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Job characteristics in smart industries and the challenges for job design

Master Thesis

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Track Human Resource Management

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December 2016

Preface

At the symposium ‘HRM, technology and innovation: Back to the Future’ Prof. dr. Tanya Bondarouk introduced me to the topic Smart HRM. During the World Café Smart HRM themes such as ‘HRM practices in Smart Industries’ and ‘New jobs in Smart Industries‘ were discussed. These very interesting but also difficult issues steered me towards an idea for my thesis. When delving into these topics I soon came across a study called ‘The Future of Employment’ by Frey and Osborne (2013) from Oxford University. The controversial outcome of their study triggered me to study the effects of automation and other smart industry consequences on jobs and job content. Unlike Frey and Osborne I’ve chosen not to focus on jobs and tasks that are disappearing, but on the changes in job content. From that point of view, it made sense to focus on one of HRM’s core functions: job design. Even though my study on job design in a smart industry era is rather exploratory, I believe it may serve well as a starting point for discussion and further research. In this study I presume that jobs are changing rather than disappearing. However, I do believe that there should also be considerable attention for the negative effects of technological progress in order to invent solutions to counteract phenomena like job polarisation and inequality.

I’ve had a great time working on such an interesting topic. I’ve learned a lot about the challenges arising from technological progress and the importance of anticipating on these developments. This study has also enabled me to develop myself and to learn about the kind of HR professional I want to become and the topics I want to be concerned with in my future career.

I would like to thank Tanya Bondarouk for introducing me to the topic and for all the time and effort she invested in supervising me. I also want to thank my second supervisor Jan de Leede for sharing his knowledge and for his helpful feedback. I want to thank the companies that participated in this study, in particular their employees who gave me the opportunity to interview them. Lastly, I want to thank my family and friends for their help and support.

Daniek Bosch
December, 2016

Abstract

Based on new technologies and driven by new economic and social trends, we are now at the brink of a fourth industrial revolution that is transforming the industry into a so called 'smart industry'. Smart industries are known for their high degree of flexibility in production, in terms of product needs, volume, timing, resource efficiency and cost, being able to fine-tune to customer needs and make use of the entire supply chain for value creation. It is enabled by a network-centric approach, making use of the value of information, driven by ICT and the latest available proven manufacturing techniques. As with every industrial revolution, new concerns arise about technological unemployment and inequality. Many researchers have studied how new technologies and computerization will impact the labour market by means of jobs that will most likely disappear. However, little is known about what actually changes in the content of jobs and how these changes will affect the design of jobs.

To keep pace with rapid environmental changes, work design has undergone a transformation in the past few years and is more and more focussing on relational and proactive perspectives. Job design researchers are increasingly recognizing that jobs, roles, tasks and projects are embedded in interpersonal relationships, connections and interactions. But now, at the start of the smart industry era, striking changes in job content as a result of digitisation, new technologies and connectivity make traditional work design theory worth considering again. That is why this study focuses on the traditional and task-focused work design model as proposed by Hackman and Oldham. The JCM model includes five core characteristics: skill variety, task identity, task significance, autonomy and feedback on the job. This study builds on the notion that jobs are not disappearing, but that job content is changing in terms of task characteristics. The purpose of this study is to understand jobs in the context of smart industry and to identify the consequences for job design by exploring five core job characteristics. In order to answer the main question, in-depth interviews were conducted with participants from seven companies that are familiar with smart industry.

The results show that the participants do experience multiple changes in terms of traditional task characteristics. Most participants agree on the fact that skill variety and feedback on the job are surely increasing as a result of smart industry. Automation of simple routine tasks seems to free-up time to perform other more important tasks and there is a growing demand for multifunctional employees. An increase in feedback on the job appears to be a logical consequence of sensors and big data collection, therefore the opinions on this topic were completely unambiguous. With regard to task identity and autonomy, opinions are more conflicting. For example, some interviewees believe that task identity becomes stronger as employees are increasingly able to perform multiple parts of the job, while others believe that the opposite seems to occur since jobs

and tasks are becoming more complex. The same goes for autonomy. On the one hand, automation of tasks provides more freedom to perform other tasks, but on the other hand, new technologies make it easier to measure and control performance. This might also feel like a limitation of freedom.

The interviewees found it difficult to determine whether a certain change is a result of smart industry or just a consequence of continuous development, especially because we are still in the initial phase of the revolution. But even though this study is rather exploratory, it shows a first impression of what changes in job characteristics and it stresses the importance of job design. Multiple propositions concerning the five job characteristics can be presented for discussion and further research. The JCM model seems to hold in the era of smart industry but it can be questioned whether it is enough to explain the complexity of jobs. Also social and contextual characteristics turn out to be very important and are suggested to include in further research.

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1. Introduction

Many researchers have tried to capture the work context of the twenty-first century and have introduced new characteristics, work outcomes and new mechanisms (Grant & Parker, 2009; Humphrey, Nahrgang & Morgeson, 2007; Morgeson & Campion, 2003; Parker, Wall & Cordery, 2001). Job design researchers are increasingly recognizing that jobs, roles, tasks and projects are embedded in interpersonal relationships, connections and interactions (Grant & Parker, 2009). Right now, at the brink of the era of smart industries, it becomes even more important to reconsider theories of work design. Not only the contexts of jobs are changing but computerization and new manufacturing technologies are causing a striking change in the content of jobs. Computers are already substituting human tasks, while new complementary tasks have emerged, and this is only the beginning. In 2013, a research called 'The Future of Employment' by Frey and Osborne from Oxford University fanned the debate about robotics that might substitute for human labour, with unemployment as a result. Frey and Osborne (2013) have examined the susceptibility of jobs to computerization and have forecasted that 47% of all jobs in the USA could be computerized or robotized within the next 20 years. Especially workers in transport and logistics occupations, office and administrative jobs, and production are in the high-risk category (Frey & Osborne, 2013). In 2014, Deloitte reproduced the Oxford study in the Netherlands with equal outcomes, and also Minister Asscher of Social Affairs and Employment outlined a scenario of technological unemployment at the Social Affairs and Employment congress in 2014.

Brynjolfsson and McAfee (2014) use Moore's law to explain how rapidly technology is changing through exponential growth. Moore observed that the amount of integrated circuit computing power you could buy for one dollar had doubled each year, meaning that every year you could buy twice as much power as in the year before. Moore's law also turned out to work on processors, memory, sensors and many other elements of computer hardware. Brynjolfsson and McAfee (2014) argue that technology does more than just make computing devices faster, cheaper, smaller and lighters, it also allows them to do things that previously seemed out of reach. These technological advances have resulted in what Brynjolfsson and McAfee (2014) call the Second Machine Age, but which is often referred to as the fourth industrial revolution. The fourth industrial revolution is characterized by the combining of technologies such as additive manufacturing, automation, digital services and the Internet of Things, and the growing movement towards exploiting the convergence between emerging technologies (Maynard, 2015). These are all important enablers of what we in the Netherlands refer to as 'Smart Industry'. Several countries have been creating strategies to develop their industries to a higher level so they can compete in the global economy and face the challenges of the coming years. Smart

Industry is an approach that makes use of economical and technological trends in order to introduce a common strategy to prepare the Dutch manufacturing industry for the changes in the future (Smart Industry, 2015). It is a term similar to the German Industry 4.0 and largely overlaps with other developments that may variously be labelled Smart Factories, the Industrial Internet of Things, or Advanced Manufacturing (EPRS, 2015). Smart industries are defined as 'industries that have a high degree of flexibility in production, in terms of product needs (specifications, quality, design), volume (what is needed), timing (when it is needed), resource efficiency and cost (what is required), being able to fine-tune to customer needs and make use of the entire supply chain for value creation. It is enabled by a network-centric approach, making use of the value of information, driven by ICT and the latest available proven manufacturing techniques' (Smart Industry, 2015, p. 17). Smart industries are the result from several economical and technological changes. New technologies will enable a new way of participation and new business models, they will enable creating new products and services and will provide new ways of organising production. These new ways of doing business are necessary to create an industry that can address the global economic and social challenges in order to still compete with fast growing international competitors (Smart Industry, 2015).

Prior to the fourth industrial revolution, the advent of global work, virtual work, telework, and self-managing teams has already replaced static jobs with dynamic roles, tasks, and projects that are constantly shifting and changing. As such, the meaning of performance in organisations is changing (Grant & Parker, 2009). Parker (2014) argues that when new technologies and strategies are introduced, job design is an important practice that should be proactively considered. But unfortunately, it is often disregarded. The field of job design was largely developed as a response to the technically oriented design of demotivating alienating jobs that emerged after the industrial revolution (Parker, 2014). Since then, a lot of research has been conducted in the field of job design and a dozen new theories have been established. Many scholars assumed that the fundamental questions about work design have been answered. However, a global shift from manufacturing economies to service and knowledge economies has dramatically altered the nature of work in organisations. To keep pace with these important and rapid changes, work design has undergone a transformation in the past few years with a focus on relational and proactive perspective (Grant & Parker, 2009). Now, at the start of the smart industry era in which tremendous changes are expected to take place, manufacturing industries are back in the spotlights. Striking changes in job content as a result of digitisation, new technologies and connectivity make traditional work design theory worth considering again.

There have already been many studies conducted on how new technologies and computerization will impact the labour market by means of jobs that will most likely disappear (Frey & Osborne, 2013; Deloitte, 2014). Others have studied and tried to predict the type of tasks that will disappear due to computerization and how this shapes human skill demands (Autor, Levy & Murnane, 2003). There have been numerous debates on these topics and many researchers have questioned whether there will me more or less jobs in the future. However, little is known about what actually changes in the content of jobs and how these changes will affect the design of jobs. In contrast with previous studies, the importance of this study lies in the nature of jobs rather than the number of jobs. This study builds on the notion that jobs are not disappearing, but that job content is changing in terms of task characteristics. For now, we assume that jobs will be redefined rather than being eliminated.

According to Grant and Parker (2009) jobs need to be constantly redesigned to alter the structure and content of the work, with the aim of improving performance, employee motivation and well-being. Advances in technology, a growth in knowledge work, and other such forces mean that jobs and tasks are becoming more complex (Parker, 2014). On the contrary, large numbers of simplified and deskilled jobs still exist, and the division between these low-skilled jobs and high-skilled jobs increases. Especially at the brink of a new 'smart' era that is expected to have a huge impact on employment by means of increased complexity and automation, it is of great importance to reconsider task structures of jobs in order to understand the implications and consequences for job design. Therefore, the purpose of this study is to understand jobs in the context of smart industry and to identify the consequences for job design. To understand the task structure of jobs in smart industries, a few core job characteristics will be examined. This leads to the main research question:

'What are the changes in job characteristics in the era of smart industries and what are the consequences for job design?'

This paper proceeds as follows. In the next chapter, existing literature on the concepts smart industry and job design will be reviewed in order to understand jobs in the context of smart industry. The third chapter explains the methodology used for examining the research question. The results are presented in the fourth chapter and will be further discussed in the fifth chapter. The fifth chapter also contains the limitations of the study, some recommendations for further research and a final conclusion.

2. Exploring the concepts smart industry and job design

The theory chapter consists of two parts. First, the concept smart industry is further described by means of its drivers and impact, including the history of technological impact on employment. The second part explores the concept of job design by outlining both its traditional and emerging theories. In the final section, the two concepts are brought together and assumptions are made about the changes in job design characteristics in the smart industry era, eventually resulting in the research question.

2.1 Three characteristics of smart Industry

As mentioned in the introduction, smart industries are defined as 'industries that have a high degree of flexibility in production, in terms of product needs (specifications, quality, design), volume (what is needed), timing (when it is needed), resource efficiency and cost (what is required), being able to fine-tune to customer needs and make use of the entire supply chain for value creation. It is enabled by a network-centric approach, making use of the value of information, driven by ICT and the latest available proven manufacturing techniques' (Smart Industry, 2015, p. 17). The definition demonstrates that smart industry is built upon three pillars: a network-centric approach, the digitisation of information and communication and the next generation of manufacturing technologies.

In the coming years, a network-centric approach to production is expected to replace linear production process with intelligent and flexible network approaches. Networks like these can interconnect machines, products and parts across production plants, companies and value chains (Smart Industry, 2015). While at the beginning of the twenty-first century connectivity was a feature of only the digital world, in the smart industry era the digital and real worlds are connected (Roland Berger, 2014). This advanced connectivity ensures real-time data acquisition from the physical world and information feedback from the cyberspace (Lee, Bagheri & Kao, 2015). The network-centric approach might lead to a radical optimisation of production in existing value chains, and will eventually lead to the birth of the 'value network' (Smart Industry, 2015). The network-centric approach is not only about connecting the real world and the digital one, it will also result in new relationships with suppliers and customers. Customer needs have changed over the years and new markets are highly focussing on customization and innovative new products. Customers not only demand high quality products, they increasingly pay for the experience or service, instead of just buying the product itself (Smart Industry, 2015).

This increase in customer intimacy and value chain participation is substantially empowered by the digitisation of information and communication. The digitisation of information and communication was one of the key enablers of the third industrial revolution. The Internet and further software development were instrumental in this. Within smart industry, digitisation is brought to another level. It will not only enable communication between all partners in the value chain, but digitisation of product quality, user-characteristics and production parameters based on sensory systems will also be crucial to new innovations in the production process, products and services (Smart Industry, 2015). Integrating product development with digital and physical production has been associated with large improvements in product quality and significantly reduced error rates (ERPS, 2015). Also, huge amounts of data can be produced and combined with the latest analytics technologies and expertise. This so called 'Data-driven Operational Excellence' might help to achieve yet unreachable levels of productivity and product quality (Capgemini, 2014).

The next generation of manufacturing technologies, including new modular approaches, next generation robots, new ways of manufacturing like 3D printing and sensors, will enable cost-effective flexible manufacturing to meet the specific demands of customers. These advanced manufacturing technologies will drive the design of new materials and will give a great push to lifecycle management and recycling (Smart Industry, 2015). Central to new manufacturing technologies are its enablers. Technology enablers that seem to be the basis for smart industry are Cloud Computing, Machine-to-Machine communication, Advanced Analytics, Mobile, Advanced Robotics, 3D printing and Community Platforms, of which the first three seem to be highly necessary for realizing smart industry (Capgemini, 2015). Smart factories that apply these new technologies allow increased flexibility in production, possibly resulting in mass customization that will allow the production of small lots or even single items due to the ability to rapidly configure machines to adapt to customer-supplied specifications and additive manufacturing. This can be realized by the combination of automation of the production process, the transmission of data about a product as it passed through the manufacturing chain, and the use of configurable robots (EPRS, 2015).

The three smart industry pillars as proposed by the Dutch team Smart Industry contain a lot of similarities and linkages. Central to all three of them is the worldwide network of interconnected objects called the 'Internet of Things'. The Internet of Things (IoT) is basically the idea that virtually every existing physical thing can also become a computer that is connected to the Internet (ITU, 2005; Fleisch, 2010). Everyday objects that feature tiny computers and become 'smart things' can be connected to each other and devise for online communication between people and things and between things themselves. These intelligent machines are termed Cyber-Physical Systems (CPS) and can be defined as transformative technologies for managing interconnected systems between its physical assets and computational capabilities (Baheti & Gill, 2011). While ICT initially aided human-to-human and human-to-machine communication, it is now revolutionising machine-to-machine applications that will create many new automated devices and will thus affect business and the whole economy (Glova, Sabol & Vajda, 2014). The main strength of the IoT is the impact that it is expected to have on several aspects of everyday-life and the behaviour of its users (Atzori, Iera & Morabito, 2010). From the perspective of business users, its most apparent consequences will be visible in fields such as automation, industrial manufacturing, logistics, business/process management, and intelligent transportation of people and goods (Atzori et al., 2010). Because of the tremendous impact it will most likely have on business and economy, it should not be surprising that the IoT is extensively discussed as a disruptive technology (Atzori et al., 2010; Fleisch et al., 2010; Borgia, 2014; Miorandi, Sicari, De Pellegrini & Clamtac, 2012).

2.2 Possible consequences for employment

The changes in technologies, digitisations and connectivity have several implications for the Dutch industry. Since network-centric production is core to smart industry, it will result in changes in the structure of value chains and networks. It will lead to the emergence of new and adjusted existing products and services, especially due to increasing flexibility and automation. Smart industry will result in new business models to earn money and new competitors might be entering the market. And as a result of all this, new skills and other jobs would be necessary (Smart Industry, 2014). The effect of technological change on the labour market has always been a major topic in economic research. Automation through robots and increasing flexibility in work has reduced the need for low-skill and repetitive tasks, but on the other hand, it increases the need for more specialised work to reorganise the manufacturing systems and perform maintenance activities (Smart Industry, 2014). A central theme in the technology and skills discussion is whether technological development leads to an upgrade or downgrade of skills (Ben-ner & Urtasun, 2013; Spitz, 2004). Brynjolfsson and McAfee (2014) state that ‘there has never been a better time to be a worker with special skills or the right education, because these people can use technology to create and capture value. However, there has never been a worse time to be a worker with only ‘ordinary’ skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate’ (p. 9). Especially employees who are more experienced in IT and communication are required due to the increase in information and interaction with partners (Smart Industry, 2014). And since software will become an integral part of manufactured products, manufacturers have to establish the corresponding skills (Capgemini, 2014).

The most basic model used by economists to explain the impact of technology on skills suggests that technology increases overall productivity equally for everyone. However, a slightly more complex model allows for the possibility that technology may be rather ‘biased’ towards some and against others (McAfee & Brynjolfsson, 2014). In recent years, automation, processing software, computer-controlled machines and other systems have substituted for particularly workers in clerical tasks. By contrast, new technologies like big data and analytics have increased the value of people with the right engineering, creative, or design skills. Many researchers have studied this trend and call it 'skill-biased technical change' that favors people with more human capital (Acemoglu, 1998; Autor, 2010; Levy & Murnane, 2012).

According to Frey and Osborne (2013) the increasing demand for high-skilled workers can be explained by the falling price of carrying out routine tasks by means of computers, which complements more abstract and creative services. Autor, Levy and Murnane (2003) and Levy and Murnane (2004) distinguish between both routine and non-routine tasks, and manual and cognitive tasks. Tasks are routine when they "can be accomplished by machines following explicit programmed rules" and nonroutine when "the rules are not sufficiently well understood to be specified in computer code and executed by machines" (Autor et al., 2003, p.1283). Cognitive tasks can be either analytic tasks or interactive tasks. Substitution by computers seemed evident for both manual and cognitive routine tasks, while non-routine tasks where considered difficult to computerize. According to Autor et al. (2003) routine and codifiable tasks are the most subject to machine displacement. It can be argued that the task model as proposed by Autor et al. (2003) is not complete because nowadays computers can do way more than ten years ago (Davenport & Kirby, 2015; Frey & Osborne, 2013). To be more specific, computers are also able to substitute for a wide range of non-routine tasks, which might mean that the predictions based on current task models will not hold in the twenty-first century anymore.

2.3 The history of technological impact on employment

The era of smart industry is often referred to as the fourth industrial revolution, and like its predecessors it promises to transform the ways we live and the environments we live in (Maynard, 2015). Typical characteristics of this fourth industrial revolution are its velocity; it is evolving at an exponential rather than linear pace, its breadth and depth; it will lead to unprecedented paradigm shifts in economy, business, society and individually, and its system impact; it involves the transformation of entire systems across countries, companies and society as a whole (Schwab, 2016). As with every industrial revolution, concerns arise about what the impact of the new technologies will be on jobs, work and wages. The worries about technological unemployment are not new to this modern era. Throughout history technological process has created enormous wealth, but also undesired disruptions (Frey & Osborne, 2013). Today, on the brink of the fourth industrial revolution, new concerns arise about technological unemployment, labour market polarization and inequality. There are different opinions on how technology will impact jobs and wages. On one side of the debate there are those who believe that new technologies are likely to replace human workers, among them Karl Marx, Harry Braverman and

John Maynard Keynes. On the other side are the ones who believe that workers will be just fine, because real wages and the number of jobs have increased steadily throughout industrial innovations (Brynjolfsson & McAfee, 2015). An important question for this fourth industrial revolution is whether this time the revolution is different from the previous ones. A better understanding of the history of technological impact provides a better perspective on whether this will be the case (Mokyr, Vickers & Ziebarth, 2015).

The first industrial revolution that started in the eighteenth century happened when power-driven machinery replaced hand labour. More complex machines were able to perform tasks faster and more efficiently than humans. The second industrial revolution took place when mechanical takeover made mass-production of goods possible. Factories and assembly lines were created to produce products for mass consumption (Allen, 2009). Most literature on the industrial revolution is written as if it only affected output, productivity, and economic welfare because of an increase in income. But technological process also affected other significant aspects of the economy, like substitution of machinery for human labour (Mokyr, 2001). Every industrial revolution in the past was accompanied by the disappearance of jobs and the emergence of new jobs, but machinery in the industrial revolution could only substitute for a limited number of human workers. Simultaneously, technological progress also increased the demand for other jobs and types of labour (Mokyr et al., 2015). The third industrial revolution, commonly referred to as the Computer Revolution, began with the first commercial uses of computers around 1960 and continued till the Internet and e-commerce development in the 1990s (Frey & Osborne, 2013). The Computer Revolution caused a rapid decline in computing costs and introduced self-service technology, but at the same time resulted in automation of tasks in the financial and retail industries, eliminating copy typist occupations and repetitive calculation tasks (Gordon, 2012).

Throughout history, technological process has enormously shifted the composition of employment, from agriculture and artisan, to manufacturing and clerking, to service and management occupations (Frey & Osborne, 2013). The concern about technological unemployment could be considered exaggerated, because human labour always remained. Computerization never fully eliminated jobs because humans always had the ability to adopt and acquire new skills through education and training. However, when computerization enters more cognitive domains this will become increasingly challenging (Brynjolfsson & McAfee, 2011). Most discussions on how technology may affect human labour are focused on current jobs, which can surely offer insights in which jobs and tasks are likely to be substituted in the near future, but offers way less insight in the emergence of new jobs in the future (Mokyr et al., 2015). According to Rifkin (1995) new technologies have substituted for employment in given sectors in the past, but new sectors arose and absorbed the displaced workers (Rifkin, 1995). Still, after the third industrial revolution all traditional sectors were experiencing technological displacement and high unemployment rates. Rifkin (1995) argues that the only new sector that arose after the third industrial revolution is the knowledge sector, containing a small elite of entrepreneurs, scientists and other professionals. Even though this sector is still growing, it is not expected to create jobs for more than a fraction of the jobs in traditional sectors that are already and will be eliminated. Kern and Schumann (1984) have also argued that where automation is occurring a 'holistic principle of labour skill appropriation' is emerging because the introduction of new technology 'frequently allows – or even demands – the tailoring of jobs for higher qualifications as well as broader responsibilities or at least a less detailed division of labour (p. 59). Despite differences in sectorial specificities, in the view of Kern and Schumann the process of contemporary restructuring causes a generally increased demand for a new type of skilled worker (Preece, McLoughlin and Dawson, 2000). In his book The End of Work, Rifkin (1995) predicts that the new information and communication technologies will polarize the world in two groups – the ones that control the technologies and the growing number of permanently displaced workers.

As to the difference between the previous revolution and the current one, Davenport and Kirby (2015) describe three eras of automation and explain why the current automation wave is scarier than the previous ones. During the first automation era machines took away the dirty and dangerous work from human beings. This era, also known as the first industrial revolution, had mainly positive consequences for human labour. The second automation era took away the dull work and relieved humans from routine tasks. However, in the twenty-first century automation era machines can even take decision making away from humans. Artificial intelligence allows machines to make even better decisions than humans. The technological developments of the industrial revolution acted as a substitute for human labour, but machines back then were not able to reason, compare, compute, read, sense and other human capabilities. If artificial intelligence and robotics continue to develop, which is likely to happen, they will be able to perform all sorts of human activities to a certain extent (Mokyr et al., 2015). Ford (2015) points out that the impact of automation is broader-based this time, because not every industry was affected centuries ago, but every industry uses computers today. Schwab (2016) describes the three critical characteristics of this industrial revolution; its velocity, its breadth and depth, and its system impact. He argues that this revolution is evolving at an exponential rather than a linear pace. Exponential progress allows technology to keep racing ahead and is mainly what distinguishes this revolution from the previous ones. Its velocity allows the possibility of making science fiction reality in the coming years. This revolution will lead to unprecedented paradigm shifts in economy, business, society and individually and involves the transformation of entire systems across (and within) countries, companies and society as a whole (Schwab, 2016).

2.4 Job design theories

For many years, job design has attracted the attention of many researchers. With continuous changes in the ways of working, processes and technologies, job design remains an important issue. It can be viewed as one of the core building blocks in any work system and is a key factor when organisations are trying to increase their productivity or other aspects of organisational performance (Challenger, Leach, Stride, & Clegg, 2012). Job design describes how jobs, tasks and rules are structured, determined and modified and how this affects individual and organisational outcomes (Grant & Parker, 2009). A well-designed working condition is supposed to internally motivate employees to perform effectively on their jobs (Hackman & Oldham, 1976).

The history of job design started with Taylor's ideas on Scientific Management (1911) that focused on the most efficient way to execute tasks by breaking them down into simpler jobs. From there on, it was just a small step to the idea of controlling work through the use of a moving assembly line that was first introduced in Ford's car factory in 1914. From that moment job simplification became widely embedded within the industrial world, at first only in manufacturing but later spreading to other domains (Parker et al., 2001). Over the years job simplification became a topic of interest and many researchers concluded that simplified jobs are boring and demotivating and that repetitive jobs can have negative psychological consequences. This led to the first proposals for task variety and job enrichment, an idea spurred by the Two-factor model of Herzberg et al. (1959). The Two-factor model distinguished between motivators or intrinsic factors and hygiene factors. The theory failed to confirm its basic premise, but inspired the practice of job enrichment, or the creation of challenging and responsible jobs to promote motivation and performance (Paul, Robertson & Herzberg, 1969). Other practices that emerged as motivational antidotes to simplified jobs are job enlargement; the expansion of the content of jobs by including additional tasks, and job rotation (Parker, 2014). Hackman & Oldham (1976) stated that 'those who advocate job rotation claim that work motivation can be kept reasonable high by rotating employees through several different jobs, even though each of the jobs would become monotonous and boring if one were to remain on it for a long period of time' (p. 253). Besides using job rotation as a means of reducing boredom and fatigue (Miller, Dhaliwal & Magas, 1973), frequent rotation among production jobs can be used for orientation and placement (Wexley & Latham, 1981) and can serve as a learning mechanism (Ortega, 2001).

Based on the job enrichment approach and other motivational theories (Herzberg et al., 1959; Porter & Lawler, 1968; Turner & Lawrence, 1965; Vroom, 1964) Hackman and Oldham (1976) built their Job Characteristics Model (JCM). The JCM, the dominant motivational model of work design, exists of five core job characteristics and proposes that each of these characteristics contributes to personal and work outcomes. The core job dimensions skill variety, task identity, task significance, autonomy, and job-based feedback are meant to contribute to three psychological states of employees that must be present for internally motivated work behaviour to develop; experienced meaningfulness of the work, feeling responsible for work outcomes, and understanding the results of their work efforts. In turn, these psychological states were proposed to lead to a number of beneficial personal and work outcomes such as high internal motivation, high quality of work performance, high satisfaction with the work and reduced turnover (Hackman & Oldham, 1976).

The first core dimension skill variety refers to the degree to which a job requires a variety of different activities in carrying out the work, which involves the use of different skills of the employee (Hackman & Oldham, 1976). It is important to distinguish skill variety from task variety because the use of multiple skills is distinct from the performance of multiple tasks (Morgeson & Humphrey, 2006). The use of multiple skills is often challenging and thereby more attractive. Still, jobs that involve the performance of a number of different tasks are likely to be more interesting and pleasant to perform (Sims, Szilagyi, & Keller, 1976). On the other hand, when jobs are already complex, increasing task variety may also produce job overload (Morgeson & Humphrey, 2006). Task identity is the degree to which the job requires completion of a whole product or service, meaning that the job is done from beginning to end by one person (Hackman & Oldham, 1976). The rationale behind task identity is that the results of the job can be easily identified (Sims et al., 1976). It turns out that jobs that involve an intact task, for example the completion of an entire product or providing a complete service, are often more interesting to perform than jobs that involve only small parts of the task (Hackman & Oldham, 1980). Task significance is the extent to which the job has considerable impact on the lives or work of others. This could be the customer or someone else in the external environment or someone in the immediate organisation, like colleagues (Hackman & Oldham, 1976). Employees in jobs that include activities that have a significant effect on the physical or psychological well-being of others are likely to experience more meaningfulness in the job they are performing (Hackman & Oldham, 1980). Like task significance, also the characteristics variety and identity determine the experienced meaningfulness of the job, which is the degree to which the individual experiences the job as one which is generally meaningful, valuable, and worthwhile (Hackman & Oldham, 1976).

The fourth characteristic, autonomy, refers to the degree to which the job provides freedom, independence and discretion in scheduling the work and carrying it out. Autonomy is the job characteristic that is predicted to prompt employee feelings of personal responsibility for the work outcomes (Hackman & Oldham, 1976). Autonomy is probably the most widely studied job characteristic and has obtained a central place in motivational work design approaches

(Morgeson & Humphrey, 2006). Morgeson and Huphrey (2006) found that both work scheduling and decision-making authority can be conceptualized as different aspects of autonomy rather than as separate constructs, therefore these categories are often both included in the autonomy category. The construct of variety has been linked closely to autonomy, both theoretically and empirically (Dodd & Ganster, 1996). Dodd and Ganster (1996) believe this is the case because variety sets some upper limit on the amount of autonomy that can be exercised in a given job.

Feedback, the last dimension, depends on whether the job results in obtaining direct and clear information about the final product or service and thus leads to knowledge about the effectiveness of the employee's performance (Hackman & Oldham, 1976). The emphasis is on feedback obtained directly from the job itself, instead of feedback from others, in order to enhance knowledge of the results of the job (Hackman & Oldham, 1980). Although Hackman and Oldham (1976) focus specifically on feedback from the job, early theorizing suggests that feedback should also come from others (Hackman & Lawler, 1971). Feedback also figures prominently in goal setting theory (Latham & Locke, 1979). Humphrey et al. (2007) propose that having both autonomy and feedback on the job is essential in order to be able to pursue cherished goals. Successful goal completion requires employee flexibility in how these goals are pursued (Locke & Latham, 1990). Thus, if employees have decision-making autonomy in the process leading to goal completion, they are likely to have higher levels of experienced meaning (Maddi, 1970). In addition, it is crucial that employees also receive feedback on the process in order to learn about their performance and proximity to their goal (Locke & Latham, 1990). If employees learn that they are not moving toward goal accomplishment, having autonomy means having the ability to change their behaviour or path. Thus, having these two characteristics in the job should also lead to more experienced meaning and positive work outcomes (Humphrey et al., 2007). The meta-analysis by Humphrey et al. (2007) shows that all five characteristics from the JCM model relate to its proposed outcomes.

Whereas most job design scholars focus on the motivational aspects of work design, another research stream in job design called the socio-technical systems theory (STS) focuses on the relationship between socio and technical systems (Trist, 1981). The objective of socio-technical design is the joint optimization of the socio and technical systems. One of the most important values of the socio-technical systems approach is the need to humanize work through the redesign of jobs. When new technical systems or new technologies are introduced, human needs must not be forgotten (Mumford, 2006). The STS theory also gave rise to the idea of autonomous work teams, nowadays also known as self-managing teams (Parker et al., 2001). The JCM model by Hackman and Oldham (1976) and the STS theory remain the most common approaches to job design research today (Parker et al., 2001). The biggest difference between socio-technical systems theory and job design theory is that the socio-technical systems approach considers the whole organisation or unit, whereas job design theory solely focused upon a single job and its interrelated functions (Rousseau, 1977). STS principles were early influences on group work design, which is appropriate when individual roles are interdependent and there is a need for collective working (Parker, 2014). With respect to group work design, most attention was given to group autonomy, which occurs when team members are allocated collective responsibility for their work (Parker, 2014). Group autonomy is associated with positive job attitudes like job satisfaction and organisational commitment (Maynard, Gilson & Mathieu, 2012).

Several researchers have criticized the JCM model and job design theories in general because they only include a subset of all the characteristics that can affect employees' behaviour. Among others Humphrey et al. (2007) argue that the JCM model only includes a limited set of motivational characteristics. A logical limitation of traditional job design theories is that they have all been developed based on studies conducted in the mid twentieth century, especially in large manufacturing plants. The work context and composition of the workforce have changed dramatically since then. Parker et al. (2001) state that existing job design theories do not speak to the reality and complexity of the current situation. Based upon this, Parker et al. (2001) presented a new Elaborated Job Characteristics Model with a broader range of characteristics and a wider set of outcomes. An important and practical contribution to work design theory is to include contextual factors in the model. This makes salient how easily and directly contextual factors can influence job characteristics and thus work design (Grant & Parker, 2009). Adding contextual factors to the model makes it easier to predict and understand the types of work designs in different settings (Parker et al., 2001). Morgeson and Humphrey (2006) distinguished twenty-one core job characteristics in their Work Design Questionnaire, covering four categories: task motivation, knowledge motivation, social characteristics, and contextual characteristics, and found excellent support for it. In addition to these emerging perspectives, Grant and Parker (2009) advocate for two new directions in job design theory with an emphasis on two particular perspectives: the relational perspective and the proactive perspective. These perspectives map onto two of the most critical context features that organisations must manage in order to be effective: interdependence and uncertainty. The relational perspective focuses on how jobs, roles, and tasks are more socially embedded than ever before, while the proactive perspective captures the growing importance of employees taking initiative to anticipate and create changes in how work is performed, based on increased in uncertainty and dynamism (Grant & Parker, 2009).

New theories and thoughts on job design contain the idea that employees can design their own jobs to a certain extent, while traditional work design theory assumes that others, such as managers, design jobs or that the design is derived from broader organisational and technological choices (Parker, 2014). In the past years, researchers have examined the different ways in which employees themselves take the initiative to modify their own jobs, roles and tasks. Wrzesniewski and Dutton (2001) introduced the concept of job crafting in order to capture the actions employees take to shape, mold, and redefine their jobs (p. 180). Job crafting is defined as changing the boundaries and conditions of job tasks and job relationships and of the meaning of the job (Wrzesniewski & Dutton, 2001). This means that employees can change how the work is carried out, how often they interact and with whom, and how they cognitively ascribe meaning and significance to their work (Tims & Bakker, 2010). Former ideas on how employees are being proactive and take initiative to discuss employment arrangements are role adjustment, role negotiation and idiosyncratic deals (I-deals). I-deals are special terms of employment negotiations between individual workers and their employers (present or prospective) that satisfy both parties' needs (Rousseau, Ho & Greenberg, 2006, p. 977). Job crafting differs from these former concepts because it involves proactive changes in job design that are not negotiated with the organisation or supervisor. Also, job crafting does not explicitly state a long-term focus, but may occur as a solution of short duration (Tims & Bakker, 2010). In addition, Clegg and Spencer (2007) argue that job designs are traditionally considered as relatively fixed and propose the idea that job designs are flexible and adjustable in the short term. To emphasize the importance of proactive behaviour of employees, Grant and Parker (2009) have introduced a Dynamic Model of Work Design and Proactive Behaviour in which the mechanisms, moderators and outcomes are all relevant to proactive behaviours rather than traditional job performance. A part of this model considers how proactive behaviours can influence work characteristics. For example, negotiating involvement in a wider range of projects can lead to an increase in task and skill variety, and by establishing better connections with-end users, employees enhance their job impact (task significance) and contact with beneficiaries (Grant & Parker, 2009). In summary, proactive behaviours can shape work characteristics such as the ones from the JCM.

Work design theories have helped researchers to explain how the design of a job can affect behavioural, psychological, and physical outcomes (Grant & Parker, 2009). But over the years the nature of work has changed dramatically, in fact, 'the very meaning of the concept of job is changing' (Hackman & Oldham, 2010, p. 7). It seems almost impossible to create a job design model that includes all relevant and potential variables. Grant et al. (2010) have tried to put job design in context and named a wide range of dramatic changes in work contexts that have occurred over the past few decades that yet have to be integrated in job design theory. These changes including the shift to a service-oriented economy, a more knowledge-based industry, more emotional and interpersonal tasks, globalization and breakthrough technology give rise to new questions about the nature, effects and the design of jobs (Grant, Fried, Parker & Frese, 2010). In fact, these ongoing changes in the environment would require jobs to be constantly redesigned. Parker et al. (2001) propose that (future) work design theories should develop in two directions simultaneously, with on the one hand a general model that contains basic characteristics, relevant factors and outcomes. On the other hand, there should be a diversity of empirical studies into certain variables from the general model but in a particular context. This will lead to more specific models for particular types of work.

2.5 Job characteristics in smart industries

For years, motivational theories have dominated psychological approaches to work design, mainly as a response to demotivating jobs that emerged after the industrial revolution. But how relevant are motivational perspectives in today's workplaces? Advances in technology, a growth in knowledge work, and other such forces mean that jobs are becoming more complex (Parker, 2014). As a result, other approaches such as the proactive employment and the relational approaches to designing work have complemented traditional work design theory. However, besides increased complexity in work, large numbers of simplified and deskilled jobs still exist, especially in the manufacturing industry, and the gap between good and bad jobs continues to grow (Parker, 2014). Particularly in these industries, the consequences of new technologies and new business approaches are expected to have a huge impact on the content and nature of work.

As a result of the changes in work content, multiple assumptions can be made about changes in task characteristics. Automation of routine tasks might lead to an increase in task variety since the computerization of some tasks will simply free-up time for human labour to perform other tasks (Frey & Osborne, 2013). On the other hand, automation might also lead to a simplification of tasks when machines take away work that involves reasoning, comparing, computing, sensing and other human capabilities (Davenport & Kirby, 2015). Greater involvement of customers by means of increased connectivity could lead to more commitment from employees, as they are more connected to the customer. This might lead to an increased feeling of task significance. Grant (2007) argued that when jobs are structured such that employees have contact with those who benefit from their work, customers for example, employees empathize with the beneficiaries, which encourages employees' effort, persistence and helping behaviour. Another consequence of automation is that when several tasks are automated and employees are being educated in order to perform a greater range of tasks, it is highly likely that employees will be able to perform a greater part of the job task by themselves. This might result in increased task identity. Task identity means that employees do not just execute tasks but also improve them (Parker, 2014). Continuous improvement might be an obvious consequence of constantly collecting big data, recognizing patterns and customer feedback, in other words, feedback on the job. Feedback on the job is the characteristic of which with certainty can be said that it will increase as a result of smart industry (Smart Industry, 2014) As mentioned before, besides feedback obtained from data, also increased customer involvement should lead to detailed feedback on the product, offering the opportunity to adjust and develop new products (Smart Industry, 2015). In a similar manner, when employees have the autonomy to control variance at the source, they obtain immediate feedback about the effects of their actions (Wall & Jackson, 1995). It seems that all job characteristics are closely related to each other when changes in job context occur.

As with task variety, freeing up jobs from dull- or simple tasks might lead to increased freedom and thus a greater feeling of autonomy. Employee participation might also be a result of smart industry that leads to increased feeling of autonomy. Advocates of lean manufacturing and self-determination theory argue that employees can be motivated even if they lack job autonomy as long as they have a sense of choice through participation in decision-making (Gagné & Deci, 2005). Similarly, Treville and Antonakis (2006) argued that the lack of autonomy over work timing and methods can be compensated for by other positive aspects of work design, such as high levels of accountability, high skill variety and task identity, and high levels of feedback. In support of these ideas, research has also shown that job autonomy reduces machine downtime because operators learn to prevent faults (Leach et al. 2003). Providing autonomy seems to be suitable in the era of smart industry since, for example, employees with autonomy can often respond faster to problems than specialists can (Wall & Jackson, 1995). Besides that, they can often make better decisions than supervisors as they can access unique information that is only available from those doing the work (Langfred & Moye, 2004).

The era of smart industry will certainly cause some changes in various job characteristics, possibly resulting in multiple implications for job design. In contrast with the latest theories and studies on job design, the emergence of smart industry particularly in manufacturing organisations might ask for a more traditional approach to job design as it involves drastic changes and possible simplification of tasks. Therefore, the five core dimensions of the original JCM model by Hackman and Oldham (1976) will be studied in relation to smart industry. More specifically, this study examines the changes in the job characteristics skill variety, task identity, task significance, autonomy and feedback on the job as a result of smart industry developments, and considers the consequences of smart industry for job design.

3. Method

3.1 Research design

As smart industry is only in its initial phase, the number of organisations that are already involved in or familiar with smart industry is relatively low. The study therefore contains a small number of participating companies and will be rather exploratory. The data has been collected through conducting in-depth interviews in which the organisations' experiences with smart industry will be discussed. As smart industry is a fairly new topic and has not been studied in combination with job design, this study will mainly view a first impression on the topic and outline some early thoughts and ideas. Both the research question and interview questions are formulated in past tense, but because it is only the start of the era of smart industry, also predictions on future changes will be taken into consideration. This means that the study contains the examination of what has already changed and what is expected to change according to the interviewees. An exploratory qualitative study is the most suitable way to collect the necessary in-depth data to determine these changes smart industry has induced in the design of jobs.

3.2 Operationalization of constructs

The job design components from the JCM model (Hackman & Oldham, 1976) and the three pillars from Smart Industry (2015) are operationalized in table 1.

Table 1 - Operationalization of constructs

Construct and definition	Examples
1. Job Design	
1.1 Skill variety 'the degree to which a job requires a variety of different activities in carrying out the work, which involve the use of a number of different skills and talents of the person' (Hackman & Oldham, 1976, p. 257).	• Number of tasks • Variety of tasks • Variety of skills need for tasks
1.2 Task identity 'the degree to which the job requires completion of a "whole" and identifiable piece of work; that is, doing a job from beginning to end with a visible outcome' (Hackman & Oldham, 1976, p. 257)	• Completing whole piece of work • Being able to deliver entire service
1.3 Task significance 'the degree to which the job has substantial impact on the lives or work of other people, whether in the immediate organisation or in the external environment' (Hackman & Oldham, 1976, p. 257)	• Impact on people outside organisation (customers)
1.4 Autonomy 'the degree to which the job provides substantial freedom, independence, and discretion to the individual in scheduling the work and in determining the procedures to be used in carrying it out' (Hackman & Oldham, 1976, p. 258)	• Work-scheduling autonomy • Decision-making autonomy
1.5 Feedback 'the degree to which carrying out the work activities required by the job results in the individual obtaining direct and clear information about the effectiveness of his or her performance' (Hackman &	• Job provides direct and clear feedback on performance • Job provides direct and clear information on effectiveness

Oldham, 1976, p. 258).	
2. Smart Industry	
2.1 Network-centric approach 'high quality, network-centric communication between players, humans and systems, in the entire value network, including the end-users' (Smart Industry, 2015)	• Communication within the entire value network • Communication with end-users • Intelligent and flexible network approaches
2.2 Digitisation 'digitisation of information and communication among all value chain partners and in the production process on all levels' (Smart Industry, 2015)	• Enabled communication in entire value network • Digitisation of product quality and user characteristics through sensory systems
2.3 Manufacturing technologies 'granular, flexible, and intelligent manufacturing technologies, adjustable on the fly to meet highly specific end-user demands' (Smart Industry, 2015)	• New modular approaches • New ways of manufacturing (new systems and machines) • Sensors

3.3 Selection of cases

The case companies were selected through purposeful sampling. First, companies that are participating in smart industry fieldlabs, more specific fieldlabs in the North and East of the Netherlands, were approached. Smart industry fieldlabs are environments in which companies and knowledge institutions can purposefully develop smart industry solutions. They also strengthen the link with research, education and policy within a particular smart industry theme (Smart Industry, 2014). Next, also other companies that are often mentioned in relationship to smart industry were asked to participate in the research. All participating companies differ in size, operate in different industries and are active in different fieldlabs, and are therefore expected to have different interpretations and ideas on smart industry. They also differ in the number of years they are involved with smart industry, which is however highly dependent upon what they consider to be part of smart industry. Eight of the twenty-six approached companies agreed to participate in the study. An introduction to the sample can be found in the next chapter. The eighth company was omitted from the analysis as it turned out that this organisation had trouble with implementing smart industry solutions due to their specific products. Because they were barely affected by smart industry developments they experienced no changes at all. However, it is a nice example of a company that is operating in a very specific sector and therefore is not able to easily improve its process by implementing new technologies and thus changes their employees' work content and design.

3.4 Data collection

The data has been collected through document analysis and semi-structured interviews. The document analysis includes a brief analysis of the case company's website and possibly additional documents, through which information was collected that might be valuable for the interview input and the analysis. In each company one or two interviews were conducted, differing from an interview with one person to an interview with three persons. Among the interviewees were HR professionals, managers and CEO's, selected by the company based on their knowledge about smart industry and job design. The interviews consisted of two main parts. The first part of the interview started with a number of questions about smart industry in order to establish the level of involvement in smart industry. Topics that were discussed are customer intimacy, improved product quality, automation and the emergence of new machines and systems. This resulted in an assessment of the most visible smart industry solutions in each organisation. The second part of the interview contains questions on changes in employment and job design, starting with discussing the emergence and disappearance of jobs, the shifts in education level and specialisms, and the changes in work content. After discussing the general changes in work content, the key job characteristics skill variety, task identity, task significance, autonomy and feedback were addressed. The interviewees were asked about the changes in these characteristics and possible changes in the near future. The interview protocol can be found in Appendix D.

Mainly due to the differences in experiences with smart industry, the length of the interviews ranges from 45 minutes to 1 hour and 45 minutes. It turned out that some interviewees already had a lot of ideas on smart industry or related topics. These interviewees needed more time to explain and express their thoughts on the topic in comparison to the interviewees who simply answered the interview questions. Eight interviews were conducted face-to-face, and one was conducted by phone. All interviews were recorded in order to transcribe them correctly afterwards. The transcripts were sent back to the interviewees for a final check. An overview of the conducted interviews can be found in table 2.

3.5 Data analysis

The interviews were transcribed afterwards in order to ensure a correct analysis. A deductive approach is followed as the research starts with an extensive theoretical examination. The interview transcriptions were analysed and categorized by means of the topic list, which also served as a basis for the subsequently adopted codes. This categorization serves as a tool in order to uncover patterns among the data. Some new categories arose during the analysis and others were further broken down into subcategories. Examples of new topics that arose are the fourth industrial revolution and leadership. When the question whether smart industry can be considered a fourth industrial Revolution emerged during one of the first interviews it was decided to include this as a question in the subsequent interviews. Leadership was not initially included in the questionnaire, but sometimes mentioned by interviewees. Thereafter, also the topic leadership was discussed in the interviews when relevant. Another important question that was later included in the interviews is whether smart industry is mainly visible in the products or in the process. This is a distinction that became clear in the first conducted interview. For some organisations this distinction turned out to be evident. Therefore this became one of the first questions in the subsequent interviews. A list of codes and quotes can be found in appendix A.

The objective of the analysis was to identify the changes in task characteristics of job design due to elements of smart industry. The analysis is variable-oriented, meaning that the focus will be on the interrelations among variables, but also aims to understand the differences and similarities between the cases (Babbie, 2013). The case companies and participants are kept anonymous in the analysis in order to ensure privacy.

Table 2 - Overview interviews

Organisation	Type/branche	Function interviewee(s)	Time
DEMCON	High-end technology supplier of products and systems (medical, industrial, high-tech)	Sr. Business Manager HR advisor	0:52
TRUMPF	Provider of machine tools (laser technology)	General Manager	1:00
		Project Manager	0:48
Eaton Industries	Manufacturer of power management solutions	HR manager Manager Business Development Segments	1:42
Thales	Electronic systems company (defence, aerospace)	HR director HR advisor Chief Technical Officer	1:05
Philips Consumer Lifestyle	Producer of consumer lifestyle products (electric razors)	Corporate affairs lead advanced manufacturing	1:46
Auping	Producer of high-quality beds and mattresses	Production Manager	0:55
		HR Business Partner	0:42
Electromach Stahl	Supplier for explosion proof materials and system solutions for the Oil & Gas industry	Sales Manager Technology Manager	1:15
Enerpac	Manufacturer of high-pressure hydraulic products	Global Director	0:20
Total			8,26

4. Findings

In this chapter, the findings from the interviews are reported. The topics were derived from the theoretical models as shown in the theory chapter. The case companies are introduced in the first paragraph. The second paragraph contains the characteristics of smart industry as viewed by the case companies. The third paragraph includes the job design findings.

4.1 Case company introduction

The seven case companies are briefly introduced in table 3. Hereafter, the companies are kept anonymous.

Table 3 - Case company introduction

Company	Size	Type of company	Smart industry focus	Smart industry relation	Relevant information for analysis
DEMCON	230 employees	High-end technology supplier of products and systems (medical, industrial, high-tech)	Products	Participating in fieldlab Flexible Manufacturing	Operating in high-tech business for years. Smart industry is nothing new to DEMCON
TRUMPF	70 employees in Hengelo – about 11.000 worldwide	Provider of machine tools – mainly laser technology	Products	Participating in fieldlab Flexible Manufacturing	With a German mother holding they are also concerned with Industrie 4.0
Eaton Industries	850 employees in Hengelo, about 96.000 worldwide	Manufacturer of power management solutions	Mostly process	Big player in East Netherlands – mentioned in relation to smart industry	Multinational production company. They are relatively new in the smart industry area and have recently started to study it
Thales	1.400 employees in Hengelo, about 2.000 in total	Supplier of electronics for defense and security applications (radar and communication systems)	Mostly products	Participating in fieldlab Secure Connected Systems Garden	Recently introduced 'Smart Working @ Thales' as own interpretation of new ways of working
Philips Consumer Lifestyle	2.000 employees in Drachten, about 105,000 worldwide	Producer of consumer lifestyle products (electric razors)	Process	Participating in fieldlab Flexible Manufacturing and fieldlab of Smart Factories	Recently brought back production from China (reshoring) as a consequence of smart industry
Royal Auping	180 employees in operations	Producer of high-quality beds and mattresses	Process	Often mentioned in relation to smart industry	Has recently undergone a huge transformation in the production process
Electromach Stahl	More than 200 employees, more than 2.000 worldwide	Supplier for explosion proof materials and system solutions for the Oil & Gas industry	Mostly product	Mentioned in relation to smart industry	Difficulties with innovation because of safety problems and need for proven technology

4.2 Characteristics of smart industry

The first question 'In what way is smart industry most evident in your organisation?' showed great differences in how companies experience and interpret smart industry within their organisation. One of the interviewees states:

> *"Smart industry is considered a very broad term that captures a lot of concepts."*

Other interviewees compare and mix up smart industry with New Ways of Working and Lean Manufacturing, and interviewees from organisations that have a German parent company use the term Industrie 4.0. In order to determine to what extent the case companies are actually involved in smart industry, some specific questions on customer- and supplier involvement, collecting high value information, improved product quality, new systems and machines and automation of tasks were formulated. But first, the interviewees were asked how they experience smart industry in their organisation and were they believe smart industry is most evident.

In the first interview it became clear that companies can have smart industry solutions in their process and in their products. In some organisations smart industry is most evident in the process. Company D, for example, has undergone a tremendous change within its production process by radically shortening its lead time from 4 weeks to 4 hours. However, they do not have any smart industry solutions in their products, meaning that except for the quicker delivery there are barely any (visible) changes for the customer. Company B on the other hand, mainly provides smart industry solutions for the customer, but does not experience any drastic changes within its own process. Because of its highly advanced products and high level of creativity there is hardly any automation or standardization in Company B's production process. These two companies show a clear distinction between smart industry in either process or product, however, at most companies it is visible in both.

Examples of smart industry outcomes and solutions that are visible at the moment are for example automation of the production process, more use of software, searching for new application areas and integration of systems. According to the interviewees they are all implemented with the aim of improving the production process and sometimes the quality of the products. Integration of systems is an action that seems to be apparent in every case company. All companies mention the integration of several systems like ERP, CAD and personnel systems. This not only happens within the organisation, some companies are also connecting their systems to their customers' and suppliers' systems. This event will be further discussed later.

Another finding that quickly became apparent is that the level of innovation and automation is highly dependent upon the type of organisation. For companies like Company E, where proven-technology is required because of the safety issues they have to deal with, it turns out to be a lot harder to keep up with smart industry developments. Company E's interviewees explain that in terms of innovation and new technologies the industry that they are operating in is lagging 5 to 10 years behind compared to other industries. Because safety is most important in the oil and gas industry, it is necessary to use proven-technology. Obviously, this makes it harder to introduce new technologies and innovations, as they need to be thoroughly tested first.

The type of company and the level of innovation and automation might explain why some people consider smart industry a fourth industrial revolution, while others believe its impact cannot be compared to the first and second industrial revolutions. Employees of companies that have undergone the most changes seem to easier reckon smart industry as an industrial revolution than the ones for whom not much has changed. Most interviewees do not have a clear opinion on whether it can be considered a fourth industrial revolution, as this is only the beginning. Although, most of them seem to believe that the consequences of this revolution will not be as strong as the previous ones, but they will be visible throughout society.

> *"It is part of a much bigger revolution; the digital transformation. That means it is a social revolution, of which smart industry is a part."*

Another interviewee agrees on this and explains that it will have more impact on society because it is applicable for most people. As to the importance of smart industry, all participants agree on the fact that they need to anticipate on the changes and challenges that they are facing as organisation. Only a few interviewees mentioned the importance of smart industry in broader perspective and referred to the opportunity of 'reshoring'. An interviewee stated:

> *"Smart industry is the life-line for the Dutch manufacturing industry. It is highly necessary for keeping production in West-Europe and the Netherlands."*

Customer and supplier involvement

All companies experience more involvement of the customer, in some organisations more strongly than in others. An interviewee mentioned that instead of the other way around, their customers are involving them in their process. Company C, for example, not only provides their customers machines but is also asked to help think along about logistics, planning and order flows. This also relates to an often-mentioned appearance; the shift from product to service delivery.

"The product becomes less meaningful. It is everything that is surrounding it that becomes more important: service"

However, an interviewee from Company A adds that not every customer wants to be actively involved in the process. The level of customer involvement is therefore also dependent upon the type of customer.

"Some customers are rather conventional and do not ask for high involvement, while other customers want their logistics systems to be fully integrated into our systems."

Also key to smart industry is the role of the supplier. An interviewee of Company G mentioned that involvement of all parties in the supply chain is key for innovation and that they want their suppliers to innovate for them. This makes sense, as value chain participation is a key factor for smart industry.

"If you want to streamline and automate the whole process, than all parties in the value chain need to participate."

Collecting high value information

Several companies are collecting data or have the ability to do so, but at the moment they are not optimally exploiting or not even using the data that is being collected. One of Company A's interviewees admits that they are currently looking into big data collection, but that they are not actually involved in it at the moment. He considers this "the service market that is still open" and believes that they can benefit a lot more from data collection. The same goes for Company G, of which an interviewee states:

"We are definitely measuring a lot in our process, but we are going to do that way more because we are not optimally using the possibility right now."

Often mentioned in relation to collecting information through sensing is predictive maintenance. Especially producers of systems and machines, like Company A and Company C, consider it of high value that they can predict when one of their machines will break down and therefore needs service. In this way they can provide service in advance for their customers. Yet, for both Company A and Company C this is something that they want to achieve in the long run.

"Most of the data that we have, we do not do anything with it. Which is really a shame."

Also the interviewees from Company D mention hat they are not optimally using the data they are collecting. They also point out to the opportunity to predict and act on problems prematurely, which at this point seems to be the most valuable outcome of big data collection. None of the interviewees mentioned anything about collecting customer information or other possibilities of data collection.

Improved product quality

The thoughts on whether smart industry solutions have improved the product quality differ per company. Not everyone believes that smart industry solutions have improved the quality of the products so far. As stated by an interviewee from Company G:

> *"For us it is more important that the process becomes more efficient and effective, while the quality stays the same."*

Other companies believe that automation has improved their products because of standardization and repetitive production. An interviewee from Company D explains that in some ways it has improved the product quality because they can produce repetitive now. Repetitive production could have improved the product quality because fewer human errors are made. Another argument for improved product quality is that the process is more transparent now, meaning that errors are earlier visible now and can be recovered more easily. It can be questioned whether this is a result of smart industry or an effect of lean manufacturing, but that is something that is true for multiple events.

New systems and machines

The only actual new machine or system that was mentioned in the interviews is 3D-printing. Except for 3D-printing new products or new developments are often an evolution or expansion of existing products. As stated by one of the interviewees:

> *"New developments mainly arise from connecting systems and existing products."*

An interviewee of Company D explains that they are constantly seeking for new solutions in other business areas and sectors. Another interviewee explains that a lot of machines and systems are not per se new, but they might be for the company they are applied in. An interviewee of Company C mentions that it is quite new for them to focus this much on software. Where they used to focus mainly on their machines with software as a piece of necessity to program them, now software and machine have to deliver a system to the customers together. Although software is not something new, for some organisations it is quite new to work this much with it.

Another way of working with new products and machines is to let other organisations do it for you. This is for example the case at Company G. One of the interviewees explains how this works for them.

> *"We are making more use of other parties to do that for us. We are regularly outsourcing production processes that are now also available in the commercial world. That makes us as organisation smaller, but the companies that we are working with are growing in scope."*

According to the same person it is also a smart industry idea "to make sure that, within the entire value chain, innovation takes place where it should be". With this he is emphasizing that all parties in the value chain should participate and function together for maximum effectiveness.

Automation of tasks

Also when it comes to automation of tasks it turns out that the level of automation is highly dependent upon the type of organisation. A traditional production company and a creative high-tech company obviously have very different levels of automation. The same goes for companies that operate in a very specific industry or sector. An often given example, mentioned by several interviewees from different companies, is the transition from drawing in drawing offices to drawing with computer-aided design systems (CAD). However, all interviewees agree on the fact that there is always a human component that you cannot entirely rule out. Monitoring and using your senses are often mentioned as tasks or skills that can only be done by human beings.

> *"No matter how far a process is automated, there is always the possibility of a mistake. That is why we always need people to monitor the process."*

Most interviewees mention that it is very important to consider the effects of automation. According to some interviewees the consequences and effects of automation can go much further now. An interviewee states:

> *"I believe digitalization is the main driver of automation and faster communication. However, you have to be more careful because the effects of miscommunication can be extended much further."*

Another interviewee explains that automation means investing in processes, materials, and people.

"That means you have to know very well in which direction you want to go. You cannot change your minds easily afterwards, that is why it has way more consequences than when you are doing it manually."

All interviewees have ideas about the benefits of automation, but also seem to be well aware of its downsides.

Shifts and changes in employment

Even more than automation of tasks and disappearance of jobs, the interviewees experience shifts in employment and changes in content.

"The number of employees hasn't changed that much, but there is a clear shift to higher educated work."

This shift to higher educated work is visible in every participating organisation. All interviewees agree on the fact that you need a higher educated workforce in order to keep up with the fast changing technological developments. For some companies this not only applies to production or operational staff. At some companies this also led to a demand for higher educated people in areas like HR, Finance, and Communication. Another interviewee explains the shift from low-skilled technicians to higher-skilled ones, an occurrence that is visible in almost every production company.

"Earlier, for several functions in order to do the job a LTS diploma (MBO 1 and 2) was just fine. Nowadays you see that for these functions you need an MBO 3 degree or sometimes even MBO 4. This is mainly a result of the extra technical aspects that make the job and the employee's role more complex. But also because sometimes we can do the job with less people, but than we need higher educated employees because they have to perform more and different tasks."

Other companies like Company G experience a major reduction in staff, of which also a part is outsourced to other companies. One of the interviewees explains that the intellectual contribution becomes bigger while production works decreases. New jobs and tasks seem to be emerging, but these are jobs for higher educated people. Company G's interviewee mentions that with regard to changes in work content the software part becomes larger compared to the mechanical part. Another fact that most interviewees agree on is the need for analytical skills.

"You have to be able to connect things. You should be able to oversee the entire chain and that means you have to be more analytical. In some cases this means that you have to educate your employees. Employees have to be able to perform more different skills. They need to be multifunctional. In other cases routine work fully disappears and specials are taking its place and therefore you need different people."

4.3 Job characteristics findings

In the initial phase of smart industry it is not always possible to determine what has already changed in job characteristics. The interviewees therefore comment on what has already changed and on what changes they expect in the near future.

Skill variety

Most interviewees seem to agree on the fact that smart industry leads to more variety in tasks and skills. One of Company B's interviewees believes that the work that remains becomes more interesting. He explains that this is mainly because of the fact that employees can and have to serve several machines now, resulting in more flexibility and more variety. His colleague adds that this also applies to support staff by saying that because of automation you are less busy with administrative tasks allowing you to focus more on policy related tasks. Another argument for more skill variety is that employees are required to be multifunctional. In contrast with a few years ago, they should be able to perform more and different tasks now. In order to be able to perform a wide range of tasks, they need to be educated more broadly. An interviewee from Company C explains that if you educate your employees more broadly, they will automatically have more variety in their jobs. Company D's interviewee adds to this that when you are being all-round and multifunctional, this automatically leads to more skill and task variety.

One of the interviewees links skill variety to customer involvement and explains that skill variety increases because they have to view the product from the customer's perspective and offer system solutions. Another argument he gives for changes in task variety is the continuous emergence of new products and the increased variety of technologies that is making the work way more challenging for an engineer. Company F's interviewee says that work becomes more varied because of the decreasing routine component and the increased dominance of continuously thinking along and continuously improving. The 'thinking along in order to improve' part also affects employees' autonomy. Some interviewees believe that giving employees more freedom and responsibilities might also lead to more variety. At Company A the interviewees agree on the fact that variety in tasks will probably increase. However, one of the interviewees explains that some tasks might be simplified. Machine operators for example might have tasks that become a bit monotonous.

Company D's participants agree to the fact that smart industry does not necessarily lead to more variety by saying that:

> *"it could lead both ways, but we've designed it in a way that it leads to more variety because we want to be more flexible."*

An interviewee adds that without rotation the work might have become more monotonous. With this he is explaining that more variety in work is particularly a result of job design, while the other companies seem to believe that increased task variety is a direct result of smart industry.

Company G's interviewees have the opposite opinion and do not believe that smart industry leads to more variety in work for their employees. An interviewee of Company G explains that it could be that the higher level of flexibility that is asked from employees leads to more variety and diversity, but that would be highly dependent upon the situation. They do acknowledge that by trying to make employees more flexible and multifunctional, the work might also become more diverse. The same goes for Company E. For some of the employees at Company E the job might have become more omnifarious, but that does not apply to everyone. An interviewee explains that for some employees the work even gets less depth because of the ease of certain tools and programs. This, for example, applies to software engineers who used to invent a program themselves, while now a lot of it happens almost automatically.

All interviewees agree on the fact that routine work disappears, which might lead to more work variety. Still, it is highlighted that this accounts for the work that remains. One of the interviewees mentions that it is great that repetitive work will reduce, but the downside of this event is that not everyone is able to keep up with it. This is however another discussion point. It can be concluded that in most of the case companies elements of smart industry lead to more different tasks. Still, this is often dependent upon the situation and the employee's function. The findings on this topic clearly show that smart industry can either lead directly to a greater variety of tasks or lead to more variety by design.

Task identity

Task identity is a topic that not always applies to every type of job and thus every employee. Especially for non-production companies the questions on this subject were harder to answer. One interviewee questioned the applicability of this topic to his company and states that this question is primarily meant for manufacturing companies. Still, some interviewees have a few ideas or opinions about it.

Company B's interviewee concludes that when the total package of tasks has expanded, then basically the ability to complete the whole task or product has too. Given that every case companies' representative agrees on the fact that the range of tasks of an average employee has expanded, it would makes sense that they also believe that employees are now more capable of completing a whole product by themselves. However, most interviewees believe this is not the case. Company C's interviewee explains that for now completing a whole product by one person is not the case, but that in fact it is the preferred situation.

> *"We want to reach the point where an engineer can build the product from A to Z, including software."*

For now, they still make a distinction between the engineer who installs the machine and a software installer who connects the machine with the office. Interviewees of Company A and Company E agree on the fact that their machines and systems are too complex and consist of multiple components like electronics, sensors and steel. You simply cannot let one person perform all these tasks because it involves craftsmanship. One of Company A's employees says:

> *"It would be perfect if one team could build a machine from A to Z. But one person performing all these actions, that would be impossible."*

Company G's interviewees have the same opinion. They consider the complexity of their products the main reason why the products need multiple employees with different skills and expertise to produce it. At Company D's production process every employee performs a single step, but employees do rotate between those steps, explains one of its interviewees. This does not mean that one employee is able to complete a whole product. But again, job rotation is applied to let employees perform multiple elements of the total product.

Task significance

Some different arguments for increasing task significance were mentioned. Especially the changes in impact on customers – people outside the organisation - were discussed during the interviews. When discussing impact, the emotional impact and feelings of the employee about whether they have influence is meant. Company B's interviewee noted that individual production puts the customer closer to the organisation. Employees feel this too and therefore have the feeling that they have more influence on the final product, and thus the customer. The interviewees of Company D also emphasized this phenomenon.

> *"Emotional impact increases because employees feel the customer in the factory."*

At Company D, the customer's name is displayed on the product, meaning that employees know exactly for whom they are producing. This increases the involvement of employees to a product and customer, and the way employees feel about the importance of their job for the customers. An interviewee of Company C states:

> *"When employees are more all-round they can fix all sorts of things themselves without having to involve a colleague or specialist. Hence, they can make more impact."*

By stating this he describes that the degree of impact is mainly caused by the extent to which an employee can immediately support the customer. Company F's interviewee believes that employees can make more impact if they want to and have the capability to do so. Although, he does not believe that this is a result of smart industry. Company A's interviewee explains that because of automation you have to deliver the product with less people. Through this, the employees' involvement in a product increases. He also stresses the fact that employees can have a stronger impact because their output is more clear and visible due to lean production. Here again it can be questioned whether an increase in emotional impact is a result of smart industry. At Company G and Company E they do not believe that there are any changes in the degree of impact on other people due to smart industry. In summary, the clearest example is the increasing level of customer intimacy that leads to more employee involvement, resulting in the feeling that the work employees are doing is important and has consequences for other people.

Autonomy

An interviewee explains that when more tasks are automated it might be the case that employees have to operate several machines, leading to more flexibility and more variety. It can also lead to more variety because you can learn more by analyzing and identifying relations. This allows you to forecast and predict certain events. You can for example identify abnormal values and thus predict whether something will happen or might go wrong. From the view of the interviewee, the opportunity for predictive maintenance, as discussed in the previous paragraph, can give more freedom to employees. However, he also mentions that constantly measuring and controlling has a downside. Measuring and predicting fluctuations and deviations make it easier to control and coordinate the process and the employees working on it. You could say that this gives more freedom, but on the other hand is "big brother watching you".

At Company C both interviewees agree on the fact that at their company smart industry does not lead to more autonomy and freedom. However, employees do have the opportunity now to participate in the process and express their opinions, especially in the preliminary phase. Some interview results show that sometimes participation and autonomy are considered somewhat similar, yet other interviewees believe these are two very different concepts. Another interviewee has a total different view on this topic. He believes that, not just for his company but organisations in general, extensive automation is mainly intended to reduce costs.

> *"Extensive automation ensures that you can do the job with fewer people. This actually limits employees' freedom."*

He admits that it could lead to more freedom because automation allows you to perform other tasks, but still believes that most people experience it as a limitation of their freedom and not the other way around. It should be appointed that automation is not the only outcome of smart industry, but for many production companies it might be the most tangible one. Two other statements that might complement this opinion are "system says no" and "the system decides what you should do". Extensive automation could also cause a situation in which the machines decide what employees should do. This again might rather be understood as a restriction of freedom instead of providing it.

At Company D a distinction is made in work scheduling autonomy and the freedom or opportunity to improve the work.

> *"Our employees have less freedom now in when the work is done, but more freedom in improving their work".*

Another interviewee agrees on the fact that improving work is also a part of autonomy by saying:

> *"It will lead to more autonomy. You have to stick to the standard, but you also need to improve it."*

Another vision of one of the interviewees is that autonomy has more to do with management culture and leadership style. Which could be considered as an argument for autonomy as a result of design instead of a direct consequence of smart industry. Autonomy can be considered a clear example of a job characteristic that is given to employees by management or supervisors, that is, it is designed and does not suddenly arise. Another interviewee believes that there already was an increase in autonomy in jobs before smart industry. Although, he believes that smart industry has reinforced it.

Feedback on the job

As mentioned in relation to autonomy, measuring and predicting fluctuations and deviations allow you to control and coordinate the process. An interviewee explains that this also has consequences for feedback on the job. When you are able to collect more information and receive it quicker, it is easier to give immediate feedback on the job.

> *"If our employees have deviations in their work or other errors, they know it right away because they have to communicate it themselves. We have departmental meetings every morning in which we discuss these sorts of things. So employees are always aware of the problems and errors that have occurred the day before."*

An interviewee of Company C believes that more feedback on the job is an obvious result of smart industry because improved communication is a huge aspect of it. Another interviewee adds that it is mainly digitalization that has made communication and thus feedback a lot easier. Also at Company G the feedback loops are very short, which is also part of lean principles and visual management.

> *"Because we're working closely together and see direct results, we can act on it very quickly if necessary."*

Here again it can be questioned whether a shorter feedback loop is a result of smart industry or an already existing development as a result of for example lean production. Another interviewee mentions that because of their improved production process they can control abnormalities now and have the ability to do this even more in the upcoming years. He states that they can also measure performance per work cell, meaning that performance is not only being measured for an entire process or group of people, but can be traced back to a single person.

Company F's interviewee states that within the production process the factual feedback will be much more adequate and quicker. For example, the number of products produced, the number of errors, the times you had to intervene, and how fast are maintenance people on the spot, that kind of feedback.

> *"However, I do not believe that feedback on how you function as a person will change that much and quickly. That also has more to do with culture and leadership."*

This is another argument that shows that actual better feedback, in other words personal feedback, is not a direct result of smart industry but should be personally given by supervisors and is thus highly dependent upon leadership. However, he believes that factual feedback often leads to personal feedback and is therefore a great opportunity.

> *"People are more involved and will be sooner confronted with the quality of the process they are responsible for. This leads to feedback and offers learning opportunity."*

Company A's interviewee agrees with this opinion.

> *"It allows you to perform quicker feedback loops and big data can give you a lot of insight in performance. But it highly depends on what you do with the data otherwise it is useless. Management style is very important."*

In summary, all interviewees believe that the amount of data that can be collected through new smart industry solutions is a great opportunity and something that organisations must absolutely benefit from. However, there are some doubts on whether better and quicker feedback is a direct result of smart industry.

> *"Because of all information services there is more information available that can helps us look errors and improvements in production more quickly. However, with all due respect, I do not consider this a result of Industrie 4.0. It is a further development of existing systems".*

Also the distinction between factual feedback and personal feedback is worth thinking about. Factual feedback seems to be a direct result of smart industry solutions, but personal feedback might be something that needs to be designed.

4.4 Overview of smart industry and job design findings

The interview findings are summarized in two tables. Table 4 shows the smart industry findings and table 5 provides an overview of the changes in job characteristics as perceived by the respondents.

Table 4 – Overview of smart industry findings per company

	Most visible smart industry outcome	Network-centric/ customer and partner involvement	Digitalization and communication	New production machines and systems	Level of automation
Company A	Integration of systems. Importance of service	Integration of logistic systems. Active customer involvement (product). More flexibility	Improved communication. Should make more use of big data and collection of valuable info.	Connecting existing systems	Systems (ERP, HR services) Routine work, but new and higher-level work has occurred.
Company B	Automation and improvement of production (products)	High customer intimacy because of custom-made products	Improved quality and big data collection	3D printing and several new but specific machines	Very low, high level of creativity
Company C	Searching for new application areas. More use of software	More custom-made solutions and customer involvement	Connecting systems	3D metal printing. Development of traditional machines	Low at the sales office. A little bit through new systems
Company D	Improvement and acceleration of production process through automation – make to order	Mass customization. Changes in supply chain because of make to order	Improved quality because of automation	Combined and connected techniques	Automation of welding. New systems (ERP, HR)
Company E	More tracking and tracing, and software in products	Process alignment with customers	Predictive maintenance	-	Automation of systems (ERP)
Company F	Automation of production process	-	-	-	High level of automation of routine-work
Company G	Process automation and smart working	Suppliers are highly involved in the process	More efficient process with equal quality. Digitalisation is most important driver	Outsourcing instead of introducing new systems and machines	Also outsourcing work and tasks

Table 5 - Overview of changes in job characteristics

	Task variety	Task identity	Task significance	Autonomy	Feedback
Company A	More variety because of flexibility and versatility	No, different components ask for expertise	More significance, but mainly because of lean production.	Probably not, because you have to do the job with less people.	More feedback, but this also depends on management style
Company B	More variety as work that remains becomes more interesting and diverse	Probably greater feeling of identity because total task package has been expanded	More significance through customization and individual production. Customer involvement.	More autonomy because of prediction possibilities. But also more checking on employees	More feedback. Easier to measure data and predict, and to get more info
Company C	More variety, but education and training is necessary	Not yet more identity, but is preferred situation	More significance would be the case when employees are all-round	No more autonomy, but more participation	Definitely more feedback
Company D	More variety, but because of job rotation and not as a direct consequence	No increase, but workers rotate so they have to perform more tasks	Yes. Feeling the customer in the factory leads to more impact. Also because of individual production	Not per se. Less freedom in when and where, more freedom in improving their work	More feedback by daily monitoring and measuring and focusing on deviations
Company E	Not per se, highly dependent on function and tasks	No changes. Work might become smart, but stays the same	No changes	No changes in autonomy as a result of smart industry	More information available, but this is a continued development
Company F	More variety, routine work reduces and continuous improvement becomes more important	-	More significance for those who want to and have the capabilities	More autonomy, but also very dependent on leadership and management style	Yes, but maybe not on how you function as a person
Company G	Not per se. You want employees to become more employable	No increase, more people are needed for complexity of the product	No difference	Yes, will lead to a high level of autonomy, but this was already the shift	More feedback, because of short feedback loops

5. Discussion and conclusion

Smart industry manifests itself in many different ways and for most case companies it is just starting to develop. On the other hand, some interviewees note that smart industry is just a new term for something that is going on for years now. The interview results confirm that the case companies are still in the initial stages of smart industry, some of them slightly further than others. Although many interviewees reach equal conclusions on how aspects like automation and digitalization affect organisations, there are also a lot of different opinions on certain topics. The extent to which smart industry is already visible seems to be highly dependent upon the type of organisation. Several companies mentioned that rapid innovation is not always possible in the sector they are operating in. For example when they are operating in the defence sector, or when technology needs to be proven in order to ensure safety. For now, at the start of the smart industry era, it seems that the case companies have a more specific focus in terms of smart industry solutions, for example on either their products or the production process. A distinction can be made between companies that are actively involved in optimizing their production process by automating tasks and introducing new systems and technologies, and companies that are concerned with the manufacture and supply of machinery and systems that enable this optimization. This is one of the main reasons why the influence of smart industry on tasks and jobs within organisations can be very diverse.

It turned out to be difficult to determine whether changes in job characteristics occurred due to smart industry related factors or other organisational or general developments. The interviewees seem to have trouble in deciding when something is a result of smart industry or just a consequence of continuous improvement or other management philosophies like Lean and New Ways of Working. For example, Company G has recently introduced a smart working initiative, which is their interpretation of New Ways of Working, but has many similarities with smart industry ideas. At Company D, several practices that have recently been implemented, like multifunction employees, Kanban, and JIT purchasing are typical Lean manufacturing practices (Fullerton, McWatters & Fawson, 2003). However, these practices could also be considered part of smart industry. For example, the improved product quality through increased transparency in the process, resulting in more visibility and easier recovering of errors. This might be more a result of Lean management than smart industry, but then again, that depends on what you consider to be part of smart industry. It seems that sometimes companies have no idea that what they are doing is actually part of what is called smart industry. A statement by one of Company D's employees confirms that they did not intended to introduce smart industry.

"We were not focusing on smart industry, we were busy with optimizing our production process through finding new techniques to apply. Later the awareness came that this is in fact smart industry."

It appears that most aspects of smart industry are not necessarily new, but can be considered a further development of existing processes and systems. But then again, another thought on innovation holds that the true work of innovation is not coming up with something big and new, but instead recombining things that already exist (Brynjolfsson & McAfee, 2014, p. 79). Another appearance that shows that we are still in the initial phase of smart industry is the use of smart products. Organisations have started to introduce these smart products that are equipped with sensors providing information about their environment and, for example, their current use and status (Capgemini, 2014). Particularly the possibility of predictive maintenance is often mentioned by interviewees and referred to as a great opportunity. On the other hand, a lot of valuable information that is already being collected or could be collected through sensory systems is often disregarded or unexploited. Most case companies are aware of the fact that they are collecting tons of information and that big data would be a great opportunity to enhance business operations, still, they admit that they are not optimally exploiting the possibilities at the moment.

In terms of employment, most changes seem to occur for lower educated people. All companies are experiencing a shift from lower skilled jobs to high skilled jobs. This is also reflected in literature studies and is sometimes referred to as skill-biased technological change (Acemoglu, 1998; Autor, 2010; Levy & Murnane, 2012). There seem to be many changes in job content and shifts towards highly educated work, but it appears that this does not necessarily lead to the disappearance of jobs. A clear example of why job design is a very important topic in relation to smart industry has been noticed at Company D. An answer of one of Company D's representatives to a question on whether smart industry leads to more task variety perfectly describes the importance of job design:

"It could lead both ways, but we've designed it in a way that it leads to more variety because we want to be more flexible."

Company D's interviewee explains that the smart industry changes that have been carried out in their factory do not necessarily lead to more variety, they might even lead to simplification of tasks, but they have designed the work in a way that leads to more variety. By implementing job rotation they make sure their employees become more flexible because they have to be able to perform more and different tasks. Even though some tasks might be even simpler than before, rotation between tasks ensures that jobs include multiple tasks and become more diverse.

Skill variety

McAfee and Brynjolfsson (2011) have argued that of course, many occupations that are being affected by these developments are still far from fully computerizable, meaning that the computerization of some tasks will simply free-up time for human labour to perform other tasks. This is in accordance with the view from an interviewee of Company B, who believes that the work that remains becomes more interesting. He states that this is mainly because of the fact that employees can and have to serve several machines now, resulting in more flexibility and more variety. From the respondents' perspectives it seems that, with regard to skill variety, computerization can lead both ways. Ben-ner and Urtasun (2013) proposed the question "Does computerization increase or reduce the extent of skills that workers are required to have?". They found that the skills in jobs that were already higher in task complexity before computerization emerged are mostly positively affected by computer-based technologies (Ben-ner & Urtasun, 2013). This might be a reason for the fact that higher skilled employees, at for example Company B, seem to experience more task variety due to automation and computerization. Also, whereas routinization is often conceptualized as a characteristic of simple jobs, researchers have begun to recognize the possibility that routinized tasks can be intertwined with complex jobs to stimulate proactivity and creativity by freeing up psychological resources (Grant & Parker, 2009, p.346). Based on the skill variety findings a possible proposition for discussion or further research could be:

Proposition 1: Automation of routine tasks will free-up time to perform other tasks and therefore leads to more skill variety.

Task identity

Most participating companies agree on the fact that smart industry does not lead to a situation in which employees can perform whole tasks alone or complete an entire product by themselves. In fact, it might even be the other way around as products become more complex and contain multiple specialist areas. The completion of an entire product or service by one employee will then become even more difficult, often impossible. On the other hand, employees are becoming more multifunctional and are often requested to perform a greater part of the task by themselves. For example, in an ideal situation, engineers would also run the software part and are being extensively trained to do so at the moment. Nevertheless, the complexity and versatility of the job ensure that it is difficult for an average engineer to deliver an entire product or service. A possible solution that might create a feeling of task identity, one that was mentioned during the interviews and also in relation to skill variety, is job rotation. Employees might not be able to assemble a complete product alone, but because of job rotation they should be able to perform most of the tasks that are necessary to complete the product. This might give employees the feeling that they are doing a job from beginning to end with a visible outcome, and thus still lead to experienced meaningfulness of the job (Hackman & Oldham, 1976). Besides creating a feeling of task identity, job rotation was also perceived to lead to changes in skill variety and thus kills at least two birds with one stone. As stated by Hackman & Oldham (1976): “Those who advocate job rotation claim that work motivation can be kept reasonable high by rotating employees through several different jobs, even though each of the jobs would become monotonous and boring if one were to remain on it for a long period of time” (p. 253).

Proposition 2: Increased complexity in the process hinders the ability to perform a complete task or produce a complete product and therefore has a negative effect on task identity.

Task significance

In the view of the respondents, task significance seems to be changing as a result of increased customer intimacy. Individual production and customization might put the customer closer to the organisation, consequently, employees feel more involvement with the customer. Since these new ways of producing are important aspects of smart industry, the increase in customer involvement and therewith task significance, can be considered a direct result of smart industry. Customers become more involved in the process and sometimes even ‘visible’ in the factory. According to the interviewees it is the increase in customer involvement that causes a greater feeling of emotional impact for employees and also affects the feelings of responsibility. It not only seems to be leading to experienced meaningfulness of the work as proposed in the model of Hackman & Oldham (1976) but also to experienced responsibility for outcomes of the work. An example of customers being ‘visible’ in the factory is shown at Company D, where the name of the customer is labelled on the product. So that employees are not producing the product for a number or for stock, but for an actual person. Grant (2007) argued that when jobs are structured to provide employees with contact with beneficiaries, employees can emphasize, identify with, and take the perspective of beneficiaries, and thereby develop stronger affective commitments to them (Parker & Axtell, 2001 in Grant & Parker, 2009, p.328). These affective commitments to beneficiaries, combined with an awareness of impact on beneficiaries, will strengthen employees’ prosocial motivations, encouraging higher levels of effort, persistence, and helping behaviour (Grant, 2007 in Grant & Parker, 2009, p.328). Putting customer information on the product label instead of a number could therefore be considered as a form of job design in order to create more experienced responsibility.

Proposition 3: Increased customer involvement creates more employee engagement and could therefore be positively related to task significance.

Autonomy

Autonomy turns out to be the job characteristic where respondent opinions are most divergent. On the one hand, the possibility of predicting and forecasting events such as the need for maintenance as a result of data collection might lead to greater perceived autonomy in the job. On the other hand, the downside of constantly measuring and controlling is that employees might have the idea that they are being watched all the time. Another contradictory example given by one of the interviewees is that extensive automation should lead to more freedom as it provides more time to perform other tasks. However, when automation is implemented to ensure that the job can be done with fewer people, it might also feel like a limitation of freedom. Some interviewees explain that smart industry does not necessarily lead to an increase in autonomy, but that employees do have the opportunity to participate in the process, especially in the preliminary phase. These variables are often considered somewhat similar, as both variables lead to perceived control by employees (Spector, 1986). In many studies autonomy is being examined in relation to worker participation and autonomy is sometimes even defined as the opportunity to participate in decision-making (Gardell, 1982; Kalleberg, Nesheim & Olsen, 2009). Participation in the process and in decision-making can be considered perceived control for employees and can thus be experienced as autonomy or freedom.

One of the interviewees mentioned that autonomy has more to do with leadership style and is almost never a direct result of a certain change. If developments in terms of smart industry do not provide more autonomy for employees, worker participation can be considered a job design practice to simulate a similar outcome. Even though not every respondent believes that smart industry leads to more autonomy for employees, it could be considered a logic outcome that employees receive more autonomy, as they need to be able to act quickly to changes and respond rapidly to service needs. Employees with autonomy can often respond to problems faster than specialists can (Wall & Jackson 1995). Also the amount of accessible information can be considered a reason for giving employees more autonomy as they can often make better decisions than supervisors can because they can access unique information that is only available to those doing the work (Langfred & Moye 2004). Evidence shows that when work is designed to provide autonomy, employees develop greater confidence in their capabilities to carry out a wider range of tasks and responsibilities effectively (Parker, 1998), which seems to be exactly what companies expect from their employees in the era of smart industry.

Proposition 4: The possibility of predicting and forecasting certain events offers employees the possibility to anticipate in an early stage, which might create a feeling of autonomy.

Feedback on the job

While there are different opinions on whether smart industry directly causes changes in variety and autonomy or that these changes occur as a result of design, there is no doubt among respondents on the fact that smart industry leads to more factual feedback on the job. All interviewees believe that their feedback loops are better and quicker now as a result of digitalization and sensory systems. However, whether this leads to personal feedback is another question. An interviewee pointed out that organisations might want to consider whether the feedback they are giving is purely factual or also personal. If it is not personal, it might be not as effective as they believe it to be. However, Hackman and Oldham (1976) dropped feedback from agents as a job characteristic to focus exclusively on feedback from the job itself. When discussing feedback on the job as meant in the JCM, factual feedback is the type of feedback that is referred to. Morgeson and Humprey (2006) reintroduced interpersonal feedback to work design theory and research. Considering the growth of the service sector, interpersonal feedback is perhaps more critical today then in any previous area (Grant & Parker, 2009). That smart industry leads to more data and information can be considered a fact. This ongoing collection of data allows users to receive instant and real-time feedback. Factual feedback often serves as a basis for personal feedback, but whether it is actually converted into interpersonal feedback seems to be highly dependent upon leadership and management style. But even though the feedback is not personal, employees themselves might gather insights from the available data and act on it themselves.

Proposition 5: Lots of data can be collected through digitization and sensory systems, this leads to rapid and clear feedback on the job.

Validity of the JCM

The JCM model seems to be a good start for examining job characteristics in an era of extensive automation and connectivity, but it can be questioned whether the five discussed characteristics are enough to explain the complexity of jobs within smart industry. Over the years, the core JCM elements have been expanded by several work design researchers. Parker et al. (2001) have proposed an elaborated model of work design by expanding the number of work characteristics and outcomes, and by adding contextual and personal antecedents. Humphrey et al. (2007) argue that the motivational approach should be complemented with social characteristics and work context characteristics, and Grant and Parker (2009) advocate for more focus on the relational and the proactive perspective. In this study, the choice was made to focus solely on the original task-focused approach to job design as proposed by Hackman and Oldham (1976). Even though many manufacturing and other low-skilled jobs have been outsourced to developing countries, there are still many low-quality job designs in developed countries and the gap between highly skilled knowledge work and deskilled low-paid work seems to be growing (Parker, 2014). Traditional job enrichment practices might still prove useful in addressing problems related to repetitive and fragmented tasks, and physical demands (Grant & Parker, 2009).

However, this does not mean that social characteristics and contextual factors are not important. In fact, the interview findings emphasize the importance of organisational context by showing the differences in changes between certain industries. For example, the extent of automation and innovation seem to be highly dependent upon the type of organisation. The industry the organisation is operating in is therefore an essential context factor. The most obvious example of an important change in work context is the ongoing decline in manufacturing jobs and the rise in service work (Osterman, 1997). This shift has caused major changes in work characteristics. It is therefore important to take into consideration whether the organisation that is being studied is very service-oriented or a more traditional manufacturing company. A possible solution for contextual differences is that work design theories develop in two directions simultaneously; with on the one hand a general model that contains basic characteristics, relevant factors and outcomes, and on the other hand a diversity of studies into certain variables from the general model but in a particular context (Parker et al., 2001). This should result in a variety of specific models for particular types of work and industries.

Besides contextual characteristics, also the importance of social characteristics is reflected in the findings. The difference between personal feedback and factual feedback was mentioned a few times in relation to feedback on the job, and was sometimes considered to be even more important. Also the importance of leadership, referred to as social support in work design theory, has been discussed often. Social support is the extent to which a job provides opportunities for getting assistance and advice from either supervisors or coworkers (Karasek, 1979). Especially in relation to feedback and autonomy, the role of the supervisor is viewed to be highly important, and has probably received too little attention in this study. Also the degree to which the job has substantial impact appears to be closely related to interaction outside the organisation and interdependence, which are typical social characteristics in job design theory.

5.1 Limitations

Besides the limited set of job characteristics, another limitation of this study is the small number of companies participating in it. As smart industry is a fairly new topic it was difficult to find suitable companies who also felt confident enough to participate. The low number of cases does not make the study generalizable but shows a first impression of what changes in job characteristics due to smart industry and what its consequences are for job design. The same is true for case-specific results that are based upon the perceptions of one, two or three employees. Obviously this does not mean that their view represents the view of the entire organisation. Also, the companies were targeted based on their involvement in smart industry displayed on smart industry platforms. During the data collection it became clear that this does not necessarily mean that employees of these companies experience a lot of changes due to smart industry. This is particularly true for originations where smart industry is mainly visible in product solutions. A better sample for a research on job design and changes in job content would be a number of companies that have recently transformed their factory by for example adding new technologies, by automating tasks and implementing new systems.

Another limitation of this study is the difference in perceptions on smart industry. While some interviewees consider smart industry a new and recently launched initiative, others believe that developments in its main components have been going on for years and that smart industry is just a buzzword. Besides, aspects from smart industry are often associated with practices from Lean manufacturing and New Ways of Working, which might make it even more confusing to determine whether something can be considered to be part of smart industry. In addition to this, some changes in job characteristics seemed to be part of an existing movement. For example, one participant mentioned that there already was an ongoing growth in autonomy for workers. The same might be true for feedback on the job. Developments like these make it more difficult to determine whether the changes in job characteristics were actually consequences of smart industry or part of an existing trend. Besides, not all interviewees had the same degree of knowledge on smart industry as it involves a fairly technical part. And not all interviewees had enough understanding of the changes in tasks of their employees and of specific actions that have been taken by the organisation in order to save and/or redesign jobs. In order to determine what has actually changed for employees and how they experience these changes, it might be valuable to also conduct interviews with production workers and engineers themselves.

5.2 Practical implications

Especially for organisations that have to deal with the effects of automation of job tasks, job design practices are highly important to take into consideration. Job design practices such as job rotation and job enrichment have already been proven to be possible solutions for preventing simplified and routinized work, and seem to be still important in the smart industry era. An important task for supervisors and managers is to consider the changes in job characteristics and to design the work in a way that it leads to increased internal work motivation and other personal and work outcomes. This is especially true for manufacturing companies, where some jobs might run the risk of becoming simplified and monotonous again through automation of tasks. On the other hand, many jobs are being enlarged, especially non-routine jobs, and employees are often required to be multifunctional and to perform a variety of tasks. This mainly has positive consequences for motivation and performance, but employees might also be faced with an overwhelming number of choices and tasks to prioritize, which may undermine these positive outcomes. Not only supervisors are responsible for the redesigning of jobs, but also employees themselves should behave proactively and can take initiative to negotiate or craft their own jobs. Either way, work needs to be constantly redesigned in order to keep up with the ongoing changes the nature of work.

5.3 Suggestions for further research

This study is rather explorative as it only delivers some first insights in the starting phase of smart industry. A study in a later stage of smart industry might result in more interesting findings as organisations can then better describe what has actually changed in job tasks. Some propositions for discussion were already put forward in the discussion and could serve as a starting point for additional and more extensive research. Since the sample size of the study was quite low, a future study needs to involve a larger sample of companies that are involved in smart industry. Besides a larger sample size, a distinction could be made between organisations that experience changes in their process and suppliers of smart industry solutions. It seems that high-tech product and systems suppliers often consider smart industry as a result of continuous development, while (manufacturing) companies that implement these new systems might experience major sudden changes. A recommendation would be to, for example, focus solely on manufacturing companies where employees actually experience changes in their job due to implementations of new machines or applications.

With regard to the JCM model, it appears to be a suitable model to show some first insights in the changes in job characteristics as a result of smart industry related factors. The five traditional characteristics are still affected when technological or other developments are taking place. However, also contextual and social characteristics seem to be important when trying to describe the complexity of jobs. Contextual factors like industry and type of organisation were found to be very important for this study. In future studies, researchers might want to include contextual and social factors in order to explain the changes in job characteristics and to determine the implications for job design. Especially industry, social support, interaction outside the organisation, and interdependence might be important characteristics in smart industries. Also leadership and management style should receive considerable attention in job design studies. After all, they are the ones within the organisation who are responsible for designing jobs.

5.4 Conclusion

Even though this study is rather exploratory and the number of participating cases is rather small, the results stress the importance of job design in the smart industry era, especially in manufacturing organisations. Particularly when it comes to automation and robotization, the practice of job design should be taken into consideration. This makes sense, as the interest in the topic of job design arose in response to the wide-scale adoption of scientific management principles that led to job simplification. When automation leads to job simplification, job design practices such as job rotation and job enlargement are opportunities to discourage or prevent simplification of jobs, in fact, they might even lead to more variety. Job design can therefore be considered a very relevant HR-practice in the smart industry era as it can counteract the negative consequences of automation.

Luckily, it seems that smart industry mainly has positive effects on job characteristics. In most cases, the work that remains becomes more diverse and involves more different tasks. Automation of routine tasks might free-up time to perform other tasks and the demand for multifunctional employees increases. Many jobs are being enriched and enlarged as autonomy and skill demands are rising, and lots of feedback on the job leads to opportunities to actively participate in the process and immediately improve the work. There also seem to be positive changes in task significance as a result of increased customer involvement and interaction outside the organisation, and employees are more and more able to perform a greater part of the job by themselves. It seems that the JCM model still holds in the era of smart industry since changes and developments in connectivity and automation still seem to affect the core job characteristics. However, the degree of change seems to be highly dependent upon the type of organisation and the industry it is operating in. And an increase in connectivity and interactive value chain participation also has major consequences for the social characteristics of a job.

Still, the advances in smart industry are evolving at a rapid pace as a result of exponential growth, and uncertainty is becoming increasingly complex as the pace of organisational transformation is rising. It can therefore be concluded that continuous advances in work design are essential in order to create motivational jobs in an era of rapid developments in technology, increased automation and growing connectivity.

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