long-term future. With geographically widely dispersed end customers in the primary sector (agriculture and forestry), market change can be expected to be slow. In the short- and mid-term Fransgard Maskinfabrik A/S will probably not need to adapt to Industry 4.0-related changes, which limits future potential in this direction. On the positive side, the

company does not seem to be exposed to significant risks brought about by Industry 4.0, since it has a solid position in its market niche. The extensive export activities and the nature of intermediaries as well as end customers also contribute to solidifying the position of the company.

Case 2: Teksam ApS

General characteristics: Teksam Aps specializes in dry-cast concrete machinery production. The company is located near a deep water seaport in the relatively remote North-Western part of Denmark. Specializing in processing technology for dry concrete, the company is a supplier to the construction industry and specializes in producing machinery for complicated concrete shapes and forms. As its main competence, the company produces machinery that can accommodate the customer's need for highly modularized elements. Opposed to the wet-cast concrete variety, which comes in liquid form before drying out, dry-cast concrete is used in applications where buildings and structures need to be formed in more complex shapes and forms. Dry-cast concrete is used when there should be a flow around objects, for instance when there is a need for reinforcement. At the company's technological core is the technology, which implements unidirectional vibrations in the machinery products. In particular, dry-cast concrete is used in applications where it is necessary to create a range of identical pieces with one and the same form. One of the advantageous properties of dry-cast concrete is the ability to create specific shapes for dedicated applications in the construction sector. As one example, dry-cast concrete is used to build solid road barriers, which are sometimes used to redirect traffic or to separate driving lines. There are many possible applications for this technology. It is possible to produce concrete benches or channelling elements than can be used to conduct water as outflows flow parallel to roads or highways. With 20 employees, the company has a differentiated product line consisting of steel material, hydraulic technology, and electronics which are operated through manual controls. In the last five years, the company has demonstrated a positive performance although the income situation has been declining. Although equity could be preserved, the declining balance sheet indicates a reduction of external debt.

Table 13.2 Teksam ApS

Number of employees	Gross income (in mln euro)	Equity (in mln euro)	Balance (in mln euro)
20	0.35	0.4	1.1

Source: Based on data from NNErhverv (2015)

Internationalization: Teksam Aps has built up a network of agents and collaboration partners in diverse geographical locations like the USA, Canada, Mexico, and India, and including various partners in European countries. The company also attends international trade shows (Table 13.2).

Vertical integration: essentially, Teksam ApS is (similar to Fransgard Maskinfabrik A/S) a metal processing engineering company. In the upstream value chain direction, the company is sourcing processed input material in the form of steel and other products needed to construct vibration-based dry-cast concrete machines: electrical motors, hydraulic components, etc. With a relatively small base of employees, the company constructs a line of quite complex products. On the shop floor, work is conducted manually without much automation, which is typical of SMEs in this size range. The company has been successful in building up mid-level technological competences in vibration technology for dry-cast concrete which gives competitive advantages and potential for value creation. From the upstream value chain position, where standard input is sourced, Industry 4.0-related initiatives will most likely come from the supplier side. For Industry 4.0-related development prospects, the most interesting opportunities may be identified in the downstream direction of the value chain. The company's products are serving the construction industry and can be employed for building infrastructure projects.

Horizontal integration: Teksam ApS is serving the construction and public infrastructure sectors where large-scale projects are frequent. As Industry 4.0 gains track, there might be a need for new type of buildings and public infrastructure where individual custom design is required. The company is able to produce specialized modularized components which may be very specific to the individual case. Today, construction projects are handled in standardized ways, for example, there could be a larger lead constructor

who is working with a number of sub-suppliers. In other cases, smaller suppliers can collaborate on a larger project. Because of its specialization and special competence it has built up, the company could participate in such types of Industry 4.0-related construction projects where there is a need for firms who are able to deliver specific and modularized input.

Major findings: it is reasonable to assume that the construction and infrastructure sector may become affected by Industry 4.0. For suppliers of input who contribute in the building processes, there may be attractive new opportunities as a result of changing modes of collaboration between firms that contribute to input. These opportunities came as a result of changes in the vertical and horizontal structures of the global value chain. In the future, Industry 4.0 will most likely make an impact on the construction industry. For example, architects can use software programs for architectural design and organization, which can send calls for bids to potential suppliers. If Teksam ApS develops the ability to implement corresponding digital interfaces to receive bids, the company could profit substantially from upcoming Industry 4.0-related opportunities. To be able to profit from such opportunities, the company needs to be able to adapt to future changes and requirements. In particular, the company needs to upgrade its product line to provide IT interconnectivity where it has not, at this point, built up the relevant competences. For a smaller company like Teksam ApS, this can be a substantial challenge due to ingrained traditions but also due to availability of relevant competences in the local labour market.

Teksam ApS is located in a remote area with a seaport where the competences of the local population may not be in line with the company's future requirements in terms of employees' qualifications. If the company were located in the Danish capital of Copenhagen, where there is a larger workforce with relevant competences, these types of challenges might be easier to overcome.

Case 3: Reo-Pack A/S

General characteristics: Reo-Pack A/S is a company specializing in packaging technologies for large-scale merchandise. Reo-Pack A/S produces

Table 13.3 Reo-Pack A/S

Number of employees	Gross income (in mln euro)	Equity (in mln euro)	Balance (in mln euro)
55	0.35	0.8	4

Source: Based on data from NNErhverv (2015)

equipment for automated pallet wrapping, handling, and labelling. Being located 50 km south of the regional capital of Aalborg in the rural Western part of Northern Jutland, the company has 55 employees. In terms of product lines, the company has special competences in wrapping pallets which are used for handling larger and heavier quantities of merchandise. There is also machinery for handling and wrapping pallets and products like large paper rolls. Another machine in the product line wraps waste paper in large chunks. Wrapping takes place with plastic foil, which is wrapped around the product with a palette underneath for stability and ease of transportation, for example, by fork lifting equipment.

Internationalisation: with subsidiaries in Germany and Great Britain, Reo-Pack A/S has exported to more than 25 countries (Table 13.3).

Vertical integration: as a mechanical engineering company, Reo-Pack A/S sources pre-processed metal components, hydraulic technology, and electronics including electrical motors. From the upstream perspective – just as is the case in the companies we discussed above – Industry 4.0-related initiatives can be initiated by suppliers or by the company itself. The range of suppliers is diverse and the company is sourcing internationally. Given the industrial sector where the company is active, specific opportunities may come up. Due to new individualized products and services, individualized packaging solutions will be needed (Jazdi 2014). Industry 4.0 will lead to new systems in distribution and procurement, where flexibility becomes important to serve individualized customer needs. As a small and flexible company, it will be able to draw substantial benefits if it is able to adjust internal processes so that customers can be served individually. This means that Reo-Pack A/S needs to build up competences to produce adaptable packaging machines with interfaces that support individualized product configurations along the stages within the value chain. Large industrial firms are most likely to start new initiatives in this direction and given that these can be developed, sufficient negotiating power will follow suit. On the factory floor

the company is not deviating from the practice of relying on automated machines and manual handling of the shop floor, just as is in the case of the other firms discussed in this chapter.

Horizontal integration: For Reo-Pack A/S substantial opportunities can evolve through Industry 4.0. As a relatively small player, the company can collaborate with other players who compete at the same horizontal stage of the value chain. As existing manufacturing systems are becoming increasingly decentralized, the result will be an increased decomposition of classical production hierarchies leading to decentralized self-organizations (Lasi et al. 2014). In this scenario, there will be greater demand for flexible solutions to handle and package diverse products and related services. Reo-Pack A/S could become an interesting collaborator with similar companies in the packaging engineering sector. In this way, potential customers could profit from distributed and diversified offerings, which could be flexibly adapted to changing market requirements.

Major findings: Industry 4.0 holds the potential for new options by integrating a variety of application systems. For this to become possible, partners in cyber-physical networks need to continuously act upon real-time information in market environments that are changing rapidly. In cyber physical systems, the flows of tangible goods are a mirror transfer of digitalized information across data networks. In general terms, this increases the need to make the logistics more versatile in order to handle physical products, so that tangible products can be handled in efficient and flexible processes. Specializing in packaging technologies, Reo-Pack A/S can profit from upcoming opportunities if it si able to link its own system (production and end products) into the information flow. For example, the company's packaging systems would wrap a range of flexibly manufactured items according to specified sellers' instructions. One item in a production line would, for example, be stored in a local warehouse, while the next one would be sent overseas by ship freight. According to the destination of the products, there will be varying requirements and different packaging techniques and related input materials. Therefore, Reo-Pack A/S will need to build up competences for equipping its packaging machines with computational intelligence so that it can respond to individual customer requirements. It will be critical for the company to find qualified personnel with competences in IT in order to be able to profit from the new opportunities.

Case 4: Dansk Varmepumpe Industri A/S

General characteristics: through a dense network of dealers in Denmark and Norway, Dansk Varmepumpe Industri A/S offers terrestrial heat solution for end customers. To serve their market segment, the company offers a range of geo-thermal heat pumps and related equipment. The company also develops and commercializes technologies to combine geo-thermal with solar energy. Dansk Varmepumpe Industri A/S has competences in offering complex solutions to satisfy individualized and specific customer needs. Customers are in the business to business (B2B) as well as in the business to consumer (B2C) market segments. Through a network of dealers, the companyreaches out to end customers to deliver turn-key solutions through its dealer network.

Internationalization: Dansk Varmepumpe Industri A/S relies on its extensive dealer network in Denmark. In terms of international presence, the company has a less dense (compared to Denmark) network of dealers in neighbouring Norway (Table 13.4).

Vertical integration: being embedded in the supply chain, Dansk Varmepumpe Industri A/S can profit from flexible sourcing of inputs. If a sufficient degree of modularization and automation can be achieved, the company will be able to serve individual customer requests. The company needs to focus on sustainability and resource efficiency in the design of its own manufacturing process, as well as on the implementation of customer-centred products and services. In the future, market demand can be expected to be more individualized and fragmented (Lasi et al. 2014). To satisfy expected demand, the company strives for increased modularization with clearly defined interfaces to improve its own product lines. The company could benefit from a higher degree of modularization in two ways. Firstly, on the shop floor modularization would facilitate flexible and, if possible, automated production. Production of specific modules could be sourced from third parties. Secondly, the implementation of a

Table 13.4 Dansk Varmepumpe Industri A/S

Number of employees	Gross income (in mln euro)	Equity (in mln euro)	Balance (in mln euro)
31	0.69	2.5	3.6

Source: Based on data from NNErhverv (2015)

modular system would help to satisfy specific customer requests in terms of functionality and scope of the products and services.

Horizontal integration: if successfully managed, Dansk Varmepumpe Industri A/S could profit from opportunities stemming from the emergence of cyber-physical systems. In the energy sector, such developments are already clearly visible. For example, the spot price of energy (for example, in the form of electricity) is determined by future expected developments in the energy market. Such developments can be weather or predicted availability of energy sources. For example, the company could develop technologies, which enable installations to anticipate market expectations autonomously and adapt energy management correspondingly. Through modular technology, there will be opportunities to cooperate with horizontal partners in building up cyber-physical systems. In this way, smaller companies can link up to compete against larger competitors in the industry.

Major findings: the green energy sector, in which Denmark is among the technology leaders, offers attractive prospects. In the long run, the need for resource efficiency will increasingly return to the political agenda and potentially lead to new policy initiatives pushing for new technologies with a potential to develop new type of products and services. The need to find flexible solutions for energy consumers who have different requirements offers potential for successful future business development. Dansk Varmepumpe Industri A/S, in developing and selling solutions for the application of terrestrial heat for heating buildings, can create opportunities through developing collaborative solutions with other firms who offer similar or complementary green technologies. These could be firms in the solar energy sector or trading companies that specialize in trading spot and future contracts for electricity supply. Such types of collaboration can lead to new cyber-physical systems where hardware functionality merges with computational intelligence, thus offering substantial future potential for a small company like Dansk Varmepumpe Industri A/S.

Case 5: Jydsk Løfte- og Maskinteknik ApS

General characteristics: specializing in the manufacture of lifting and handling equipment, Jydsk Løfte- og Maskinteknik ApS is located in the industrial area of the town of Hobro, close to the highway that links

Aarhus to the Northern Jutland regional capital of Aalborg. The company produces hand tools for more comfortable lifting and handling for simple muscle power driven applications that can be useful in logistic distribution centres where a multitude of packets need to be handled in a comfortable way by operating personnel. Apart from such relatively simple tools, the company has built up special competences for vacuum driven lifting technology for lifting materials like steel-sheets or glass panels. Based on its specific competences, the company offers solutions to equip commercial buildings and warehouses with crane installations for lifting and handling diverse merchandise. With these technologies, even heavy items, which could not be lifted by human power, can be handled in an easy and swift way by one single person. The lifting equipment can be highly customized to a specific client's needs. For example, repetitive tasks like moving heavy panels around on the factory floor can be solved by the robots the company produces. These robots can be deployed in scenarios where humans should not work because of security or health-related considerations. In addition to its product offerings, the company offers an after-sales service to maintain the installations during their life cycle (Table 13.5).

Vertical integration: similar to the above discussed cases, Jydsk Løfte- og Maskinteknik ApS sources pre-processed metal products, as well as a range of other input components like electrical equipment and other special material. As a result of Industry 4.0, there will be increasing requirements for new modes of organizing new systems in distribution and logistics. This offers new opportunities for business development, but being a small company with limited experience in IT technologies and implementing computational intelligence, the company will be challenged to update its capabilities. If it can manage the upgrading efforts and successfully move into becoming an integrated player in new cyber-physical systems, the company has the opportunity to occupy attractive market niches.

Table 13.5 Jydsk Løfte- og Maskinteknik ApS

Number of employees	Gross income (in mln euro)	Equity (in mln euro)	Balance (in mln euro)
35	1.8	0.68	1.42

Source: Based on data from NNErhverv (2015)

Horizontal integration: Jydsk Løfte- og Maskinteknik ApS is mainly integrated to the upstream and downstream side of the supply chain. With it product specialization, the company needs to find methods of cooperating with other firms at the same horizontal level of the supply chain to complement its own capabilities. With increasing integration of product intelligence into existing physical products, the company could move into production of modular components that could be interconnected with the products of other firms at the horizontal level to offer specific and individualized solutions to customers on the downstream side of the value chain.

Major findings: although Jydsk Løfte- og Maskinteknik ApS does not have exclusive competences, being an SME with a high degree of flexibility and a focus on services, the company has the potential to successfully compete within Industry 4.0 scenarios. The company is exposed to competition from large internationally-oriented specialists in robotics for handling merchandise where it will not be able to compete in all application scenarios. Therefore, the company needs to find and occupy a market and operational niche in a decentralised scenario where it can successfully operate and be shielded from larger competitors. Due to its small size and flexibility, this firm has the ability to develop solutions for specific customer needs. As is the case with other firms in this sample, there is a need to develop addition competences in IT. As computational intelligence will be merging with physical systems, the company risks being left behind if it is not able to upgrade its competences to integrate computational intelligence into the existing systems to link into upcoming networks based on cyber physical technologies.

Case 6: Nordmark Maskinfabrik A/S

General characteristics: Nordmark Maskinfabrik A/S takes a position as a sub-supplier to the heavy machinery construction sector, for instance the windmill industry. The core competence of the company is in CNC (Computerized Numerical Control) processing of heavy items of up to 80 tons. The company has the capabilities for effective mass production, but can also process highly specific and customized single orders.

Table 13.6 Nordmark Maskinfabrik A/S

Number of employees	Gross income (in mln euro)	Equity (in mln euro)	Balance (in mln euro)
70	5.7	4.9	12

Source: Based on data from NNErhverv (2015)

The company has specialised in 3D (three dimensional) form processing and accumulated competences in precise production of complicated prototypes. The company acts as a consultant in the areas of design, development, and construction of complex technologies in machinery technology. The company operates out of three main production sites, two in Northern Jutland and a third – in Mid-Jutland south of Aarhus. Moreover, there are more than 20 CNC treatment centres the company can draw on, which enables it to deliver to the entire European market. It also offers services in quality management as well as storage. The company is continuously investing in new technologies and additional production capacities (Table 13.6).

Internationalization: Nordmark Maskinfabrik A/S exports to European markets.

Vertical integration: in the vertical value chain, Nordmark Maskinfabrik A/S currently takes a position between machine construction companies from which it purchases production equipment and is a supplier to producers of heavy industrial equipment. In this position, it acts as an intermediary, creating links by producing intermediary products. To bridge the link between the upstream and down-stream supply chain, the company also acts as a designer for prototypes and provides a variety of consulting services. The company acts as a facilitator by offering warehousing services. In this position, the company has a double function as a producer of intermediary industrial input, and perhaps more importantly, as a conduit for technical and process knowledge within the supply chain.

CNC provides tool marking machines which can produce metal workpieces with very high precision. CNC machines are controlled by means of CAD (computer aided design) programs. With CNC and CAD, Nordmark Maskinfabrik A/S already has a technology in place which has the potential to be integrated into more wide-spanning Industry 4.0 applications.

Horizontal integration: CNC and CAD technologies can facilitate global value chain integration at the vertical level. Likewise, these

technologies offer the potential for horizontal integration, which has not been fully exploited. As a strategic facilitator, Nordmark Maskinfabrik A/S is currently linked to the upstream and downstream of the supply chain, with little horizontal connections. As Industry 4.0 starts to gain ground, there is a potential for increased expansion of the supply chain in the horizontal direction. With expected individualization of demand and increasing negotiating power of buyers, it could become an interesting proposition for the company to work with firms who have complementary product offerings. The requirements for increasing individualization from the buyer side can make it attractive and necessary to collaborate with other specialists at the same horizontal level in order to complement the individual competences of each firm with the aim to better serve customer requirements.

Major findings: among this sample, Nordmark Maskinfabrik A/S is perhaps the company that shows the most interesting potential for Industry 4.0 development. Acting as a producer of intermediary industrial input that complements its offering with other knowledge intensive services, like consulting, where a high degree of technological and logistical proficiency is required, the company may eventually shift to a position of provider of specific knowledge and play out its competences in its field. As both producers of mechanical engineering production machines and assemblers of heavy industry move into Industry 4.0, the company has the potential to act as a channel for transmission and coordination of the upstream and downstream side of the value chain. As conditions become more complex as a result of technological changes and increasingly specific end customer demands, the company could create new horizontal links to enhance the performance and functionalities of its intermediary production as well as develop and enhance knowledge intensive services.

Conclusions

We find that Industry 4.0 offers opportunities to all investigated companies, although to varying degrees. These companies have a solid technology, which is proven and accepted in their respective markets. The degree of technological intensity differs between the companies: with products that are mechanically mounted on tractors Fransgard Maskinfabrik A/S

has not implemented digital interfaces in its products and there is apparently no immediate reason why it should start doing so. Therefore, in the sample Fransgard Maskinfabrik A/S is probably still the most distant from Industry 4.0. As a machinery supplier to the construction industry, Teksam ApS has potential for Industry 4.0-related developments. Teksam ApS technology helps customers in the construction industry to create and shape specific shapes and forms, offering interesting market development potential if Teksam ApS is able to initiate the necessary technological trajectory. These two firms source input material from suppliers of pre-processed input materials such as steel sheets. They also source manufactured components such as electrical motors and hydraulic equipment. Here Industry 4.0 potential may be limited, at least in the midterm, unless the suppliers change their practices and start implementing new innovative technologies, which may force the firms in our sample to react and likewise update their supply chain in line with the Industry 4.0 framework.

Specialising on the market for logistics solution, Jydsk Løfte- og Maskinteknik ApS and Reo-Pack A/S have both in their own way promising potential, since Industry 4.0 demands technology with flexibility in packaging and handling. These two companies offer technologies which are technically solid but do not live up to future requirements in terms of IT integration. In this sense Nordmark Maskinfabrik A/S is already much ahead on the learning curve since this company is in possession of and able to handle diverse IT technologies. Dansk Varmepumpe Industri A/S also has interesting potential since it is well positioned to link into upcoming networks of green energy supply.

All of these companies have, albeit to a varying degree, potential for the adoption of Industry 4.0 oriented development. However, we also identify significant hurdles the companies need to overcome if they want to be successful players in future Industry 4.0 developments. With the exception of Nordmark Maskinfabrik A/S and Dansk Varmepumpe Industri A/S, who are already mastering digital technologies, all other firms have no or little relevant IT capabilities. This can turn out to be a problem for the future, as technologies increasingly move into Industry 4.0 applications. To achieve integration of physical hardware and computational intelligence, the companies need to learn how to implement

the necessary hard- and software interfaces so that they can link up into cyber-physical systems. In this area, the main challenge will be the identification of sufficiently qualified personnel with IT competences. None of these companies has the required technological competences, and we can expect that it will be difficult to fill this gap. To conclude, we identified a number of challenges the companies need to overcome:

- Add computational intelligence to existing operations and products.
- Streamline the vertical value chain, in particular operations on the shop floor.
- Collaborate with new partners at the horizontal level to complement their offerings which could be necessary to satisfy future individualized customer demand.

Industry 4.0 can create substantial changes in negotiating power between the implied parties, and these issue has yet to be explored. A firm with sufficient negotiating power may, through implementation of Industry 4.0, improve its negotiating power. Industry 4.0 will lead to open standards and increased transparency. Openness can bring third party competitors into the frame when standards and operational interfaces become increasingly transparent.

For all companies, the question is if and when to initiate Industry 4.0 development. The companies could start implementing Industry 4.0 independently of the suppliers. This would most likely happen through changes in the downstream value chain. Such changes could be triggered by substantial changes in the industries in which the companies in this sample are active. Naturally, the question is when and in how this will occur. As we discussed in the introductory part of this chapter, new cyber-physical production systems will lead to new ways of serving customers not only through adapting and individualizing components, but also in the product development stage, the planning stage of production, as well as the production processes themselves. Such changes would naturally have a significant impact on the way the companies in this sample organize their internal value chain. Moreover, Industry 4.0 changes have the potential for new business model innovations. New opportunities for organizing the value creation process

can attract new entrants with innovative ways of organizing their operations, which might then threaten incumbent industry players.

As we saw, all companies are niche players in their respective markets and are currently showing satisfactory success and stability. With one exception where internationalization is limited, they show a substantial international presence, which can provide additional stability. All firms enjoy satisfactory performance but it also becomes clear that their resource base is relatively limited. If the companies are not capable of financing the necessary upgrade of operations to accommodate Industry 4.0, they may be left behind and other competitors will take advantage of upcoming opportunities.

A second significant problem is the availability of qualified personnel. If the firms in our sample engage in Industry 4.0, they need to significantly upgrade the competences of their staff, in particular with regards to IT. As firms start to engage more in Industry 4.0, the scarcity of IT competences may become more accentuated in future. Demographic changes and international competition might make it more difficult to find personnel with the required competences. As a high taxation country and with a language that is relatively difficult to learn for many foreigners, finding a qualified workforce in the international markets may be an uphill battle for Danish SMEs, in particular if they are located away from urban centres, which are currently seen as attractive places to live. Political decision-makers should therefore put Industry 4.0 on their agenda now for designing the right steps to secure future development.

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