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Abstract

Current literature on Industry 4.0 technologies has mainly explored their relationship to the employment dynamics, or to the required competencies and emerging roles. This paper is complementing current literature with a perspective focused on organizational design. The aim of the paper is to explore how organizations are re-designed when Industry 4.0 technologies are implemented.

The paper is based on 15 case studies carried out in Italian manufacturing companies and data was collected from 70 semi-structured interviews to relevant roles involved in the implementation of digital technologies. Results show that, when Industry 4.0 technologies are implemented, organizations are redesigned following an employee control-oriented or following an employee commitment-oriented organizational design. These results show that organizational design is the result of decisions, and is not determined by technology. The implications of our findings are presented and discussed.

Keywords: Industry 4.0 technologies, organizational design, control on the employee, employee commitment

1 Introduction

The latest advances of information and communication technologies in manufacturing have led towards what is considered as the fourth technological revolution, alias Industry 4.0, expected to facilitate fundamental shifts in how products are produced, by creating a transparent, integrated and intelligent manufacturing environment (Brennan et al, 2015).

Current literature has started exploring Industry 4.0 technologies, employing two alternative approaches. The first approach addresses the question: "Are Industry 4.0 technologies substituting work?" distinguishing two possible scenarios on how technology is shaping employment dynamics (Romero et al, 2016). On one hand, a highly techno-centric scenario, with extensive automation of many work processes (e.g., Dworschak and Zaiser, 2014), and on the other hand, the human-centric scenario that analyzes how technologies are changing the composition of (not reducing) jobs, focusing on skill requirements and on the way economic systems, organizations and individuals can build them (Waschull, Bokhorst and Wortmann, 2017). The above-cited approaches have provided limited considerations on the organizational choices that companies make when introducing Industry 4.0 technologies.

In order to fill this gap, we aim to analyze how organizations are re-designed when Industry 4.0 technologies are implemented. Assuming a socio-technical perspective, we look at micro and macro variables most likely to be revisited when technology-driven change occurs. The choices made by organizations on those variables are expected to be radically different when different designs are adopted.

In order to achieve our objective, we use data from 70 interviews carried out in 15 Italian manufacturing companies that have implemented Industry 4.0 technologies. Our results show that in the companies analyzed, the adoption of Industry 4.0 technologies is associated with two main models of organizational design: (i) Employee control oriented design, and (ii) Employee commitment oriented design.

2 Theoretical Background

2.1 Industry 4.0 objectives, technologies, benefits

Even if defining Industry 4.0 remains a challenge, an established definition that captures its main features is as follows: Industry 4.0 relates to the diffusion, implementation and application of networked information-based technologies to the manufacturing enterprise (Hirsch-Kreinsen, 2016). To untangle the skein of technologies, the Smart Manufacturing (SM) Laboratory of Politecnico di Milano University has clustered the technologies in two main groups (Osservatorio SM, 2015).

The first group includes *Information and Communication Technologies*, composed of three main families : *Internet of things* ,*Manufacturing big data and analytics* and *Cloud manufacturing*. In the second group, called *Operational Technologies*, three other main families can be distinguished:, *Advanced automation*, *Advanced human-machine interface,* and *Additive manufacturing*. The synergetic cooperation between these two groups is expected to enhance results (Osservatorio SM, 2015).

Not only the integration of technologies is expected to increase the quality, efficiency and productivity, but the ability to collect, analyze and share smart data is expected to enable the creation of new business models (Stock and Seliger, 2016). Moreover, real time information allows the reduction of overstock situations, and the facilitation and optimizing of processes such as inventory and warehousing management (Zhou, Chong and Ngai, 2015).

Given the expected benefits, adopting Industry 4.0 technologies is therefore considered a key driver for the competitive advantage of European manufacturing industries (Kelly, 2015). Accordingly, for supporting manufacturing companies in the adoption of Industry 4.0 technologies, several public policies have been developed by European countries. The Italian approach to Industry 4.0 is based on the national plan, known as the 'Piano Calenda', a public policy views technological innovation not only as a tool to increase the contribution of manufacturing to the national GDP, but also as a tool for combining greater productivity with the renowned skills of the artisan manufacturing (Vitali, 2016).

The changes brought about by Industry 4.0 technologies have not only a great influence for industrial production, but they also have relevant organizational implications (e.g., Brynjolfsson and McAfee, 2017). In this context, this paper aims to provide empirical evidence on how businesses that have implemented Industry 4.0 technologies have redesigned their organizations.

2.2 Industry 4.0 technologies and organizational design: a summary of the debate

In the last thirty years, a vibrant debate has emerged on the evolution of organizational design, i.e. the extent to which current organizations are designed following Tayloristic or post-Tayloristic principles (e.g., Masino, 2005), as scholars claim that these technologies can be used either to design organizations still informed by the Tayloristic principles, or otherwise to design organizations informed by totally different principles (Negrelli and Pacetti, 2018). Hence, the debate seems sharply polarized into two alternative directions.

The first direction views Industry 4.0 technologies as enablers of an organization design which follows the Tayloristic model, that we label here as *employee control-oriented organizational design*. Such organizations present three key features. First feature is related to decreased employee autonomy. The capacity of Industry 4.0 technologies to make decisions autonomously results in less employee autonomy, as more and more decisions would be taken by a company's technical staff in the form of control algorithms (Dworschak and Zaiser, 2014). Second feature relates to the high formalization of jobs. In order to exploit the new controlling opportunities offered by Industry 4.0 technologies, jobs are designed to be highly formalized.(Bonomi, 2018). The third feature relates to the de-skilling implication that Industry 4.0 technologies would have on employees. Indeed, the over-controlled employee, who is not required to make any decision but to strictly follow rules and procedures while performing fragmented and individual-based tasks, is also not required to possess specific competencies, as the machines already possess the necessary knowledge for making effective decisions (Acemoglu, 2002).

The second direction of the debate sees Industry 4.0 technologies as enablers of an organizational design informed by post-Tayloristic principles, that we label here as the *employee commitment-oriented organizational design*. Several factors (market, regulatory issues, technology, etc.,) have been pushing companies for years into organizational structures informed by post-Tayloristic principles, and Industry 4.0 is seen as a speeding up this process (Anand and Daft, 2017). In line with this view the organization is designed aiming to achieve employee commitment, a strategy characterized by three key features. The first feature consists in greater employee autonomy (Venkatesh, Bala and Sykes, 2010). When using knowledge provided by technologies workers find it easier to decide on how to perform their tasks and how to find the best ways of performing their tasks (Dewet and Jones, 2001). The second feature relates to the fact that employees are typically requested to perform significant (so, less fragmented), team-based (so, characterized by social interaction), and less formalized jobs. According to Bayo-Moriones, Margarita and Fernando (2015), the greater volume of information and knowledge exchange provided by Industry 4.0 technologies increases job interdependencies, and organization of work that is now done around teams (Bayo-Moriones, Margarita and Fernando, 2015). Last feature relates to greater employee development, as with new technologies employees have the chance to develop their competencies (Dworschak and Zaiser, 2014).

2.3 Assessing current knowledge, and moving forward

The polarization between the two above-presented alternative directions presents a risk, i.e. assuming that the Industry 4.0 technologies have deterministic effects on organizational design. A consequence of this assumption is that organizational design is seen as nothing but an adaptation to technological constraints. Therefore, choices, agency, designers, or the complex political processes which typically inform organizational design are not fully recognized.

Refusing this deterministic perspective, we argue that the design of the organization always requires choices, as in face of the same technologies we can potentially experience different organizational designs. Multiple choices, or work organization "solutions," exist for each situation (Parker, Van der Browck and Holman, 2017). Therefore, we reject any kind of technological determinism, and hold a socio technical approach, that suggests that productivity and stakeholder satisfaction could be maximized via joint optimization based on stakeholder participation in the early-stages of the design process (Trist, 1981, cited in Morgeson and Humphrey, 2008).

Assuming a socio-technical perspective, we look at how companies have re-designed their organization on the variables which literature suggests as most likely to be revisited when technology-driven change occurs. The variables cover both micro (i.e., nature of work, job variety, teamwork, skills and competences, level of formalization, autonomy) and macro (i.e., number of organizational layers, role of role of middle management, coordination mechanisms and collaboration) aspects of organizational design. The choices made by organizations on those variables are expected to be radically different when employee control-oriented or employee commitment-oriented design is adopted.

Therefore, our study explores to what extent the organizational design of the companies that have implemented Industry 4.0 technologies is informed by the employee control-oriented or the employee commitment-oriented organizational design.

3 Methodology

3.1 Method and Sampling

Considering the novelty of the subject, the present paper was developed through 15 case studies, which are considered sufficient to obtain satisfactory results (Eisenhardt, 1989). The data used in the study are secondary source data, obtained from the collection of 20 case studies (five of which were deemed unsuitable) carried out from the association 'Torino Nordovest'[1].

Companies were selected based on the extent and types of the Industry 4.0 technologies implemented. Literature has been used to formulate and stimulate some initial questions, as well as to suggest suitable areas for theoretical sampling (Strauss and Corbin, 1998). Table 1 presents a sample of the 15 companies selected and a summary of their main characteristics.

The research method is based on semi-structured interviews. In total 70 interviews were conducted, with the individuals that – in each organizations – were involved in the implementation of Industry 4.0 technologies and related organizational design. Professional roles that participated in the interviews include such positions like, operators, technicians, engineers, unit heads, HR, administrative assistants, and top management. Table 1 shows the number and roles of interviewees by company.

Each interview, each lasting anywhere between fifty minutes and an hour and twenty minutes, was recorded and transcribed in its entirety (integral). The empirical data was collected between September 2017 and June 2018.

3.2 Interview guide and organizational variables considered

In most interviews information was collected using an interview guide with an initial open question aimed at inviting the interviewee to freely share about his/her experience (Mayring and Brunner, 2007).

The interview guide has been developed to provide information related to the following three areas: (i) company key features, strategy and history; (ii) technological innovations introduced, and reasons for their introduction; (iii) the way the organization has been re-designed.

[1] A comprehensive report of the evidence from the 20 cases is available in: Magone A., and Mazali T. (2018). Il lavoro che serve, Guerini e Associati. The interview protocol is available from the authors upon request.

In order to develop a model that integrates different organizational variables, the third area of the interview guide was built following two theoretical pillars. The first pillar is based on the sociotechnical systems approach (e.g., Parker, Wall and Cordery, 2001). The second pillar is based on contributions that focus on technology-driven work redesign (e.g., Morgeson and Humphrey, 2006). Based on the above, we identified those organizational variables which are the most likely to be redesigned when new technologies are implemented; their list and definitions are as follows.

Nature of work is divided in two dimensions: *physical and cognitive demands*. Physical demands reflect the level of physical activity or effort required for the job (Morgeson and Humphrey, 2008). Cognitive demands reflect the person's general level of cognitive processes required for the job (Hunter and Hunter 1984).

Job Variety relates to the extent to which employees are required to execute a large variety of tasks on the job (Morgeson and Humphrey, 2006). Essentially, job variety reflects the concept of task enlargement (Lawler, 1969).

Teamwork. A team can be defined as two or more individuals who socially interact (face to face or, increasingly, virtually) possess one or more common goal and are brought together to perform organizationally relevant tasks.(Kozlowski and Ilgen, 2006, p.79).

Level of formalization relates to the very nature of job bureaucracy, such as written rules, procedures, and instructions used by organizations to facilitate coordination and control of work (Nemeth et al, 2006).

Skills and competences include the variety of skills and competences required to complete the work (Morgeson and Humphrey, 2006)

Autonomy refers to the extent of discretion that employees have in order to make work related decisions and decide on work methods and scheduling (Fried et al, 1999).

Number of organizational layers pertains to the hierarchical structure of an organization, where each hierarchical level describes the span of control for each manager (Daft, Murphy and Willmott, 2017).

Role of middle management. Middle management is the intermediate management of a hierarchical organization that is subordinate to the executive management, and is responsible for the creation of an effective working environment and can be more control or development oriented (Daft, Murphy and Willmott, 2017).

Collaboration. The broad definition of this variable reflects the mechanism through which group members can help each other to learn and enhance performance. It has often been noted that Industry 4.0 technologies have important implications for interpersonal relationships at work (Wall et al, 1990).

Coordination mechanisms are mechanisms that imply the use of strategies and behavior patterns directed toward the integration and alignment of actions, knowledge and objectives of interdependent members with the aim of achieving common goals (Malone and Crowston, 1994).

Co.	Sector	Size	Technologies implemented	Nr Interviews	Role of Interviewees
1	Design/furniture	Large	Automation; Personalized CAD and IT interface	5	President, Managing Director, Supply Manager, Operators
2	Metalmechanic	Large	IoT; Sensors; Tailor made machines; AI; Robots	5	President, General Director, HR Manager, IT Manager, Plant Manager
3	Metalmechanic	Large	Smart factory; Collaborative robotics; Virtual reality, big data; Digital twin specialist; Exoskeleton; Collaborative robot; Smartwatch	5	Corporate HR vice-President, HR Training Manager, Public and Media Relations,

					Innovations Manager
4	Technological	Large	IoT	3	CEO, CTO, Chief Product and Marketing Officer
5	Technological	Large	Automated machines; Management systems software updates	3	General Manager, Engineering Director, Head of Process Engineering
6	Food	Medium	IS; Barcode reader; E-commerce; Warehouse automation system	3	CEO, Head of Special Projects, Promotion and Communication Executive
7	Metalmechanic	Medium	Automatization of machines; Online camera control of mechanical parts assembly; Electronically made assembly cards; Interacting displays; Robots; Automation of the management system of production and industrial accounting; WhatsApp communication	12	President, Sales Manager, Head of Technical Office, Head of Quality, Operators (production, quality, etc.), Unit Head
8	Metalmechanic (medical field)	Large	3D technology; Software with semi-predefined solution pieces; Automated finishing systems; Collaborative robots; Real time production; Automated warehouse; Augmented reality; Virtual reality; Digitalization of the distribution network	7	VP Operations, Production Director, Product Development Engineer, VP HR, HR Education Specialist, Operator
9	Elctromechanic	Large	Automated warehouse; Real time production and maintenance; Robots; Additive manufacturing	3	HR, I 4.0 Responsible, Simplification and Industrialization Officer
10	Metalmechanic	Large	Computer Interface with the machine; machine built-in video cameras; Built-in sensors; Cloud; IoT; 3D printing; Additive manufacturing	3	HR Business Partner, Product Manager, Special Innovation Projects
11	Technological	Large	Cloud; Digital twin; Predictive maintenance; Smart working; Office 365	4	SOA, Chief Digital Officer, Location Head, Technical Secretary
12	Metalmechanic	Medium	On the machine built-in electronic system; On the machine built-in cameras; Automatic warehouse; Dedicated computer for each printer; Wi-Fi connection	4	Managing Director, Operators
13	Technological	Small	CAD; Barcoding; On the machine built-in tablets; 3D printer; Automated warehouse	3	General Director, Export Manager, Administration Director
14	Food	Medium	Digital reporting line; IoT; Automated machines; Barcoding; E-commerce	4	CEO, Production Head, Junior Marketing Specialist, Administrative Assistant
15	Logistics	Large	Automated machines; Different IT instruments; Geo-localizing software; Digitalization of production chain management systems; Exoskeleton	6	General Director, Innovation Manager, Assistant to Direction, Unit Heads

Table 1 Sample of companies

3.3 Data Analysis

Data analysis was carried out in three stages. During the first stage, the authors independently selected the parts of the interview transcriptions related to organizational changes following the implementation of the Industry 4.0 technologies; the selected parts were then compared by the researchers, aggregated and used for the creation of a common database.

During the second stage, the authors worked towards a theory-informed thematic coding framework by comparing and contrasting each other's interpretations and categories and discussing similarities and differences (Guest, MacQueen and Namey, 2012). These discussions led to the creation of a first coding template (King, 2004), and subsequent database testing by each author was performed.

The third stage included the analysis by organization of the way each of the considered organizational variables has been redesigned when Industry 4.0 technologies were implemented. During the third stage, for each organizational variable, similarities and/or differences present among organizations were analyzed. Consequently, the variables were categorized into common and uncommon design choices. The first category refers to those variables on which the studied organizations present the same design patterns, i.e. made similar choices when they implemented Industry 4.0 technology. Diversely, uncommon design choices refers to those organizational variables on which the studied organizations present different design patterns, i.e. made different choices when they implemented Industry 4.0 technology.

4 Results and Analysis

Following we will present the results in two sections. In the first section we discuss common design findings, while in the second section uncommon ones. In each section we report exemplary cases from the 15 studied organizations.

4.1 Common design choices findings

In this section, we describe key findings for common design choices. Data shows that all the companies, for which we have information, present the same design pattern (i.e., no company made alternate choices) on the following variables: nature of work, job variety, teamwork, number of organizational layers and collaboration.

Nature of work In terms of *physical demands* results show that work has become less labor intensive;. In terms of *cognitive demands*, there seems to be a positive relationship between them and the implementation of Industry 4.0 technologies.This topic relates directly to Company 1, a large company that operates in the design/furniture sector which through a high level of automation and digitalization (extensive use of personalized CAD and IT interface) has highly standardized its production processes. The below excerpts affirm how work in Company 1 has become not only less manual, but also more cognitive:

> *Says a supply manager: …Now the work is easier. The workers use the software to make the machine do the manual work that they used to do…'*
>
> *Says an operator:…and so we can say that the operators reason more compared to before, before they used to do things automatically, they had to do so, instead in front of the machine now they have to reason, use their heads more…*

Job Variety Evidence shows that Industry 4.0 technologies are associated with higher job variety. In order to integrate with the new technological processes, profiles of the workers involved have become more multitasking as employees are required to perform a number of different tasks. Company 9 is a large electro-mechanic company that produces water pumps in the submersible, and drainage and surface ranges for agricultural and industrial use. This company has not only automated production processes, but also has recognised a pressing need in the industry for a cost-effective solution for real-time reporting of production and maintenance data, and for that reason they make high usage of collaborative robotics and additive manufacturing. Due to high digitalization and automation, the tasks of the operator have been broadened. As one operator simply puts:

> *…The old operator was the one who put the mold, prepared the tools for the machine, today in addition to those skills and tasks, which have not been lost, there are more tasks related to automation, monitoring, which previously were tasks of the specialists office...*

Collaboration. There is an increase of collaboration between line and technical staff across most organizations. Company 2, is a large metal mechanic company that makes extensive use Industry 4.0 instruments such as: IoT, built-in sensors, tailor made machines, AI, and robots. In this company there is a general consensus on the fact that digitalization and internet of things are associated with a higher degree of complexity in work processes, which coincides with a growing demand for technical skills. In order to fill this gap, an IT manager explains the importance of collaboration between staff and line workers:

> *...It happened to me, which is a very positive thing, to be part of these inter-functional teams between IT and line workers that fill technical gaps automatically…*

Teamwork Advanced technologies seem to be associated with increased teamwork. In Company 15, that operates in the logistics sector, new technological instruments such as: automated machines, different IT instruments, geo-localizing software, digitalization of production chain management systems, and the exoskeleton, have generated the need for more teamwork, where most skilled worker is transferring knowledge. Says one unit head:

> *...We have more teams, made of for example 5 workers, and for each team we try to have an experienced key person as point of reference. They are not team leaders or formal team-leaders …*

Number of Organizational Layers Interestingly it was found that most organizations report less hierarchical layers. In Company 2, a large metal mechanic company that produces pumps, pistons and designs hydraulic system components, the advanced technologies like IoT, built-in sensors, tailor made machines, AI and collaborative robots have been related to the optimization and simplification of the cycles of production that before were complicated by regulatory systems. There is also better integration with the supply chain, the warehouse, etc. This crucial (integrative) aspect of smart factory grew together with the simplification of the structure of organization, which has become leaner, flatter. In the words of the IT manager:

> *…we are quite innovative not only in production aspects, lean production, Industry 4.0, and IT aspects. This project is part of lean if you want, lean production that brings with itself a flatter organizational structure...*

Taken together, above findings indicate that Industry 4.0 technologies are associated with an increase in cognitive work, decrease in physical demands, more job variety, more collaboration and teamwork, and less hierarchical layers.

4.3 Uncommon design choices findings

The variables that belong to the uncommon design choices are: employee autonomy, coordination mechanisms, role of middle management, level of formalization, and skills and competences. Following we present in details the results obtained.

Autonomy. Findings show that in some companies Industry 4.0 technologies are associated with an increase of managerial control over workers and reduction of employee autonomy. For instance, Company 7 is a medium metal mechanic company that has implemented technological tools like automation of machines, online camera control of mechanical parts assembly, electronically made assembly cards, interacting displays and collaborative robots. The new machines can be set up from the electronically equipped central technical office. Findings highlight the capacity of Industry 4.0 technologies to control the resulting productivity of the employee. Respondents placed more emphasis on the increased possibility of control on the individual behavior and performance, while there is no change at the level of workers' discretion (e.g. pace, method). Here is how the sales manager describes the effects of automation on controlling performance:

> *…For us automation is already incorporating all the data... Also in the program HIPER there is an interaction between machine and man, in the sense that there is a continuous transmission of all the performed processes, so through the exchange of data we obtain every result in all its phases…*

On the other side, in other companies advanced technologies are related with increased employee autonomy. For instance, Company 11 operates in a dynamic and unpredictable context. The implementation of technological instruments such as predictive maintenance empowers employees to be more proactive, involved and more autonomous in maintaining the equipment, while the implementation of smart working has placed more emphasis on the degree of freedom that an employee has in scheduling work. The story told by the SOA shows how the organization in order to meet its objectives is basing its philosophy in giving more trust and favouring the autonomy of its employees:

> *...The more fluid way of working implies, on the one hand, the acquiescence of a sense of responsibility from all employees which must be further reinforced, with new technological tools….from the managers perspective this is deprivation from some privileges and some tranquility that hierarchical control normally entitles, which now must be transformed into a capacity of government much more based on objectives and results, giving autonomy and trust to people...*

Coordination mechanisms. In some companies an increase in coordination mechanisms is reported. In Company 4, a large technological company, that produces Industrial computers, and embedded software systems (IoT), the digital technologies of communication have reduced the costs of processing and transmission of information which in turn facilitates the exchange of information. This fosters the creation of new forms of interaction/coordination. The chief information officer of this company describes the importance of digital communication tools:

> *…As chief information officer I manage all the information systems, therefore all the support tools, also of communication, of internal company sharing information, i.e. the so-called intranet. This digital communication tool is crucial for us as we have to extract the information from the mail of employees and put it in the repository and that everyone shares, the information must be live repositories.*

In other companies, technology has provided the tools to increase human interaction/collaboration (more meetings, etc.). For instance, Company 3 is a large metal mechanic company that is specialized in automation, in producing robots for welding, and designing technology solutions that enable digital manufacturing. The company places value on quickly adapting to market demands that in turn translates into the need for a flexible operating model, a structure that places importance on horizontal networks, where human collaboration dominates. Industry 4.0 technologies implemented such as Intranet make more information available to frontline workers, and offer workers more flexibility (they can now send their suggestions at any time), and by doing so, the technologies favor more human interaction. The innovation manager reaffirms the above:

> *…and then also at the level of internal coordination, at a higher level, surely there are many initiatives, as already said, the periodic coordination of the various centers of excellence and innovation, the monitors that are distributed throughout the company, where the initiatives are presented so that everyone is aware of what the initiatives are and what are the possible problems and who are the people to turn to. And that brings more human communication and interaction, which is fundamental in this context...*

Role of middle management. The relationship between technology and the role of middle management seems to vary. In some organizations this role seems to be emphasized in a traditional way (i.e., more control and execution powers). Company 6, a medium range family owned company is operating in the food sector. They have implemented Industry 4.0 instruments like IS, barcode reader, e-commerce, warehouse automation system, etc., and have realized that they need a better organizational structure to manage the company through the recent technological changes. To realize this, they have decided to emphasize the controlling role of middle management. In this regard the following image is introduced by the CEO of the company:

> *...The receivables have doubled, the growth of the personnel has made the restructuring of the company unavoidable, we have inserted an HR function, intermediate levels and the organization has a better structure to manage the changes…*

In other companies results show a middle management drained of its powers. More elements of the managing process are now being executed by the machinery, something clearly shown in Company 7. Company 7 is a medium company operating in the metal mechanic sector that apart from advanced automation has implemented technological innovations like online camera control of mechanical parts assembly, electronically made assembly cards, interacting displays, collaborative robots, etc. These technological innovations have turned out to provide remote assistance to the process of control and supervision performed by middle management. Here is how the quality manager describes the above:

> *…From here we see the progress of all the machines, we see the causes of downtime from anyone of the PCs in the company I can see them. What the operator sees at the machine's monitor, we see it here too. We don't have to move. Here, for example, I see number of theoretical daily pieces, downtime, I see the causes, the next work steps, the times ... This program is linked to the quality control islands that are found in some production locations, close to some machines, that did not exist before. For me, all the programs that continue to be developed in this sector will be such that in this position man will be increasingly substituted by the machines...*

On the other side, findings show that some organizations point to the key role of middle management, as a more supporting and guiding role. For example, Company 8 is a large metal mechanic company which strengths lay in the innovation, quality, and the development of new products. To achieve growth goals they have reshaped their technological structure by adopting Industry 4.0 technological tools such as additive manufacturing that has provided new customized solutions. Adopting Industry 4.0 technologies has also demanded an organizational and cultural approach that emphasizes an agile/proactive management model, so that decision-making authority is delegated to employees, and managers are required to support them in making the right choices. Empowering the developmental role of middle management is one of the frontiers of their organizational redesign, as explained from VP of HR in the following extract:

> *...We have also worked on managerial skills in order to strengthen middle management by building a sort of toolbox of the boss, on the development of employees, motivation and conflict management, communication...*

Level of formalization. Results show a higher level of formalization for some organizations. For example, in Company 1, the passage from the crafting model to the digital model of production is reflected in the passage from the informal knowledge of the production line to the formalized knowledge. Through automation, personalized CAD and IT interface the company has standardized many processes and formalized work:

> *...While before we had an infinite quantity of flows, we have now managed to contain them, therefore there is more order in production; we know how to solve problems or how to approach production. The way how to work, is more defined than before, before there were several ways to get to the goal, while today everything is more standardized not so much the solution as the work process...*

At the same time findings indicate that in other organizations the level of formalization is lower, albeit the advanced technology. In Company 11, which strength lays in offering services with extremely distinctive skills, the advanced technology (like predictive maintenance) has enriched the traditional offer of services. This organization, which activities are diversified and not standard pushes toward a more personalized way of working. Says chief digital officer:

> *...The goal is to have a management able to predict even one week's work on activities that are not always standard and are in fact very diversified, it is much more about the soft aspects than on the quantitative ones. So, if at the end of the pilot phase, for example, we will also find an univocal way to give an extra tool to our middle management to work, we give it if they ask for it, if there is a need, it is not a standardization of the work….On the contrary, we work more and more towards the personalization of work…*

Skills and Competences. In some organizations interviewees report evidence of deskilling after the adoption of Industry 4.0 technologies. In Company 1, for example, due to high level of automation, machines operate in a continuous cycle and independently, and for particular tasks automation has acquired full control of production that now do not need to be manned. This process has resulted in *deskilling*. While discussing such phenomenon, an operator gives the following explanation:

> *...there is an increase in the technical skills, but looking at the factory side the skills decrease. The panel comes out already finished, ready and in the label there is written where they should bring it. The technician at the end does not even worry about what panel is going through. While before he used to take care of the panel and of the machine...*

Data shows that in other organizations, Industry 4.0 technologies is associated with the acquirement of new skills among employees. For instance, company 8, is a large metal mechanic company that has implemented many Industry 4.0 elements such as: 3D technology, software with semi-predefined solution pieces, automated finishing systems, collaborative robots, real time production, automated warehouse, augmented reality, virtual reality, and digitalization of the distribution network. The demand for integration with the new processes has transformed the profiles of all the figures involved, in particular it has been related to the enhancement of technical skills. The greater uncertainty produced by digital technologies, asked for more transversal skills in order to handle unpredictable job situations. This together with an open organizational vision that places importance on relationships has resulted in a shared perception of an increase need for more transversal set of skills. A relevant illustration is presented by the production director:

> *...I have had for two years, during the implementation of digital technologies, the goal of encouraging polyvalence and poly-competence; we have done many projects, now we can say that it is an acquired lifestyle. Even if it is not so trivial to move between tasks, this is made possible through a well done method that supports people in developing with new skills...*

5 Overall interpretation and discussion

The present work aimed to provide an analytical description of how organizations that implemented Industry 4.0 technologies have been redesigned. We focused our gaze on a wide set of organizational variables, trying to provide evidence to common and uncommon patterns.

Results presented in common design choices show that work has become more cognitive, less manual, and more various. Results also indicate that technology promotes more teamwork and collaboration, while organizations opt for a simplified or flatter organizational structure (see Table 2). As such, these results imply that organizations that have implemented Industry 4.0 technologies are redesigned in continuity with post-Tayloristic principles, and in line with key features of lean organization. This leads us to the preliminary conclusion that the design choices made by all organizations are not enough to call for an organizational revolution, but instead the “organization 4.0” is facing an evolutionary phase of the post-Tayloristic organization. This finding reinforces the first objection to the techno-centric view, which employs a deterministic approach and submits to the technological imperative, as it calls into question the "disruptive" effect of current technological transformations (Salento, 2018, p.8).

Variables		Results/Choices	Companies
Nature of work	Cognitive demands	More cognitive	1,2,3,5,6,7,8,9,10,11,12,13,14

	Physical demands	Less manual	1,3,5,6,7,8, 13,14,15
Job variety		More Variety	5,7,8,9
Collaboration (Line plus technical staff)		More Collaboration	1,2,3,4,8,10,11,15
Teamwork (among peers)		More teamwork	1,2,3,4,8,10,11,15
Nr of organizational layers		Flatter organizational structure (less layers)	2,3,7,8,11

Table 2 Common design findings

On the other side, results presented in the uncommon trends category provide evidence that in some companies the implementation of Industry 4.0 technologies is associated with higher levels of control, higher levels of formalization of work, a de-skilling effect, and a depleted role of middle management. By contrast, in other companies, Industry 4.0 technologies are associated with the development of more technical and transversal skills, enhancement of employee autonomy, and a more engaged and supportive middle management. Taken together, these results seem to support that on one hand technologies seem to enable an *employee control-oriented organizational design* and on the other hand, they seem to enable an *employee commitment-oriented organizational design.* The two organizational designs are mutually exclusive, as companies opted for choices that fall either in one or in the other (see Table 3).

Variables	Results/Choices	Control oriented companies	Results/Choices	Commitment oriented companies
Autonomy	Less autonomy Control as property of the machine; or still on the manager	6,7	More autonomy Control as property of the employee, or of the team	3,8,11
Coordination mechanisms	Technology provides more data, used by the manager for more coordination; Technology directly coordinates employees. A common result is: less need for human communication	1, 2, 4, 6, 9	Technology provides more data used by employees and teams for better coordination; Technology creates the need for more human communication (more meetings, etc.)	3, 8, 11
Role of middle management	Role of middle management emphasized (in a traditional way) Middle management drained of its role (more elements of the process are executed by the machinery)	2, 3, 6, 7, 9	Middle management has stake in the decision making of the company; playing a more supporting, and guiding role	8, 11
Level of formalization	Higher	1, 2, 4, 6, 9, 12, 13, 14, 15	Lower	8, 11
Skills and Competencies	Deskilling Acquirement of only technical skills	1, 2, 4, 6, 9, 12, 14, 15	More technical plus transversal skills	8, 11

Table 3 Uncommon design findings

6 Theoretical and practical Implications

Peter Berger (1974) has pointed out that technology is often presented in mythological forms, and this happens above all in times of crisis (Salento, 2018). However, in most situations, technology is not neutral: it benefits some factors of production, while directly or indirectly reducing the compensation of others (Acemoglu, 2007).

Our findings present interesting theoretical and practical implications in this perspective. We consider that the results of our study are in line with the socio-technical perspective adopted in this paper, which recognizes that technologies in themselves create possibilities and potential, but ultimately the future of organizations will depend on the choices they make. Therefore, the current theoretical debate about the two perspectives (i.e. Industry 4.0 technologies as enablers of control-oriented vs commitment-oriented organizational designs) seems to be oversimplified, since it is not taking into consideration the agency of the organization. Our results indeed confirm the existence of different organizational designs.

The main practical implication shares the concern that organizational actors need to act with caution (i.e., the "de-mythologized" view) when implementing Industry 4.0 technologies. The assumption that technology is neutral and that it will automatically generate positive outcomes for all actors involved is not supported, and thus efforts should be made to rather co-design a socio-technical system that is inclusive of all interested stakeholders.

In addition, our results yield implications for policy makers, in raising awareness that supporting financially the implementation of Industry 4.0 technologies might mean supporting organizations in becoming more employee control-oriented. In other words, public policies aimed at increasing economic performance of manufacturing companies (at shareholders' benefit) might do so at employee's expense. Thus, public policy makers should be receptive not only to the implementation of Industry 4.0 technologies, but also to *the way* these technologies will be incorporated in the organizational design.

6 Limitations and directions for future research

A first limitation of this study is that our sampling strategy has been centered on a single variable (i.e. Industry 4.0 technologies implemented), therefore future studies employing different sampling strategies may help make our findings more generalizable. Second, the data has been gathered through interviews, so more observation is needed in order to be more conclusive. In addition future research should consider differences in structural features of the organization (e.g., size, industry, specific technologies adopted) which might affect organizational design.

Third limitation has to do with the theoretical perspective that we employ in this paper, i.e. the socio-technical perspective. The literature focused on how work comes to terms with the new technology is versatile and entails different theoretical perspectives. For example, some explicitly 'worker- centric' studies like Edward's 'Contested Terrain' (Edwards, 1979) emphasize how, in face of the tension between worker's and manager's interests, various technical relations of production generate particular forms of labor organization, or help to maintain existing organizational forms. Thus, it becomes important to further investigate the phenomenon employing other relevant concepts

Lastly, particular attention should also be placed on how the emerging design choices are individually and collectively interpreted by employees and other relevant actors (e.g. unions). It could be interesting to explore the effects of design choices, and the interpretations on work intensification, different dimensions of employee well-being, and on employee and organizational performance.

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