

Industrial Sustainability: Modelling Drivers and Mechanisms with Barriers

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Abstract

Sustainability's relevance is constantly increasing among industrial decision makers, policy-makers and scholars. To improve sustainability performance, firms must adopt industrial sustainability measures. These have been proven to positively impact on overall firm's performance, but their rate of adoption is still low, and barriers to their adoption need to be properly tackled by drivers. This work is based on a review of literature on drivers to sustainability and to the areas of occupational health and safety, eco efficiency, and energy efficiency, and contributes to industrial sustainability research presenting a novel framework of drivers. The framework comprehends a model of drivers and a model of mechanisms: the former encompasses previous literature contributions and aims to characterize drivers for the adoption of measures in all areas of industrial sustainability; the latter aims to evaluate if a driver may tackle specific barrier or boost the action of another driver.

We conducted a preliminary validation of the framework in nine Italian manufacturing firms. Regarding model of drivers, capacity to represent, usefulness and ease of use were evaluated; concerning model of mechanisms usefulness and ease of use were evaluated. Results seem to be sound with an overall positive evaluation of the framework by all the interviewees. Model of drivers was appreciated for its structure and completeness, and for its ability to enhance knowledge and awareness; model of mechanisms was considered useful for properly foster the adoption of a measure within the firm. The framework could be useful for industrial decision makers and policy-makers to better direct resources and efforts to foster the adoption of industrial sustainability measures.

Keywords: Industrial sustainability; Drivers; Barriers; Mechanisms; Measures; Decision-making

1 Introduction

The real need to improve sustainability in industrial activities (Rademaekers et al., 2011) has spurred in recent years the interest of policy-makers and industrial decision makers (IDMs). Even if firms started to include sustainability at a strategic level (Gutowski et al., 2005), current modes of production cannot be considered sustainable, and significant changes are needed, at a technological, managerial, organizational and behavioural level (Blok et al., 2015). The Triple Bottom Line model

(TBL) (Elkington, 1998) identifies sustainability as the intersection of three different pillars, namely economic, environmental and social. In the industrial context, we can refer to corporate sustainability (CS), industrial sustainability (IS) and manufacturing sustainability (MS). Basing on literature, CS is related to strategy (Lozano, 2015), MS to production system (Garetti and Taisch, 2012), while IS refers to an industrial plant level (i.e. not just the production line), and requires actions involving materials, products, processes, plants and production systems (Tonelli et al., 2013), besides an integration with the normal activity of the firm (Evans et al., 2009), for further details, please refer to (Trianni et al., 2017b). For these reasons we defined IS as the research domain of the present study. IS has been often identified by previous literature with the areas of occupational health and safety (OHS) (Charmondusit et al., 2014; De Araujo and Gomes De Oliveira, 2012; Weidema, 2006), and eco efficiency (EcoEff) (Alves and Dumke De Medeiros, 2015; Gimenez et al., 2012; Kleine and Von Hauff, 2009), with a growing relevance of energy efficiency (EnEff) issue within the latter, (Lee, 2015; Pehlken et al., 2015; Tonelli et al., 2013). OHS and EcoEff can be identified using the TBL model respectively as the intersections of social and economic pillars, and environmental and economic pillars (Gimenez et al., 2012; Pagell and Gobeli, 2009).

To improve their sustainability, firms have to adopt measures in all IS areas, i.e. industrial sustainability measure (ISMs), as defined in (Trianni et al., 2017b). Although there is good evidence that such ISMs are effective and can impact positively on firms' performance (Fleiter et al., 2012; Norsiah et al., 2015; Tompa et al., 2009), many firms still struggle with their adoption. OHS is still considered one of the major challenges both for firms and policy-makers (Cagno et al., 2016), and there is a general recognition that the improvement of working conditions is a collective concern, driven by both humanitarian and economic considerations (Eurostat, 2016). The situation is critical also regarding EcoEff and EnEff: industrial sector is among the biggest consumers of resources and producers of waste (Eurostat, 2016). Even if ISMs have shown to positive affect economic and financial performance (Ambec and Lanoie, 2008; Fleiter et al., 2012), their adoption is still actually slow (Anderson and Newell, 2004; Vermeulen and Witjes, 2016).

In addition, industrial firms often care more about the economic impact of ISMs than social or environmental ones. Trade-offs have been largely identified (Salzmann et al., 2005) both between economic and environmental goals, and between economic and social ones (Beckmann et al., 2014; Haffar and Searcy, 2017). In particular, firms usually prioritize economic aspects over the others (Fennema, 2000; Van Der Byl and Slawinski, 2015), particularly in the short term (Lozano et al., 2015): pursuing only economic goals is, however, not enough to deliver long-term sustainability (Dyllick and Hockerts, 2002), for which it is necessary to also leverage on measures able to improve social and/or environmental performances, bringing relevant economic benefits as well (Henri and Journeault, 2009; Tanzil and Beloff, 2006).

The low rate of adoption of ISMs is due to barriers that make firms perceive ISMs as burdensome or unprofitable (Cherniack and Lahiri, 2010; Shi et al., 2008), or requiring too many organizational changes (Smith and Carayon, 2009; Martín-Peña et al., 2014). Barriers to IS and to its specific areas have been largely discussed in literature, and a novel model for barriers to IS has been recently developed by Trianni et al. (2017b). But, along with the barriers, one should understand the drivers that foster firms to adopt ISMs (Sudhakara Reddy et al., 2014), in particular, those that may help firms in implementing ISMs. Drivers can be seen both as the opposite of a barrier (Thollander and Ottosson, 2008) or as a mean to overcome barriers (Cagno et al., 2017). They can be both internal and external in origin, with reference to the firm (Sarkis et al., 2010), promoted by one or more stakeholders, and can influence organization and decision-making process (Trianni et al., 2017a). Taking inspiration from previous research (Trianni et al., 2017a), we can define an IS driver as "a factor promoted by one or more stakeholders, stimulating the adoption of an ISM, influencing a portion of the organization and a part of the decision-making process so to tackle existing barriers". Driver to single areas of IS have been largely discussed in literature, focusing on a specific industrial sector, geographical area or firm's dimension (Govindan et al., 2015; Pransky et al., 1999; Venmans,

2014), but none of these contributions has offered a comprehensive overview on drivers to IS. Indeed, contributions related to IS as a whole, like (Arruda et al., 2013), identify very few drivers and are less structured than contributions related to single areas. Recently, some authors considered the existence of mechanisms between drivers and barriers (Cagno et al., 2017; Trianni et al., 2017a, 2016) and between drivers (Lozano, 2015), while other authors (Cagno et al., 2015) identified also main actors involved in these mechanisms, but a formalization of the latter has not been developed yet.

The present work aims at developing a single, comprehensive framework for drivers to the adoption of ISMs, i.e. a model of drivers and a model of mechanisms between drivers and barriers, as well as between drivers. The model would be of considerable interest as it would underline possible interdependences among the different IS areas and highlight similarities and differences, developing an effective strategy for the identification of drivers fostering the adoption of ISMs; the model of mechanisms would rather capture how and to what extent either drivers are able to overcome or eliminate barriers, by means of mechanisms between drivers and barriers, or to boost the impact of another driver, by means of mechanisms between drivers. It is apparent how an enhanced knowledge of such mechanisms would be essential, on the one hand, for policy-makers to be more effective in designing regulations to improve the sustainability in the industrial sector, on the other hand, for IDMs to develop an improved understanding and awareness when evaluating the adoption of ISMs (Cagno and Trianni, 2014).

The remainder of the paper is structured as follows: in Section 2, literature review is conducted; in Section 3 the new framework, including the model of drivers and the model of mechanisms both between drivers and barriers, and between drivers, is introduced; in Section 4 research methods used for the validation of the model are reported, as well as the procedure for the evaluation of the validity of the model; in Section 5 the results obtained are reported and discussed. Lastly, conclusions are provided in Section 6, along with limitations of the study and possible further research.

2 Literature review

The literature review is divided into two parts. In the first part we briefly recap literature related to barriers to the adoption of ISMs, in the second part we focus on the review of the literature on drivers for the adoption of ISMs.

2.1 Barriers to the adoption of ISMs

Barriers to the adoption of ISMs has been recently discussed in literature by Trianni et al. (2017b). In particular, authors reviewed contributions related to the different areas of IS and to IS in the overall. They underlined that literature referred to single areas of IS had been largely developed. Indeed, for each area, research focused both on theoretical (Cagno et al., 2013; Hasle and Limborg, 2006; Silva Lopes et al., 2013) and empirical studies (Dobes, 2013; Mellor et al., 2011; Schleich, 2009). Moreover, different contexts have been taken into account in all the different areas, i.e. various industrial sectors (Chan, 2008; Okazaki and Yamaguchi, 2011; Whysall et al., 2006), diverse geographical areas (EASHW, 2010; Murillo-Luna et al., 2011; Venmans, 2014), and different firms' sizes (Kostka et al., 2013; Lamm, 1999; Zhang et al., 2009). Despite the considerable number of developed contributions on the topic, Trianni et al. (2017b) underlined that none of these studies offers a comprehensive overview on IS in the overall, pinpointing that research hitherto has been quite limited, as also noticed by Paramanathan et al. (2004). Some authors indeed have evaluated barriers to IS (Arevalo and Aravind, 2011; Frankental, 2001), underlying in particular difficulties in the integration of all the areas (Dyllick and Hockerts, 2002; Van Marrewijk, 2003), but contributions lack of a theoretical underpinning (Paramanathan et al., 2004), and are less structured than those applied to specific IS areas. Another interesting point underlined by Trianni et al. (2017b) is that barriers were addressed only at a general level, so without any reference to specific measures: Cagno and Trianni (2014) and Collins et al. (2010) started to evaluate barriers to specific measures, but they

did it without an integrated approach, focusing respectively only on EnEff or on a different pillar of sustainability at a time.

Summing up, Trianni et al. (2017b) developed a new theoretical model for barriers to IS, underlining possible interdependences among the different IS areas and taking the perspectives of the IDM considering the adoption of ISMs (Cagno et al., 2013; Trianni et al., 2013). Given the novelty of the work by Trianni et al. (2017b), as well as the comprehensive literature review conducted by the authors, we decided to take the proposed model, reported in Table 1, as the reference for this work.

Category	Barrier	Definition
Organization	Lack of time	The firm does not have enough time for the implementation of the intervention
	Lack of staff	The firm does not have enough staff for the implementation of the intervention
	Resistance to change/ Inertia	The organization can be against the change because it leads to a modification in ways of working and in habits
	Attitude/Other priorities	The culture and the values of the firm inhibit the implementation of the interventions. Moreover, the decision making might be focused almost exclusively on core the business activity, thereby focusing mainly on productivity-related interventions.
	Communication	There is a lack of communication or inadequacy of communication between management and workers or between the workers themselves
	Workplace and task	Not considering the workplace (analysis of the workplace, such as hazard exposures) and the tasks (design, pace, repetition, pressure and psychosocial issues) during the implementation of an intervention may have inhibitory consequences
	Organizational system	The firm is a social system influenced by goals, routines, and the organizational structure and is dominated by the decision making. There are several factors related to the company's structure that can hinder interventions.
Management behaviour	Commitment/ Awareness	The manager has no awareness and/or commitment.
	Expertise	The manager lacks adequate management skills with respect to the issue or has limited expertise.
Workers behaviour	Not trained/skilled	A lack of adequate skill or training of the personnel, with respect to a specific intervention area, can hinder the implementation of the intervention.
	Awareness	The staff lacks awareness on the issue and ignores it, which are criticalities of the firm with respect to the issue.
	Involvement	Employees not involved are not given a fair opportunity to take active part in the decision-making and realization process.
	Incorrect behaviour	The adoption of wrong behaviours by the personnel can hinder the implementation of sustainability interventions in cases in which an active participation of the personnel is required
Information	Lack of information	There is a lack of information or inadequacy of the information owned by the firm regarding all the aspects related to intervention implementation.
	Trustworthiness of information sources	There are problems with the trustworthiness of the information sources, and the sources are not adequate.
Technology/ Service	Lock in	The solution is incompatible with the status quo of the system.
Economic	Limited access to capital	The firm does not have sufficient capital for the implementation
	Hidden cost	Investment entails extra costs or the loss of benefits, which are not properly estimated in the investments analysis.
	Risk	There are risks related to the success of the interventions e.g., interruption of production and losses in quality.
	Investments cost	High investments costs prevent firms from implementing sustainability interventions.
	PBT	The intervention is not sufficiently profitable, e.g., with low returns and a long period of time required.

Table 1. The model of barriers to industrial sustainability. Source: Trianni et al. (2017b). For each barrier, a definition is provided.

2.2 Drivers for the adoption of ISMs

We carried out a background analysis of drivers to IS and of the different IS areas, so to obtain a better understanding of the extant literature. We searched for relevant literature querying international databases, i.e. SCOPUS, Google Scholar and ISI Web of Science. We also used snowball method, i.e. starting from a set of selected contributions, we searched for other relevant literature looking at

references and citations of the initial set of selected contributions (Heckathorn and Cameron, 2017; Skolarus et al., 2017; Wohlin, 2014). Regarding keywords, we used combinations of *driver* and similar terms, e.g. *driving force*, *fostering factor*, combined with terms related to the different areas considered, i.e. *IS*, *OHS*, *EcoEff*, *EnEff* (for further details please refer to the specific literature analysis for each area). The first set of contributions obtained (articles, conference proceedings, books, and chapters) was very wide, showing in particular, a soaring importance of the topic in the last ten years. We decided to focus on contributions published in the last 20 years (1997-2017) and written in English, and to eliminate duplicates and contributions related to medicine in terms of surgery, medical operations and nursing. The remaining contributions were submitted to a title and abstract analysis, after which we obtained a deriving set of 152 contributions. This set was then submitted to a further refinement by a complete analysis of the text. In the end, 68 contributions were considered. In Table 2 contributions considered for the literature background analysis for each area are reported. In the following sections, we reported one reference for each driver identified in literature. The full list of references can be found in Table A1 of the Appendix.

Authors and Year	Journal	Type of study	Organization of drivers	Context	Main findings
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Authors and Year	Journal	Type of study	Organization of drivers	Context	Main findings
Azapagic and Perdan, 2000	Trans IChemE	T	Listed	-	Public opinion, improving firm's image, adoption of certification
Gabzdyllova et al., 2009	Journal of Cleaner Production	E	Ranked	Wine industry; New Zealand	Environmental Values, Commitment, Product quality
Collins et al., 2010	Business Strategy and the Environment	E	Ranked	New Zealand	Internal: Values and beliefs, Employees, Shareholders, Parent firm External: Customers, Government (local and central), Competitors, Pressure groups
Koho et al., 2011	International Symposium on Assembly and Manufacturing 2011	E	Ranked	Spain	Business strategy; Values; Top management support
Arruda et al., 2013	Sustainability	E	Ranked	Heavy construction industry; Les; Brazil	Changes in production standards, economic globalization, contractor demands and environmental laws.
Santini et al., 2013	Agricultural and Food Economics	T	Listed	-	Institutions, associations, regulators and market demand; Entrepreneurs and top management; Sustainability and strategy
Bocken et al., 2014	Journal of Cleaner Production	T	Listed	-	Technology advancement, Level of innovation, Systems perspective, Innovative approaches to collaboration, Education and Awareness
Kara et al., 2014	Journal of Manufacturing Technology Management	E	Presented	OEM, ETM, Recycling; Asia, Australia, EU, USA	Firm image, Environmental responsibility, Long term market, Economic benefits, Legislation
Klewitz and Hansen 2014	Journal of Cleaner Production	T	Listed	-	Values of owner-manager (and staff), Environmental regulation, Pressure groups, Reputation, talent attraction, New consumer/consumer needs
Schrettle et al., 2014	International Journal of Production Economics	T	Grouped	-	Exogenous: Environmental regulation, Societal values and norms, Market drivers Endogenous: Culture, Strategy, Resources
Sy, 2014	Industrial Engineering and Management Systems	E	Presented	Philippines and Thailand	Economic responsibility, Legal responsibility, Environmental responsibility
Fonseca, 2015	Sustainability	E	Ranked	Portugal	Internal context, external context, stakeholder orientation, managers' satisfaction
Kuksayrac, 2015	Journal of Cleaner Production	E	Ranked	Turkey	Research and development, education and training, education and standards
Lijo and Gopalakrishnan, 2015	World Journal of Science, Technology and Sustainable Development	T/E	Grouped	-	Long term customer relationship, resource scarcity, product stewardship, ecological responsibility, long term selection of technology, image, brand, social identity for the firm
Lozano, 2015	Corporate Social Responsibility and the Environmental Management	T/E	Listed	-	Internal: Proactive leadership, Business case, Firm's culture External: Reputation, Customers demand and expectations, Regulations and legislation
Merli et al., 2015	Sustainability	E	Ranked	Italy	Improving image, increasing employee satisfaction, obtaining competitive advantages (SMEs ad LEs), Attracting new customers (Micros)
Lloret, 2016	Journal of Business Research	E	Ranked	Mexico	Firm reputation, new market opportunities, cost saving, brand
Suriyankietkaew and Avery, 2016	Sustainability	E	Ranked	SMEs, Thai	Amicable labour relations, valuing employees, social responsibility, strong and shared vision

Authors and Year	Journal	Type of study	Organization of drivers	Context	Main findings
Pransky et al., 1999	Ergonomics	T/E	Listed	Manufacturing, LEs, USA	Incentive programmes
Tait and Walker, 2000	Journal of Safety Research	E	Ranked	UK	Awards, Lead to increasing motivations and further investment in health and safety
ENWHP, 2001	Report	E	Ranked	SMEs, Europe	Integrate workplace health issues in the daily management practices, Involvement of employees, Exemplary leadership behaviour
Antonsson et al., 2002	Report	E	Ranked	SMEs, Sweden	Support network, tailored legislation, intermediaries
Roy et al., 2003	Conference	E	Ranked	Canada	Knowledge, Collaboration with network of companies
Vecchio-Sadus and Griffiths, 2004	Safety Science	T/E	Grouped	Australia	Synergies between OHS and business and proactivity, Communication, Reward and recognition
Walker and Tait, 2004	Safety Science	E	Ranked	SMEs, UK	External support (intermediaries), Training program for SMEs, Collaboration with others stakeholders
Gangwar and Goodrum, 2005	Construction Management and Economics	E	Ranked	Construction industry, USA	Incentive awards, Individual personal motivation
Hasle and Limborg, 2006	Industrial Health	T	Listed	SMEs	External support (intermediaries, unions, authorities, companies), Dialogue
Kogi, 2006	Industrial Health	E	Ranked	SMEs, Asia	Participation, Communication

	Vecchio-Sadus, 2007	Safety Science Monitor	T/E	Listed	Australia	Communication
	Sims, 2008	Thesis dissertation	T/E	Grouped	-	External incentives, Management attitude, Organization
	Miller and Haslam, 2009	Safety Science	E	Ranked	UK	Business case approach, concern about corporate responsibility and reputations, legal compliance
	Hale et al., 2010	Safety Science	E	Ranked	-	Culture, Communication, Motivation
	Cagno et al., 2011	Safety Science	E	Ranked	SMEs	Collaboration, ICT tools
	Cagno et al., 2016	Safety Science	T/E	Listed	-	External support of consultants Knowledge of effective interventions, ICT tools, Collaboration with networks

EcoEff	Van Hemel and Cramer, 2002	Journal of Cleaner Production	T/E	Grouped	SMEs, Holland	External: Customer demands, government regulation, Suppliers development Internal: Environmental benefit, cost reduction, image improvement
	Del Río González, 2005	Business Strategy and the Environment	E		Pulp and paper, Spain	Improving image, regulatory requirements, management commitment
	Ekins, 2005	Journal of Industrial Ecology	T	Listed	-	Voluntary company's action and public policy
	Altham, 2007	Journal of Cleaner Production	E	Ranked	Australia, SMEs	Economic benefits, maintaining licence to operate
	Masurel, 2007	Business Strategy and the Environment	E	Ranked	Printing, SMEs, Holland	Improving working conditions, Legislation, Moral Duty
	Fernandez-Viné et al., 2010	Journal of Cleaner Production	T/E	Grouped	Food, chemical, textile, wood, paper, SMEs, Venezuela	Market pressure, economic taxes, legal requirements
	Santolaria et al., 2011	Journal of Cleaner Production	T/E	Listed	SMEs and LEs, Spain	Environmental impact reduction, energy efficiency, marketing and brand value, legislation adjustment
	Dagilūūtė and Juknys, 2012	Journal of Cleaner Production	E	Ranked	Lithuania	Market economy, Modern technologies, Increased in energy price
	Brammer et al., 2012	Business strategy and the Environment	E	Ranked	Extractive, metals and engineering, chemicals, printing and paper and timber sectors, SMEs, UK	Legislative compliance, Long term financial benefits, Customer pressure
	Fernandez-Viné et al., 2013	Journal of Cleaner Production	T/E	Grouped	Manufacturing, SMEs, Venezuela	Decreasing costs, improving the quality of products, legislation
	Mittal et al., 2013	Conference Proceeding, 20th CIRP International Conference	T/E	Listed	India and Germany	Legislation, cost savings, top management commitment
	De Medeiros et al., 2014	Journal of Cleaner Production	T/E	Grouped	Experts in product development	R&D, marketing and production integration, Stakeholder, integration (suppliers, universities, environment specialists, etc.), Customer expectation fulfilment and Knowledge about factors that drive sustainable buying
	Govindan et al., 2015	Journal of Cleaner Production	T/E	Listed	Chemical, Food, Iron and Steel, Automotive components, Textile, Paper, Electrical, LEs, India	Compliance with regulation, stakeholders, customers
	Mittal and Sangwan, 2015	Journal of Multi-Criteria Decision Analysis	E	Ranked	Different perspectives; government, industry experts	Competitiveness, Incentives, Organizational resources

EnEff	De Groot et al., 2001	Energy Economics	E	Ranked	Netherlands	Reduction of cost, Green image, Investment subsidies
	Anderson and Newell, 2004	Resource and Energy Economics	E	Ranked	Manufacturing, SMEs, USA	Publicly financed energy audits
	Rohdin and Thollander, 2006	Energy	E	Ranked	Non-energy intensive Manufacturing, Sweden	Long term strategy, Increasing in energy price, Commitment
	Thollander et al., 2007	Energy Policy	E	Ranked	Manufacturing, SMEs, Sweden	Long term strategy, Commitment, Environmental company profile
	Rohdin et al., 2007	Energy Policy	E	Ranked	Foundry, Sweden	Long term strategy, Commitment, Environmental company profile
	Thollander and Ottosson, 2008	Energy Efficiency	E	Ranked	Pulp and paper, Sweden	Cost reduction, Commitment, Long term strategy
	Hasanbeigi et al., 2010	Energy Efficiency	E	Ranked	Textile industry, Cement industry, Thai	Reducing costs (related also to Increasing in energy price), Improving staff Health and Safety, Improving product quality
	Ren, 2009	Journal of Engineering and Technology Management	E	Ranked	Petrochemical, OECD	Cost reduction, Fierce competition, Commitment
	Apeaning and Thollander, 2013	Journal of cleaner Production	E	Ranked	Industrial, Ghana	Cost reduction, Rising in energy prices, Government compliance
	Cagno and Trianni, 2013	Applied Energy	E	Ranked	Manufacturing, Italy	Allowances or public financing, External pressures, Long-term benefits
	Thollander et al., 2013	Applied Energy	E	Ranked	Foundry, Finland, France, Germany, Italy, Poland, Spain, Sweden	Financial, Organizational, External
	Brunke et al., 2014	Journal of cleaner Production	E	Ranked	Iron and Steel, Sweden	Cost reduction, Management commitment, Long term strategy
	Sudhakara Reddy et al., 2014	Energy Conservation and Management	T	Listed	-	Awareness, decrease in technology price, increase in energy price, technology appeal, non-energy benefits, environmental regulation
	Venmans, 2014	Journal of cleaner Production	E	Ranked	Ceramic sector, Cement sector, Lime sector, SMEs-LEs, Belgium	Cost reduction, Management commitment, Environmental image
	Lee, 2015	Sustainable Development	E	Ranked	Steel industry, Korea	Cost savings, Demand from owner, Energy tax
	Sathitbun-anan et al., 2015	Energy Efficiency	E	Ranked	Sugar industry, SMEs-LEs, Thai	Green image, Reducing energy, Subsidies
	Trianni et al., 2016	Energy Efficiency	T	Grouped	Industrial	Regulatory, Economic, Informative

Table 2. Drivers literature review. The table reports all the contributions considered in the literature review for each area (i.e. IS, OHS, EcoEff, EnEff). The table is organized in order to provide, for each contribution, the followings: i) *Authors and year*; ii) *Journal*; iii) *Type of study*: theoretical (authors develop a theoretical model without any empirical application), empirical (authors provide an

empirical application, e.g. case studies, survey, of a model developed in another contribution) or both of them (authors develop a theoretical model and provide an empirical application on it), according to the distinction already made in (Martín-Peña et al., 2014; Murillo-Luna et al., 2011; Seuring, 2013); iv) *Organization of drivers*, i.e. the way in which drivers are presented in the study: listed (presented as a list), grouped (organized in categories), ranked (ranked according to their relevance); v) *Context*: geographical areas and sectors on which the contribution focuses (if any); vi) *Main findings*: main insights emerged.

2.2.1 Drivers to IS

Conducting the literature review related to drivers to IS, we focused both on IS and CS since the two concepts are often misled and to some extent interconnected: despite research is focused on IS, including CS offers a larger and more detailed analysis of existing literature (Trianni et al., 2017b). The discussion is characterized by both theoretical contributions (Schrettle et al., 2014) and empirical ones (Lloret, 2016), summarized in Table 2. Presence of both internal and external drivers with reference to the firm is pinpointed (Lozano, 2015).

Regarding external drivers, external pressures are recognized as ones of the main drivers. Pressures may be related to stakeholders (Fonseca, 2015), like pressure groups (Klewitz and Hansen, 2014), institutions and association (Santini et al., 2013), and customers (Kara et al., 2014). Legislation is considered a very important fostering factor as well (Sy, 2014), along with market, in the specific market opportunities (Küçüksayrac, 2015) and market differentiation (Gabzdylova et al., 2009). The importance of collaboration has been likewise underlined (Bocken et al., 2014). Considering internal drivers, business strategy was given a strong relevance (Koho et al., 2011), as well as long-term vision (Kara et al., 2014). Values (Klewitz and Hansen, 2014) and culture (Fonseca, 2015) result to be very important drivers, along with firm's image and reputation (Azapagic and Perdan, 2000). Management support and commitment are recognized as relevant (Santini et al., 2013), along with personal management satisfaction (Gabzdylova et al., 2009). Regarding employees, it is underlined the importance of satisfied ones (Merli et al., 2015). Lastly, the relevance of four other main drivers is pinpointed, i.e. product quality (Suriyankietkaew and Avery, 2016), innovation and technology (Bocken et al., 2014), economic benefits (Lloret, 2016), and resources scarcity (Schrettle et al., 2014). Empirical studies evaluate drivers in different contexts. Some of them focus on specific geographical areas, like Zealand (Collins et al., 2010) and Portugal (Fonseca, 2015), while others consider different sectors, such as heavy construction industry (Arruda et al., 2013) and wine industry (Gabzdylova et al., 2009). Lastly, some consider different sizes of firms, as SMEs (Suriyankietkaew and Avery, 2016) and LEs (Arruda et al., 2013).

2.2.2 Drivers to Occupational Health and Safety (OHS)

The discussion is characterized by both theoretical contributions (Hasle and Limborg, 2006) and empirical ones (Hale et al., 2010), as shown in Table 2. Contributions pinpoint the presence of both internal and external drivers with reference to the firm (EASHW, 2010). Regarding external drivers, the importance of regulation is underlined, in terms of tailored legislation (Antonsson et al., 2002), external economic incentives (Pransky et al., 1999), and compliance (Miller and Haslam, 2009). Relevance is also given to external support (Hasle and Limborg, 2006), in particular, collaboration (Cagno et al., 2016) and presence of networks (Antonsson et al., 2002), e.g. knowledge ones (Roy et al., 2003). Lastly, also the importance of suppliers' role is underlined (Walker and Tait, 2004).

Concerning internal drivers, the presence of rewards and internal incentives is a very strong fostering factor (Gangwar and Goodrum, 2005), as well as communication and dialogue within the firm (Hale et al., 2010), and integration of safety related measures in firm's daily activities (ENWHP, 2001). Regarding organization, several drivers are identified, such as motivation of employees (Vecchio-Sadus and Griffiths, 2004), management (Sims, 2008), participation (ENWHP, 2001), training (Cagno et al., 2016) and presence and knowledge of examples (Kogi, 2006), as well as of an internal safety policy (Walker and Tait, 2004). Information and communication technology tools are considered an important boost for the adoption of measures (Cagno et al., 2016), as well as a business

case approach (Miller and Haslam, 2009).

Empirical studies evaluate OHS drivers in different contexts. Some studies focus on specific geographical areas like UK (Tait and Walker, 2000) and Australia (Vecchio-Sadus, 2007), while others consider different sectors, like manufacturing (Pransky et al., 1999) and construction industry (Gangwar and Goodrum, 2005). Lastly, others consider different sizes of firms, as SMEs (Cagno et al., 2011) and LEs (Pransky et al., 1999).

2.2.3 Drivers to Eco Efficiency (EcoEff)

We included in our background analysis of drivers to EcoEff also contributions addressing concepts closely related to or overlapped with EcoEff, (Glavič and Lukman, 2007; Van Berkel, 2007), such as cleaner production (WBCSD and UNEP, 1998). Discussion about EcoEff drivers includes both theoretical contributions (Ekins, 2005) and empirical ones (Dagiliūtė and Juknys, 2012), as reported in Table 2. It is interesting to note that most of the contributions found in literature comprehend both a theoretical model and its empirical validation (Fernández-Viñé et al., 2013). Contributions pinpoint the presence of both internal and external drivers with reference to the firm (Bossle et al., 2016).

Concerning external drivers, regulatory pressure is considered one of the most important (Masurel, 2007), along with the will of avoiding sanctions (Ekins, 2005). Presence of public benefits (Santolaria et al., 2011) and financial incentives (Mittal and Sangwan, 2015) represent keys factors for the adoption of measures too. Market drivers are recognized as promoting factors, like an increase in resources price (Dagiliūtė and Juknys, 2012), resource scarcity (De Medeiros et al., 2014), improve of competitiveness (Fernández-Viñé et al., 2010), and new market opportunities (Del Río González, 2005). Other external drivers are related to pressures (Van Hemel and Cramer, 2002), and to market demand (Govindan et al., 2015). Supply chain may play an important role as well, in terms both of pressure (Mittal et al., 2013), and involvement (Hojnik and Ruzzier, 2016). Collaboration (De Medeiros et al., 2014), cooperation, (Bossle et al., 2016), and presence of an expert network, (Ghazilla et al., 2015) can foster the adoption of measures too. Regarding internal drivers, cost saving is for sure one of the main drivers, (Mittal et al., 2013), as well as efficiency (meant as the reduction in resources use) (Van Hemel and Cramer, 2002) and revenues (Hojnik and Ruzzier, 2016). An important role is played also by firm image (Del Río González, 2005), and by an opportunity of increasing market share (Bossle et al., 2016). Regarding the organization, main drivers have been identified with commitment (Govindan et al., 2015), competences (De Medeiros et al., 2014), values (Masurel, 2007), management concern (Bossle et al., 2016), and employees' demand (Govindan et al., 2015). Moreover, a clear strategy (Brammer et al., 2012), voluntary agreement (Hojnik and Ruzzier, 2016) and having a certification (Bossle et al., 2016) may foster the adoption of measures too. Other drivers identified refer to opportunities related to innovation (Ghazilla et al., 2015), research and development (De Medeiros et al., 2014), technology development (Mittal and Sangwan, 2015), reduction of risk (Van Hemel and Cramer, 2002), and increasing in product quality (Fernández-Viñé et al., 2013). Lastly, also information (Ekins, 2005) and past experiences (Hojnik and Ruzzier, 2016) are relevant drivers.

Empirical studies evaluate EcoEff drivers in different contexts. Some studies focus on specific geographical areas, like Venezuela (Fernández-Viñé et al., 2013, 2010), and India and Germany (Mittal et al., 2013), while others consider different sectors, like extractive metal, engineering, chemicals, printing and paper and timbering (Brammer et al., 2012) or manufacturing in general (Ghazilla et al., 2015). Lastly, others consider different sizes of firms, as SMEs (Altham, 2007) and LEs (Govindan et al., 2015)

2.2.4 Drivers to Energy Efficiency (EnEff)

Discussion about EnEff is very wide, nevertheless, most of the contributions are empirical, as Table 2 shows. Attempts to theoretically encompass drivers to energy EnEff recently emerged in (Trianni

et al., 2017a) and (Johansson and Thollander, 2018). Contributions pinpoint the existence of both internal and external drivers, with reference to the firm (Apeaning and Thollander, 2013).

Regarding external drivers, policies (Anderson and Newell, 2004) and regulation (Sudhakara Reddy et al., 2014) are recognized as important fostering factors, along with subsidies (De Groot et al., 2001), public financing (Thollander et al., 2013), third parts financing (Rohdin et al., 2007) and taxes reduction (Sathitbun-anan et al., 2015). External pressures, like customers or NGO's ones, are relevant too (Lee, 2015), along with increasing in energy price (Abeelen et al., 2013). Presence of networks (Thollander and Ottosson, 2008), and the possibility to have support from experts (Lee, 2015) are considered important too. Lastly, international competition may foster the adoption of measures (Ren, 2009).

Concerning internal drivers, cost reduction is largely recognized as relevant (De Groot et al., 2001). Long term strategy (Brunke et al., 2014), firm's image (Aflaki et al., 2013), green concerns (Ren, 2009) and voluntary agreements (Lee, 2015) are relevant too. Moreover, people with real ambition (Rohdin et al., 2007), management vision and commitment (Thollander et al., 2013), and the adoption of an energy management system (Apeaning and Thollander, 2013) are considered important fostering factors. Lastly, other drivers have been taken into account, such as availability of information (Trianni et al., 2017a), development of technology (Venmans, 2014), increasing product quality (Hasanbeigi et al., 2010), reduction of risk (Venmans, 2014), improving working conditions (Sathitbun-anan et al., 2015), and non-energy benefits (Sudhakara Reddy et al., 2014).

Empirical studies evaluate EnEff drivers in different contexts. Some studies focus on specific geographical areas like Sweden (Rohdin and Thollander, 2006) or Korea (Lee, 2015), while others consider different sectors like textile and cement industry (Hasanbeigi et al., 2010) or printing (Masurel, 2007). Lastly, some consider different sizes of firms, as SMEs (Thollander et al., 2007), and SMEs and LEs together (Sathitbun-anan et al., 2015).

2.3 Emerging gaps

Conducting the literature review, some interesting issues emerged. First, barriers and drivers may vary in the different steps of the decision-making process. This is considered for OHS (Masi et al., 2014; Saksvik et al., 2003), EnEff (Aflaki et al., 2013; Hasanbeigi et al., 2010), and EcoEff (Hojnik and Ruzzier, 2016). Second, the importance of taking in consideration the different perspectives of different decision makers when adopting a measure is highlighted (Cagno et al., 2018; Cagno and Trianni, 2014; Mittal and Sangwan, 2015), in line with Langley et al. (1995) that emphasizes the individual rather than the organizational level of analysis of the decision-making process, pinpointing that the process is driven mainly by personal insights and emotions. Indeed, because of their different backgrounds, aims and commitment, different decision makers may perceive different relevance of barriers and drivers to the adoption of specific measures (Sudhakara Reddy et al., 2014; Thollander and Palm, 2012). This is connected also to the complexity of the decision-making process for sustainability-related decision (Arvai et al., 2012; Gibson, 2006), connected in turn to different stakeholder requirements (Frini and Benamor, 2017; Gong et al., 2016; Nicolăescu et al., 2015). Third, the importance of considering mechanisms between drivers and barriers (Trianni et al., 2017a), as well as between drivers (Lozano, 2015), is underlined. Regarding mechanisms between drivers and barriers, they have been hitherto evaluated only with reference to EnEff: Sudhakara Reddy et al. (2014) underlined the need for understanding the relationship between drivers and barriers, to effectively assess the easiness and the proper way for tackling barriers; Cagno et al. (2015) defined the mechanism as a driver, promoted by a stakeholder, acting on a main barrier of a given decision-making step, considering also the different perceptions of the most relevant actors involved; Trianni et al. (2017a) proposed a framework for describing the effect of drivers on barriers in the decision-making process, as well as a preliminary identification of the major stakeholders to promote drivers, explaining in particular that a driver can act on a barrier with a certain strength along the whole

decision-making process, and can also act simultaneously on another barrier, in all the different steps of the decision-making process, and the same for all the barriers; Cagno et al. (2017) conducted a further step specifying that the same driver could affect the same barrier with different strength in two separate steps of the decision-making process, a driver could tackle multiple barriers in a specific step with different strength and more drivers could affect the same barrier in a specific step.

Mechanisms between drivers have been evaluated, focusing on CS, by Lozano (2015) who stated there is a barrier that divides internal and external drivers for sustainability, depicting firms as closed systems: he thus proposed a new category of drivers, called ‘connecting drivers’, which can offer a more in-depth understanding of operant drivers, and help firm respond quickly to external drivers, thus promoting and rewarding internal ones.

Besides the previous considerations, after the literature review the lack of an integrated framework for drivers to the adoption of ISMs emerges. In particular:

1. There is a lack of a model of drivers for the adoption ISMs. Research to date has mainly evaluated drivers to IS by considering one area of IS at a time (Dagiliūtė and Juknys, 2012; Lee, 2015; Sims, 2008), rather than taking a holistic perspective, and thus failed to take into account possible interdependencies. Contributions that have investigated drivers to IS as a whole, identified very few drivers with respect to those identified in single areas of IS (Lloret, 2016) and models and frameworks developed are less structured than those applied to specific single areas of IS (Sy, 2014). Moreover, almost all previous studies do not model drivers to specific ISM. The importance of underline specific barriers and drivers to the adoption of measures has been pinpointed by Trianni et al. (2017b), but so far contributions related to the topic just focused on barriers to EnEff measures (Cagno et al., 2018; Cagno and Trianni, 2014) or on one pillar of sustainability at a time, thus not considering all the areas of sustainability together (Collins et al., 2010).
2. There is a lack of a comprehensive model for the identification of the mechanisms between drivers and barriers, and between drivers, since no contribution so far has modelled mechanisms between drivers and barriers and between drivers to IS as a whole: nevertheless, as stated by Cagno and Trianni (2014), modelling both mechanisms between drivers and barriers and between drivers themselves could provide a relevant contribution to the development of tailored policies and industrial practices.

3 Development of a new framework for drivers and mechanisms

3.1 Development of the model of drivers

Contributions related to the different areas of IS presented several commonalities, such as the distinction between external and internal drivers in origin, with further distinction into categories, quite helpful to shape the new model of drivers for the adoption of ISMs. Taking inspiration by huge body of extant literature, we reorganized drivers into internal and external, as well as within categories. The external drivers’ categories we identified are: *regulatory, support, external pressures, and market*; the internal drivers’ categories we identified are: *organization, staff, information, innovation and economic*.

Drivers affecting the three IS areas presented a considerable overlap; however, some differences are worth noting. We extended or adapted some driver’s definition provided in literature, so to fit drivers referred in literature to one or two areas, to all the three areas and to IS in general. We found that some drivers could also apply to domains other than those cited. For instance, *communities and partners’ pressures* were reported in literature as drivers for EcoEff (Del Río González, 2005), EnEff (Cagno and Trianni, 2013) and sustainability as a whole (Gabzdylova et al., 2009), but not for OHS: they may, however, also foster the adoption of OHS related measures; *past experience and knowledge*

of business case was identified in literature as a driver for sustainability (Lozano, 2015), OHS (Kogi, 2006) and EcoEff (Hojnik and Ruzzier, 2016), but it can be a relevant driver for EnEff too; *support from industrial association* was considered by literature as relevant for OHS (Sims, 2008), EcoEff (Ghazilla et al., 2015), and EnEff (Lee, 2015), and it can be easily extended to sustainability as a whole; *dialogue and encouragement* was recognized by literature as an important driver for EnEff (Sathitbun-anan et al., 2015) and OHS (Vecchio-Sadus, 2007), but it may be relevant also to EcoEff and sustainability in general.

3.2 Description of the drivers

3.2.1 External drivers

Taking inspiration from previous literature (Gabzdylova et al., 2009; Hojnik and Ruzzier, 2016; Santini et al., 2013), an external driver has its origin externally to the firm and it is promoted by external stakeholders.

Regulatory

- *Compliance with regulation*: sustainability is subjected to legislation and governmental regulation, which firm must be compliant with (Van Hemel and Cramer, 2002);
- *Regulatory sanctions and taxes*: sanctions and taxes imposed by regulators to firms not achieving one or more sustainability performance thresholds (Hasle and Limborg, 2006).

Support

- *External funding*: presence of monetary support, e.g. loan from financial institution. It includes the so called third- part financing (Thollander et al., 2007);
- *Public subsidies*: creation of public monetary funds for firms (Mittal et al., 2013).
- *Cooperation and network with other companies*: support to the adoption of ISMs provided by other companies. This support consists of sharing knowledge, resources and common initiatives (Jochem and Gruber, 2007; Walker and Tait, 2004);
- *Support from industrial associations*: support to the adoption of ISMs provided by industrial associations. This support consists of sharing knowledge, resources and common initiatives (Roy et al., 2003);
- *Support from consultant*: support provided by external consultants. This may consist in providing competences and knowledge (Antonsson et al., 2002);
- *Support from government*: support provided by government. This may consist in providing advice and information for the adoption of ISMs (Fernández-Viñé et al., 2013).

External Pressures

- *Customers' pressures*: customers' awareness on sustainability issues (Govindan et al., 2015);
- *Communities' pressures*: communities' awareness on sustainability issues (Mittal et al., 2013);
- *Partners' pressures*: commercial partners' awareness on sustainability issues (in particular other firms of the supply chain) (Govindan et al., 2015);
- *Shareholders' pressures*: shareholders' awareness on sustainability issues (Govindan et al., 2015);
- *Competitors' actions*: competitors have already adopted specific ISMs (Van Hemel and Cramer, 2002);
- *Public opinion*: public opinion's awareness on sustainability issues (Govindan et al., 2015).

Market

- *Increase of market share and sales growth*: prospect of increasing market share (Bossle et al., 2016);
- *New market opportunities*: prospect of new market opportunities (Bossle et al., 2016);

- *Increasing in resources price*: continuous and predictable increase in resources price (Sudhakara Reddy et al., 2014);
- *Creating competitive advantage*: when a firm see sustainability as a competitive tool, the topic is of primary importance to achieve business target (Bossle et al., 2016);
- *Resources scarcity*: depletion of natural resources and concerns on sustainability (Govindan et al., 2015).

3.2.2 *Internal drivers*

Basing on previous literature (Gabzdylova et al., 2009; Hojnik and Ruzzier, 2016; Van Hemel and Cramer, 2002), an internal driver has its origin internally to the firm and it is promoted by internal stakeholders, regardless the influence of external parties.

Organization

- *Improving firm brand and image*: reputation plays a vital role in any firm's growth. Hence to retain the firm image, the adoption of ISMs is mandatory (Govindan et al., 2015);
- *Improvement of sustainability related performance*: willingness of improving sustainability related performance (Hasanbeigi et al., 2010);
- *Anticipation of regulatory changes*: the desire of a firm to be compliant not only with the existing, but also with the upcoming regulation (Cagno and Trianni, 2013). Moreover, firms staying ahead of regulations can have a competitive edge over those struggling to keep up (Ekins, 2005);
- *Organizational values and culture*: firm's values and culture consistent with sustainability (Koho et al., 2011);
- *Past experiences in sustainability and knowledge of business case*: past experience in sustainability and availability of knowledge of effective business cases for sustainability (Sims, 2008);
- *Including sustainability at strategic level*: in order to enhance sustainability, a major challenge for managers is the degree of integration of sustainability principles (such as in the form of strategy objectives, vision and mission) into the overall firm strategy (Schrettle et al., 2014), in particular with a long term perspective (Hasanbeigi et al., 2010);
- *Adoption of certifications/ management systems*: adoption of certifications and management systems (Bossle et al., 2016);
- *Voluntary agreements*: it results from the government public policies, or from the collaboration among different firms that enter into a contract bringing benefits in terms of sustainability (Venmans, 2014).

Staff

- *Management commitment*: committed management to enhance sustainability (Koho et al., 2011);
- *Employee commitment*: committed employees to enhance sustainability (Koho et al., 2011);
- *Training and education*: training and education programs increase the awareness and the knowledge of the personnel, who is thus more motivated to intervene or correctly behave (Walker and Tait, 2004).

Information

- *Dialogue and encouragement*: the principle of dialogue and encouragement is essential for team-working and community building, allowing people, tasks, processes and systems to interact purposively and co-operatively to sustainability objectives (Vecchio-Sadus, 2007);
- *Availability, trustworthiness and clarity of information*: to properly make a decision, firms should be provided with reasonable amount of relevant information. Indeed, even if available, information is often disaggregated and considered unreliable (Thollander et al., 2007).

Innovation

- *Product innovation*: implementing product innovation may help firm in improving its sustainability performance (Bossle et al., 2016);

- *Technology innovation*: adopting technology innovation may lead to improved sustainability performance (Del Río González, 2005);
- *Quality*: increasing quality may help firm in improving its sustainability performance (Fernández-Viñé et al., 2010);
- *Greater efficiency in processes*: the aim of increase process efficiency may foster firm in increasing also sustainability performance, i.e. a more efficient process consumes less resources (Masurel, 2007).

Economic

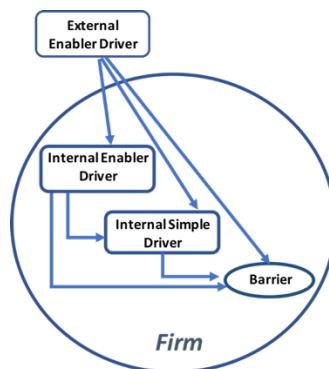
- *Cost savings*: prospect of a reduction in cost. More in detail, the cost saving is related to the reduction of resource use (EcoEff and EnEff) (Mittal et al., 2013; Thollander and Ottosson, 2008) and of accidents (OHS) (Tait and Walker, 2000);
- *Increasing incomes*: prospect of increasing incomes, in particular the profit maximizing objective served as an important stimulus (Sy, 2014).

3.3 Development of the model of mechanisms

Basing on the definition provided by Cagno et al. (2017, 2015) and Trianni et al. (2017a), we consider a mechanism as a relation between a driver and a barrier and/or another driver, prompted by a stakeholder, both internal or external to the firm, in a specific step of the decision-making process, considering also the different perspectives of the different IDMs. In particular, the driver can act both on a barrier and on other driver with a certain strength, and it can also act simultaneously on another barrier or driver, in all the steps of the decision-making process. Moreover, a driver could act on multiple barriers and drivers in a specific step with different strength, and more drivers could affect the same barrier or driver in a specific step.

In our study, we focussed on the development of theoretical mechanisms with rationale presented in Figure 1 and details presented in the following. In particular, on the one hand, we consider drivers that may impact directly on a barrier; on the other hand, we consider drivers that may boost the impact of another driver on a barrier, thus acting as an enabler, as showed with further detail in the following.

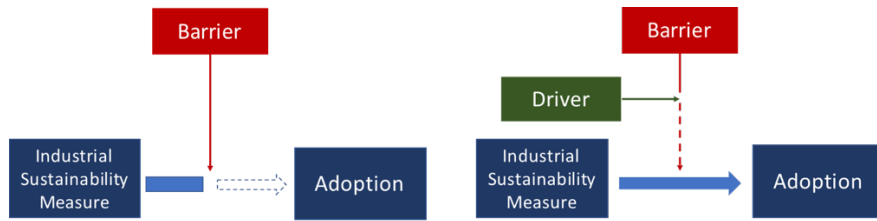
Figure 1. Mechanisms between drivers and barriers and between drivers. An external driver may impact directly on a barrier and/or may boost the impact of an internal driver on a barrier, thus acting as an enabler. A set of the internal drivers may impact directly on a barrier and/or may boost the impact of another internal drivers on a barrier, thus acting as enablers. Another set of internal drivers may only impact on barriers, thus acting as simple drivers.



3.3.1 Mechanism between drivers and barriers

A driver can tackle a barrier and this means that the driver can help the firm in the adoption of an ISM by reducing (or eliminating) the effect of the barrier. The mechanism between drivers and barriers is represented in Figure 2. In developing the mechanisms, we used the model for barriers to the adoption of ISMs proposed by Trianni et al. (2017b).

Figure 2. Mechanism between drivers and barriers. The adoption of an ISM can be prevented by the presence of a barrier. A specific driver may tackle the specific barrier, reducing or eliminating the effect of the barrier, so that the adoption of the ISM is less hindered or not hindered anymore.



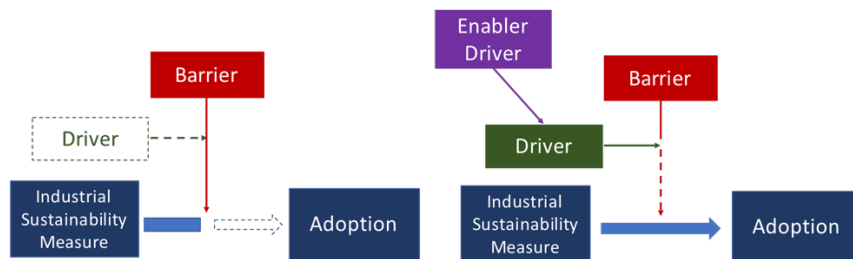
For example, the new market opportunities driver is able to influence firm’s attitude, and the presence of external funding, is able to influence both management and workers’ awareness, as also observed in (Trianni et al., 2017a). It has been largely underlined, indeed, that attitude and other priorities, as well as the awareness can play a very relevant role in preventing the adoption of ISMs, see e.g. (EASHW, 2010; Murillo-Luna et al., 2011; Rohdin and Thollander, 2006).

Past experience in sustainability may then reduce the risk associated with the possible adoption of an ISM, since, given the experience, firm might be able to better identify and evaluate potential risks, as well as potential mitigation actions, see also (Morioka and Carvalho, 2014; Razali and Tahir, 2011).

3.3.2 Mechanism between drivers

Some drivers can activate the action of other drivers (Lozano, 2015). This type of drivers are named *enabler drivers*, since they enable another driver to foster the adoption of an ISM, i.e. they enable the driver to tackle barriers. This mechanism between drivers is represented in Figure 3. All external drivers are enablers; regarding internal drivers, they are divided in enablers and *simple* drivers: the internal enabler drivers can activate other internal drivers, whilst the simple ones can only act directly on barriers. All the enablers can both enable the action of another driver on a barrier, or directly tackle a barrier.

Figure 3. Mechanism between different drivers. The adoption of an ISM could be foster by the existent of a specific driver. Nevertheless, it may happen that this driver is not able by itself to promote the adoption of the ISM. An enabler driver may activate this driver, making possible to it to foster the adoption of the ISM.



For instance, resource scarcity driver enables a greater process efficiency (driver), thus improving firm’s sustainability. If the resources used by the firm for its process are scarce (e.g. rare earths), this would represent a push towards more efficient processes, as they may lead to a reduction in resources consumption. In turn, since scarce resources are usually subjected to price fluctuation and increase, such reduction in the use of resources (due to the more efficient processes), would lead to cost savings too. Improving company brand and image may foster the adoption of certifications, as well as voluntary agreements, in order to make stakeholders perceive the firm as committed to sustainability, see also (Murmura et al., 2018; Santos et al., 2017).

The model of drivers is reported in Table A1 of the Annex. For each driver, we indicated its origin and category, as well as references. In the last column, the type of driver is reported (i.e. enabler external, enabler internal or simple).

4 Validation of the framework

In order to assess the validity of the model of drivers and the model of mechanisms, we conducted nine case studies with audio-recorded semi-structured interviews, questionnaires, company visit and secondary material, within Italian manufacturing firms. Multiple sources of evidence have been gathered to increase the validity of the analysis (Voss et al., 2002; Yin, 2009). Manufacturing sector is indeed very important in Italy, and presents still ample room for further improvement in performance related to the different areas of IS (INAIL, 2014; Eurostat, 2016). The sample is thus heterogeneous by activity, size¹ and turnover, and homogeneous regarding country (Morioka and Carvalho, 2014; Osagie et al., 2016). The sample size is suitable to provide evidence of the theoretical generalizability of an emerging theory (Eisenhardt, 1989), rather than statistical one (Hillebrand et al., 2001; Stuart et al., 2002), as previous research shows that a set from 6 up to 10 cases is considered as adequate for validating the initial set of propositions (Eisenhardt, 1989; Pagell and Wu, 2009). We chose to perform investigation interviewing twelve people in leadership positions in charge of EcoEff, EnEff and OHS, so to gather multiple perspectives on sustainability issues, as reported in Table 3.

Firm	Sector	Number of employees	Turnover	Persons interviewed
Firm 1	Manufacture of actuators	118	40 M€	OHS manager; OHS assistant
Firm 2	Manufacture of precision mechanics components	160	16 M€	Health, Safety and Environment Manager
Firm 3	Manufacture of plastic packaging for beauty and home	320	140 M€	Sustainability and quality manager
Firm 4	Manufacture of bathroom wooden furniture	108	18 M€	Technical director; OHS and environment manager
Firm 5	Manufacture of compressors	400	49 M€	Health, Safety and Environment manager
Firm 6	Manufacture of mechanical components	180	135 M€	OHS manager
Firm 7	Manufacture of steel and polyethylene pipes	170	30 M€	OHS and environment manager
Firm 8	Manufacture of vehicles chassis	120	60 M€	Plant manager; Health, Safety and Environment manager
Firm 9	Manufacture of domestic heater and integrated thermal system	400	70 M€	Quality and Health, Safety and Environment manager

Table 3. Sample investigated. For each firm of the sample the following are reported: Sector, Number of Employees, Turnover, Persons interviewed.

Data collection has been organized in three steps. First, we selected our research sample, starting from a database (AIDA, 2017) containing relevant industrial information, on the basis of firm sector, number of employees, and turnover. Upon their acceptance, after a preliminary contact by e-mail or phone, we gathered relevant secondary data (from e.g., firm websites, reports) regarding how those firms are structured, their production processes, as well as projects, initiatives, etc., towards increased IS.

Second, we conducted our investigation into the firms. Interviewees were asked to introduce the firm, focusing on sector, main production processes, number of employees, turnover and attitude toward sustainability. We then performed a plant tour, so to directly observe the status quo, as well as to identify possible problems related to IS areas. Finally, the main interview took place, by taking questionnaires as a guide, so to standardize the sequence in which the questions were asked and minimize the impact of contextual effects (Patton, 1990). We also asked several additional open-ended

¹ We adopted the classification proposed in (European Union, 2003), i.e. we considered SMEs firms with a staff headcounts minor than 250, LEs firms with a staff headcounts equal or higher than 250.

questions, supplemented by questions emerging during the interview, and free comments, as Diccio-Bloom and Crabtree (2006) suggest. We presented the model of drivers to interviewees, describing every single driver. We asked interviewees to evaluate drivers for their firm and to specific ISMs considered for the adoption in their firm. Moreover, we asked interviewees to identify possible mechanisms between drivers and barriers and between drivers, both in general terms and concerning the adoption of specific ISMs considered in their firm. Furthermore, we asked interviewees to evaluate our framework according to three main performances, namely capacity to represent, usefulness and ease of use, as follows:

- *capacity to represent*: capacity of the proposed model to represent the full set of drivers to IS, drivers sufficiently distinct and with the same level of detail;
- *usefulness*: point out both “new” drivers (i.e. not hitherto aware of), better structure of current knowledge (drivers already identified), usefulness to design and implement ISMs, model as valuable support for drivers’ identification, enhancing firms’ knowledge and awareness;
- *ease of use*: effort paid to understand and apply the model.

Finally, regarding the model of mechanisms, we validated the mechanisms developed in theory as well as their usefulness and ease of use.

In the third step, we transcribed and coded interviews, also making a comparison with secondary data and other findings emerged during the interview, trying to identify possible misalignments. In case, we followed up with a second meeting (either face to face or phone) for further clarification.

5 Results and discussion

We based our model evaluation on the judgment of all interviewees (twelve), rather than on firms’ overall judgments (nine), as in some case studies, interviewees from the same firm had differing opinions, as previous research shows (Cagno et al., 2018; Cooremans, 2012; Thollander and Palm, 2012).

Figure 4 shows that the results of the validation of the model of drivers were positive with respect to the three performances considered. Regarding *capacity to represent*, the model was judged complete and all the twelve interviewees considered the drivers specified in the model to be sufficiently distinct and detailed. Concerning *usefulness*, the model led the interviewees to identify hidden drivers and to better structure what they may have already in mind. The former aspect was underlined, for example, by OHS manager of Firm 6, who “*never considered external drivers such as public opinion and community expectations, since our market is a B2B one. Nevertheless, now I do think it is necessary to consider them for having a complete view on drivers*”, and by OHS manager of Firm 1, who declared that “*hitherto, firm underestimated some drivers, putting them in macro categories*”; the latter aspect was pinpointed also by OHS manager of Firm 1, who considered the model exhaustive and detailed, and by technical director of Firm 4, who stated his firm has “*a similar model but not so well structured and detailed*”. In addition, all the interviewees judged the model very useful for the designing and implementation of measures, and able to provide a valid and quick help for the identification of drivers. OHS manager of firm 6, for example, stated his firm already has “*an internal model for the evaluation of drivers but for sure it needs to be integrated with yours*”, and OHS assistant of Firm 1 declared “*model could be useful in sponsoring a project within the firm: it is possible to show pros and cons by a business plan*”. Interviewees underlined also that the model allowed them to have a complete view on the drivers, enhancing their knowledge and awareness; the model, indeed, as stated by health, safety and environment (HSE) manager of Firm 2 “*is very useful to point out aspects usually faced, but not always considered or clearly identified. Considering also these aspects can help us in properly and better understanding all the implications related to the adoption of measures, thus basically enhancing our awareness on the topic*”.

Respecting *ease of use*, the model succeeded in the vast majority of interviewees, in particular, as HSE manager of Firm 5 said for the “*concise but exhaustive view on drivers*” the model is able to provide; it is worth noting that also who deemed the model as a little bit complex, offered here a quite

positive judgment, highlighting however that it was worth using it because of the high quality of the information provided.

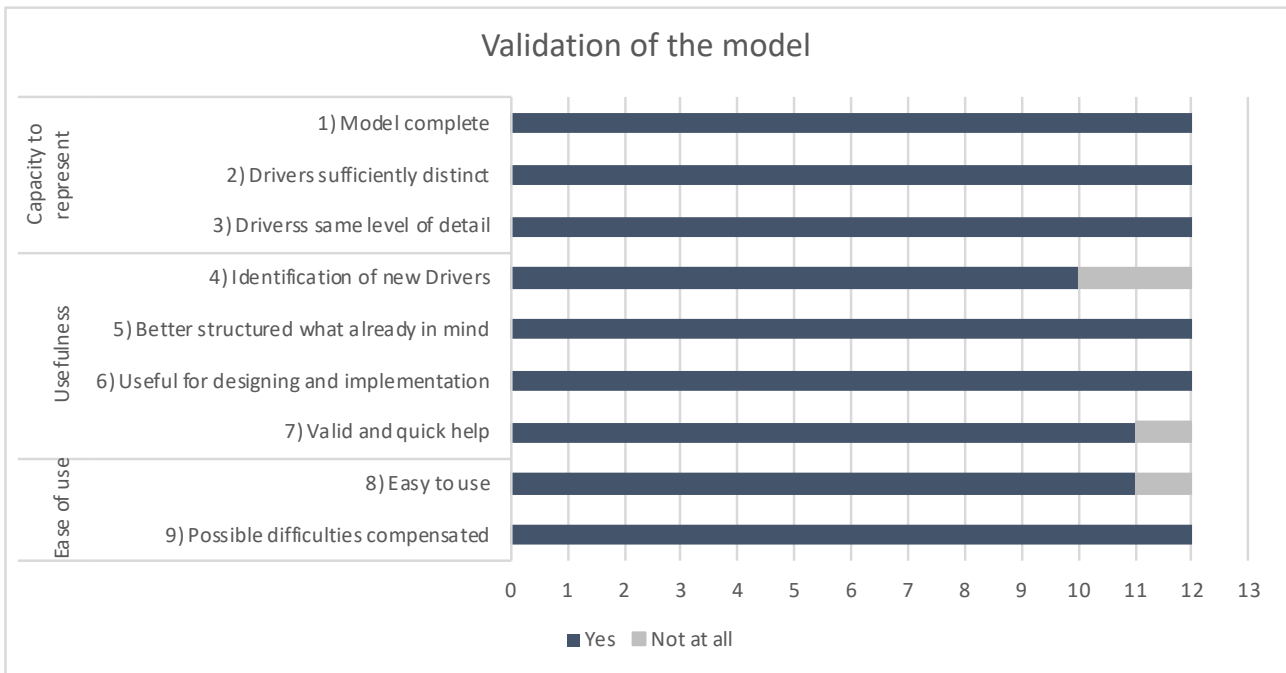


Figure 4. Results of the validation of the model of drivers.

In addition to previous considerations, it is relevant to underline that interviewees particularly appreciated the structure of the model proposed, as well as its organization in categories. This is an important achievement, which was pointed out as major research gap by literature, as so far contributions on drivers on IS were less structured than those applied to specific single areas of IS, either with just macro-categories, e.g. (Kara et al., 2014; Sy, 2014), or without even a categorization, e.g. (Bocken et al., 2014; Gabzdylova et al., 2009). Second, as pointed out by the literature review, contributions on drivers to IS identified very few drivers with respect to those identified in single areas of IS, e.g. (Collins et al., 2007; Lloret, 2016), whilst the model proposed here has been particularly valued for its completeness and *capacity to represent*. Third, interviewees underlined the *usefulness* of the model as guideline for drivers they were hitherto not provided with and “*would not be able to develop*” as quality and HSE manager of Firm 9 said, thus providing firms with a new view on drivers to the adoption of ISMs. Moreover, the model was considered a helpful instrument for enhancing collaboration among different departments of the same firm. Indeed, reporting the opinion of HSE manager of Firm 2 “*the model is a holistic one, and allows collaboration among different departments; the division in categories is very helpful, since categories are related to the diverse firm’s department like commercial, financial, quality, safety and production*”.

The model for drivers, given the previous considerations, presents several aspects of novelty, moreover it can identify general drivers to sustainability, as well as evaluate drivers to specific measures in the different areas of IS, and the combined evaluation of different areas of IS allowed to identify in specific area drivers not identified before, e.g. *dialogue and encouragement* for EcoEff, and *communities and partners’ pressures* for OHS.

The results of the preliminary validation of the model of mechanisms were positive too. In particular, all the mechanisms identified by the interviewees were previously identified in theory. Nevertheless, due to the small number of respondents, it was not possible to verify all the theoretical mechanisms, but the overlap obtained is particularly significant. All the twelve interviewees stated the model of mechanisms between drivers and barriers and between drivers was very useful and almost all of them stated it was easy to be used. The only hindrance underlined was the time needed for filling the matrix,

since it contained quite a lot of information, but, at the same time, interviewees thought it was necessary to properly analyse and understand all the possible mechanisms. This aspect was underlined for example by OHS manager of Firm 1, who stated: “*I took me quite a long time to evaluate all the mechanisms but it is necessary for having a proper evaluation of mechanisms: going too fast I would have probably missed some of them*”.

Main mechanisms between drivers and barriers identified during the interviews can provide insights into those that may be the most relevant ones for firms, as reported in Table 4:

- *Increase incomes* can provide a higher availability of money, thus reducing the barrier of *limited access to capital*;
- *Cost saving* can as well contrast *limited access to capital*, being associated with an increased availability of money;
- *Dialogue and encouragement* can help improving *communication*;
- *Training and education* has a very important role since it is able to contrast several barriers related to employees, i.e. *not trained/ skilled* employees, employees’ *awareness* and *incorrect behaviour*;
- *Commitment* of employees can contrast both *not involved* employees and employees’ *lack of awareness*;
- *Organizational values and culture* can have an effect on management *commitment/awareness* towards sustainability;
- *Regulatory sanctions and taxes* can overwhelm management *commitment/awareness* towards sustainability as well.

Examples of mechanisms between drivers and barriers are provided by OHS manager of Firm 1: “*a positive behaviour of the parent company tends to destroy non-safe approaches*”, and “*commitment of the management provides the correct example and reduces the problem of resistance to change*”.

Main mechanisms between drivers identified during the interviews can provide insights into those that may be the most relevant ones for firms:

- *Increase of market share and sales growth* may lead to *increasing incomes, cost saving* and stimulate a *greater efficiency in processes*;
- *New market opportunities* can foster the adoption of *technology innovation*;
- *Competitors’ actions* may encourage the firm in developing *product innovation* as well as *technology innovation*;
- *Consumers’ pressures* can help in increasing the *management commitment*;
- *Improvement of sustainability related performance* may stimulate both *management commitment* and *employees commitment*;
- *Quality related drivers* can, as well, prompt *management commitment*.

An example of mechanism between drivers was provided by OHS assistant of Firm 2, who stated that “*efficient and effective production system must be guaranteed to provide a compliant product and keep up with the market demand*” since “*competitiveness can be obtained minimizing costs*”, for which “*technology innovation, optimal working conditions and motivation of the personnel are necessary*”. Table 5 and Table 6 report, respectively, mechanisms between enabler (external) and internal drivers, and enabler (internal) and simple drivers.

The model of mechanisms resulted very helpful for increasing awareness, as underlined by HSE manager of Firm 5. In addition, OHS manager within Firm 1 stated “*the model allows to fully explore all reasoning behind the decision-making process*”. Similarly, HSE manager of Firm 9 appreciated the completeness of the model and its ability to bringing out possible criticalities within the firm. In this way, as declared by OHS manager of Firm 6, and confirmed by OHS manager of Firm 1 as well as sustainability and quality manager of Firm 3 “*the mechanisms matrices are able to immediately underline the criticalities and weakness, so that one is able to identify straightway what it is necessary*”.

to and strategic actions”.

Moreover, interviewees particularly appreciated mechanisms between drivers and barriers, as emerged talking with sales manager of Firm 4, and HSE manager of both Firm 5 and Firm 7. In particular, plant manager of Firm 8 said: *“mechanisms between drivers and barriers are very interesting, since barriers are the first thing that someone face when trying to adopt an ISM”.*

The model of mechanisms was thus able to properly address the research gaps identified after the literature review. In comparison with previous literature contributions, our model is able to enhance the knowledge and awareness of IDMs, as well as to provide them with a holistic and complete view on mechanisms, considering for the first time both mechanisms between drivers and barriers and mechanisms between drivers for IS. Indeed, the extant contributions describing the single mechanisms between drivers and barriers were focused only on EnEff (Cagno et al., 2017; Trianni et al., 2017a, 2016), thus not providing a complete view on the IS. Also regarding mechanisms between drivers, acknowledging we based our work on previous literature (Lozano, 2015), we broadened the research by theoretically modelling every single mechanism and considering also mechanisms between drivers and barriers, rather than only the ones between dr

			Drivers																												
			External													Internal															
			Regulatory		Support			External Pressures				Market				Organization					Staff		Information		Innovation		Economic				
Barriers	<u>Organization</u>	Lack of time	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
		Lack of staff	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Resistance to change/Inertia	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Attitude/ Other priorities	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Communication	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Workplace and task	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Organizational system	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	<u>Management behavior</u>	Commitment/ Awareness	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
		Expertise	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	<u>Workers behaviour</u>	Not trained/ skilled	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
		Awareness	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
		Not involved	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
	<u>Information</u>	Incorrect behaviour	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
		Lack of information	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
	<u>Technology/ Service</u>	Trustworthiness of information	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
		Lock in	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
	<u>Economic</u>	Limited access to capital	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
		Hidden costs	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	

		Enabler (internal)								
		Organization		Innovation				Economic		
		Improving firm brand and image	Improvement of sustainability related performance	Product innovation	Technology innovation	Quality	Greater efficiency in processes	Cost savings	Increasing incomes	
Simple drivers	Organization	Anticipation of regulatory changes								
		Organizational values and culture								
		Past experiences in sustainability and knowledge of business case								
		Including sustainability at strategic level								
		Adoption of certifications/ management systems								
		Voluntary agreements								
	Staff	Management commitment								
		Employee commitment								
		Training and education								
Information	Dialogue and encouragement									
	Availability, trustworthiness and clarity of information									

Table 6. Main mechanisms between enabler (internal) drivers and simple drivers identified during investigation. The light blue boxes indicate mechanisms identified by 1 to 4 interviewees; the blue boxes indicate mechanisms identified by 5 to 8 interviewees; the dark blue boxes indicate mechanisms identified by 9 to 12 interviewees.

6 Conclusions

In this study, we presented a novel framework of drivers for ISMs, including a model of drivers as well as a model of mechanisms between drivers and barriers, and between drivers. In our validation of the model, interviewees positively evaluated the capacity to represent the full set of drivers to IS with sufficient distinction between them and with the same level of detail. Moreover, they appreciated the capacity to point out hidden drivers, but also to offer a structured view on already identified drivers for the adoption of ISMs, with valuable information easily presented, thus enhancing their knowledge and awareness on IS drivers. Regarding the mechanisms, interviewees appreciated the usefulness of the novel approach, particularly for the mechanisms between drivers and barriers, thus understanding whether and to what extent a barrier can be overcome by a driver, but also the mechanisms between drivers, thus looking at whether a driver may act as an enabler for one or more other drivers.

Empirical evidence has shown that our novel framework provides several useful insights. First, it allows an enhanced knowledge of sustainability issues, thus pointing out also multiple perspectives between different internal stakeholders, so clarifying the extant opportunities to promote ISMs in their company. Second, it points out that a single driver could act on multiple barriers to the adoption

of ISMs, thus showing important possible synergies by leveraging on a given driver. Third, it shows that external drivers may act directly onto barriers, reducing the resistance to the adoption of ISMs, but also as enablers on internal drivers, stimulating internal stakeholders to tackle existing internal barriers to ISMs adoption.

In conclusion, our framework may represent a valuable instrument to be adopted by IDMs, as it helps not only to better understand the most important drivers, but also to organize internal resources and develop appropriate implementation strategies for improved IS within an industrial company. Moreover, thanks to the distinction between external and internal drivers, companies could better understand the most effective drivers tackling existing barriers. Further, external stakeholders (e.g., technology suppliers or service providers) offering solutions for improved IS could benefit by taking this framework to assess the most effective ways to promote their solutions within a specific company, as the mechanisms between drivers and barriers (but also external drivers and internal drivers) do not depend just on the firm, but also on the specific ISM considered. Finally, policy-makers focusing their activities on promoting IS, would take benefit by considering this framework to develop a more effective regulatory framework, thus more specifically designing incentives to encourage firms to adopt ISMs.

Unfortunately, considering the sample investigated, we could not interview multiple internal stakeholders in all firms, i.e. one for each area of IS, and for geographical constraints, we were able to conduct the validation of the model only in Italy. Another limitation can be represented by the study scope on specific areas of IS (OHS, EE, EnEff), thus neglecting implications related to possible remaining areas of sustainability in general terms.

To conclude, we would like to mark some further research avenues. From a theoretical perspective, the study could be complemented, on the one hand, by a framework able to relate each driver to the stakeholder(s) that may promote them, also considering the different steps of a decision-making process; on the other hand, by a framework for measuring the performance of companies with respect to IS, thus evaluating the relationships among barriers, drivers and level of performance reached with reference to the adoption of a specific ISM. Furthermore, it would be worth investigating how these relationships vary according to different perspectives of IDMs and when considering from both a single firm perspective and/or from a system context one, i.e. a supply chain or an industrial district. From an empirical perspective, it would be very interesting to investigate a larger sample of firms, differing with respect to e.g. country, size, sector, labour and capital intensity, energy intensity etc., in order to identify the main drivers, and similarities and differences in the drivers according to the different types of possible firms' clusters. This empirical knowledge could represent a valuable support for local and regional policy-makers, as well as other stakeholders (e.g. industrial associations and groupings), so to shape more effective policies for increased IS.

Annex

<i>Origin</i>	<i>Category</i>	<i>Driver</i>	<i>References</i>	<i>Type</i>
External	<u>Regulatory</u>	<i>Compliance with regulation</i>	IS: Arruda et al., 2013; Gabzdylova et al., 2009; Kara et al., 2014; Klewitz and Hansen, 2014; Küçüksayraç, 2015; Lozano, 2015; Schrettle et al., 2014; Sy, 2014 OHS: Cagno et al., 2016; EASHW, 2010; Miller and Haslam, 2009; Walker and Tait, 2004 EcoEff: Altham, 2007; Brammer et al., 2012; De Medeiros et al., 2014; Del Rio González, 2005; Ekins, 2005; Fernández-Viñe et al., 2013, 2010; Ghazilla et al., 2015; Hojnik and Ruzzier, 2016; Masurel, 2007; Mittal et al., 2013; Mittal and Sangwan, 2015; Van Hemel and Cramer, 2002 EnEff: Apeaning and Thollander, 2013; Brunke et al., 2014; Hasanbeigi et al., 2010; Johansson and Thollander, 2018; Sathitbun-anan et al., 2015; Sudhakara Reddy et al., 2014; Thollander et al., 2013; Thollander and Ottosson, 2008; Venmans, 2014	Enabler (external)
		<i>Regulatory sanctions and taxes</i>	OHS: Cagno et al., 2016 EcoEff: Ghazilla et al., 2015; Santolaria et al., 2011 EnEff: Abeelen et al., 2013; Apeaning and Thollander, 2013; Lee, 2015; Sathitbun-anan et al., 2015; Thollander et al., 2013	Enabler (external)

<u>Support</u>	<i>External funding</i>	<p>IS: Merli et al., 2015</p> <p>OHS: Cagno et al., 2016, 2011; Gangwar and Goodrum, 2005; Sims, 2008; Tait and Walker, 2000</p> <p>EcoEff: De Medeiros et al., 2014; Del Río González, 2005; Ghazilla et al., 2015; Govindan et al., 2015; Hojnik and Ruzzier, 2016; Mittal et al., 2013; Mittal and Sangwan, 2015</p> <p>EnEff: Apeaning and Thollander, 2013; Brunke et al., 2014; De Groot et al., 2001; Johansson and Thollander, 2018; Lee, 2015; Rohdin et al., 2007; Thollander and Ottosson, 2008; Trianni et al., 2017a</p>	Enabler (external)
	<i>Public subsidies</i>	<p>OHS: Cagno et al., 2016, 2011; Gangwar and Goodrum, 2005</p> <p>EcoEff: De Medeiros et al., 2014; Del Río González, 2005; Ghazilla et al., 2015; Govindan et al., 2015; Mittal et al., 2013; Mittal and Sangwan, 2015; Santolaria et al., 2011</p> <p>EnEff: Anderson and Newell, 2004; Brunke et al., 2014; Cagno and Trianni, 2013; De Groot et al., 2001; Johansson and Thollander, 2018; Lee, 2015; Sathitbun-anan et al., 2015; Thollander et al., 2013; Thollander and Ottosson, 2008; Trianni et al., 2017a</p>	Enabler (external)
	<i>Cooperation and network with other companies</i>	<p>IS: Lozano, 2015</p> <p>OHS: Antonsson et al., 2002; Cagno et al., 2016; Hasle and Limborg, 2006; Vecchio-Sadus and Griffiths, 2004</p> <p>EcoEff: Bossle et al., 2016; De Medeiros et al., 2014; Fernández-Viñé et al., 2010; Ghazilla et al., 2015; Hojnik and Ruzzier, 2016</p> <p>EnEff: Apeaning and Thollander, 2013; Brunke et al., 2014; Johansson and Thollander, 2018; Lee, 2015; Sathitbun-anan et al., 2015; Thollander et al., 2013; Thollander and Ottosson, 2008; Trianni et al., 2017a</p>	Enabler (external)
	<i>Support from industrial associations</i>	<p>OHS: Cagno et al., 2016, 2011; Sims, 2008</p> <p>EcoEff: De Medeiros et al., 2014; Ghazilla et al., 2015</p> <p>EnEff: Brunke et al., 2014; Cagno and Trianni, 2013; Johansson and Thollander, 2018; Lee, 2015; Thollander et al., 2013; Thollander and Ottosson, 2008</p>	Enabler (external)
	<i>Support from consultants</i>	<p>OHS: Antonsson et al., 2002; Cagno et al., 2016; Hasle and Limborg, 2006</p> <p>EcoEff: Bossle et al., 2016; Ghazilla et al., 2015</p> <p>EnEff: Johansson and Thollander, 2018; Lee, 2015; Thollander et al., 2013; Thollander and Ottosson, 2008; Trianni et al., 2017a</p>	Enabler (external)
	<i>Support from government</i>	<p>OHS: Cagno et al., 2016</p> <p>EcoEff: De Medeiros et al., 2014; Fernández-Viñé et al., 2013</p> <p>EnEff: Brunke et al., 2014; Cagno and Trianni, 2013; Johansson and Thollander, 2018; Thollander et al., 2013; Trianni et al., 2017a</p>	Enabler (external)
<u>External Pressures</u>	<i>Customers' pressures</i>	<p>IS: Collins et al., 2010; Fonseca, 2015; Gabzdylova et al., 2009; Kara et al., 2014; Klewitz and Hansen, 2014; Küçüksayraç, 2015; Lijo and Gopalakrishnan, 2015; Lozano, 2015; Santini et al., 2013</p> <p>OHS: EASHW, 2010</p> <p>EcoEff: Bossle et al., 2016; Brammer et al., 2012; De Medeiros et al., 2014; Del Río González, 2005; Fernández-Viñé et al., 2013, 2010; Ghazilla et al., 2015; Govindan et al., 2015; Masurel, 2007; Mittal et al., 2013; Mittal and Sangwan, 2015; Santolaria et al., 2011; Van Hemel and Cramer, 2002</p> <p>EnEff: Aflaki et al., 2013; Brunke et al., 2014; Cagno and Trianni, 2013; Johansson and Thollander, 2018; Lee, 2015; Thollander et al., 2013; Thollander and Ottosson, 2008</p>	Enabler (external)
	<i>Communities' pressures</i>	<p>IS: Collins et al., 2010; Fonseca, 2015; Gabzdylova et al., 2009; Klewitz and Hansen, 2014; Lozano, 2015</p> <p>EcoEff: Del Río González, 2005; Ghazilla et al., 2015; Mittal et al., 2013</p> <p>EnEff: Brunke et al., 2014; Cagno and Trianni, 2013; Johansson and Thollander, 2018; Thollander et al., 2013; Thollander and Ottosson, 2008; Venmans, 2014</p>	Enabler (external)
	<i>Partners' pressures</i>	<p>IS: Collins et al., 2010; Fonseca, 2015; Gabzdylova et al., 2009; Klewitz and Hansen, 2014; Lozano, 2015</p> <p>EcoEff: Brammer et al., 2012; Del Río González, 2005; Ghazilla et al., 2015; Govindan et al., 2015; Hojnik and Ruzzier, 2016; Mittal et al., 2013; Mittal and Sangwan, 2015; Van Hemel and Cramer, 2002</p> <p>EnEff: Cagno and Trianni, 2013</p>	Enabler (external)
	<i>Shareholders' pressures</i>	<p>IS: Arruda et al., 2013; Collins et al., 2010; Fonseca, 2015; Gabzdylova et al., 2009; Klewitz and Hansen, 2014; Lijo and Gopalakrishnan, 2015; Lozano, 2015</p> <p>OHS: Walker and Tait, 2004</p> <p>EcoEff: Del Río González, 2005; Govindan et al., 2015; Hojnik and Ruzzier, 2016</p> <p>EnEff: Cagno and Trianni, 2013; Johansson and Thollander, 2018; Sathitbun-anan et al., 2015; Thollander and Ottosson, 2008; Venmans, 2014</p>	Enabler (external)
	<i>Competitors' actions</i>	<p>IS: Collins et al., 2010</p> <p>EcoEff: Del Río González, 2005; Ghazilla et al., 2015; Govindan et al., 2015; Van Hemel and Cramer, 2002</p>	Enabler (external)
	<i>Public opinion</i>	<p>IS: Azapagic and Perdan, 2000; Collins et al., 2010; Lozano, 2015; Schrettle et al., 2014</p> <p>EE: Brammer et al., 2012; Hojnik and Ruzzier, 2016; Mittal et al., 2013; Mittal and Sangwan, 2015; Van Hemel and Cramer, 2002</p> <p>EnEff: Brunke et al., 2014; Johansson and Thollander, 2018; Thollander et al., 2013; Thollander and Ottosson, 2008; Venmans, 2014</p>	Enabler (external)

	<u>Market</u>	<i>Increase of market share and sales growth</i>	IS: Klewitz and Hansen, 2014; Küçüksayraç, 2015; Lozano, 2015 EcoEff: Altham, 2007; Bossle et al., 2016; Brammer et al., 2012; Del Río González, 2005; Hojnik and Ruzzier, 2016	Enabler (external)
		<i>New market opportunities</i>	IS: Arruda et al., 2013; Gabzdylova et al., 2009; Klewitz and Hansen, 2014; Küçüksayraç, 2015; Lloret, 2016; Lozano, 2015 EcoEff: Del Río González, 2005; Ekins, 2005; Fernández-Viñe et al., 2013; Ghazilla et al., 2015; Hojnik and Ruzzier, 2016; Van Hemel and Cramer, 2002 EnEff: Sathitbun-anan et al., 2015	Enabler (external)
		<i>Increasing in resources price</i>	EcoEff: Dagiliūtė and Juknys, 2012; Fernández-Viñe et al., 2010 EnEff: Abeelen et al., 2013; Anderson and Newell, 2004; Apeaning and Thollander, 2013; Johansson and Thollander, 2018; Lee, 2015; Rohdin and Thollander, 2006; Sudhakara Reddy et al., 2014; Thollander et al., 2013; Thollander and Ottosson, 2008; Trianni et al., 2017a; Venmans, 2014	Enabler (external)
		<i>Creating competitive advantage</i>	IS: Kara et al., 2014 EcoEff: Fernández-Viñe et al., 2013; Ghazilla et al., 2015; Hojnik and Ruzzier, 2016; Mittal et al., 2013; Mittal and Sangwan, 2015 EnEff: Apeaning and Thollander, 2013; Brunke et al., 2014; Hasanbeigi et al., 2010; Johansson and Thollander, 2018; Lee, 2015; Ren, 2009; Rohdin et al., 2007; Sathitbun-anan et al., 2015; Thollander et al., 2007; Thollander and Ottosson, 2008; Trianni et al., 2017a	Enabler (external)
		<i>Resources scarcity</i>	IS: Lijo and Gopalakrishnan, 2015; Lozano, 2015; Schrettle et al., 2014 EcoEff: Fernández-Viñe et al., 2013	Enabler (external)
<u>Internal</u>	<u>Organization</u>	<i>Improving firm brand and image</i>	IS: Azapagic and Perdan, 2000; Kara et al., 2014; Klewitz and Hansen, 2014; Küçüksayraç, 2015; Lijo and Gopalakrishnan, 2015; Lloret, 2016; Lozano, 2015; Merli et al., 2015 OHS: Miller and Haslam, 2009 EcoEff: Del Río González, 2005; Ekins, 2005; Fernández-Viñe et al., 2010; Ghazilla et al., 2015; Govindan et al., 2015; Masurel, 2007; Mittal et al., 2013; Mittal and Sangwan, 2015; Santolaria et al., 2011; Van Hemel and Cramer, 2002 EnEff: Aflaki et al., 2013; De Groot et al., 2001; Hasanbeigi et al., 2010; Sathitbun-anan et al., 2015; Trianni et al., 2017a; Venmans, 2014	Enabler (internal)
		<i>Improvement of sustainability related performance</i>	EcoEff: Ekins, 2005; Ghazilla et al., 2015; Govindan et al., 2015; Santolaria et al., 2011; Van Hemel and Cramer, 2002 EnEff: Aflaki et al., 2013; Apeaning and Thollander, 2013; Hasanbeigi et al., 2010; Johansson and Thollander, 2018; Lee, 2015; Sathitbun-anan et al., 2015; Thollander et al., 2013; Thollander and Ottosson, 2008	Enabler (internal)
		<i>Anticipation of regulatory changes</i>	IS: Gabzdylova et al., 2009 EcoEff: Ekins, 2005; Mittal et al., 2013 EnEff: Cagno and Trianni, 2013	Simple
		<i>Organizational values and culture</i>	IS: Fonseca, 2015; Gabzdylova et al., 2009; Lijo and Gopalakrishnan, 2015; Lozano, 2015; Schrettle et al., 2014; Sy, 2014 OHS: Miller and Haslam, 2009 EcoEff: Bossle et al., 2016; De Medeiros et al., 2014; Fernández-Viñe et al., 2013; Ghazilla et al., 2015; Masurel, 2007 EnEff: Johansson and Thollander, 2018; Sathitbun-anan et al., 2015; Sudhakara Reddy et al., 2014; Thollander and Ottosson, 2008	Simple
		<i>Past experiences in sustainability and knowledge of business case</i>	IS: Lozano, 2015 OHS: Cagno et al., 2016; Kogi, 2006 EcoEff: Ekins, 2005; Ghazilla et al., 2015; Hojnik and Ruzzier, 2016	Simple
		<i>Including ISainability at strategic level</i>	IS: Bocken et al., 2014; Koho et al., 2011; Lijo and Gopalakrishnan, 2015; Santini et al., 2013; Schrettle et al., 2014 OHS: ENWHP, 2001; Miller and Haslam, 2009 EcoEff: Ghazilla et al., 2015; Masurel, 2007; Van Hemel and Cramer, 2002 EnEff: Apeaning and Thollander, 2013; Brunke et al., 2014; Cagno and Trianni, 2013; Hasanbeigi et al., 2010; Johansson and Thollander, 2018; Lee, 2015; Rohdin et al., 2007; Rohdin and Thollander, 2006; Sathitbun-anan et al., 2015; Thollander et al., 2013, 2007; Thollander and Ottosson, 2008; Trianni et al., 2017a	Simple
		<i>Adoption of certifications/ management systems</i>	IS: Azapagic and Perdan, 2000; Santini et al., 2013 EcoEff: Bossle et al., 2016; Del Río González, 2005; Hojnik and Ruzzier, 2016 EnEff: Apeaning and Thollander, 2013; Brunke et al., 2014; Johansson and Thollander, 2018; Lee, 2015; Rohdin et al., 2007; Rohdin and Thollander, 2006; Thollander et al., 2013; Thollander and Ottosson, 2008; Venmans, 2014	Simple
	<i>Voluntary agreements</i>	EcoEff: Ekins, 2005; Ghazilla et al., 2015; Hojnik and Ruzzier, 2016; Masurel, 2007 EnEff: Rohdin et al., 2007; Trianni et al., 2017a; Venmans, 2014	Simple	
	<u>Staff</u>	<i>Management commitment</i>	IS: Fonseca, 2015; Gabzdylova et al., 2009; Klewitz and Hansen, 2014; Koho et al., 2011; Lozano, 2015; Santini et al., 2013 OHS: Cagno et al., 2011; ENWHP, 2001; Sims, 2008 EcoEff: Bossle et al., 2016; Del Río González, 2005; Ghazilla et al., 2015; Hojnik and Ruzzier, 2016; Mittal et al., 2013; Mittal and Sangwan, 2015 EnEff: Brunke et al., 2014; Cagno and Trianni, 2013; Hasanbeigi et al., 2010; Johansson and Thollander, 2018; Lee, 2015; Ren, 2009; Sathitbun-anan et al., 2015; Thollander et al., 2013; Trianni et al., 2017a; Venmans, 2014	Simple

	<i>Employee commitment</i>	IS: Gabzdylova et al., 2009; Lozano, 2015; Sy, 2014 OHS: Cagno et al., 2011; Vecchio-Sadus and Griffiths, 2004 EcoEff: Bossle et al., 2016; Ghazilla et al., 2015; Govindan et al., 2015; Masurel, 2007 EnEff: Ren, 2009; Sathitbun-anan et al., 2015; Trianni et al., 2017a	Simple
	<i>Training and education</i>	IS: Bocken et al., 2014 OHS: Cagno et al., 2016, 2011 EcoEff: Ghazilla et al., 2015 EnEff: Sathitbun-anan et al., 2015; Trianni et al., 2017a	Simple
<u>Information</u>	<i>Dialogue and encouragement</i>	OHS: Cagno et al., 2016; Hasle and Limborg, 2006; Roy et al., 2003; Vecchio-sadus, 2007 EnEff: Sathitbun-anan et al., 2015	Simple
	<i>Trustworthiness, clarity and availability of information</i>	OHS: Cagno et al., 2016; Miller and Haslam, 2009 EcoEff: Ekins, 2005; Ghazilla et al., 2015 EnEff: Sathitbun-anan et al., 2015; Trianni et al., 2017a	Simple
<u>Innovation</u>	<i>Product innovation</i>	IS: Arruda et al., 2013; Küçüksayrac, 2015 EcoEff: Bossle et al., 2016; De Medeiros et al., 2014; Fernández-Viñé et al., 2013, 2010; Van Hemel and Cramer, 2002 EnEff: Sathitbun-anan et al., 2015	Enabler (internal)
	<i>Technology innovation</i>	IS: Bocken et al., 2014 EcoEff: Bossle et al., 2016; Dagiliūtė and Juknys, 2012; De Medeiros et al., 2014; Del Río González, 2005; Ekins, 2005; Fernández-Viñé et al., 2013, 2010; Hojnik and Ruzzier, 2016; Mittal et al., 2013; Mittal and Sangwan, 2015; Van Hemel and Cramer, 2002 EnEff: Brunke et al., 2014; Johansson and Thollander, 2018; Sathitbun-anan et al., 2015; Sudhakara Reddy et al., 2014; Venmans, 2014	Enabler (internal)
	<i>Quality</i>	IS: Gabzdylova et al., 2009; Küçüksayrac, 2015 EcoEff: Fernández-Viñé et al., 2013, 2010; Ghazilla et al., 2015; Van Hemel and Cramer, 2002 EnEff: Hasanbeigi et al., 2010; Sathitbun-anan et al., 2015	Enabler (internal)
	<i>Greater efficiency in processes</i>	IS: Arruda et al., 2013 EcoEff: Ekins, 2005; Van Hemel and Cramer, 2002 EnEff: Ren, 2009	Enabler (internal)
<u>Economic</u>	<i>Cost savings</i>	IS: Gabzdylova et al., 2009; Kara et al., 2014; Küçüksayrac, 2015; Lloret, 2016; Lozano, 2015 OHS: EASHW, 2010 EcoEff: Altham, 2007; Bossle et al., 2016; Brammer et al., 2012; Del Río González, 2005; Fernández-Viñé et al., 2013; Ghazilla et al., 2015; Hojnik and Ruzzier, 2016; Masurel, 2007; Mittal et al., 2013; Mittal and Sangwan, 2015; Santolaria et al., 2011; Van Hemel and Cramer, 2002 EnEff: Apeaning and Thollander, 2013; Brunke et al., 2014; De Groot et al., 2001; Hasanbeigi et al., 2010; Johansson and Thollander, 2018; Lee, 2015; Sathitbun-anan et al., 2015; Thollander et al., 2013; Thollander and Ottosson, 2008; Trianni et al., 2017a; Venmans, 2014	Enabler (internal)
	<i>Increasing incomes</i>	IS: Gabzdylova et al., 2009; Kara et al., 2014; Sy, 2014 EcoEff: Altham, 2007; Brammer et al., 2012; Hojnik and Ruzzier, 2016	Enabler (internal)

Table A1. The new model for drivers for the adoption of industrial sustainability measures.

Categories are divided, according to their origin in External and Internal. For each driver, references are provided for each of the four areas considered in the literature review. In the last column, the type of driver is specified, i.e. Enabler (external), Enabler (internal) or Simple.

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