How can companies start implementing the Smart Industry concept?

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1. Introduction

It has been proposed that the recent economic crisis marks the time period before the adjustment of economic systems, organizations, and industries to a new techno-economic paradigm (TEP) (Perez, 2010). Currently this TEP seems to be driven by a new industrial revolution based on the emergence of the Internet of Things (IoT) (Rifkin, 2014). As the World Economic Forum (WEF) report puts it, "Inventions of the last decade, such as social networks and the sharing economy, have had less effect on increased productivity and sharing knowledge between companies than the Internet revolution" (p.15).

Integration of the manufacturing process via the Internet of Things (IoT) is considered by many to be Industry 4.0. Within the Netherlands, the Smart Industry concept is defined as "smart use of ICT to interconnect machines for smart operation" (Huizinga et al., 2015). The Netherlands has a good Information Communication Technologies (ICTs) infrastructure. However, the result of a Smart Industry survey showed that 86 percent of entrepreneurs in the Netherlands are still relatively uninformed about the Smart Industry concept and its implications for their business (Action Agenda Smart Industry, 2014).

The underlying definitions, elements, and consequences of Industry 4.0 are still not clear (Brettel, Friederichsen, Keller, & Rosenberg, 2014; Hartmann & Halecker, 2015). There is no commonly agreed-upon definition of the Smart Industry concept. Moreover, this concept contains several different elements, including technological concepts such as Cyber Physical Systems (PCS), Big Data, and Cloud Computing which are difficult to define based on the literature. The current work culture (e.g. the fear of losing a job because of the application of new technology or the fear of sharing knowledge), supply chain collaboration, financial issues, lack of skilled staff, and outdated business models are obstacles for the Smart Industry mentioned in previous studies (FME, 2015; Huizinga et al., 2015; KvK, 2015). In particular, non-technology sectors (such as agriculture and construction) and very small companies are less inclined to utilize opportunities emerging from the Smart Industry concept (KvK, 2015).

Technology is not the only pillar of the Smart Industry concept. As Lee, Bagheri and Kao (2014) argue, "Implementation of the Industry 4.0 is not only about connectivity between machines and using sensors, but the presence of correct information at the right time for the right purpose is a necessity" (p.3). Information is the value driver that leads to new business models in the (traditional) industry (Sol, 2015).

Organizational change is required in order to capture the potential of Information Technologies (IT) in companies (Brettel et al., 2014; Tippins & Sohi, 2003). Schuh, Potente, Varandani, Hausberg, and Fränken (2014) argue that collaboration is an organizational driver that fosters the Smart Industry. They propose a framework for collaborative practices with three dimensions: coordination, cooperation and communication.

Kagermann (2015) claims that employees will perform new tasks such as systems planning and coordination rather than simple tasks in smart factories. Thus, the Smart Industry concept reduces the half-life of the academic skills of staff. Actually, increasing the use of self-controlling systems that communicate via the Internet and/or humans may lead to unforeseen problems. Thus, the workers need to coordinate to solve new kinds of problems arising from the Smart Industry concept (Brettel et al., 2014). The companies should involve employees in the decision-making procedure (Kagermann, 2015). This will lead to an increase in the productivity of companies (Black & Lynch, 2001).

Michaels, Natraj, and Van Reenen (2014) investigated eleven OECD countries (including the Netherlands) from 1980 to 2004 and found empirical evidence for skill shortages in many regions. According to Holtgrewe (2014), "Apart from the technical skills, ICT workers increasingly need nontechnical skills and competencies such as English, project management and organizational skills, team working and communication skills, and both creativity and systematic ways of working" (p.16). Burmeister, Luettgens, and Piller (2015) claim that "a good way to go beyond technological capabilities and focus on the customer or user perspective is to participate in relevant conferences or working groups and connect both within and outside the industry to broaden the view" (p.34).

This current research was undertaken by University of Technology Eindhoven in collaboration with High Tech NL and the Smart Industry Program Office. It investigated the current stage of development of smart solutions in the Dutch industry by conducting nine case studies and an internet-based survey. The aim was to answer the following questions:

1) Why is the Smart Industry concept vital for innovation of Dutch companies?
2) How can companies start implementing the Smart Industry concept?

2. Case studies

In the second step of the research, nine case studies were conducted. Table 1 summarizes the data regarding the sector and size of the companies involved in the case study.

Case	Core Business	Size	Sector	Age of Company
Company A	Agriculture machinery	140	Manufacturing	20
Company B	Processing machines	45	Manufacturing	70
Company C	Automation & robotics	6	Consultancy, research and other specialized business services	15
Company D	Software and services	10-19	Consultancy/ICT/Manufacturing	7
Company E	IT and document management	1300	Information and communication	20
Company F	Machines for automation	3500	Manufacturing	70
Organization G	IT and statistics	1800	Public sector	112
Organization H	Social service	350	Public	> 100
Company I	Business app	13	Information and communication	5

Table 1-Case study companies' information

The age of the Smart Industry initiative is different among the companies. While company A and H have been using the Smart Industry concept since around 2010, company B and F were using the concept long before that. Company D was founded based on the Smart Industry concept. Company C, D, E, F and I offer services for customers and help them to implement the Smart Industry concept.

The case studies show that the Smart Industry has many facets. Each company has its specific way of implementing the concept and using it for more innovation activities. The Smart Industry solutions are tailor made because every company is different. One company lacks skilled employees, while another one lacks an Enterprise Resource Planning (ERP) system. Companies using the Smart Industry concept are looking within their organization to find the most serious knowledge gap.

There has been a revolution in data science (the so-called Big Data). In the past, each set of data was used for only specific purposes. However, nowadays relationships between different data sets have become closer and more complex. Thus, an individual data set can be used for multiple purposes. This is why smart companies such as organization G try to create an information pull.

2.1. Smart technologies

Human-human, human-machine and machine-machine communications are three important contributions of ICT to the Smart Industry. There is no single technology within the Smart Industry concept, but instead there is a convergence of ICTs, IoT and advanced manufacturing technologies. Based on the Smart Industry report, Huizinga et al. (2015) have stated that:

> Machine to machine (M2M) communication is revolutionized by new ICTs. Sensor technology, embedded systems, cloud technology, advances in RFID and GPS constitute the Internet of

> Things, an Internet-style network of interconnected, intelligent machines termed CPS. Secure and robust network, which are powered by more intuitive forms of human-machine interaction, is another contribution of ICT. Finally, ICT enables the practical application of manufacturing techniques such as 3D printing to a large extent (p.21-22).

The case study companies do not yet have all the technology domains of the Smart Industry concept. For example, a non-manufacturing organization such as G does not need to use 3D printing at the moment. Each of the organizations has started implementing the Smart Industry concept using different technologies. For example, company A started by using ERP software for better control of its production process. However, it continuously invests in new technologies such as automated guided vehicles (AGV) as the next step in implementing the Smart Industry concept to keep up with the fast pace of technological change and new demands in the market. Another example is company D. So far its staff has worked with email, phone and documents. They have had no way to accumulate data. Currently, they are considering implementing sensors in everything to generate data. As a consequence, creating and analyzing data and cloud computing will be more important for company D than they were in the past.

2.2. Human capital

The smart companies, such as company A, have innovative employees who take initiative for the Smart Industry solutions. They know the ambition and target of their company for the future. They know that the new technologies – such as robotics – do not replace workers, but help them perform their tasks. Company B, which has been using robotics in the manufacturing process for 30 years, is a very good example in support of this claim. As my interviewee from company C stated, “Currently the most important challenge for the customers in adoption of the Smart Industry concept is to acquire the right knowledge and employees who can deal with this new knowledge”. Furthermore, my interviewee from company “I” argued, “if the companies have sufficient knowledge of what the Smart Industry concept can bring to their companies, they are more likely to implement it”.

The case studies confirmed that investment in IT is not sufficient to implement the Smart Industry concept. Organization G, for example, has changed its approach to investment in IT. Nowadays, the employees in organization G are asked to increase their productivity by improving the processes and they are assured that necessary IT solutions will be provided based upon request.

As my interviewee from company E put it, “in the past, managers used to make almost all the decisions. Now, the employees have a bigger share in defining the whole strategy of their company”. Another example is company D, which takes advantage of the agility and flexibility of young engineers to offer

the best services to its customers. The young engineers do not know how much is possible, but they sometimes end up with findings that actually are possible to implement. My interviewee from company I believes that “the age of employees, per se, is not an explanatory factor in using the Smart Industry. However, the younger generations, who have studied IT, expect a lot from the technology”.

Employees need to learn both technical and non-technical skills. Organizing weekly brainstorming sessions encourages a multi-disciplinary working culture in the organization and improves the non-technical skills of employees. The example of company F supports this claim. The company believes that its engineers need to improve their communication skills and learn to think across sectors and across disciplines.

Involving all groups of employees may seem easy in small companies, but this is a challenging issue in large organizations. Organization G is very actively pursuing this goal. The idea is that staff should have a broader perspective of their job. The company makes the steps and targets as small and easy as possible. For example, it encourages staff to collaborate with other parties through participation in activities that are organized by a networking organization, which has members from industry, university and governmental organizations.

Another important finding is that the vocational training is not only for workers; managers may also need to update their skills, especially soft skills such as communication. Company A is very good example of this, as its managing director decided to follow an academic education to upgrade his knowledge.

2.3. Challenges

Each company is confronted with special challenges as it implements the Smart Industry concept. According to my interviewees, access to financing and lack of sufficient knowledge about the Smart Industry solutions are common among small companies. Meanwhile, the complexity of organizations, traditional way of working, and quick technology changes are perceived to be the serious barriers for the large companies. Other obstacles, such as parties’ lack of interest in collaboration, are common among all companies. For example, organization H collaborates with other municipalities to implement the information platform. Multidisciplinary employees from each party have met in order to share knowledge between organizations. They were successful to some extent in sharing information based on their relationship and trust. However, it appeared to be very difficult in practice, especially when the organizations wanted to share information in a formal way, because each organization has customers who do not allow their data to be used for additional purposes. One solution for addressing this challenge lies

in enhancing staff's soft skill. Case study G and F also highlighted the importance of engaging all groups of employees in collaboration with other organizations.

3. Survey study

In order to generalize the empirical findings, an online survey was conducted on a sample of 2273 members of Smart Industry Program Office. In the period from April 13 till June 1 2016, data was gathered from 219 respondents, of which only 78 responses were completed and submitted. Comparing sector, size and age of organizations in the 78 observations with 90 incomplete responses showed quite a large degree of similarity between them.

Of the respondents, 12.82% are part of an enterprise group with a head office located in a foreign country; 26.92% of the companies are small, 28.21% of them are medium sized and 44.87 % of them are large. The sample included companies from all industry sectors, but especially the "Manufacturing" (55.13%) and "Consultancy, research and other specialized business services" (29.49 %) sectors. It was possible for the respondents to choose more than one industry classification based on the Dutch Standaard Bedrijfsindeling (SBI, 2008).

The respondents were asked to give a score from 1 to 10 representing their level of investment in the Smart Industry in period 2013 to 2016 based on their available budget. They perceived their companies as giving investment in the Smart Industry as high priority. (Mean = 6.35, Standard Deviation = 2.78). Moreover, the respondent companies were highly innovative in the period 2013 to 2016.

The result showed that every degree of "smartness" occurs in each size category. However, investment in the Smart Industry is perceived to be more important for the bigger companies.

Information from "clients or customers from the private sector", "suppliers" and "within enterprise or enterprise group" were the most important for the respondent companies in their innovation activities in the period 2013 to 2016.

The most important contribution of the Smart Industry concept was to provide process innovation to companies. However, a considerable percentage of the companies (41.79%) did not succeed in increasing their turnover by using the Smart Industry concept during the period 2013 to 2016. The most serious challenges for companies in the Smart Industry concept are lack of time and cost of ICT systems.

It was not a single technology, but a group of ICT, IoT and advanced manufacturing technologies – the so-called "smart technologies" – that was important among the respondent companies. IoT technologies (especially sensor and RFID tags) were perceived to be more important than commonly used ICT

technologies such as the internet, company website, and telecommunication in the Smart Industry concept.

Investment in human resources can be done by training current employees or hiring new employees. All groups of employees in an organization, especially new employees and young people, are important in the implementation of the Smart Industry concept. Social innovation activities such as the organization of a workshop and vocational training are perceived to be necessary to ensure the company has the needed employee profile to implement the Smart Industry concept.

Including different combinations of control variables showed that human capital is the most significant predictor variable for the successful implementation of the Smart Industry concept. Moreover, application (and use) of smart technologies and human capital development complement each other in 'smart' companies (correlation coefficient = 0.656). Thus, the Smart Industry concept requires finding the balance between smart technologies and human capital to apply smart solutions to the core competency of an organization or company. This balance is necessary for success with the Smart Industry concept.

According to this survey study, investment in the Smart Industry concept leads to increased capacity, reduced costs, reduced environmental impact and real-time intelligence. The results are high-quality and customized products, increased revenue and turnover and business growth.

Finally, this study identified three groups of smart companies based on their investment in smart technologies and human resources. The Smart Industry concept was more important for large companies than small companies in this period. The smarter companies have more international cooperation partners. Moreover, the "information from suppliers" was more important for them than it was for the other two groups. They also used real-time data for supply chain management more than the two other groups did in the period 2013 to 2016.

Although three groups were not found to be different in innovation activities, the effect of innovation in increased capacity of their production or services, reduced environmental impacts, closer relationships with their customers were found to be significantly different.

The respondents believed that the investment of their organizations in the Smart Industry concept led to more innovation activities and increased turnover in the period from 2013 to 2016. Surprisingly, companies in group three did not increase their turnover by using the Smart Industry concept during this period.

4. Conclusion

This study confirmed the important role of digitization and the Smart Industry concept in increasing the innovation activities of Dutch companies in recent years. Companies classified as “smart” do not focus on end products, but on the innovation process as a whole. Thus, the Smart Industry concept is not limited to high-tech sectors. The integration of a manufacturing process with ICTs makes the whole production process smarter.

The smart companies have increased their production capacity, business and turnover. However, organizational change and process innovation are required to flexibly provide new, high-quality products and services in Europe and the rest of the world.

Companies do not use smart technologies by accident. The solution for all companies lies in updating the knowledge of all their staff regarding the Smart Industry concept. Small companies do not need to worry about insufficient funding if they want to start implementing the Smart Industry concept. Innovative employees who know the vision and goals of their company can help their organization to define a target based on the available (even limited) budget. Large companies can overcome the complexity of their organizations by engaging their employees in the decision-making process regarding the use of smart technologies. Moreover, the employees should not limit their work to their own disciplines, but instead should collaborate with other disciplines to use smart technologies for innovation activities.

Companies need to either train their current staff or hire new knowledge employees, especially young engineers, if they want to start implementing the Smart Industry concept. The participation of groups of both technical and non-technical employees in relevant open lectures, working groups and workshops is a good starting point for the vocational training. Social innovation plays a very important role in this implementation, as it brings different parties together for a short collaboration experiment and brainstorming session regarding the Smart Industry concept.

The writer of this article, Moein Hasan Zadeh Saraee, finalized his study of Innovation Sciences at the University of Technology Eindhoven with an internships at the Dutch branch organization for high-tech industry, High Tech NL, which is part of FME. This article summarizes his thesis based on research focusing on the fourth industrial revolution and the implementation of Smart Industry in operational companies.

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