

The Unknown Known: Perceptions of Industry 4.0 shaped by SMEs' Executives

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Summary: The implementation of Industry 4.0 (I4.0) has been a top priority for industrial companies for several years now. While existing studies focus on risks, advantages, and transformation roadmaps, the concept's ambiguous nature and its organisational implications warrant closer look. Previous research indicates that the interpretive flexibility of I4.0 leads to diverse definitions influenced by profiles and expectations of actors behind them. Moreover, it has been demonstrated that companies' readiness to implement I4.0 is shaped by the perceptions of their managers. Yet, current research overlooks how managers navigate I4.0's conceptual ambiguity during organisational change. Addressing this gap, our study provides initial insights from a mixed-method research's first phase—an online survey of industrial SME executives in Belgium's Walloon region. Preliminary findings reveal diverse managerial perceptions of I4.0, categorised into three thematic groups encompassing seven perception categories.

Word Count: 1880

Introduction

While Industry 4.0 (I4.0) has gained popularity among both academics and practitioners for digital and organisational transformations in companies, many managers still struggle with understanding the concept itself (Sony and Naik, 2019; Machado *et al.*, 2021; Stentoft *et al.*, 2021). Several studies demonstrated that the conceptual ambiguity of I4.0 hinders leaders of companies, especially of small-and medium-sized ones, from devising strategies around implementing I4.0 technologies or participating in discussions on this matter (Mertens and Wiener, 2018; Orzes, Poklemba and Towner, 2020; Hansen, Christiansen and Lassen, 2024).

The dominant perspective in academic literature defines I4.0 as the Fourth Industrial Revolution, characterised by a data-driven paradigm interconnecting physical, digital, and human elements, capable of real-time responses within and outside organisations (Ghobakhloo, 2018; Klingenberg, Borges and Antunes, 2019; Zheng *et al.*, 2021). By deciding to introduce key I4.0 technologies such as the Internet of Things, Big Data, Artificial Intelligence, or Robotics, managers of companies unplug a series of organisational changes (Bellantuono *et al.*, 2021; Brodeur, Deschamps and Pellerin, 2023). Besides considering the transformation of existing processes, managers must think of involving various stakeholders into such decisions, empowering and training their employees, and, above all, communicating a clear vision and plan regarding the upcoming transformations (Brodeur, Deschamps and Pellerin, 2023). Achieving the latter might become trickier than it seems, as there is still no consensus on a common definition of I4.0 (Moeuf *et al.*, 2018; Kowalikova, Polak and Rakowski, 2020).

As a matter of fact, according to Pfeiffer (2017, p.111), “there is no *single* Industry 4.0” as the adoption of innovations depends on companies’ industrial branch, specificities, and needs. While the narrative behind I4.0 remains specific in certain aspects, such as the integration of technologies, it serves as an adaptable foundation for various actors in their interpretations of the concept (Meyer, 2019). Concerning public organisations or industry associations, the concept is generally presented as a promising solution to enable the economy and make industries more competitive (Meyer, 2019; Woźniak-Jęchorek *et al.*, 2024). Regarding companies, their managers tend to associate I4.0 with a positive scenario for increasing operational efficiency and changing business model, a fashionable label for advertising new technologies, or a fuzzy concept full of uncertainties and potential risks (Wilkesmann, Steden and Schulz, 2018; Meyer, 2019).

Among the variety of types of companies, small and medium-sized enterprises (SMEs) deserve a closer look regarding their positioning towards I4.0 for several reasons. On one hand, previous studies demonstrated that SMEs often struggle to leverage the advantages of I4.0 (Tamvada *et al.*, 2022). Typically lagging behind large companies in terms of financial, technological, and human resources, SMEs often lack a general understanding of the concept and how it can be introduced within their organisations (Hansen, Christiansen and Lassen, 2024). On the other hand, existing studies pinpoint several characteristics of SMEs that can be mobilised in favour of I4.0 implementation (Horváth and Szabó, 2019). SMEs are defined by their flexibility and agility that allows them to quickly react towards organisational changes triggered by I4.0 (Müller, Kiel and Voigt, 2018; Andrade, Franco and Mendes, 2023). Moreover, management-oriented research on I4.0 underscores the role of SMEs’ executives in their openness towards its implementation (Prause, 2019; Cugno, Castagnoli and Büchi, 2021). CEOs, deeply involved in the day-to-day operations of SMEs, wield centralised decision-making authority, thus playing a key role in defining the company’s position and vision of I4.0 (Horváth and Szabó, 2019; Moeuf *et al.*, 2020). For instance, SMEs’ managers can define I4.0 as a guarantee to remain competitive (Meyer, 2019) or a threat potentially favouring large corporations at their expense (Wilkesmann, Steden and Schulz, 2018). Nevertheless, to the authors’ knowledge, little

attention has been paid to managerial perceptions of I4.0 within SMEs, nor how SME executives might enact the broad interpretive space of the concept. Therefore, the authors of this study decided to tackle this gap by exploring the following research question:

How do SMEs' managers enact the conceptual ambiguity of I4.0?

To address this research question, a mixed-method study is planned to be conducted among executives of industrial SMEs in Wallonia, the federal region in the south of Belgium. The preliminary analysis of the data obtained during the quantitative phase of the study allowed to identify three groups of managerial perceptions of I4.0, which can be further detailed into 7 categories. The qualitative part of the study will aim to enrich the results by focusing on the sensemaking processes that managers apply to the concept. According to Weick (1995), when actors and organisations face a puzzling situation, they tend to construct their understanding based on the materials at their disposal, such as their perspectives, experiences, and context. Based on such sensemaking activities, they enact their ideas about the situation by interacting with their environment (Weick, 1995). By conducting in-depth interviews with managers, we aim to identify various factors interplaying with their sensemaking processes of I4.0 and to understand how they enact the concept by implementing it within their SMEs.

Method

To address the research question, the study mobilises a sequential design, where the quantitative phase in the form of an online questionnaire precedes the qualitative phase in the form of semi-directive interviews (Plano Clark, 2011). Whereas the quantitative data allows identifying patterns related to managerial perceptions of I4.0, the subsequent qualitative phase will help us to delve deeper and gain a more profound understanding of these results (Curry et al., 2009; Bryman, 2006).

The targeted participants were managers and CEOs of industrial SMEs based in the Walloon Region of Belgium. This geographical context was considered relevant for the study due to the role of SMEs as a substantial part of the region's economy and their growing interest in the use of I4.0 technologies (Union Wallon des Entreprises, 2022; Agence du Numérique, 2022).

To measure the perceptions of I4.0, an open-ended question was created, inviting participants to share their definition of I4.0 in a few words or phrases. The online questionnaire was sent to 600 managers of Walloon industrial SMEs selected from a publicly available database of local public services, entitled *Entreprises en Wallonie*. Selection criteria were set regarding company size (under 250 employees) and industry sector (excluding all service sectors). The questionnaire was administrated via a general email containing a study description and an invitation to participate. It remained open for a period of 12 weeks, starting in June 2023, with three reminders sent to increase the response rate. Excluding a missing data and textual responses considered inaccurate, a total of 95 valid responses were received, indicating a response rate of 16 percent. The textual responses were considered as inaccurate because their content included a description of the core business of respondents' companies without any reference to the definition of I4.0. Table 1 illustrates the distribution of the sample according to company size, industrial sector, ownership type, and respondents' roles.

Sample characteristics		Number of firms	Percentage
Company size	Less than 10 employees	15	15.79
	10-19 employees	16	16.84
	20-49 employees	26	27.37
	50-99 employees	18	18.95
	100-199 employees	16	16.84

	200-249 employees	4	4.21
<i>Company sector</i>	Manufacture of food products	9	9.47
	Manufacture of beverages	3	3.16
	Manufacture of textiles	3	3.16
	Printing and reproduction of recorded media	1	1.05
	Manufacture of chemicals and chemical products	3	3.45
	Manufacture of basic pharmaceutical products and pharmaceutical preparations	2	2.11
	Manufacture of rubber and plastic products	6	6.32
	Manufacture of basic metals	7	7.37
	Manufacture of fabricated metal products, except machinery and equipment	17	17.89
	Manufacture of computer, electronic and optical products	7	7.37
	Manufacture of electrical equipment	5	5.26
	Manufacture of machinery and equipment n.e.c.	7	7.37
	Manufacture of motor vehicles, trailers and semi-trailers	1	1.05
	Manufacture of furniture	1	1.05
	Other manufacturing	5	5.26
	Repair and installation of machinery and equipment	1	1.05
	Waste collection, treatment and disposal activities; materials recovery	5	5.26
	Remediation activities and other waste management services	1	1.05
	Construction of buildings	1	1.05
	Civil engineering	2	2.11
	Specialised construction activities	4	4.21
<i>Ownership type</i>	Family	66	69.37
	International	20	21.05
	Public	8	8.39
	Employee ownership	1	1.19
<i>Respondents' roles</i>	Director	79	83.16
	Manager	16	16.84

Table 1. Sample characteristics.

Data Analysis and Preliminary Results

We conducted a multi-coder data analysis (Olson *et al.*, 2016; Church, Dunn and Prokopy, 2019) to discern patterns based on similarities in definitions of I4.0 shared by SMEs' executives. This method was deemed most suitable as it aimed to enhance the coding process by adding an extra layer of rigour and scrutiny, while also incorporating diverse viewpoints of researchers (Church, Dunn and Prokopy, 2019). Based on the textual responses, the authors of the study mobilised an inductive coding approach: through several rounds of discussion, they refined and constructed an initial codebook consisting of 7 categories of I4.0 definitions. Then, a group of six researchers was invited to independently code the textual definitions of I4.0 using this codebook. Following this exercise, a collective session was organised to discuss the results obtained and further refine the codebook. As a result, several definitions were associated with the categories different from the authors' proposition. This change emerged due to the establishment of two criteria clarifying the rationale behind associating each definition of I4.0 with the identified category. Based on this feedback, the authors convened to validate the categorisation of I4.0 definitions, which led to further refinement of the criteria by adding a third one. The entire coding process was aligned with the logic that instead of aiming for clear-cut categories of managerial perceptions of I4.0, the authors attempted to determine dominant tonalities of each category present in each definition of I4.0.

Based on the preliminary analysis of the results, managerial perceptions of I4.0 concept can be represented in three trends regrouping seven categories (Table 2). Firstly, managers may perceive the concept of I4.0 as *a means*, associating it with modes of application such as essential technologies or design principles for its implementation. This category of perceptions tends to address what I4.0 can provide to companies in terms of tools and can be further divided into techno-centred and data-driven categories. Secondly, managers may perceive I4.0 as *a purpose*, associating it with goals or a set of improvements that I4.0 allows companies to achieve. Here, the perceptions tend to address why companies decide to implement I4.0 and can be further divided into transformative, performance-seeking, people-minded and multidimensional categories. Finally, managers may perceive the concept of I4.0 as *a limit*, associating it with a series of factors that undermine its nature or suitability for organisations. This category of perceptions tends to address for whom I4.0 is reserved and can include a critical category.

Trend	Category	Definition	Examples of textual response
Means	<i>Technology-oriented</i>	The notions of integrating key I4.0 technologies and/or basic processes for their integration (automatization, digitalisation).	“integrating digital technologies into existing business processes”
	<i>Data-driven</i>	The notions of interconnecting various elements via integration of I4.0 technologies and/or processes related to data management.	“Interconnecting data flows between management and planning tools, production tools and HR as a whole.”
Purpose	<i>Transformative</i>	The notions of transforming and improving companies globally.	“Mandatory change in the extension of the existing state of affaires”
	<i>Performance-seeking</i>	The notions of boosting the efficiency, the productivity, the durability, the competition, and client relations of the company.	“Digitalisation for greater efficiency and anticipatory management of performance and risks”
	<i>People-minded</i>	The notions of transforming working conditions of human operators	“Reduced administrative workload, down-top information feedback”
	<i>Multidimensional</i>	The inclusion or combination of “People” and “Performance” purposes.	“Use new technologies to increase productivity while better interconnecting people and machines.”
Limit	<i>Critical</i>	The questioning, the judgement and/or disapproval of I4.0 concept.	“generally unthinkable in our very specific profession”

Table 2. Managerial perceptions of I4.0.

The diversity of perceptions demonstrates the conceptual ambiguity of I4.0 concept, characterised by its broad interpretative space. Since the study is in its exploratory phase, the authors attempted to identify potential elements that the respondents might mobilise in their sensemaking processes related to I4.0 (Weick, 1995). With respect to the representativeness of each factor within the sample, several observations were made. Critical and data-driven perceptions of I4.0 were exclusively represented by directors. Critical perceptions of I4.0 were shared only by respondents from family-owned companies. Respondents from companies with more than 100 employees mostly perceived I4.0 as a means, with the majority falling into techno-centred or data-driven categories. These elements might emerge from the contextual materials indirectly influencing SMEs’ executives grappling with the conceptual ambiguity of I4.0.

To explore the reasons behind these observations and incorporate elements related to organisational context and respondent personalities, the authors are currently conducting interviews with the respondents who have agreed to participate in the qualitative phase of the study. Initial interviews with several managers within the same company allowed an interesting observation. A discrepancy in the perception of I4.0 and the company's maturity in terms of its implementation was observed between a manager specialised in industrialisation and another in customer relations. According to the industrialisation manager, the company was nearing the I4.0 excellence with technology implementation and increased agility. In contrast, the commercial manager noted the absence of key aspects of I4.0, such as interconnectivity between departments still working in silos or enhanced interaction with customers.

The authors believe that this observation, along with forthcoming results, will contribute to management literature by emphasising the significance of the sensemaking process in implementing of I4.0 within SMEs. The study aims to demonstrate how perceptions of I4.0, combined with managers' experiences and SMEs' contexts, can influence the organisational transformation in the scope of I4.0 implementation. Furthermore, the findings can be mobilised to challenge stakeholders behind various incentive and support programs aimed at guiding SMEs in I4.0 implementation, adapting their offers to better meet SMEs' needs.

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