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Digital transformation in manufacturing organisations and its effects on performance

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Summary

This paper investigates the role of digital transformation in manufacturing companies. The study was conducted by interviewing managers and employees from the case companies. The main findings of the study show the benefits (e.g. increasing efficiency, customisation and flexibility) as well as the drawbacks (e.g. implementation costs, lack of digital skills, and loss of market share if not done properly). Furthermore, some lessons learned on the sequence of the digital transformation, supplier aspects, cost savings, are also presented. The paper concludes with a summary of research findings, and future directions.

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1. Introduction

Digital transformation, i.e. the use of digital technologies to transform industry's processes and strategies, has become a major trend, especially in the manufacturing industry because of the nature of the industry, which makes the digital transformation more appealing due to the potential of reducing time, costs and therefore increase productivity and performance (Kane *et al.*, 2015; Liere-Netheler *et al.*, 2018). However, digital transformation is not always successful and there are companies that cannot keep up with it and cannot develop and implement it quickly enough, such as the bankruptcy of movie-rental company Blockbuster (Kane *et al.*, 2015; Liere-Netheler *et al.*, 2018). It is important to understand what impact digital transformation has had on the manufacturing industry since so many companies are investing money and time in digital transformation. To improve the success rate of future digital transformation, avoid further losses during the transformation process, and save money on transformation costs, it is important to understand how digital transformation has affected the manufacturing industry.

Owing to a greater role of digital technologies in the adoption of Industry 4.0 (big data, augmented reality, computer simulations, etc.) in manufacturing organisations across the globe, the research questions addressed in this paper are: *What is the influence of digital transformation on manufacturing firms?* and *What are the experiences of digital transformation in manufacturing firms?*

This paper is structured as follows. Section 2 presents a literature review about digital transformation in manufacturing industry, including the benefits and disadvantages. Section 3 provides the qualitative methodology. Section 4 presents the analysis and findings. Section 5 provides some discussion about this research based on the data and a comparison to relevant previous literature. Section 6 draws the conclusions as well as provides some limitations and avenues for future research.

2. Literature review

2.1 Definitions

The term "digital" refers to digital technologies defined as a combination of information, computing, communication and technology (Bharadwaj *et al.*, 2013), and transformation implies breakthroughs, process improvements and ultimately good results (Daszko and Sheinberg, 2005). Digital transformation is a popular approach among practitioners in recent years (Reis *et al.*, 2018), and many companies are in the process of digital transformation. There are three terms that are used a lot in this area and many people confuse them to use them, but they are different. Digitisation is the process of moving from an analog to a digital form, it is the information, not the process, that is digitised. The definition of digitisation is less controversial (Legner *et al.*, 2017). As digitisation evolved, there was a greater focus on the role of digital for social development, with new technologies arising from digital technologies (McAfee, 2009). Digitalisation is more broadly defined but mainly refers to changing the way people interact through digital technology, with more emphasis on the creation of new business models and value-creating opportunities (Bloomberg, 2018). There is a greater focus on the outcomes that result from digitisation (Iansiti and Lakhani, 2014). Digital transformation is more broadly defined, with some considering conducting ERP iterations as part of digital transformation (Chanias, 2017), but others argue that digital transformation requires more intense change processes and outcomes (Wang *et al.*, 2018), such as new business models arising from the application of digitization (Berman, 2012), or new ways of operating and strategies (Bharadwaj *et al.*, 2013). In summary, digital transformation places more emphasis on the strategic aspects of the company and on cross-disciplinary organisational changes and the implementation of new technologies (Bloomberg, 2018).

2.2 Digital transformation in manufacturing industry and the industry 4.0

The fourth industrial revolution has accelerated the demand for digitalisation (Maroufkhani *et al.*, 2022), and digitalisation and intelligence have become an important trend in modern manufacturing. In order not to be left behind in the era of Industry 4.0, several countries have issued guidelines on the digital transformation of manufacturing to promote the transformation and upgrading of their manufacturing industries, such as the Made in China 2025 in China and the Industry 4.0 initiative in Germany (Yu *et al.*, 2021). However, the manufacturing industry is slower to absorb new technologies than the information technology, media, and financial industries (Young and Rogers, 2019), although the manufacturing industry is confident in automation and learning from big data and digital technologies (Ramaswamy *et al.*, 2017). At the same time, the main areas where the implementation of Industry 4.0 will have an impact are the production aspects, such as automated production, and the optimisation of services or the provision of customised services according to the needs of the customer. There will also be an increase in human-machine interaction and information flow (Dutta *et al.*, 2020). There is a direct correlation between the size of a company and its attitude to embrace Industry 4.0, with large firms typically being more receptive to the introduction and use of disruptive technologies than small firms, which are often concerned about the risks and barriers this entails (Dutta *et al.*, 2020). This study relies on the Resource Based View (Barney, 1991) which states that organisations should have valuable, rare, inimitable and non-substitutable (VRIN) resources to remain competitive.

2.3 Benefits of pursuing digital transformation on manufacturing organisations

The benefits of digital transformation for manufacturing organisations are numerous, such as reduced labour costs, increased employment of highly skilled individuals, increased profitability, development of a competitive advantage, increased market share, and increased innovation.

Tedious and repetitive tasks can be simplified through digitization, resulting in shorter workflows, easier communication and collaboration between employees after digitization, increased productivity and reduced work costs (Gebayew *et al.*, 2018). Companies' labour costs are reduced through digital transformation, workflows are accelerated and companies' productivity increases, leading to increased profitability (Gebayew *et al.*, 2018; Frendiana and Soediantono, 2022). Companies may incur new costs to hire highly skilled labour in some circumstances, such as when digital talent needs to be hired directly to lead digital teams or manage digital tools, but this in the long run still saves labour costs and creates new jobs for highly skilled people, which in the long run can also contribute to the transformation of the labour market (Corejova and Chinoracky, 2021). Furthermore, the use of new digital technologies can contribute to the development of new competitive advantages and, to a certain extent, new business models that can increase the competitiveness of companies in the market (Genzorova *et al.*, 2019). The optimisation of the business can meet the needs of the customers and promote the company to have more customers and business, increasing the company's share in the market (Gebayew *et al.*, 2018; Miethlich *et al.*, 2021). The cultivation of a digital culture gives companies the ability and awareness to be constantly digital, increasing their ability to innovate (Căpuşneanu *et al.*, 2021; Young and Rogers, 2019; Bican and Brem, 2020). In fact, we cannot actually imagine how far the long-term beneficial effects of digital transformation can take us (Genzorova *et al.*, 2019).

2.4 Disadvantages and risks of pursuing digital transformation

Digital transformation can create certain disadvantages and risks. Examples include costs, losses due to poor results, disruption to the organisational structure, increased risk to information security, and disruption to the main business.

The process of digital transformation, from the initial preparation to the implementation of the transformation, entails significant costs and expenses, which may put the financial chain of the

company under pressure (Díaz *et al.*, 2022). If a company's digital transformation fails or the results of the transformation are not actually well utilised, this can result in wasted costs (Díaz *et al.*, 2022), and digital transformation is a disruption of existing workflows and the organisational structure may change as a result, which inevitably affects employees, who are an important asset for the company (Stalmašeková *et al.*, 2017; Boneva, 2018). Digital transformation also entails the risk of redundancies, as digitisation may lead to some jobs becoming redundant, such as some basic positions (Corejova and Chinoracky, 2021), while the negative effects of unjustified redundancies will need to be remedied when they are identified later in the digital transformation, creating new costs in the process of rehiring and employee adaptation (Dokuchaev, 2020). The use of digital technologies may result in increased risks to information security, with more frequent digital interactions brought about by digitisation potentially leading to privacy breaches of customers (Dokuchaev, 2020), and new security protections are not kept up to date, which also increases the risk of business being attacked through digital means, and even the risk of new criminal offences (Díaz *et al.*, 2022; Yucel, 2018a; Miethlich *et al.*, 2021). It may also cause companies to rush to catch up with the new trend of digital transformation due to competitive market pressures, pulling manpower and funds into digital transformation operations, resulting in a disruption to their main business (Yucel, 2018a; Warner and Wäger, 2019). Digital transformation is bound to be a highly complex and long-term process, and it is during this long process that employees will gradually feel the various discomforts associated with digital transformation (Genzorova *et al.*, 2019; Warner and Wäger, 2019).

2.5 Cost and the ROI (return on investment) of the digital transformation

The cost of digital transformation consists of several different components, including, for example, markets lost due to digitalisation (Yucel, 2018b). Much of the existing research focuses on how to calculate the ROI of digital transformation. analysing ROI helps digital

transformation projects to make the right investment decisions when developing their strategies.

ROI is not straightforward but is judged by the growth in revenue of the new tool. Companies can identify opportunities that can bring significant performance improvements to the company through digital transformation, with the most significant ROI as the primary objective when undertaking digital transformation projects (Albukhitan, 2020).

2.6 Digital transformation in manufacturing firms

2.6.1 The sequence of digital transformation

Digital transformation usually changes the status quo of a company and requires an ongoing coordination process within the company based on this (Yokoi *et al.*, 2019; Wade *et al.*, 2017). Crucially, the logic of digital transformation is the Plan-Do-Check-Act Cycle (Deming, 2000), as the nature of digital transformation is long-lasting and requires companies to constantly adapt their strategies in a dynamic and changing environment, so that digital transformation in companies often lasts for more than a few years (Gray *et al.*, 2015). The logical sequence of digital transformation is to conduct a digital audit survey, create a digital transformation strategy, set a measurable goal, rank the tasks according to their importance and priority, evaluate the transformation results and develop measures to improve the transformation results (Boneva, 2018).

In the traditional sequence of strategy implementation, it is usually considered that a detailed strategy is set by management before implementation (Majchrzak *et al.*, 2016; Matt *et al.*, 2015). However, in the strategy of digital transformation, the complexity of its structure and environment, as well as the sudden emergence of digital transformation leads to a situation that contradicts traditional perceptions (Majchrzak *et al.*, 2016). Similarly, studies have shown that the initial stages of digital transformation are ambiguous and random, and that there is plenty of scope for participants to experiment and evaluate before finalising their directions and

strategies during the initial stages of transformation (de Brentani and Reid, 2012; Gregor and Hevner, 2015). Chanas and Hess (2016), show that digital transformation is a bottom-up process that starts within an organisation before it has developed a digital transformation strategy. However, Mugge (2020) states that top-down is the most effective management model to drive digital transformation. Furthermore, there are also studies that suggest that digital transformation is an improvised process and not a process of strict implementation of strategies coming from management, and that management may tend to make decisions based on intuition (Zimmer, 2019).

2.6.2 The relationship between digital transformation and the characteristics of a company's workforce

Digital transformation is relevant to both the leaders and employees of a company. Living in an era of digital Darwinism (Goodwin, 2018), the importance of digital transformation has become common knowledge for company management (Yokoi *et al.*, 2019; Boneva, 2018), but there is still no clear understanding of the ways and means to pursue digital transformation (Porfirio *et al.*, 2021). Managers play a more strategic role in the digital transformation and act as facilitators and coordinators of the digital concept (Porfirio *et al.*, 2021; Singh and Hess, 2020; Imran *et al.*, 2021). It is also particularly important to develop digital awareness and agility related to digital technologies among employees, as managers often promote digital transformation by supporting the needs of the company's production, finance-related people within the organisation, and in some cases by using full participation in skills training as a way to master digital tools to improve employees' digital skills and awareness (Wirtz, 2019; Ulas, 2019). However, according to reports, many leaders rush into large-scale and radical digital transformation because they are not willing to lag behind their competitors and fear being left behind in the market, resulting in high costs of digital transformation (Porfirio *et al.*, 2021; AlNuaimi *et al.*, 2022).

Digital literacy refers to the skills, knowledge and ability of employees to master and use digital technologies (Dery *et al.*, 2017; Khan and Vuopala, 2019). However, the digital literacy of employees within an organisation is also crucial to the success of digital transformation, including the ability to use digital tools and platforms (Cetindamar *et al.*, 2021). However, most of the existing research has neglected the role played by employees. Because digital technology includes software rather than hardware (Henderson and Venkatraman, 1999), employees must not only participate in the digital transformation, but also enhance their own transformation in the company's transformation (Murawski and Bick, 2017), otherwise it can lead to a situation where employees are not in tune with the application of the results of the transformation afterwards (Cetindamar *et al.*, 2021).

2.6.3 Digital transformation of companies in relation to suppliers

Suppliers are a frequent part of the digital transformation process, which is changing or facilitating the relationship between companies and their suppliers (Bresciani *et al.*, 2018; Matarazzo *et al.*, 2021). Digital transformation, trust and joint problem solving are at the root of what enables companies to build healthy supply chains, and as digital exchange between customers and suppliers is bound to increase after digital transformation, trust between the two parties becomes very important (Klein and Todesco, 2021), with both parties seeing digital technology as a means of integrating and adding value to resources, for example by sharing an information exchange platform with suppliers and improve operational efficiency, etc., rather than seeing digital technology as a substitute for trust (Faruquee *et al.*, 2021; Andal-Ancion *et al.*, 2003). In several studies, it has been suggested that linking and interacting with suppliers in new processes to achieve mutual value appreciation and win-win situations is key to implementing digital transformation with suppliers (Coreynen *et al.*, 2017; Opresnik and Taisch, 2015; Frank *et al.*, 2019).

2.6.4 Barriers to digital transformation

A much-cited obstacle to digital transformation is the lack of digital skills, the lack of people within companies and in the talent market who are flexible in the use of production and digital technologies leads to barriers to transformation (Ebert and Duarte, 2018; Vogelsang *et al.*, 2019a). The second obstacle is the limitation of technology, the limitation of IT infrastructure on the one hand and the security of data on the other, digital transformation means increased interaction of information and many companies are concerned about information security and the difficulty of protecting the privacy of the business (Vogelsang *et al.*, 2019b; Lammers *et al.*, 2019; Ebert and Duarte, 2018). The third obstacle is a personal one; digitisation will inevitably make information more transparent, which leads to performance becoming more transparent as well and will bring about more job scrutiny, a concern that is more prevalent especially among grassroots employees (Ebert and Duarte, 2018). There is also a greater fear of unemployment among grassroots employees, with digital transformation displacing part of the workforce and making it possible for companies to resort to redundancies, and an increased fear of unemployment among employees (Dengler and Gundert, 2021; Van Veldhoven and Vanthienen, 2021). The fourth obstacle is an organisational one, a lack of digital awareness in leadership, where leaders may know that digital transformation should be undertaken but do not understand the exact direction or the specific implementation processes, and lack a clear company strategy and measurement system to judge the outcomes of digital transformation (Vogelsang *et al.*, 2019a; Ebert and Duarte, 2018; Gupta, 2018). Financial issues are also part of the organisational barriers, with long payback periods for digital projects leading to an inability to see a return on investment in the short term and a less clear ROI, which can cause concern among company leaders, and insufficient funding can directly lead to digital projects not being carried out (Linderoth *et al.*, 2018; Cichosz *et al.*, 2020). A final obstacle is the environment, where there is still a lack of standards and laws to protect the process and results

of digital transformation, especially for some smaller companies. New business models require new laws to protect the companies and people operating under this model (Brink and Packmohr, 2022; Vogelsang *et al.*, 2019a).

2.7 The future of digital transformation in manufacturing

Digital transformation implies restructuring and opportunities, and many manufacturing companies have started digital transformation with the aim of increasing supply chain resilience due to COVID-19 pandemic and have made significant efforts to develop digital transformation talent (Chenneveau *et al.*, 2020). Furthermore, the focus on increasing and balancing digital resilience in the process of digital transformation is gradually increasing (Casalino *et al.*, 2019). the impact of COVID-19 has led manufacturing companies worldwide to increase their focus on digital transformation, such as: big data, automation, and advanced manufacturing technologies, and setting digital transformation as part of their corporate strategy, which will also help them to better adapt to change (Agrawal *et al.*, 2020).

3. Methodology

Typically, data collected is divided into primary data, which is collected for some specific purpose, and secondary data, which is some data originally collected for other purposes, including primary data and published abstracts (Bishop and Kuula-Luumi, 2017; Sturgis *et al.*, 2009). Primary data in qualitative analysis is usually collected through observations, interviews and focus groups (Hox and Boeijs, 2005). Interviews are a way of obtaining information through discussions with a purpose. Interviews are classified as unstructured interviews, semi-structured interviews and structured interviews (Saunders *et al.*, 2009).

In this study, five semi-structured interviews were carried out with senior managers and employees at global manufacturing organisations, based in China. The interviewees were core to this research as they brought their job experience with particular emphasis on digital

transformation. The interviews are useful for more in-depth and extensive research on the impact and experiences of digital transformation on manufacturing firms' experiences (Newcomer *et al.*, 2015). The interviews for this study allowed the interviewees to use their native language to conduct exploratory research (deMarrais and Lapan, 2003). In line with the characteristics of this study, the data will be analysed using thematic analysis, which is a type of qualitative analysis that elaborates on the data and explains different themes, and thematic analysis is considered the most appropriate research method in attempting to discover interpretations (Boyatzis, 1998). Thematic analysis first requires organising and familiarising oneself with the data, turning the audio recordings of the interviews into text, which can be transcribed using software and checking the transcription results, and finally translating using translation software (Alhojailan, 2012). The interviews were conducted online via Teams and each interview lasted between 45-80 minutes. Transcribed files of interview transcripts can be found in *Appendix 1*.

4. Findings

4.1 Definitions

As for the definition of digital transformation, plant manager sees digital transformation as a way of using historical information data that has happened before, ending this siloed state, combining them effectively and then making judgments about future business, and of course helping to make existing work easier. Manager 1 sees digital transformation more from the user's perspective, seeing it as a way of making our lives more transparent, intelligent and efficient. Manager 2 sees digital transformation throughout the supply chain, including smart manufacturing, how to use digital tools to support operations, and how to use digital to better serve customers.

“The first is efficiency, the second is the ability to predict, for example, digital twins, and the third is client-side response, which helps us to quickly determine changes in our customers.” ---Plant Manager

4.2 The relationship of digital transformation in manufacturing industry and the industry 4.0

Regarding the relationship between digital transformation and Industry 4.0 in the manufacturing sector, the plant manager's view is that first and foremost industrialisation is about increasing efficiency, saving energy and improving human well-being, and that digital transformation is the way to achieve these goals. manager 1 sees digital transformation as driving and accelerating Industry 4.0, manager 2 sees digital transformation as a tool and a way to achieve Industry 4.0, manager 1 believes that digital transformation drives and accelerates Industry 4.0, manager 2 believes that digital transformation is a tool and a way to achieve Industry 4.0, employee 1 believes that digital transformation is a necessary way to Industry 4.0, and employee 2 believes that the two are parallel and intersect very closely. Almost all interviewees expressed the view that digital transformation is a tool and a way to achieve Industry 4.0. However, employee 2 considers the two to be cross-cutting and parallel.

“If Industry 4.0 were the human body, digital transformation might be the blood vessels, which are spread all over the body.” ---Employee 1

4.3 Benefits of digital transformation

According to the results of the interviews, the benefits of digital transformation are distributed in three main areas: operations, firm and employees (see **Table 1**). In terms of operations, digital transformation can enhance employee and leader decision-making and improve operational efficiency, increase the commonality of data, reduce errors caused by workplace miscommunication, improve employees' sensitivity to market conditions, improve their judgement, and become more flexible in responding to customers' needs, increasing the

possibility of providing tailored services. In addition, digital transformation can improve the tightness and relevance of the firm with its customers. In addition to improving productivity and market competitiveness, digital transformation can also reduce labour costs and keep up with trends in smart manufacturing. Lastly, digital transformation can provide employees with training resources to enhance their digital skills and awareness, which can increase their chances of becoming digital experts and leaders in the long run.

“How do we make people better? It must be a company with good processes and systems, plus good tools to help people. Digitalisation can help our employees' abilities to improve more quickly, because the tools help him to bring foresight and direction.”-

--Plant Manager

Table 1: Benefits of digital transformation

Type	Examples
Operations	Helping to make decisions and increase efficiency
	Improve commonality of data and reduce communication errors
	Increased market sensitivity and judgment
	More flexibility and customization for customer needs
Firm	Increase tightness and relevance to customers
	Improving productivity and market competitiveness
	Keeping up with smart manufacturing trends
	Reduced labour costs
Employees	Providing more training resources

	Enhancing digital skills and digital awareness
	Increase the likelihood of employees becoming digital experts and leaders

Plant manager and Manager 1 mentioned the benefits for both firm and employee, with a particular focus on the benefits of digital transformation for the company's employees. In recent years, the company has offered employees free digital skills training courses, which are graded accordingly and allow them to lead digital projects if they reach certain levels. Employees focused more on the benefits of the digital transformation in terms of operations, such as improving the company's competitiveness through smart manufacturing.

4.3 Disadvantages and risks

The interviews revealed that the disadvantages and risks of digital transformation are mainly in the areas of the firm, cost and labour (see **Table 2**). Firstly, there is the risk of firm formalism, which can lead to digitisation simply for its own sake. It is risky for businesses to fail to standardise their digitalisation tools, leading to the isolation of data, the inability to use the tools developed by each other to extract data, and the loss of market competitiveness that will result from blind digitalisation. Lastly, in terms of the workforce, there is a shortage of people with both business and digital skills, which can be difficult to train and find, and a mismatch in digital outcomes can make work more difficult and lead to dissatisfaction among employees.

Table 2: The drawbacks and the risk of digital transformation

Type	Drawbacks and Risks
Firm	Formalism, Digitisation for the sake of digitisation
	Data isolation due to inconsistent development tools

	Loss of market competitiveness due to blind digitalisation
Cost	Wasteful costs and resources due to misfit of project results
	It may require more expensive labour to confirm data accuracy and results
Labour	Talent with both business and digital skills is scarce
	Mismatch of project outcomes leading to an increased difficulty for employee

Digitisation for the sake of digitisation by companies and leaders was the most mentioned issue in the interviews.

“I don't really think it will have a negative impact. I think it's a balanced outcome, you can't go digital for the sake of going digital, because what digital requires is that although it may seem like we're saving some people's work, you're adding more people to make sure your data is accurate.” ---Plant Manager

“It is a terrible waste of resources if companies implement projects haphazardly without thinking through their prospects. Especially in large companies, after investing huge amounts of resources with little success, the consequent reaction is a decrease in market competitiveness, because my competitor may have succeeded in digital transformation and its productivity has increased.” ---Employee 1

Four interviewees mentioned the issue of formalism and digitisation for the sake of digitisation due to the trend towards digital transformation, with plant managers and managers focusing more on the development aspect of digital tools and the negative impact of failed digital transformation on employees, while employees were more concerned about the negative impact of a blind digital transformation on top of their work. The employees were more

concerned about the negative impact of a blind digital transformation at the top of the company on their work and the costs involved. Despite this, all interviewees agreed that digital transformation is the way of the future, it may have negative effects, but the long-term benefits outweigh the disadvantages, and they will go for this route.

4.4 Cost and ROI (Return on Investment)

Based on the results of the interviews, the main costs of digital transformation fall into three categories (see **Table 3**). The first is labour and time costs. Recruiting and hiring digital project leaders, drawing on existing staff to join digital projects, training the company's staff in digital skills and awareness, learning and adapting staff to digital products and systems, collecting detailed data, filtering and processing data are all significant costs associated with the company's time and labour. The second part of the R&D costs is the investment in software and hardware and the cost of using the platform. The third component is outsourcing, where some companies or departments outsource digital transformation projects directly to specialist agencies such as Accenture and Deloitte, a tri-party agency (Shi, 2021).

Table 3: Costs of digital transformation

Type	Costs
Labour and Time	Hiring digital talent
	Redeployment of existing employee
	Training employees
	Learning and applying digital products and systems
	spent on detailed data collection
	Filtering and processing data

Research and Development	Software and Hardware
	platform usage fees
Outsourcing	Outsourcing to specialist agencies

For return on investment, 0% or close to 0% in the short term (1-3 years), the long term may bring efficiency gains, product upgrades and market share expansion that cannot be measured in terms of the amount of money alone.

“Investing in digital transformation is about avoiding spending more money. I think that even if there is no return, if it grows by no more than 2% of the company's investment, I think it is worth it.” ---Plant Manager

According to plant manager and managers, labour costs are the highest, and some of the time spent results in labour costs. According to plant managers, finding and hiring someone with business knowledge and digital skills can be more difficult and costly than expected. On the other hand, the employee believes that R&D investments in software and hardware and the use of platforms account for a large part of the cost, but also emphasizes the negative impact of strategic mistakes at the top. Interviewees agreed that they would not see a return on investment in the short term but would see a positive impact and return on digital transformation over the long term across all areas of the company.

4.5 Digital transformation in manufacturing firms

4.5.1 The sequence of implementing digital transformation

As shown in **Figure 1**, digital transformation within a company is usually top-down, usually starting with senior management setting the strategy and direction of the digital transformation, followed by gathering the needs of front-line production operations staff at the production end,

where usually in departments with the most pressing needs and the easiest to understand transformation needs, such as warehouse, process, quality, and logistics. On the non-production side, digital tools or digital platforms are collected and developed according to the needs of each department or branch, and are implemented in each department for learning and use to improve efficiency.

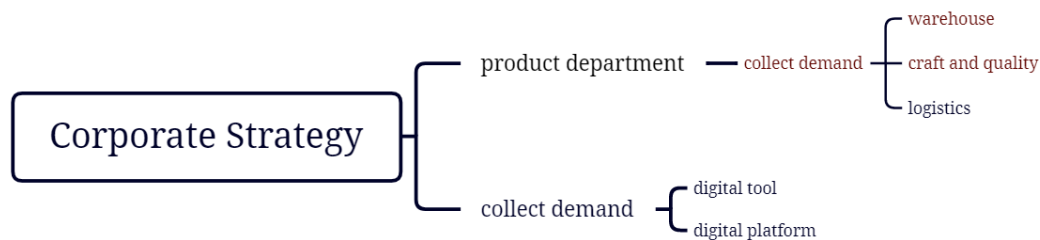


Figure 1 : Digital transformation sequence

All the interviewees agreed that the digital transformation strategy within a company is top-down and evolves from company strategy to employee behaviour. Plant managers and managers believe that digital transformation is usually point-to-surface within a company and is synchronised throughout, but that the pace varies depending on demand. In contrast, employees perceive digital transformation, especially on the production side, as linear, with a clear sequence, and believe that the first transformation within a company is on the supply chain side, where it is easiest to identify which departments can be monitored or controlled through data, as well as where the transformation is most closely related to profits and costs. The link between cost and profit is most obvious and strong.

4.5.2 The relationship between digital transformation and the characteristics of a company's workforce

The interviewees' perception of whether digital transformation is highly relevant to the personal qualities of the leaders (see **Table 4**) varied, with plant manager believing that it is very highly relevant and that a leader needs to anticipate the future in three to five years and make strategic decisions about digital transformation based on this. Manager 1 believes that it is highly relevant and that leaders need to take on the task of Manager 2 thinks it is not highly relevant, that a leader just needs to fully understand the business and announce a digital strategy, and that there will be professional people to do digital projects, e.g., outsourcing. Employee 1 thinks it is not highly relevant, that the bigger the company the clearer the organisation and the more specialised departments there are, and that there will be employee 2 believes that it is highly relevant and that developing a strategy requires leadership experience and knowledge.

Table 4: Relationship with personal qualities of the leader

Interviewee	Yes or No	Reasons
Plant Manager	Yes	The strategy and literacy required to anticipate the future
Manager 1	Yes	Forecasting; transferring concepts and structures to staff
Manager 2	No	There is a professional team to do it
Employee 1	No	The larger the company the less relevant it is, as there is a dedicated department
Employee 2	Yes	Requires leadership with a sense of designated strategy

The perception of whether digital transformation is relevant to the age group of the company's employees was very uniform across the interviewees, with a strong correlation between age and perception of relevance, with younger employees being more receptive to new things, having lower learning costs, being more receptive, thinking more actively, and being more comfortable with this digital tool and more enthusiastic about learning about it.

“For most people, as they get older, their mindset is gradually solidified. The more difficult it is to accept something new, the more inertia he has in his thinking, which means the higher the learning cost.” ---Employee 2

4.5.3 Management structure for the digital transformation projects

Digitalisation projects require different management structures depending on the situation; Plant manager believes a strong matrix model is best suited for the manufacturing industry, which needs to manage digital tools and platforms in a unified manner. Manager 1 believes that it is better to use strong matrix management at the beginning of the overall digital transformation of the company, but once the digital platform has been established and a certain level of digital awareness has been reached by all employees, a transition to a weak matrix can be made for subsequent projects. Manager 2 believes that a weak matrix approach is preferred, especially for cross-functional, cross-plant, and even cross-country digital transformation projects, or a weak matrix approach when a professional consultancy is used directly for digital transformation and an internal team manages the project. According to Employee 1, digital transformation must be managed in a strong matrix within large multinational manufacturing companies because of its importance, and the digital manager should be at least half or one level above those he works with. Employee 2 believes that in manufacturing companies, a weak matrix approach is preferred to management because digitalisation is a long-term ongoing process for such companies, unlike in the IT industry, where project lifecycles are shorter,

delivery times are faster, and the project can be transferred to operations and maintenance after it is delivered.

“In fact, there are many problems in moving projects forward, such as practical difficulties, but it is much easier to drive the process through the business units themselves, rather than a separate project team.” ---Manager 1

4.5.4 Digital transformation of companies in relation to suppliers

About how to implement digital transformation and the results of digital transformation with their suppliers. Based on the interviewees' responses, **Figure 2** shows five areas of intervention. First, it is necessary to encourage suppliers to implement or use the results of the digital transformation in accordance with the company's requirements. The second step is to select suppliers with strong associations to implement digital transformation in your own production lines, and to comply with confidentiality agreements other companies have with their suppliers. A third method is to select suppliers who have already implemented digital tools. The fourth step is to form a community of interest, to find a win-win model that can help suppliers to lean production and reduce costs, but also to gain a greater voice and become a community through stock ownership. Fifth, suppliers must develop digital awareness and implement digital transformation from a long-term cooperation perspective.

Plant managers and managers reported there was not much resistance to implementing digital transformation with suppliers, whereas employees reported a lot of resistance, especially due to the lack of digital awareness among suppliers and the fact that grassroots staff members were the most resistant.

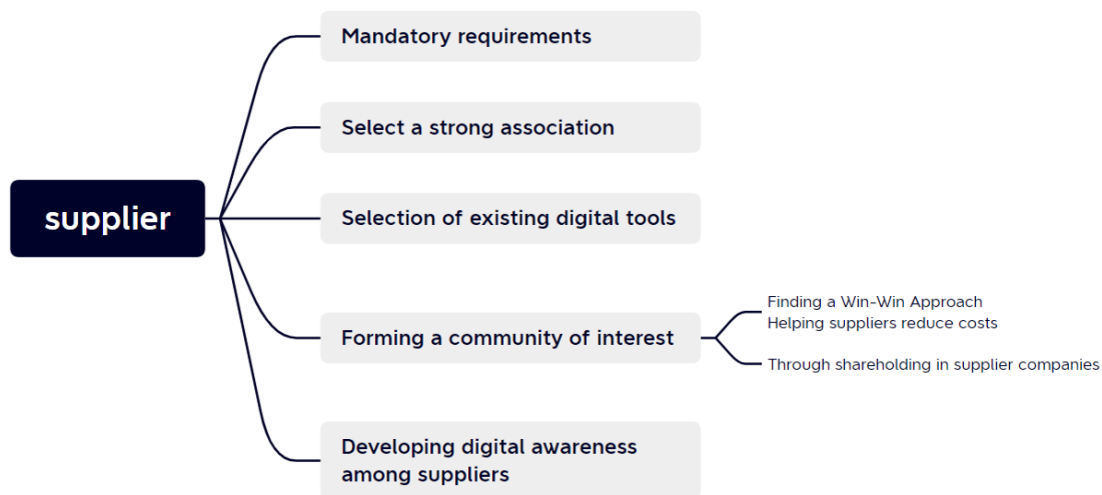


Figure 2: Digital transformation with suppliers

4.5.5 Barriers and solutions

There are many obstacles to the digital transformation process (see **Table 5**), one of the most frequently mentioned by all the interviewees is that companies are going digital for the sake of going digital, which is a trend that has been catching up with companies in recent years. investment also requires great care. There are three ways to address this: firstly, by ensuring that the people leading digital transformation projects have a good understanding of the business and its needs; secondly, by holding digital competitions within the company and judging whether digital projects are worthwhile through competition and setting criteria in the process; and finally, by communicating fully with frontline employees to understand what the business really needs. The second obstacle is how to provide detailed data that matches the requirements of the digital transformation project. The solution is to clarify the direction and the layers that need to be achieved at the beginning of the project. The third obstacle is the lack of cooperation from grassroots employees. The solution is to find a win-win common ground of interest to convince employees. The fourth obstacle is that leaders are overly optimistic about the results of the digital transformation and have made early redundancies and staff transfers.

The solution is that leaders need to check the project regularly during implementation in order to be fully informed and employees need to provide transparent and accurate data to leaders. The fifth obstacle is the pressure of the cost of digital transformation and the potential loss of significant costs if the results are not applicable. The solution is to outsource to a specialist digital transformation agency to reduce the cost of staff turnover and increase the success of the transformation.

Table 5: Barriers to implementing digital transformation and potential solutions

Barriers	Solutions
Digital for digital's sake, bad decisions Determining whether a project is worth investing in	Ensure digital talent fully understands the business
	Conducting a digital transformation competition to continuously evaluate the usefulness of projects in the process
	Understanding the needs of end-of-line staff
Provide data for digital transformation with matching levels of detail	Clarify the direction and the level of digitalisation that needs to be achieved when developing the strategy
Uncooperative grassroots staff	Finding win-win benefits to convince employees
Leaders are overly optimistic about the results of digital transformation and	Regular checks during the project implementation phase to fully understand, Data Transparency

make early redundancies or staff transfers	
The pressure of costs associated with the success of digital transformation	Outsourcing to specialist agencies

“Digitisation for the sake of digitisation will only disrupt all our information and create chaos, and it brings with it an increased likelihood of poor decision-making.” ---Plant Manager

“This business employee at the very end of our business is the one who understands the business processes best. These needs are actually triggered by the employees at the very end. Or the top level throws out a question and the person at the end of the line answers it in order to get the most realistic feedback. The leader then chooses from this feedback what must be met at a certain cost, because the cost is not infinite.” ---Employee 1

4.5.6 Methods to reduce cost

The above summarises the main costs in digital transformation and, according to the research, there are a number of methods to reduce them (see **Table 6**). They are divided into three areas: labour, process and result. Firstly, in terms of workforce, developing the digital skills of business-savvy people reduces the high cost of finding and hiring external talent; choosing new employees with high learning ability to acquire digital skills in a shorter period of time, and developing a company-wide digital campaign to develop employees' interest in digitalisation and self-directed learning to reduce costs through employee self-drive. Secondly, in terms of process, costs can be reduced by communicating with frontline business people in the early stages of a digitisation project in order to understand the real business needs and to prepare

before investing a lot of manpower and resources; by accumulating and summarising digitisation experience in the course of the project; and by creating some standardised digitisation templates. Finally, in terms of results, we calculate the manpower savings at the end of the digitisation project, rationalise staff arrangements, minimise unnecessary staff turnover and reduce the cost of redeployment and recruitment.

Table 6: Methods to reduce cost

Type	Methods
Labour	Developing the digital skills of business-savvy people
	Choose employees who are good learners when hiring
	Digitalisation of the whole workforce, increasing employee self-drive by developing interest
Process	Refine processes to fully understand business needs
	Accumulating and learning from digital transformation experience
	Create some digital transformation templates
Result	Carefully assess the labour savings of the project to prevent unnecessary staff turnover

“We have started to digitise the whole staff, everyone has to have this mindset and everyone better have this skill then as soon as a person has this interest, then he will become a digital master.” ---Manager 1

“By communicating the operational processes to the smallest detail, the cost of developing something that is properly used will not be wasted.” ---Employee 2

Plant managers and managers save money mainly in terms of staff development and hiring, while employees save money mainly in the implementation and closing stages of projects.

4.6 The future of digital transformation in manufacturing

As **Figure 3** shows, there are various future directions for digital transformation. The first is to emphasise the greater role that machines will play in the workplace, where problems can first be analysed by machines, where machines can learn, where machines can judge, where they can assist humans in solving problems and where they can reduce work errors. The second is to focus on developing human-machine interaction. The third is to make people's work more convenient and easier, for example by reducing human workload through machines and improving human happiness. The fourth is that digital transformation will gradually transition from manufacturing to upstream suppliers, enabling digital transformation of the entire supply chain. The fifth is smart manufacturing, where more factories will transition from traditional manufacturing methods to smart manufacturing and create smart factories. The sixth is people-centric, starting with the needs of the business.

Although each interviewer expressed different predictions on the future direction of digital transformation, they all expressed that digital transformation is developing around the needs of people themselves and will continue to adhere to this direction in the future.

“Because our needs for the future are becoming more and more complex, and the highly decentralised customer needs have led to an increase in our labour costs, I think that for the manufacturing industry, the aim is to make our work simpler and more efficient. The specific direction is, of course, to make our business grow in a healthy way while keeping costs under control.” ---Plant Manager

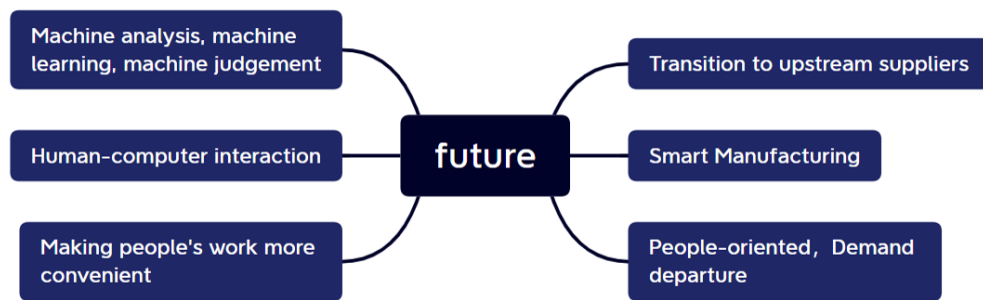


Figure 3: The future of digital transformation

5. Discussion

This paper addressed the following research questions: *What is the influence of digital transformation on manufacturing firms?* and *What are the experiences with digital transformation in manufacturing firms?*

Based on the results of the interviews, the first is the benefits of digital transformation, where the positive effects on the operation and the firm are very similar to the benefits stated in the literature review, but the interviews revealed more benefits for the employees of the company, and the leaders of the company are more concerned about the effect of digital transformation on the employees. Secondly, the disadvantages and risks of digital transformation were identified. The issue of digital security, which has been frequently mentioned in previous studies, was not mentioned in the interviews, suggesting that such issues are less frequent in practice (Matt *et al.*, 2015). In terms of costs, wasted costs due to project failures were recognised in both the interviews and the literature review as an issue of great concern. Rather, the risks of labour, which were rarely mentioned in the literature review, were highlighted in the interviews, particularly in terms of hiring and employee satisfaction. Finally, in terms of costs and ROI, the literature review on costs is very scarce and the lack of literature in this area is complemented by the fact that the main costs of digital transformation were identified in the

interviews in the areas of labour and time, R&D and outsourcing, especially in terms of hiring and training digital talent, which is more expensive than expected. Some of the methods used in the ROI section of the literature were not mentioned in the interviews, probably because the interviewees' main business is not financial, but they all said that digital transformation is worthwhile and necessary in the long run.

In the literature review, there are three sequences of digital transformation: bottom-up, top-down and improvisation. Based on the interview results, it can be learned that digital transformation in the manufacturing industry is more of a top-down sequence, usually for the top of the company to develop a good digital transformation strategy first. According to the interview data also the specific transformation order of the supply chain related departments was obtained. In terms of the link between the characteristics of a company's workforce and digital transformation, the literature review shows the role of personal qualities of leaders in digital transformation, such as the need for leaders to develop strategies, spread digital awareness and coordinate efforts, as well as the damage that can be caused to a company if leaders digitise blindly and aggressively, all of which were confirmed in the interviews (Khin and Ho, 2018). Less attention was paid in the literature review to the role of the quality of employees in digital transformation, and the correlation between the age group of employees and the learning and application of digital tools was drawn from the interviews (Fischer *et al.*, 2020). Regarding the management structure of digital projects, three management models are mentioned in the literature review, and according to the interviews, in practice companies tend to use a strong matrix approach to managing digital transformation projects, with a digital manager leading a dedicated project management staff for digital projects. This is also mainly due to the complexity of digitalisation projects and the tight timeframe. The research on the implementation of digital transformation to suppliers emphasises the importance of respect, trust and win-win situations, as well as the need to integrate resources and value data from both

sides, which was confirmed in the interviews, which also revealed the possibility of training suppliers on digital awareness and requirements for supplier selection (Saarikko *et al.*, 2020). However, there was no consensus in the interviews on whether there was any resistance to the implementation of suppliers, probably due to the different perspectives of leaders and employees, who are the ones who work with suppliers. In terms of barriers and solutions, the interviews confirmed the literature review's concerns and lack of cooperation from the staff at the grassroots level, the barriers posed by the lack of digital awareness among leaders and the financial problems associated with the high costs and low short-term returns of digital transformation and provide solutions to the five identified barriers to digital transformation. Finally, given the limited literature on ways to reduce costs, and the interviews yielded three main solutions in terms of labour, process and result, filling the gap in this area.

6. Conclusions

This paper explored what impact digital transformation has had on manufacturing companies and what lessons can be learned, to provide lessons for subsequent digital transformation in large companies and even in small and medium-sized enterprises, to improve the success of the transformation and to increase the survival and competitiveness of companies in the era of Industry 4.0. To achieve this, semi-structured interviews were carried out with managers and employees at five large multinational manufacturing companies with extensive experience in digital transformation. The study also explored the impact of digital transformation on manufacturing companies in terms of pros and cons, risks and costs, as well as the sequence of digital transformation, the relationship between workforce attributes and digital transformation, the management model of digital projects, how digital transformation projects are implemented in supplier companies, and the barriers to digital transformation, which are particularly critical in real-world company operations. This study fills some of the research

gaps and lacunae in these areas and provides relevant lessons for companies undergoing and will undergo digital transformation in the future.

In terms of future research, firstly, supply chain management is an especially important part of manufacturing companies, and more research could be done on the order of transformation of digital transformation in supply chain-related departments. The funds allocated to digital transformation in practice are limited, so it is particularly important to clarify the order of transformation. Secondly, the results of the study show that in practice managers are paying more attention to the development of digital transformation awareness among their staff, and research into how to make digital training more efficient and systematic is a topic that needs to be looked at in the future. Furthermore, more research and solutions are needed on how to increase the digital awareness of managers and how to limit the negative impact of leaders in digital projects. Finally, there is also an urgent need to focus on how digital transformation can be implemented to the second, third and even more source suppliers. Digital transformation is still in full swing and there will be a great deal of experience generated over time, and it is important to take stock of the lessons learned in time.

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Appendix: Semi-structured interview questionnaire

1. In your experience of working in the manufacturing industry, in which areas does digital transformation usually happen first?
2. In your experience, what is the sequence of digital transformation in the manufacturing industry?
3. Do you think the process of digital transformation in manufacturing is bottom-up (employee behaviour - company strategy) or top-down (company strategy - employee behaviour)?
4. Do you think digital transformation in the manufacturing industry is highly relevant to the quality of a company's leaders?
5. Do you think digital transformation in manufacturing is highly correlated with the age group of the company's employees?
6. Do you think the management structure of digital transformation projects in manufacturing companies is a strong matrix or a weak matrix?
7. How do you think digitalisation projects should be implemented to suppliers?
8. In your experience, what are the main costs of digital transformation in the manufacturing industry?
9. Do you think there are any ways to reduce the cost of digital transformation in the manufacturing industry?
10. In your work experience what do you think are the most common pitfalls and difficulties encountered in digital transformation in manufacturing Is the right and worthwhile part of digital transformation
11. How do you think we can avoid these pitfalls and difficulties and improve the success rate of digital transformation?

12. What do you think are the positive impacts of digital transformation in manufacturing on the company?
13. What do you think are the negative impacts of digital transformation in manufacturing on companies?
14. In your work experience, what do you think is the short-term return on investment for digital transformation in the manufacturing industry?
15. In your work experience, what do you think is the long-term return on investment for digital transformation in the manufacturing industry?
16. What do you think is the difference and connection between digital transformation and Industry 4.0 Industry 4.0 includes digital transformation?
17. What do you think is the direction of future digital transformation?