Organizational Barriers Towards Industry 4.0

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Abstract
In the last decade, researchers have given particular attention to the Fourth Industrial Revolution (4IR), also known as Industry 4.0 (I4.0), due to its potential to improve internal processes efficiency, real-time control of their supply chains and boost competitiveness of companies regardless of their industry and size. Even agricultural sector has been experiencing a transformation leading to automation and abandonment of traditional practices. Entities willing to embrace and enjoy the benefits of 4IR need to adapt to it. Those stuck with usual business and processes risk to be inadequate for a changing environment and misfit it: they are likely to run out of business. The 4IR represents an opportunity for companies as they can increase their profits and monitor their value chain entirely. However, challenges and obstacles more or less difficult to surmount can impede and slow down the digitalization introduced by 4IR. These hurdles are of different nature ranging from strategic, human resources and operational. Operational barriers are the focus of the present paper. Through the means of a questionnaire filled out by owners and employees with managerial and non-managerial functions it was investigated (among the others) what are in order of importance the perceived main barriers of this category that obstacle them from becoming highly digitalized and complete the digitalization process. The sample comprises Slovak and Italian companies from different industries and of diverse characteristics. The survey showed that data security and financial availability are perceived to be the most important barriers of the operational barriers.

Keywords: challenges for companies, digitalization, Fourth Industrial revolution, Industry 4.0, operational barriers

JEL Classification: Q16, O30, O33

1. Introduction
Starting from last decade, entities have been undergoing the digitalization process, continuation of a first generation of automation and of digital machineries introduced in the 1980s by the third industrial revolution, which was possible thanks to the rise of mass-market personal computer and the spread of connectivity infrastructure, the growing use of digital design tools in manufacturing and services. In 2011, during the Hannover fair (Germany), 4IR was labelled Industry 4.0 (I4.0) and, years after years, it has increased its popularity among scholars as well as among the general public, especially for its implications. To mention, Internet of Things (IoT) and Digital Public Identity systems are based on I4.0 technological principles. Not only is this revolution about automation, but also a radical transformation for what regards the industry structure through horizontal, vertical, and end-to-end digital integration of supply chain (Kagermann, Wahlster & Helbig, 2013). Every sector, industries, and companies regardless of their dimensions deal at different extents with the 4IR. Adapting to it can mean for them survival and boosted competitive position. Furthermore, the usage of advanced technologies and techniques improves internal process efficiency and cost reductions. Resource efficiency, quality, flexibility and sustainability can be reached through the
deployment of Industry 4.0 technologies (Mangla, Kusi-Sarpong, Luthra, Bai, Jakhar & Khan, 2019). In agriculture, Industry 4.0 is called Agriculture 4.0 and its implementation has the potential to increase the efficiency of production, reduce incurred costs and make practices more environmentally friendly.

Employing the novelties introduced by 4IR is often hindered by challenges and obstacles that vary from sector to sector, entity, and level of technological advancements of the latter at the time of the digital transformation. These challenges and obstacles are of different nature varying from strategic, human resources and operational (Marcon, Marcon, Le Dain, Ayala, Frank & Matthieu, 2019). The focus of this paper is on operational barriers. Based on previous explorative research, this study is quantitative and aims at identify the main barriers of this category in product and service industry. Partial objective aims at analysing the general rank of the main three classes of barriers.

1.1 Industry 4.0

Industry 4.0 integrates the latest technologies in the value creation, representing the result of technical progress information and communication technologies (ICTs) (Delera, Pietrobelli, Calza & Lavopa, 2022). It is an intelligent networking of machines and processes for industry aided by ICTs (Platform Industrie 4.0, n.d.). I4.0 is closely linked to Cyber-Physical Systems (CPS) (Deloitte, 2015), transformative technologies which manage interconnected systems between its physical assets and computational capabilities (PwC, 2016). In this setting, customers cover a central role, more active than the past: products are more precisely tailored according to their requirements and customization. This creates new business opportunities (Allmendinger & Lombreglia, 2005).

The application of I4.0 technologies in agriculture is often referred as Agriculture 4.0. In such a context, agriculture could be enhanced and multiple opportunities can be exploited (Spanaki, Karafili & Despouli, 2021). The identified benefits for 4.0 are valid for agriculture too (Bernhardt et al., 2021). Particularly, benefits come from the use of information, technology, equipment and a wide range of services (Spanaki, Karafili, Sivarajah, Despoudi, & Irani, 2021). Compared to traditional farming, farms may now exploit data, which can improve practices and operations of individual and large groups of farms. Besides, it can provide a way to ensure the transparency of the farming practices and sustainability of the agricultural sector and agrifood production processes (Spanaki et al., 2021).

Technologies such as artificial intelligence (AI), Internet of Things (IoT), cloud computing, advanced robotics, augmented reality, virtual reality, big data analytics and internet of things are examples of the arsenal a “smart” company possesses and that can use to its own advantage. In the specific case of Agriculture 4.0, example of technologies are parallel travel systems with GNSS for logistics on the field: all process data are recorded and analysed externally via data networks. Ready to improve the productivity and innovativeness of manufacturing [and service] firms, technologies 4.0 unlock new opportunities in the optimization of production processes and product functionality (Niebel, Rasel & Viete, 2019; Zabidin, Belayutham, & Che Ibrahim, 2020). According to the findings of Masood and Sonntag (2020) flexibility, cost, efficiency, quality and competitive advantage are the key gains that companies can experience from it. Other benefits for organizations regard cost reduction through their control, real-time control over the value chain and rapid adaptation to customers’ needs and demand. Moreover, faults in production processes can be identified quickly (Kaziboni, Nkhonjera, & Roberts,
This leads to obvious cost saving. A machine monitoring the process reports the problem to specialized personnel so that they can promptly intervene.

I4.0 enhances sustainable and more environmentally friendly practices. Indeed, employing control software and hardware can provide efficient solutions for energy savings, control of emissions, machine maintenance (Garetti and Taisch, 2012). Green practices in turn are likely to award companies by attracting more customers and increase profits as they would pay more for a certain product in name of the environmental cause. In a fierce competitive environment and continuously changing customer needs, therefore, it becomes essential to adapt.

Not only is I4.0 relevant and interest topic in engineering, but also, in the last years, has gained relevance in management studies, where innovation is essential for the firm development (Malerba, 2007 cited in Piccarozzi, Silvestri, Aquilani & Silvestri, 2022) and survival. What is more, on the business level, I4.0 is expected to improve quality management processes (Herceg, Kuč, Mijuškovič & Herceg, 2020). The effective implementation of I4.0 initiatives indeed equips smart companies with a competitive advantage and novel business opportunities leading to a change in their business models. Entities stuck with the past and that refuse this innovation risk to lose contact with their environment, to be beaten by those “smarter” and to run out of their businesses.

The digital transformation of I4.0 is not always smooth, though. Barriers and challenges hinder entities and slow down their innovation process, to make a transition towards customized products, decrease lead times and implement more sustainable operations and products (Halse & Jaeger, 2019). In this regard, the exploratory work of Marcon et al. (2019) contributed to define the main obstacles to overcome for manufacturing companies. Accordingly, the main categories of barriers are: strategical, operational and human resources. Organizational culture, psychological aspects and demanded competences (human resource aspects) should not be underrated because of the implications that they have for the actors within the organization. Financial constraints would limit entities to adopt the latest technologies to run their business and obsolescence of machineries and imply more expenses required to purchase new ones (some operational barriers). Lastly, a lack of digital vision and a strategy paving the way to I4.0, and the inability to forecast and adapt to changing customer needs are example of what constitute strategical barriers.

Depending on the sector and industry, barriers could vary as for what regards the difficulties to overcome them. For a company that carries out its operations in the high-tech industry is highly likely to have a smoother transition than a company doing its business in the construction one. Maturity and readiness models, beyond the scope of this research, are usually employed to test the readiness for initialization of the digitalization process (Herceg et al., 2020), i.e. the status of digital transformation of a company (Chaniaς & Hess, 2016).

1.2 Operational barriers towards I4.0

The main focus of this paper is on operational barriers: this subparagraph explores more in details this category.

According to Marcon et al. (2019), operational barriers regard all the aspects a company needs to consider in enabling a digital technology to work in both innovation process and outcome. Therefore, functional elements that make possible digitalization belong to this family of barriers and challenges. Always in their work, the specific ones are presented and described:

- **Obsolescence**: digital technology soon unusable after a relatively short period of time.
- **Compatibility**: with newly introduced technology with the already installed ones.
• **Resources**: lack of appropriate tools, resources and needed infrastructure.
• **Financial**: the actual costs and investments required to embrace the transformation.
• **Organization**: lack of operational processes and time to implement the digital technologies.
• **Data security**: fear of being hacked, lack of confidentiality and reliability, etc.
• **Life cycle barrier**: maintenance and support of the new technologies.
• **Industrial context**: company’s environment and industrialization degree which determine the starting point of digitalization.

Bonamino and Frech (2020) found among the operational ones - that they classified under technologies - interoperability (compatibility of technologies), full guarantee of safety (i.e. data security) and “scalability” (i.e. capacity of a platform to provide all necessary resources for an application to run correctly). Moreover, Chang, Cheung, Cheng and Yeung (2008) found that the higher the compatibility with a newer technology, the likely that technology is adopted.

Data security is also one of the main concerns in the literature (e.g. Amaral & Peças, 2021; Majumdar, Garg & Rohan, 2021; Müller, 2019; Marcon et al., 2019), as the risk is represented by the disclosure of confidential information and the absence of rules that can guarantee protection. Transparency problems would even be related to it. With available information about the order data, customers could put pressure on a company and competitors could acquire know-how and use it at their own advantage. Furthermore, frightening of hacking attacks to their systems is very relevant. In the agricultural sector, this worry would make small and medium farms resisting Agriculture 4.0. They are indeed doubtful about data sharing concerns and access control policies of the parties’ data (Angelopoulos, Brown, McAuley, Merali, Mortier, & Price, 2021; Ioannou, Tussyadiah & Lu, 2020).

### 2. Data and Methods

With this paper, the aim is to identify the most important operational barriers, in general, what companies that carry out their operations in different industries consider as most significant. For the analysis, it is important to define the different types of industries. They are classified in two major types: manufacturing (or product) and service industries. Service industries are usually involved with customers (final user or B2B), sometimes they deliver goods (e.g. FedEx), but they do not produce them. They deliver an intangible good “produced” at the time of the time of its consumption. For instance, the group comprises firms active in training, engineering, advanced diagnostics, ranging from basic after-sales services to complex solutions that combine products and services (Kowalkowski, Kindström & Brehmer, 2011; Gitzel, Schmitz, Fromm, Isaksson, & Setzer, 2016; cited in Bonamino & Frech, 2020). Firms belonging to product industries make tangible products instead: for example, car manufacturing, furniture and heavy machinery.

Taking into account Chang et al. results (2008), the same could perhaps hold in 4.0 technologies. In addition to this, Bonamino and Frech’ study (2020) would suggest the importance of compatibility. Besides, the importance given to data security by several studies may suggest that data security as well will be so fundamental concern for entities. The following research hypothesis was assumed:

**H1**: Compatibility and data security are ones of the most relevant barriers for both manufacturing and service companies.
In management literature and in practices, financial resources - the available resources to purchase novel technologies - cover a key role for the digital transformation process. Probably, being manufacturing companies more capital intensive than service ones, they would require higher investments to pursue the 4.0 initiatives. Therefore, the postulation was:

**H2**: Financial availability will be one of the most relevant barriers for manufacturing companies; it will have lower importance for service companies.

To test the objectives, a questionnaire was sent by email to company’s actors with managerial and non-managerial duties. The sample of respondents worked in Slovak and Italian companies. In total, 102 answers were collected divided as follows: 62 from Italy and 40 from Slovakia; 38 out of 102 had foreign participation in their capital structure and only 4 companies were publicly/state owned. They operated in 30 different sectors. In some sectors, only few operated, so they were grouped in two main groups (the risk of close to zero variances was avoided). This would have not allowed further analysis. As such, two main categories were identified, service and tangible products industries: 63 for the former and 37 for the latter (2 answers were removed as not classifiable). Of the product group, mechanical and electrical engineering (13) were the main companies belonging to this category, followed by commerce (5) and agriculture (4). For what regards service companies, financial and professional services are more than half in the industry (23 over 37).

Generally, the dimension of companies varied from very small (less than 10 employees) (26), to small (10-49 employees) (22), midsized (50-249 employees) (26), and large companies (over 250 employees) (28). Similarly, work positions of respondents were grouped under 5 labels: lower managers, middle managers, top managers, owners, and others (other positions).

The questionnaire, the basis of a larger study on barriers and challenges of all categories, foreseen 3 parts: classification of companies and employees, Likert scale and ranking questions. For the current, relevant are the first and third parts. The respondents had to rank operational barriers – among those identified by Marcon et al. (2019) - in order of importance according to those perceived as the main hindering the digitalization. Further task was to rank main categories of barriers: strategic, operational and human resources.

Garrett ranking method was chosen for the analysis of the ranking questions. To know more please refer to Garrett’s publication “Statistics in Psychology and Education” (1926).

### 3. Results and Discussion

From the questionnaire, some important and unanticipated results can be observed. Interviewers ranked the main family of barriers. Regardless of their industry, it emerged the primary importance of strategic barriers (Table 1). Without a path to follow, an entity would be lost and its objectives would not be clear. Moreover, a strategy illustrates the organization’s strategic actions aiming at gaining a competitive advantage in the market (Porter, 1980). As a result, the critical role played by it would justify the first position of strategic barriers in the ranking. Operational barriers assume a secondary importance in this context. Probably, in the analysed companies of the service industry, operations will not undergo the changes happening in the industry sector. The majority of the interviewed firms, which belongs to this group, are indeed involved in financial and professional services, and as such they would mostly have to continue to work with customers in “traditional ways” (online and offline service). Yet, AI may eventually overcome these ways making the customer service and the relationship with the customers different.
Table 1: Rank of group of barriers

| Product Ind. | Rank | Service Ind. | Rank |
|--------------|------|--------------|------|
| Strategic    | 1    | Strategic    | 1    |
| Operational  | 2    | Human resource | 2    |
| Human resource | 3    | Operational | 3    |

Source: Author’s processing

Analysing Table 2, the first positions in the two industries are occupied by data security and financial availability. This outcome corroborates hypothesis H2 and rejects H1.

Table 2: Ranking of operational barriers per industry

A. SERVICE INDUSTRY

| Rank | Barrier          |
|------|------------------|
| 1    | Data security    |
| 2    | Financial availability |
| 3    | Organization     |
| 4    | Resources        |
| 5    | Industrial context |
| 6    | Compatibility    |
| 7    | Life cycle barrier |
| 8    | Obsolescence     |

B. PRODUCT INDUSTRY

| Rank | Barrier          |
|------|------------------|
| 1    | Data security    |
| 2    | Financial availability |
| 3    | Industrial context |
| 4    | Organization     |
| 5    | Life cycle barriers |
| 6    | Resources        |
| 7    | Obsolescence     |
| 8    | Compatibility    |

Source: Author’s processing

In a revolution like the 4IR, it is probably foreseen an entire restructuring of business models and as such technologies used. Therefore, compatibility would be of minor importance for companies involved in the digital transformation. The latest technologies would hardly be compatible with the company’s ones: the principle that a certain technology will be likely to be adopted in case its compatibility with those already installed in a company does not hold. Looking again at Table 2, Compatibility appears in the last positions in service industries (sixth over eight) and the bottom for product industries. As debated in the literature, the latter is in some way forced to invest in and install it to be able to compete and improve its business processes, regardless of, once again, the compatibility degree with “old” technologies.

Data security ranked in the first position in both industries confirms other study’s outcome of I4.0. Indeed, a gap in the legislation of rules aiming at protecting data and company’s assets (e.g. intellectual property) so important for the preservation of its competitive advantage make the issue of data security such a priority. A security challenge companies face is due to the particular susceptibility of Industrial Control Systems (ICS) to cyberattacks. To solve bugs and flaw in - usually very complex - systems frequent upgrades are essential. A way to reduce the risk may be the training of employees because, if unexperienced, they may be the means through which a malicious software (e.g. malware) can get access and steal precious information. In the financial and professional sector, securing data of clients is a must due to their value and their sensitiveness.

Financial availability is the second challenge for significance in the groups of industries. This result is different than what foreseen in H2: the hypothesis is rejected. The availability of monetary resources therefore is equally crucial in the sample under analysis for a smooth transition and completion of 4IR. Not only has a company to invest in the actual equipment and technology, but also it should provide its actors with tools that enable their usage. Among these tools, a considerable weight is covered by training, required for employees to learn how to operate the technology and orientate in a “smart” company. In addition to training, Masood and Sonntag (2020) found that the investment covers hiring the “right people” too. These people should be compatible with company’s culture and with the competences required and expected to be employed in the everyday business.
4. Conclusion

The current industrial revolution is bringing entities to experience improvements in their businesses and operations by digitalizing processes and integrating entire value chains. This trend regards not only manufacturing companies but also service ones. In agriculture, the set of practices linked to I4.0 are called Agriculture 4.0 and brings to it considerable advantages. I4.0 is characterised by cyber-physical systems in which large amount of information about a machine or process can be documented and analysed in real-time. Digital farming may improve practices and operations from gathered data as well as ensure transparency of the farming practices and sustainability.

This article has stressed the necessity for entities to become smarter (i.e. to introduce I4.0 initiatives). Indeed, those that will stack with current practices have high chances to lag behind competitors. In order to make the digital transformation brought by 4IR, barriers and challenges should often be taken into account. The main barriers hindering the transformation were identified to have a strategic, human resources and operational nature (Marcon et al., 2019). Here, the latter was analysed more in depth. According to the results of the questionnaire, the first two barriers for product and service industries are exactly the same: data security and financial availability, which would stress their central role. Due to its nature, technology 4.0 generates loads of data (Big Data), containing precious information that with lack of regulation could be stolen with no consequences. Financial availability, then, is the fuel of the 4IR, as without funds, the digitalization process cannot be implemented.

4.1 Limitations

The study has some limitations, concerning the geographic area and the generality of the result because of the sample size. The sample comprises companies of two European countries and only a hundred of answers collected. Future research may aim at analysing the results in other countries from other continents.

Potential shortcomings derive from the nature of close-ended questions as well. Certain features, for example certain barriers not in the list may affect the respondents or certain may not influence them.

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