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How do Industry 4.0 technologies influence organisational change? An empirical analysis of Italian SMEs

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Abstract

Purpose This article aims to investigate the organisational implications of adopting Industry 4.0 (I4.0) technologies, giving specific attention to operations. The paper addresses these implications in two directions: organisational prerequisites for, and consequences of, I4.0 technologies.

Design/methodology/approach The research is based on a multiple case study of Italian Small and Medium Enterprises (SMEs) in manufacturing. Ten case studies have been developed through interviews, company visits and secondary data collection.

Findings The multiple case study results show that: i) a lean organisational structure supports effective adoption of I4.0 technologies; ii) introducing such technologies is linked to developing a new kind of job profile (i.e., the "Autonomous Operative Job Profile"); and iii) higher levels of technology adoption create a higher need for non-technical competences.

Research limitations/implications A limitation of this research relates to the highly heterogeneous maturity levels of the sampled companies, due to the relative newness of the I4.0 paradigm. Future research could, therefore, longitudinally analyse the technology integration process within organisations.

Practical implications This research provides preliminary evidence about how organisations and technologies co-evolve, thus suggesting that managers should co-design these areas. It also demonstrates the extreme importance of designing a structured process and a clear set of human resource management tools to favour SME organisational development.

Originality/value The study is built upon a conceptual framework, derived from the sociotechnical perspective, that analyses the interconnections between technology implementation and organisational change. From the results, three research propositions are derived to be tested on a larger scale.

Keywords Industry 4.0; Sociotechnical; Technology; Small- and medium-sized enterprises; Case study; Organisational change

1. Introduction

The increasing digitalisation of the value chain, as stipulated by the well-known Industry 4.0 (I4.0) paradigm, represents an eminently technology-based opportunity to change how companies generate value for their customers (Oesterreich and Teuteberg, 2016). This new paradigm is strongly techno-centric. Indeed, the primary driving factors are new technological applications, such as cyber-physical systems (CPS), which can communicate with each other and adapt to mutable contexts (Monostori, 2014), and Internet of Things (IoT) objects, which interconnect people, products, assets and systems through real-time data exchange (Ghobakhloo, 2018; Lee et al., 2016).

Consequently, many companies have begun a digital transformation journey, which encompasses potentially radical changes involving the whole firm, including its organisation, physical infrastructure, human resources, process management and manufacturing operations and technologies (Gilchrist, 2016). Today's debate focuses, to a great extent, on the role of technologies in creating or destroying jobs (Weber, 2016; World Economic Forum, 2016). At the same time, however, companies are keen to understand how the I4.0 paradigm can impact professional skills and competences, as well as the company's organisational structure (Erol et al., 2016).

Developing a proper strategy to effectively manage the transition towards the Smart Manufacturing model requires specific attention to organisational structure. The effectiveness of I4.0 technology adoption depends on organisational characteristics and, specifically, on a company's readiness to leverage such technologies. Scientific literature only partially addresses the organisational impacts of technology introduction, as more emphasis is devoted to technology's effects on competences (Gehrke et al., 2015; Kagermann et al., 2013). Therefore, the research presented in this paper aims to extend this perspective by investigating the potential relationship among technology adoption decisions (usually referred to as 'I4.0 technologies' in the remainder), competences, and organisational structure.

This work will focus mainly on the impacts of I4.0 technologies on organisations. To do so, it adopts a reference framework that allows an in-depth analysis of the relationships and impacts among relevant aspects of the I4.0 scenario. This framework is rooted in the sociotechnical model (Trist and Emery, 2005), and puts together aspects linked to organisations (at the macro and micro levels), technologies, and competences (both technical and non-technical).

A further contribution of this research concerns identifying implications connected to introducing I4.0 technologies in the manufacturing context. A multiple case study approach, carried out in ten Italian Small and Medium Enterprises (SMEs), provides evidence of the complex challenges entailed in introducing new technologies while contextually approaching changes to the organisational structure and workers' skillsets.

A third contribution, stemming from the on-field analysis, is the formulation of three research propositions, thus contributing to the research stream about organisational and competence development in the I4.0 era.

The paper is structured as follows. Section 2 presents a literature review about I4.0 and Socio-Technical Systems (STS) theory, focusing on the relationships between organisations, technology, and human factors. Section 3 illustrates the research methodology. Section 4 introduces the proposed reference framework, with a detailed description of considered dimensions, while Section 5 discusses the results of the case study research. In Section 6, three research propositions are formalised and discussed. Section 7 concludes the paper and discusses the contributions of the work, its limitations and potential further directions for research development.

2. Related literature

2.1. I4.0 and sociotechnical systems

I4.0 and related terms—such as Smart Manufacturing, Digital Manufacturing, Advanced Manufacturing, etc.—involve a set of characteristics, technologies and enabling factors, which are integrated in the industrial scenario to govern manufacturing operations (Mittal et al., 2016) and achieve higher levels of operational efficiency and productivity (Lu, 2017). Several contributions to the extant literature point out that I4.0 has an important, long-term, strategic impact on global industrial development and, consequently, there is a growing demand for research providing insights into the issues, challenges, and solutions related to designing, implementing and managing smart manufacturing systems (Xu et al., 2018). I4.0 brings several business opportunities for manufacturers, promoting the shift to high-performance production processes and advancing companies' servitisation, thereby enabling new, digital, service-related business models and outcome-based contracts, which increase complexity and require new management and organisational strategies (Ardolino et al., 2018; Cenamor et al., 2017; Cimini et al., 2017; Zheng et al., In press).

As mentioned in the introduction, a common factor characterising the main definitions of I4.0 (Kamble et al., 2018; Schmidt et al., 2015) is their techno-centric perspective, in which technological advancements are the main trait of this industrial revolution. Oztemel and Gursev (2018) review the technologies and technical challenges related to I4.0. However, beyond technological implementation, introducing the I4.0 paradigm poses challenges concerning operational, organisational and managerial levels, which must cope with the digital transformation. Consequently, implementing I4.0 technologies presents, not only scientific and technological challenges, but also social and political issues (Zhou et al., 2016). The I4.0 paradigm allows the integration of a set of emerging technologies to add value to the whole lifecycle, but it simultaneously demands a sociotechnical evolution of the human role in the production system (Frank et al., 2019).

Investigating how technology introduction impacts the workforce arose as a relevant research stream in the 1950s, resulting in a vast amount of work grounded in STS theory (Trist and Murray, 1993; Trist and Emery, 2005). The STS approach merges the technical (i.e., tools, equipment and processes) and the social (i.e., people and their relationships) systems. The present authors deem the STS theory appropriate for describing the future industrial scenario, as the interaction between humans and technology is becoming increasingly critical and beneficial (Stern and Becker, 2017). However, despite I4.0 being characterised mainly by digitalisation and advanced automation, the human role inside a smart manufacturing system is expected to remain dominant (Jäger and Ranz, 2014).

An enlarged perspective about STS for I4.0 has been modelled by Dregger et al. (2018) and is based on the Human-Technology-Organisation (HTO) concept, which studies the interactions of these three sub-systems—as they are directly related to the whole system's performance (Karltun et al., 2017)—to describe the dynamic behaviour of a production system.

Starting from the HTO, and focusing on the organisation and how it evolves in an I4.0 context, this work gives attention to the interface between *technology and organisation* (TO). The interfaces between *human and technology* (HT) and between *human and organisation* (HO) have not been considered. According to Dregger et al. (2018), the HT interface concerns the development of intelligent assistance systems and the design of human-oriented systems to ensure proper communication and collaboration among operators and technological systems (i.e., machines). This work, instead, aims to identify the impacts of technology on human work regarding competences and tasks, here considered as organisational variables. Conversely, the HO interface has not been considered because it does not include the technological perspective, whose impacts on organisations are the focus of this research. Despite this, the sociotechnical approach suggests considering also the human aspects—i.e., those related to the HO and HT interfaces. However, focusing on the human subsystem and its relationships with the others would require a specific analysis, capable of untangling all relevant aspects of the individual dimension. For the purposes of this research, therefore, the human aspects will be analysed from a collective perspective, detecting the indirect effects of technology on the organisational variables of human skills and jobs.

The literature concerning the relationships between organisational aspects following new technology introduction has not been sufficiently explored within the I4.0 concept (Charalambous et al., 2017). However, several human-related organisational aspects, such as workforce training, communication and information/knowledge sharing processes and participation in the organisational processes of innovation, have been investigated in the literature and have been considered critical for effective organisation of firm processes following new technology introduction. First, communication, as information and knowledge sharing, is of fundamental importance, especially in transmitting the correct information concerning when, how and why organisational changes are envisaged. This will prevent false news from circulating and mitigate resistance (Bierwolf, 2017; Charalambous et al., 2015). Workforce training is another important aspect, especially if the training of the individual is also integrated with moments of team training (Fraser et al., 2007) and with actions that boost knowledge sharing between more experienced and newly hired operators (Rehman et al., 2014). Finally, the employees' direct involvement in renovating organisational processes is a crucial element for the success of the transition from traditional to innovative organisational models (Zhang et al., 2009).

Since the seminal works on sociotechnical theories, attention has been given to the interface between technology and organisation. Traditionally, sociotechnical literature has addressed the co-evolution of technology and organisation, highlighting micro-level impacts on tasks and job roles (Leonard-Barton, 1988). The macro-level—which involves organisational design (Mintzberg, 1980) and the evolution of organisational structures (i.e., how it is influenced and impacted by new technology introduction)—has, so far, been neglected and under-researched. Some authors have taken a holistic view of organisational change triggered by new technologies, creating a debate around whether organisations tend to lag behind technological change (Damanpour and Evan, 1984) or mutually adapt with it (Ettlie, 1988).

Notably, an organic design of the organisation, built on decentralisation, empowerment, low formalisation and collaboration, is assumed to be more suitable for an innovative and changing environment. Furthermore, some specific organisational structures can be identified as facilitators of I4.0, namely the matrix and the team-based structures, specifically designed to have a flat hierarchy and high decentralisation (Shamim et al., 2016).

Hirsh-Kreinsen (2016) theorises a connection between the evolution of work and the evolution of the organisation. Two organisational types are hypothesised, reflecting the two possible evolutions towards either *upgrading* or *polarising* qualifications. The first scenario (i.e., upgrading) assumes the automation of the simplest and most routine jobs, while more complex and productive jobs, made easier by information offered through new technologies, will be made available to low-skilled employees. This upgrade of skills and jobs towards giving employees new roles as decision-makers and coordinators will be enabled by creating a network of equally entitled employees, with no defined tasks or jobs. In this context, the organisation will evolve towards a *swarm organisation*, in which every level will be characterised by 'structural openness' and high flexibility.

The second scenario (i.e., polarisation) assumes the replacement of medium-skills jobs, which will be automated and substituted by machines. Some low-skill jobs involving very simple activities, such as monitoring and control tasks unsuitable for automation, will be maintained, as well as the high-skill jobs associated to highly-qualified experts. In this context, a *polarised organisation* will emerge, characterised by a sharp division of labour and rigid structures (Hirsch-Kreinsen, 2016).

2.2. Research contribution to literature

The preceding literature review highlighted evidence about the difficulty of studying the direct impacts of new technology introduction on the organisation, which has been found to either lag behind or adapt to the technology. This leads to the hypothesis that technology and the organisation must co-evolve, so the latter will be ready to embrace the new roles and tasks created by the former. A holistic view over the HTO dimensions allows identification of the most relevant challenges and opportunities generated by the I4.0 paradigm.

Job roles and skills appear to be directly impacted, as stated by the emerging literature on competence models, focusing on the new competences needed in an I4.0-oriented organisation (Erol et al., 2016; Gehrke et al., 2015; Prifti et al., 2017). Interestingly, these contributions highlight the need to balance technical skills, derived from technology usage, with soft skills—stating that this combination is fundamental to stimulating organisational change (Rehman et al., 2014).

However, some literature gaps can also be identified in the current scientific debate surrounding I4.0. First, attention is mainly paid to its impacts on competences, and only partially to its impacts on organisational structures. Secondly, focus is commonly given to large companies, characterised by important spending possibilities, while limited attention is paid to SMEs, whose real benefits and requirements for I4.0 implementation have not been fully explored (Moeuf et al., 2018). Finally, empirical evidence and analysis is still limited, and additional evidence can be useful to support companies in foreseeing investments' implications.

Thus, the main objective of this research is to study the impacts generated by the introduction of I4.0 technologies on the organisation of SMEs—giving attention, not just to competences, but, more generally, to the various organisational sub dimensions.

3. Methodology

Building a conceptual framework is a fundamental step when designing empirical research (Voss et al., 2002). A framework clarifies the main points to be studied (Miles and Huberman, 1994), thus helping to shape the initial research design, measure constructs more accurately and provide a firmer empirical ground for the new theory (Voss et al., 2002). The framework developed in this research is based on previous literature about the sociotechnical model. It brings together organisation characteristics (at macro and micro levels), technology and competences (i.e., technical, methodological, personal and interpersonal). Multiple case study methodology has been chosen to explore the relationships shown in the framework—i.e., the link between technology and macro- and micro-organisation, as well as the link between technologies and skills. This methodology has been applied to SMEs, allowing for logical and literal replication and enabling identification of similarities and differences between the cases (Chetty, 1996).

Field-based research methods, like case studies, are especially suitable for coping with the growing frequency and magnitude of changes in technology and managerial methods (Lewis, 1998), as is the case with I4.0 adoption. Multiple case studies also enable broader explorations of research questions and theoretical elaboration, as well as a more precise delineation of constructs and relationships (Yin, 2009). There is no ideal number of cases in multiple case study methodology (Eisenhardt, 1989); the theoretical saturation is reached when incremental learning is minimal because the researchers begin collecting previously seen observations (Glaser and Strauss, 1967).

3.1. Case selection

The selection of the companies analysed in this research has been conducted according to a judgemental sampling approach (Henry, 1990) and has been mainly based on available data from a local branch of the General Confederation of Italian Industry. The selection resulted in ten companies representative of the principal sectors in northern Italy, thus providing a clear picture of the region's current situation, while considering different sectors, needs and criticalities (Table 1).

Company	Industrial sector	Roles interviewed	Turnover	Employees
A	Manufacture of electrical equipment	• Plant manager • HR manager	< €20 M	< 100
B	Manufacture of machinery for beverages	• HR manager	€20÷€50 M	100÷200
C	Manufacture of food machinery	• HR manager • Product development manager	€20÷€50 M	< 100
D	Manufacture of machinery and equipment	• CEO • HR manager	< €20 M	< 100
E	Manufacture of basic metals	• HR manager	€20÷€50 M	100÷200
F	Manufacture of machinery and equipment	• Commercial manager	< €20 M	< 100
G	Manufacture of textiles	• General manager	< €20 M	100÷200

H	Industrial automation	• HR manager	< €20 M	< 100
I	Manufacture of machinery and equipment	• Member of the board of directors	€20÷€50 M	100÷200
J	Manufacture of furniture components	• CEO	€20÷€50 M	100÷200

Table 1 – Company demographics

For each company, the human resources managers and/or the main people responsible for the innovation were interviewed. The roles of interviewees were initially chosen because the human resources managers were considered to be the most appropriate people to explain how technological investments have impacted the companies' organisational structures, which is the goal of this research. Most companies do not have an innovation manager, so the human resources manager manages transitions to new technologies and monitors employees' skills, roles and tasks. This includes managing new hires and determining the best methods of internal mobility, taking into account workers' needs and points of view, so as not to create situations of misunderstanding and inconvenience. Moreover, the people to be interviewed were often directly indicated by the companies once the purpose of the analysis was made known and after the companies had received the interview protocol.

The interviews were semi-structured, based on an interview protocol designed by the researchers (available in Appendix 1). This protocol initially assessed the companies' demographic data. It then covered the two dimensions of the conceptual framework, illustrated in Section 4. Each interview was conducted by at least two researchers, supported by a representative of the General Confederation of Italian Industry. Each interview, integrated with secondary data (retrieved from the companies' websites, reports and internal documents), was then summarised in a case report and revised by each company for validation purposes.

The interviews were carried out from March to June 2018, about one and a half years after the launch of Italy's national industry plan, 'Piano Nazionale Industria 4.0', which aimed to support companies investing in new technologies, modernising machinery, creating new patents and pushing innovation.

4. Conceptual framework

The conceptual framework of this research was grounded on the theoretical models presented in the literature (Emery, 2000; Galbraith, 2002; Leavitt, 1965), as well as the seminal works of Leavitt (1965). Several studies in sociotechnical literature have focused their attention on two related dimensions: technology and organisation (Doms et al., 1997; Kull et al., 2013; Lei et al., 1996). Thus, the present authors coherently structured a theoretical model to explicitly consider these two concepts.

A specific literature review was conducted to properly determine the dimensions to include in the theoretical model. Figure 1 summarises the theoretical model and further develops the studied dimensions. Table 2 also reports the literature contributions used to define the framework dimensions.

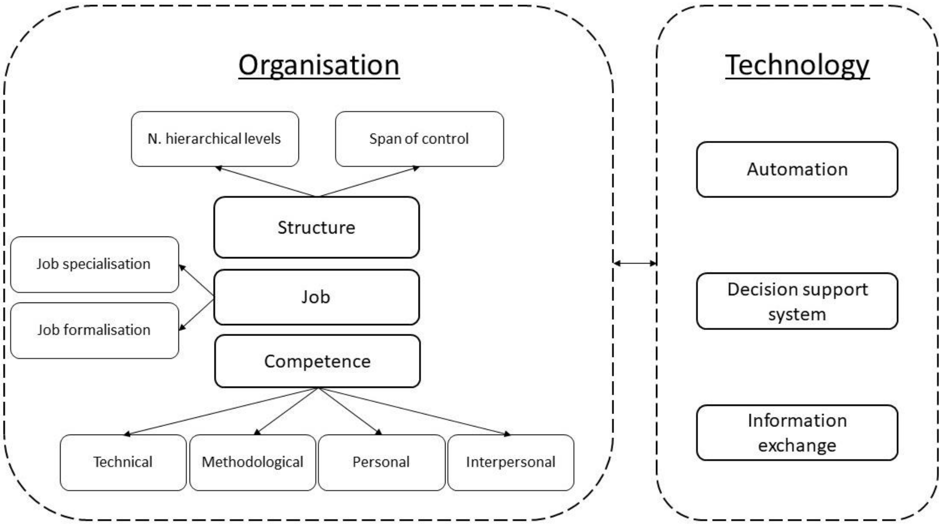

Figure 1 - Conceptual framework

Dimensions	Subdimensions	References
Organisation	Structure	Child, 1972; Pugh et al., 1968; Ouchi and Dowling, 1978; Mintzberg, 1989
	Job	Mintzberg, 1989
	Competence	Hecklau et al., 2016
Technology	Automation	Hermann et al., 2016; Mittal et al.,2016; Oztemel and Gursev, 2018
	Decision-support system	Oztemel and Gursev, 2018; Lu, 2017
	Information exchange	Hermann et al., 2016; Mittal et al.,2016

Table 2 – Literature for framework dimensions development

4.1. Technology

For this study's purpose, identifying the principal features that characterise I4.0 technologies is crucial. To do so, the conceptual and theoretical frameworks presented in the literature have been reviewed. Hermann et al., (2016) describe four design principles of I4.0: interconnection, information transparency, decentralised decisions and technical assistance. Mittal et al. (2016) present a more thorough list of characteristics associated with Smart Manufacturing and, among them, clusters are identified, such as context awareness, modularity, heterogeneity, compositionality and interoperability. Contrarily, Oztemel and Gursev (2018) choose to link specific technologies with three principal components of I4.0, which they define as 1) digitisation and integration of vertical and horizontal value chains, 2) digitisation of products and service offerings and 3) digital business models and customer access. Considering the abovementioned features, three constructs related to technology are included in the framework for the present study.

- *Automation* encompasses all potentialities offered by advanced manufacturing systems that can perform production processes with high productivity, thanks to intelligence embedded in machines and equipment, which become Cyber-Physical Systems. Referring, for example, to the abovementioned I4.0 features, automation is based on the features of technical assistance, information transparency and modularity.
- *Information exchange* refers to the connectivity of products, processes and people provided by IoT technologies, which improve communication and enable real-time data exchange between humans and information systems. Realising such an information exchange entails interoperability and standardisation among devices and systems, which are the main challenges for implementing I4.0 (Thoben et al., 2017).
- *Decision support system* includes the analytics and optimisation potentials provided by data analysis and visualisation. Decision-making can become more responsive, and corrective actions on the shop floor can be implemented more efficiently and effectively, with the support of data analysis tools that are able to convert data from different sources into information. In this construct, different features, such as decentralised decisions and context awareness, converge.

4.2. Organisation

Organisation considers the organisational dimensions that characterise any company. Galbraith (2002) states that every organisation must be coherent among five different dimensions: Strategy, People, Rewards, Process and Structure. The 'Strategy' dimension refers to an organisation's goals; all other dimensions must coherently adapt to the strategy an organisation decides to pursue. The 'People' dimension refers to human resources policies and their influence on employees' skills and mindsets. The 'Rewards' dimension is related to the reward system that influences people's motivation to perform. The 'Process' dimension is related to the information and decision-making processes and, thus, to the level of autonomy and specialisation individuals have. Finally, the 'Structure' dimension refers to the organisation's architecture and, thus, the location of decision-making power.

Other authors have suggested revisions to this model concerning specific applications, such as project management (Aubry and Lavoie-Tremblay, 2018; Müller et al., 2019; Sankaran et al., 2017), knowledge management (Chouikha, 2016), service management (Avadikyan et al., 2016; Raddats and Burton, 2011), and operations management (Cagliano et al., 2019; Longoni et al., 2014).

Based on these contributions, and given the present research focus, the authors have redefined the organisation concept into three subdimensions: competence, job and structure.

The **competence** subdimension, which is similar to Galbraith's (2002) 'People' dimension, includes aspects related to the skills employees need to be productive in their I4.0 organisations. Although the term 'competence' is frequently used, there is not a commonly accepted definition, and multiple interpretations have been presented in the literature (Sampson and Fytros, 2008). The present authors consider a competence to be a 'cluster of related knowledge, skills and attitudes that affects a major part of one's job (a role or responsibility), that correlates with performance on the job, that can be measured against well-accepted standards, and that can be improved via training and development' (Parry, 1996). In the context of I4.0, four categories of competences can be recognised, as described by Hecklau et al. (2016):

- *Technical competences* refer to state-of-the-art knowledge, increasingly related to IT, automation programming and data analysis.
- *Methodological competences* include skills and abilities to handle situations and problems, such as conflict solving, creativity and decision-making.
- *Personal competences* include values, motivations and individual attitudes. Among them, it is possible to find flexibility, a motivation to learn and the ability to work under pressure.
- *Interpersonal competences* represent social skills and abilities to communicate and cooperate with others, such as networking skills, leadership skills and the ability to work in a team.

The **job** subdimension, related to Galbraith's (2002) 'Process' dimension, pertains to the design of positions within an organisation. It is, therefore, connected to the roles played by humans and their individual positions (Mintzberg, 1989). Introducing I4.0, and the organisational change it entails, is expected to create new jobs, but, still, it is not clear whether the prevalent scenario will be skill polarisation, with standardised and formalised jobs, or skill upgrading (see Section 2.1), in which workers will be autonomous decision-makers performing various tasks (Hirsch-Kreinsen, 2016).

In accordance with Mintzberg (1989), the constructs within this subdimension are as follows:

- *Job specialisation* includes the horizontal (i.e., the number of different tasks performed) and the vertical (i.e., control over the performed tasks and level of autonomy) dimensions.
- *Job formalisation* concerns work process standardisation and regulation of workers' behaviour.
- *Training* refers to the process through which the skills and knowledge required to perform a specific job are taught to employees (Mintzberg, 1989). Training plays an important role in sustaining the I4.0 paradigm and related innovations, given that many industries in most developed countries are experiencing talent shortages (European Commission, 2017).

The **structure** subdimension concerns the organisational structure and includes two main constructs, allowing it to be described without strict reference to a specific or ideal structure (e.g., functional, divisional, matrix, hybrid).

- *Number of hierarchical levels* or *vertical span* is defined as the number of job positions in the chain of command, from the chief executive to the employees working on output (Child, 1972; Pugh et al., 1968).
- *Span of control* is a measure of the limits of hierarchical authority exercised by a single manager. It influences the closeness of contact between superior and subordinates (Ouchi and Dowling, 1978) and directly affects the unit size—i.e., the number of positions grouped in a single organisational unit (Mintzberg, 1989).

These two variables allow for defining the configuration (i.e., the shape and roles structure of the organisation (Pugh et al., 1968)) and evaluating the flatness of the organisational structure. Fewer hierarchical levels and a wider span of control are symptoms of a flat organisation (Mintzberg, 1989), which has been advocated as an appropriate structure to complement introducing I4.0 technologies (Hirsch-Kreinsen, 2016; Shamim et al., 2016).

5. Case study research

This section describes the exploratory multiple case study carried out in this project. First, the interview protocol (available in Appendix 1) is summarised. Second, the results emerging from the case analysis are discussed.

5.1. Interview protocol

The interview protocol was designed to reflect the conceptual framework dimensions, as presented in Section 4. The protocol contains a brief introductory paragraph, delineating the primary data of the interviewed enterprise (i.e., objectives, products, organisation chart, investments). This is followed by sections related to the main framework dimensions in the study.

Concerning the technology dimension, the interview protocol investigates how companies invested in the past, and how they are investing currently, in new I4.0 technologies, focusing on the sectors and the processes involved (see section B in interview protocol in Appendix 1). To account for various levels of adoption and the different investments at the moment of the interviews, six possible levels of technology adoption have been defined (Hall et al., 1975).

- *Non-use*: the company has extremely low or null knowledge of the technology.
- *Orientation*: the company is acquiring information on the technology and on what it implies in terms of value proposition and competences required of workers.
- *Preparation*: the company is performing preliminary activities for introducing the technology.

- *Testing*: the company is performing a test to assess the impact of introducing the technology.
- *Routine*: the company uses the technology routinely. Small changes are admissible solely aimed at improving technology use.
- *Refinement and integration*: some changes are allowed to the routine use to better optimise and integrate the technology with existing processes.

During the interviews, specific attention was given to how and why the company decided to introduce the technology and which technical skills were required to do so.

Regarding the second framework dimension (i.e., Organisation), the protocol investigated the impacts on the macro level (i.e., macrostructure, staff, decision power) (section C) and the micro level (i.e., roles, tasks, polyvalence, workplace) (section D).

Afterwards, the protocol aimed to deeply investigate the changes occurring at the collaboration and coordination level (section E) and the related impacts that these changes produce on workers' skills (section F).

5.2. Results

This section reports the primary evidence from the multiple case study. For brevity's sake, the most interesting results from the cross-case analysis are presented. The results will be reported according to the conceptual framework dimensions.

5.2.1. Technology

All the enterprises involved in the case studies are currently investing in I4.0 technologies. However, they are at different stages of this implementation, as depicted in Table 3. The six technologies listed in this table were inductively selected from the interview results. Thus, only the technologies in which the interviewed companies have invested are listed in Table 3.

	Automation		Decision support system		Information exchange		
Company	**Advanced manufacturing solutions**	**Advanced robotics**	**Simulation**	**Augmented reality**	**IoT and big data**	**Cyber security**	**Average**
A	●●●●●	●	●●●●	●	●●●●●	●●●●●	●●●●
B	●●●	●	●●	●	●●●	●	●●
C	●●●	●	●	●●●●●●	●●●●●●	●●	●●●
D	●●●●●	●●●●●	●●●●●	●	●●●●●	●	●●●●
E	●●●●	●	●●●●●	●	●●●	●●	●●●
F	●●●●●	●●●●●	●	●	●●●●●	●●●●●	●●●●
G	●●●●	●	●	●	●●●	●●●	●●
H	●●●	●●●●●●	●	●●●●	●●●●	●	●●●
I	●	●	●	●	●	●	●
J	●●●●	●	●●●●●	●	●	●●	●●
Overall rate of technological implementation	●●●●	●●	●●●	●●	●●●●	●●	

Legend:

●	Non-use	●●●●	Testing
●●	Orientation	●●●●●	Routine
●●●	Preparation	●●●●●●	Refinement and integration

Table 3 – Stages of implementation for the sampled companies

Companies are not uniformly adopting technology. The results show that advanced manufacturing solutions, such as smart machines and smart robotics, are the first technologies in which most companies invest, integrating new, interconnected and easily programmable machines into their production environments. The second most adopted technologies are IoT and Big Data solutions. As an original request following the adoption of interconnected machines, data exchange and analysis emerge as fundamental. Smart machines generate a considerable quantity of data, which companies can analyse and use to optimise production processes. Such data may also prove extremely useful for improving the knowledge of manufacturing processes and enabling new approaches, such as preventive assets maintenance and real-time product quality control. The third most adopted technology in this sample is simulations, which concerns the virtual representation of products and processes, used to reduce time and money expenditure in physical prototypes and tests. Finally, only a few companies implement other considered technologies (advanced robotics, augmented reality, and cybersecurity). In fact, despite their awareness of the potential and positive effects of such technology implementation, companies still have limited time, money and organisational resources to enrich their investment portfolios in I4.0 technologies.

5.2.2. *Organisation: Structure*

The organisational chart of the interviewed companies has also been analysed from a macro organisation perspective. The matrix organisation structure was the most widely adopted (companies A, B, C, E and I) and was reported as being the most useful. This structure envisages few hierarchical levels and a wide span of control, with workers responding to both functional and departmental responsibilities and business units being strictly connected. In the past, the functional organisation was the most widely diffused in the sample; the organisational chart was characterised by several levels between the chief roles and the workers, and all the business units were separated and independent. The need to become more agile and responsive about market requirements and the I4.0 environment pushed companies to change their organisational structure. For some companies (C, E and I), the matrix organisational model was utilized before the advent of I4.0, especially with the introduction of lean manufacturing paradigms. Company E's human resources manager stated: 'The organisational chart is revised every two or three months. In 2015[,] it had a pyramidal shape [;] nowadays [,] it is more like a matrix'. Another group of companies (A and B) began changing their organisational structure with the implementation of I4.0 technologies. Company B's human resources manager stated that 'there has been an erosion of hierarchical levels so that employees could understand that the firm is not structured as a pyramid, but as a network'. Finally, a few companies (D, G, H and J) are still transitioning towards a matrix structure. Company D's CEO said that 'the organisational chart of the company is not changed yet, but the newest activities and innovations [will] soon lead to a reduction of hierarchical levels'. Interestingly, even companies that did not change their organisational structure (e.g., company F) began experiencing effects from the introduction of new technologies through either a reduction in hierarchical levels or a widening of the span of control.

5.2.3. *Organisation: Job*

Concerning the job subdimension, two topics emerged as relevant in the I4.0 context: *polyvalence* and *specialisation*. Polyvalence represents the ability to perform different tasks depending on the company's needs. According to Camps et al. (2016), 'the notion of polyvalence implies that employees can work on different tasks and under diverse circumstances, thus reducing the costs and time needed to mobilise them to carry out new duties or jobs'. In other words, polyvalence is the horizontal mobility of workers among several tasks. With the introduction of new technologies in the production environment, employees are increasingly required to enlarge their knowledge and perform

tasks with several IT systems and devices. Company G's general manager affirmed: 'Our company is attempting to train more flexible people and polyvalent figures, able to work in a team and lead orders and projects to success'.
On the other side, vertical specialisation plays an important role, as stated by Company B's human resources manager: 'Looking at the organisational impacts, some required competences have changed. In particular, specialised figures increased in number in production departments'. According to the interviews, acquiring experience and abilities in a specific piece of work or activity implies increased worker autonomy in the execution of their tasks—that is, vertical specialisation. In light of the potential offered by real-time information sharing, which increases awareness in employees, autonomous decision-making and work methods are crucial.
The changes in vertical and horizontal specialisation have been mirrored by the introduction of new job positions in all sampled companies, both at the operational (e.g., automation specialists, software and data scientists, industrial designers) and managerial levels (e.g., product manager, project manager, process owner). Most of these new positions, reflecting the need for new competences, require proper training. Therefore, the studied companies relied on both external and internal training programs, as shown in Table 4.
Concerning job formalisation, none of the companies experienced any change with the introduction of I4.0 technologies, except company D, which began providing employees with instructions and procedures through digital devices (digitalised job formalisation).

Company	New figures	Job vertical specialisation	Job horizontal specialisation	Job formalisation	Training
A	Information Technology expert; Engineer within the technical function	Lower	Lower	No changes mentioned	External and internal
B	Technical office manager; Automation specialist; Product manager	No changes mentioned	No changes mentioned	No changes mentioned	External and internal
C	Technical office manager; Mechanical engineer; Researcher with expertise in automation engineering; Software and data scientist	Lower	Lower	No changes mentioned	External
D	Advanced coding languages developer	Lower	Lower	Digitalized	External and internal
E	Project manager; Automation specialist	Lower	Lower	No changes mentioned	External and internal
F	Technician with expertise in electronic and computer	Lower	Higher	No changes mentioned	External

	science; Product and project manager				
G	Adaptation of existing figures	Lower	Lower	No changes mentioned	External and internal
H	Technical office manager; Automation specialist; Product manager	Lower	No changes mentioned	No changes mentioned	Internal
I	Key innovation users; Program Manager; Process owner	Lower	Lower	No changes mentioned	External
J	Product and process engineer; Industrial designers	Lower	Lower	No changes mentioned	Internal

Table 4 – Detailed results about the job dimension

5.2.4. Organisation: Competences

The analysis of new competences required of employees in the interviewed firms is based on the four groups of competences identified in Section 4.2. Among the technical competences, efficient and advanced use of IT devices—such as computers, mobile devices and automation devices (i.e., PLC)—is required. Additionally, knowledge and use of software, like ERPs, MESs and specific IT tools, are crucial for effective factory management. Data analysis skills are also increasingly necessary for performance control and benchmarking, and technicians dealing with new production machines must be familiar with high-level programming languages. Company A's plant manager stated: 'Our firm is looking for workers with several competences in the computer science field: they should be able to manage computerised and numerical control machines, to analyse data and to transform data into easily understandable information that can be converted into actions'.

Interestingly, all the companies had either already developed the required technical competences or had begun training their employees to acquire them, reflecting the urgency of having technical competences once new technologies are introduced.

From the methodological point of view, the most required competences are management and planning abilities, such as problem-solving, project management, change management, knowledge and risk management. Moreover, decision-making skills and abstraction abilities are useful for defining and pursuing short- and long-term objectives. Company E's human resources manager stated: 'Given that the industry has changed, also the concept of work evolved: now we have to define clear objectives, plan work, define a vision and manage all the possible risks[,] not only focusing on the short term[,] but also taking into account the long term'.

Personal competences concern individual attitudes useful for work in the I4.0 context. According to the interviewed firms, leadership and the ability to transfer knowledge to others are the most relevant skills, followed by an open mindset, critical thinking, creativity and a systemic vision of situations.

Finally, considering interpersonal competences, self-management skills, such as flexibility and task management, emerged as less critical. On the other hand, great emphasis was placed on social competences. Above all, collaboration and information sharing are relevant, followed by teamwork and networking capabilities. Communication skills are essential to customer relationships, as well.

The need for methodological, personal and interpersonal competences emerged from the cases, but few companies (A, D, F and H) have already started investing in their development. These companies are also the most advanced in terms of technology adoption. Table 5 reports the details of the competence groups in the studied companies. The table shows the status for each competence group within a specific company as follows:

- *Present*: the company has already developed the required competences; as a consequence, it is not lacking a specific group of competences.
- *Training*: the company has put in place actions to train its employees and let them acquire all or some of the competences belonging to a specific group.
- *Required*: the company perceives the lack of a specific group of competences, but no efforts have as yet been dedicated to their development.

Company	Technical competences	Methodological competences	Personal competences	Interpersonal competences
A	Present	Training	Required	Required
B	Training	Required	Required	Required
C	Present	Required	Required	Required
D	Training	Present	Required	Required
E	Training	Training	Training	Training
F	Training	Present	Required	Required
G	Present	Required	Required	Required
H	Training	Present	Required	Required
I	Training	Required	Required	Required
J	Training	Required	Required	Required

Table 5 – Detailed results about the competence dimension

6. Discussion

Stemming from the results presented in the previous section, the relationships between technology and the three organisational subdimensions are here discussed, specifically focusing on the results that are widespread among the most cases. Three propositions are derived from the authors' elaboration of the main evidence. They are meant to be considered as a basis for future research developments in the SME context.

6.1. Relationship between technology and structure

The results presented in the previous section demonstrate a relationship between technology adoption the evolution of organisational structures. The companies were specifically asked to discuss the changes they experienced in their organisational structures alongside the introduction of I4.0 technologies. Although a new structure was never mentioned by the interviewees as the main novelty, it was usually presented as a natural consequence of and adaptation to the new machines, tasks and working environment. This evidences that, in the context of the analysed SMEs, organisational change tends to lag behind technology introduction, in line with one of the possible developments hypothesised in the literature (Damanpour and Evan, 1984). As reported in the results section, the only cases in which the organisational structure change anticipated the new technology adoption were cases in which the change was stimulated by the introduction of lean culture (C, E and I). Other companies (D, G, H and J) are planning a reorganisation towards leaner organisational structures. As Company H's human resource manager stated: 'The main impact of the introduction of new technologies is the need for corporate reorganisation. We are planning many interventions towards a reorganisation and a reduction of the hierarchical levels'. The reduction of hierarchical levels is being experienced by companies (A and B) that have already reacted to the advent of I4.0. Generally, all companies in the sample experienced a reduction of hierarchical levels and a widening of the span of control alongside the introduction of I4.0 technologies.

An ideal strategy for implementing important technological innovations should consider organisational aspects (Gehrke et al., 2015). Organisational structure, hierarchical levels and the level of bureaucracy inside a firm are not detached from production processes and technological advancements. It is fundamental for firms to introduce changes at the macro-organisational level to avoid problems and bottleneck situations with communication and bureaucracy difficulties.

Organisational changes, whether already in place or planned in the sample companies, display a tendency to adapt to technological changes through introducing organisational structures characterised by a wider span of control and a reduced number of hierarchical levels, in line with previous claims in the literature (Hirsch-Kreinsen, 2016; Shamim et al., 2016) that have never been supported with empirical analysis. This is reflected in the simultaneous increase in the adoption of matrix structures across most of the sampled SMEs, mainly to help coordination and adaptation. To limit the potential negative effects of similar organisational structures (e.g., resource inefficiency, overlapping of roles), introducing lean principles allows companies to better solve the trade-off between organisational efficiency and effectiveness. Therefore, the first research proposition of this study emerges:

RP1: *An organisational structure characterised by a wide span of control and a low number of hierarchical levels is associated with the adoption of I4.0 technologies.*

6.2. Relationship between technology and jobs

As anticipated in the results section, the increasing need for polyvalence and specialisation have brought all the interviewed companies to define and start training new job profiles and roles. Particularly, it is possible to envisage the development of a new type of job profile, which all the present case studies have already begun to design. As an example, this is well reflected by Company D's human resources manager's words: 'Workers have greater decision-making power. The aim is to provide them with an informative content that allows them to choose which is the best thing to do at that moment: directing the autonomous management of their activities (empowering them) and relieving all activities with low value and motivation'. The emergence of new job profiles is further confirmed by the extensive adoption of both internal and external training to make up for skills shortages in the job market in all the sample companies (see Table 4). These new job profiles are characterised by a moderate level of horizontal specialisation, but a higher grade of autonomy than the operative job profiles; therefore, the authors refer to them as *Autonomous Operative Job Profiles*. Moreover, from the studied cases these job profiles emerged as requiring deep technical competences, but they should be sustained with additional methodological, personal and interpersonal competences. Therefore, the evidence from the case studies suggests that SMEs are evolving towards the skills upgrade scenario, characterised by employees developing new roles as decision-makers and coordinators (Hirsch-Kreinsen, 2016).

Figure 2 shows the positioning of the Autonomous Operative Job Profiles according to the level of vertical (i.e., amount of control over the task performed) and horizontal (i.e., the number of different tasks performed) specialisation (Mintzberg, 1980; Spina, 2012, p. 44). Figure 2 also characterises these job profiles in terms of competences.

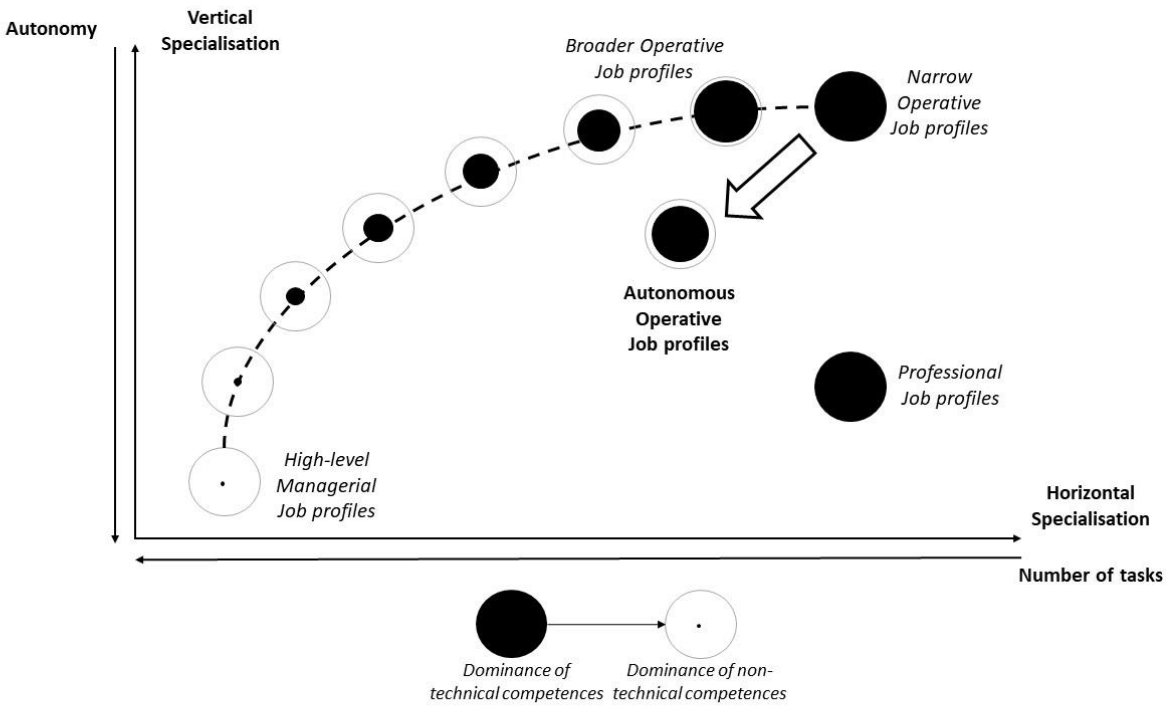

Figure 2 - Positioning of autonomous job profiles in terms of vertical and horizontal specialisation

The newly identified job profile is in accordance with the results regarding the higher independence and proactivity of workers, especially at the lowest level of the organisational chart. As a consequence, the authors have developed the following research proposition:

RP2: *Introducing I4.0 technologies is linked to the development of a new job profile, characterised by a relatively high degree of autonomy and intermediate horizontal specialisation, combining technical and non-technical competences (i.e., 'Autonomous Operative Job Profile').*

6.3. Relationship between technology and competence

From the analysis of the results, a relationship emerges between the technologies' level of adoption and the competences required, thus evidencing the direct relationship between technology implementation and competence development (Erol et al., 2016; Gehrke et al., 2015; Hecklau et al., 2016; Prifti et al., 2017).

All the interviewed companies, regardless of their levels of technology adoption, manifested a need for technical competences as an immediate impact of new technology implementation. In the short term, companies focus more on the technological aspect without fully considering the organisational and human issues. This is supported by the empirical evidence provided here, given that all the sampled companies are either developing (B, D, E, F, H, I and J) or have already developed (A, C and G) the technical competences they need. However, firms cannot rely only on technical competences. In fact, in the medium- to long-term, firms should pay attention also to methodological, personal and interpersonal competences to increase business value. These competences require a higher effort in the long-term, as the changes in organisation and people's behaviours require more time to be effective. This is confirmed by the fact that all the sampled companies have at least started requiring 'soft' competences, but only a few of them have recognised the importance of these skills either by acquiring them (D, F and H) or by starting training programs (A and E). These companies are also more advanced in their levels of technology adoption. Hence, a final research proposition arises:

RP3: *With increasing adoption of I4.0 technologies, companies will first experience the need to develop technical competences, while the need to develop methodological, personal and interpersonal competences will arise in more advanced stages.*

To summarise, Figure 3 comprehensively shows the main results emerging in relation to the initial conceptual framework and the three outlined research propositions.

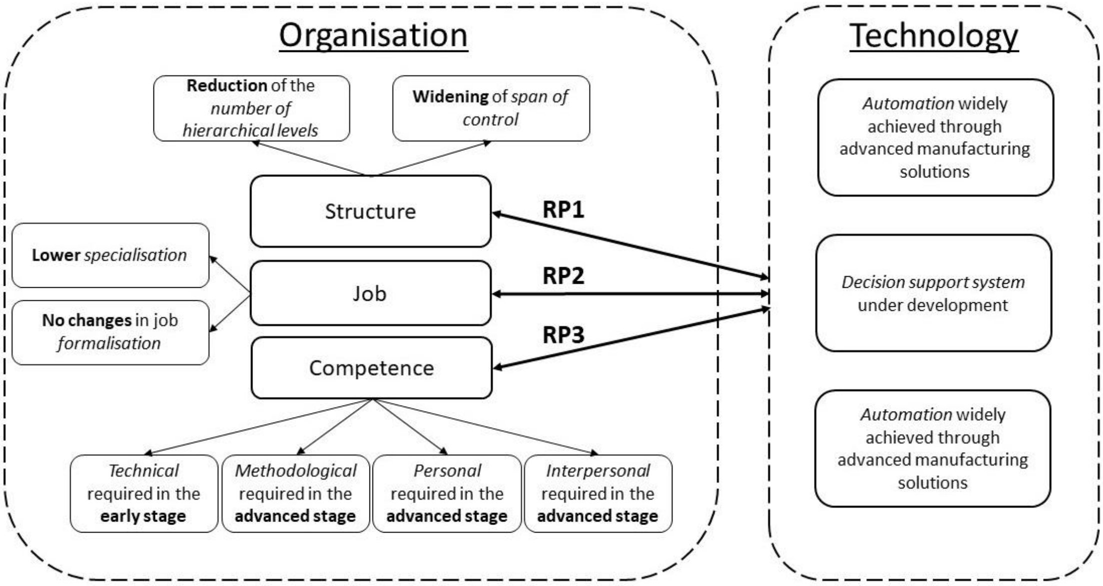

Figure 3 - Main results and research propositions conceptualisation

7. Conclusion

This paper contributes to comprehending the interconnections between technology implementation and organisational change. In particular, it provides empirical evidence of the impacts of I4.0 technologies on SMEs' organisational development—identifying three research propositions that highlight how companies are structuring the components of a sociotechnical system to cope with the possibilities and challenges of new technologies. The results suggest different reflections that both researchers and managers should pursue in the near future. From a research perspective, four main issues require additional research.

First, a key topic concerns how organisations and technologies co-evolve and, thus, how companies should co-design these two areas. A common mistake companies often make (to which I4.0 technologies are no exception) is assuming that technological investments (e.g., acquiring a new machine) will automatically generate positive impacts on performance and that the organisation should adapt to the technological solution. On the contrary, technologies should not guide organisation redesign, but companies should leverage them to make the organisation capable of adapting to new processes. Unfortunately, in many cases, companies underestimate the cost and difficulties of introducing new technical solutions in an organised system. This problem is even more critical for SMEs, which, on one side, can more easily adapt to changes, but, on the other side, lack the resources to support organisational innovations (Löfving et al., 2014).

Another consideration relates to organisational development. The analysed companies showed interesting differences in how they addressed this point. Only a few companies had a structured development plan, while others moved step-by-step—adapting their actions according to intermediate investment results. Part of this behaviour is arguably due to the size of the sampled companies (particularly their difficulty in allocating full time resources to manage organisational change projects). However, it is also due to the unavailability of clear guidelines and methods for addressing the specific changes under consideration. For this reason, the authors posit that designing a structured process and a clear set of tools to favour SME organisational development is of extreme importance.

Another key topic is in particular how SMEs can get access to the competences required by the new organisational structure. Some sampled companies hired new employees with the required competences, while others developed various solutions to improve their current employees' competences. This issue, however, requires further investigation in SMEs that, due to a limited set of resources (both financial and human), require support to properly invest in the necessary competences.

A last point relates to methods of empowering the organisation. This works states that I4.0 technologies can lead to adopting new forms of work organisation (i.e., Autonomous Operative Job profiles). This implies that the individuals managing the new technology must go through a process of empowerment (Honold, 1997). Therefore, the authors argue that the characteristics of the new jobs described here could require specific methods of empowering the individuals in the organisation, and identifying the most effective approach for this empowerment could be extremely important.

7.1 Managerial implications

According to the managerial implications of this work, the findings can be summarised along five main guidelines, which managers should give proper attention.

First, technological investments in I4.0 must be co-designed with the organisation. Managers sometimes perceive that, when the technology is there, they will find a way to make it work, but these empirical results clearly show that this is not the case. On the other hand, given the novelty of I4.0 technologies, it may take too long for a company to really prepare itself to make the investment. Therefore, technological investments and changes in the organisation must be co-developed, leveraging strong support and involvement from the operational roles.

Related to this, a second point is that companies should properly evaluate the maturity of their organisation, with specific attention paid to structure, jobs and competences. Running a proper organisational assessment, besides being a useful investment, is critical for evaluating individuals' real capabilities to deal with new approaches, as well as the level of investment required to fill competence gaps.

Third, regarding SMEs, the focus of this work, it is generally advisable to proceed with caution and take small steps in technology acquisitions and development. Experimentation is key to understanding the interventions both at technological and organisational levels. It is also very useful to understand the real potential of similar investments. From this perspective, companies should clearly define their expectations and why they are investing in I4.0. However, they should also be open to change and adaptation.

As a fourth point, companies should never underestimate the time required by, and the difficulties entailed in, developing and acquiring competences. The key point of I4.0 technologies is that they rely on interdisciplinary competences that are typically more difficult to acquire and develop. Often, companies do not easily find the required profiles available on the market, and, thus, they must make direct investments.

Lastly, companies should consider creating a coordination role within the organisation to overview all sociotechnical innovation projects—guaranteeing proper alignment among the different organisational units that is coherent with company strategy.

7.2 Limitations and future research directions

In the end, it is necessary to highlight the main limitations of this work. First, the sample is only composed of Italian companies; therefore, some of the results may be biased by the geographical, cultural and political characteristics of the location. In addition, the selected companies are all in northern Italy, and this geographical location could lead to a greater or lesser propensity for investing in new technologies. However, since most of the considered companies are extremely internationalised, both in terms of sales and operations, some of the potential biases are limited. Although the authors are aware that there are several context factors influencing the adoption of new technologies, they have preferred to choose a uniform sample (SMEs in the northern Italy) to make a comparison without too many external elements affecting the observed phenomenon (i.e., the change in organisational structure and the impacts on skills and corporate roles following I4.0 technology introduction).

A second limitation relates to the novelty of the I4.0 concept and, in particular, to the different levels of implementation in the considered companies when the data was collected. The authors expect that more reliable evidence could emerge when the currently analysed processes are widespread and settled in the various organisations. However, they also argue that the actual findings are still reliable since the adoption of a case study approach allowed verification of the actual implementation levels. Future works could comparatively address differences between SMEs in various countries and contexts. Comparisons could also be examined between changes that occur in SMEs and those that occur in large, multinational companies.

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Appendix 1: Interview protocol

OBJECTIVE OF THE INTERVIEW: Investments in so-called I4.0 technologies, identify and bring out:

- The birth, evolution and disappearance of roles and tasks
- The impact of the adopted technologies on the skills required of workers
- Organisational changes introduced by technology adoption
- Expectations and issues related to investments

A. ENTERPRISE

- DESCRIPTIVE DATA
- STRATEGIC OBJECTIVES
- PRODUCT FAMILIES
- COMPANY ORGANISATION CHART
- ANNUAL SHARE OF INVESTMENTS IN R&D (% OF TURNOVER)
- INVESTMENT NEWS I4.0 FROM SITE / ARTICLES

B. TECHNOLOGY INVESTMENTS I4.0

- HOW IS THE COMPANY INVESTING? (AREAS AND TECHNOLOGIES)
  - o Concerning the so-called I4.0 technologies, in which area is the company mainly investing?
    - Manufacturing, logistics, after-sales, maintenance, product development, other?
    - Which business processes have been involved (transversality)?
  - o In which particular technologies?
    - Advanced Manufacturing solutions (reconfigurable technologies)
    - Advanced robotics (e.g., exoskeletons)
    - Collaborative robotics (e.g., robots)
    - Augmented reality
    - Product simulation (e.g., digital twin)
    - Process simulation
    - Big Data Internet of Things (Iot) (big data and analytics, e.g., predictive maintenance through data analytics)
    - Cybersecurity
    - Other technologies included in the ‘Calenda Plan’ (additive manufacturing, horizontal/vertical integration, industrial IoT, cloud)
  - o For each technology indicated, at what level of adoption is the company currently (1 to 6)?
    - Non-use
    - Orientation
    - Preparation
    - Test

- Systematic use
- Optimisation and integration

• BENEFITS/OBJECTIVES RELATED TO INVESTMENTS

o Why were the investments made? What were the desired benefits? (ex: increased efficiency and self-sufficiency)

o At what point is the project related to the investment? In the investment plan for the project, what investments have already been made, and what investments are planned for the future?

o What were the benefits of the investments made? Do they coincide with those desired?

o Have you encountered any problems with the implementation?

o What types of risks did you consider about the investment, and how did you manage them?

o Have you received funding/incentives?

o Have investments in new technologies led to changes in the volume of the workforce or movements? Has there been any change in the geographical location of production facilities?

• HOW WAS THE INTRODUCTION OF INNOVATION PROGRAMMED AND MANAGED (how was it communicated, steps, timing, modalities, the involvement of workers)?

o Has the company participated in external training courses on I4.0?

o What is the level of individual knowledge concerning I4.0? (for the person interviewed and for the decision-makers who chose to introduce the innovation)

o Does the company have active Alternating Work School programs?

o Has the company had the support of external consultants? (e.g., evaluating investments and possible financing, defining the implementation phases of innovation in the I4.0 field)

o Is there resistance to change on the part of the company's employees?

• TECHNICAL SKILLS

o Were any innovations entirely new for the company?

o Have you noticed a lack of technical expertise as a result of introducing new technologies?

o What investments have been made in terms of training and education?

o After implementing the innovation, did you need assistance from the supplier to develop the skills required to use it?

o Are the company's infrastructures sufficient to support the innovation introduced? (ex: all data in the cloud, but slow connection; each time you access the files the time required is long).

o Have working groups been set up to manage technological innovations?

C. IMPACTS ON ORGANISATION (MACRO LEVEL)

• MACROSTRUCTURE/STAFF/DECISION POWER (always ask for the reasons for the changes)

o About the above investments and innovations, has the company's organisational chart changed? How?

o Have organisational units been outsourced or internalised?

- Has there been an impact on the orientation of your business as a result of these changes? (more customer-oriented, service-oriented, sustainable, etc.)
- Has there been a reduction (or increase) in hierarchical levels? How was it possible to achieve this? (more significant delegation to lower levels, transversal figures, centralisation/decentralisation of decision-making power, etc.)

D. IMPACTS ON THE ORGANISATION (MICRO LEVEL)

- TYPE AND QUALIFICATION OF THE ROLE IMPACTED
  - Which jobs/roles/missions have been affected by the innovative change?
  - Has the individual’s work changed at an operational level? (e.g., the impacted role has the same actions as before or was adapted to new work processes).
  - For impacted roles, was it necessary to increase or decrease the scope of control (number of people coordinated)?
  - Have they received more or less responsibility?
  - Have there been any changes in the hierarchical position?
- DESCRIPTION AND QUALIFICATION OF TASKS (VARIETY/VOLUME/SPEED)
  - About the tasks of the impacted roles, how have they changed in terms of variety (number of different tasks to be performed)?
  - Do the tasks include more interdisciplinary activities (e.g., not only technical activities but also organisational/analysis activities), or are they very specialised?
  - Has the change in tasks led to a change in production volume (quantity of output/number of interventions carried out)?
  - How have they changed in terms of speed (time required to carry out the different tasks assigned)?
- CONTENT OF THE WORK - COGNITIVE CONTENT / POLYVALENCE AND AUTONOMY / PHYSICAL ENVIRONMENT
  - Do the new tasks require more sophisticated technical skills?
  - Do the new tasks require more complex collaboration/interaction skills?
  - Did the impacted roles have to develop new knowledge?
  - How did the new knowledge develop? How were the workers trained?
  - As a result of innovation, do the impacted roles operate alone or in teams?
  - Should the workers make their own decisions? Alternatively, should they follow standardised procedures? (e.g., greater autonomy in decisions, controlling the operations of a machine or even reworking the results)
  - Are the new tasks expendable in different contexts compared to those for which they were designed (polyvalence/flexibility)?
  - Have changes been made to the working environment? (e.g., workplace layout changes; time optimisation)

E. COLLABORATION AND COORDINATION (IMPACT AT BOTH MICRO AND MACRO LEVELS)

- How have the different organisational units coordinated changed?
- Have courses been made to increase aptitude for teamwork?
- Have virtual collaboration methods (chat, information systems, teleworking, etc.) been introduced?
- Have there been any changes in the time devoted to developing social relations and strengthening the working network (e.g., corporate events, meetings, courses)?

F. IMPACT ON SKILLS OF ORGANISATIONAL CHANGES (MACRO, MICRO AND COLLABORATION)

- Were actual figures trained and instructed to develop new skills? Which ones?
- Have new figures been hired? If so, which ones? Of what extraction? (technical, economic, managerial, IT, etc.)
- Were the workers able to adapt to the change? Are they able to manage the work? Do workers work together, proactively?