Barriers and Drivers for the Adoption of Industrial Sustainability Measures in European SMEs: Empirical Evidence from Chemical and Metalworking sectors

Abstract

As industrial sustainability measures and interventions play a central role in enhancing the sustainability performance in industrial firms, it is of great importance to properly understand the factors that might influence the decision-making process leading to their adoption, namely barriers and drivers. However, there is scarce empirical literature discussing barriers and drivers to industrial sustainability as well as the effect of contextual factors or of the firm's approach towards sustainability issues. For this reason, we conducted an exploratory investigation in 26 small and medium enterprises operating in the chemical and metalworking manufacturing sectors across Germany and Italy. Our preliminary findings show that the sampled firms are mainly hindered by economic barriers and fostered by external drivers. The investigation highlighted the influence of the contextual factors sector, country, and size on the perception of barriers and drivers. Moreover, the presence of a dedicated manager for sustainability, the number of certifications held by a firm, and a holistic definition of sustainability, seem to affect the barriers and drivers perceived by the sampled industrial decision-makers. The paper concludes by offering insights to both theoretical and practical discussion over the adoption of industrial sustainability measures, while also providing additional knowledge to practitioners and policy makers on critical areas for the improvement of industrial sustainability.

Keywords

Barriers; Drivers; Industrial Sustainability; Small and medium-sized enterprises; Sustainable production; Empirical Investigation

1 Introduction

The sustainability-related debate is constantly gaining relevance in the industrial and management-related discussion, and sustainability is recognized as a competitive factor for the industry (Bastas and Liyanage, 2019). Fostering the adoption of practices, actions, interventions to attain sustainable performance in all its dimensions - environment, social and economic, also in light of meeting the Sustainable Development Goals (SDGs) (United Nations, 2015) and the upcoming European Green Deal (European Commission, 2019a), is thus crucial. Within an industrial context, the above-mentioned practices, actions, interventions can be addressed as Industrial Sustainability Measures

(ISMs). ISMs are technical or organizational measures, tailored on a specific firm's characteristics, intended at improving a firm's overall sustainability performances (Klewitz and Hansen, 2014); ISMs can address one or more sustainability pillars, whilst having no impact or a positive impact on the others (Trianni et al., 2017b). ISMs proved to be effective and can bring positive impacts on the overall firms' performance (Hami and Utara, 2015): nonetheless, industrial firms are still struggling with their adoption due to a number of barriers (Trianni et al., 2017b), and should be fostered by drivers for sustainability (Sudhakara Reddy et al., 2014). Understanding the barriers and drivers influencing the sustainability decision-making process within firms is of fundamental importance (Cantele et al., 2020) and necessary to help industrial decision-makers properly address the challenges of enhancing their sustainability performance (Paletta et al., 2019).

The need for understanding the factors influencing the adoption process of ISMs is particularly relevant for Small and Medium-sized Enterprises (SMEs) (Cantele and Zardini, 2018). SMEs still present ample room for improvement in all the areas of industrial sustainability (Trianni et al., 2017b). In the European landscape, SMEs are key to economic growth, innovation, job creation, and social integration (Eurostat, 2018), representing 99.8% of firms (European Commission, 2019b). SMEs significantly contribute to the use of resources, pollutant emissions and occupational injuries and fatal accidents (Micheli et al., 2021; Sáez-Martínez et al., 2016). The single SMEs usually do not have a great impact in terms of sustainability but their combined effect is relevant from an environmental and social perspective: SMEs account for about 70% of industrial pollution (Cantele et al., 2020; Meng et al., 2018) and about 80%-90% of occupational injuries and fatal accidents (European Agency for Safety and Health at Work, 2009). However, SMEs are not always aware of their impact (Feil et al., 2017) and overall less inclined than larger firms to undertake transformational changes (Mitchell et al., 2020). Besides, they can also differ from larger firms in terms of the importance of managerial values (Sáez-Martínez et al., 2016). The latter is a relevant aspect as the majority of European SMEs are independent (Eurostat, 2018) so that the owner plays a pivotal role towards growth and innovation (Marcati et al., 2008; Ribeiro-Soriano, 2017) and enhancement of sustainability (Chassé and Courrent, 2018).

Previous literature showed that contextual factors can influence the barriers and drivers perceived by industrial decision-makers in charge of the ISMs adoption within the firm (Cagno et al., 2018). Also, the firm's approach towards sustainability issues emerged as a factor able to influence the adoption process (Trianni et al., 2019). Empirical research in different settings of applications is thus necessary not only to understand the main barriers and drivers to the adoption of ISMs, but also to highlight possible differences according to specific characteristics of the context under investigation. Valuable literature contributions have been developed addressing barriers and drivers to the adoption of ISMs,

nonetheless, some issues still exist – see also Trianni et al. (2017b). Specifically, research has not explored yet the importance of sustainability according to a holistic perspective, rather focusing on its specific areas and pillars. Further, studies addressing simultaneously barriers and drivers are lacking. Moreover, the influence of single and multiple contextual factors or of the firm's approach towards sustainability issues on the perceived barriers and drivers is to be discussed yet. The aim of the present study is thus to empirically investigate the main barriers and drivers to the adoption of ISMs, with a specific focus on industrial SMEs. Additionally, the study also aims at exploring how such barriers and drivers are influenced by contextual factors – specifically the firms' size, sector, and country, and by the firms' approach towards sustainability issues.

The remainder of the paper is organized as follows: Section 2 presents a literature review introducing the main aspects analysed in the present research, offering an overview of the main limitations of the extant literature, and developing the research questions of the present study; the methods employed for the empirical investigation are introduced in Section 3, while Section 4 presents the results from the empirical investigation, discussed in the light of the extant literature. In Section 5 we draw conclusions, acknowledging the limitations of the present study, and sketching future research avenues.

2 Literature Review

The section reviews the main concepts investigated in the present work, namely barriers and drivers, contextual factors, and the firm's approach towards sustainability challenges, also highlighting the specific focus of the present research. The main limitations identified in the extant literature are summarized and the research questions are derived.

2.1 Barriers and Drivers

Barriers are factors hampering, delaying, or even blocking an action aimed at enhancing the current firm's performance (Hueske and Guenther, 2021), so that the action can be perceived as burdensome or unprofitable (Tanco et al., 2021), requiring too many organizational changes (De Paiva Duarte, 2015), not strategic and not linked to the core business (Cooremans, 2011). Barriers can originate within the firm or externally (Trianni et al., 2017b). Among external ones, authors acknowledged the relevance of regulatory aspects, as lack of effective legislation (Orji, 2019), lack of incentives and bureaucracy burden (Cannas et al., 2020). Other external barriers might be referred to the lack of adequate external support to firms aimed at enhancing their sustainability performance (Sheoran and Kumar, 2020), or the lack of interest by the external market in sustainable product or processes (Pande and Adil, 2021). Concerning internal barriers, research identified several human-related issues linked

to employees and management (Tanco et al., 2021), in the form of e.g. lack of awareness (Mitchell et al., 2020), lack of competences and skills (Caldera et al., 2019), resistance to change (De Paiva Duarte, 2015). Barriers were also identified at an organizational level (Virmani et al., 2020), as limited resources (Hueske and Guenther, 2021). Other important internal barriers to the adoption of ISMs are related to economic aspects (Álvarez Jaramillo et al., 2019), as high costs and the return of the investment (Bocken and Geradts, 2020).

Along with the barriers, it is necessary to consider and study the drivers that may foster the adoption of an ISM (Sarkis et al., 2010). Previous research addressed drivers either as the opposite of a barrier (Thollander and Ottosson, 2008) or as a means to overcome barriers (Cagno et al., 2017), influencing a portion of the organization and a part of the decision-making process, stimulating the adoption of an ISM (Trianni et al., 2017a). Likewise, drivers can be internal or external (Sarkis et al., 2010). Regarding external ones, external pressures have a central role in fostering the adoption of ISMs and can be exerted by different stakeholders (Trianni et al., 2017a), as communities and partners (Lozano, 2015), institutions and associations (Santini et al., 2013), customers (Kara et al., 2014). Legislation is pivotal as well (Sy, 2014), above all in terms of effective legislation supporting the sustainability transition (Orji, 2019); also the market appears instrumental in fostering the adoption of ISMs, specifically in terms of market opportunities (Küçüksayraç and Kuçksayraç, 2015). Further, the importance of support and collaboration is underlined (Bocken and Geradts, 2020; Caldera et al., 2019). Concerning internal drivers, firms' strategy and values are considered crucial (Fonseca, 2015; Klewitz and Hansen, 2014), along with the firm's image and reputation (Yadav et al., 2018). Also the support from the management is recognized as relevant (Hallstedt et al., 2013). Factors as innovation or technology advance are considered instrumental in fostering the enhancement of sustainability (Grigorescu et al., 2019; Nasiri et al., 2017). Lastly, the economic drivers are highlighted, particularly in terms of cost savings (Lloret, 2016).

2.2 Contextual Factors

Contextual factors can affect the overall strategies of firms (Choudhury, 2016), influencing the adoption of interventions (Sousa and Voss, 2008). As the adoption process of an ISM is influenced by barriers and drivers, contextual factors might affect their perception by industrial decision-makers. The list of possible contextual factors is rather extensive (Masi et al., 2015; Trianni et al., 2020). A first opportunity for a classification allows for the identification of external and internal factors (Löfving et al., 2013): external contextual factors consider the environment in which the firm operates and with which the firm interacts; internal contextual factors are related to the characteristics of the firm. Löfving et al. (2013) provided a list of possible factors, including Macro-environment, Market

and Suppliers in the external factors, and Industry, Size, Ownership, Organizational culture, and Leadership style in internal ones. Sousa and Voss (2008) reconducted the contextual variables considered in previous literature to four main factors, namely National context and culture, Firm size, Strategic context, and Other organizational variables – as, for example, the type of industry. Some of those contextual factors have been largely investigated in previous literature.

The country in which the firm operates relates to its macroenvironment, determining the behavior of a firm (Khanna, 2015). Different countries are associated with political and environmental differences (Hansen and Coenen, 2015). Van Boxstael et al. (2020) and Jehling et al. (2019) conducted a multi-country study underlining the role of different geographies on the energy transition, and Pflitsch and Radinger-Peer (2018) studied the sustainability transition in university from different countries. Additionally, Maletič et al. (2016) highlighted how the country can also influence the level of adoption of practices for the exploitation (incremental improvement) and exploration (innovation) of sustainability in organizations.

The sector can significantly affect the firm's behaviour (Arana-Solares et al., 2019; Marodin et al., 2016), with differences in terms of sustainability reporting across sectors (Al Hawaj and Buallay, 2021; Kumar et al., 2015). The presence of different standards across sectors is shown to influence the behavior towards sustainability (Turcotte et al., 2014), and the focus on specific sectors could surely reduce the research generalizability (Cambra-Fierro and Ruiz-Benítez, 2011).

As for the size, Sousa and Voss (2008) noted that distinguishing between small and large firms is of pivotal relevance. Compared to larger firms, SMEs have limited resource in terms of time, staff, and capital (Tremblay and Badri, 2018). Also, SMEs should be not considered as a whole, but should be addressed separately according to their size (O'Regan and Ghobadian, 2004; Russo and Tencati, 2009) - that is micro, small or medium (European Union, 2003).

2.3 Firm's approach towards sustainability issues

A firm's approach towards sustainability issues could affect its overall sustainable transition (Trianni et al., 2019). In some cases, misalignments and misperceptions between the claimed definition of sustainability and the effective actions undertaken by the firm could appear (May and Stahl, 2017).

In particular, the firm's approach towards sustainability issues can influence the values of the firm, and in turn competencies and capabilities (De Oliveira et al., 2018). The lack of a shared understanding of the concept of sustainability can undermine its successful improvement (Held et al., 2018). Further, research noted that the presence of a specific manager in charge of sustainability could be related to higher financial and sustainability performance and enhancement (Jansson et al., 2017; Velte and Stawinoga, 2020). The presence of a dedicated and specialized manager can influence the

overall firm's approach towards sustainability (Peters et al., 2019), reinforcing commitment and awareness (Thakhathi et al., 2019). Moreover, certifications are usually linked to better performance of the firm (Marshall and Brown, 2003; Pekovic, 2015); nonetheless they alone are insufficient in leading to positive operational outcomes (Abad et al., 2013; Fernández-Muñiz et al., 2012), with research arguing that symbolic adoption could prevent a firm from performing a real internal change (Ferrón Vílchez, 2017).

2.4 Limitations of the extant literature

Valued contributions have empirically investigated barriers and drivers to the adoption of ISMs. Nonetheless, some specific issues still need to be addressed.

First, a large share of the literature is still focusing on specific areas of industrial sustainability, not providing a holistic perspective on it. Within the concept of industrial sustainability, the literature has identified different areas of interest, as Occupational Health and Safety (OHS), Eco-efficiency, and Energy-efficiency (Gimenez et al., 2012; Pagell and Gobeli, 2009). Several relevant contributions address the barriers and drivers to industrial sustainability focusing on one of its areas at a time. The area related to environmental sustainability and green issues is the most addressed one, as also highlighted by Álvarez Jaramillo et al. (2019), and examples can be found in the works of Miras-Rodríguez et al. (2015) and Yin et al. (2020). Other interesting streams are identified with reference to energy efficiency (see e.g., Fleiter et al. (2012) and Thollander et al. (2013)), and to OHS (see e.g., Bonafede et al. (2016) and Tremblay and Badri (2018)).

Second, the limited number of contributions taking a holistic perspective on sustainability do not provide a combined investigation of barriers and drivers, with contributions either limited to the sole identification of barriers (see e.g., Tanco et al. (2021) and Virmani et al. (2020)), or exclusively addressing drivers (see e.g., Böttcher and Müller (2015) and Dicuonzo et al. (2020)).

Third, an overview of the influence on contextual factors is largely lacking (Sharma and Narula, 2020), with scattered examples of studies addressing differences between two countries (Mittal et al., 2013), small vs large enterprises (Russo and Tencati, 2009) or two sectors within the same country (Paolucci and Galetto, 2020). Most of the authors, nonetheless, offered analyses focused exclusively on a single sector or country. As for the sector, examples can be found referring to India (Malek and Desai, 2019), Romania (Costache et al., 2021) or South Africa (Fatoki, 2019); regarding the sector, illustrations can be appreciated in the automotive sector (Virmani et al., 2020) or the fashion industry (Palmaccio et al., 2021). Regarding the size, Balasubramanian (2020) provided some inferences as for the differences between large firms and small and medium ones focusing on barriers and drivers affecting environmental practices. The analysis of the impact of contextual factors on the perception

of barriers and drivers is far from being mature and, particularly, no previous contributions have explored simultaneously multiple contextual factors.

Fourth, to the best of the authors' knowledge, no study has so far investigated the impact of the way sustainability is defined by the firm, the presence of a dedicated manager for sustainability and the certifications held on the perceived barriers and drivers. Such an investigation would nonetheless be fundamental for better frame the overall effort towards sustainability enhancement.

2.5 Research Questions

Following the aforementioned gaps, the present study aims to empirically investigate the main barriers and drivers to the adoption of ISMs. The study specifically focuses on SMEs, given their prominent role is the European economy and in terms of sustainability impacts. Additionally, as contextual factors and the firms' approach towards sustainability issues demonstrated to affect the overall firm strategy, the present study targets also the investigation of their influence on the perceived barriers and drivers. The present study will thus address the following research questions:

- RQ1. What are the main perceived barriers and drivers to the adoption of ISMs in industrial SMEs?
- RQ2. How contextual factors influence the perception of barriers and drivers to the adoption of ISMs in industrial SMEs?
- RQ3. How the firm's approach towards sustainability issues influences the perception of barriers and drivers to the adoption of ISMs in industrial SMEs?

The present research will consider as contextual factors the firms' country, sector, and size. Contextual factors were selected on the basis of the overall recognition of their relevance in affecting the adoption of interventions (Sousa and Voss, 2008). Furthermore, as noted above, research has largely overlooked to discuss their influence when more of them are considered simultaneously. Particularly, taking inspiration from previous literature (Trianni et al. (2019), the size contextual factor aims at contrasting SMEs with more or with less than 50 employees. Also, the present research will analyse barriers and drivers according to the way sustainability is perceived and defined within the firm; the presence of a specific manager in charge of sustainability within the firms; the certifications held (see Section 2.3.).

3 Research Methods

We performed our empirical investigation relying on the conduction of semi-structured interviews complemented with the collections of secondary data. The method is deemed as appropriate for the

conduction of exploratory research (Cooper et al., 2006). We focused our attention on SMEs located in Germany and in Italy and operating in the chemical and metalworking sectors, investigating a total of 26 firms. The overall process followed for the empirical investigation is reported in Figure 1. In the following, details over each specific phase are reported.

Figure 1. Overview of the process followed for the empirical investigation.

3.1 Sampling

Germany and Italy were selected as pivotal economies within the European context (Eurostat, 2020). The two countries present different interesting characteristics for example in terms of R&D Investments (European Commission, 2019b), Industry 4.0 adoption (Deloitte, 2018; Germany Trade & Invest, 2018), and reception and transposition of the SDGs within national legislations and strategic plans (SDSN & IEEP, 2019). The different characteristics could lead to possible interesting different results, and the literature showed a particular interest in the two countries, performing comparisons between them (Centi and Perathoner, 2009; Paolucci and Galetto, 2020). The chemical and metalworking sectors both play a fundamental role in the European economy (European Union, 2017), and are characterized by rather different features (Arrighetti and Ninni, 2012; Paolucci and Galetto, 2020). Main differences can be detected in terms of e.g., consumption of raw materials and energy (Verband der Chemischen Industrie, 2012), technology (Federmeccanica, 2018; Gholami et al., 2020), solutions and priorities for energy efficiency, safety and sustainability (Barthelemy and Agyeman-Budu, 2016; McKim, 2018; Nobrega et al., 2019). The above-mentioned aspects could lead to possible interesting different results for the purpose of the present research.

The investigated sample, built according to a quota sampling (Hibberts et al., 2012), is reported in Table 1. The sample is balanced by looking at both the two different countries (50% German firms; 50% Italian firms) and the two different sectors (54% Metalworking firms; 46% Chemical firms).

Additionally, the sample results rather balanced also in terms of small firms (42%) and medium ones (58%)[1]. In terms of interviewees, the key informants at each firm were selected according to their involvement in the decision-making process and knowledge of sustainability-related aspects, for a total of 29 managers. Most of the interviewees were CEOs (48%), followed by Product/production managers and sales managers (both 10%), and by health safety and environment (HSE), and safety manager (both 7%).

Firm	Sector M: metalworking; C: chemical	Country G: Germany; I: Italy	Size- N° of employees S: small; M: medium	Person interviewed
Firm 1	M	G	M - 160	Safety manager
Firm 2	M	G	S - 35	Production manager
Firm 3	M	G	M - 50	HR manager
Firm 4	M	G	S - 4	CEO
Firm 5	M	G	S - 8	Administrative employee
Firm 6	M	G	S - 5	Sales manager
Firm 7	M	G	M - 148	CEO
Firm 8	C	G	M - 50	CEO
Firm 9	C	G	M - 50	Production manager
Firm 10	C	G	S - 35	Business Development manager
Firm 11	C	G	M - 240	Product manager
Firm 12	C	G	M - 75	CEO
Firm 13	C	G	M - 250	Sales manager
Firm 14	C	I	M - 57	Sales manager; Safety manager
Firm 15	C	I	S - 3	CEO; HSE manager
Firm 16	C	I	M - 60	Technical director
Firm 17	C	I	M - 250	HSE manager
Firm 18	C	I	S - 49	CEO
Firm 19	C	I	M - 65	CEO
Firm 20	M	I	S - 3	CEO
Firm 21	M	I	S - 9	CEO
Firm 22	M	I	S - 32	CEO
Firm 23	M	I	M - 55	CEO
Firm 24	M	I	S - 15	CEO
Firm 25	M	I	M - 50	CEO
Firm 26	M	I	M - 53	CEO; Purchasing and logistics manager

Table 1. The sample investigated. The table reports the details of the firms investigated in terms of Country, Sector, Size, and person interviewed.

3.2 Data collection and analysis

We selected firms from the database "ORBIS" (https://orbis.bvdinfo.com) and contacted them by e-mail or phone call. For those confirming their participation in the research, we collected secondary data from websites and reports in terms of information about the firm's structure, processes, initiatives towards enhanced sustainability.

We carried out the semi-structured interviews with the support of a questionnaire, allowing for the addition of supplementary questions and the collection of free comments emerging during the interview (Adams, 2015). In the first part of the interview, we asked the respondents to briefly introduce their firm – products; the number of employees and turnover; production processes - and we addressed specific questions on sustainability, particularly asking how sustainability was defined,

[1] Based on European Union (2003), we divided in Small (up to 50 employees) and Medium (from 50 up to 250 employees).

perceived, and managed within the firm. In the second part of the interview, we addressed barriers and drivers. We asked interviewees to assess the main barriers hindering and the main drivers fostering the adoption of ISMs in their firms. Each interview lasted on average 1 h. Details of the protocol used for the conduction of the semi-structured interviews and of the different multiple sources of evidence are provided in Appendix A.

The interviews were transcribed and coded. We corroborated the findings from the different sources of evidence – secondary materials, interviews, field notes - allowing for a follow up with a second contact for further clarification in case of misalignments.

A structural coding - suitable for the analysis of semi-structured protocols, was applied (Saldana, 2009). In a first phase, we conducted a line-by-line coding with the merging of codes from the interviews' analysis. In this phase, we identified quotes related to the codes in the interviews; the concepts were held as much as possible as conveyed and articulated by the informants (Silva et al., 2018). In a second phase, we verified the opportunity to aggregate the emerged codes. More in detail, we considered the possibility of merging them, based on associations, similarities, and overlapping, modifying their names (Silva et al., 2018) and reducing their number (Caldera et al., 2019). For the codes emerged in the first phase and related to general information and firm's approach towards sustainability issues, we aggregated by referring to the different sections of the semi-structured interview's protocol (see Appendix A) and on aspects emerged as relevant in previous research - see Cagno et al. (2019) and Neri et al. (2021). As for the codes emerged if the first phase and related to barriers and drivers, we performed the aggregation by reorganizing them based on the models of Trianni et al. (2017) and Neri et al. (2018). We selected the two models for barriers and drivers respectively as i) recent literature appreciated the integrated and balanced approach provided by the two models towards sustainability (Bastas and Liyanage, 2019; Orji, 2019); ii) they address industrial sustainability, while many other valuable recent contributions focus on sustainable manufacturing or corporate sustainability (Bocken and Geradts, 2020; Pathak et al., 2021); iii) they are theoretically developed based on an extensive literature review and empirically validated different contexts in terms of firm's size and sectors, while many other valuable recent contributions focus on specific contextual factors (De Paiva Duarte, 2015; Sharma and Narula, 2020); and iv) they were validated also as for their capacity to represent barriers and drivers to industrial sustainability and the avoidance of overlap among the proposed barriers and drivers. The two models are reported in Table 2 and Table 3. Table 4 reports selected examples of how the different barriers and drivers were addressed by interviewees – Code (Phase 1), were coded in analysis according to the ones of the two models – Code (Phase 2); complete details are available in Appendix B. An example of the overall performed coding, with also the identification of sub-categories, categories, and themes, is reported in Appendix

C. The barriers and drivers emerging from the investigation and named based on the two models, have been analysed according to their frequency and reported using graphs supplemented by illustrative quotations, in line with the suggestions of Adams (2015).

Origin	Category	Barrier
External	Regulatory	Legal requirements
		Bureaucracy
		Lack of incentives
		Policy distortion
	Support	Lack of external technical support
		Lack of consultancy
	Market	Customer not ready /Lack of demand
		Uncertainty of future trend
		Distortion of price
Internal	Organization	Lack of time
		Lack of staff
		Resistance to change/Inertia
		Attitude/ Other priorities
		Communication
		Workplace and task
		Organizational system
	Management behaviour	Commitment/ Awareness
		Expertise
	Workers behaviour	Not trained/ skilled
		Awareness
		Not involved
		Incorrect behaviour
	Information	Lack of information
		Trustworthiness of information
	Technology/ Service	Lock in
	Economic	Limited access to capital
		Hidden costs
		Risk
		Investment cost
		Pay-back time

Table 2. The model of barriers to the adoption of industrial sustainability measures. Adopted from Trianni et al. (2017).

Origin	Category	Driver
External	Regulatory	Compliance with regulation
		Regulatory sanctions and taxes
	Support	External funding
		Public subsidies
		Cooperation and network with other companies
		Support from industrial associations
		Support from consultants
		Support from government
	External Pressures	Customers' pressures
		Communities' pressures
		Partners' pressures
		Shareholders' pressures
		Competitors' actions
		Public opinion
	Market	Increase of market share and sales growth
		New market opportunities
		Increasing in resources price
		Creating competitive advantage
		Resources scarcity
Internal	Organization	Improving firm brand and image
		Improvement of sustainability related performance
		Anticipation of regulatory changes
		Organizational values and culture
		Past experiences in sustainability and knowledge of business case
		Including Sustainability at a strategic level
		Adoption of certifications/ management systems
		Voluntary agreements

	Staff	Management commitment
		Employee commitment
		Training and education
	Information	Dialogue and encouragement
		Trustworthiness, clarity and availability of information
	Innovation	Product innovation
		Technology innovation
		Quality
		Greater efficiency in processes
	Economic	Cost savings
		Increasing incomes

308 **Table 3. The model of drivers to the adoption of industrial sustainability measures.** Adopted from Neri et al. (2018)

	Code (Phase 2)	Code (Phase 1)
Barriers	Bureaucracy	"Too much ***bureaucracy***, it is a major issue" "From a ***legislation perspective, there is no difference***. But we are not comparable to a multinational enterprise, and we clash with the ***bureaucracy*** that for us is extremely heavy we need to spend a million of € just in ***paperwork***"
	Customer not ready / Lack of demand	"Sure, we can suggest products, but customers have to try them out and ***customers have far too little time or interest or motivation***"
	Lack of time	"The ***time*** is of course a large factor" "We face a mix of internal barriers as ***lack of time*** and staff"
	Lack of staff	"Organizational barriers are the ones that weigh the most, we do not have the ***staff*** to implement sustainability" "Definitely the lack of ***staff,*** because we are a small company […] in any case we do not have all the ***resources*** to be able to implement all the points of the development goals"
	Commitment/ Awareness (Management)	"Also the ***mindset of the firm*** needs to change a bit, the ***management*** is missing it" "First of all, the ***manager has to believe*** it"
	Expertise (Management)	"Many ***entrepreneurs don't know***"
	Awareness (Employees)	"Another barrier is internal since sustainability is ***not perceived by employees***" "I think it's just the lack of internal rules that govern employees' behaviour. Of course, this must be accompanied by a ***sense of sustainability among all employees***, otherwise, the internal rules may not be respected or strongly felt part of the regulation"
	Incorrect behaviour (Employees)	"I think it's just the ***lack of internal rules that govern employees' behaviour.*** Of course, this must be accompanied by a sense of sustainability among all employees, otherwise, the internal rules may not be respected or strongly felt part of the regulation"
	Lock in	"Sustainability is always difficult and there are ***technical limits***"
	Limited access to capital	"Certainly, the ***resources available to the company,*** because sustainability policies are more feasible in structured companies" "It is necessary to have the ***economic possibility*** of being able to dedicate resources to be able to implement aspects of sustainability"
	Investment cost	"The implementation represents a ***cost*** to the company" "As main barriers, I perceived the ***costs*** and the return of the investment in the long period"
	Pay-back time	"As main barriers, I perceived the costs and the ***return of the investment in the long period***"
Drivers	Compliance with regulation	"The first driver is related to the ***regulation***; our activity is strongly regulated" "We must be compliant with a series of ***laws that intrinsically require sustainability***"
	Regulatory sanctions and taxes	"We have an energy manager […] they are not a cost because there is attention to the aspects for which you pay ***penalties*** [if you do not pay attention at]" "For example, we rebuilt the roof in 2009, because it was made of Eternit and the law requires it to be disposed of also to avoid ***penalties***"
	External funding	"In Italy, there are a lot of calls and competitions that can help you get ***facilitations***"
	Public subsidies	"***Tax incentives*** for sure, but also long-term savings" "On the other hand, as regards the ***tax advantages***, I think that the hyper-amortization is very useful"
	Customers' pressures	"Generally, there are ***customers who value*** it and demand that we do something in this direction" "Another important driver is the ***requests from the customer***, that foster investment"
	Partners' pressures	"***Partners*** are important, as they can foster innovation"
	Shareholders' pressures	"There is an overall increasing ***general sustainability concern***" "I think that's a driver is the ***stakeholders' well-being*** in the long term"
	Creating competitive advantage	"Furthermore, sustainability can guarantee a ***competitive advantage*** on the market due to competitive strategies in economic, social and environmental terms" "Sustainability makes us enter the ***championship of companies***, then whether we win it or not depends on us, but if it wasn't there, we wouldn't be in the championship"
	Improving firm brand and image	"As a chemical company, we are of course subject to the public eye, and want to constantly ***improve our image***" "I think the main drivers are the competitive advantage that aspects of sustainability can give you in terms [...] of the ***image*** towards all customers attentive to these issues"
	Organizational values and culture	"Already ***the company itself*** is a driver" "I think that all the actions taken in this direction are things that ***the company does for itself*** first of all"

	Including Sustainability at a strategic level	"Sustainability is one of the first ***fundamental requirements for the development*** of an Italian company" "We do not have a widespread definition no, but there is attention as for sustainability issues in decisions and investments that impact the ***strategy in the long term***"
	Management commitment	"It is driven by ***the management level***"
	Employee commitment	"It is also a concern of the management and we, for example, instruments such as meetings that are held regularly, where the ***wishes and ideas of employees are also incorporated*** into corporate management"
	Cost savings	"I think the main drivers are the competitive advantage that aspects of sustainability can give you in terms ***economic advantages***, such as a ***cost reduction***" "Tax incentives for sure, but also ***long-term savings***"

Table 4. Selected examples of the link between the different barriers and drivers as addressed by interviewees – Code (Phase 1), and as coded in the analysis - Code (Phase 2). The table reports only the barriers and drivers emerged from the empirical analysis.

4 Results and Discussion-

The present section reports and discusses the results from the empirical investigation over barriers and drivers. Firstly, we have investigated the whole sample. Secondly, we have reported the results according to a specific contextual factor, namely: sector, country, size. Thirdly, we have offered a preliminary analysis considering multiple contextual factors at the same time. Fourthly, we have explored whether the firm's approach towards sustainability issues affects barriers and drivers.

4.1 Analysis of the total sample

4.1.1 Barriers to sustainability

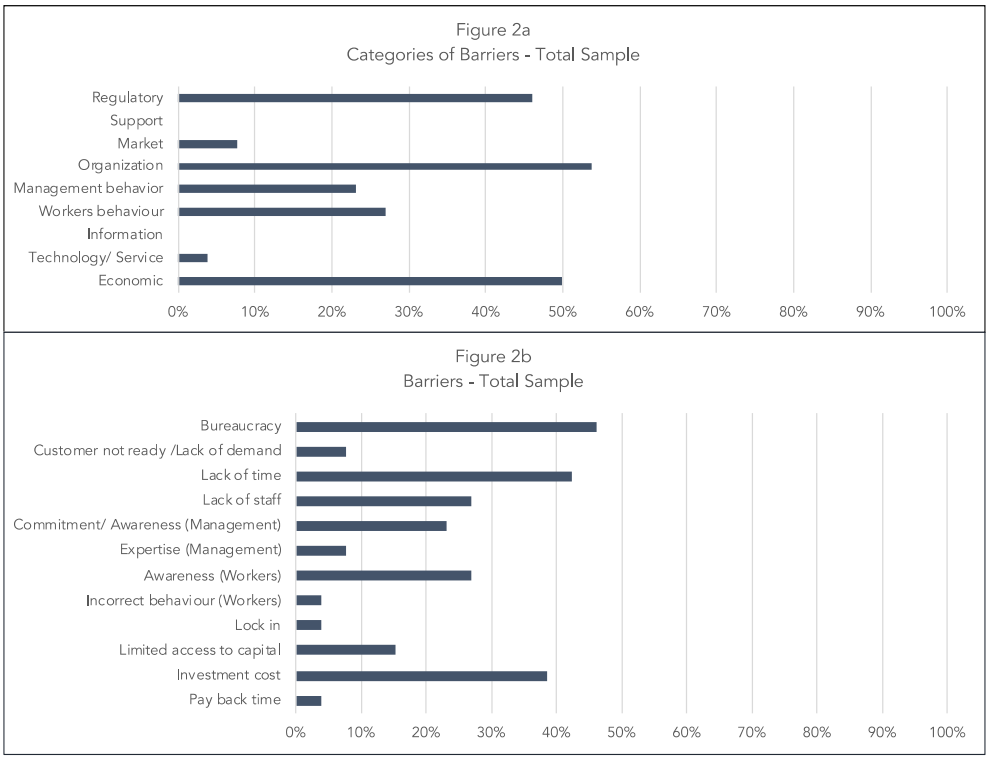
Organization, *Economic* and *Regulatory* barriers emerge as the main categories from the analysis of the total sample (Figure 2a), in line with Costache et al. (2021) and Sharma and Narula (2020). Besides, *Workers behaviour* and *Management behaviour* are deemed as important. These two categories consider several barriers related to commitment, expertise, and awareness. The relevance of these categories has been previously highlighted by Cagno et al. (2018), and more recently supported by Cantele et al. (2020). Interestingly, none of the investigated firms considered barriers related to *Information* and *Support.* The two categories of barriers are seldom in the extant literature but are included e.g., in categories related to culture (De Paiva Duarte, 2015) or legislative support (AlSanad, 2018) – thus excluding technical support. Nonetheless, the two categories are not considered among the pivotal ones in the literature addressing our geographical areas (Miras-Rodríguez et al., 2015; Trianni et al., 2017b), whereas they result moderately relevant in different countries as China (Orji, 2019), Pakistan (Mahmood et al., 2019), India (Virmani et al., 2020) or South East Asia (Majumdar and Sinha, 2019). Contextual factors and the specific context of application may thus influence this specific result. As for technical support, the low relevance of this technical barrier may show three different situations: i) companies still find themselves in an

awareness phase of the decision-making process (Cagno et al., 2015); ii) new technologies might involve disruptive changes difficult to justify within the context of normal practices of a manufacturing firm (Satterfield et al., 2009); or iii) companies are already oriented in a transition towards more sustainable production methods (Kircherr et al., 2017).

Looking at specific barriers hindering the adoption of ISMs (Figure 2b), *Economic* aspects are mainly related to *Investment cost*, followed by *Limited access to capital*. This result, in line with Cantele et al. (2020), Orji (2019) and Tanco et al. (2021), confirms the presence of a trade-off between a short- and a long-term perspective, according to which ISMs are not implemented as perceived too burdensome from an economic perspective, as already showed for specific areas of industrial sustainability (Cherniack and Lahiri, 2010; Vieira and Amaral, 2015; Walsh and Thornley, 2012). This specific aspect seems to hold for Firm G, whose CEO noted: *"generally, in a medium-sized company as we are, you should not assume that we made something from pure altruism […] In larger firms perhaps things are done purely for image […] It's more like, something* [here] *is implemented if it is feasible from an economic perspective."*

As for the *Organization* aspects, a relevant role is played by *Lack of time* and *Lack of staff*. The result finds confirmation in very recent literature addressing sustainability (Costache et al., 2021), and in the literature of two important areas of industrial sustainability such as OHS and Energy-efficiency (Cooremans, 2011; Masi and Cagno, 2015). Further, we noted that in the vast majority of firms the perception of *Lack of time* and *Lack of staff* barriers with *Bureaucracy* barrier is the same. Examples can be found in Firm 4 and Firm 8. Firm 4's CEO highlighted that to deal with bureaucracy with a specific reference to maintenance, "*every year I have to hire a person for doing the paperwork, it is too much for me*"; on the other hand, Firm's 8 CEO stressed that bureaucracy related to possible research projects "*are associated with a high number of forms […] this is very time-consuming*". Earlier research found that *Bureaucracy*-related issues reflect within the firms as problems related to the lack of staff and time (Trianni et al., 2017b). Lastly, the relevance of barriers as *Awareness* of workers and management has been largely recognized in the literature (Chowdhury et al., 2015; De Paiva Duarte, 2015; Orji, 2019).

Figure 2. Barriers - Total sample. Categories of barriers (Figure 2a) and barriers (Figure 2b) perceived by the total sample. The bars indicate the percentage of firms perceiving the category or the barrier over the total number of firms of the total sample.



4.1.2 Drivers to sustainability

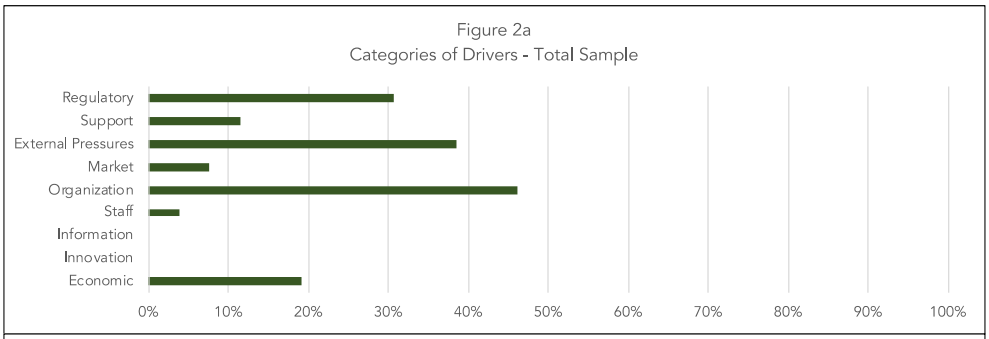
Organization, *External pressures*, and *Regulatory* represent the major categories of drivers identified in the sample (Figure 3a), in line with Orji (2019), Sharma and Narula (2020) and Sáez-Martínez et al. (2016). *Information* and *Innovation* categories were not acknowledged as important by the sample, in line with earlier literature addressing the same geographical scope (Miras-Rodríguez et al., 2015; Wagner and Llerena, 2008).

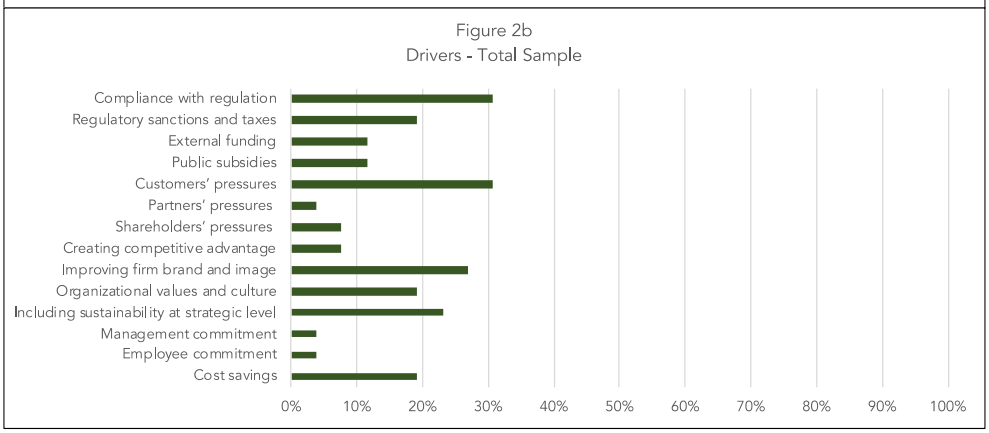
Compliance with regulation, Customer's pressures, *Improving firm brand and image*, and *Including sustainability at a strategic level* emerged as the most relevant drivers (Figure 3b), confirming findings from Mittal and Sangwan (2015), Panwar et al. (2017) and Sáez-Martínez et al. (2016). Likewise, previous authors acknowledged the importance of external pressures from customers for fostering the adoption of ISMs within firms (Bhanot et al., 2015; Fatoki, 2019). Also *Improving firm brand and image* is supported by the literature (Küçüksayraç and Kuçksayraç, 2015; Panwar et al., 2017), and has been related by Neri et al. (2018) with the organizational level and the culture, recognized as fundamental by Sáez-Martínez et al. (2016). Firm 15 offers a valuable example of how the abovementioned drivers contribute together towards enhanced sustainability. According to Firm 15 "*the legislation is very important, with specific sector description* [chemical manufacturing]", but also as they "*foster innovation*". Also, they aim "*to give to our firm the image of a safe firm, this is very important […] the management wants to provide this image and to constantly improve*".

According to the investigated sample, *Cost savings* is deemed relevant, supporting Cantele et al. (2020) and Miras-Rodríguez et al. (2015). Leveraging on Abdul-Rashid et al. (2017) and Panwar et al. (2017) the relevance of *Cost savings* could be related to reputational and competitiveness gains - see also (Fatoki, 2019; Neri et al., 2018). Our results however differ from previous research conducted in developing economies, such as Pakistan (Mahmood et al., 2019) or Bangladesh (Chowdhury et al., 2015).

All in all, drivers are still mainly related to external market and competitiveness, or compliance with regulation, as also supported by Alayón et al. (2017). Our results differ from previous research investigating two high emitting sectors in Switzerland and Norway (Littlewood et al., 2018). A possible explanation for such difference may be found in the sample of Littlewood et al. (2018), composed of larger companies with a specific structure for sustainability management. Previous research demonstrated that top management attitude may be a powerful driver towards the adoption of a proactive sustainability strategy (Genç and Di Benedetto, 2019). A proactive sustainability strategy is focused on activities as prevention and redesign of production processes (Kim, 2018), actively seeking opportunities to invest in sustainability (Park and Kim, 2016). A proactive strategy requires the development of internal capabilities and the availability of resources (Kim, 2018). Littlewood et al. (2018) recognized an overall proactive strategy of the sample they investigated, clearly stating that customers' aspects do not substantially affect firms' behaviour. Differently, our sample seems to be driven by customers' demand, cost saving and compliance with the regulation. All these drivers are associated with a reactive strategy (Kim, 2018; Park and Kim, 2016) and recognized to foster sustainability activities at a minimum level (Baah et al., 2020). Confirming a reactive approach, our investigated firms did not deem *Innovation* as a main category of drivers. In this regard, recent studies are pointing out that the adoption of innovative Industry 4.0 solutions can boost sustainability performance (Bonilla et al., 2018; Luthra et al., 2020; Stock et al., 2018).

Figure 3. Drivers - Total sample. Categories of drivers (Figure 3a) and drivers (Figure 3b) perceived by the total sample. The bars indicate the percentage of firms perceiving the category or the driver over the total number of firms of the total sample.





Both the results for barriers and drivers look aligned with previous researches concerning both overall sustainability and specific areas of industrial sustainability (Sáez-Martínez et al., 2016; Sharma and Narula, 2020); nonetheless, differences can be also appreciated, particularly when comparing our results with earlier findings across different contextual factors, as (Mahmood et al., 2019; Majumdar and Sinha, 2019; Orji, 2019). In conclusion, our investigated sample seems to take a quite reactive towards sustainability, with large organizational and economic barriers (Satterfield et al., 2009) and firms still in an awareness phase (Cagno et al., 2015). Also, major drivers are external and firms do not seem to yet exploit the benefits stemming from a proactive long-term holistic perspective on industrial sustainability (Cagno et al., 2019, 2018; Wijethilake, 2017).

4.2 Analysis according to contextual factors

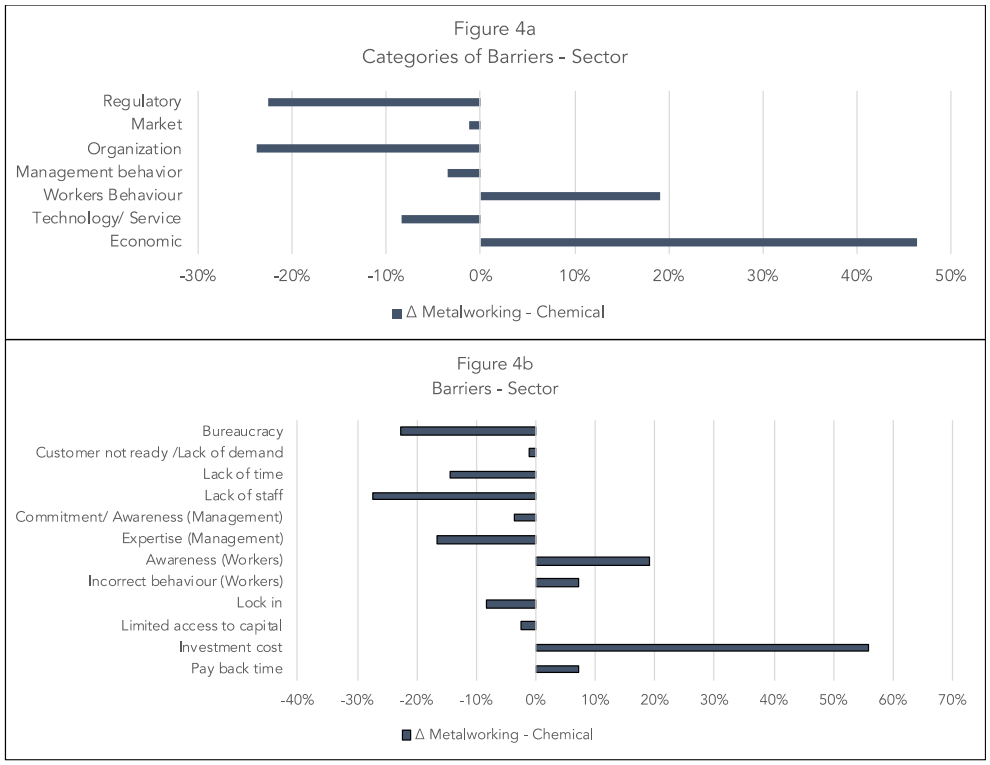
4.2.1 Analysis by sector

In general terms (Figure 4a), the sampled metalworking firms perceived a heavier impact of *Economic* barriers. As Firm 21 commented, "*barriers are mainly related to costs associated with the installation and implementation of more sustainable solutions*". The result is in line with several empirical analyses conducted in the metalworking sector worldwide, with a specific focus on energy efficiency and environmental aspects (Cagno and Trianni, 2014; Rohdin et al., 2007). However, differently from such studies, technical barriers do not appear quite crucial for sampled firms. Nonetheless, previous research argues that technical barriers are not quite relevant in the awareness phase of the decision-

making process, whereas economic and organizational aspects are pivotal (Cagno et al., 2015). This finding might indicate that sampled metalworking firms are still in an early stage of the adoption of ISMs. Investigated chemical firms instead seem to highlight more *Regulatory* and *Organization* barriers, supporting (Hall and Howe, 2010), also considering that the chemical sector is characterized by the REACH legislation (European Commission, 2007), deemed rather burdensome (Guillén-Gosalbez et al., 2009), as noted by Firm 19's CEO: "*Since the advent of REACH, there are people working only on paperwork and people that actually work on the production […] the cost of compliance is doubled and deadly*".

When looking at specific barriers (Figure 4b), *Economic* aspects in the metalworking sector seem related to *Investment cost* barrier, whose value is particularly high also compared to the total sample, as noted by previous research on barriers to industrial energy efficiency solutions (Ahmad et al., 2020; Soepardi et al., 2018). *Regulatory* issues hindering the adoption of ISMs seem to be mainly related to *Bureaucracy*, and this may confirm a different regulatory burden between the two sectors (Centi and Perathoner, 2009; European Commission, 2009). Also, a strong relationship between *Bureaucracy* and *Lack of staff* (Trianni et al., 2017b) may support the relevance of the latter for the chemical sector, as Firm 14's CEO has confirmed: "*The REACH is easier to be respected by multinational enterprises, that have resources and employees to dedicate to it*". Finally, *Workers awareness* in the metalworking sector emerges as particularly relevant, in line with the previous results by Brunke et al. (2014) and Lee (2015) for environmental sustainability aspects. According to the respondent of Firm 3: "*The conviction of the employees is a very big issue; nonetheless, it should not hold us back, because nothing* [no improvements] *comes from nothing*".

Figure 4. Barriers - Sector. Categories of barriers (Figure 4a) and barriers (Figure 4b) perceived by the different sectors. The bars report the difference between Metalworking and Chemical firms in terms of the percentage of firms perceiving the category or the barrier over the total number of firms in the specific cluster.

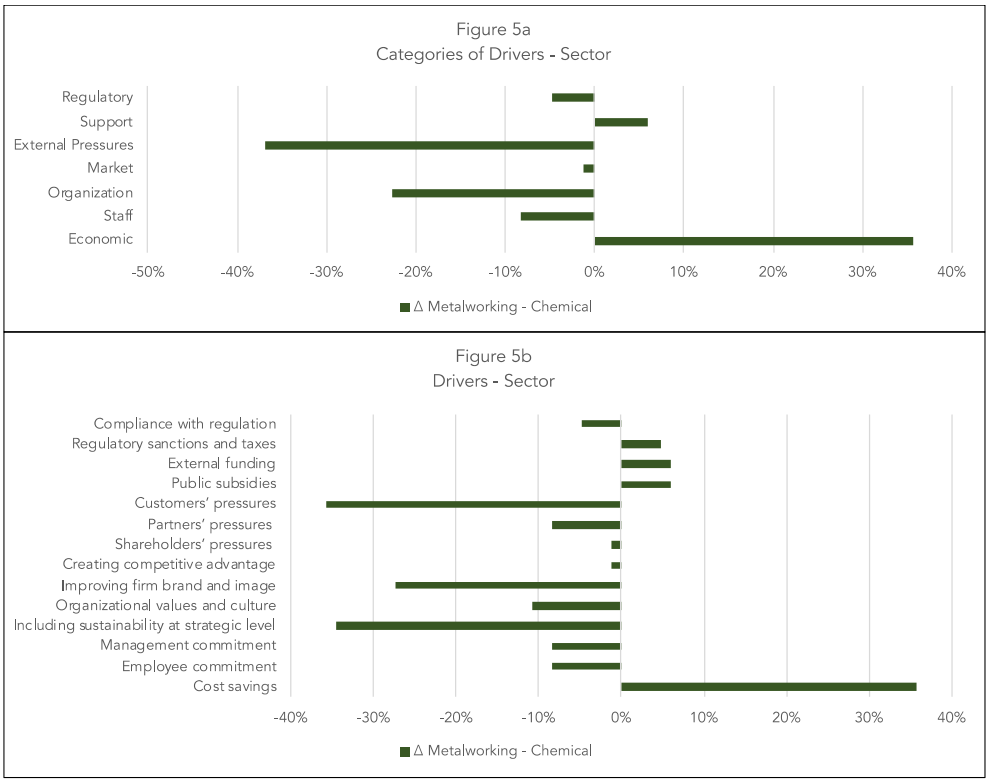


In terms of categories, *Economic* drivers represent an important category for the sampled metalworking firms (Figure 5a) (Cagno et al., 2015). The chemical sampled companies rather highlighted *Organization* and *External pressures* (EY, 2020) followed by *Regulatory* drivers (Guillén-Gosalbez et al., 2009), whilst interestingly no firm reported *Economic* drivers among the most relevant ones.

By looking at specific drivers (Figure 5b), for the metalworking sector *Cost savings* are deemed to significantly contribute to *Economic* drivers, similar to previous research (Ahmad et al., 2020; Thollander et al., 2013). As observed by Firm 25's CEO: "*One of the main drivers for sustainability is related to the competitive advantages that sustainability can bring in terms of economic aspect and specifically in terms of cost reduction*". Firm 22's CEO further deepened such considerations by claiming that investment for increased sustainability "*should not be seen as a cost, rather an opportunity*", as they can be easily paid back thanks to the cost-savings generated. For the chemical sector sampled firms, *External pressures* are mainly related to the *Customers' pressures* - not only in "business to customers" but also in "business to business" terms (CEFIC, 2017), in line with recent industrial research (EY, 2020). The specific aspect emerged from our interviews: "*Many customers are nowadays appreciating and valuing more sustainable process and environmental certifications*" (Firm 8's CEO) and "*A main driver is for sure the last part of the market*" (Firm 19's CEO). The other most perceived drivers in the chemical sampled firms are *Improving firm brand and image* and *Including sustainability at a strategic level*: according to Lozano (2015) and Neri et al. (2018), these two drivers present a strong connection with *Customers' pressures* and might lead to improved profits

(Orji, 2019). The two drivers are essential for Firm 12, whose CEO stated the main enabler for sustainability is "*the firm itself, and the image of the firm that is perceived from the outside* […] *The overall approach towards sustainability is something coming from the above of the firm*".

Figure 5. Drivers - Sector. Categories of drivers (Figure 5a) and drivers (Figure 5b) perceived by the different sectors. The bars report the difference between Metalworking and Chemical firms in terms of the percentage of firms perceiving the category or the driver over the total number of firms in the specific cluster.



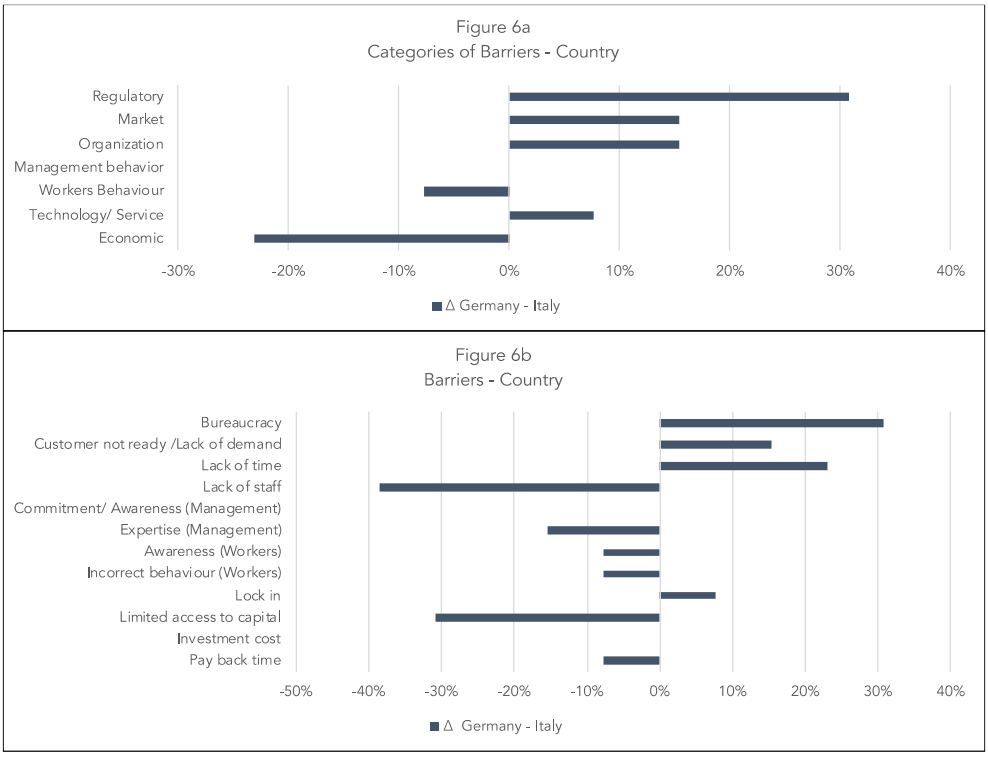
4.2.2 Analysis by country

When looking at categories of barriers by country (Figure 6a), Italian sampled firms appear to struggle more with *Economic* barriers (Cagno et al., 2017), whilst German ones with *Regulatory* and *Organization* issues, confirming previous research (Held et al., 2018; Mittal et al., 2013). Additionally, *Market* barriers are perceived in our sample only by German firms. Although the sample here is limited and further investigation is needed, the result looks aligned to previous works (Schmidt and Osebold, 2017).

Regarding detailed barriers (Figure 6b), sustainability efforts in sampled Italian firms are specifically hindered by *Limited access to capital*, whilst this has not been acknowledged for German ones (Cagno and Trianni, 2014). Further, respondents from Italian investigated firms highlighted *Incorrect behaviour* of workers – e.g., Firm's 14 Sales Manager interestingly highlighted this issue: "*As for the employees it really depends, there are those that are more proactive and have a sense of belonging with the firms, and there are the others…"* – supporting earlier findings from Cagno et al. (2018) for

specific areas of sustainability such as OHS. On the contrary, *Lack of time* has been more largely perceived as a barrier by German firms – supported by Schleich (2009) for Energy-efficiency efforts – versus a higher perception of *Lack of staff* in Italian companies, as noted by Masi and Cagno (2015) for OHS. Finally, it is worth mentioning that German companies perceive *Bureaucracy* as a major hurdle compared to Italian ones. Our findings differ from previous research conducted in Italy for specific areas of sustainability, where the high level of bureaucracy was deemed to be a relevant barrier (Masi and Cagno, 2015; Trianni et al., 2017b). Nonetheless, as from the interview conducted bureaucracy appeared as a pivotal issue for German firms: as the Business Development Manager of Firm 10 stated, "*You can, of course, complain about bureaucracy, there are obstacles, but you have to face them. Yes, we have bureaucracy in Germany*".

Figure 6. Barriers - Country. Categories of barriers (Figure 6a) and barriers (Figure 6b) perceived by the different countries. The bars report the difference between German and Italian firms in terms of the percentage of firms perceiving the category or the barrier over the total number of firms in the specific cluster.

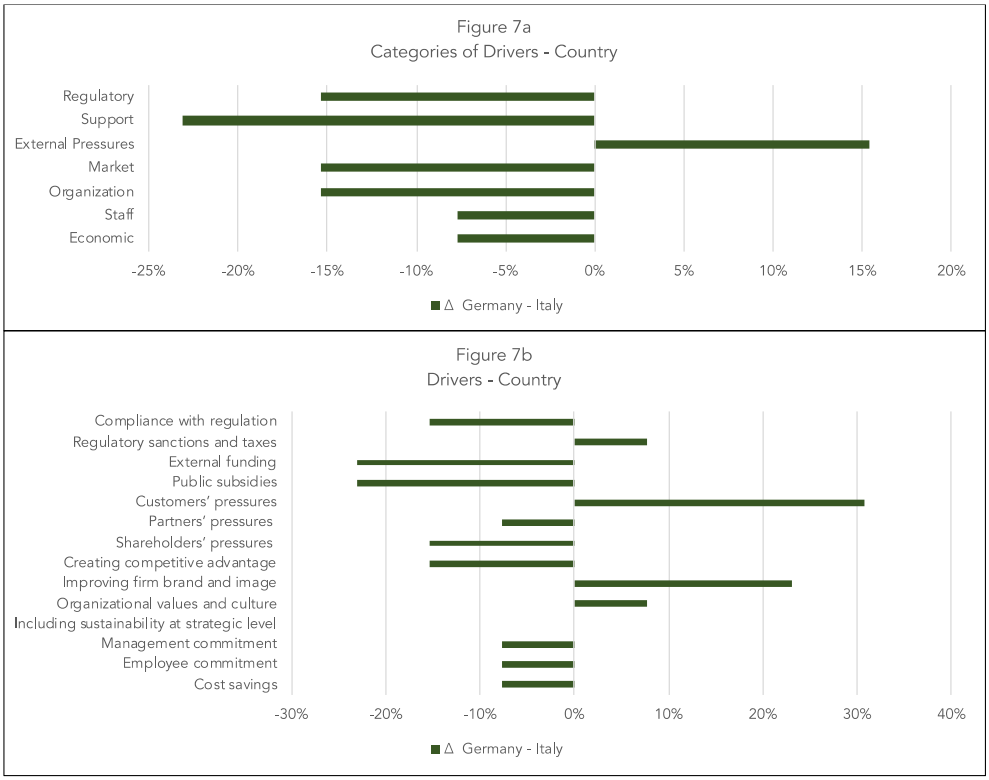


Italian sampled companies reported a higher relevance of all categories of drivers (Figure 7a) than German ones except for *External pressures* (Held et al., 2018).

In terms of specific drivers (Figure 7b), we can interestingly note a difference. German firms seem to identify a quite limited set of drivers. *Customers' pressures* and *Improving firm brand and image* seem to play a more relevant role, and are strongly related to competitiveness (Neri et al., 2018), one of the main forces driving German firms towards sustainability (Böttcher and Müller, 2015; Mittal et al., 2013; Schmidt and Osebold, 2017). Examples can be found in Firm 2 according to which "*there*

are customers that value it [sustainability] *and demand that we do something in this direction, and we expect this type of demand to constantly increase in the future*", or in Firm 7 as "*customers are increasingly demanding that certain environmental parameters are adhered to*". Rather, Italian firms seem to point out a suite of drivers. However, the largest perceived drivers are *Compliance with regulation* and *External findings and subsidies* (Cagno et al., 2017). Crucial examples are the installation of solar panels in Firm 21 and Firm 26, as both recognized the presence of incentives and external economic support: as the former, within the context of the roof removal, they "*took advantage of the situation and of the available incentives […] at that time there were still incentives*", the latter installed the panels in the year "*2012, when incentives were the highest*".

Figure 7. Drivers - Country. Categories of drivers (Figure 7a) and drivers (Figure 7b) perceived by the different countries. The bars report the difference between German and Italian firms in terms of the percentage of firms perceiving the category or the driver over the total number of firms in the specific cluster.



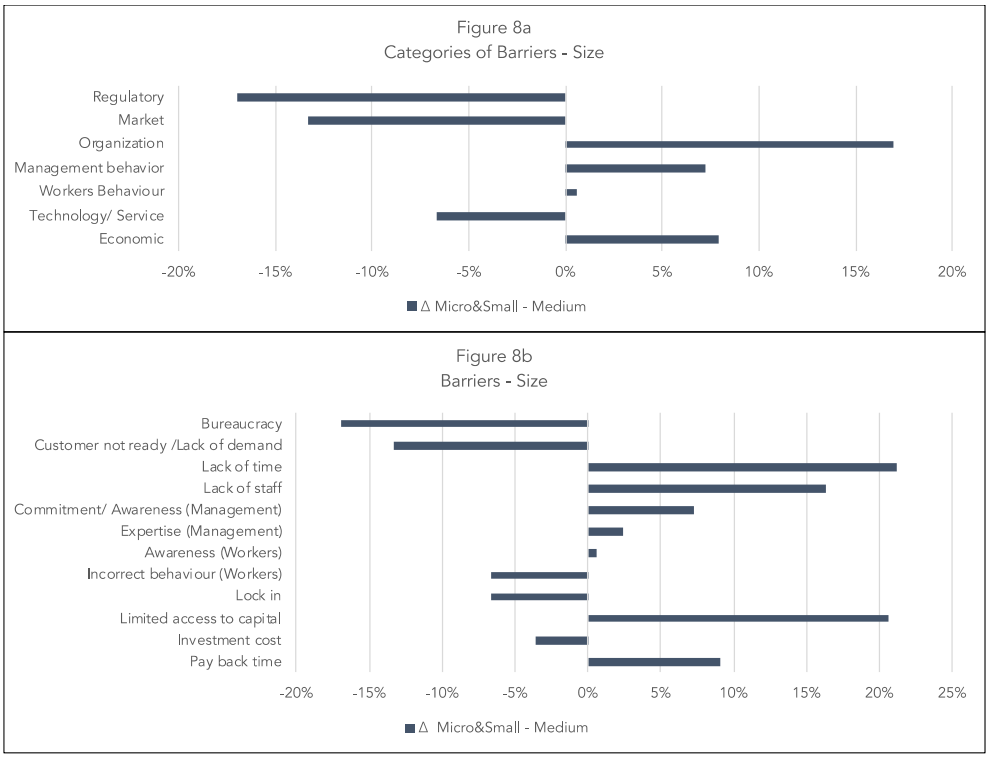
The country thus appears to be a strong contextual factor influencing the perceived barriers and drivers, in terms of both types and intensity. As discussed in Section 2.2, different countries are associated with differences in terms of both regulations and environmental aspects (Hansen and Coenen, 2015). Regulations and policies are a crucial aspect for any transition (Kemp and Never, 2017), included the sustainable one (Rosemberg, 2015): the different current legislation in Germany and Italy could have possibly represented a main determinant for the differences in the results obtained. Indeed, although both steadily moving towards the meet of the goals (SDSN & IEEP, 2019),

Germany had already adopted a "National Sustainable Development Strategy" in 2002, while Italy started the process only in 2017. Additionally, the two countries are characterized by a decentralized regional environmental policy responsibility (Nesbit et al., 2019). The present study has not investigated the specific current regulation in the two countries and their regions, and further research are necessary to determine the extent to which the barriers emerged according to the country are related to regulations or environmental aspect.

4.2.3 Analysis by firm size

By considering categories of barriers (Figure 8a), notably sampled medium-sized firms seem to present a higher relevance of *Market* and *Technology/Service* barriers: interestingly, market issues were previously discussed by Russo and Tencati (2009) for which medium-sized firms usually represent central tiers of supply chains, holding a strong relationship within their operating market; technological issues were noted by Bonafede et al. (2016) addressing barriers and drivers to OHS.
Looking at specific barriers (Figure 8b), small-sized firms seem to suffer more from *Limited access to capital* barrier, as observed by Russo and Tencati (2009). Furthermore, as for *Organization* related barriers, sampled small-sized firms perceive a higher impact of *Lack of staff* and *Lack of time*, in line with the result by Mahmood et al. (2019) and Henriques and Catarino (2015). According to Firm 18's CEO, the main barriers to the adoption of ISMs rely on the limited resource availability of the firm: *"structured firms have more resources available, and each of their workers can deal with and be in charge of a specific aspect*". Lastly, the results of our analysis show that *Bureaucracy* seems to represent a larger issue for medium-sized firms, as Firm 17 note: "*the barriers entail a dystonia between the firm's needs and the public administration issues*". Similarly, Firm 15's Technical Director bluntly conveyed his message: "*the bureaucracy is crashing me […] the bureaucracy is crazy*".

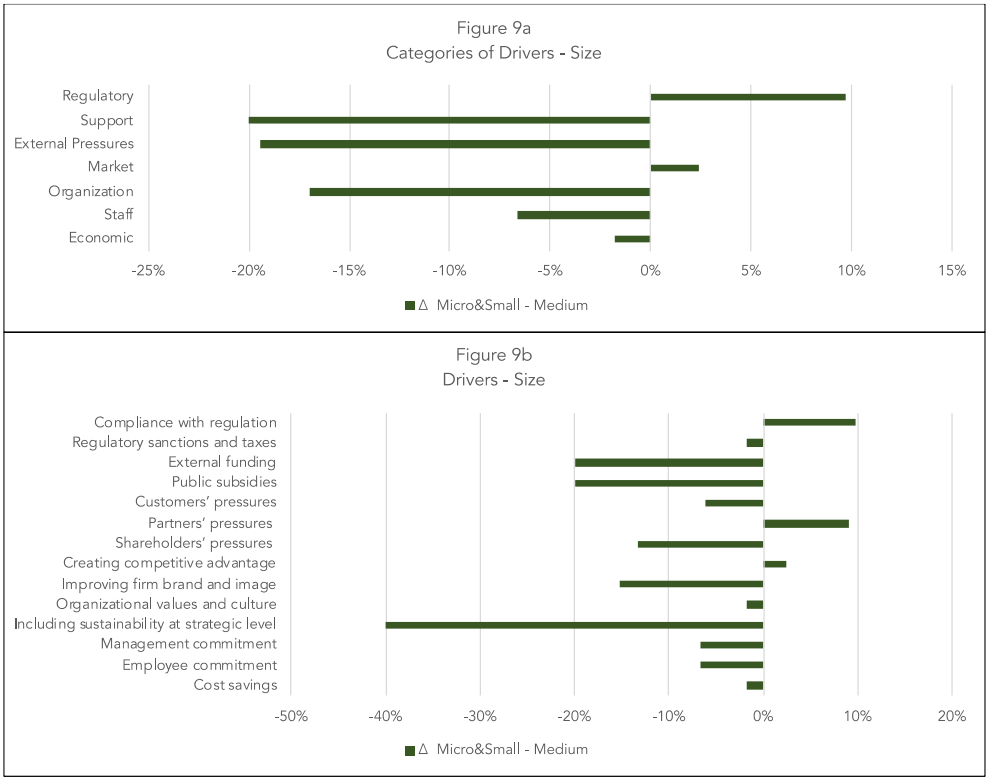
Figure 8. Barriers - Size. Categories of barriers (Figure 8a) and barriers (Figure 8b) perceived by the different sizes. The bars report the difference between Small and Medium-sized firms in terms of the percentage of firms perceiving the category or the barrier over the total number of firms in the specific cluster.



Concerning drivers by categories (Figure 9a), sampled medium-sized firms tend to perceive higher *Organization* and *External pressures* than small-sized firms. Whilst the importance of *External pressures* was noted by previous research (Cantele et al., 2020; Russo and Tencati, 2009), no correspondence was found in previous literature for organisational drivers. However, more considerations can be drawn by looking at the specific corresponding drivers, as the results share some points with Sáez-Martínez et al. (2016), according to whom larger firms are more focused on internal drivers. Additionally, sampled medium-sized companies consider *Support* as relevant, which has not been mentioned by small-sized firms that, on the other hand, note a higher relevance of *Regulatory* drivers. Whilst the former result finds confirmation in Sáez-Martínez et al. (2016) and Micheli et al. (2018), the latter is somewhat not supported.

When considering specific drivers (Figure 9b), it is noteworthy mentioning the importance of *Including sustainability at a strategic level*, highlighted exclusively by medium-sized firms, corroborating (Condon, 2004). As Firm 11's Product Manager stated, "*sustainability can be implemented only if internally driven*". The result may also support the motivation for higher relevance of *Organization* drivers in medium-sized firms. Instead, the main relevant drivers for sampled small-sized firms seem *Compliance with regulation* and *Customers' pressures*. We did not find correspondence of these drivers in the literature, but they could reflect a rather reactive strategy of small-sized firms towards sustainability (Alayón et al., 2017; Park and Kim, 2016). Customers' pressures hold particularly for Firm 22: "*We have a strong sustainability sensitivity within our firm, and we are also lucky to produce products for the sports sector, where the sensitivity is high as well*".

Figure 9. Drivers - Size. Categories of drivers (Figure 9a) and drivers (Figure 9b) perceived by the different sizes. The bars report the difference between Small and Medium-sized firms in terms of the percentage of firms perceiving the category or the driver over the total number of firms in the specific cluster.

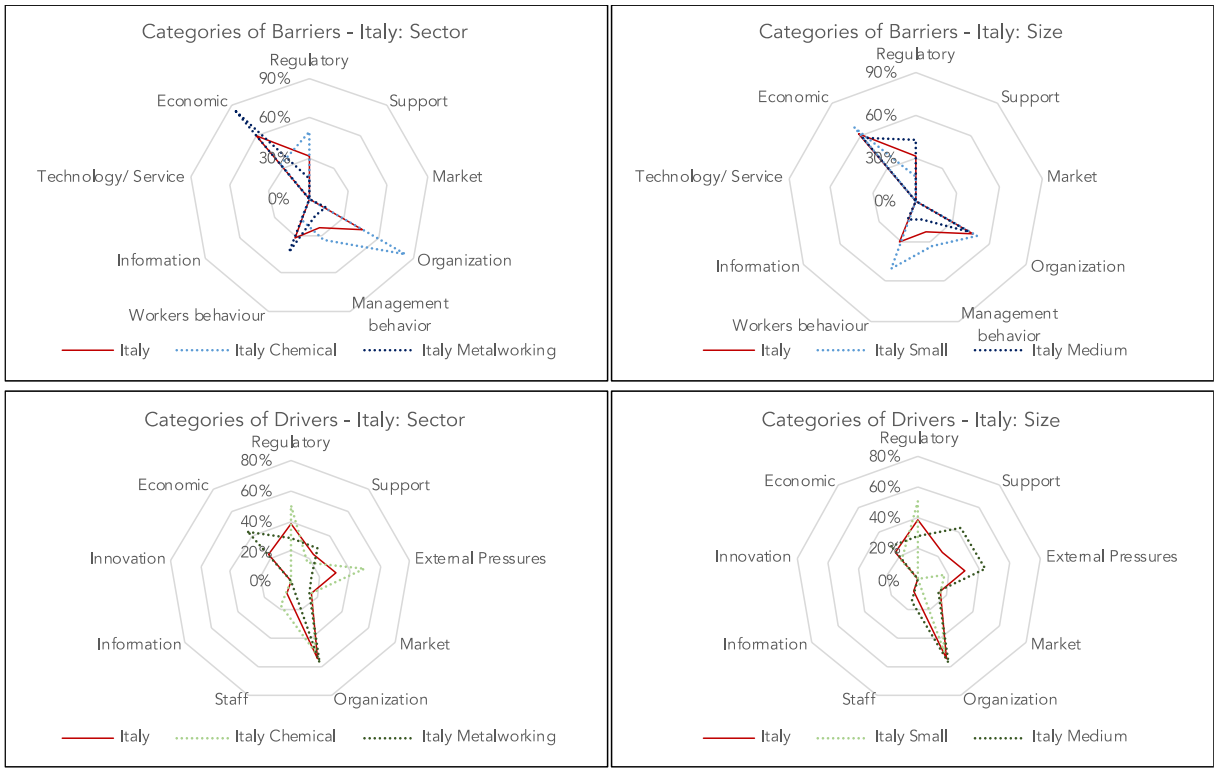


4.3 Analysis according to multiple contextual factors

We performed some additional preliminary analyses considering multiple contextual factors simultaneously. Differences can be indeed pointed out within our sample looking at multiple contextual factors, resulting, among the others, in the way the two sizes of the two sectors in the two countries investigated approach sustainability (see Section 3.1).

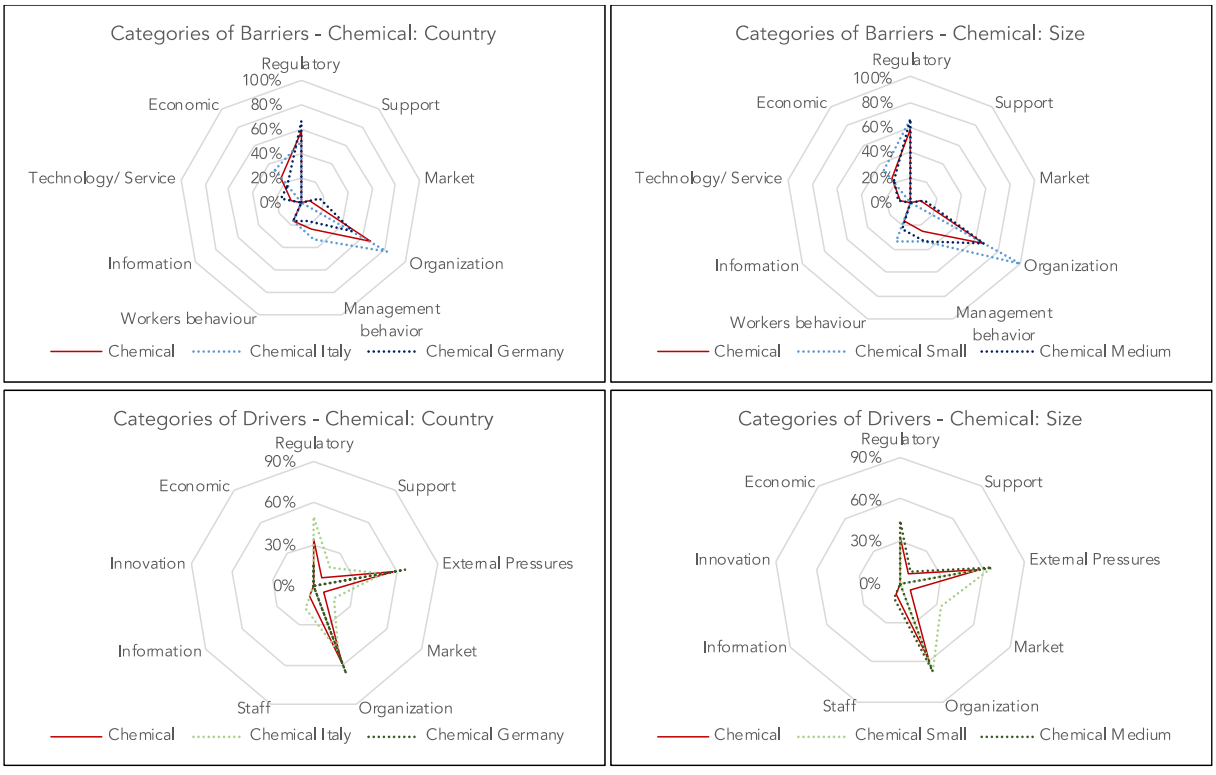
From our preliminary analyses, two main aspects emerged. First, in both countries, barriers and drivers seem to vary in terms of type and intensity more according to the sector than firm size. This aspect emerged as particularly relevant in Italian sampled firms (Figure 10). Second, differences can be noted in terms of the relevance of barriers and drivers perceived in a specific sector according to the country and the size. Considering for example the chemical sector, the different clusters of country and size contribute to the overall relevance of the category in different manners, as we can note from Figure 11. For these analyses, given the exploratory nature and the small sample, and the shortage of previous similar studies to support the findings, further research is necessary.

Figure 10. Barriers and Drivers – Country with sector and size. Categories of barriers and drivers perceived in Italy and their variation according to the sector and the size. The percentages indicate the share firms perceiving the category over the total number of firms in the specific cluster.



603

604 **Figure 11. Barriers and Drivers – Sector with Country and size.** Categories of barriers and drivers perceived in the
605 chemical sector and their variation according to the country and the size. The percentages indicate the share firms
606 perceiving the category over the total number of firms in the specific cluster.



607

4.4 Analysis according to firm's approach towards sustainability issues

To perform the analysis, we investigated the firms according to the three axes discussed in Section 2.3, namely the pillars of sustainability considered by each firm in the definition of sustainability provided; the presence within the firms of a dedicated manager in charge of sustainability; the certifications held. The details of the abovementioned axes for each firm of the sample are reported in Table 5.

Firm	Specific manager for Sustainability		Certifications held				Pillars considered in the definition of sustainability		
	Yes	No	IS0 9001	ISO 14001	ISO 5001	OHSAS 18001	Eco	Soc	Env
Firm 1		•	•				•		•
Firm 2		•	•						•
Firm 3		•						•	•
Firm 4		•							•
Firm 5		•	•				•	•	•
Firm 6		•							•
Firm 7		•	•	•			•	•	•
Firm 8		•	•				•	•	•
Firm 9		•	•					•	•
Firm 10		•	•		•		•	•	•
Firm 11		•	•					•	•
Firm 12		•	•	•	•		•	•	•
Firm 13	•		•	•	•			•	•
Firm 14		•	•				•	•	•
Firm 15	•		•	•		•	•	•	•
Firm 16		•	•	•		•	•	•	•
Firm 17	•		•	•		•	•	•	•
Firm 18	•		•				•	•	•
Firm 19		•	•				•	•	•
Firm 20		•						•	•
Firm 21		•	•				•	•	•
Firm 22		•					•	•	•
Firm 23	•		•	•		•	•	•	•
Firm 24		•					•		•
Firm 25	•		•					•	•
Firm 26	•		•				•	•	•

Table 5. Sustainability's perception and management. For each firm of the sample the following are reported: Presence of a specific manager in charge of sustainability; Certifications holds; Pillars considered in the sustainability definition provided during the interview.

4.4.1 Analysis according to the firm's perspective on sustainability

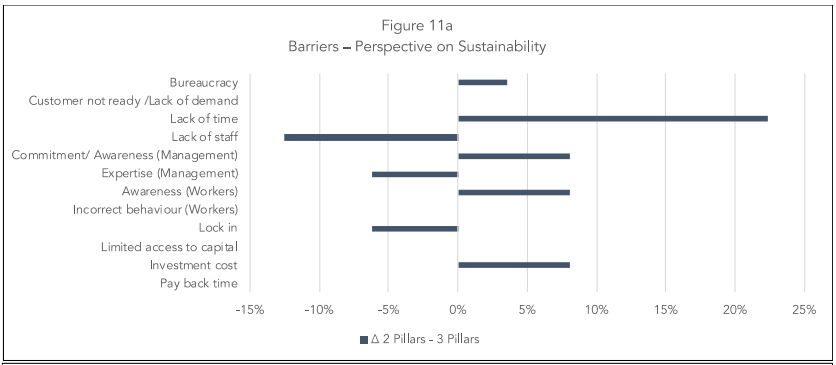
All the firms in our sample considered the environmental pillar in their definition of sustainability. 3 firms out of 26 (all German metalworking companies) considered only the environmental pillar, while 15 (almost all Italian and chemical) considered all the three pillars (Table 5). In the following, we decided to focus exclusively on firms acknowledging a perspective of at least two pillars.

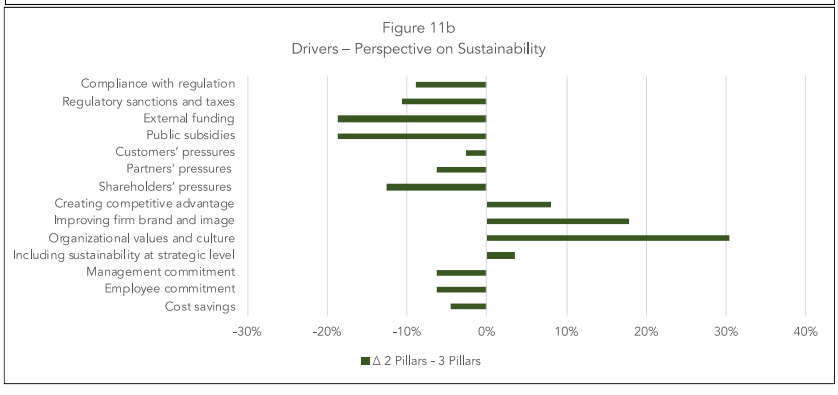
Regarding barriers (Figure 12a) we can note some interesting differences. Firms with a holistic perspective on sustainability (3 pillars) present a lower relevance of *Economic* barriers, especially in terms of *Investment Cost*, rather highlighting the importance of *Lack of staff* barrier. In this regard, companies with a holistic perspective on sustainability, despite acknowledging the multiple benefits stemming from a holistic approach, might also have a higher perception of the challenges and the

complexity of the decision-making process with a number of issues to be simultaneously considered (Nikolaou and Tsalis, 2013). As for the drivers (Figure 12b), firms with a two-pillar perspective reported higher importance of *Organization values and culture* and *Improving firm brand and image* (May and Stahl, 2017), with Firm 2 remarking that "*sustainability should start from the upper level"*. Firms with a holistic perspective on sustainability pointed out more the importance of *Compliance with regulation*, along with *Regulatory sanctions* and *External pressures* related drivers.

In conclusion, despite this exploratory investigation calls for a larger sample to allow for causal interpretations, our empirical findings corroborate earlier research (May and Stahl, 2017) highlighting the possible mismatch between how firms define sustainability and what they actually do in all sustainability areas, with companies still bound to just an environmental perspective, as noted by Yin et al. (2020), calling research and policy-making efforts in driving firm sustainability perspective to include also the social perspective.

Figure 12. Barriers and Drivers – Firm's perspective on Sustainability. Barriers (Figure11a) and drivers (Figure 12b) perceived according to the firm's perspective on Sustainability. The bars report the difference between firms considering two pillars and firms considering three pillars in their definition of Sustainability in terms of the percentage of firms perceiving the category or the driver over the total number of firms in the specific cluster.





4.4.2 Analysis by the presence of a dedicated manager for sustainability

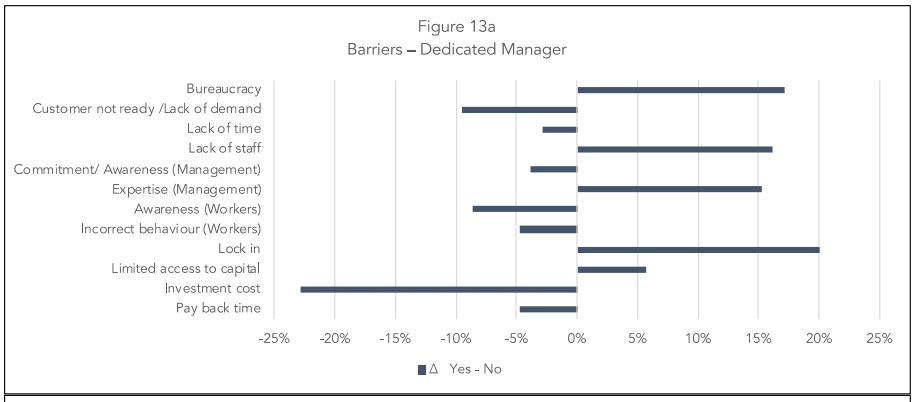
Most of the investigated firms (19 out of 26) does not have a dedicated manager in charge of sustainability (Table 5), as firms generally appear as "*too small to have dedicated staff*" (Firm 8).

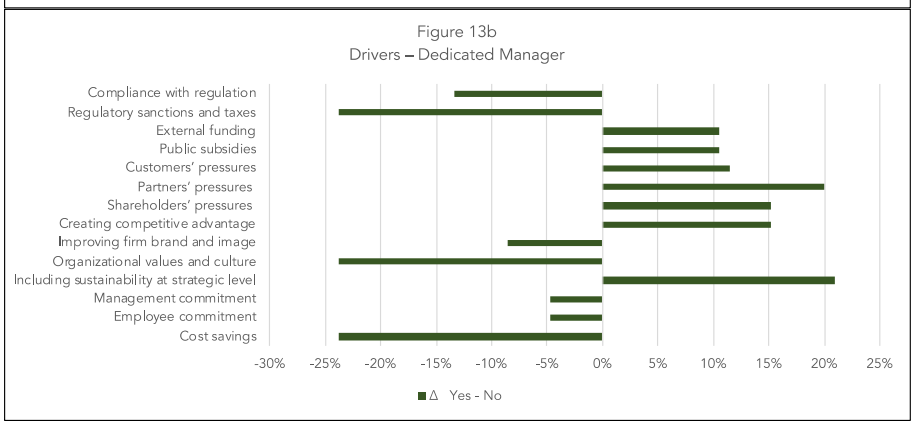
Concerning barriers (Figure 13a), sampled firms with a dedicated manager tend to perceive a higher impact of *Bureaucracy* and *Organizatio*n related barriers, particularly *Expertise of management* and *Lack of staff*. The results are aligned with earlier studies underlying the role of the project champions (Cagno et al., 2018), usually not provided with enough formal authority and control of scarce resources as the staff (Masi et al., 2014; Thollander and Palm, 2015). The main barriers for firms without a dedicated sustainability manager are related to *Economic* aspects, still seeming to remark that the lack of a dedicated manager might lead to perceive sustainability as economically burdensome without acknowledging the overall benefits achievable (Cagno et al., 2018).

Concerning drivers (Figure 13b), firms with a dedicated manager highlighted the importance of *Including Sustainability at a strategic level* and *External pressures*, particularly *Customers' pressures*. Rather, sampled firms without a dedicated manager appeared to be mainly driven by *Cost savings, Compliance with regulation,* and *Organization values and culture*. The obtained results seem to underline that firms with a dedicated manager move towards a more systemic approach towards sustainability, also thanks to collaborations and partnerships with other parties and stakeholders in general. As *Cost savings* does not represent a relevant driver for this cluster of firms, it is likely that the presence of a dedicated manager can shift the focus from a mere regulatory compliance/short-term perspective to a more strategic and long-term strategy (Derlukiewicz et al., 2020; Genç and Di Benedetto, 2019). The concept of long-term perspective clearly emerged during the interviews: Firm 23 stated that "*sustainability should entail the stakeholders' welfare in the long-term*"; further, Firm 26's CEO pointed out how "*there is a specific focus of the top management, that is me, on those decisions and investments that are able to bring positive impacts in the long-term*".

The presence of a dedicated sustainability manager seems thus to influence the barriers and drivers perceived, by tackling the lack of resources and leveraging on the strategic-oriented and competitiveness-related drivers (Cantele et al., 2020; Fuente et al., 2017).

Figure 13. Barriers and Drivers – Presence of a dedicated manager for Sustainability. Barriers (Figure12a) and drivers (Figure 13b) perceived according to the presence of a dedicated manager for Sustainability. The bars report the difference between firms with and without a dedicated manager Sustainability in terms of the percentage of firms perceiving the category or the driver over the total number of firms in the specific cluster.





4.4.3 Analysis by certifications held

Considering the presence of certifications, within the sample investigated, 6 firms do not own any certification, 12 firms own one certification, 2 firms own two certifications, while 6 firms own three certifications. The certifications identified are ISO 9001, ISO 14001, ISO 50001, and OHSAS 18001 (Table 5). ISO9001 and ISO14001 are well distributed in the two countries, although ISO 50001 is held only in Germany, and OHSAS 180001 only in Italy. Additionally, the chemical sector seems to hold more certifications than the metalworking one, as also confirmed by International Organization for Standardization (2017). As for size, medium-sized firms hold more certifications than small-sized ones, in line with Martín-Peña et al. (2014) and May and Stahl (2017). Considering the suggestion of Zeng et al. (2007), in our analysis, we considered two clusters: firms holding up to one certification and firms holding more than one certification.

Concerning barriers (Figure 14a), firms with no or just one certification seem to present a larger relevance of *Economic* ones, whilst their relevance for firms holding at least two certifications is fairly low, while we can note a stronger perception of the *Bureaucracy* barrier. For example, Firm 15's Technical Director stated that to survive competition with larger firms and multinational corporations "*we have to be as structured as possible, but as agile as possible: sustainability, certifications and commitment are for us a fundamental aspect of strategic development*"; nonetheless, as also previously noted, the related "*bureaucracy is crazy*".

As for drivers (Figure 14b), firms holding up to one certification are mainly driven by *Cost savings* and *Compliance with regulation*; firms with more than one certification perceive a slightly stronger effect of *Regulatory sanctions and taxes* barriers and appear to be mainly driven by *Including sustainability at a strategic level*, *Improving firm brand and image* and *Customers' pressures*. The latter drivers emerged as pivotal in different cases, with Firm 14 claiming that requests for costumers "*foster investments*", and Firm 20 highlighting that *"The drivers are […] the customers who require a certain type of product, made with specific characteristics and certified".*

The overall results seem to show that an increasing number of certifications somehow reflect a more strategic and long-term perspective towards sustainability subsists, with decreasing importance of economic barriers and stronger leveraging on the inclusion of sustainability at a strategic level and brand and firms' image improvement. Our preliminary findings are in line with Wang et al. (2016) and Wiengarten et al. (2017) who conclude that firms with more certifications also achieve higher performance since they adopt a systematic and synergic approach.

Figure 14. Barriers and Drivers – Certifications held. Barriers (Figure13a) and drivers (Figure 14b) perceived according to the number of certifications held. The bars report the difference between firms holding 0 or 1 certifications and firms holding 2 or 3 certifications in terms of the percentage of firms perceiving the category or the driver over the total number of firms in the specific cluster.

5 Conclusions

The present research aimed at contributing to the extant discourse on industrial sustainability by providing empirical evidence on the main perceived barriers and drivers to the adoption of ISMs in manufacturing European SMEs and on factors that might influence their perception. We deem the research to provide a valuable contribution from different perspectives.

From an academic perspective, this is a first attempt to offer empirical evidence on the main issues in adopting ISMs by looking simultaneously at all the areas of industrial sustainability, as well as on a single picture for barriers to and drivers for. Further, we have explored three important contextual factors at the same time, namely the sector, the country and the firm size, plus additional characteristics related to the firm's approach towards sustainability issues, namely the pillars included in the firm's definition of sustainability, the presence of a dedicated sustainability manager, and the presence of certifications.

According to the findings of our exploratory investigation, the industrial sector is still hindered by economic barriers and driven by external factors, thus not fully exploiting the benefits deriving from a proactive and long-term strategy towards industrial sustainability. The contextual factors preliminarily explored have shown to potentially influence the relevance of barriers and drivers, thus being crucial for a proper understanding of their impact on the decision-making process of adopting an ISM. Likewise, the firm's approach towards sustainability issues seems to be important in shaping the relevance of barriers and drivers, in particular the presence of a dedicated manager for sustainability and an increasing number of certifications held by the firm.

Our findings could effectively support industrial decision-makers by offering a better understanding of the major issues when adopting ISMs. From a policy-making perspective, the present study can provide a contribution in highlighting what firms need to enhance their sustainability, thus aiming at better tailored policies, actions, subsidies, and incentives according to the different specific needs. This is particularly crucial considering the SDGs and the upcoming European targets within the European Green Deal.

In conclusion, we would like to acknowledge some limitations of the present study paving the road for future research. Firstly, we were unable to interview people in the exact same leadership positions within the SMEs. Secondly, our quota sampling, despite being appropriate for the present research, does not allow a statistical generalization. Further research should possibly enlarge the sample by offering additional empirical investigation, also considering a random sampling method. Thirdly, concerning the investigated contextual factors, our analysis has been limited in number and scope, but future studies could consider exploring other sectors and other countries. In particular, the regulatory and environmental context in which firms operate (that may differ by country) may

severely shape the response of the firms, and therefore further research encompassing those elements should be conducted. Additionally, future research is recommended to investigate more contextual factors, e.g. the strategic context or the governance structure, eventually triangulating them with the proactive or reactive sustainability strategy characterizing the investigated firms.

Further insights could come from analysing barriers and drivers to specific ISMs and not in general term. Barriers and drivers could also vary according to the different phases of the decision-making processes, offering another interesting research stream. Lastly, another important research avenue is represented by a simultaneous investigation of the possible relationships between perceived barriers and drivers and enhanced sustainability performance.

References

Abad, J., Lafuente, E., Vilajosana, J., 2013. An assessment of the OHSAS 18001 certification process: Objective drivers and consequences on safety performance and labour productivity. Saf. Sci. 60, 47–56. https://doi.org/10.1016/j.ssci.2013.06.011

Abdul-Rashid, S.H., Sakundarini, N., Ariffin, R., Ramayah, T., 2017. Drivers for the adoption of sustainable manufacturing practices: A Malaysia perspective. Int. J. Precis. Eng. Manuf. 18, 1619–1631. https://doi.org/10.1007/s12541-017-0191-4

Adams, W.C., 2015. Conducting Semi-structured Interviews, in: Newcomer, K.E., Hatry, H.P., Wholey, J.S., Newcomer, K.E., Hatry, H.P., Wholey, J.S. (Eds.), Handbook of Practical Program Evaluation. pp. 492–505. https://doi.org/https://doi.org/10.1002/9781119171386.ch19

Ahmad, I., Arif, M.S., Cheema, I.I., Thollander, P., Khan, M.A., 2020. Drivers and Barriers for Efficient Energy Management Practices in Energy-Intensive Industries: A Case-Study of Iron and Steel Sector. Sustainability 12, 7703. https://doi.org/10.3390/su12187703

Al Hawaj, A.Y., Buallay, A.M., 2021. A worldwide sectorial analysis of sustainability reporting and its impact on firm performance. J. Sustain. Financ. Invest. 1–25. https://doi.org/10.1080/20430795.2021.1903792

Alayón, C., Säfsten, K., Johansson, G., 2017. Conceptual sustainable production principles in practice: Do they reflect what companies do? J. Clean. Prod. 141, 693–701. https://doi.org/https://doi.org/10.1016/j.jclepro.2016.09.079

AlSanad, S., 2018. Barriers to Implementation Sustainable Cement Manufacturing in Kuwait. Eur. J. Sustain. Dev. 7, 317–322. https://doi.org/10.14207/ejsd.2018.v7n4p317

Álvarez Jaramillo, J., Zartha Sossa, J.W., Orozco Mendoza, G.L., 2019. Barriers to sustainability for small and medium enterprises in the framework of sustainable development—Literature review. Bus. Strateg. Environ. 28, 512–524. https://doi.org/10.1002/bse.2261

Arana-Solares, I.A., Ortega-Jiménez, C.H., Alfalla-Luque, R., Pérez-Díez de los Ríos, J.L., 2019. Contextual factors intervening in the manufacturing strategy and technology management-performance relationship. Int. J. Prod. Econ. 207, 81–95. https://doi.org/10.1016/j.ijpe.2018.11.003

Arrighetti, A., Ninni, A., 2012. German and Italian manufacturing performances: a premise to a comparison. Econ. E Polit. Ind. 5–16. https://doi.org/10.3280/POLI2012-002001

Baah, C., Opoku-Agyeman, D., Acquah, I.S.K., Issau, K., Moro Abdoulaye, F.A., 2020. Understanding the influence of environmental production practices on firm performance: a proactive versus reactive approach. J. Manuf. Technol. Manag. 32, 266–289. https://doi.org/10.1108/JMTM-05-2020-0195

789 Balasubramanian, S., 2020. Firm size implications for environmental sustainability of supply
790 chains : evidence from the UAE 31, 1375–1406. https://doi.org/10.1108/MEQ-01-2020-0004
791 Barthelemy, P., Agyeman-Budu, E., 2016. European chemical industry's contribution to sustainable
792 development. Curr. Opin. Green Sustain. Chem. 1, 28–32.
793 https://doi.org/10.1016/j.cogsc.2016.08.002
794 Bastas, A., Liyanage, K., 2019. Setting a framework for organisational sustainable development.
795 Sustain. Prod. Consum. 20, 207–229. https://doi.org/10.1016/j.spc.2019.06.005
796 Bhanot, N., Rao, P.V., Deshmukh, S.G., 2015. Enablers and barriers of sustainable manufacturing:
797 Results from a survey of researchers and industry professionals. Procedia CIRP 29, 562–567.
798 https://doi.org/10.1016/j.procir.2015.01.036
799 Bocken, N.M.P., Geradts, T.H.J., 2020. Barriers and drivers to sustainable business model
800 innovation: Organization design and dynamic capabilities. Long Range Plann. 53, 101950.
801 https://doi.org/10.1016/j.lrp.2019.101950
802 Bonafede, M., Corfiati, M., Gagliardi, D., Boccuni, F., Ronchetti, M., Valenti, A., Marinaccio, A.,
803 Iavicoli, S., 2016. OHS management and employers' perception: Differences by firm size in a
804 large Italian company survey. Saf. Sci. 89, 11–18. https://doi.org/10.1016/j.ssci.2016.05.012
805 Bonilla, S., Silva, H., Terra da Silva, M., Franco Gonçalves, R., Sacomano, J., 2018. Industry 4.0
806 and Sustainability Implications: A Scenario-Based Analysis of the Impacts and Challenges.
807 Sustainability 10, 3740. https://doi.org/10.3390/su10103740
808 Böttcher, C.F., Müller, M., 2015. Drivers, Practices and Outcomes of Low-carbon Operations:
809 Approaches of German Automotive Suppliers to Cutting Carbon Emissions. Bus. Strateg.
810 Environ. 24, 477–498. https://doi.org/10.1002/bse.1832
811 Brunke, J.C., Johansson, M., Thollander, P., 2014. Empirical investigation of barriers and drivers to
812 the adoption of energy conservation measures, energy management practices and energy
813 services in the Swedish iron and steel industry. J. Clean. Prod. 84, 509–525.
814 https://doi.org/10.1016/j.jclepro.2014.04.078
815 Cagno, E., Neri, A., Howard, M., Brenna, G., Trianni, A., 2019. Industrial sustainability
816 performance measurement systems: A novel framework. J. Clean. Prod. 230, 1354–1375.
817 https://doi.org/10.1016/j.jclepro.2019.05.021
818 Cagno, E., Neri, A., Trianni, A., 2018. Broadening to sustainability the perspective of industrial
819 decision-makers on the energy efficiency measures adoption: some empirical evidence. Energy
820 Effic. 11, 1193–1210. https://doi.org/10.1007/s12053-018-9621-0
821 Cagno, E., Trianni, A., 2014. Evaluating the barriers to specific industrial energy efficiency
822 measures: an exploratory study in small and medium-sized enterprises. J. Clean. Prod. 82, 70–
823 83. https://doi.org/10.1016/j.jclepro.2014.06.057
824 Cagno, E., Trianni, A., Abeelen, C., Worrell, E., Miggiano, F., 2015. Barriers and drivers for energy
825 efficiency: different perspectives from an exploratory study in the Netherlands. Energy
826 Convers. Manag. 102, 26–38. https://doi.org/10.1016/j.enconman.2015.04.018
827 Cagno, E., Trianni, A., Spallina, G., Marchesani, F., 2017. Drivers for energy efficiency and their
828 effect on barriers: empirical evidence from Italian manufacturing enterprises. Energy Effic. 10,
829 855–869. https://doi.org/10.1007/s12053-016-9488-x
830 Caldera, H.T.S., Desha, C., Dawes, L., 2019. Evaluating the enablers and barriers for successful
831 implementation of sustainable business practice in 'lean' SMEs. J. Clean. Prod. 218, 575–590.
832 https://doi.org/10.1016/j.jclepro.2019.01.239
833 Cambra-Fierro, J., Ruiz-Benítez, R., 2011. Sustainable business practices in Spain: a two-case
834 study. Eur. Bus. Rev. 23, 401–412. https://doi.org/10.1108/09555341111145780
835 Cannas, V.G., Ciccullo, F., Pero, M., Cigolini, R., 2020. Sustainable innovation in the dairy supply
836 chain: enabling factors for intermodal transportation. Int. J. Prod. Res.
837 https://doi.org/10.1080/00207543.2020.1809731

838 Cantele, S., Vernizzi, S., Campedelli, B., 2020. Untangling the Origins of Sustainable Commitment:
839 New Insights on the Small vs. Large Firms' Debate. Sustainability 12, 671.
840 https://doi.org/10.3390/su12020671
841 Cantele, S., Zardini, A., 2018. Is sustainability a competitive advantage for small businesses? An
842 empirical analysis of possible mediators in the sustainability–financial performance
843 relationship. J. Clean. Prod. 182, 166–176. https://doi.org/10.1016/j.jclepro.2018.02.016
844 CEFIC, 2017. Chemestry can. Accelerating Europe towards a sustainable future.
845 https://chemistrycan.com/what-is-chemistry-can/.
846 Centi, G., Perathoner, S., 2009. From Green to Sustainable Industrial Chemistry, in: Sustainable
847 Industrial Chemistry. Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, pp. 1–
848 72. https://doi.org/10.1002/9783527629114.ch1
849 Chassé, S., Courrent, J.-M., 2018. Linking owner–managers' personal sustainability behaviors and
850 corporate practices in SMEs: The moderating roles of perceived advantages and environmental
851 hostility. Bus. Ethics A Eur. Rev. 27, 127–143.
852 https://doi.org/https://doi.org/10.1111/beer.12176
853 Cherniack, M., Lahiri, S., 2010. Barriers to implementation of workplace health interventions: an
854 economic perspective. J. Occup. Environ. Med. 52, 934–942.
855 https://doi.org/10.1097/JOM.0b013e3181f26e59
856 Choudhury, R.G., 2016. Relationship between contextual factors , business performance , and
857 strategy : a study of manufacturing and service industries in India. Bus. Manag. Rev. 7, 295–
858 303.
859 Chowdhury, M.M.H., Hossain, M.M., Dewan, M.N.A., 2015. A framework for selecting optimal
860 strategies to mitigate the corporate sustainability barriers. Corp. Ownersh. Control 13, 462–
861 481.
862 Condon, L., 2004. Sustainability and Small to Medium Sized Enterprises - How to Engage Them.
863 Aust. J. Environ. Educ. 20, 57–67. https://doi.org/DOI: 10.1017/S0814062600002305
864 Cooper, D.R., Schindler, P.S., Sun, J., 2006. Business Research Methods. McGraw-Hill New York.
865 Cooremans, C., 2011. Make it strategic! Financial investment logic is not enough. Energy Effic. 4,
866 473–492. https://doi.org/10.1007/s12053-011-9125-7
867 Costache, C., Dumitrascu, D.-D., Maniu, I., 2021. Facilitators of and Barriers to Sustainable
868 Development in Small and Medium-Sized Enterprises: A Descriptive Exploratory Study in
869 Romania. Sustainability 13, 3213. https://doi.org/10.3390/su13063213
870 De Oliveira, A.C., Sokulski, C.C., Da Silva Batista, A.A., De Francisco, A.C., 2018. Competencies
871 for sustainability: A proposed method for the analysis of their interrelationships. Sustain. Prod.
872 Consum. 14, 82–94. https://doi.org/10.1016/j.spc.2018.01.005
873 De Paiva Duarte, F., 2015. Barriers to sustainability: an exploratory study on perspectives from
874 Brazilian organizations. Sustain. Dev. 23, 425–434. https://doi.org/10.1002/sd.1603
875 Deloitte, 2018. Italia 4.0: siamo pronti? Il percepito degli executive in merito agli impatti
876 economici, tecnologici e sociali delle nuove tecnologie.
877 https://www2.deloitte.com/content/dam/Deloitte/it/Documents/process-and-
878 operations/Report%20Italia%204.0%20siamo%20pronti_Deloitte%20Italy.pdf.
879 Derlukiewicz, N., Mempel-Śniezyk, A., Mankowska, D., Dyjakon, A., Minta, S., Pilawka, T., 2020.
880 How do clusters foster sustainable development? An analysis of EU policies. Sustain. 12.
881 https://doi.org/10.3390/su12041297
882 Dicuonzo, G., Galeone, G., Ranaldo, S., Turco, M., 2020. The Key Drivers of Born-Sustainable
883 Businesses: Evidence from the Italian Fashion Industry. Sustainability 12, 10237.
884 https://doi.org/10.3390/su122410237
885 European Agency for Safety and Health at Work, 2009. Occupational safety and health and
886 economic performance in small and medium-sized enterprises: a review.

887 https://osha.europa.eu/en/tools-and-publications/publications/reports/TE-80-09-640-EN-
888 N_occupational_safety_health_economic_performance_small_medium_sized_enterprises_revi
889 ew/view.
890 European Commission, 2019a. The European Green Deal. https://eur-lex.europa.eu/legal-
891 content/EN/TXT/PDF/?uri=CELEX:52019DC0640&from=EN.
892 European Commission, 2019b. Annual Report on European SMEs 2018/2019 - Research &
893 Development and Innovation by SMEs. https://doi.org/10.2826/500457
894 European Commission, 2009. FWC sector competitiveness studies - Competitiveness of the EU
895 metalworking and metal articles industries. https://www.sectorcompetitiveness.com/studies-
896 and-projects/sector-competitiveness-studies/.
897 European Commission, 2007. Corrigendum to Regulation (EC) No 1907/2006 of the European
898 Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation,
899 Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals
900 Agency, amending D. https://eur-lex.europa.eu/eli/reg/2006/1907/corrigendum/2007-05-29/oj.
901 European Union, 2017. The future of industry in Europe. https://doi.org/10.2863/709269
902 European Union, 2003. Commission Recommendation of 6 May 2003 concerning the definition of
903 micro, small and medium-sized enterprises. http://data.europa.eu/eli/reco/2003/361/oj.
904 Eurostat, 2020. Industrial production statistics [WWW Document]. URL Manufacturing statistics -
905 NACE Rev. 2 (accessed 5.15.21).
906 Eurostat, 2018. Statistics on small and medium-sized enterprises [WWW Document]. URL
907 https://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_small_and_medium-
908 sized_enterprises (accessed 9.13.18).
909 EY, 2020. Remaining customer- centric in an evolving chemicals landscape.
910 https://www.ey.com/en_gl/advanced-manufacturing/how-chemicals-companies-can-remain-
911 customer-centric-as-sectors-evolve.
912 Fatoki, O., 2019. Drivers and barriers to sustainability manufacturing practices by small and
913 medium enterprises in South Africa. Acad. Entrep. J. 25, 1–12.
914 Federmeccanica, 2018. L'industria metalmeccanica [WWW Document]. URL
915 https://www.federmeccanica.it/centro-studi/industria-metalmeccanica.html (accessed 12.1.18).
916 Feil, A.A., De Quevedo, D.M., Schreiber, D., 2017. An analysis of the sustainability index of
917 micro- and small-sized furniture industries. Clean Technol. Environ. Policy 19, 1883–1896.
918 https://doi.org/10.1007/s10098-017-1372-7
919 Fernández-Muñiz, B., Montes-Peón, J.M., Vázquez-Ordás, C.J., 2012. Safety climate in OHSAS
920 18001-certified organisations: Antecedents and consequences of safety behaviour. Accid.
921 Anal. Prev. 45, 745–758. https://doi.org/10.1016/j.aap.2011.10.002
922 Ferrón Vílchez, V., 2017. The dark side of ISO 14001: The symbolic environmental behavior. Eur.
923 Res. Manag. Bus. Econ. 23, 33–39. https://doi.org/10.1016/j.iedeen.2016.09.002
924 Fleiter, T., Schleich, J., Ravivanpong, P., 2012. Adoption of energy-efficiency measures in SMEs—
925 An empirical analysis based on energy audit data from Germany. Energy Policy 51, 863–875.
926 https://doi.org/10.1016/j.enpol.2012.09.041
927 Fonseca, L.M., 2015. Strategic drivers for implementing sustainability programs in portuguese
928 organizations-let's listen to aristotle: from triple to quadruple bottom line. Sustain. (United
929 States) 8, 136–142. https://doi.org/10.1089/SUS.2015.29004
930 Fuente, J.A., García-Sánchez, I.M., Lozano, M.B., 2017. The role of the board of directors in the
931 adoption of GRI guidelines for the disclosure of CSR information. J. Clean. Prod. 141, 737–
932 750. https://doi.org/10.1016/j.jclepro.2016.09.155
933 Genç, E., Di Benedetto, C.A., 2019. A comparison of proactive and reactive environmental
934 strategies in green product innovation. Int. J. Innov. Sustain. Dev. 13, 431–451.
935 https://doi.org/10.1504/ijisd.2019.10020056

Germany Trade & Invest, 2018. Industry overview - The machinery & equipment industry in Germany. https://www.gtai.de/GTAI/Navigation/EN/Invest/Service/Publications/industry-specific-information,t=the-machinery-and-equipment-industry-in-germany-,did=372458.html.

Gholami, H., Saman, M., Sharif, S., Md Khudzari, J., Zakuan, N., Streimikiene, D., Streimikis, J., 2020. A General Framework for Sustainability Assessment of Sheet Metalworking Processes. Sustainability 12, 4957. https://doi.org/10.3390/su12124957

Gimenez, C., Sierra, V., Rodon, J., 2012. Sustainable operations: their impact on the triple bottom line. Int. J. Prod. Econ. 140, 149–159. https://doi.org/10.1016/j.ijpe.2012.01.035

Grigorescu, A., Maer-Matei, M.M., Mocanu, C., Zamfir, A.-M., 2019. Key Drivers and Skills Needed for Innovative Companies Focused on Sustainability. Sustainability 12, 102. https://doi.org/10.3390/su12010102

Guillén-Gosalbez, G., Grossman, I.E., Guillén-Gosálbez, G., Grossmann, I.E., You, F., Graziano, D.J., Snyder, S.W., 2009. Optimal design and planning of sustainable chemical supply chains under uncertainty. AIChE J. 55, 99–121. https://doi.org/10.1002/aic.11662

Hall, G.M., Howe, J., 2010. Sustainability of the chemical manufacturing industry-Towards a new paradigm? Educ. Chem. Eng. 5, e100–e107. https://doi.org/10.1016/j.ece.2010.09.001

Hallstedt, S.I., Thompson, A.W., Lindahl, P., 2013. Key elements for implementing a strategic sustainability perspective in the product innovation process. J. Clean. Prod. 51, 277–288. https://doi.org/10.1016/j.jclepro.2013.01.043

Hami, N., Utara, U., 2015. An empirical study on the impact of sustainable manufacturing practices and innovation performance on environmental sustainability. J. Teknol. 77, 57–68. https://doi.org/10.11113/jt.v77.6043

Hansen, T., Coenen, L., 2015. The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. Environ. Innov. Soc. Transitions 17, 92–109. https://doi.org/10.1016/j.eist.2014.11.001

Held, M., Weidmann, D., Kammerl, D., Hollauer, C., Mörtl, M., Omer, M., Lindemann, U., 2018. Current challenges for sustainable product development in the German automotive sector: A survey based status assessment. J. Clean. Prod. 195, 869–889. https://doi.org/10.1016/j.jclepro.2018.05.118

Henriques, J., Catarino, J., 2015. Sustainable value and cleaner production - Research and application in 19 Portuguese SME. J. Clean. Prod. 96, 379–386. https://doi.org/10.1016/j.jclepro.2014.02.030

Hibberts, M., Johnson, R.B., Hudson, K., 2012. Handbook of Survey Methodology for the Social Sciences, in: Gideon, L. (Ed.), Handbook of Survey Methodology for the Social Sciences. Springer New York, New York, pp. 1–520. https://doi.org/10.1007/978-1-4614-3876-2

Hueske, A.K., Guenther, E., 2021. Multilevel barrier and driver analysis to improve sustainability implementation strategies: Towards sustainable operations in institutions of higher education. J. Clean. Prod. 291, 125899. https://doi.org/10.1016/j.jclepro.2021.125899

International Organization for Standardization, 2017. ISO Survey [WWW Document]. URL https://www.iso.org/the-iso-survey.html (accessed 5.6.19).

Jansson, J., Nilsson, J., Modig, F., Hed Vall, G., 2017. Commitment to Sustainability in Small and Medium-Sized Enterprises: The Influence of Strategic Orientations and Management Values. Bus. Strateg. Environ. 26, 69–83. https://doi.org/10.1002/bse.1901

Jehling, M., Hitzeroth, M., Brueckner, M., 2019. Applying institutional theory to the analysis of energy transitions: From local agency to multi-scale configurations in Australia and Germany. Energy Res. Soc. Sci. 53, 110–120. https://doi.org/10.1016/j.erss.2019.01.018

Kara, S., Suphunnika, I., Kayis, B., 2014. Sustainable product development in practice: an international survey. J. Manuf. Technol. Manag. 25, 848–872. https://doi.org/http://dx.doi.org/10.1108/09564230910978511

985 Kemp, R., Never, B., 2017. Green transition, industrial policy, and economic development. Oxford
986 Rev. Econ. Policy 33, 66–84. https://doi.org/10.1093/oxrep/grw037
987 Khanna, T., 2015. A Case for Contextual Intelligence. Manag. Int. Rev. 55, 181–190.
988 https://doi.org/10.1007/s11575-015-0241-z
989 Kim, K., 2018. Proactive versus Reactive Corporate Environmental Practices and Environmental
990 Performance. Sustainability 10, 97. https://doi.org/10.3390/su10010097
991 Kircherr, J., Hekkert, M., Bour, R., Huibrechtse-Truijens, A., Kostense-Smit, E., Muller, J., 2017.
992 Breaking the Barriers to the Circular Economy, Deloitte.
993 https://www.uu.nl/sites/default/files/breaking_the_barriers_to_the_circular_economy_white_p
994 aper_web.pdf.
995 Klewitz, J., Hansen, E.G., 2014. Sustainability-oriented innovation of SMEs: a systematic review. J.
996 Clean. Prod. 65, 57–75. https://doi.org/10.1016/j.jclepro.2013.07.017
997 Küçüksayraç, E., Kuçksayraç, E., 2015. Design for sustainability in companies: Strategies, drivers
998 and needs of Turkey's best performing businesses. J. Clean. Prod. 106, 455–465.
999 https://doi.org/10.1016/j.jclepro.2015.01.061
1000 Kumar, V., Gunasekaran, A., Singh, K., Papadopoulos, T., Dubey, R., 2015. Cross sector
1001 comparison of sustainability reports of Indian companies: A stakeholder perspective. Sustain.
1002 Prod. Consum. 4, 62–71. https://doi.org/10.1016/j.spc.2015.08.005
1003 Lee, K., 2015. Drivers and barriers to energy efficiency management for sustainable development.
1004 Sustain. Dev. 25, 16–25. https://doi.org/10.1002/sd.1567
1005 Littlewood, D., Decelis, R., Hillenbrand, C., Holt, D., 2018. Examining the drivers and outcomes of
1006 corporate commitment to climate change action in European high emitting industry. Bus.
1007 Strateg. Environ. 27, 1437–1449. https://doi.org/10.1002/bse.2194
1008 Lloret, A., 2016. Modeling corporate sustainability strategy. J. Bus. Res. 69, 418–425.
1009 https://doi.org/10.1016/j.jbusres.2015.06.047
1010 Löfving, M., Säfsten, K., Winroth, M., 2013. The contextual role for manufacturing strategy
1011 formulation in small and medium-sized enterprises, in: 20th EuROMA Conference. Dublin.
1012 Lozano, R., 2015. A Holistic Perspective on Corporate Sustainability Drivers. Corp. Soc.
1013 Responsib. Environ. Manag. 22, 32–44. https://doi.org/10.1002/csr.1325
1014 Luthra, S., Kumar, A., Zavadskas, E.K., Mangla, S.K., Garza-Reyes, J.A., 2020. Industry 4.0 as an
1015 enabler of sustainability diffusion in supply chain: an analysis of influential strength of drivers
1016 in an emerging economy. Int. J. Prod. Res. 58, 1505–1521.
1017 https://doi.org/10.1080/00207543.2019.1660828
1018 Mahmood, Z., Ali, W., Iqbal, J., Fatima, S., 2019. Drivers and Barriers of Sustainability Practices in
1019 Emerging and Developing Economies. J. Bus. Soc. Rev. Emerg. Econ. 5, 213–222.
1020 https://doi.org/10.26710/jbsee.v5i1.683
1021 Majumdar, A., Sinha, S.K., 2019. Analyzing the barriers of green textile supply chain management
1022 in Southeast Asia using interpretive structural modeling. Sustain. Prod. Consum. 17, 176–187.
1023 https://doi.org/10.1016/j.spc.2018.10.005
1024 Malek, J., Desai, T.N., 2019. Prioritization of sustainable manufacturing barriers using Best Worst
1025 Method. J. Clean. Prod. 226, 589–600. https://doi.org/10.1016/j.jclepro.2019.04.056
1026 Maletič, M., Maletič, D., Gomišček, B., 2016. The impact of sustainability exploration and
1027 sustainability exploitation practices on the organisational performance: a cross-country
1028 comparison. J. Clean. Prod. 138, 158–169. https://doi.org/10.1016/j.jclepro.2016.02.132
1029 Marcati, A., Guido, G., Peluso, A.M., 2008. The role of SME entrepreneurs' innovativeness and
1030 personality in the adoption of innovations. Res. Policy 37, 1579–1590.
1031 https://doi.org/10.1016/j.respol.2008.06.004
1032 Marodin, G.A., Frank, A.G., Tortorella, G.L., Saurin, T.A., 2016. Contextual factors and lean
1033 production implementation in the Brazilian automotive supply chain. Supply Chain Manag. 21,

417–432. https://doi.org/10.1108/SCM-05-2015-0170
Marshall, R.S., Brown, D., 2003. Environmental reporting: what's in a metric ? Bus. Strateg. Environ. 12, 87–106. https://doi.org/10.1002/bse.354
Martín-Peña, M.L., Díaz-Garrido, E., Sánchez-López, J.M., 2014. Analysis of benefits and difficulties associated with firms' Environmental Management Systems: the case of the Spanish automotive industry. J. Clean. Prod. 70, 220–230. https://doi.org/10.1016/j.jclepro.2014.01.085
Masi, D., Cagno, E., 2015. Barriers to OHS interventions in Small and Medium-sized Enterprises. Saf. Sci. 71, 226–241. https://doi.org/10.1016/j.ssci.2014.05.020
Masi, D., Cagno, E., Hasle, P., Farnè, S., 2015. Enhancing the implementation of Occupational Health and Safety interventions through a design of the socio-technical interaction. Saf. Reliab. Methodol. Appl. - Proc. Eur. Saf. Reliab. Conf. ESREL 2014 1319–1327. https://doi.org/10.1201/b17399-182
Masi, D., Cagno, E., Micheli, G.J.L., 2014. Developing, implementing and evaluating OSH interventions in SMEs: A pilot, exploratory study. Int. J. Occup. Saf. Ergon. 20, 385–405. https://doi.org/10.1080/10803548.2014.11077059
May, G., Stahl, B., 2017. The significance of organizational change management for sustainable competitiveness in manufacturing: exploring the firm archetypes. Int. J. Prod. Res. 55, 4450–4465. https://doi.org/10.1080/00207543.2016.1261197
McKim, A.S., 2018. Overcoming sustainability barriers within the chemical industry. Curr. Opin. Green Sustain. Chem. 14, 10–13. https://doi.org/10.1016/j.cogsc.2018.04.020
Meng, B., Liu, Y., Andrew, R., Zhou, M., Hubacek, K., Xue, J., Peters, G., Gao, Y., 2018. More than half of China's CO2 emissions are from micro, small and medium-sized enterprises. Appl. Energy 230, 712–725. https://doi.org/10.1016/J.APENERGY.2018.08.107
Micheli, G.J.L., Cagno, E., Calabrese, A., 2018. The Transition from Occupational Safety and Health (OSH) interventions to OSH outcomes: An empirical analysis of mechanisms and contextual factors within Small and Medium-sized Enterprises. Int. J. Environ. Res. Public Health 15, 1621. https://doi.org/10.3390/ijerph15081621
Micheli, G.J.L., Cagno, E., Neri, A., Cieri, E., 2021. Non-safety costs: A novel methodology for an ex-ante evaluation. Saf. Sci. 133, 105025. https://doi.org/10.1016/j.ssci.2020.105025
Miras-Rodríguez, M.M., Escobar- Peréz, B., Machuca Domínguez, J.A., 2015. Sustainability drivers , barriers and outcomes : Evidence from European High Performance Manufacturing companies, in: 2015 International Conference on Industrial Engineering and Systems Management (IESM). https://doi.org/10.1109/IESM.2015.7380271
Mitchell, S., O'Dowd, P., Dimache, A., 2020. Manufacturing SMEs doing it for themselves: developing, testing and piloting an online sustainability and eco-innovation toolkit for SMEs. Int. J. Sustain. Eng. 13, 159–170. https://doi.org/10.1080/19397038.2019.1685609
Mittal, V.K., Egede, P., Herrmann, C., Sangwan, K.S., 2013. Comparison of drivers and barriers to green manufacturing : a case of India and Germany, in: Re-Engineering Manufacturing for Sustainability. Springer Singapore, pp. 723–728. https://doi.org/10.1007/978-981-4451-48-2_118
Mittal, V.K., Sangwan, K.S., 2015. Ranking of drivers for green manufacturing implementation using fuzzy technique for order of preference by similarity to ideal solution method. J. Multi-Criteria Decis. Anal. 22, 119–130. https://doi.org/10.1002/mcda
Nasiri, M., Tura, N., Ojanen, V., 2017. Developing Disruptive Innovations for Sustainability: A Review on Impact of Internet of Things (IOT), in: 2017 Portland International Conference on Management of Engineering and Technology (PICMET). IEEE, pp. 1–10. https://doi.org/10.23919/PICMET.2017.8125369
Neri, A., Cagno, E., Di Sebastiano, G., Trianni, A., 2018. Industrial sustainability: modelling

drivers and mechanisms with barriers. J. Clean. Prod. 194, 452–472. https://doi.org/https://doi.org/10.1016/j.jclepro.2018.05.140

Neri, A., Cagno, E., Lepri, M., Trianni, A., 2021. A triple bottom line balanced set of Key Performance Indicators to measure the sustainability performance of industrial supply chains. Sustain. Prod. Consum. 26, 648–689. https://doi.org/https://doi.org/10.1016/j.spc.2020.12.018

Nesbit, M., Filipova, T., Stainforth, T., Nyman, J., Lucha, C., Best, A., Stockhaus, H., Stec, S., 2019. Development of an assessment framework on environmental governance in the EU Member States. https://doi.org/10.2779/299476

Nikolaou, I.E., Tsalis, T.A., 2013. Development of a sustainable balanced scorecard framework. Ecol. Indic. 34, 76–86. https://doi.org/10.1016/j.ecolind.2013.04.005

Nobrega, J.H.C., Pio, P.G.C., Fernandes, G.L., Botêlho, S.T., Araujo, T.C., Anholon, R., Ordóñez, R.E.C., Rampasso, I.S., Leal Filho, W., Quelhas, O.L.G., 2019. Sustainability in manufacturing processes: practices performed in metal forming, casting, heat treatment, welding and electrostatic painting. Int. J. Sustain. Dev. World Ecol. 26, 684–697. https://doi.org/10.1080/13504509.2019.1655111

O'Regan, N., Ghobadian, A., 2004. Testing the homogeneity of SMEs. Eur. Bus. Rev. 16, 64–77. https://doi.org/10.1108/09555340410512411

Orji, I.J., 2019. Examining barriers to organizational change for sustainability and drivers of sustainable performance in the metal manufacturing industry. Resour. Conserv. Recycl. 140, 102–114. https://doi.org/10.1016/j.resconrec.2018.08.005

Pagell, M., Gobeli, D., 2009. How plant managers' experiences and attitudes toward sustainability relate to operational performance. Prod. Oper. Manag. 18, 278–299. https://doi.org/10.1111/j.1937-5956.2009.01050.x

Paletta, A., Fava, F., Ubertini, F., Bastioli, C., Gregori, G., Camera, F. La, Douvan, A.R., 2019. Universities, industries and sustainable development: Outcomes of the 2017 G7 Environment Ministerial Meeting. Sustain. Prod. Consum. 19, 1–10. https://doi.org/10.1016/j.spc.2019.02.008

Palmaccio, M., Dicuonzo, G., Belyaeva, Z.S., 2021. The internet of things and corporate business models: A systematic literature review. J. Bus. Res. 131, 610–618. https://doi.org/10.1016/j.jbusres.2020.09.069

Pande, B., Adil, G.K., 2021. Assessment of the current state of sustainability in a manufacturing firm. Int. J. Product. Perform. Manag. https://doi.org/10.1108/IJPPM-04-2020-0151

Panwar, R., Nybakk, E., Hansen, E., Pinkse, J., 2017. Does the Business Case Matter? The Effect of a Perceived Business Case on Small Firms' Social Engagement. J. Bus. Ethics 144, 597–608. https://doi.org/10.1007/s10551-015-2835-6

Paolucci, V., Galetto, M., 2020. The collective bargaining of flexicurity: A case for sector-level analysis? The Italian chemical and metalworking sectors compared. Hum. Resour. Manag. J. 30, 165–179. https://doi.org/10.1111/1748-8583.12255

Park, H., Kim, Y.K., 2016. Proactive versus reactive apparel brands in sustainability: Influences on brand loyalty. J. Retail. Consum. Serv. 29, 114–122. https://doi.org/10.1016/j.jretconser.2015.11.013

Pathak, P., Singh, M.P., Badhotiya, G.K., Chauhan, A.S., 2021. Identification of Drivers and Barriers of Sustainable Manufacturing BT - Optimization Methods in Engineering, in: Tyagi, M., Sachdeva, A., Sharma, V. (Eds.), . Springer Singapore, Singapore, pp. 227–243. https://doi.org/http://doi-org-443.webvpn.fjmu.edu.cn/10.1007/978-981-15-4550-4_14

Pekovic, S., 2015. Quality and environmental management practices: Their linkages with safety performance. Prod. Plan. Control 26, 895–909. https://doi.org/10.1080/09537287.2014.996623

Peters, G.F., Romi, A.M., Sanchez, J.M., 2019. The Influence of Corporate Sustainability Officers on Performance. J. Bus. Ethics 159, 1065–1087. https://doi.org/10.1007/s10551-018-3818-1

Pflitsch, G., Radinger-Peer, V., 2018. Developing Boundary-Spanning Capacity for Regional Sustainability Transitions—A Comparative Case Study of the Universities of Augsburg (Germany) and Linz (Austria). Sustainability 10, 918. https://doi.org/10.3390/su10040918

Ribeiro-Soriano, D., 2017. Small business and entrepreneurship: their role in economic and social development. Entrep. Reg. Dev. 29, 1–3. https://doi.org/10.1080/08985626.2016.1255438

Rohdin, P., Thollander, P., Solding, P., 2007. Barriers to and drivers for energy efficiency in the Swedish foundry industry. Energy Policy 35, 672–677. https://doi.org/10.1016/j.enpol.2006.01.010

Rosemberg, A., 2015. Sustainable industrial transformation: For whom and where to start? Development 58, 540–548. https://doi.org/10.1057/s41301-016-0040-2

Russo, A., Tencati, A., 2009. Formal vs. informal CSR strategies: Evidence from italian micro, small, medium-sized, and large firms. J. Bus. Ethics 85, 339–353. https://doi.org/10.1007/s10551-008-9736-x

Sáez-Martínez, F., Díaz-García, C., González-Moreno, Á., 2016. Factors Promoting Environmental Responsibility in European SMEs: The Effect on Performance. Sustainability 8, 898. https://doi.org/10.3390/su8090898

Saldana, J., 2009. The coding manual for qualitative researchers. SAGE, Los Angeles, CA.

Santini, C., Cavicchi, A., Casini, L., 2013. Sustainability in the wine industry: key questions and research trends. Agric. Food Econ. 1, 9. https://doi.org/10.1186/2193-7532-1-9

Sarkis, J., Gonzalez-Torre, P., Adenso-Diaz, B., 2010. Stakeholder pressure and the adoption of environmental practices: the mediating effect of training. J. Oper. Manag. 28, 163–176. https://doi.org/10.1016/j.jom.2009.10.001

Satterfield, M.B., Kolb, C.E., Peoples, R., Adams, G.L., Schuster, D.S., Ramsey, H.C., Stechel, E., Wood-Black, F., Garant, R.J., Abraham, M.A., 2009. Overcoming nontechnical barriers to the implementation of sustainable solutions in industry. Environ. Sci. Technol. 43, 4221–4226. https://doi.org/10.1021/es802980j

Schleich, J., 2009. Barriers to energy efficiency: a comparison across the German commercial and services sector. Ecol. Econ. 68, 2150–2159. https://doi.org/10.1016/j.ecolecon.2009.02.008

Schmidt, J.S., Osebold, R., 2017. Environmental management systems as a driver for sustainability: state of implementation, benefits and barriers in German construction companies. J. Civ. Eng. Manag. 23, 150–162. https://doi.org/10.3846/13923730.2014.946441

SDSN & IEEP, 2019. The 2019 Europe Sustainable Development Report. https://eu-dashboards.sdgindex.org.

Sharma, A., Narula, S.A., 2020. What motivates and inhibits Indian textile firms to embrace sustainability? Asian J. Sustain. Soc. Responsib. 5, 6. https://doi.org/10.1186/s41180-020-0032-8

Sheoran, M., Kumar, D., 2020. Benchmarking the barriers of sustainable consumer behaviour. Soc. Responsib. J. https://doi.org/10.1108/SRJ-05-2020-0203

Silva, M.E., Pereira, S.C.F., Gold, S., 2018. The response of the Brazilian cashew nut supply chain to natural disasters: A practice-based view. J. Clean. Prod. 204, 660–671. https://doi.org/10.1016/j.jclepro.2018.08.340

Soepardi, A., Pratikto, P., Santoso, P.B., Tama, I.P., Thollander, P., 2018. Linking of barriers to energy efficiency improvement in Indonesia's steel industry. Energies 11, 1–23. https://doi.org/10.3390/en11010234

Sousa, R., Voss, C.A., 2008. Contingency research in operations management practices. J. Oper. Manag. 26, 697–713. https://doi.org/10.1016/j.jom.2008.06.001

Stock, T., Obenaus, M., Kunz, S., Kohl, H., 2018. Industry 4.0 as enabler for a sustainable development: A qualitative assessment of its ecological and social potential. Process Saf. Environ. Prot. 118, 254–267. https://doi.org/10.1016/j.psep.2018.06.026

Sudhakara Reddy, B., Assenza, G.B., Assenza, D., Hasselmann, F., 2014. Erratum: Barriers and drivers to energy efficiency - A new taxonomical approach (Energy Conversion and Management (2013) 74 (403-416)). Energy Convers. Manag. 86, 1193. https://doi.org/10.1016/j.enconman.2014.06.077

Sy, M.V.U., 2014. Drivers of corporate social responsibility leading to sustainable development. Ind. Eng. Manag. Syst. 13, 342–355. https://doi.org/10.7232/iems.2014.13.3.342

Tanco, M., Kalemkerian, F., Santos, J., 2021. Main challenges involved in the adoption of sustainable manufacturing in Uruguayan small and medium sized companies. J. Clean. Prod. 293, 126139. https://doi.org/10.1016/j.jclepro.2021.126139

Thakhathi, A., le Roux, C., Davis, A., 2019. Sustainability Leaders' Influencing Strategies for Institutionalising Organisational Change towards Corporate Sustainability: A Strategy-as-Practice Perspective. J. Chang. Manag. 19, 246–265. https://doi.org/10.1080/14697017.2019.1578985

Thollander, P., Backlund, S., Trianni, A., Cagno, E., 2013. Beyond barriers – A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden. Appl. Energy 111, 636–643. https://doi.org/10.1016/j.apenergy.2013.05.036

Thollander, P., Ottosson, M., 2008. An energy efficient Swedish pulp and paper industry – exploring barriers to and driving forces for cost-effective energy efficiency investments. Energy Effic. 1, 21–34. https://doi.org/10.1007/s12053-007-9001-7

Thollander, P., Palm, J., 2015. Industrial Energy Management Decision Making for Improved Energy Efficiency—Strategic System Perspectives and Situated Action in Combination. Energies 8, 5694–5703. https://doi.org/10.3390/en8065694

Tremblay, A., Badri, A., 2018. A novel tool for evaluating occupational health and safety performance in small and medium-sized enterprises: the case of the Quebec forestry/pulp and paper industry. Saf. Sci. 101, 282–294. https://doi.org/10.1016/j.ssci.2017.09.017

Trianni, A., Accordini, D., Cagno, E., 2020. Identification and Categorization of Factors Affecting the Adoption of Energy Efficiency Measures within Compressed Air Systems. Energies 13, 5116. https://doi.org/10.3390/en13195116

Trianni, A., Cagno, E., Marchesani, F., Spallina, G., 2017a. Classification of drivers for industrial energy efficiency and their effect on the barriers affecting the investment decision-making process. Energy Effic. 10, 199–215. https://doi.org/10.1007/s12053-016-9455-6

Trianni, A., Cagno, E., Neri, A., 2017b. Modelling barriers to the adoption of industrial sustainability measures. J. Clean. Prod. 168, 1482–1504. https://doi.org/10.1016/j.jclepro.2017.07.244

Trianni, A., Cagno, E., Neri, A., Howard, M., 2019. Measuring industrial sustainability performance: Empirical evidence from Italian and German manufacturing small and medium enterprises. J. Clean. Prod. 229, 1355–1376. https://doi.org/https://doi.org/10.1016/j.jclepro.2019.05.076

Turcotte, M.-F., Reinecke, J., den Hond, F., 2014. Explaining variation in the multiplicity of private social and environmental regulation: a multi-case integration across the coffee, forestry and textile sectors. Bus. Polit. 16, 151–189. https://doi.org/DOI: 10.1515/bap-2012-0016

United Nations, 2015. Transforming our World: The 2030 Agenda for Sustainable Development. https://sustainabledevelopment.un.org/post2015/transformingourworld.

Van Boxstael, A., Meijer, L.L.J., Huijben, J.C.C.M., Romme, A.G.L., 2020. Intermediating the energy transition across spatial boundaries: Cases of Sweden and Spain. Environ. Innov. Soc. Transitions 36, 466–484. https://doi.org/10.1016/j.eist.2020.02.007

Velte, P., Stawinoga, M., 2020. Do chief sustainability officers and CSR committees influence CSR-related outcomes? A structured literature review based on empirical-quantitative research

findings. J. Manag. Control 31, 333–377. https://doi.org/10.1007/s00187-020-00308-x
Verband der Chemischen Industrie, 2012. The German Chemical Industry in 2030. https://www.vci.de/vci-online/services/publikationen/broschueren-faltblaetter/vci-prognos-study-the-german-chemical-industry-2030-update-2015-2016.jsp.
Vieira, L.C., Amaral, F.G., 2015. Barriers and strategies applying cleaner production: a systematic review. J. Clean. Prod. 113, 5–16. https://doi.org/10.1016/j.jclepro.2015.11.034
Virmani, N., Bera, S., Kumar, R., 2020. Identification and testing of barriers to sustainable manufacturing in the automobile industry: a focus on Indian MSMEs. Benchmarking 28, 857–880. https://doi.org/10.1108/BIJ-08-2020-0413
Wagner, M., Llerena, P., 2008. Drivers for Sustainability-Related Innovation: A Qualitative Analysis of Renewable Resources, Industrial Products and Travel Services (No. 22). Strasbourg.
Walsh, C., Thornley, P., 2012. Barriers to improving energy efficiency within the process industry with a focus on low grade heat utilisation. J. Clean. Prod. 23, 138–146. https://doi.org/10.1016/j.jclepro.2011.10.038
Wang, X., Lin, H., Weber, O., 2016. Does Adoption of Management Standards Deliver Efficiency Gain in Firms' Pursuit of Sustainability Performance? An Empirical Investigation of Chinese Manufacturing Firms. Sustainability 8, 694. https://doi.org/10.3390/su8070694
Wiengarten, F., Humphreys, P., Onofrei, G., Fynes, B., 2017. The adoption of multiple certification standards: perceived performance implications of quality, environmental and health & safety certifications. Prod. Plan. Control 28, 131–141. https://doi.org/10.1080/09537287.2016.1239847
Wijethilake, C., 2017. Proactive sustainability strategy and corporate sustainability performance: The mediating effect of sustainability control systems. J. Environ. Manage. 196, 569–582. https://doi.org/10.1016/j.jenvman.2017.03.057
Yadav, N., Gupta, K., Rani, L., Rawat, D., 2018. Drivers of Sustainability Practices and SMEs: A Systematic Literature Review. Eur. J. Sustain. Dev. 7, 531–544. https://doi.org/10.14207/ejsd.2018.v7n4p531
Yin, S., Zhang, N., Li, B., 2020. Enhancing the competitiveness of multi-agent cooperation for green manufacturing in China: An empirical study of the measure of green technology innovation capabilities and their influencing factors. Sustain. Prod. Consum. 23, 63–76. https://doi.org/10.1016/j.spc.2020.05.003
Zeng, S.X., Tian, P., Tam, C.M., 2007. Overcoming barriers to sustainable implementation of the ISO 9001 system. Manag. Audit. J. 22, 244–254. https://doi.org/10.1108/02686900710733125

Appendix A

Details of the protocol used for the conduction of the semi-structured interviews and of the different multiple sources of evidence.

Source of Evidence 1. Semi-structured interview	
General questions	• Interviewee/s introduction (role within the firm, interests, background, experience) • Firm's description (turnover, employees, sector)
Products and processes	• What products do you produce? • What production process activities do you perform?
Sustainability	• How do you define sustainability within your firm? • Who is in charge of sustainability within your firm? • How is sustainability managed within your firm? • What certifications related to sustainability does your firm own?
Barriers and Drivers to the adoption of Industrial Sustainability Measures	*After having defined the concepts of barriers; drivers; industrial sustainability measure* • What are the main barriers that hinder the adoption process of industrial sustainability measures in your firm? • What are the main drivers that can foster the adoption process of industrial sustainability measures in your firm? *To stimulate the discussion:* • What actions/interventions did you adopt towards increased sustainability in your firm? • What barriers and drivers affected the adoption process of these measures?
Source of Evidence 2. Field notes	
Field notes – semi-structured interview	Field notes collected during the conduction of the semi-structured interview within the firms (descriptive and reflective).
Source of Evidence 3. Secondary data	
Firm's website	General firm's information; certifications; sustainability reports and initiatives.
News and press	News related to the firm, also in terms of initiatives toward enhanced sustainability

Appendix B

Complete details of the link between the different barriers and drivers as addressed by interviewees – Code (Phase 1), and as coded in the analysis - Code (Phase 2). The table reports only the barriers and drivers emerged from the empirical analysis.

	Code (Phase 2)	Code (Phase 1)
Barriers	Bureaucracy	*"**Bureaucracy*** and the associated costs"
		"Too much ***bureaucracy***, it is a major issue"
		"***Bureaucracy***"
		"Research projects, in particular, are associated with a ***large number of forms***, but that has to be the case, there is no getting around it"
		"You can of course complain about ***bureaucracy***; it is an obstacle, but you have to face it"
		"We have ***bureaucracy*** in Germany"
		"I wouldn't say ***bureaucracy***"
		"Regulatory barriers are the most relevant, especially ***bureaucracy***"
		"As for the external barriers certainly ***bureaucracy***"
		"The ***bureaucracy*** is crashing me […] the bureaucracy is crazy"
		"The barriers entail a dystonia between the firm's needs and the ***public administration issues***"
		"I would say spontaneously that the ***authorities*** stand in the way"
		"Mainly I think that ***bureaucracy*** and costs are the biggest barriers"
		"Since the advent of REACH, there are people who do ***paperwork*** and others who actually work only on products and services"
		"From a ***legislation perspective, there is no difference***. But we are not comparable to a multinational enterprise, and we clash with the ***bureaucracy*** that for us is extremely heavy we need to spend a million of € just in ***paperwork"***
	Customer not ready /Lack of demand	"***Customers do not want*** this type of innovation"
		"Sure, we can suggest products, but customers have to try them out and ***customers have far too little time or interest or motivation***"
	Lack of time	"Especially the creation of documentation [...] is associated with an ***enormous amount of*** personnel, ***time***, and so on"
		"The ***time*** is of course a large factor"
		"But of course, on the one hand, there is the ***time***"
		"Of course, you could have ***more time***"
		"Research projects are associated with many forms [...] This is ***very time-consuming***"
		"Certainly, the ***resources available to the company,*** because sustainability policies are more feasible in structured companies"
		"The cost and the ***resources to be used*** are certainly barriers. It is necessary to have the economic possibility of being able to dedicate ***resources*** to be able to implement aspects of sustainability"
		"In any case, we do not have all the ***resources*** to be able to implement all the points of the development goals"
		"The REACH is easier to be respected by multinational enterprises, that have ***resources*** and employees ***to dedicate to it***"
		"The management costs in ***terms of resources*** are considerable"
		"We face a mix of internal barriers as ***lack of time*** and staff"
	Lack of staff	"***Staff recruitment*** is difficult"
		"Organizational barriers are the ones that weigh the most, we do not have the ***staff*** to implement sustainability"
		"Certainly, the ***resources available to the company,*** because sustainability policies are more feasible in structured companies"
		"The cost and the ***resources*** to be used are certainly barriers. It is necessary to have the economic possibility of being able to dedicate ***resources*** to be able to implement aspects of sustainability"
		"Especially the creation of documentation [...] is associated with an ***enormous amount of personnel***, time, and so on"
		"Definitely the lack of ***staff,*** because we are a small company […] in any case we do not have all the ***resources*** to be able to implement all the points of the development goals"
		"The REACH is easier to be respected by multinational enterprises, that have resources and ***employees to dedicate to it***"
		"We do have a ***lack of internal personnel"***
		"The management costs in ***terms of resources*** are considerable"
		"We face a mix of internal barriers as ***lack of*** time and ***staff***"

	Commitment/ Awareness (Management)	"Also, sometimes ***we do not know*** what we could do"
		"Also the ***mindset of the firm*** needs to change a bit, the ***management*** is missing it"
		"Major barriers for our development are related to the ***internal organization***"
		"The ***awareness*** is one of the main barriers within our firm"
		"The first problem is the ***awareness***"
		"Who manages the firm should believe in sustainability, but many entrepreneurs don't know or ***are not interested in it***"
		"First of all, the ***manager has to believe*** it"
	Expertise (Management)	"Also, sometimes ***we do not know*** what we could do"
		"Many ***entrepreneurs don't know***"
	Awareness (Employees)	"The ***conviction of the employees*** is an important point"
		"Another barrier is internal since sustainability is ***not perceived by employees***"
		"I think it's just the lack of internal rules that govern employees' behaviour. Of course, this must be accompanied by a ***sense of sustainability among all employees***, otherwise, the internal rules may not be respected or strongly felt part of the regulation"
		"As for the ***employees*** it really ***depends, there are those that are more proactive*** and have a sense of belonging with the firms, ***and there are the others***"
		"The ***awareness*** is one of the main barriers within our firm"
		"The first problem is the ***awareness***"
		"Major barriers for our development are related to the ***internal organization***"
		"Also, sometimes ***we do not know*** what we could do"
	Incorrect behaviour (Employees)	"I think it's just the ***lack of internal rules that govern employees' behaviour.*** Of course, this must be accompanied by a sense of sustainability among all employees, otherwise, the internal rules may not be respected or strongly felt part of the regulation"
	Lock in	"Sustainability is always difficult and there are ***technical limits***"
	Limited access to capital	"It is necessary to have the ***economic possibility*** of being able to dedicate resources to be able to implement aspects of sustainability"
		"Certainly, the ***resources available to the company,*** because sustainability policies are more feasible in structured companies"
		"In any case, we do not have all the ***resources*** to be able to implement all the points of the development goals"
		"The REACH is easier to be respected by multinational enterprises, that have ***resources*** and employees ***to dedicate to it***"
	Investment cost	"Most of the time it is about the ***price***"
		"The implementation represents a ***cost*** to the company"
		"As main barriers, I perceived the ***costs*** and the return of the investment in the long period"
		"Mainly the ***high costs*** at the time of installation"
		"Mainly I think that bureaucracy and ***costs*** are the biggest barriers"
		"The ***cost*** and the resources to be used are certainly barriers"
		"The main internal barrier is ***costs***"
		"Mainly ***costs***"
		"Usually, sustainability does not entail a cost reduction, rather it brings to an ***increase of costs***"
		"I believe that ***costs*** are the main internal barrier for the environmental and social issues"
		"As an entrepreneur of a small business, I tell you that: first of all, the ***economic aspect*** is considered"
	Pay-back time	"As main barriers, I perceived the costs and the ***return of the investment in the long period***"
Drivers	Compliance with regulation	"Especially the creation of ***documentation for materials*** […] is increasing rapidly"
		"It is driven by ***legal requirements***"
		"Among the main drivers, there is the ***compliance with regulations***"
		"The ***legislation*** is extremely important"
		"The perspective from which I see it is the ***legal perspective***"
		"The drivers are certainly the ***laws*** and also the customers who require a certain type of product, made with certain characteristics and therefore certified"
		"Another driver may be the ***law*** that requires you to behave in a certain way"
		"The first driver is related to the ***regulation***; our activity is strongly regulated"
		"We are a very peculiar industry: the quality must be aligned with the ***legal requirements***"
		"All our products have an initial stage in their development that puts at the first place the environmental impact […] this is a ***requirement*** and a necessary step"
		"We must be compliant with a series of ***laws that intrinsically require sustainability***"

Regulatory sanctions and taxes	"We have an energy manager […] they are not a cost because there is attention to the aspects for which you pay ***penalties*** [if you do not pay attention at]"
	"If you give back to the network a deteriorated current or in case of system malfunctions […] you pay ***fines***"
	"For example, we rebuilt the roof in 2009, because it was made of Eternit and the law requires it to be disposed of also to avoid ***penalties***"
	"Use and disposal of substances are clearly regulated and must also be ***documented*** [to avoid sanctions]"
	"Well, we have targets we have to be adhered to [to avoid sanctions]"
External funding	"In Italy, there are a lot of calls and competitions that can help you get ***facilitations***"
	"We took advantage of the ***incentives*** that existed at the time for solar panels"
	"We have recently also received an ***award*** [for sustainability]"
Public subsidies	"***Tax incentives*** for sure, but also long-term savings"
	"In Italy there are a lot of calls and competitions that can help you get ***facilitations***"
	"On the other hand, as regards the ***tax advantages***, I think that the hyper-amortization is very useful"
Customers' pressures	"Generally, there are ***customers who value*** it and demand that we do something in this direction"
	"Many ***customers*** now ***value*** having an environmental certificate, for example"
	"So it is the case with ***customers,*** certifications are ***required***"
	"Depending on the market, some ***customers want*** something like that"
	"The drivers are certainly the laws and also the ***customers who require*** a certain type of product, made with certain characteristics and therefore certified"
	"It is driven by the ***external requests from the customer***"
	"Certifications are usually ***required by customers***"
	"Another important driver is the ***requests from the customer***, that foster investment"
Partners' pressures	"***Partners*** are important, as they can foster innovation"
Shareholders' pressures	"There is an overall increasing ***general sustainability concern***"
	"I think that's a driver is the ***stakeholders' well-being*** in the long term"
Creating competitive advantage	"Furthermore, sustainability can guarantee a ***competitive advantage*** on the market due to competitive strategies in economic, social and environmental terms"
	"I think the main drivers are the ***competitive advantages*** that sustainability can give you"
	"Sustainability makes us enter the ***championship of companies***, then whether we win it or not depends on us, but if it wasn't there, we wouldn't be in the championship"
Improving firm brand and image	"As a chemical company, we are of course subject to the public eye, and want to constantly ***improve our image***"
	"Of course, we also make sure that we ***look good on the outside***"
	"We try to give a ***secure image*** of our company, this is important"
	"I think the main drivers are the competitive advantage that aspects of sustainability can give you in terms [...] of the ***image*** towards all customers attentive to these issues"
	"The world is moving in this direction and therefore the ***impact of visibility*** is certainly"
	"It is also in ***our interest*** that we act as sustainably as possible, even if it is, of course, difficult to achieve absolute figures in a manufacturing industry"
	"Sustainability is an ***ethical advantage***"
Organizational values and culture	"Customers tend to ask less for things like this [sustainability]. It's more done for ***internal reasons***"
	"Yes, that will be done if ***driven internally***"
	"Already ***the company itself*** is a driver"
	"We try to give a ***secure image*** of our company […] it is something innate in our firm"
	"I think that all the actions taken in this direction are things that ***the company does for itself*** first of all"
	"I have been working here for 25 years and have always recognized myself in the ***company's values***: think global act locally"
Including Sustainability at a strategic level	"We also record ***what we want to improve*** in terms of production ***what goals we want to achieve***. Sometimes you can't really improve old processes, but we try to"
	"It is also a concern of the management and we, for example, ***instruments such as meetings*** that are held regularly, where the wishes and ideas of employees are also incorporated into corporate management"
	"The firm has within itself the ***innate desire to always grow,*** and this could be another important driver"
	"As we are quality management certified, it is of course also a ***constant improvement process*** where ***sustainability issues are taken into account***"
	"Sustainability is one of the first ***fundamental requirements for the development*** of an Italian company"
	"We do not have a widespread definition no, but there is attention as for sustainability issues in decisions and investments that impact the ***strategy in the long term***"

		"Social aspects are taken into ***consideration when decisions have to be made***"
		"The world is moving in this direction [...] it puts the company with a ***positive orientation towards sustainability*** issues"
	Management commitment	"It is driven by ***the management level***"
	Employee commitment	"It is also a concern of the management and we, for example, instruments such as meetings that are held regularly, where the ***wishes and ideas of employees are also incorporated*** into corporate management"
	Cost savings	"If ***energy-economical*** parts [of the investments] are also included, that is, of course, a lot more interesting"
		"The ***savings*** that occur once the investment has been amortized"
		"Once you realize the ***economic benefits*** it brings then you implement it"
		"I think the main drivers are the competitive advantage that aspects of sustainability can give you in terms ***economic advantages***, such as a ***cost reduction***"
		"Tax incentives for sure, but also ***long-term savings***"

1277

Appendix C

Details of the coding performed for Firm 10, Firm 14, and Firm 17.

Theme: General Information

Theme	Categories	Sub-categories	Code (Phase 2)	Code (Phase 1)	Firm 10	Firm 14	Firm 17
General Information	**Sector**	Sector	**Sector**	Sector		"We operate in the chemical sector"	
			Product	Product	"We manufacture products such as fluids for metal processing and oil for drilling and cutting oil components."	"We are specialized in surfactants"	"We started with the fertilizer, and then we moved to pesticides. Now Firm n.d. produces the active principle, we produce the final product".
	Size	Number of employees	**Number of Employees**	Number of Employees	"We are about 35"	"We are about 57 people"	"There are slightly less than 250 employees"
		Turnover	**Turnover**	Turnover	"€ 25 to 50 million would be the level that suits us."	"Last year our turnover was about 50 million €"	"Our turnover is slightly more than 50 million €"
	Certification and Guidelines	Certification	**ISO 9001**	ISO 9001	"We hold the ISO 9001 and an energy management certification"	-	"We are certified ISO 9001 and 14001, and OHSAS 18001. We hold a certification that is very rare in Italy and it is a certification of the safety management system. Hazardous materials must have an appropriate management system, and, in addition, we have decided to have it certified". *All the firms of the Group comply to the* **ISO 9001:2008 certification**. *Firm 17 also complies with* **ISO 14001 certification** *and Safety Management System Certification. The final goal […] is to pursue Quality in every production stage and process, ensuring the best possible products and policies for customers and stakeholders. (Firm's website)*
				Quality Certification		"The quality-related certification has been implemented on our previous approach toward safety […] before getting the quality certification we had internal guidelines for safety" (I1)	
			ISO 14001	ISO 14001			"We are certified ISO 9001 and 14001, and OHSAS 18001. We hold a certification that is very rare in Italy and it is a certification of the safety management system. Hazardous materials must have an appropriate

						management system, and, in addition, we have decided to have it certified". *All the firms of the Group comply to the* **ISO 9001:2008 certification**. *Firm 17 also complies with* **ISO 14001 certification** *and Safety Management System Certification. The final goal […] is to pursue Quality in every production stage and process, ensuring the best possible products and policies for customers and stakeholders. (Firm's website)*
			ISO 50001	Energy Management Certification	"We hold the ISO 9001 and an energy management certification	
			OHSAS 18001	OHSAS 18001		"We are certified ISO 9001 and 14001, and OHSAS 18001. We hold a certification that is very rare in Italy and it is a certification of the safety management system. Hazardous materials must have an appropriate management system, and, in addition, we have decided to have it certified". *All the firms of the Group comply to the* **ISO 9001:2008 certification**. *Firm 17 also complies with* **ISO 14001 certification** *and Safety Management System Certification. The final goal […] is to pursue Quality in every production stage and process, ensuring the best possible products and policies for customers and stakeholders. (Firm's website)*
		Other Standards or Guidelines	**Environmental Standards and Guidelines**	Sustainable Palm Oil Association	"We got recently involved in the RSPO, the Roundtable on Sustainable Palm Oil. It is an association of the far East, gathering firms that use sustainable palm oil, that is palm oil that is grown in plantations not causing deforestation" (I1)	
			Safety Standards and Guidelines	Safety Guidelines	"The quality-related certification has been implemented on our previous approach toward safety […] before getting the quality certification we had internal guidelines for safety" (I1)	

1284

Theme: Sustainability

Theme	Categories	Sub-categories	Code (Phase 2)	Code (Phase 1)	Firm 10	Firm 14	Firm 17
Sustainability	**Definition**	General Definition	**Holistic perspective**	Holistic perspective (three-pillar)	"We see ourselves as a company that works in a sustainable manner"	"Sustainability within our firm is mainly related to the elimination of chemical products and components or the elimination of raw materials that entail environmental or human health issues" (I1)	"Every company must manage its business according to three pillars. The first pillar is profitability; the second is the responsibility towards its employees; the third is the environment" *The Group adheres to the global voluntary initiative Responsible Care, aimed at promoting firms'* **health, safety,** *and* **environmental performance**, *and communicating with stakeholders about their products and processes. Since the first implementation in 1992, the Group has strictly complied with all Responsible Care rules. (Firm's website)*
		Environment pillar	**Environmental sound products and production**	Environmental friendly products	*The focus of the firm is on the development of environmentally friendly products according to the latest technical standards and in compliance with current health and safety regulations. When possible, the firm supports the use of local raw materials and reduce the use of chemistry. (Firm's website)*		"Sustainability is a fundamental concept for the development of the pesticide because it is a very peculiar product. The pesticide must be spread on the soil to kill the insects, but it must not intact the plant. It is thus of fundamental importance that it is sustainable […] Some pesticides as the DDT, mitigated or eliminated the problem of malaria […] but it has a serious environmental persistence and remains in the soil for a long time […] This is a social dilemma for the third world's countries […] Today in Italy we claim and try to the same, but in a way that is compatible with the environment. All our products have an initial stage in their development that puts at the first place the environmental impact […] this is a requirement and a necessary step, as the product must be approved by the Ministry to be commercialized."
				Environmental friendly production		"Sustainability for us is to use sustainable products or palm oil from sustainable plantations" (I1) "Sustainability within our firm is mainly related to the elimination of	"Every company must manage its business according to three pillars. The first pillar is profitability; the second is the responsibility towards its employees; the third is the environment"

					chemical products and components or the elimination of raw materials that entail environmental or human health issues" (I1)	"It is necessary to manage the business in a way that is compatible with the environment"
			Local material	*The focus of the firm is on the development of environmentally friendly products according to the latest technical standards and in compliance with current health and safety regulations. When possible, the firm supports the use of local raw materials and reduce the use of chemistry. (Firm's website)*	"Sustainability for us is to use sustainable products or palm oil from sustainable plantations" (I1)	
	Social pillar	**Occupational Health and Safety**	Employees	"We are therefore also concerned with long-term employee loyalty and a good working atmosphere that is good for the well-being of the employees. It is not ok to work with employees who do not have the necessary satisfaction"		"Every company must manage its business according to three pillars. The first pillar is profitability; the second is the responsibility towards its employees; the third is the environment" "The first community is the one of our employees […] The first project has been the WHP, work health place, launched by the Region, that fostered our employees in taking more healthy life choices, in particular as for the feeding. At the end of the project, we received a certified accreditation from the Region as a workplace in which workers' health is supported […] but we do more, we go into the detail of the specific issues of each worker, suggesting them checkups according to the age and gender […] we also host parties for children, we organize group cycling excursions or soccer matches… taken alone all these actions can seem limited, but all together they make the difference"
			Working environment	"We are therefore also concerned with long-term employee loyalty and a good working atmosphere that is good for the well-being of the employees. It is not ok to work with employees who do not have the necessary satisfaction"		
			Safety	*The focus of the firm is on the development of environmentally friendly products according to*	"We strictly follow the safety requirements for workers. As for sustainability, the discourse is	"It is not only safety and health, but also wellbeing"

				the latest technical standards and in compliance with current health and safety regulations. When possible, the firm supports the use of local raw materials and reduce the use of chemistry. (Firm's website)	milder or let's say less felt. For sustainability, we do not have specific needs. Safety is our number one priority; sustainability is a more philosophic discourse" (I1) "Social sustainability means to try to guarantee the maximum safety level for the employees […] The first thing we focus on when we develop a new product is the safety of the workers, from that, all the other things come like a waterfall […] if something is carcinogen, here it does not enter for sure" (I1) "Sustainability within our firm is mainly related to the elimination of chemical products and components, or the elimination of raw materials that entail environmental or human health issues" (I1)	
			Wellbeing			"It is not only safety and health, but also wellbeing"
		External local stakeholders	Local suppliers			"As for the external stakeholders, we privilege local suppliers, local enterprises with reduced environmental impact"
			Local enterprises			"As for the external stakeholders, we privilege local suppliers, local enterprises with reduced environmental impact"
			Schools			"We also interact with the external community […] we gifted the local school with an electronic whiteboard, we helped in the construction on a square supported by the municipality"
	Economic pillar	**Profit**	Profitability	"The owners are of course interested in increasing the profits"		"Every company must manage its business according to three pillars. The first pillar is profitability; the second is the responsibility towards its employees; the third is the environment"
		Customers	Customer satisfaction		"Economic sustainability is strictly connected to and depends on what customers want; it means to guarantee a good relationship with the customer […] We are not particularly interested in other economic aspects as we do not	*The quality policy guarantees the best levels of customer satisfaction through the provision of the highest quality. (Firm's website)*

						have any liquidity related issues" (I1)	
	Sustainability within the firm	Sustainability approach	**Focus**	General Focus	"We see ourselves as a company that works in a sustainable manner"		"Our firm is perfect for your research. We are a medium enterprise, very focused on environmental issues"
			Concept	Concept		"To some extent the concept needs to be better inserted within the daily activity of the firm, but we have for sure a common and shared care for the environment and safety" (I2)	"Sustainability is a fundamental concept for the development of the pesticide because it is a very peculiar product. The pesticide must be spread on the soil to kill the insects, but it must not intact the plant. It is thus of fundamental importance that it is sustainable […] Some pesticides as the DDT, mitigated or eliminated the problem of malaria […] but it has a serious environmental persistence and remains in the soil for a long time […] This is a social dilemma for the third world's countries […] Today in Italy we claim and try to the same, but in a way that is compatible with the environment. All our products have an initial stage in their development that puts at the first place the environmental impact […] this is a requirement and a necessary step, as the product must be approved by the Ministry to be commercialized."
				Philosophy			"There is an overall and shared sustainability philosophy within the firm"
				Values			"I have been working here for 25 years and I have been always felt aligned with the firm's values […] Think global act local […] For example, in Brazil when we opened the new facility, the authorities asked us to monitor the condition of the river's fauna in the three following years, so we have an expert there doing all the evaluation […] In Italy we haven't reached this level yet, so, as a Group, we think globally but we act according to the local legislations […] We made investments in China, they are still lagging behind but in 10 years they did what we did in 50 years."
			Time Horizon	Long term	"As a small and family-run firm, the son of the actual		

					manager it is expected to take over the company […] it is no sense for the company to only think only over a few years, but also think in the long term." We are therefore also concerned with long-term employee loyalty and a good working atmosphere that is good for the well-being of the employees. It is not ok to work with employees who do not have the necessary satisfaction"		
		Sustainability in practice	**Actions**	Actions	-	*The firm grown always with a special focus on the environment and safety. For the future, the management is aiming at implementing sustainable actions as i) the achievement of specific certification as GMP and GMP Plus; the update on the production plants; iii) the optimization and reduction of by-products; iii) energy efficiency and emissions reduction. (Firm's website)*	*The group signed the principles of* **Environmental Sustainability** *issued by Confindustria. The Group collects yearly an* **Environmental Report** *documenting activities and expenses made towards the protection of the environment and safety, and towards the ensure of a sustainable development framework. (Firm's website)*
			Reporting	Reporting			"Our firm started publishing the environmental report in the 90s, and the firm is sensitive toward sustainability since then"
			Research	Research			*Federichimica recognized the effort of Firm 17 in terms of industrial research for Sustainable Chemistry (https://annuario.federchimica.it/)*
	Manager in charge of sustainability	Sustainability Manager	**HSE Manager**	HSE Manager			"I'm in charge of sustainability as. The health, safety and environmental manager"
		No Sustainability Manager	**Safety manager**	Safety manager		"No, but we have a safety manager"	
			Top Manager	Top Management	"Sustainability is mainly a concern of the top management"		

Theme: Barriers

Codes with a * are based of Trianni et al. (2017b).

Theme	Categories	Sub-categories	Code (Phase 2)	Code (Phase 1)	Firm 10	Firm 14	Firm 17
Barriers	**Barriers originating outside the firm**	Legislation*	**Bureaucracy***	Bureaucracy	"You can of course complain about bureaucracy, there are obstacles, but you have to face them. Yes, we have bureaucracy in Germany, but on the other hand, we have a neutral bureaucracy that is the same for everyone. In other countries, you might have corruption or obstacles that apply to certain groups"	"The most important barriers are for sure related to bureaucracy […] within the chemical sector the most important issue is to be compliant with the REACH, that for us it is extremely burdensome. To be compliant with it we need to spend a million of € just in paperwork […] Theoretically, we have all the information that we need, but meeting the requirements from a practical perspective is a disastrous mess" (I1) "From a legislation perspective there is no difference. But we are not comparable to a multinational enterprise, and we clash with the bureaucracy that for us is extremely heavy" (I1)	
				Public Administration Issue			"The barriers entail a dystonia between the firm's needs and the public administration issues"
				Paperwork		"The most important barriers are for sure related to bureaucracy […] within the chemical sector the most important issue is to be compliant with the REACH, that for us it is extremely burdensome. To be compliant with it we need to spend a million of € just in paperwork […] Theoretically, we have all the information that we need, but meeting the requirements from a practical perspective is a disastrous mess" (I1)	
				Complicated procedure for incentives		"The same applies for incentives: they do exist, but when we discuss on how to practically implement a project the procedure is so complicated that we give up" (I1)	
				Burdensome process		"From a legislation perspective there is no difference. But we are not comparable to a multinational enterprise" (I1)	
	Barriers originating within the firm	Internal Organization	**Organization**	Organization		"Major barriers for our development are related to the internal organization" (I1)	
			Lack of staff*	Employees limited availability		"The REACH is easier to be respected by multinational enterprises, that have resources and employees to dedicate to it" (I1)	

					A great impulse to the growth of the firm derived from the election of the new general manager. They allowed the firm to position within the best firms in the Region and to compete with multinational organizations, characterized by higher availability of resources, as economic budget, or personnel. (Firm's website)
			Lack of internal personnel		"We do have a lack of internal personnel […] we would need a 15-20% additional workforce (I1)
			Resources availability		"The REACH is easier to be respected by multinational enterprises, that have resources and employees to dedicate to it" (I1)
		Lack of time*	Time availability	"Well, we are relatively well-positioned, we have achieved a lot in the last few years. The situation, of course, could be improved if you can have more time"	
			Resources availability		"The REACH is easier to be respected by multinational enterprises, that have resources and employees to dedicate to it" (I1)
	Management	**Management Awareness/ Commitment ***	Mindset of the Management		"Also the mindset of the firm needs to change a bit, the management is missing it" (I2)
	Workers	**Workers awareness***	Proactiveness of workers		"As for the employees it really depends, there are those that are more proactive and have a sense of belonging with the firms, and there are the others…" (I1)
			Commitment of workers		"As for the employees it really depends, there are those that are more proactive and have a sense of belonging with the firms, and there are the others…" (I1)
	Economic	**Limited access to capital***	Limited economic resources		*A great impulse to the growth of the firm derived from the election of the new general manager. They allowed the firm to position within the best firms in the Region and to compete with multinational organizations, characterized by higher availability of resources, as economic budget, or personnel. (Firm's website)*
		Investment cost*	Cost reduction		"Usually, sustainability does not entail a cost reduction, rather it brings to an increase of costs" (I1)

Theme: Drivers

Codes with a * are based of Neri et al. (2018).

Theme	Categories	Sub-categories	Code (Phase 2)	Code (Phase 1)	Firm 10	Firm 14	Firm 17
Drivers	**Drivers originating outside the firm**	Regulation	**Compliance with regulation***	Regulation		"The first driver is related to the regulation; our activity is strongly regulated" (I1)	
				Regulated activity		"The first driver is related to the regulation; our activity is strongly regulated" (I1)	
				Legal requirements			"We are a very peculiar industry: the quality must be aligned with the legal requirements" "All our products have an initial stage in their development that puts at the first place the environmental impact […] this is a requirement and a necessary step, as the product must be approved by the Ministry to be commercialized."
		Customers	**Customers' pressures ***	Request from customers	"Certifications are usually required by customers, but in most cases the ISO 9001 is sufficient. Other certifications are also required, but small-medium enterprises are already considered well equipped only with it. If such a system is present in small companies, it will also cover aspects of environmental protection, product development, avoidance of hazardous substances"	"Another important driver is the requests from the customer, that foster investment" (I1) *The increasing requests from the customers and the market in terms of the highest standards for safety and environmental protection led to an increase commitment of the firm towards sustainability within its production processes. (Firm's website)*	
				Focus on customers' needs			"The focus on the customer is mainly addressed in terms of timeliness and completeness"
	Drivers originating within the firm	Organization	**Improving firm brand and image***	Firm's Image	"As a chemical company, we are of course subject to the public eye, and want to constantly improve our image"		
			Organizational values and culture *	Company's value			"I have been working here for 25 years and have always recognized myself in the company's values: think global act locally"
			Including Sustainability at strategic level *	Goals of improvement	"We also record what we want to improve in terms of production what goals we want to achieve. Sometimes you can't really improve old processes, but we try to"		
				Constant improvement			"As we are quality management certified, it is of course also a constant improvement

				process where sustainability issues are taken into account”
	Management	**Management commitment***	Concern of the management	“It is also a concern of the management and we for example, instruments such as meetings that are held regularly, where the wishes and ideas of employees are also incorporated into corporate management”
	Employees	**Employees’ commitment***	Ideas and suggestions from employees	“It is also a concern of the management and we, for example, instruments such as meetings that are held regularly, where the wishes and ideas of employees are also incorporated into corporate management”

1297