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Industry 4.0 and organisations: Key organisational capabilities

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Abstract. The fast-paced evolution of digital technologies, termed the fourth industrial revolution (4IR), influences organisations to realise digital technology potential from a holistic point of view. In this context, organisational competitiveness relies on whether organisations' business value-creation capabilities are adaptable and flexible. The purpose of this study was to consider the 4IR key organisational capabilities that organisations require to ensure sustainability and to create business value. We identified 14 4IR organisational capabilities and operationalised these capabilities by mapping them to the dynamic capabilities sensing (strategic leadership, external drivers, data value), seizing (decision-making, technology features, software services and solutions) and transforming (business model, process optimisation, product efficacy, organisation, customer) as defined by Teece. Three 4IR organisational capabilities, namely employees, skills and expertise, as well as communication, are relevant across all three dynamic capabilities. By applying the 4IR organisational capabilities, organisations will be able to consider the end-to-end impact of 4IR on them and to address action plans to sustain value, or to create new business value.

Keywords: Industry 4.0, Organisational capabilities, Dynamic capabilities

1 Introduction

To remain competitive, organisations have to manage the significant evolution of digital technologies from two perspectives: firstly, the scope of the evolution and secondly, the pace at which it takes place [1, 2]. This evolution of digital technology, referred to as the fourth industrial revolution (4IR) [3, 4], is associated with aspects such as artificial intelligence, the internet of things, big data, robotics, cloud computing and augmented reality [5]. However, for organisations to realise the 4IR potential from a comprehensive point of view, 4IR-relevant organisational aspects such as an 4IR-relevant strategy, digital business model innovation, technology investment optimisation, workforce management complexity, digital eco-systems, technology-centric convergence, virtual model and physical environment linkage, value chain digitalisation and product portfolio innovation, must be considered [6].

While 4IR potentially offers great value to organisations, traditional business models struggle to meet and keep up with the demands of the new digital economy, potentially threatening their sustainability [7]. Furthermore, emerging technological implementation and transformation fail to realise the desired business value-creation intentions [8].

Organisational competitiveness therefore relies on whether organisations' business value-creation capabilities are adaptable and flexible [9]. Such efficacy of capabilities enables organisations to adjust organisational and technology strategies dynamically and to ensure sustained alignment between the organisation's capabilities and business value creation [9, 10].

This research study was conducted to understand the required capabilities better and to ensure that the identified capabilities enable business value-creation in the context of 4IR. The focus of this paper is therefore on contributing to the discourse on what 4IR organisational capabilities entail, by considering the following research question: "*What are the 4IR key organisational capabilities that organisations need to consider?*" We reflect on this research question by considering an overview of 4IR in an organisational context and how it affects key organisational capabilities required.

In this paper, we firstly provide an overview of literature in section 2, followed by the research approach in section 3. In section 4 we present a discussion on the data analysis and findings, while section 5 details the contribution of the study. Section 6 concludes the paper.

2 Background

The aim of 4IR is to use technology to realise improved operational efficiency and productivity, to optimise business systems and to improve customer experience [11, 12]. Furthermore, human-machine interaction enables enhanced value-added services, automatic data exchange and communication, as well as analysis across value chains [13, 14] This contributes to business process efficacy and ultimately enables the creation of quality products and services at lower cost [7, 11].

In this section, we consider 4IR in the context of organisations, organisational capabilities and organisational capability theory.

2.1 Industry 4.0 and organisations

The evolution of digital technologies had a significant impact on organisations [15], altering organisational practices as 4IR technologies (e.g. the internet of things, robotics, etc.) replaced routine and repetitive jobs [16]. Process visualisation and machine learning techniques may be applied to detect flaws and to optimise outputs [15]. To allow organisations to manage these multiple internal and external factors to enhance business value and create a sustainable competitive advantage, 4IR horizontal and vertical integration alignment must be considered [16, 17]. The activities of a horizontally integrated organisation focus on its core competencies and build their end-to-end value chain through establishing partnerships. Alternatively, a vertically integrated company manages most of its value chain in-house, e.g. product development, manufacturing, sales, distribution and marketing [15-17].

Therefore, to allow organisations to manage multiple complexities introduced by 4IR, the development and application of new models and methods are required [18].

These models and methods need to consider complex systems, comprehensive infrastructure consisting of a high-quality information network and internet connectivity, security and privacy, data protection, work organisation and design, and the effective use of resources [3, 17, 19, 20]. As these complex systems affect the roles of employees and managing teams of highly specialised technical experts, organisational performance needs to take cognisance of skilling employees to operate in the new technological revolution, with specific profiles that are currently non-existent [21, 22].

2.2 Organisational capabilities and challenges

Organisational capabilities are intangible assets and refer to the “collective skills, expertise, and alignment of the people” in the organisation [23 : 119]. Capabilities span the whole organisation, as opposed to competencies that tend to be associated with an individual employee [23]. Such organisational capabilities represent the ways in which people and resources are combined to accomplish work [23, 24]. Capabilities therefore refer to the ability to take action (e.g. a decision), to carry out a set of strategic or operational activities, to accomplish a practised or routine activity, or to perform a collection of routines such as processes or procedures [25, 26]. In this context, the importance of management capability to adapt effectively to changing environments by “re-configuring internal and external organisational skills and resources” is highlighted [27].

However, scholars report many challenges with regard to organisational capabilities in the context of 4IR [8]. Some of these challenges include identifying which strategic technologies to focus on, considering multiple factors when complex requirements and their impact on business value-creation must be assessed and balancing market-pull and technology-push approaches to find new business value-creation initiatives based on new technology capability [7, 8, 28]. At an operational level, challenges include inconsistent business processes, duplicated software solutions, limited system capability to support operations and lack of end-to-end visibility and transparency [7-9, 29].

2.3 Organisational capability theory

As organisations initiate and execute transformation of their business, technology and operational aspects, they utilise capability maturity models and metrics to monitor the measurement of success [28]. Maturity models have proven to be a significant tool to guide organisations in improving their capabilities and process orientation [30], and several maturity models have been developed with the aim to evaluate progress of organisational capability improvement [31-33]. Maturity models, in the context of capabilities, track the improvement (maturing) of organisational and technological systems in order to increase their capabilities over time with the aim to achieve the defined future state [32]. Some examples of such capability maturity models include the capability maturity model consisting of a five-staged structure (initial, repeatable, defined, managed, optimising) [34], a maturity model for assessing organisational process capabilities consisting of nine dimensions (products, customers, operations, technology, strategy, leadership, governance, culture, people) [32], a quality management maturity grid consisting of 14 steps [35] and multiple project management maturity models [36].

For the purpose of this study and in the context of 4IR, dynamic capabilities were considered as defined by David Teece [37]. Teece's [27, 37] concept of dynamic capabilities presumed that organisations require the ability to navigate fast-changing markets by reshaping the organisation's asset structure and realise the essential internal and external transformation. The dynamic capabilities included three aspects: *sensing* (the capacity to explore and shape opportunities and threats), *seizing* (to take hold of opportunities) and *transforming* (to maintain competitiveness through improving and reconstructing the organisation's tangible and intangible assets) [27]. These three capabilities, sensing, seizing and transforming, were deemed key to ensure that an organisation may reach the next transformative stage [24].

3 Research Approach

The objective of this paper is to present the 4IR key organisational capabilities that organisations need to consider. In order to achieve the objective, data collection was carried out in two steps. Firstly, a systematic literature review (SLR) to synthesise the existing body of completed and recorded work produced by researchers, scholars and practitioners was conducted to identify 4IR organisational capabilities [38, 39]. Peer-reviewed and academic sources such as technical reports, books and conference proceedings were selected for the SLR process [40, 41]. To include all references to 4IR and organisational capability, the search terms were chosen as: ("fourth industrial revolution" and "organisational capability") or ("Industry 4" and "organisational capability"). The initial research studies extracted (165) (Figure 1) were screened by applying specific criteria such as non-English studies, anecdotal or opinion-based papers and duplicate studies that formed part of the result set. Inclusion criteria consisted of peer-reviewed publications and technical reports relevant to the research question. After the initial search, as well as the application of inclusion and exclusion criteria, 153 publications were selected as shown in Fig. 1.

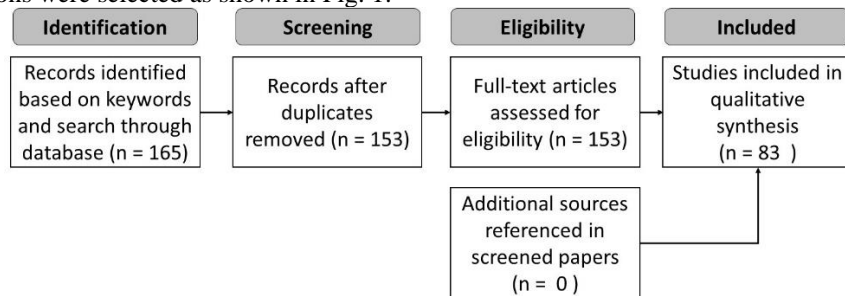


Fig 1. Total number of papers extracted and analysed

We concluded a detailed screening of abstracts and analysis of the full text of the prospective papers, after which 83 papers were assessed in detail. Papers were excluded based on criteria such as studies not being associated with the research question, a keyword mismatch and irrelevance (e.g. about speech, about psychology, about racial analysis).

Secondly, semi-structured interviews were conducted in order to enrich the organisational capabilities defined through the SLR. A semi-structured interview guide was designed, guided by the SLR findings and consisting of two sections: the initial section captured respondent demographic information, followed by the second section containing the questions regarding key 4IR capabilities. Nine respondents were identified through purposive sampling based on their experience and knowledge related to the research study [42]. The profiles of respondents are summarised in Table 1.

Table 1. 4IR organisational capabilities extracted from the literature

Organisational level	Tenure at current organisation		Industry sector
	1	2	
Senior Management	1	9-12	Education Communication and information technology sector
Executive	4	16+	3
Middle Management	2	3-5	4
Specialist	2	6-8	1
			Aviation

Seven of the nine respondents (78%) confirmed that they had undergone a digital transformation project in the past five years.

4 Data Analysis and Findings

The aim of this paper is to consider the 4IR key organisational capabilities. Themes and main themes were identified in the selected studies through a two-step process: firstly, descriptive codes were used to identify themes [43] and secondly, open coding was used to identify emerging main themes [44]. Table 2 depicts the extracted capabilities, identified themes, as well as the references.

Table 2. 4IR organisational capabilities extracted from the literature

Theme	Capability from the literature	References
Leadership	Accountability	[23, 45]
Leadership	Co-created leadership/leadership	[7, 23, 45-49]
Organisation	Coherent brand identity	[23, 46]
Customer	Collaboration	[23, 50]
Product efficacy	Creativity	[46, 51]
Customer	Customer connectivity	[5, 7, 23, 45]
Data value	Data-driven decision support	[5, 28, 47, 48, 50-52]
External environment	Deal with external disasters	[45, 47]
Customer	Dialogue	[45, 46, 48]
Organisation	Diversity and inclusion	[45, 46, 48]
Product efficacy	Efficiency	[23, 46]
Employees	Employee voice	[46, 48, 50, 51]
Employees	Employee-driven improvement	[46, 47, 51]
Skills and expertise	Enterprising behaviour	[7, 46, 47, 51]
External environment	Environment and market	[7, 8, 53]
Product efficacy	Flexibility	[46, 51, 53]
Product efficacy	Innovation	[8, 23, 46, 51, 52]
Skills and expertise	Legal and regulatory	[8, 45, 51]
Organisation	Organisational culture	[7, 28, 48, 51, 54]
Organisation	Organisation design	[7, 46, 47, 54, 55]
Organisation	Organisational agility	[28, 52]
Organisation	Organisational knowledge and continuous learning	[23, 48, 51, 54, 55]
Product efficacy	Product and service personalisation	[5, 28]

Theme	Capability from the literature	References
Product efficacy	Process transparency	[8, 46, 47, 50, 51, 54]
Product efficacy	Quality	[45-47, 49, 53]
Leadership	Shared mind-set	[23, 45, 51]
Product efficacy	Speed	[7, 23, 28]
Leadership	Stakeholder relationship management	[28, 51]
Leadership	Strategic unity	[7, 23, 45, 51]
Skills and expertise	Talent	[7, 8, 23, 45-47, 51]
Technology	Technology (context relevance and efficacy)	[7, 23, 28, 45, 47-51]
External environment	Waste minimisation and green practices	[45-47, 49, 53]

We identified nine unique 4 IR capability themes, namely leadership, organisation, customer, product efficacy, data value, external environment, employees, skills and expertise and technology.

The qualitative data collected through the nine semi-structured interviews were analysed in order to identify 4IR capability themes. Major themes identified included customer, data, customer experience, employee, technology, external driver and business. Secondly, common themes highlighted in the interviews were collated and the frequency of the comment was noted, as shown in Table 3. The theme *customer* was mentioned 49 times (21%), while *technology features* and *data value* were presented 43 (18%) and 36 (15%) times respectively.

Table 3. 4IR organisational capabilities extracted from the semi-structured interviews

Theme	Description	Frequency count	
Customer	customer experience, customer value, customer; customer travel experience; seamless customer experience; customer touch point; word of mouth; level of customer experience; free customer experience; many new customer	49	21%
Technology features	digital technologies; latest technology; new technology; new tools; next generation technology; bespoke technological solutions; old-fashioned way; unique software features; new digital technology; technology	43	18%
Data value	data; analysis of data; scientific data modelling; appointment of data; data science capabilities; use of data; value of data; new data services; master data management; actuarial scientific data; data processing capabilities; big data	36	15%
External drivers	4IR criteria; i4.0 type solutions; current newest trends; external driver; biggest external driver; industry; thorough impact assessment; technology intelligence process; company image	18	8%
Product efficacy	efficient products delivery; products	17	7%
Employees	employees; healthy team culture; behavioural change management; massive organisational shift; electronic skills matrix; employees' entry; whole organisation; organisational culture	16	7%
Skills and expertise	continuous learning opportunities; digital training platform; digital skills; certain software professionals; high-quality skillsets; domain of expertise; software services company; use of technology	10	4%

Theme	Description	Frequency count	
Process optimisation	process of innovation; internal workflow tools; exit process/ invoice; way of work; many manual processes; internal process; way of working; business improvement opportunities	9	4%
Strategic thinking	strategic objectives; digital transformation objectives; much revenue; digital strategy; lockdown strategic initiative	8	3%
Organisation	business unit; elements of business; new business unit; digital business unit	7	3%
Software services and solutions	competitive software services; services provider relationship; use of services; solutions development philosophy; specific solutions development; system implementation project	6	3%
Business model	virtual company; new business model; business value; business case approval; approved business case; differentiated business model	8	3%
Decision-making	decision making; core pillar; significant focus	4	2%
Communication	internal communications tools; information sharing tools; personalised communication	4	2%
	Total comments	235	100%

We integrated the 4IR capabilities extracted from the literature (Table 2) with the capabilities extracted from the interview transcripts (Table 3), as shown in Table 4.

Table 4. Integrated 4IR organisational capabilities

Theme	4IR capabilities from the literature	4IR capabilities from semi-structured interviews
Business model		virtual company; new business model; business value; business case approval; approved business case; differentiated business model
Communication		internal communications tools; information sharing tools; personalised communication
Customer	Collaboration, Customer connectivity, Dialogue	customer experience, customer value, customer; customer travel experience; seamless customer experience; customer touch point; word of mouth; level of cx; free customer experience; many new customers
Data value	Data-driven decision support	data; analysis of data; scientific data modelling; appointment of data; data science capabilities; use of data; value of data; new data services; master data management; actuarial scientific data; data processing capabilities; big data
Decision-making		decision-making; core pillar; significant focus
Employees	Employee voice, Employee-driven improvement, Shared mind-set	employees; healthy team culture; behavioural change management; massive organisational shift; electronic skills matrix; employees' entry; whole organisation; organisational culture
External drivers	Deal with external disasters, Environment and market, Waste minimisation and green practices	4IR criteria; i4.0 type solutions; present newest trends; external driver; biggest external driver; industry; thorough impact assessment; technology intelligence process; company image

Theme	4IR capabilities from the literature	4IR capabilities from semi-structured interviews
Strategic leadership	Accountability, co-created leadership/leadership, Stakeholder relationship management, Strategic unity	strategic objectives; digital transformation objectives; much revenue; digital strategy; lockdown strategic initiative
Organisation	Coherent brand identity, Diversity and inclusion, Organisational culture, Organisation design, Organisational agility, Organisational knowledge and continuous learning	business unit; elements of business; new business unit; digital business unit
Process optimisation	Efficiency, Speed, Process transparency	process of innovation; internal workflow tools; exit process/invoice; way of work; many manual processes; internal processes; way of working; business improvement opportunities
Product efficacy	Creativity; Flexibility; Innovation; Product and service personalisation; Quality	efficient product delivery; products
Skills and expertise	Enterprising behaviour, Legal and regulatory, Talent	continuous learning opportunities; digital training platform; digital skills; certain software professionals; high-quality skillsets; domain of expertise; software services company; use of technology
Software services and solutions		competitive software services; services provider relationship; use of services; solutions development philosophy; specific solutions development; system implementation project
Technology features	Technology (context relevance and efficacy)	digital technology; latest technology; new technology; new tools; next-generation technology; bespoke technological solutions; old-fashioned way; unique software features; new digital technology; technology

Where a particular 4IR capability was not present in the review of the literature or the interview data, we indicated that cell with a diagonal line. It may be observed that the enriched dataset shown in Table 4 consists of 14 4IR capabilities; the capabilities identified from the literature were enriched by four capabilities highlighted in the interviews, namely business model, communication, decision-making, and software services and solutions.

The *technology features capability* focuses on context relevance and efficacy of the 4IR digital technologies and how these technological opportunities translate into business value. The *business model capability* refers to the opportunities 4IR provides to organisations to differentiate their business models or create new business models, with the aim to increase or add business value. This capability is also informed by the *external driver capability* enabling the organisation to understand 4IR criteria and solution types (technology intelligence) deeply in order to inform differentiation. *Strategic leadership capability* combines these aspects into coherent strategic objectives, creating strategic unity and ensuring that all stakeholders are managed in this process. *Communi-*

nication capability is important from two perspectives: both internally in the organisation and externally to customers. Communication and knowledge-sharing internally in the organisation empower employees to make sense of the 4IR strategies, while communication with customers is personalised, based on the particular customers' profile and engagement with the organisation. *Customer capability* means the management of a seamless customer experience and all the capabilities in the organisation required to achieve it. Such personal customer experiences are possible through the *value of data capability*, where large datasets are analysed using different techniques to enable data-driven decision support, not just as it relates to the customer, but also generating business value insight for the organisations. This highlights the *decision-making capability* that enables actionable insights through a process of factual analysis and learning, rather than based on intuition only.

Employees as a 4IR capability refer to the management of the key impact on employee-driven improvement enabled by 4IR technologies, the significant organisational shift required towards a transformational culture and the impact on employee skills to deal with the new organisational and technology landscape. This capability is strongly associated with the *skills and expertise capability*, where an organisation must invest in continuous learning opportunities and a digital training platform to foster these high-quality skillsets. Organisational culture, organisational design, organisational agility and the establishment of new/revised business units based on the business model choice all form part of the *organisational capability*. The *process optimisation capability* refers to efficiency, process transparency and innovation, as it influences and relates to business improvement opportunities and ultimately the new way of work in an organisation. The *product efficacy capability* underpins two key aspects. The first is the creativity, flexibility and innovativeness of product design and service personalisation, and the second the efficacy of product delivery. A *software services and solutions capability* refers to competitive software services, whether an organisation follows an internal solutions development philosophy, or whether a service provider relationship and use of services are considered.

In order to report and operationalise the findings presented in Table 4, we mapped these to the dynamic capabilities sensing, seizing and transforming as defined by Teece [37] and present the detail in the next section.

5 Key 4IR organisational capabilities

The aim of this paper is to consider the key 4IR organisational capabilities. Fourteen 4IR organisational capabilities were extracted from the literature and from nine semi-structured interviews, whereafter the findings were operationalised by mapping them to Teece's 3 [37] dynamic capabilities depicted in Fig. 2. The definitions of dynamic capabilities theory informed the association to the particular 4IR organisational capability.

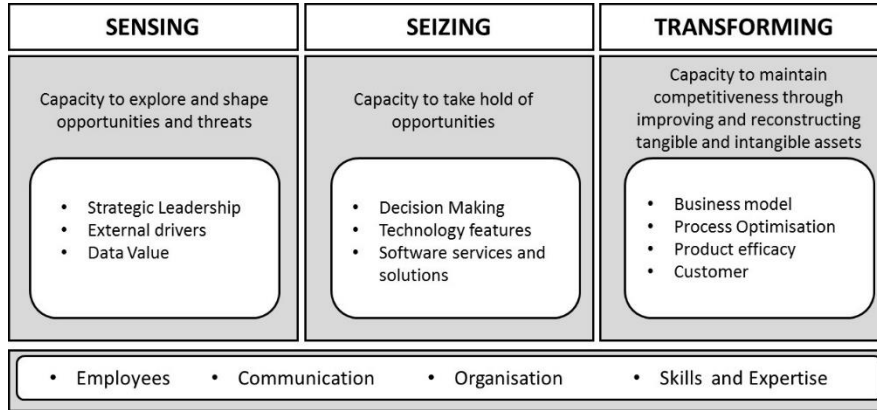


Fig. 2. 4IR relevant organisational capabilities (mapped to Teece's dynamic capabilities [37])

For an organisation to create business value in the 4IR world, it must constantly explore opportunities and be aware of potential threats in order to navigate fast-changing markets. To achieve this, through strategic leadership organisations must constantly scan (sense) the environment, consider external drivers that could have a potential impact on their concerns and obtain data-driven insights. Through this sensing dynamic capability, organisations may then seize opportunities, i.e. decide which opportunities to implement or which threats to address. These decisions will be informed by the technology features, software services and solutions to which the organisation has access. The next step is to implement these decisions and transform the organisation through business model changes, process optimisation, product and organisational capabilities – all to the benefit of the customer and ultimately to create value for the organisation.

Three 4IR organisational capabilities, namely employees, skills and expertise, and communication, are relevant across sensing, seizing and transforming. Employees and their skills and expertise are applied throughout the process, and this process will be affected by transformation. Communication – internal and external – will also take place across all three activities of sensing, seizing and transforming and will play a significant role during transformation. We have therefore placed these three 4IR capabilities across sensing, seizing and transforming.

6 Conclusion

Organisations must deal with significant evolution of digital technology (4IR) to remain competitive. While 4IR digital technologies potentially offer great value to organisations, traditional business models struggle to keep up with the demands of this new digital economy and require digital capabilities to sustain or create business value. In this study we considered the 4IR key organisational capabilities that organisations require to navigate the 4IR digital technology evolution. We identified 14 4IR organisational capabilities based on an SLR and nine semi-structured interviews. To operationalise the 14 4IR capabilities identified, we mapped these to the sensing, seizing and transforming dynamic capabilities defined by Teece [24]. By applying the

4IR organisational capabilities, organisations will be able to consider the end-to-end impact of 4IR on the organisations and to address action plans to sustain value holistically.

As the study proposes 4IR organisational capabilities in the context of dynamic capabilities, further research may be conducted to test the proposal in a real-world scenario in an organisation.

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