Transactional, Instrumental and transformational leadership: what is more effective for an Industry 4.0 transformation?

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ABSTRACT

In this paper the relationship between Industry 4.0 and leadership is researched. Up to now, leadership is often used as a change management tool, yet Industry 4.0 adoption consists of a longer time period, therefore the role of leadership may differ. A theoretical framework is proposed which shows the relationship between the Industry 4.0 maturity level and the leadership style that is mostly used to reach said maturity level. This research consists of a mixed-methods approach: 16 leaders were interviewed about the used Industry 4.0 technologies in their organization and their leadership style. In the second phase the insights gained from the interviews were discussed with seven experts in a focus group. The data suggests that transformational and instrumental leadership are more effective for an Industry 4.0 implementation than transactional leadership. Furthermore it is suggested that there may be a relationship between the Industry 4.0 maturity level of an organization and the leadership style. The interviews suggest that transformational and instrumental leadership is used more in organizations with a higher Industry 4.0 maturity. The opposite goes for transactional leadership. The theoretical implications are that ideal leadership behaviours during an industry 4.0 transition is a combination of transformational and instrumental leadership. Therefore managers are advised to involve their followers in the vision and strategy formulation, ensure there is a larger vision and make use of the knowledge capabilities of the employees.

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Industry 4.0, Full-range theory of leadership, Maturity model, Change management, Exploratory, mixed-methods research design

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1. INTRODUCTION

The fourth industrial revolution is taking the world by storm. There have been several industrial revolutions in the past. The first one being mechanization, the second is the use of electricity the third digitalization and now Industry 4.0, also called Smart Industry (Lasi et al., 2014). Industry 4.0 means for manufacturers to make a transition to a dynamic and smart version of their manufacturing process. This can be done by adopting, amongst others cyber-physical system technologies (Tortorella et al., 2019). Many companies are planning to take steps to, or have started making their workplace more digital and often these are not accessed from a fixed physical place anymore (Dahlan et al., 2018). However this advancement of the digital workplace differs a lot per industry, and while some industries are further ahead, bigger companies also tend to have more resources to implement changes such as Industry 4.0 practices (Mittal et al., 2018).

When implementing a change like digitization, the leadership style of management can be an important and useful driver. One popular leadership theory is the full-range leadership theory. The full-range leadership theory, consisting of transformational and transactional leadership, provides leadership styles that can be adopted by anyone and that proven effective leaders can apply both transactional and transformational leadership (Bass, 1985). Antonakis and House (2014) suggest that this full-range leadership theory is incomplete and therefore added instrumental leadership as a more pragmatic approach and considered it a “fuller full-range” leadership theory. It has already been proven that transformational leadership can be very effective, when implementing change, especially for radical innovations (Bass, 1990; Nijstad et al., 2014). Furthermore, a transformational leader with a strong motivation can positively impact follower motivation (Gilbert & Kelloway, 2018), which in turn can help the success of the change. However employees may react very differently towards the Industry 4.0 transition, depending on their perspective and the level of emotion that plays a role (Schneider

& Sting, 2020), similarly, the emotions of employees may fluctuate during a change (Ashkanasy et al., 2017). Next to that, the transition to Industry 4.0 is not an immediate change, and often happens in stages, the so-called maturity stages. These maturity stages describe different levels of Industry 4.0 adoptation (Mittal et al., 2018). Therefore other leadership styles, besides transformational leadership may provide a better fit for some stages.

In this thesis the different sub-dimensions of transformational, instrumental and transactional leadership are compared to different maturity stages of Industry 4.0 development using interviews. Since the maturity stage of the organization as a whole is assessed the interviews are held with top level managers and directors. Based on the results a proposed framework is formed to see which leadership style should be most effective during which maturity stage.

When transitioning to the first maturity stage, employees are introduced to Industry 4.0 or sometimes artefacts of Industry 4.0, they need to adapt to its way of working, which can have strong consequences (Cirillo et al., 2021). However when transitioning to the final maturity stage, the employees already know the concept of Industry 4.0, however, this change may be more complicated and it may be beneficial to implement it step by step (Calabrese et al., 2020), in turn resulting in different change management and possibly different leadership approach. The combination of leadership and Industry 4.0 is a relatively unstudied topic in the Industry 4.0 transition. This research seeks to fill that knowledge gap and does so using a maturity model of Industry 4.0. As this is an exploratory research the aim is to provide insights in a nascent theory of leadership styles in relationship to different Industry 4.0 maturity levels. However, as the data gathered is qualitative in nature, further research will need to confirm this theory.

In order to fill the research and practical gap the following research question is proposed:

How can an effective manager's leadership style support the transition across organizational Industry 4.0 adoption maturity stages?

In order to answer this research question the following sub-questions will be answered:

1. To what extent does leadership impact the effectiveness of the Industry 4.0 transition?
2. Which effective leadership behaviours can be observed per Industry 4.0 maturity stage?
3. How can a leadership style contribute to an effective Industry 4.0 transition?
4. What is the effectiveness of each leadership practice in an Industry 4.0 transition?

In terms of practical implications the effectiveness of different leadership styles is measured during different maturity stages, this can give managers and leaders the know-how on when which style of the fuller full-range leadership theory should be used. This in turn may smoothen the transition to Industry 4.0. Next to that insight is given in the possibility of how leadership may impact change management and the transition over a longer period of time.

2. THEORETICAL BACKGROUND

2.1 Leadership

Leadership is a topic that is divided in terms of literature. Research since 2000 has covered a multitude of leadership styles and theories, including but not limited to: transformational leadership, shared leadership, authentic leadership and ethical leadership (Anderson & Sun, 2017). These leadership theories have overlap and some are more often used than others. There has been extensive research on leadership, which is the reason why so many theories and the success of a leadership style is dependent on the context, like personality, situational context and culture as well (Asrar-ul-Haq & Anwar, 2018).

One most often used is the full-range leadership theory, with transformational and transactional leadership (Anderson & Sun, 2017; Bass, 1990). However, since this theory omits a pragmatic approach Antonakis and House (2014) have added instrumental leadership to this theory. This leadership theory is used in this research for several reasons, firstly the concepts of transformational, transactional and instrumental leadership are exhaustive (Antonakis & House, 2014; Hughes et al., 2018). The addition of instrumental leadership prevents the possible

inflation of the results, as a leadership style may be relatively higher to the other one, thus preventing a possible omitted variable bias. Secondly, there is extensive earlier research about transformational and transactional leadership in relation to innovation (Anderson & Sun, 2017; Bass, 1990; Bednall et al., 2018; S. Gilbert & Kelloway, 2018; Nijstad et al., 2014). As instrumental leadership is long-term oriented and has a goal-setting approach, this may provide a useful addition in a long transition. Thirdly the idea behind the full-range theory is that leaders may and can use each of the leadership styles interchangeably (Anderson & Sun, 2017; Antonakis & House, 2014; Asrar-ul-Haq & Anwar, 2018; Bass, 1990).

Both transformational and transactional leadership were introduced by Bass (1985) who described transformational leadership as the process where the leader inspires confidence and elevates the value of outcomes by expanding the interests of the followers, transactional leadership on the other hand is described as an exchange process where followers' needs are met if they meet a set of performance measures (Bass, 1985).

Transformational leadership is generally based on four different sub-dimensions (see, also, Table 1): idealized influence (i.e., charisma), inspirational motivation, intellectual stimulation, and individualized consideration (Bednall et al., 2018). Idealized influence is the degree to which a leader behaves admirably and causes followers to identify themselves with the leader (Judge & Piccolo, 2004). Inspirational motivation is the degree of communication of the vision so it inspires and motivates the followers using behaviours that add emotional qualities (Bednall et al., 2018; Judge & Piccolo, 2004). The dimensions of intellectual stimulation refer to the leader challenges assumptions, takes risks and asks for follower's ideas (Judge & Piccolo, 2004). Lastly, individualized consideration refers to the mentoring and coaching of the followers attending to their psychological needs (Bednall et al., 2018; Judge & Piccolo, 2004). This individualized consideration also increases the level of autonomy according to Gilbert et al. (2017).

Transactional leadership	Transformational leadership	Instrumental leadership
Contingent reward	Idealized influence	Environmental monitoring
Management by exception (active)	Inspirational motivation	Path–goal facilitation
Laissez-faire	Individualized consideration	Outcome monitoring
Management by exception (passive)	Intellectual stimulation	Strategy formulation

Table 1 Literature-based sub-dimensions of transactional, transformational and instrumental leadership (Antonakis & House, 2014; Bass, 1990; Bednall et al., 2018; Judge & Piccolo, 2004)

Transactional leadership is mostly viewed as an exchange process. It is represented as setting objectives and monitoring outcomes (Bass, 1985). The transactional leadership style has a strong focus on clarifying roles and tasks. A transactional leader typically encompasses four key dimensions (Table 1): contingent reward, management by exception (active), laissez-faire and management by exception (passive). In some studies laissez-faire is seen as a leadership style on its own, however as this leadership style is about abdicating responsibility and avoiding decision making (Bass, 1990). To not omit this variable and as it can be partially applied this is included in the transactional leadership, furthermore there is a strong overlap in the use of management by exception (passive) if laissez-faire and transactional leadership were to be separate. The dimension contingent reward means that if an objective is met the employee gets

rewarded (Bass, 1985). An important notion to this contingent reward is that it needs to be an explicit reward, for an implicit reward is more associated with transformational leadership (Goodwin et al., 2001). Management by exception (active) means that a leader is actively searching for deviations (Aga, 2016; Bass, 1990). Management by exception (passive) means for a leader only to take action if there is a serious problem and standards are not met (Aga, 2016; Bass, 1990). Though transactional may be often considered as ineffective, this is not always true, the provision of structure transactional leadership initiate results in higher leader effectiveness (Hoogeboom & Wilderom, 2019).

Instrumental leadership was introduced to add a functional or pragmatic dimension to transformational and transactional leadership (Anderson & Sun, 2017; Antonakis & House, 2014). Instrumental leadership is defined as: "the application of leader expert knowledge on monitoring of the environment and of performance, and the implementation of strategic and tactical solutions" (Antonakis & House, 2014). Instrumental consist of environmental monitoring, path-goal facilitation, outcome monitoring and strategy formulation (Table 1). Environmental monitoring is the degree to which the leader is actively scanning the internal and external environment (Antonakis & House, 2014). A leader's behaviour towards supporting goal attainment and goal clarification is called path-goal facilitation (Antonakis & House, 2014). Thirdly Antonakis and House (2014) describe outcome monitoring as the leader giving feedback in order to improve performance. Lastly, the degree to which leaders actions are focussed on developing goals, objectives to support the strategic function is considered strategy formulation (Antonakis & House, 2014). In Table 1 the three leadership styles are listed with the different factors that compromise them.

There is some overlap between the leadership styles and their sub-dimensions. Rowold (2014) argues that this overlap exists in the following points

- When leaders are formulating a vision, a strategy can be designed to achieve this vision.
- The leaders can scan the environment for resources to achieve the vision and provide their followers with the necessary resources.
- When leaders have engaged with followers with the purpose of strategy formulation, they will consequently assign tasks and define goals.
- After transactional goals are formulated, the leader can make use of outcome monitoring to give appropriate feedback.

However, as a leader has limited time the leader will likely only focus on one or two leadership styles and thus instrumental leadership can still be researched as a unique and valid approach (Rowold, 2014).

2.2 Industry 4.0 adoption and the role of leadership

In this study the role of top-managers is analyzed. This is done as they have an impact on the Industry 4.0 adoptation of not only their followers, but also the organization as a whole (Oreg & Berson, 2019). Furthermore, the functions of the top-managers interviewed mostly correspond with the most relevant Industry 4.0 role. For example, the head of operational excellence, chief operations officer or chief innovation & digital officer.

Industry 4.0 is an umbrella term, for multiple new technologies and practices (Dalenogare et al., 2018). Like previously stated, one of these technologies is cyber-physical systems, but there are many more. Bai et al. (2020) provide an elaborate, but not exhaustive, list of technologies: Additive manufacturing, artificial intelligence, augmented reality, autonomous robots, big data analytics, blockchain, cloud, cobotic systems, cybersecurity, unmanned aerial vehicle, global positioning system, industrial Internet of Things, mobile technology, nanotechnology, RFID, Sensors and actuators and simulation. These new technologies bring opportunities and challenges with them. Table 2 gives an overview of several opportunities for organizational development and challenges in terms of the transition and change management, based on Bai et al., 2020; Dantas et al., 2021; Gualtieri et al., 2021; Lasi et al., 2014; Schumacher et al., 2016. The challenges mentioned are not exhaustive but they can be effectively tackeled by applying leadership practices.

OPPORTUNITIES	CHALLENGES
Shorter development process	Higher chances for stress and burnouts
Individualization on demand	Physical employee safety
Flexibility	Increased cognitive load
Decentralization	Loss of motivation, due to fear of unemployment
Resource efficiency	Highly complex change
Optimization of energy use	Lack of clear Industry 4.0 vision
Circular business	Failure to asses capabilities
Reliable production processes	
Waste management	
Promotion of renewable energy	

Table 2 Opportunities and challenges of Industry 4.0 (Bai et al., 2020; Dantas et al., 2021; Gualtieri et al., 2021; Lasi et al., 2014; Schumacher et al., 2016)

Many of these opportunities can provide managers with a reason on why to (partially) implement Industry 4.0 and the challenges can be a barrier. Furthermore, leadership can help lower the barrier to many of these challenges. According to Simetinger and Zhang (2020), effective leadership can help overcome complex change. Transformational leadership can lower stress levels (Yao et al., 2014). Safety specific transformational leadership can lower employee safety (Xia et al., 2021). Transformational leadership can play a reducing factor for the cognitive load as well, but it is debatable whether it is a causal relationship (Hentrich et al., 2017; Maurer & Lord, 1991). Van Dun & Kumar (2021) suggest that the fear of unemployment can be lessened if the managers have a clear vision and serious attention to employee's sentiment. A clear Industry 4.0 vision is something that can both be provided by Instrumental,

transactional and transformational leadership in a different form (Aga, 2016; Antonakis & House, 2014). And lastly, leadership can play an effective role in enhancing knowledge management around capabilities (Shamim et al., 2016).

Hence, leadership may play an important role in overcoming Industry 4.0 challenges. However, as the Industry 4.0 transition takes place during a longer duration, challenges may arise and grow during different maturity stages. Therefore the leadership styles are mapped onto an Industry 4.0 maturity model.

2.3 Maturity model

A maturity model is a framework in which the effective realisation of an organizational transition is defined using different stages (Wagire et al., 2020). The previous development of several Industry 4.0 maturity models allows for a selection of an established model that fits this study best.

The maturity model is selected based on several criteria:

- The model can be applied across industries
- The model gives an overview of the organisational industry 4.0 performance across multiple dimensions
- The model needs to have been developed in the last four years to ensure relevance and inclusion of recent developments
- The model needs to have at least four maturity levels

The model needs to be able to be applied across industries since the study is addressing the Industry 4.0 development in a not sector-specific manner. Furthermore, as the study is aiming to give an overview of the relationship between leadership and Industry 4.0 development in the organization as a whole, the model needs to measure not just one department or aspect of the Industry, but all or almost all. The fourth industrial revolution is a still-developing field of research, therefore the model needs to give a contemporary overview, and it therefore needs to be published recently. Our study requires some level of specificity of the maturity model to develop a relevant leadership Industry 4.0 model, therefore the arbitrary amount of levels of at

least four is chosen as it allows to differ enough per level, but also is specific enough. If there are three or fewer maturity stages, the difference between the stages may be too big and therefore resulting in inconclusive results.

The research by Simetinger and Zhang (2020) provides a good starting point for the maturity model selection. Based on the aforementioned criteria the following two maturity models can be selected: M2DDM, Maturity Model for Data-Driven manufacturing (Weber et al., 2017) and Industry 4.0-MM, Assessment model for Industry 4.0 (Gökalp et al., 2017). These models both focus on service-oriented architecture and can therefore be applied to information systems organizations. However, even though both the model by Weber et al. (2017) and Gökalp et al. (2017) can be applied well to the computer technology sector they have less relevance in the operations management area of Industry 4.0.

Based on the research of Simetinger and Zhang (2020) there is therefore not a good fit for this study. However, they did not take into account the more recent maturity model provided by Wagire et al. (2020). This maturity model can be applied across industries, gives an overview across different dimensions, has been developed recently and has 4 maturity levels and fits, therefore, all requirements. As the model uses weights to calculate the scores for each dimension, as well as for the total maturity level, the maturity level of a non-manufacturing firm can also be calculated with this model. Next to that in the model of Wagire et al. (2020), several soft assessment criteria are also taken into account, amongst which leadership. However as in this study, the soft assessment criteria are already researched, these questions will not be taken into account. Wagire et al. (2020) proposes a maturity model with the levels outsider, digital novice, experienced and expert. The level outsider means that there are no or limited exposure to Industry 4.0 activities, nor plans to implement the Industry 4.0 technologies and therefore have a maturity score between 1 and 2. The level 4 expert means that the organization has successfully implemented all or most Industry 4.0 technologies. The levels in between, two

and three, mean that Industry 4.0 is somewhat implemented, but there is room to improve. The model consits of 38 assesment criteria, however as leadership is also a research area, the 14 soft assesment criteria are not taken into account, as a large overlap would then exist. The dimensions and assesment criteria are presented in table 3.

Value chain and processes	**Smart manufacturing**	**Products and services**	**Base technology**
Digitalisation of vertical value chain	Autonomous and collaborative robots (Cobots)	AR/VR/MR	Cloud computing network for resource sharing
Real time monitoring and control	Software systems like ERP	Additive manufacturing	Cloud computing network for data stroring
End-to-End IT planning	Identifiers (bar/QR codes)	Mobile devices and wearbles	Internet of Things
Digitalisation of production equipment	Intelligent sensors	Blockchain technology	Internet of services
Digitalisation of horizontal value chain	Machine to machine and human to machine communication	Smart product	Big data
	Digital platforms for supplier integration		Simulation tools

	Digital platforms for customer integration	Artificial intelligence
		Industrial cyber security

Table 3 Industry 4.0 maturity model based on Wagire et al. (2020)

2.4 Change management

To deal with employee resistance to the change and to implement change more smoothly change management can be used. However the transition to Industry 4.0 is not an instant one or a single change, yet a collection of mutliple changes during a longer period. Therefore regular organizational change management practices to are possibly not enough, as the short-term as well as the long-term conflicts need to be overcome paralelly (Kemp et al., 2007).

In order to facilitate a long term transition with multiple changes, maturity models can provide structure. In fact, Industry 4.0 applications can be seen as a change management pull (Lasi et al., 2014). This means for instance that the transition to a shorter development process is a change, which requires change management practices, but this single change does not mean that Industry 4.0 as a whole is adopted. Simply put, in a transition a large collection of smaller changes happen. Change management methods can therefore be used as a tool for each small step and they can support the culture change, which is required over the long term (Kemp et al., 2007).

When an organization stimulates change, like in a lean culture, the Industry 4.0 organizational structure was fitted better to adopt the technology and this allows for a smoother transition (Cimini et al., 2020). This can be due to the lean concept of placing responsibility lower in the organization (Ingvaldsen & Benders, 2016), which is also a common practice in Industry 4.0 adoption (Cimini et al., 2020).

Another complication for change management is that, since the Industry 4.0 transition is a digital one, most companies are not used to operating digitally and even small-scale digitalization efforts can create large resistance (Kadir & Broberg, 2020).

Thus, in order to use change management practices, managers need to focus on the implementation of new digital technologies. Kadir and Broberg (2020) propose to look at implementing new technology in three steps, before during and after and for these three phases they propose the change model in figure 1. This change management model addresses many of the challenges of Industry 4.0 presented in Table 1. Important to note is that this change management model is suitable for one technology implementation, for instance this could be used for the implementation of additive manufacturing, thus suitable for a single change. For instance, of the before phase, A and B address the clear Industry 4.0 vision and C and E address the assessment of capabilities. Implementing the new digital technologies successfully can thus be supported by change management.

Figure 2 depicts how a manager should go about managing a technology change. Calabrese et al. (2020) discuss barriers for a successful implementation of Industry 4.0 technologies and how the right goals can guide the implementation. One thing that stands out is that to find the right technological enablers in order to achieve the goals there are different classifications of the type of technology they enable.

Change management is closely linked with leadership, in fact in business organizations, the type of leadership has a direct relationship with a commitment to the change and around 30% of this commitment to change can be explained by leadership (Hechanova & Cementina-Olpoc, 2013). Abrell-Vogel and Rowold (2014) estimate a similar percentage of commitment. The change management model can support the leader to increase the commitment to change.

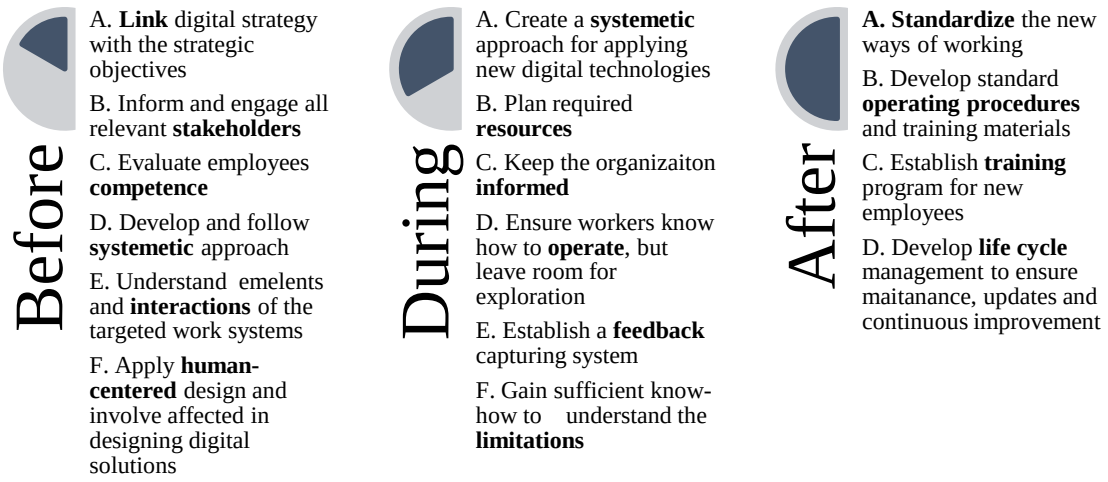

Figure 1 Change management digital transformation adapted from Kadir and Broberg (2020)

Though change management can provide a useful support for the technology implementation, Industry 4.0 as a whole is better considered as a transition. And, as Kemp et al. (2007) explain, a strong vision and good leadership is very important in such a transition. Therefore leadership may play an even more important role than in change management.

3. METHODOLOGY

3.1 Research design

In order to research the different maturity stages in comparison to the leadership style, an interview method will be applied. As this is an exploratory research interview in a nascent research field the goal is to form a conceptual framework and contribute to theory building. A mixed-methods approach is used, with interviews and focus groups. These research methods are by nature open-ended and therefore provide a good starting point for a nascent research field (Edmondson & McManus, 2007). The interviews with leaders involved in or guiding the industry 4.0 transition at different maturity levels gave insight in the current state of development of the topic, and the focus groups were used to give practical insights. A more elaborate methodology can be read below.

3.2 Sampling of interview and focus group participants

The sampling for the interviews and observations is partially based on the four-step approach by Robinson (2014) and partially convenience sampling (Farrokhi & Mahmoudi-Hamidabad, 2012). The four steps used are: a) define a sample universe, b) decide on a sample size, c) devise a sample strategy and d) source the sample (Robinson, 2014).

The first step, define a sample universe, is about setting inclusion and exclusion criteria. The sampling is partially homogeneous and partly heterogeneous. In the study designated leaders are selected who played a prominent role in the Industry 4.0 transition, in this sense they are homogeneous. This can be the leader of the transition in general, the head of a department or a leader who fulfilled another prominent role in the transition, the exact role the leader played is based on convenience sampling. However, organisations are selected that have gone through different maturity stages of the Industry 4.0 transition. For example, leaders who are experimenting with certain technologies and leaders who see Industry 4.0 as one of their central selling points. In that sense they are heterogeneous. The selection is taking place across industries, therefore there is no purposeful selection of organisations in terms of industry, for that selection there is no required level of hetero- or homogeneousness, yet as is visible in table four, organizations from eight different industries participated. Lastly, as this study is done in cooperation with a consultancy firm, the sample will all have some connection to this consultancy firm.

The sampling strategy is largely convenience sampling, but with some strong restrictions. As previously stated, the sample of the first phase interview requires the following restrictions: a) the leader had a prominent role in the Industry 4.0 transition and b) the organisation in which the leader performed the change is somewhat engaged with Industry 4.0 technologies. This means that from the technology-related dimensions provided by Wagire et al. (2020) at least one dimension has a score of two or higher, this selection was done by a gatekeeper

organization. With these restrictions, the research will be narrowed down to avoid too much generalisation (Robinson, 2014).

The sourcing of the sample will be done by using study advertising, via another organisation as the gatekeeper, to acces the required participants (Robinson, 2014). Meaning that using the network of an organization multiple leaders were approached. The participants had full knowledge of what the study is about and, if interested, receive a presentation and have the possibility to ask questions at the end of the study. In total 16 leaders were interviewed, all between the estimated ages 40 and 60, from which each of the four maturity levels is covered at least once, but preferably twice. This amount allows analysing cross-case generalities, without too much data (Robinson, 2014). General leader demographics can be found in Table 4. Important to note is that the leaders all worked at different organizations, only in one case the leader worked at the same organization, yet in a completely different department.

Leader	Gender	Industry	Multinational organization	Industry 4.0 maturity score	Nationality	Position wihtin company
Leader 1	Male	Shipbuilding	No	1,9	Dutch	Managing director
Leader 2	Male	Energy	No	1,9	Dutch	Managing director
Leader 3	Male	Energy	Yes	2,1	German	CCO
Leader 4	Male	Energy	Yes	2,4	Dutch	Large team head
Leader 5	Male	Maritime	Yes	2,5	Dutch	COO
Leader 6	Male	Rail	Yes	2,5	Dutch	CEO
Leader 7	Female	Retail	yes	2,7	Dutch	Director
Leader 8	Male	Energy	No	2,8	Dutch	CFO
Leader 9	Female	Energy	Yes	2,9	Dutch	Large team head
Leader 10	Female	Energy	Yes	2,9	German	Department head
Leader 11	Male	Shipbuilding	Yes	3,1	Dutch	Director
Leader 12	Male	Manufacturing	Yes	3,1	Dutch	Director
Leader 13	Male	Energy	Yes	3,3	Dutch	Associate director
Leader 14	Male	Energy	Yes	3,3	German	Director
Leader 15	Female	Technology	Yes	3,4	German	Director
Leader 16	Female	Electrical engineering	Yes	4,0	Dutch	Department head

Table 4 Leader demographics with their respective Industry 4.0 maturity score as based on the interviews

A further look at the demographics reveals overlaps between the leaders, yet also highlights some difference. All the leaders are in some aspect in a technical industry. Even leader 7, who is active in the retail industry, mainly focusses on e-retail. 13 of the 16 leaders work in multinational organizations. Lastly all of the leaders work in high-level functions in organizations. Next to the directors and C-level officers, the department heads do have autonomy and can make decisions on their own. Leader 4 and 9 works in a cross department team centered on improvement processes, for leader 4 specifically centered on digital transformation and for leader 9 mostly on the change processes for improvement processes, amongst which digital transformations. Lastly, leader 13, though not at the director level, in the associate director role this leader does have a lot of autonomy and direct responsibility for multiple projects and processes in the organization.

Afterwards, two focus groups with in total seven experts were held to discuss the results and see if the findings are in line with their professional or academic experience. The experts were selected from the author's network on either their expertise with leadership and with the implementation of technological developments. The focus group participants had at least three years of experience in coaching leaders, studied relevant academic topics, and some had experience in implementing innovative solutions, such as Robot process automation (RPA). Lastly the experts did all have a background in the consultany. The ages of the focus group experts differed between mid 20 and mid 50. After the focus groups the interview results were recoded as they led to new insights.

Expert	Gender	Background	Expertise	Nationality	Seniority in role
Expert 1	Male	Consultancy	Sustainability	Dutch	Junior
Expert 2	Male	Consultancy	Leadership	Dutch	Senior

Expert 3	Female	Consultancy	Change management	Dutch	Medior
Expert 4	Female	Consultancy/ academic	Leadership	Dutch	Senior
Expert 5	Male	Consultancy	Change management	Dutch	Senior
Expert 6	Male	Consultancy	Change management and technology	Dutch	Senior
Expert 7	Male	Consultancy	Change management	Dutch	Senior

3.3 Data collection

As Edmondson and McManus (2007) suggest the interviews will be open-ended with guiding questions. However since only interviewing may give a biographical lens, which only highlights the study through the perception of the interviewees (May, 2012) another methodology is required to remove this bias.

Therefore a focus group is held afterwards. These focus groups have the goal to see if theory meets practice. All of the participants have extensive knowledge and experience in the implementation of new management practices, technologies and change processes in general. During the focus groups, the results, possible conclusions and anecdotes were presented in order to steer the discussion and gather meaningful results.

The interviews have an appreciative approach, as this approach fits well to both information system data collection as well as leadership data collection (Bäckström et al., 2018; Schultze & Avital, 2011). This appreciative approach has as benefit that it is focussed on change, but also fosters creativity of what can be, which helps to find the underlying values. Next to that appreciative inquiry, highlights the core capabilities, design requirements, success factors and aspirations (Schultze & Avital, 2011), which fits nicely with the purpose of the study, to find out what leadership style performs best with which Industry 4.0 maturity level transition.

The interviews have several goals, to find out what maturity level the firm operates at right now and to find out what leadership style got them there. The maturity model consists of 24

measurement items, therefore the research requires partially a structured approach. However to analyse the leadership style a more unstructured approach is required, as the assumptions and values behind the actions can be understood using this method (Bäckström et al., 2018).

3.4 Data analysis

The data gathered from the interviews are split into two parts. Firstly the data about the leadership style is abductively coded based on the grounded theory data collection models. Furthermore, the data analysis is iterative and exploratory. The data is analysed using careful reading, coding and analytical grouping. More specifically the data categorization and coding system provided by Gioia et al. (2013). This means that initially first-order concepts are created, these are informational labels, which are not yet categorized. These have then been made into theoretical concepts and partially categorized in the 2nd order concepts and lastly they were divided into aggregate dimensions, which describe overarching themes. These themes are partially based on the leadership themes but also other emerging themes. The data structure based on Gioia et al. (2013) can be found in the results chapter. The leadership related aggregate dimensions are pre-determined as the transformational, transactional and instrumental leadership. However the 2nd order concepts are not. In this research plausible abductive coding is used (Bamberger, 2018). Abductive coding allows to elicit tentative claims, thus in this case that translates to first open and explorative coding in the first-order concepts, which are then divided into 2nd order themes. These 2nd order themes are then matched to the aggregate dimensions as far as possible. This form of coding can than be used to narrow down the possible explanations of why and how leadership can positively impact the Industry 4.0 transformation.

The data gathered about the Industry 4.0 measurements are analysed using the measurement items provided by Wagire et al. (2020). As previously stated the maturity model consists of 24 measurement items, these measurement items can be split up in to four dimensions, according

to the model not all of equal size and weight (Wagire et al., 2020). Based on the maturity model developed by Wagire et al. (2020) the weights of each of the dimensions, adjusted to using only four of the dimensions, are as follows: Value chain & process 27%, Smart manufacturing technology 21%, product & services-oriented technology 24% and Industry 4.0 base technology 29%. Noteworthy are the large deviations in the product & services-oriented technology. This means that for calculating the end result the score of a dimensions are multiplied by the weight of the dimension and then added up. These items are rated based on the answers during the interview. For instance trials with 3D printing will give a score of 2/5, occasional use of 3D printing, for instance in research and development, a 3/5. Frequent and consistent use of 3D printing as a small step or for a small part 4/5, and 3D printing as a central part of the manufacturing process will give a score of 5/5. The lowest score is a 1/5, meaning no use of 3D printing. As the scoring is done by one external researcher, there are less arbitrary numbers, meaning trials with 3D printing will get the same score across different organisations. This makes them more comparable. On the other hand, it removes some of the detailed knowledge, so therefore some aspects of the technologies may be overlooked.

The focus groups were not coded, but they were transcribed. This enabled the possibility to review what was said during the focus groups, but at the same time allowed the results to be analysed tailored to the interview results.

3.5 Ethics

Ethics in research is essential to form an as objective as a possible perception of the reality, but also not to directly or indirectly harm any of the research participants. During this research, interviews are held and potentially sensitive information is discussed. During the set-up of the research, the ethics committee of the University of Twente accepted the research proposal. During the interviews anonymity was assured, the interviews were recorded, but secured on a

safe external hard drive. Lastly, in order to make sure that none of the information can be traced back to the individuals or the companies, the transcriptions were anonymized.

4. RESULTS

The sixteen interviews and two focus groups yielded the following results. Firstly a number based outline is of the results is presented in terms of industry 4.0. The leaders are divided in terms of maturity score and then based on the Gioia et al. (2013) method the qualitative results are discussed per aggregate dimension per Industry 4.0 maturity level. The focus groups are used to support the qualitative results per maturity level. The aggregate dimensions are based on the leadership styles (transformational, transactional and instrumental), but also organizational strategic development frequently came up during the interviews.

4.1 Industry 4.0 maturity

The industry 4.0 maturity scores are as presented in the chapter methodology - sampling table 4. When transcribing the maturity scores to maturity levels, there are two organizations at the outsider level, eight organizations at the digital novice level, five at the experienced level and one at the expert level. Meaning that the Industry 4.0 scores have significant discrepancies between each of the leaders. Leader 5 and 10 are at the outsider level, while leader 1 has the highest and can be classified as at the expert level. It is important to note that due to the nature of the research, the Industry 4.0 maturity score portrayed here is the leaders' perception of the Industry 4.0 development, rather than the actual Industry 4.0 maturity.

As the Industry 4.0 maturity can be split up into four dimensions, it becomes apparent that there are large deviations per leader per dimension. In Figure 3 the Industry 4.0 development is displayed with the scores per dimension, with a thick boarder at the change of levels; outsider, digital novice, experienced and expert.

Leader	Industry 4.0 score	Value chain & process	Smart manufacturing technology	Product & services oriented technology	Industry 4.0 base technology	Average Industry 4.0 score per industry

Leader 1	1,9	2,3	1,6	2,1	1,6	2,5
Leader 2	1,9	2,2	1,8	1,6	2,0	2,7
Leader 3	2,1	2,8	1,8	1,5	2,4	2,7
Leader 4	2,4	2,9	2,4	1,2	3,1	2,7
Leader 5	2,5	2,1	3,0	1,8	3,0	3,1
Leader 6	2,5	2,2	3,2	2,5	2,3	3,1
Leader 7	2,7	3,7	3,4	1,0	2,7	3,1
Leader 8	2,8	2,2	2,5	3,5	3,1	2,7
Leader 9	2,9	3,7	2,4	2,5	3,0	2,7
Leader 10	2,9	3,7	2,4	2,5	3,0	2,7
Leader 11	3,1	3,4	3,4	2,3	3,2	2,5
Leader 12	3,1	3,8	2,6	3,6	2,5	3,1
Leader 13	3,3	3,3	4,0	2,7	3,4	2,7
Leader 14	3,3	3,3	4,0	2,7	3,4	2,7
Leader 15	3,4	3,5	3,3	3,3	3,5	2,5
Leader 16	4,0	4,0	3,2	4,4	4,4	4,0
average	2,8	3,1	2,8	2,4	2,9	

Table 5 Industry 4.0 development per leader per dimension and Industry average, based on the industries provided in table 4

The dimensions portrayed in table 5 do not contribute equally to the Industry 4.0 maturity displayed in table 4. As stated earlier the dimensions do not contribute equally to the total Industry 4.0 maturity score. With the lowest contributing dimension smart manufacturing technology and the highest Industry 4.0 base technology.

Some industries only were only present once in the sample and therefore show no deviation from the industry average. In table 5 the Industry 4.0 score and their industry average are also displayed and there are some clear differences between the industry average and the scores of the leaders' perception of the Industry 4.0 score. Leader 1 and 15, belonging to the same industry, especially show a huge difference. This shows that there are other factors impacting the Industry 4.0 development and leadership may play a role.

Using the Industry 4.0 maturity model the leaders can be arranged into 4 categories; outsider, digital novice, experienced and expert (Wagire et al., 2020). The leadership results are discussed per each of these categories. Leaders 1 and 2 are in the category outsider, leaders 3

to 10 are in the category digital novice, leaders 11 to 15 are in the category experienced and leader 16 can be placed in the category expert.

4.2 Leadership on the Industry 4.0 transition

Comparably to the other leadership styles, Instrumental leadership was referred to the most, with it equalling the frequency of transactional and transformational combined, however it was not the most effective leadership style, this likely was transformational leadership. In terms of instrumental leadership mostly the dimensions of outcome monitoring and path-goal facilitation were present. Strategy formulation was also somewhat present and outcome monitoring not as much. The other leadership styles were mostly present in the form of management by exception (active) for transactional leadership and for transformational leadership; intellectual stimulation and inspirational motivation.

When looking at the leadership style per leader there were some clear differences between the leaders, some clearly exhibited other styles than others. Figure 2 is a visualisation of their self-perceived leadership style per leader, the black lines again show the borders between the Industry 4.0 maturity level. Here it can be clearly seen that for most leaders the instrumental leadership style was most prevalent, but some leaders deviated. Furthermore, all leaders, except for leader 8, discussed at least somewhat aspects of all the three leadership styles.

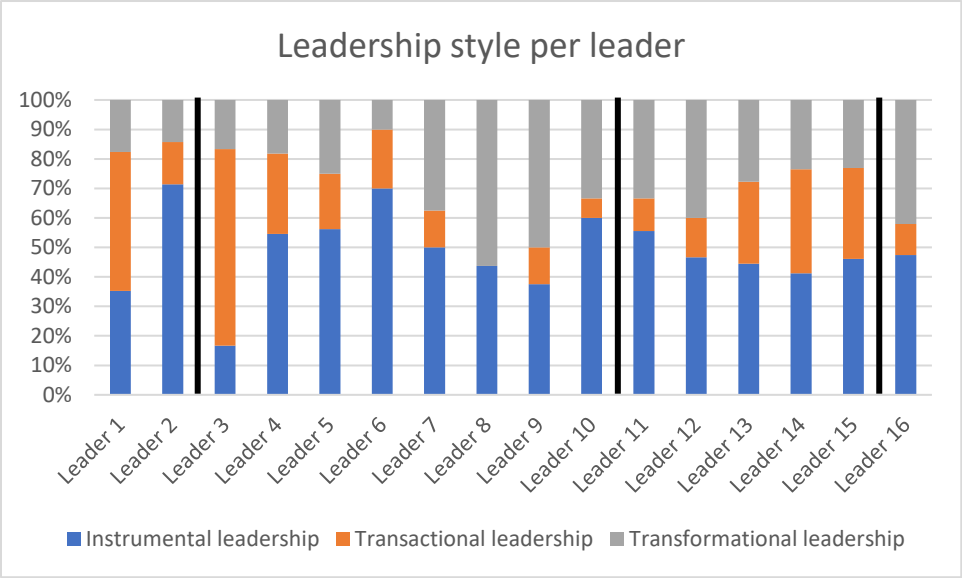

Figure 2 Overview of the leadership styles per leader

When comparing the leadership style as presented in figure 2 to the Industry 4.0 scores as presented in table 5, the balance between the leadership styles seems to shift to a more balanced and more tranformational and instrumental leadership focussed. The same appears to be true for most of the Industry 4.0 dimensions. During one of the focus groups, the dimension smart manufacturing technology was highlighted as surprising, as the scores for this category appeared to be related less to the leadership style. It could be that this was technology related and not leadership related. In the focus group during the discussion on why this would be the case, two suggestions were made. Firstly some of the technologies belonging to this dimension were a bit older, they had become more of a commodity. The second suggestion was that these were very work-floor oriented technologies, meaning that a more pragmatic and direct approach would be more effective.

As stated the leadership was coded using first order concepts, second order themes and aggregate dimensions (Gioia et al., 2013). The coding is displayed in table 6.

First order concepts	Second order themes	Aggregate dimension
Informing leader gives independence Own targets own results	Autonomy	Transformational leadership

Make own choice Not controlling every decision		
Reach consensus Iterative communication	Identify with vision	
Outline bigger picture Futureproof vision Align vision team with organization Do the right thing Insights for future	Broader vision	
Role modelling New board position Set example	Lead by example	
History as a driver Driven by vision Intrinsic motivation Meaningful work	Lead with purpose	
Active listening Make people feel heard Frequent personal talks Set a personal goal Individualized communication Connected	Personally involved	
Honesty Talking and explaining Openness Not one truth Sincerity	Transparency	
Guarantee quality Justify expenses All about KPI's Obedience	Check & control	Transactional leadership
If progress no intervention Within rules much freedom	Freedom	
Lack purpose Unclear goal Need for direction	Lack of vision	
Make it measurable Clarify expectations	Objective based	
Culturally distant relationship Personal goals No initiation	Personally distant	
Directive Centralized Hierarchy Targets are set	Top-down	
Take responsibility Need for reaction Place responsibility Expectation to speak up	Ownership	Instrumental leadership

Find solution to mistakes		
Resonsibility means duty		
Achieve the maximum not the goal		
Seek the problem within		
Expectation of authenticity	Authentic	
Self-awareness		
Loyalty to own values		
Help overcome hurdles	Empower	
Promote own decision making		
People support what they create		
Atmosphere to speak up		
Recognise and use talent		
Possibility to be in charge		
Support target setting	Facilitate	
Assume responsibility to enable		
Work environment to excel		
Enablement		
Connect the right people		
Align priorities	Strategic vision evaluation	
Create frame and divide		
Stakeholder influence		
Vision open for feedback		
Participation counsel		
Encourage training	Learning environment	
Facilitate training		
Stay curious		
Regular evaluations		
Personal goals		
Visible signs of change	Make progress visible	
Show succes and failure		
Progress visualiser		
Constant new opportunities	Innovative adaptability	Organizational development
Required improvement		
Innovation in new angles		
Exchange as stimulation	Systematic creativity	
Entrepreneurial thinking		
Design thinking		
Brainstorming		
Disruptive innovation		
Agile instead of hierarchy	Culture change	
Digitalisation changes culture		
From physical to digital		
Organizational hierarchy change		
From harsh to calm		
Deep domain knowledge	Expertise	
Hybrid teams		
Selection on learning ability		
Skills development		
Knowledge sharing		

Table 6 Coding leadership results based on Gioia et al. (2013)

4.2.1 Leadership on the Industry 4.0 transition, level: outsider

Based on the interviews leader 1 and leader 2 are placed in this catagory. Firstly, as is visible in figure 2, they both showed a relatively low level of transformational leadership in the interview. There is no clear difference in terms of Instrumental and transactional leadership on the other hand. In the coding two 2nd order themes came to pass relatively frequently. Check & control and ownership. Interestingly these themes conflicted sometimes in their statements. For instance leader 1 explained that it was important to keep asking questions and make clear agreements, yet at the same time leader 1 also wanted to place responsibility where it belongs and micro manage less. Similarly leader 1 stated that he felt that his leadership style was supportive, yet later on the topic of discussion was more on directive leadership.

In the interview leader 2 had some conflicting statements, which made it difficult to truly assign one leadership style. For instance, even though most of the statements were in line with Instrumental leadership, the leader also acknowledged that the involvement of the top-level management was very abstract. The leader explained that at lower levels of the organization the work was more content-oriented: *"the higher in the organization you are, the more abstract it becomes, less content actually."* Unlike other mostly instrumental leadership styles, this case presented a strong focus on strategy formulation and environment monitoring, while path-goal facilitation and outcome monitoring were less present.

The angle on the strategy formulation was interesting as well. Though the previously mentioned statement shows the presence of hierarchical differences, leader 2 also explained their vision on leadership: *"Our vision on leadership is: as little hierarchy as possible, using the talent that is there as much as possible"* . Though this statement cannot be placed directly in one leadership category, it does conflict somewhat.

Lastly both leaders went into detail about the importance of ownership in goal setting, with leader 2 stating that: *"You can achieve the goal, but still decide that it is not the maximum you can achieve"*.

4.2.2 Leadership on the Industry 4.0 transition, level: digital novice

There is not a clear coherent leadership style at this level, but in figure 2 it becomes visible that the leaders with a higher score in terms of Industry 4.0 maturity at the digital novice level, transformational leadership is shown more.

Leader 3 presented a large portion of transactional leadership. This is also not something that was about to change in the future as this leader was describing on how they were creating a new target system, so you could better measure the performance of the employees. On the other hand this leader did discuss a culture change in terms of organizational strategic development: *"But that is a little bit of the nature of Company that the guys were really used to, to quite harsh managers in the past. And the loudness of the voice has really increased when something went wrong. Now, I guess they they appreciate someone having more calm, but being very clear in what he wants to get"*.

In the focus group it was discussed that transactional leadership can work, but that it might fit better in either a short-term crisis situation or on a manufacturing site.

Leader 4 had a relatively balanced leadership style, yet mostly instrumental. He portrayed a bit of a struggle between finding the purpose for the employees and giving them enough freedom: "*We have certain idea of what we would like to achieve in the long term, huh in the sense of efficiency improvement and cost savings. ehm, but if you then look at a project level. Are we still trying to figure out how exactly to monitor, say, the performance of individual project*". This shows that there is an ideology, but the translation to the individual level is still difficult. Furthermore he explained: *"Product owners really need to have the space to steer their project*

and not be micromanaged by programme leaders and directors." This shows the importance of the translation to the individual. In the focus groups it was shortly discussed that the purpose for the individual is very much important. And that this is something you see more often. That there is a larger ideology, but the employees cannot identify themselves enough. Other leaders, such as leader 9 emphasised on this too.

Leader 5 had a similar balance to his leadership as leader 4. One value that was most present in his leadership style was authenticity. Leader 5 shortly summarised this in the statement: "*I think it's very important that people see me as honest, sincere, open, I never want to set myself up as one, as the boss"*. In multiple statements this authenticity came to pass, but also transparency was a big theme. Leader 5 did also present some forms of transactional leadership, he wanted to be in control and took up most of the responsibility: *"If you let one thing go to waste and think: well, that's just a little executor and it doesn't matter at all, then you have mega problems, because every little thing can become a gigantic oil slick", "So I put someone there who can't do it, then I blame myself and I am going to support that person"*. This puts him in a weird position where is very much in charge and takes the responsibility, but does not want to be seen as the boss. Lastly he made an interesting statement about new product development: *"What I've often noticed is that once you have a business case and everyone believes in it, people don't really look at it to see if it's actually being achieved"*.

Leader 6 was one of the most instrumental leaders. He explained this himself as the military leadership model: *"That's a model in which everyone has a clear role within the team and within that team, everyone can be in charge at any time, in theory. But when things get really tense, then at some point someone has to make a decision"*. Logically ownership and empowerment were large themes in his leadership: *"so ultimately you have to lead somewhere,*

eh, so you'll have execution power and what I just said, about taking ownership, you'll also feel ownership of the result to be achieved". Lastly another big theme in enabling an Industry 4.0 transition was the right application of knowledge: *"we started with someone who could, our employees, who already had experience with image recognition and he took it upon himself to pull that project"*. Using the knowledge available to get results. In the focus groups it was also mentioned that leaders often do not make use of the available knowledge to get results. That external parties are hired, while sometimes they already have the talent available. Furthermore he also described that a culture shift is required in order to adapt to Industry 4.0: *"we come from is a railway culture, say, we had found it difficult to take ownership, for projects, task functioning. They are now introducing that, so you really do have a clear role."*.

Leader 7 presented mostly a combination of instrumental and transformational leadership. The main topic in her leadership style was personal involvement, next to that she presented a larger variety of instrumental leadership aspects. One quote which describes this personal involvement as a leader was: *"Motivation lies in a number of things, such as yourself but also in the feeling that you can fall back on your boss".* Furthermore statements such as: *"It is important to be connected. Someone only functions well when everything is right at home. It is old school to keep it separate"* supported this notion.

Leader 8 was the most transformational leader that was interviewed. He had a strong inspirational motivation and tried to portray a vision. This became apparent from a statement such as: *"I hope with my work to lay the foundation for the future of you and my daughters and the new balance."* With the new balance he meant the balance between earth's ecosystem and the human need for energy and electricity. He explained that they were very much trying to adopt the new technologies, but they did this more with a moon-shot ideology, investing in

some very new technologies, with the idea of: *"There is more than just financial return, so sometimes you have to go into a number of things to learn to experience, and then later, when it gets bigger, then you have already learned a lot. That is also return."*. He described that the commitment from the employees to the final goal was very important and they did this with intrinsic, but also physical tools: *"that's why we gave all the employees shares as a Christmas present in a park. So, yes, that's how you also act, eh, that you also see that you are shareholder together."* In the focus group the transformational leadership style was discussed as very logical to be effective in the Industry 4.0 transition. It was argued that transformational leadership provides a long-term final goal, which inspires followers and therefore it creates a pull effect, where followers want to achieve this final goal.

Leader 9 had a style between instrumental and transformational leadership. This leader was very set on the vision communication as being the most important item on the Industry 4.0 transition. She explained that effective vision communication needs to come from the top, but in order to be effective the adaptation should take place lower in the hierarchy: *"we start from the top, but then we immediately go bottom up"*. According to her the top leaders are the ones who make the biggest impact on the transition and that change and they should lead by example. Next to that in a transition a clear purpose is important, yet "*I always say: it doesn't help to write down a purpose once*", "*we need a compelling story*", such as "*So last year we unfortunately had a few accidents, so we now have a very big theme*". These are statements which were not directly linked to each other during the interview, but do present her emphasis on purpose. Leader 9 also described that the digitalisation process resulted in a huge culture change, showing that their organization is in a stasis of openess to change.

Leader 10, the last of the leaders in the category digital novice also had a balance between transformational and instrumental leadership, but leaning more towards instrumental leadership. She emphasised the importance of the vision communication: *"And you need to also explain it to people to understand that they understand why why we are doing this"*. Similarly to leader 9, on the accident, she described the effect of a burning platform *"And what I was saying about this, this burning platform, a strategic direction, this is this is definitely important"*. She also had some aspects of her leadership in common with leader 7: *"it's also important that I create a kind of atmosphere of trust and openness that. that my team knows that I back them up and then they can really do things and not ask me for approvals or an agreement to do something"*. Leader 10 presented the argument for a need for culture change as well. She argued mainly that in order to implement Industry 4.0 effectively organizations need to shift to a learning culture: "*So we need to really have a learning culture. So it's not like we used to have years ago"*.

4.2.3 Leadership on the Industry 4.0 transition, level: experienced

Leader 11 is the first of the leader at the level of experienced. Leader 11 too had a balance between instrumental and transformational leadership. The main topic on the leadership topic was the importance of the learning environment: *"That's what I think is important and that's also the leadership that I try to put in there. So I don't think it's at all somewhere in the middle things go wrong and they come that way and that's not to be learned from under someone's feet. And how can we prevent that from happening in the future"*. With this statement he meant that mistakes happen, but the most important thing is that the employee and you as a leader learn from it. Furthermore he emphasised the importance of a good leader follower relationship on a personal level. *"It's important for me, for my person and for my management team, that we have good relationships with men and that we can call them to arrange things."* Lastly Leader 11 also argues that the expertise in industry 4.0 also provides you with a strong selling point: "*That shows something about how data-driven you are and how well you are and what data*

you use to achieve that knowledge and how you can better serve the customers through data and that the most can not be used at all."

Leader 12 again had a balance between mainly instrumental and transformational leadership. Though his case was interesting as the organization was very much top-down, command and control, while his personal leadership was more trying to place the decision-making lower in the hierarchy. The result then was that on his teams the decision-making was held lower than on other teams *"I'm trying to empower my teams who are on those teams to make their own choices"*. When describing his own leadership style he said the following: *"So I constantly try to see myself as a, as a coach, as a facilitator of continuous personal development of the people in my team"*. And he tried to facilitate this in the following way: *"I am a kind of broker in innovation, in ideas, and I tie people together from inside and outside the company who have the passion and the mission to achieve great things together."* Leader 12 also described knowledge as a central element in a succesful digital transformation: "*by creating around me people who have those skills and capabilities that are necessary for say this, this new way of, of selling offerings"*. Lastly he also stated that he and his organization are involved in creating a disruptive innovation, which maximizes the usage of Industry 4.0 technologies.

Leader 13 was balanced in all three leadership styles, having almost equal parts of each style. He discussed ownership and responsibility often with statements as: *"I especially have to set the bar that they have to reach, but not interfere with how they do it"* and "*I can, give you responsibility, but if you don't take it up, then I still have a problem"*. But he was also discussing transactional leadership style with *"every euro you spend or about if it is a wage, or something else. Then you have to be able to explain why the company is better for it"*. But he was also personally involved: "*we hired 120 and I tell them all myself how important I think the*

behaviour and the culture is". This leader might be a good example of what was discussed in the focus groups. A good leader is able to adapt themself to every leadership style, depending on the scenario.

Leader 14 was mostly an instrumental leader, but still with a balance of transactional and transformational leadership. The most important aspect of his leadership he described as active-listening: *"Listen to people talk about what you would call active listening, if you will. And yeah, that's maybe the most important thing."*, or *" experience is, if you're feeling that people are heard and listened to, it's easier even with unpopular decisions."* One thing he noted as especially important in change and transition management was: *"it's always worth discussing on priorities. The more alignment you can get, the less difficulties you have in implementing in the long run"*. So together it shows opinion on how important involving the employees in the strategy formulation is. This is something that aligns well with leader 15 and 16, the change is easier if the employees are involved and can really speak up and feel heard. Next to that he described that sometimes discussion is good, but when something needs to happen there is someone to take charge: *"It's not that this is purely top down, but we align, but in the end I'm giving the charge"* According to the focus groups the strength of the instrumental leadership is that even though Industry 4.0 may be abstract and during many interviews some aspects were also described as in the maybe in 20 year time frame, an instrumental leader may provide the necessary push. This could make it in some cases more effective than transformational leadership. This was also described as transformational leadership enables changes and instrumental leadership drives change.

Leader 15 is the last of the leaders being at the experienced level. And as previously stated she supported that change is easier if people feel heard. So her organization too put a consistent

mechanism in place for involving the followers in the strategy: *"Every year we look at our strategy and the strategic plan, how we can improve it. Within that, we then have a look what are the areas we need to frame and we need to support and then giving the team the responsibility to to develop and work that further"*. This statement can also be connected with the statement from leader 4 about translating the vision and strategy to the individual level, she continued on this further with the statement: *"people support what they create"*. Next to that she also connected with what the statement that change needs to start from the top as leader 9 and 10 also stated: "*whatever you want to change or any transformation you want to serve, it needs to start at the top. Otherwise it will not start at al"*. Her leadership, being relatively balanced, but with mostly instrumental leadership, also embraces some aspects of transactional leadership, such as: "*But it's all about financial and gross KPIs full stop*". Lastly leader 15 also mentioned the importance of knowledge in the digital age: "*The example I mentioned earlier is AI so there's so much good knowledge out there and good companies, all kinds of sites you could partner with that sometimes it does make much more sense to partner. Then develop it all on your own."* With this she argues that knowledge is such a central element in the Industry 4.0 transition and that when you don't have this in-house it may be more beneficial to partner, but you do need the knowledge.

4.2.4 Leadership on the Industry 4.0 transition, level: expert

Leader 16 was the only leader in this category. Her leadership too was balanced. She described a situation where the also experienced the effects of suboptimal leadership: *"Those goals are sharp. Only we had. We couldn't really show a result yet, you know, at first it was like this is what we're going to do without having a final picture"*. This emphasised the importance of having a broader vision. She described the development there and how they finally created the final picture and how the development suddenly went so much faster and new opportunities were created. In the interview she discussed a lot about making an impact with leadership during periods of lower motivation: *"I always hope that people stay motivated to do what they have to*

do, even during bad times, where you can help to get them over hurdles". She also described the importance of good knowledge application, similar as leader 6 did. In the focus groups it was discussed that the limitation of instrumental leadership, may lie in that it is largely reliant on the leader and their knowledge. An instrumental leader will still be the push, the driving force. This can work, but in a changing environment the pull as discussed in transformational leadership may be more effective. Just as leader 12 Leader 16 was also very involved in a disruptive innovation, which maximizes the usage of Industry 4.0 technologies.

5. DISCUSSION

The goal of the research was to find out whether certain leadership styles, from the 'fuller full-range theory' can make the transition to a higher Industry 4.0 maturity level go more efficiently and effectively (Antonakis & House, 2014; Bass, 1990). The study used a mixed methods approach containing 16 leader interviews at high levels of different organizations, the other method was to use two expert focus groups to see if the theory fits the practice. These methods sought to answer the question: "*How can an effective manager's leadership style support the transition across organizational Industry 4.0 adoption maturity stages?*" Using the interviews and the focus groups the leadership styles from higher maturity levels are compared to the leadership styles from the middle and lower maturity levels. Furthermore in the interviews also results from transition best-practices are gathered where leaders explained on how they dealt with a certain transition.

The leadership style likely influences the effectiveness of the industry 4.0 development. A combination of instrumental and transformational leadership, likely works best.

The effectiveness of the leadership style cannot be accurately measured, yet based on the results the instrumental leadership style may provide an early push in the transition, while the transformational style works better for the long term change.

Therefore to answer the research question: *"How can an effective manager's leadership style support the transition across organizational Industry 4.0 adoption maturity stages?"* this study would suggest that by applying a combination of transformational and instrumental leadership, with special attention to the vision formulation, knowledge application and a potential cultural change, a leader can support a smooth Industry 4.0 transition across maturity stages.

There is not a concrete clear indication that the effectiveness of different leadership styles change per industry 4.0 maturity, however this was also not debunked. Based on the interviews and the focus group there is some cause for belief that this may be the case, yet future research is required.

Both instrumental and transformational leaders have a similarly high score in terms of Industry 4.0 maturity, these leadership styles appear to be more likely to be used in companies with a more developed Industry 4.0. In the qualitative analysis especially parts of these leadership styles came forth as being effective. Leaders 14, 15 and 16 both discussed the *"people support what they create"* element as being very important for the Industry 4.0 transition. Other aspects that came forth as especially important was the role-modelling of the leaders and in line with that, that change needs to come from the top. This was a topic that leader 15 genuinely supported and leader 9 and 10 saw as an improvement possibility. Their relative Industry 4.0 maturity scores may confirm that this would support the change. Leader 4 and 9 emphasized the importance of translating the vision to an individual's purpose important as well as this could provide better motivation. From leader 11 and on the leadership styles were relatively balanced This was also the way the full-range theory was meant (Bass, 1990). So that a leader can adjust themselves to the situation and thereby use the most suitable leadership style

These results are largely in line with what the theory would suggest. Earlier studies suggested that transformational leadership has a positive effect on innovation processes (Anderson & Sun,

2017; Bass, 1990; Bednall et al., 2018; Gilbert & Kelloway, 2018; Nijstad et al., 2014). This research would confirm that notion, however also argues that a combination of transformational and instrumental leadership may be more effective, than just transformational leadership.

In fact, as Birasnav (2014) suggests improved follower knowledge application may be an important driver of the industry 4.0 change. This would increase the cognitive load instead of reducing it. As effective leadership can play a role in enhancing knowledge management around capabilities, which is in line with earlier research but also confirmed in this study (Shamim et al., 2016).

The results indicate that the industry 4.0 transition goes more smoothly with a clear vision. This is something in line with earlier results, for instance van Dun and Kumar (2021) argue that such a clear vision can lessen the fear of unemployment. This is something which also came up during the interviews, but the interviews indicate that this effect may be strengthened by involving the followers in the vision formulation which belongs to the instrumental leadership style. The challenge of highly complex change, as described by Schumacher et al. (2016) appeared to be the largest challenge in the interviews. Most of the leaders tried to deal with this challenge by making sure there was a clear vision, but also communicate on a personal level with the employees.

Interestingly as well on the organizational development aggregate dimension, you can see that leaders from different maturity levels have a different organizational attitude towards Industry 4.0. The outsiders do not mention any form of organizational development or attitude, so these are not taken into account. But when looking further it becomes apparent that leaders in the digital novice maturity level are still looking into the culture change and how they are adapting. The leaders in the experienced maturity level are more focussed on how they can aquire and leverage knowledge and lastly the leader in the expert maturity level as well as one in the experienced level are using Industry 4.0 technologies in disruptive innovations. This could

mean that, next to the general organizational development, the leaders use a different message in the way they communicate their vision.

As stated in the results smart manufacturing technology appeared to be less influenced by the leadership style. Next to the age of the technologies Huang et al. (2011) argue that of transformational leadership, only the charismatic dimensions, being inspirational motivations and idealized influence, really have a positive impact on implementing ERP systems. They argue that this would be the case due to often very tight budgets and planning, therefore there would be less freedom for individualized consideration and intellectual stimulation. Furthermore only the relational aspect of buyer and supplier integration, being a precursor of a digital platform for supplier and customer integration, is impacted by leadership, whereas relational commitment, information sharing and supplier development are not (Birasnav et al., 2019). By leadership is meant the combination of transactional and transformational leadership. These could partially explain the difference in the smart manufacturing technology dimension.

5.1 Practical implications

The information provided in this research gives leaders direct guidelines on which leadership styles may be more effective during the various stages of their organization's industry 4.0 transition. For instance the during a transition to a higher maturity level vision communication appears to be very important. A leader can improve their vision communication by involving the followers in the formulation of the vision, but also to see how the vision translates to them at an individual level. This supports the motivation of the followers as they can see how their individual work contributes to achieving the vision. Furthermore coaching and setting objectives may work well in the beginning of the change, the change becomes more effective when there is a pull from the final goal to the followers. And thus the inspiration for the future is also very important.

It may be that more technologically advanced companies hire more instrumental and transformational leaders. Thus to create organizational improvement the hiring process may be a good place to start by paying attention to the leadership styles that are brought into the organization.

6. LIMITATIONS AND FURTHER RESEARCH

There are several limitations to this research. In this chapter first a limitation is mentioned and then a suggestion for future research is made on how they can omit and or deal with this limitation.

Firstly the causality of the relationship is unassessed. This could that more technologically developed organisations hire more transformational or instrumental leaders than the suggested other way around.

- In a future study a longitudinal study in a larger organization to see how the leaders will need to adjust during a whole Industry 4.0 transition, this will deal with this variable. A suggestion would be to follow multiple leaders within two organizations in different industries. This will give a clearer view of the effectiveness of the leadership of multiple leaders within a certain organization across different maturity stages. The leaders will need to adjust themselves and what adjustments are effective and which aren't can be measured as the implementation takes place in different areas of the organization. This would work well to create a clear elaborate construct (Edmondson & McManus, 2007).

Since the research has taken place across different industries, there may be some side effects and the relationship may not be causal. In order to research this relationship, the average industry scores were taken, compared to the leader's score and correlated with the Industry 4.0 score. As the sample size is limited some industries only appear once. Though the industry is taken into account, which likely impacts the effectiveness of leadership (Lieberson & O'Connor, 1972; Zhu et al., 2005), some technologies are more relevant for certain industries

than for others. This results in a uneven distribution of the Industry 4.0 adoptation. For instance, for retail blockchain may be less interesting at first sight than for an energy contracting company.

- Future research could be focussed at only one industry. This would make the leadership results more comparable.

Furthermore, there was only one individual who took, transcribed and coded the interviews. This may result in an interviewer bias, and the selection of the codes may be influenced by the their interpretation of the text. Therefore some nuances may not have been picked up.

- Future research could make use of multiple interviewers, transcribers and coders. This would omit this bias. At the same time this could also make the results less comparable.

Fourth, though the sample is relatively similar, there are some differences in terms of the positions in the organizations. This may have had an effect on their interpretation of the industry 4.0 adoption and may also cause deviations in the amount of influence their leadership had.

- A future study could ensure that all participants are at the same level within an organization and that the organizations are of the same size.

As stated earlier there is a difference in the content of the vision, due to the organizational development and attitude towards Industry 4.0.

- A future study could also look further into the combined impact of leadership style and generalised content of the vision, to see if this further impact the effectiveness of leadership.

Next, most organizations were at the second or third maturity level. Therefore the deviations between the outsider and expert maturity levels could be explored less.

- An interesting study could only focus on best or worst practices, this would create a large gap and perhaps more concrete results can be formed.

There appeared some differences between the effect leadership had per Industry 4.0 dimension. As stated before the Smart manufacturing technology appeared to be influenced less by the leadership styles than other dimensions

- Therefore a future study could be to see if the ideal leadership style differs when working with different Industry 4.0 dimensions.

Finally, there is a perception bias, as both Industry 4.0 and leadership style are measured in a one-on-one interview. This could mean that leaders over or under evaluate their company's industry 4.0 maturity, or that they perceive their leadership differently than what it actually is.

- A suggestion would be to test the leadership and industry 4.0 using surveys to followers or to use observations as a research tool to see the industry 4.0 adaptation and leadership style in practice.

Furthermore, there are some case-specific limitations, such as the results from leader 5. As explained earlier this leader used instrumental leadership, yet in a different way than most other instrumental leaders. Interestingly the Industry 4.0 score is also lower than that of its peers. This could implicate several things: Firstly, this extremity may skew the results downwards, so in fact, instrumental leadership is in fact just as or even more effective than transformational leadership. It also may show that the way a certain leadership style is expressed may impact the effectiveness of the leadership.

Next to that, building on this research, future studies can also seek to

- Split up the leadership styles into their respective dimensions and see if there are effectivity differences there. Especially for Instrumental leadership, there is a research gap there.

- Research a potentially mediating role of leadership (Birasnav, 2014). As previous studies already highlighted it as leading towards improved organizational performance. It may also be a large mediator in Industry 4.0 transition effectiveness.

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8. APPENDIX

8.1 Focus groups slide deck

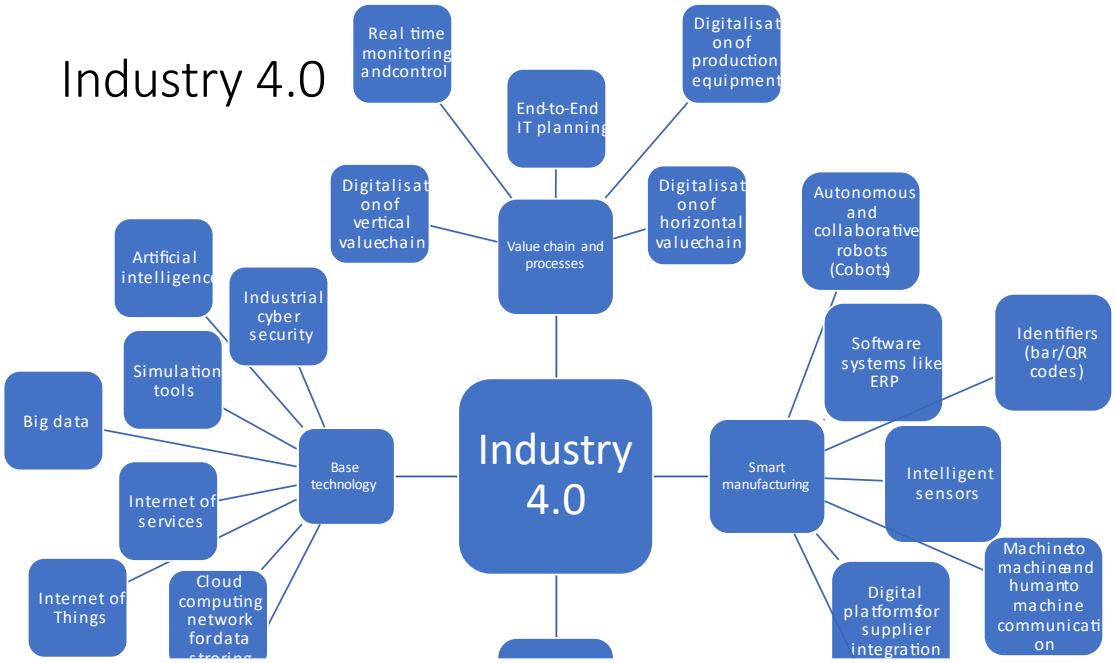
Agenda

- Purpose of the focus group
- Short presentationresults
  - Visualisation results
  - Expected relationship
  - Discussion
- Anekdotes
- Further input
- Conclusions

Purpose focus group

- To see if the collected results are in line with what you have encountered in both practice and theory
- In a focus group so that you can build on each other's ideas
- Do you think that parts are missing and can these conclusions be drawn in part
-

Industry 4.0



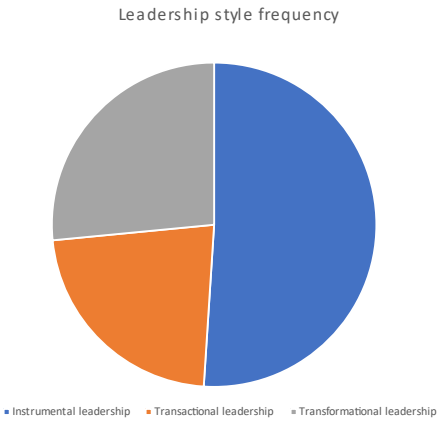
Industry 4.0 transition

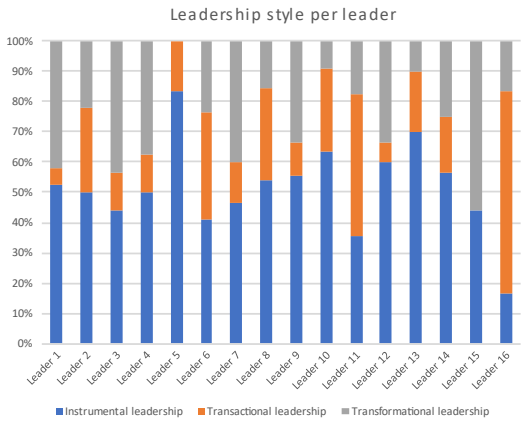
- Is a combination of multiple projects/changes
- Implementation of technologies could be seen as change management
- The whole is a transition (transition management)
- Leadership is not the only factor, but certainly plays a role

Definitions of leadership styles

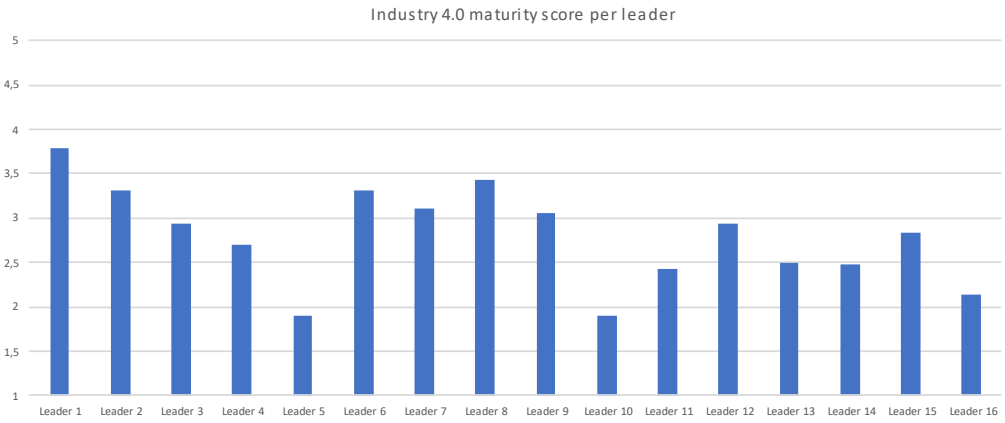
Transactional leadership	Transformational leadership	Instrumental leadership
Contingent reward	Idealized influence	Environmental monitoring
Management by exception (active)	Inspirational motivation	Path–goal facilitation
Laissez-faire	Individualized consideration	Outcome monitoring
Management by exception (passive)	Intellectual stimulation	Strategy formulation

Use leadership styles in general

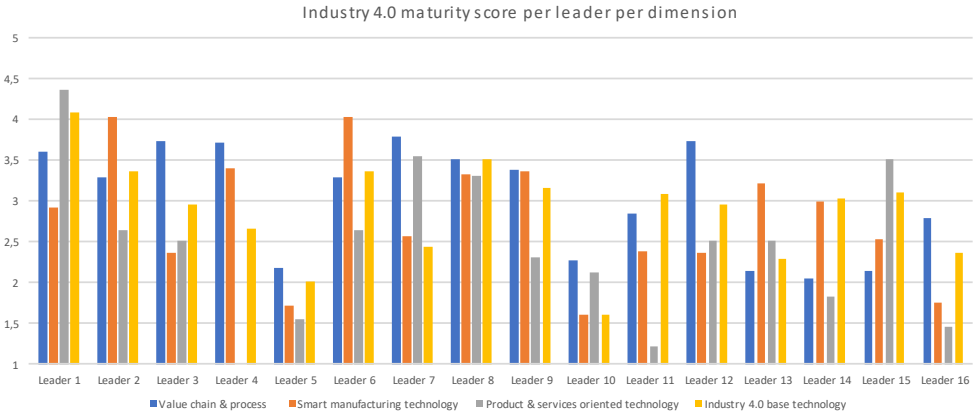




Industry 4.0 results general



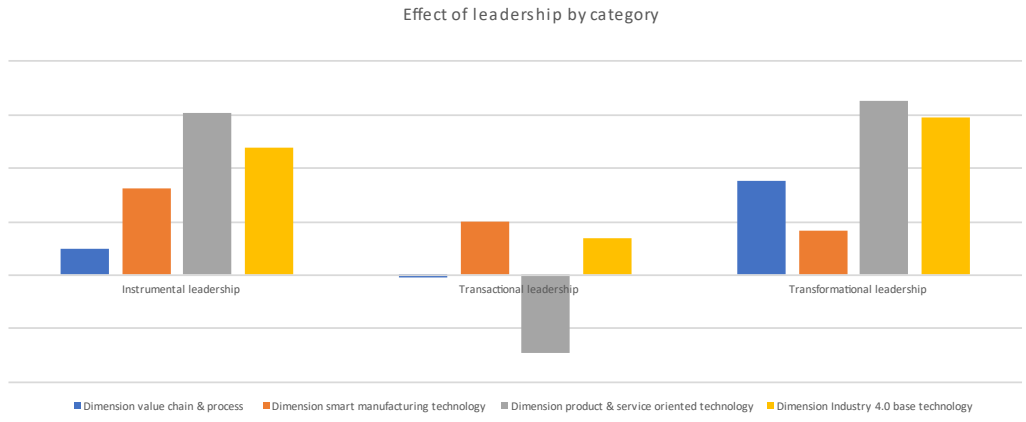
Industry 4.0 results broken down by category



Which leadership styles have an effect

- Transactional leadership has little to no effect on Industry 4.0 development, while instrumental and transformational have a similaeffect

Effectiveness leadership seems to differ by Industry 4.0 dimension



Anekdotes (leader 3)

"So what we see is a big theme with us and that and any transformation or change is the role modelling of the top management […] if they themselves are not behind it, then it is very, very difficult"

Anekdotes (leader 8)

"I think change, initially it needs to come from the top, that means it needs to be part of the purpose and the strategy and so on and so forth. Otherwise, it's, it's a toothless tiger."

Anekdotes (leader 2)

"I especially have to set the bar that they have to reach, but not interfere with how they do it"

Anekdotes (leader 8)

"people don't like to be changed, but being part of the change"

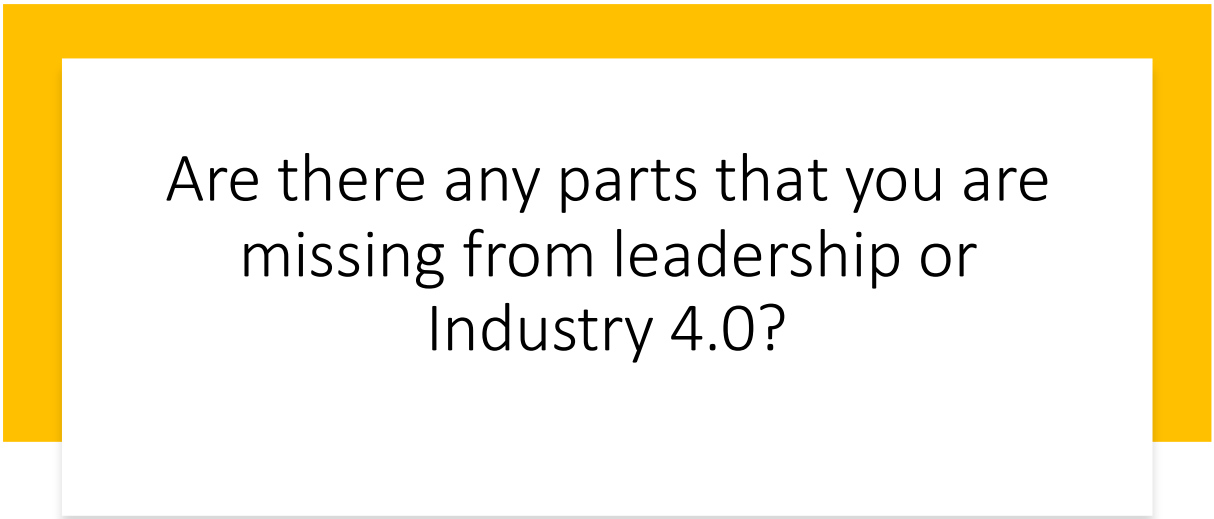
Anekdotes (leader 14)

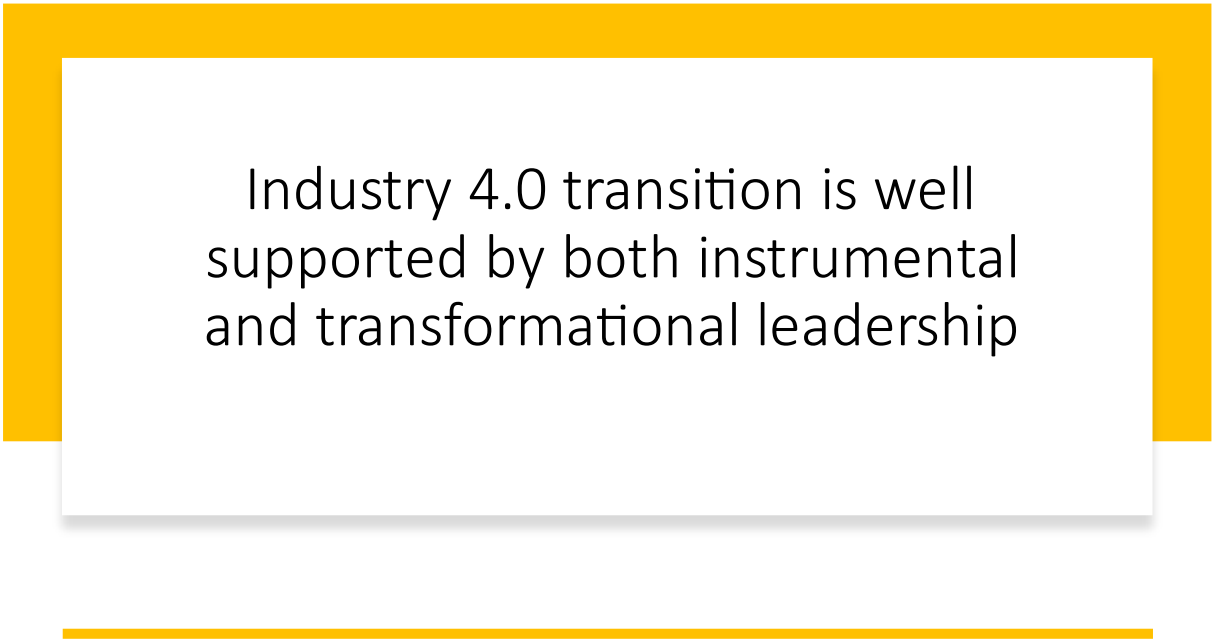
"If you let onething go to waste and think: well, that's just a little executer and it doesn't matter at all, then you have mega problems, because every little thing can become a gigantic oil slick"

Anekdotes (leader 15)

On investing in moon shots like blockchain

"There is more than just financial return, so sometimes you have to go into a number of things to learn to experience, and then later, when it gets bigger, then you have already learned a lot. That is also return."





8.2 Guiding sheet for interviews

Interview document

Welcome
Not comfortable with sharing information
Data is anonymised and cannot be traced back to you or your company
Session is recorded
First industry 4.0, then transition questions than leadership.
Break possible

Part one Industry 4.0 questions

- **What is the most advanced technology that you use?**

Value chain and processes?

- **To what degree has the development phase to the production phase has been digitalised?**
- **How much are you able to monitor the production in real time and dynamically react to changes in demand?**
- **How much does end-to-end IT enable your planning and steering process from sales forecasting, production to warehouse planning and logistics?**
- **How much is your production equipment digitalised?** (sensors, IoT connection, digital monitoring, control, optimisation and automation)
- **How much is your value chain, from customer order to supplier, production and logistics to service digitalised?**

Smart manufacturing technology

- **Do you use advanced robots for automating activities? To what degree?**
- **Do you use of enterprise resource planning?** (Like digital software systems for sharing information and obtain realt0ime feedback from the shop floor and other functional areas of the organisation to support in decision making at machine control level, production control level and corporate management level MES, CRM and PLM tools)
- **Do you use identifiers for assets?** (like bar or QR codes).
- **Do you use intelligent sensors?** (actuators, embedded systems and PLCs)
- **To what degree do you use machine to machine communication and human to machine communication?** (The company has a communication system with interoperability to exchange the information through the networked machines at the shop floor and human at different hierarchical levels.)
- **Do you use digital platforms for supplier integration?** (do you provide digital platforms to exchange real-time information about manufacturing schedules, operation activities and inventory levels with other manufacturing units, suppliers and warehouses.)
- **Do you use digital platforms for customer integration?** (The digital platforms provided to the customers to know the manufacturing status of their product, tracking product delivery and attending specific customer demands.)

Product and service oriented technology

- **Do you us AR, VR and/or MR technology?** (The company uses technological devices for 'design process enhancement by visualising issues in product development life cycle'; 'productivity improvement by providing smart glasses to the workers that assist them to improve turnaround time in supply chain and manufacturing processes'.)
- **Do you use additive manufacturing?** (3D Printing (3DP), The company employs 3DP technique at various stages of production i.e. from product conceptualisation - manufacturing to after-sales. For example: in the design phase of the new product, rapid prototyping, R & D and for after-sales spare parts supply.)
- **Do you use mobile devices and wearables to access information and communicate real time?** The company uses mobile devices (e.g. smartphones, tablets) and Wearables (e.g. smartwatches, glasses and gloves) to access the information and to communicate with several systems on a real-time basis.
- **Do you use blockchain technology to improve your e-value chain?** The company uses BT for effective and efficient e-value chains. For example, 1) transparent supply chain involving of tracking and tracing parts from supplier to their origin; tracking purchase orders and enhancing procurement data accuracy. 2) Smart contracts that include automatically verifying orders; product delivery and invoices from suppliers.

- **Do you develop smart products?** These are products with embedded intelligent sensors, that enable to sense the environment.

Industry 4.0 base technology

I wish to discuss several technologies and rate on a scale of one to five how much you make use of them. If you have any questions about the technologies, please do not hesitate to ask

- **Cloud computing network to share resources** The company uses cloud systems for remotely connecting and sharing hard resources (e.g. equipment and robots) and soft resources (e.g. data, documents and software)
- **C computing network to store data** The company stores and retrieves the information from the cloud network.
- **Internet of Things in your day to day processes** The company has communication technologies like Wi-Fi, ZigBee, and Bluetooth etc. for wireless communication and networking between the machines, robots, systems and people. The company has the capability to connect the physical things with the internet and enabling them to be as smart things.
- **Internet of Services in your day to day processes?** The company provides services via web-based technologies, allowing the company and other users to combine, create and offer new kind of value-added services.
- **Big Data** real-time data processing, The company has the capability to collect, store and manage the BD (structured and unstructured) effectively which is captured from physical objects and external elements to improve plant productivity and to minimise downtime through predictive analytics.
- **Simulation tools** The obtained data then used to simulate what-if scenario considering several affecting parameters to build futuristic scenarios for business decision support.
- **Artificial Intelligence** Machine Learning (ML) and Deep Learning (DL), The company makes use of AI-based cognitive technologies like Natural language processing, Speech recognition, Rule-based systems and Computer vision for 'higher personalisation of products and services' and 'improving the efficiency of production and business processes'.
- **Industrial Cyber Security** The company has adopted various security measures like encryption, authentication and authorisation measures that help to establish secured communication protocols to ensure IT security and data protection, as a threat may arise due to connected ecosystem.

Industry 4.0 transition questions

- When considering the previously described technologies is or are there some which you only recently implemented that you were involved in?
    - Could you describe this transition?
    - Is the implementation finished now or are you still implementing it?

- Were there difficulties when implementing these technologies
- Have your direct reports experienced changes in the technological environment, such as previously described technologies?
- Would you consider the implementation of the technology successful?
    - To the best of your knowledge are your employees satisfied or enthusiastic about the new technologies?

Part two Leadership questions

I would now like to go into some leadership tools and techniques that you might use to implement previously discussed technologies.

Transactional leadership

Contingent reward: Provides followers with material and psychological rewards contingent on the fulfilment of transactional obligations
When one of your direct reports fulfils an objective or goal, is there some form of reward for them?
Management by exception (active): Actively monitoring to ensure that standards are met
Do you have some form of monitoring system to check if the standards are met?
Laissez-faire: Avoidance of decision making and abdicates responsibility
When you are in charge of a team, how would you make decisions?
Management by exception (Passive): Reactive, intervenes after failures
Do you have a policy to prevent failures?

Transformational leadership

Idealized influence: Is the leader confident and powerful in his or her abilities and is he/she centred on values, beliefs and mission
Are their certain values you find very important in leadership?
Inspirational motivation: Does the leader energize followers, being optimistic, setting ambitious goals and communicate viability
How do you keep your followers enthusiastic?
Individualized consideration Is the leader considerate and advises, supports and coaches others, while paying attention to their individual needs
How do you interact with peoples personal lives and goals?

Intellectual stimulation: Centres on followers sense of logic and analysis, as well as challenges them to think creatively
How do you stimulate your followers to think outside the box?

Instrumental leadership

Environmental monitoring: Understand constraints and acts on opportunities presented by external factors
How do you interact with limitations and opportunities presented by the external environment
Path-goal facilitation: Removes obstacles and attributes resources for followers to reach their goal
In what way do you support your followers goal setting and achievement?
Outcome monitoring: Helps correcting mistakes and supports prevention
Are you actively involved in correcting your followers mistakes and supporting prevention?
Strategy formulation: Develops vision supportive policies and set specific objectives
Do you develop a vision and are your policies and objectives supportive of this vision?