Industry 4.0 Implementation Barriers in Small and Medium Sized Enterprises: A Focus Group Study

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Abstract – The attention devoted to Industry 4.0 by scholars, managers and policy makers has grown exponentially in the last few years. The goal of this paper is to empirically investigate the main barriers and difficulties faced by small and medium sized enterprises in Industry 4.0 implementation. We perform a systematic literature review on the topic and conduct some focus group studies in four countries (USA, Italy, Austria, and Thailand). We identify a set of barriers and obstacles and classified them into six categories: economic-financial, cultural, competencies/resources, technical, legal, and implementation process. The results of the study have significant implications for both scientific research and management practice.

Keywords - Industry 4.0, implementation, roadmap, barriers, strategy, small and medium sized enterprises.

I. INTRODUCTION

Industry 4.0 refers to the “confluence of technologies ranging from a variety of digital technologies to new materials to new processes” [1]. The attention devoted to the topic by scholars, managers and policy makers has grown exponentially in the last few years [2, 3].

Despite the focus of most of the eight priority areas for action outlined in the final report of the Industry 4.0 working group (e.g., work organization and design, training and continuing professional development, resource productivity and efficiency; [4]) and the potential of Industry 4.0 to revolutionize management theory and practices [5], extant literature has mainly studied Industry 4.0 from a technological point of view [3]. Consequently, a detailed analysis of the implementation strategies, the main barriers faced, as well as on the impact on firms’ operations and supply chains, is missing [5].

Our paper aims at starting to address the aforementioned gap by empirically investigating the main barriers and difficulties faced by SMEs in Industry 4.0 implementation. We focus on SMEs for two main reasons: (1) they are very important for many countries as a backbone of national economy; (2) on one hand they are expected to face more difficulties to adopt Industry 4.0 than large companies due to lacking resources and knowledge; on the other hand, they can more quickly change towards Industry 4.0 if a suitable roadmap is available.

II. LITERATURE REVIEW

We systematically reviewed the literature on obstacles and barriers in the implementation of Industry 4.0 technologies. We performed a keyword search in the

most important electronic database (Elsevier’s Scopus) using a combination of two set of keywords: (a) Industry 4.0-related terms (e.g. Industry 4.0, Industrial Internet, Fourth Industrial Revolution, 4^o Industrial Revolution, Internet of Things, Smart Manufacturing, Cyber-Physical Production Systems); and (b) barrier-related terms (Barrier*, Obstacle*, Challenge*, Problem*, SME*, Small and Medium Enterprise*). Through the abovementioned search strategy, we found 6,029 papers, which were then filtered using filter criteria and afterwards screened based on (i) title and (ii) abstract and then by (iii) full text. We excluded at this stage all papers that do not provide insights on the obstacles and barriers in Industry 4.0 implementation and which were written in other languages than English and German (we included as inclusion criteria also papers in German as Industry 4.0 concept was initially conceptualized in this country). The final sample consisted of 17 papers [6-22]. In addition, we added to the identified works also the following 3 studies from World Economic Forum [23], Deloitte [24] and IBM [25] found in the database Google Scholar as they address relevant content for our study. We then coded these papers based on the obstacles/barriers highlighted by each of them. The results of the systematic literature review are summarized in Table 1.

The reviewed papers highlight a set of 19 obstacles/barriers in Industry 4.0 implementation that were classified into 6 categories:

1. *economic/financial* (high investments required, lack of monetary resources, lack of clearly defined economic benefits);
2. *cultural* (lack of support by top management; preferred autonomy);
3. *competencies/resources* (lack of skilled employees, lack of technical knowledge; complexity of the Industry 4.0 application both technical and practical, need to find suitable research partner);
4. *legal* (data security concerns);
5. *technical* (lack of standards, uncertainty about the reliability of the systems, weak IT infrastructure, difficult interoperability/compatibility, technology immaturity);
6. *implementation process* (need for new business models, lack of methodical approach for implementation, high coordination effort).

TABLE I
LITERATURE REVIEW (E = empirical, C = conceptual)

		Dixit, Kumar and Kumar 2015	World Economic Forum, 2014	Müller et al 2017	Otuka et al 2016	Nyländer et al 2017	Zawra et al 2017	Heng 2014	Schröder 2017	Jäger et al 2016	Qiao and Wang 2012	Hatler 2012	Kagermann et al 2013	Geissbauer et al 2014	Schlaepfer and Koch 2014	Müller et al 2018	Koch et al 2014	IBM 2015	Meißner et al 2016	Wenking et al 2016	TOTAL
Focus on SMEs				X	X	X		X	X	X						X			X		8
Economic /Financial	High investements required									E	C	E		E		E	E	E		C	8
	Lack of monetary ressources			E					C									E		C	4
	Lack of clearly defined economic benefit		E											E			E				3
Cultural	Lack of support by top management		E											E			E	E		C	5
	Preferred autonomy			E																	1
Competencies /Resources	Lack of skilled employees		E							E					E		E		E	C	6
	Lack of technical knowledge			E		C			C			E	E	E		E		E	E	C	10
	Complexity											E						E			2
	Need to find suitable research partner			E															E		2
Legal	Data security concerns	C	E		E				C	E		E	C		E	E	E	E		C	12
Technical	Lack of standards	C	E		E		C	C	C		C	E	C	E			E		E	C	13
	Uncertainty about the reliability of the systems				E							E									2
	Weak IT infrastructure		E		E					E					E			E	E	C	7
	Storage Data	C					C										E				3
	Difficult Interoperability/Compatibility				E		C	C													3
	Technology immaturity		E											E			E				3
Implementation process	Need for new business models		E	E		C				E											4
	Lack of methodical approach for implementation								C					E					E		3
	High coordination effort			E																	1

The literature is however characterized by some significant limitations. First, most papers (58%) are published in conference proceedings or reports, therefore lacking a rigorous peer-review process. Second, only 42% of the studies are focused on small and medium enterprises. These companies have instead significant peculiarities, which call for a specific investigation. Finally, if we compare the list of barriers highlighted in Industry 4.0 literature (see Table 1) with the broader set of barriers in innovation adoption highlighted by the innovation management literature (see [26] and [27] among other), we noticed that various significant barriers are missing in Industry 4.0 literature. The comprehensiveness of the list of barriers to Industry 4.0 identified by extant literature is therefore called into question.

III. METHODOLOGY

Considering the novelty of the topic and the need for an in-depth exploration [28], we adopted the focus group

methodology. This method was developed and extensively adopted in medical and marketing research; it is now accepted and established even in social science research [29].

Four focus groups (lasting one full working day) were organized in USA, Italy, Austria, and Thailand within the EU research project ‘SME 4.0’. Each focus group was attended by 13-25 CEOs or technical managers of 7-10 SMEs belonging to different manufacturing sectors, including electronics, industrial and agricultural equipment, furniture, and metal carpentry (see Table 2). The composition of the SME sample is a result of project workshop activity organized by four partner institutions. This fact has determined the four focus groups, while production sector was preferred.

After an introduction by the researchers about Industry 4.0 and related concepts, the participants took part to some brainstorming sessions (followed by some discussion sessions) in which they were asked to reflect on (and write on post-its) several topics related to Industry 4.0 implementation, including the main barriers and

TABLE 2
FOCUS GROUPS

Key Facts	Total	Italy	Austria	Thailand	USA
Participating SMEs	37	10 (27%)	7 (19%)	10 (27%)	10 (27%)
Participants	67	13 (19%)	13 (19%)	25 (38%)	16 (24%)

difficulties faced. The data emerged from the four focus groups were then independently coded by two researchers among the authors team.

IV. RESULTS

The focus groups allowed us to highlight several barriers for Industry 4.0 implementation in SMEs. We classified them into the same six categories used for the barriers highlighted by Industry 4.0 literature: *economic-financial*, *cultural*, *competencies/resources*, *technical*, *legal*, and *implementation process* (see Table 3). A few barriers identified by previous literature have not emerged during the focus groups. However, several barriers/obstacles not highlighted by previous literature were highlighted by our case studies (see Table 3).

Majority of SMEs (from all focus groups) pointed out the high costs and uncertain return on investment of Industry 4.0 (*economic-financial* category), also due to the unclear market potential of Industry 4.0 and the long implementation process. Among the *cultural* barriers, we found the corporate culture/mentality in Italy, Austria and Thailand (in particular the lack of cooperation among functions/departments), the employee resistance in all four focus groups (due to their poor knowledge of Industry 4.0 and their fear to lose their work), the missing top management vision on Industry 4.0, and their risk aversion in Austria and Thailand. As far as the *competencies/resources* are concerned, SMEs from all four focus groups point out that they their managers and employees lack qualification and training on Industry 4.0. Another important issue concerns the capital/investments required.

SMEs in Italy, Thailand and USA point out that they have different ICT systems and their data are stored in different silos that do not communicate each other. Furthermore, they argue that their buildings are not designed for automating the internal transports. These *technical* issues make the implementation of Industry 4.0 more difficult. SMEs of some countries (e.g., Thailand and Italy) highlight some restrictions due to local laws and regulations. Finally, SMEs in Italy, Thailand and USA point out the absence of a toolset for the introduction of Industry 4.0 (*implementation process* category). Several differences can also be observed comparing the four analyzed countries (see Table 3).

V. CONCLUSIONS

Our paper is to the best of our knowledge among the first ones to shed empirical light on the main barriers for Industry 4.0 implementation in SMEs. This way we open a debate on a topic that is expected to rise significantly in the next few years. Our findings also have significant implications for managers and policy-makers.

The results of our study should be viewed in light of two major limitations. First, we adopted a focus group research methodology. Despite several actions were performed to enhance validity and reliability of our

findings, statistical generalization to a broader population is not allowed. Second, our sample consisted of 37 SMEs from four countries (Italy, Austria, Thailand and USA). Caution is therefore needed to extend our results to other contexts. Future research could empirically test our findings on a wider and more heterogenous sample.

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TABLE 3
BARRIERS IN INDUSTRY 4.0 IMPLEMENTATION

Barriers		Highlighted in literature	Italy	Austria	Thailand	USA
Economic /Financial	High investments required	X	High investments with uncertain ROI	Investment (machineries, Construction measures, ...)	Investment in Production System and Human training (capital and time)	High tool costs and time investments
			High cost and high effort			
			From what size of company an investment makes sense?			
	Lack of monetary resources	X			Capital	Capital to invest
	Lack of clearly defined economic benefit	X	Measurement of results is difficult High investments with uncertain ROI	Investments/amortization	Do we recognize the impact on our company?	
Product characteristics				Value of the product (low value is not worth)		
Cultural	Lack of trust between partners	X	Lack of intersectoral cooperation/exchange			
	Lack of support by top management	X	Clear direction in the company is necessary	Top Management support	Top Management has not awareness in Industry 4.0	
			Commitment of the management is important	Mostly an unclearly defined part of the corporate strategy	Mindset overview > process, plan, customer ...	
			Mentality of the enterprise	Indecisive top management		
			Communication or transparency			
			Courage for new things			
			Lack of total vision of industry 4.0 for logistics			
	Preferred autonomy	X				Lack of easy "best practice sharing with other companies"
	Restrictive mindset		Lack of willingness to take risks			"The way we've always done it"
			People must "want" to introduce I4.0 instead of being forced			Changing way of thinking to modern methods of thinking
	Unsupportive organizational structure				HQ's decision-making management system Complexity of the organization	
	Acceptance of employees		Acceptance of employees	Acceptance of new technologies	Attitude of a worker to accept and change	Company culture due to fear of automation
			Communication to employees	Integration of employees		
			Employees are not yet aware of the changes	No/missing acceptance (open rejection)		
	Employees afraid of losing jobs due to new tech.					
	Lack of Support from Customer/supplier				Customers who are ready to support new systems	Squeezed in the middle of supply chain, not seen as strategic partner
					Don't know the true needs of customers or the market	
	Focus on day to day					No time to sit back and strategize
Awareness about the potentialities of robots					Need to believe that if I buy a robot for a job I will still be able to use it when the job is done	
Lack of Support by the IT quarter				The organization is just a production base, not a "company". It relies on parent companies in marketing decision.		
Competencies/ Resources	Lack of technical knowledge	X	Lack of qualification and training of employees	Know-How	Gap between Traditional Operators vs. New Entrepreneurs	Resources (people)
				ICT-barriers for employees	Lack of expertise of personnel to supporting Industry 4.0 and cannot use the information effectively	Training requirements
	Complexity	X	Complexity of Industry 4.0			
	High coordination effort	X	Implementation also requires major changes from supplier			
			Not all suppliers are prepared			
	Need to find suitable research partner	X				
	Lack of knowledge of Industry 4.0 Technologies and technological providers		A complete overview of the market is not yet available		Solution provider	
			Missing overview of what makes sense for the individual SME		Lack of access to the source of Information and Technology	
					How SMEs access the source of technology and available technology	
Analysis of the need for Industry 4.0				Knowledge of the technologies		
SMEs do not have an own "department" for industry 4.0				Gap between Traditional Operators vs. New Entrepreneurs		
		Small spaces and sometimes confined conditions				
		No space for automation of the logistics or internal transports				
Factory layout constraints		Current buildings are not designed for automating the internal transports				
		Future factory planning needs to be adapted in the future				
Legal	Data security concerns	X		Data security	Data Security	
	Lack of support by government				SMEs problems are Human Resources, capital and policy	
	Bureacracy		Bureacracy as a hurdle for a dynamic implementation of I4.0			
	Restricted laws and regulations			Legal restrictions	Restricted laws and regulations	
Technical	Lack of standards	X				
	Uncertainty about the reliability of the systems	X	Uncertainty about the reliability of automated transport or storage systems			
	Weak IT infrastructure	X	Consistency of the IT still does not exist	Integration of existing infrastructure		
	Storage Data	X				
	Difficult Interoperability/ Compatibility	X	Data silos without communication between each other	old data --> need for adaption	Each company's system is different to be interlinked	Integration of new technology with old equipment
			Missing interfaces with suppliers	Interfaces/ Communication		
	Technology immaturity	X				
State of machine park					Current state of the machine park	
Implementation process	Need for new business models	X				
	Lack of methodical approach for implementation	X	Missing toolset for the introduction of Industry 4.0	Few Best-Practice-Examples	What are the initial steps to improve or implement?	There are limited support resources and a lack of formalized, distilled information on how to implement industry 4.0
			There are no methods and approaches for the correct introduction of Industry 4.0	Clear formulation of objectives vs. Solutions	When an automatic replacement is introduced. How do humans work?	
	Required time for implementation		Required time for implementation	Time capacities for project implementation		High tool costs and time investments
			The market and competition will not stop			
			Be aware that time is needed to deal with it and implement industry 4.0			
	Changes required Form implementing Industry 4.0		Adjustment of the company			
	Difficult i es Demand forecasting			Fluctuation of order volume	Difficult in Demand forecasting	
	Product characteristics		Flexibility is the highest priority			Low quantity/ frequency of orders from customers
			Modification of the process according to changing customer needs			
			Difficult use with lot size 1 or individual products			

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