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Environmental Collaboration for Sustainability in the Construction Industry: An Exploratory Study in Italy

Margherita Pero [1], Antonella Moretto [1], Eleonora Bottani [2,*] and Barbara Bigliardi [2]

[1] Politecnico di Milano, Department of Management, Economics, and Industrial Engineering, Piazza Leonardo da Vinci 32, 20133 Milan, Italy; margherita.pero@polimi.it (M.P.); antonella.moretto@polimi.it (A.M.)
[2] Università degli Studi di Parma, Dipartimento di Ingegneria e Architettura, viale delle Scienze 181/A, 43124 Parma, Italy; barbara.bigliardi@unipr.it
* Correspondence: eleonora.bottani@unipr.it; Tel.: +39-052-1905872

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Abstract: The notion of sustainability, in its three-fold meaning (economic, environmental, and social), is being adopted more and more by companies. Today it is widely accepted that sustainability cannot be achieved by firms in isolation, but requires the collaboration of all supply chain players. This issue is particularly relevant in industrial contexts where the supply chains are complex in terms of structure and number of players, such as the construction industry. Thus, the aim of the paper is to explore the sustainability practices adopted in the construction industry, with a particular attention to the role of environmental collaboration of supply chain partners in achieving sustainability. By means of multiple case study-based research, we investigate sustainability practices on a sample of construction companies of Italy, thus identifying three main sustainability approaches, which differ in both the strategic orientation towards sustainability and the level of implementation in design, purchasing, and governance processes, as well as the main variables driving the adoption of these approaches.

Keywords: sustainability; practices; environmental collaboration; construction industry; case studies

1. Introduction

"Sustainable development" is defined by the World Commission on Environment and Development [1] as the development that meets the needs of the present generations, without compromising the ability of the future generations to meet their own needs. The principle of sustainability is grounded on the premise that society should use the available resources on a scale consistent with the ability of future generations to do the same. The achievement of sustainable development thus necessitates a concerted effort in all areas of society and human activities to achieve this objective [2]. The term "sustainability", derived from the above expression, literally indicates the "ability to sustain" and is quite recent in the academic literature, being introduced approx. 35 years ago [3]. Nowadays, it is commonly recognized that sustainability covers three main pillars [4–7], i.e.,

- The *economic* perspective. An economically sustainable company should be able to produce goods at the minimum cost;
- The *environmental* perspective. An environmentally sustainable company avoids the over-use of depleting resources or, as an alternative, privileges the use of resources which have less potential for depletion [8]; and
- The *social* perspective. A socially sustainable system should ensure, among other things, fair distribution of opportunities, adequate provision of social services and gender equity [9,10].

Among the others, environmental sustainability is concerned with the maintenance of factors and practices that contribute to the quality of environment on a long-term basis. Achieving environmental sustainability requires exploiting sustainable practices for the provision of a product/service to the final customer, throughout the whole product life cycle, from the conception to the end-of-life [11,12]. Indeed, from an environmental point of view, manufacturing and logistics activities can have a relevant impact, ranging from emissions into the environment, to the consumption of resources, up to the product end-of-life [13,14]. In some industrial contexts, where the supply chains are complex in structure and involve many players, this issue is particularly relevant. Among others, examples of these contexts are the fashion industry [15], the food industry [16], and the construction industry [2,17–19].

The construction industry, in particular, is an important economic sector, as it provides physical facilities and infrastructures for people. In addition, construction has a strong indirect influence on other industries through the pattern of demand and supply [20,21]. The construction industry is also the largest industrial sector of both Europe and the US. At the European level, this industry (including contractors, manufacturers of construction products, and professional construction services) generates almost 10% of the gross domestic product and provides 20 million direct jobs [22]. At the same time, however, the ongoing progress and expansion of construction enterprises is increasingly associated with a number of sustainable development challenges [23,24]. Kneifel [25] stated that the construction industry has potential to accelerate the spread of the energy crisis and to cause environmental problems, ranging from excessive energy consumption to pollution of the surrounding environment. To be more precise, the construction industry has been accused of causing several environmental problems, including excessive consumption of global resources [26], generation of environmental pollution [27], impact on climate change by affecting quality of air and water in cities [28], and production of landfill waste [29]. According to the European Union, the construction industry employs approx. one third of the total energy of Europe; that value increases up to 50% when considering other complementary activities (e.g., the transport or manufacturing of raw materials) [30]. Again, at the European level, the construction industry is also responsible for about 35% of all greenhouse gas emissions. Similar considerations hold for the US, where the construction industry has considerable impacts on the environment, economy, and society: it employs approx. 30% of the raw materials and 25% of water, and produces 30% of the waste of the country [31]. Moreover, it has been estimated that less than 1% of the existing buildings of Europe have been built based on sustainable principles [32]. This is why, in recent years, sustainability has become one of the most important performance-related issues within the construction industry [4,18,27] and construction companies are increasingly asked to translate its strategic sustainability objectives into concrete actions [19,24]. Governments of several European countries (e.g., Italy and the UK) have also introduced financial and fiscal incentives to stimulate the renovation of existing buildings and to encourage construction companies to save energy and make wider use of renewable resources [32–34].

In spite of this relevance, little is known on how construction companies can address the sustainability challenge. Moving from this gap, in this paper we explore the sustainability practices adopted in the construction industry. Moreover, today it is widely accepted that sustainability cannot be achieved by firms in isolation but, rather, that it requires the collaboration of all supply chain players [35,36]. Therefore, this issue should be addressed with a supply chain perspective and the role of collaboration investigated. Based on this gap, this paper aims also at investigating the role of environmental collaboration of supply chain partners in achieving sustainability. Finally, the construction industry involves several companies with different features (e.g., size) and so in this paper we would like to investigate the impact of these contingencies on the adoption of sustainability practices.

The chosen methodology of analysis is multiple case study-based research, which is adopted to investigate sustainability practices on a sample of construction companies of Italy. Based on the results of the case studies, we propose a set of research propositions, to be further investigated in future research.

The remainder of the paper is organized as follows: The next section reviews the literature relevant to this study, including the sustainability practices suitable to be adopted in the construction industry and the role of collaboration for sustainability, and ends by detailing the research gaps and the contribution of this study. Section 3 details the research methodology adopted in this paper and provides an overview of the companies involved in the research. In Section 4, we present the main results from the case studies and discuss them with respect to the literature. Section 5 summarizes the key findings of the study, discusses the main limitations of the work, and proposes future research directions.

2. Research Background and Research Questions

2.1. Sustainability in the Construction Industry

The term "sustainable construction" was proposed in 1994 to describe the responsibility of the construction industry in attaining sustainability [37]. Sustainable construction addresses the role of sustainability within the built environment and includes the ecological, social, and economic factors of a construction project [38,39], in line with the three main pillars of sustainability. Nonetheless, other authors (e.g., [37]) claim that, for the specific case of the construction industry, four pillars of sustainability should be considered, namely: social, economic, biophysical, and technical. While the social economic pillars reflect the definitions provided in the Introduction, the remaining two pillars are specific to the construction industry. The biophysical pillar, in particular, covers the issues related to atmosphere, land, underground resources, marine environment, flora and fauna, while the technical pillar reflects the quality of the building structure.

In a recent conceptual paper, by reviewing the relevant literature related to the construction industry, Agyekum-Mensah, Knight, and Coffey [40] propose a 4Es (i.e., economic, effectiveness, efficiency, and ethics) and four poles (economic, social, environmental, and technology) model of sustainability in construction. According to the authors, the first pole ("economic") suggests that the construction industry should be able to sustain itself financially. This reflects the fact that the construction industry often suffers from poor economic performance, due to excessive cost overruns or delays. From a "social" perspective, the construction industry is a labour-intensive industry; therefore, its social function is to increase labour opportunities and reduce poverty [41]. With respect to the "environment", the construction industry is expected to design environmental friendly buildings and structures [2,26–28]. Indeed, an excessive use of resources is critical for the ecosystem, not only because of the resources depletion, but also because of the destruction and long-term change of natural habitats and distortions of the potable water supply [42]. The themes of environmental impact of construction and buildings, design for recycling and eco-label of building materials all relate to this point and have been extensively debated in literature [18,21,25–29,43–52]. An environmentally sustainable construction company is expected to minimize resource consumption, enhance resource reuse, exploit renewable and recyclable resources and materials, protect the natural environment, create a healthy environment, and ensure quality in creating the built environment [37,51]. Finally, the appropriate "technology" for a particular construction project should be chosen based on a techno-socio-economic environmental assessment.

Several drivers are nowadays turning the attention of construction companies to different aspects of sustainability. First, governmental regulations and national laws are more and more pushing for the construction of "low energy" or "green" buildings [4,18,21,32–34]. Several assessment methods for the environmental performance of buildings are available (see [25,26] for a detailed list); conversely, specific benchmarks related to the environmental impact of buildings are still limited [53], with only few examples available in literature (e.g., [2,4,18,19,54,55]). As a second point, construction companies are encouraged to consider the interests of all "stakeholders" during the development of a construction project [56,57]. Among them, the final customer pays increasing attention to the company's social responsibility [4,53,58]. Other stakeholders, such as public authorities, suppliers, financial providers or local governments can also drive toward the adoption of sustainability practices [38,41,53,56]. Finally, increasing sustainability is expected to be profitable also for the construction company, which could benefit from a "green" image, thanks to the decrease in environmental impacts and health related implications. In this respect, Adetunji et al. [59] have carried out questionnaire surveys in the UK construction industry and found that sustainability strategy and effective reporting to stakeholders can help enhance contractors' reputation and business competitiveness and revenue gains from improved image, loyalty, market access, and repeat businesses. Robinson et al. [60] have reported that the implementation of sustainable construction practices can lead to competitive advantages, such as cost saving from waste reduction plans, improved human development, and better labour practices by reducing the risks often associated with dirty and dangerous construction sites. Tan et al. [61] have analysed, again by questionnaire survey, the linkage between sustainability and competitiveness, and found a positive relationship. Hence, sustainable construction is, overall, regarded as highly important for the long-term viability of contractors.

2.2. Sustainability Practices in Construction Projects

The typical activities of the construction industry for the creation of a final product (e.g., a new building) include the design, energy supply, and materials supply. Any decision to create a new product involves a very significant commitment to consume resources and impact on the environment. Hence, all activities required in a construction project need to be managed in an integrated way, to ensure that sustainability is met. In the construction industry, project management activities span from pre-construction to post-construction activities [52,62], considering the design of the product, the procurement of raw materials, and the components and all of the activities from the construction to the final disposal of the building.

Due to the nature of a construction project, which requires a rigorous planning and management of all related activities [18,23,52,62], an effective project management strategy has potential to significantly improve the sustainability of the construction industry. Moreover, besides the environmental benefits, a proper management of the construction project can decrease the current cost of the construction company, the related overruns and delays [62], thus contributing to the economic sustainability.

From an environmental perspective, Ding [26] reports that an effective way of achieving sustainability in a construction project is to consider and to incorporate environmental issues at a stage even before a design is conceptualised. The systematic and iterative analysis of the environmental impact of more design solutions is commonly suggested for construction project, with the aim to finally choose the ones that allow sustainability strategies to be implemented [17,19,39]. Designers, therefore, have a key role in designing infrastructures that are environmentally sustainable [63].

Once the design option has been selected, the proper choice of suppliers and contractors, which are typically involved in the creation of a new building, could help limit the consumption of energy and resources. For instance, selecting the appropriate suppliers has potentials to significantly decrease the amount of the purchased construction materials that end up as construction waste (which accounts for approximately 9% by weight according to [64]); this is expected to bring both environmental and economic benefits.

The available literature suggests some key sustainability practices that can be adopted at the various steps of a construction project, taking into account not only the construction company, but also its upstream players (e.g., designers or suppliers), which contribute to sustainability, as well [59]. In addition, there is a large body of literature related to the more general theme of sustainability, regardless of a specific sector, from which some further practices and tools can be derived and transferred to the construction industry (e.g., [8–10,13,65–76]). Beyond the operational processes, literature also addresses the role of company's governance to implement sustainability inside the organization. For instance, Lu and Zhang [56] proposed a framework of 110 key performance indicators for architecture, engineering, and construction companies. The framework covers four-elements of corporate development essentials, namely projects, operations, governance, and stakeholders. Similarly, Zhao et al. [41] provided a set of several sustainability indicators, relevant at the corporate level, for construction companies. The rationale behind these studies is that practices, such as the organizational roles devoted to sustainability, would help control the implementation of sustainability objectives [75].

Despite the relevance of sustainability to the construction industry, the adoption of sustainability practices could be difficult to a construction company, for a number of reasons. First, the know-how related to sustainability practices is often limited to the single company and does not cover the whole construction supply chain, which is a requirement to be fully sustainable [77–81]. Indeed, sustainable construction is the result of the common efforts of several players, including investors, construction leaders, service representatives, industry suppliers, communities, and other stakeholders [82]. This is why sustainability assessment methods for the construction industry often include supply chain indicators, in terms of "supply chain impact" or "third parties' emissions" [75]. As a second point, it is often unlikely that a construction company owns a perfect knowledge of the sustainability practices of its context, because the related know-how is somehow fragmented and difficult to access [4,53]. A further main barrier to the adoption of sustainability practices is the related cost: it often happens that practices that are sustainable from the environmental point of view are not profitable from the economic perspective [53]. For instance, certifications of compliance to sustainability standards, released by known authorities, may have a significant cost [4,83]. The company's position inside the supply chain and its (consequent) bargaining power could be a further barrier to the implementation of sustainability practices [4,84].

2.3. The Role of Collaboration for Environmental Sustainability

In scientific literature, it is plainly acknowledged that collaboration plays an important role in enhancing the competitive advantage of any supply chain [6,85]. Recently, however, researchers are increasingly stating that collaboration may also have a crucial role in attaining sustainability. The rationale behind this statement is that sustainability is emerging as a specific supply chain management issue [86], meaning that it is no longer to be approached at the firm's level, but rather, its attainment requires the involvement of supply chain members. Consequently, several authors have studied the role of collaborative efforts in attaining more sustainable supply chains (e.g., [74,76–80,87–98]). Beske and Seuring [68] have introduced four key elements of collaboration that can affect sustainability; these elements are enhanced communication, logistic integration, technological integration, and joint development. Examples of how these elements can be used in practice include joint product design [94,98,99], direct involvement of a company with its suppliers and customers in planning and forecasting [96,100,101]. This latter point is particularly important for the development of green products, for which the precise knowledge about components, ingredients, and working conditions at all stages of the supply chain is essential.

When focusing expressively on the environmental performance of sustainability, some authors use the expression "environmental collaboration" as the direct involvement of an organization with its suppliers and customers in planning jointly for environmental solutions (e.g., [74,102]). According to this definition, in rich collaborative contexts, suppliers and customers ideally plan the reduction of environmental impact from production processes and products together. Therefore, environmental collaboration is based on the mutual willingness to learn about each other's operations, to plan and set goals for environmental improvement. This also implies cooperation to reduce the environmental impact associated with material flows in the supply chain [98–100]. Finally, environmental collaboration comprises a good understanding of each other's responsibilities and capabilities in the field of environmental management. Benjaafar, Li and Daskin [97] investigated the incentives and supply chain collaboration impacts on cost and CO_2 emissions. In a similar work, Ramanathan, Bentley, and Pang [89] have analysed two case studies of manufacturers' collaboration with suppliers and buyers in reducing CO_2 emissions.

2.4. Literature Gaps and Research Questions

The current literature leaves some questions open. Indeed, very limited attention has been paid to some key points, e.g., the way construction companies implement sustainability practices at the different stages of a construction project (e.g., procurement or design) or the contingencies that lead construction companies to adopt those practices. Moreover, despite the fact that the construction supply chain is complex in structure, the issue of environmental collaboration has not been explored in this industry. In this study, we try to fill these gaps; therefore, this paper is expected to contribute to the literature by exploring the use of sustainability practices among construction companies and by investigating if collaboration could be a driver for making a construction company more sustainable.

On the basis of the literature review reported above, we decided to focus on three main processes of the construction industry, namely design, purchasing, and governance. Design and purchasing were investigated with the purpose of assessing whether these processes are carried on in collaboration in construction industry and exploring the role of environmental collaboration among different companies in the construction industry. Moreover, according to Mokhlesian and Holmén [46], governance was included as a process to be analysed because of its role in enabling collaboration between supply chain players.

For these processes, we selected the key sustainability practices to investigate, again on the basis of the literature relating to sustainability, both general and industry-specific. The list of practices considered in the study is shown in Table 1.

Table 1. Sustainability practices.

Process	Sustainability Practices		Definition	"Generic" References	"Construction" References
Design	Life cycle assessment (LCA)		Methodological approach to analyse all the resources and the potential environmental impact of a building along the whole lifecycle	[11,66]	[26,31,50,51]
	Eco-design	Reduction of consumption of energy	Design to increase energy efficiency of the building	[103]	[25,39,40,53,98,100]
		Reduction of consumption of raw materials	Design aimed to maximize efficiency in the use of resources in following construction activities	[18,69,104]	[39,49,52,78,100]
		Reduction of consumption of dangerous materials	Design aimed to select material and technologies that implies the lowest use of dangerous materials	[18,105]	[50,59,60],
		Deconstruction, recycle and return	Design aimed to facilitate the disassembly and the deconstruction of the building in order to reuse and recycle the building elements	[92,105]	[38,43–45,98,100]
		Design rules to be followed by suppliers	Contractor defines guidelines for design to reduce the environmental impact of the building; these guidelines should be used by both internal and external designers	[89,98]	[1,19,79]
	Training on eco-design		Training of internal designers about sustainable construction	[71]	[19,41,58]
Purchasing	Supplier selection	Green criteria	Suppliers are selected based on environmental and social criteria	[67,71]	[41,47,57,69]
		Social criteria			
		Certification	Suppliers are required to be certified (e.g., ISO 14001; SA8000)	[80,83]	[54]
		Local suppliers	Suppliers are chosen due to the geographical proximity	[81]	[23,40,54]
	Sustainable supplier rating	Audit at the supplier	Supplier monitoring for controlling sustainable performance and sustainable processes for instance through audit in the company headquarter	[70]	[54]
		Audit in the yard	Supplier monitoring for controlling sustainable performance and sustainable processes for instance through audit in the yard	-	[54]

Table 1. *Cont.*

Process	Sustainability Practices		Definition	"Generic" References	"Construction" References
Purchasing	Green material purchasing	Recycled materials	The company promotes purchasing of green materials	[104,105]	[39,48–50,54,98,100]
		Materials without dangerous components	The company promotes purchasing of materials without dangerous components	[104,105]	[48,50,54,60]
		Smart materials	The company promotes purchasing of smart materials (e.g., painting with titanium dioxide that has the property to be self-cleaning and pollution reducing)	[104,105]	[48,50,54]
	Code of conduct to subcontractors		Extension of internal code of conduct to external subcontractors	[106]	[54]
	Technical support and training to "green suppliers"		The company provides technical support and training to suppliers, to increase their competences as well as consciousness towards sustainability	[83]	[48]
Governance	Sustainability oriented partnership		The company would set up partnership with the suppliers oriented towards the achievement of sustainable goals	[81]	[46,69,89,94,96,97]
	Organizational roles devoted to Sustainability		Identification of a sustainability manager or an inter-functional team with the goal to control the implementation of sustainability objectives	[81,104]	[11,87–93,97]
	Training on sustainability		The company organizes dedicated course or training moment about sustainability for employees	[70,72,81,105,107]	[11,19,67,87–93,97]
	Ethical code		The company defines an internal ethical code for all of their employees	[81]	[74,76,87,89–93,97]

To be more precise, at first we aim at exploring the different approaches construction companies adopt when implementing sustainability practices. We term "approach" the combination of the sustainable practices adopted and of their level of adoption. In turn, by "level of adoption" we mean the extent to which the practice is used in construction projects: to be more precise, companies can almost not use a practice, or implement it only in some selected projects, or use it in all the projects. It is expected that companies showing a strategic orientation towards sustainability, i.e., which consider sustainability as one of their competitive priorities [108], will implement more practices with a wider level of adoption [95]. Based on these considerations, we formulate the first research question (RQ1) as follows:

RQ1. How do companies in the construction industry implement sustainability in procurement, design, and governance processes?

The implementation of sustainability practices could depend on several factors. In particular, we selected four main contingencies suggested in literature, i.e.,

- *Size of the company*. In implementing sustainable practices, the approach used can vary depending on the company size. Indeed, large companies have higher financial resources for sustainability, to invest in implementing practices to increase triple bottom line performance ([4,73,106]). Conversely, small companies have a higher level of internal and external flexibility, for revising their processes according to sustainable requirements [58];
- *Level of adoption of information and communication technology (ICT)*. Several authors (e.g., [19,24,53]) suggested that ICT technologies can facilitate the implementation of sustainability practices. In fact, ICT usage enables information sharing between companies and support knowledge management, thus increasing trust and transparency, as well as performance monitoring not only internally, but also from a supply chain perspective;
- *Environmental collaboration with supply chain partners*. In deploying the sustainability practices, companies can collaborate with supply chain partners. In particular, companies collaborating with their partners during the design process can involve suppliers of goods and/or of services (e.g., designers). When an environmental collaboration is in place, suppliers can have different responsibilities and the amount of interaction with the clients can vary [36,98]. More specifically, based on literature suggestions [88–91], we identified three main levels of collaboration, namely no collaboration at all, information sharing, and full collaboration. In case of no collaboration, often companies are just used to monitor the supplier; information sharing pertains to the exchange of transactional information that could be obtained both through traditional systems (e.g., e-mail) or through ICT tools (e.g., file sharing systems, building information modelling (BIM), project management tools, etc.); full collaboration is reached when both information sharing and integration of the processes and teams are at stake;
- *Level of control of the key processes.* In line with the classification proposed by Van der Voordt and Van Wegen [49], different "levels of control" of the supply chain can be spotted in the construction industry, on the basis of who is responsible for the main processes. In each process, both planning and execution activities are to be performed, the company can be the owner of planning or/and execution activity of each process. Thereby, the level of control could support the implementation of sustainability practices. In particular, a strong control on planning activity is a way for assuring and verifying the coherence between plan and execution: therefore, we decided to focus on the level of control on planning activities. Processes considered in terms of control are design and procurement, consistently with choices made in terms of sustainability practices. We also include the construction and assembly process given the impact that sustainability practices have on this process in the construction industry and for controlling the real applications of sustainability practices themselves.

Based on these considerations, our second research question (RQ2) is:

RQ2. How the contingencies influence the approach to sustainability of the companies in the construction industry?

3. Materials and Methods

3.1. Research Methodology

To answer the above-mentioned research questions, case studies were used as the research methodology. Case studies are particularly useful in providing answers to 'How?' and 'Why?' research questions [109]. Specifically, we adopted a multiple case study-based approach and investigated eight construction companies that adopt sustainable practices.

Companies selected for the research have declared interest towards sustainability: their interest was either known to the authors of the paper or was evident because they took part in a 'Responsible Building' project, sponsored by the local association of the construction companies. All of the selected companies are based in Italy. Cases were selected with both the literal replication approach, to seek convergent results, e.g., by selecting companies showing interest towards sustainability, and the theoretical replication approach, to investigate, e.g., different level of adoption of sustainability practices or different company sizes [109]. Therefore, the resulting sample is homogeneous in terms of industry, country of origin and declared interest towards sustainability, which ensures the comparability of the results. However, it is heterogeneous, e.g., in terms of company size, as it spans from big companies to micro ones; nonetheless, this choice is consistent with the features of the construction industry at the Italian level, which consists of small enterprises (less than five employees) for more than 95% of companies [110].

The unit analysis refers to the types of managed project: for this reason, in the following sections nine case studies will be investigated and described, because company C owns two strongly different types of projects (i.e., projects partially co-financed for Case 3 vs. projects where company C is just a sub-contractor for Case 7). Case studies were carried out in 2013–2014, by means of semi-structured interviews conducted either face-to-face or by phone, with the manager of each company. These interviews were all followed by an e-mail follow up for clarifying some points or collecting missing data. Each interview took from 60 to 120 min and interviews were recorded when allowed. Moreover, data have been triangulated through secondary sources such as papers, websites, sustainability reports when available, and documents shared by the companies, as well as through direct observations.

The interviewees were asked to provide information about the company in general (name, location, main area of activity, internal organization, and so on) and the sustainability practices adopted (specifically, which practices among those identified in the literature review are adopted by the company and how they are managed). Moreover, the variables affecting the adoption of sustainability practices, i.e., level of control and collaboration, were investigated.

The data analysis was developed in terms of both within and cross-case analysis. Each case was initially analysed individually, to summarize its main features and information. Then a cross-case comparison was developed based on the codebook reported in the previous paragraph, by measuring the level of implementation of each practice, the level of control of the processes and the level of collaboration among supply chain partners as reported in Tables 2 and 3. Cross-case analysis was developed by at least three researchers initially independently, and then the results were compared to reach agreement.

Table 2 provides the main features of the companies involved in the analysis, relating to 2013. Such features are discussed in more details in the following.

Table 2. Main characteristics of the companies and case studies.

Company	Turnover (Million €)	Number of Employees	Case Investigated	Types of Project	Interviewee Role
Company A	2400	2000	Case 1	Hospitals and sport facilities, industrial and private buildings	Sustainability manager EMEA
					Commercial procurement and legal manager
					Procurement assistant
Company B	5	25	Case 2	Hospitals and sport facilities, industrial and private buildings	Owner and technical director
Company C	552	900 (50% devoted to case 7)	Case 3 and case 7	Case 3: private buildings; Case 7: Hospital facilities and commercial buildings	Health, Environment, Security and Quality manager
					Project manager of project financing
					Sub-contracting project manager
Company D	2	10	Case 4	Private and commercial buildings	Owner and technical director
Company E	12.7	14	Case 5	Hospitals and sport facilities, industrial and private buildings	Sales and purchasing director
Company F	3	15	Case 6	Private and commercial buildings	Owner and technical director
Company G	350	700	Case 8	Infrastructures, private buildings	Project manager and yard technical director
Company H	0.5	5	Case 9	Maintenance and renovation of public and private buildings	Owner and sales director

3.2. The Case Studies

The analysis described in this paper involved, overall, eight companies, labelled as Company A–Company G in the following.

Company A is an Australian multinational company, which operates all over the world. Sustainability is perceived as a source of competitive advantage. The strong managerial commitment towards sustainability has been translated into an ethical code shared at global level and in several operative policies. The company owns a department devoted to sustainability, which, among others, sets the sustainability performance target and plans. The company collaborates with suppliers in life cycle assessment (LCA) of the building and provides guidelines to the suppliers for reducing the environmental impact of the building. The suppliers' performance is assessed monthly. Audits are done regularly at the suppliers' sites. Specifically, suppliers are evaluated against sustainability criteria: whenever they do not meet the criteria, they are given some time to fill the gap. Company A develops collaborative relationships with its suppliers, incentivising them to propose innovative ideas.

Company B is a family business founded in 1980 and operates mainly in Northern Italy. The company participates to the Green Building Council Italy and has pioneered the introduction of LEED® (US, Leadership in Energy and Environmental Design) in building in Italy. Sustainability is in the company's mission. The company has developed over the years strong collaborative relationships with the suppliers, especially with design studios. They had to train the suppliers to be able to comply with LEED's rules. External designers are considered as part of the company. Suppliers are involved in design process since the early phases.

Company C is one of the largest building companies in Italy. Company C, depending on the type of projects, uses different practices and approaches. In particular, case 3 is the case for projects that are partially co-financed by the company, while case 7 is the case for projects where company C acts as sub-contractor, thus managing the purchasing and building phase without intervening in the design. Company C's mission is inspired to social values and the company is involved in international networks aimed at developing a social responsibility culture in firms. However, when projects like case 3 are developed, Company C is highly attentive to environmental and social issues, whereas for projects like case 7, the company pursues at first economic objectives. The kind of collaboration developed with suppliers by Company C depends on the type of project. As for case 3, the company collaborates with suppliers since the early stages of the design phase, to find technical solutions with the lowest environmental impact. As for case 7, the company is not involved in the design phase. In fact, the client develops the design without involving company C.

Company D is a family business that operates in Northern Italy, in the area of the city of Alessandria. The company's motto is "Building Green", to symbolize the attention devoted to sustainability. The purchasing style of the company is collaborative; in fact, over the years, the company has developed strong collaborative relationships with its suppliers. Suggestions from the suppliers are used to improve the environmental performance of the building.

Company E is a small company founded in 1975 and operates in Lombardy region in the North of Italy. Sustainability is perceived by the company as in important source of competitive advantage and a market leverage. Over the years, Company E has developed open and collaborative relationships with its suppliers. The company collaborates with suppliers since the early stages of the design phase, to share the guidelines for eco-design and to find new technical solutions with the lowest environmental impact.

Company F is a family business that operates in Lombardy region in the North of Italy. Customers' requests and market pressure increase the company attention towards sustainability, which now is part of the company's strategy. The company plans to redesign completely its processes with an eye on sustainability. They started with taking part to a project to implement a closed-loop system technology to recycle water and reduce emission and wastes in the yard. Suppliers are involved informally at the design stage, to propose innovative solutions. The company has a supply base composed of small suppliers with which it has developed open and long lasting relationships.

Company G, funded in 1977, is a medium company operating in Italy. The company declares no specific interest in the opportunity sustainability can give to differentiate itself from the competitors. Indeed, the company's clients are not interested in sustainability; therefore, Company G's strategy is to compete on price. In most of the cases, the company is not involved in the design phase of a new project. Company G maintains collaborative and informal relationships with the strategic suppliers.

Company H is a family business in the area of Bergamo, in Northern Italy. It operates in the Lombardy region. The company does not have a formalized mission. Its aim is to increase the projects' efficiency to be able to offer the lowest prices to customers. The company is rarely involved in the design phase. When possible the company provides suggestions for improvements. Long-term and collaborative relationships are in place with suppliers.

In all cases, the suppliers' compliance to the company's standards is evaluated when suppliers are selected and periodically monitored afterwards. Moreover, it can be noted that all companies have a collaborative procurement style.

4. Results and Discussion

Within-case analysis as well as cross-case analysis were used to provide answer to the research questions, as presented in the next paragraphs.

4.1. Level of Practice Adoption: Approaches to the Implementation of Sustainability (RQ1)

Table 3 reports the level of adoption of the sustainability practices in each unit of analysis, metrics used for the values are reported in the caption.

Table 3. Level of adoption of the sustainability practices. Note: H = High (practice used in all the projects); M = Medium (practice used in some selected projects); L = Low (practice almost never used). X = practice is used.

Process		Sustainability practices	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Practices in Design Process		Life cycle assessment	H	H	H	M	M	M	L	L	L
	Eco-design	Reduction of consumption of energy	H	H	H	H	H	H	H	M	M
		Reduction of consumption of raw materials	H	H	M	M	M	M	M	L	L
		Reduction of consumption of dangerous materials	H	H	H	H	H	H	H	H	H
		Recycle and Return	M	M	L	L	L	L	L	L	L
		Design rules to be followed by suppliers	H	H	H	M	H	H	M	L	L
		Training on Eco-design	H	H	M	M	M	M	M	L	L
Practices in Purchasing Process	Supplier selection	Green criteria	H	H	M	M	H	H	M	L	L
		Social criteria	H	M	M	M	H	H	M	M	M
		Certification	M	M	M	L	M	M	M	L	L
		Local suppliers	H	H	H	H	H	H	H	H	H
	Sustainable suppliers rating	Audit at the supplier	H	H	M	M	H	H	M	L	L
		Audit in the yard	H	H	H	H	H	H	H	H	H
	Green material purchasing	Recycled materials	H	H	M	M	M	M	M	L	M
		Materials without dangerous components	H	H	H	H	H	H	H	H	H
		Smart materials	M	M	L	L	L	L	L	L	L
		Code of conduct to subcontractors	H	H	H	H	H	H	L	L	L
		Technical support and trainig to "green suppliers"	H	H	H	H	H	H	M	L	L
Governance		Sustainability oriented partnership	H	H	H	H	H	H	L	L	L
		Organizational roles devoted to Sustainability	H	H	L	L	L	L	L	L	L
		Training on sustainability	H	H	H	H	L	L	H	L	L
		Ethical code	H	L	H	L	L	L	H	L	L

Results reported in Table 3 show the level of adoption of each practice. As can be seen in the table, some practices are adopted by all of the companies. For example, the practices of reducing the consumption of dangerous materials at the design stage or purchasing materials not including dangerous components are adopted to comply with law; these practices are checked through audits in the yard. All of the companies are also used to select local suppliers: indeed, a supply chain such as the construction one is strongly impacted by logistics cost and, thus, this choice reads mainly as a strategy for reducing costs, regardless of the sustainability goals. On the other hand, some practices show a lower level of adoption in our sample of companies. For instance, only case 1 and case 2 exhibit a medium level of adoption of both recycling and return at the design level and purchasing of smart materials; these practices are not implemented at all by the remaining companies of the sample. Perhaps, these practices are quite advanced for the construction industry and difficult to be implemented in all projects, even by companies with a strategic orientation towards sustainability: they could be pursued by more sustainable companies just when either project features or customers are requiring their implementation.

Out of these practices, we could group companies according to the level of practices adopted along the three main processes under investigation (performed based on the considerations of Table 2 without considering practices implemented by all companies), as shown in Figure 1. We defined the level of adoption as high if the case mentioned high in all of the practices or at maximum medium, if medium is at the highest level; we defined the level of adoption is low of the case mentioned low in all the practices or at maximum medium, if medium is the lowest level. For realising this classification, we did not consider the practices adopted in all the cases.

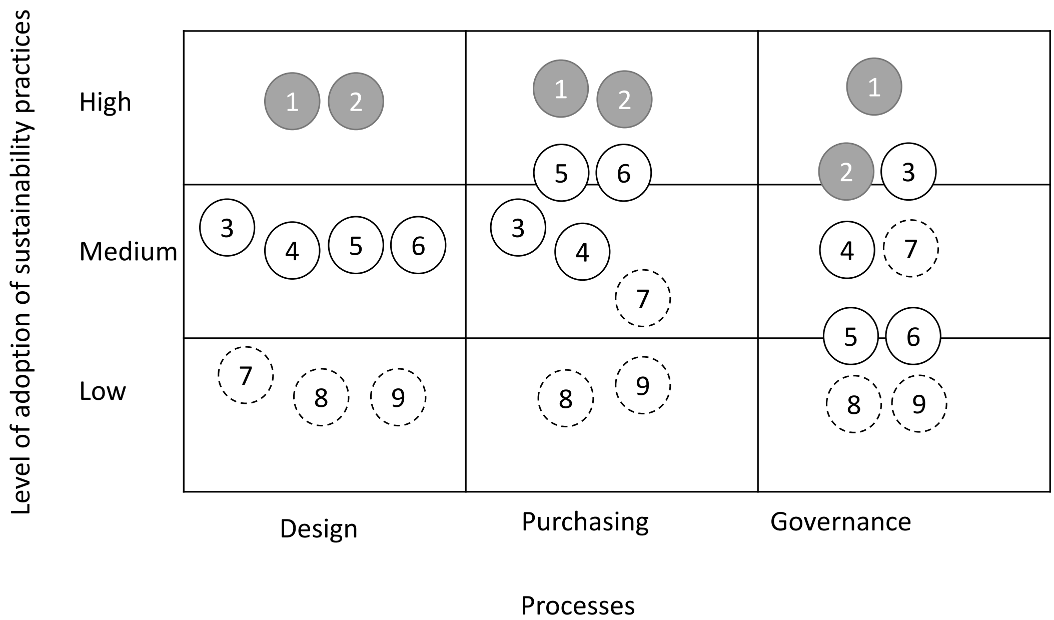

Figure 1. Level of adoption of the sustainability practices along the main processes (design process, purchasing process, and governance).

By analysing the level of adoption of the practices, we were able to answer RQ1 through the identification of the three main approaches, which can be spotted in Figure 1.

(1) *Fully sustainable* (grey balls in Figure 1): cases where all the identified practices are implemented in almost all the projects (cases 1 and 2) and along all the processes. For these companies, sustainability is also a competitive priority pursued with a strategic orientation: thereby, sustainability is a core element of all of the projects.

(2) *Partially sustainable* (white balls in Figure 1): cases 3–6, where the identified practices are implemented in some of the projects especially for design and purchasing; for governance, just a few practices were identified. Despite sustainability is a competitive priority pursued through a strategic orientation towards sustainability, it is not yet a diffused mind-set and it is considered just in a few projects, where it is required by either the features of the project or by the specific customer.

(3) *Not sustainable* (dashed balls in Figure 1): cases where the identified practices are used in a limited number of projects or almost never used (cases 7–9). These companies are implementing just those practices that are either mandatory by law or in a win-win situation with efficiency and cost reduction approaches. This behaviour is consistent with the strategic orientation of the company, given that sustainability is definitely not perceived as a competitive priority but rather as a cost.

Based on these considerations, we could propose the following research proposition (RP):

RP1: In the construction industry, three sustainability approaches could be identified, namely fully sustainable, partially sustainable, and not sustainable.

RP1a: A fully sustainable approach implies a strategic orientation towards sustainability and an implementation of this strategy through the execution of design, purchasing, and governance practices in every construction project.

RP1b: A partially sustainable approach implies a strategic orientation towards sustainability, although the implementation of this strategy through the execution of design, purchasing, and governance practices is limited to a selected number of projects.

RP1c: A not sustainable approach does not imply a strategic orientation towards sustainability; just either mandatory practices or cost-oriented practices are implemented.

4.2. Contingencies Affecting the Sustainable Approach (RQ2)

For answering RQ2, we try to raise the main contingent variables that could affect the adoption of a sustainability approach in spite of another. Table 4 reports the cross-case analysis about the contingent variables reported in literature review section. In terms of level of control, we considered two levels of analysis: "In" when the process is controlled internally, whereas "Out" when the process is outsourced to third parties. In terms of collaboration, we considered three different levels: no collaboration (if the process is performed alone without any collaboration with third parties or at maximum with a monitoring of the performance of the suppliers), information sharing (if exchange of transactional information through traditional systems or through ICT tools is in place), and full collaboration (if information sharing and integration of the processes and teams are in place). Finally, ICT adoption reports the ICT system mentioned by the company, the level of sustainability practice is defined based on data reported in previous Table 3 and, finally, firm size is defined based on the company dimension reported in Table 2.

Table 4. Main variables analyzed.

Case	Strategic Orientiation	Level of Control of Key Processes			Collaboration in Design	Collaboration in Purchasing	ICT Adoption	Level of Adoption of Sustainability Practices	Firm Size
		Design	Purchasing	Building					
Case 1	Sustainability	In	In	In	Full Collaboration	No collaboration (Monitoring)	High: BIM, Integrated data base to see changes to projects and integrated with purchasing, File sharing system at supply chain level	High	Big
Case 2	Sustainability	In	In	In	Full Collaboration	No collaboration (Monitoring)	Low: Basic ICT tools to support design and project management	High	Small
Case 3	Sustainability	In	In	In	Information sharing	No collaboration (Monitoring)	High: BIM, Vendor rating considers sustainability performance of suppliers recorded through an IT system	High	Big
Case 4	Sustainability	Out	In	In	Information sharing	No collaboration (Monitoring)	Low: ICT tools are not used	Medium	Small
Case 5	Sustainability	In/Out	In	In	Information sharing	No collaboration (Monitoring)	Low: ICT tools are not used	Medium	Medium
Case 6	Sustainability	In	In	In	Information sharing	No collaboration (Monitoring)	Low: ICT tools are not used	Medium/High	Small
Case 7	Cost	Out	Out	In	No collaboration	No collaboration (Monitoring)	High: BIM, Vendor rating considers sustainability performance of suppliers recorded through an IT system	Low	Big
Case 8	Cost	Out	In	In	No collaboration	No collaboration (Monitoring)	Medium: ICT tools are not used	Low	Big
Case 9	Cost	Out	In	In	No collaboration	No collaboration (Monitoring)	Low: ICT tools are not used	Low	Small

4.2.1. Company Size and Practice Adoption: No Direct Impact Is Identified (RQ2)

On the basis of the suggestions available in literature (e.g., [54,59,73]), we checked whether the three approaches are implemented in a different way depending on the size of the company. Actually, groups are quite heterogeneous in size, since large companies are included in all of the three sustainability approaches, as well as small companies. If we focused on the evidence of our cases, we could not conclude that the company's size is actually relevant in discriminating between the different sustainability behaviours of the construction companies. This conclusion is quite consistent with the current debate in the literature about the role of size to discriminate among different sustainability approaches [4,63]. As a matter of fact, either the availability of financial resources for large companies or the higher level of flexibility for small companies can drive comparable approaches towards sustainability. This result is particularly relevant for the Italian context, where cases were performed: as mentioned in the research methodology section; in Italy 95% of construction companies have less than five employees. Nonetheless, in spite of this contingent situation, our results suggest that size is not a barrier to the implementation of sustainability practices in the construction industry in Italy. According to this result, the following RP can be formulated:

RP2: In the construction industry, size of the companies does not discriminate among sustainability approaches.

4.2.2. ICT and Practice Adoption: No Direct Impact Is Identified (RQ2)

Similar considerations could be made for ICT adoption, which is another variable suggested in the literature as potentially relevant for sustainability (e.g., [24,53,105]). The use of ICT appears as aligned quite well with the company size, given that all of the large companies are implementing quite advanced (e.g., case 8) or strongly advanced (e.g., cases 1, 3, and 7) ICT tools (such as BIM). Conversely, small companies still exhibit a low level of ICT adoption (e.g., case 2), with some cases where ICT tools are not adopted at all (e.g., cases 4–6, and 9). As a matter of fact, ICT tools might be useful for improving the effectiveness as well as sometimes the efficiency of the design process; however, in our sample, they are still not really perceived as a tool for improving the sustainability profile of a company. For example, case 7 is strongly using ICT tools along its supply chain: this is due to the fact that the company is already operating in the construction industry with different divisions, for which it has developed a complex ICT structure to improve efficiency and effectiveness of project management. This choice is not related to sustainability at all and so the company would use ICT tools, but it does not have any specific orientation to sustainability and does implement just mandatory practices. On the contrary, case 2 is strongly oriented to sustainability, with the implementation of practices in design, purchasing and governance, always with a high level of implementation. This result is achieved without the support of ICT tools because the supply chain integration is actually obtained through frequent face-to-face meetings with subcontractors to discuss potential problems or changes to the project plans. This result is not quite aligned with the existing literature (e.g., [24]), as we found that ICT tools are actually not necessary to achieve sustainability and do not seem to play an enabling role. This result, as well, is strongly relevant in the Italian context, where the average level of adoption of ICT is quite low. These results are, therefore, encouraging, in the sense that Italian companies can also strive to improve their sustainability profile even without high financial and process investment in ICT. According to this result, the following proposition can be formulated:

RP3: In the construction industry, ICT adoption does not impact on the sustainability approach.

4.2.3. Environmental Collaboration Level and Supply Chain Control and Practice Adoption: A Direct Impact Is Identified (RQ2)

On the contrary, cross-case analysis would support the relevance of the two other variables identified in the literature, i.e., the level of environmental collaboration and control along the supply chain, which seem to enable the sustainability approach. In Figure 2, we show the positioning of cases depending on these two variables.

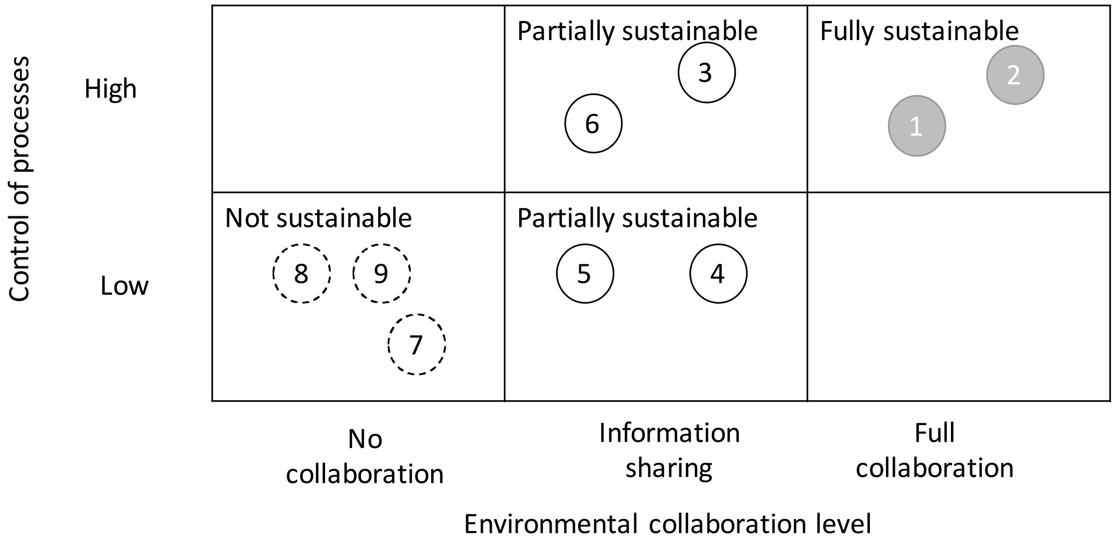

Figure 2. Impact of environmental collaboration level and control of processes on sustainability behaviours.

The level of environmental collaboration pertains to the involvement of supply chain partners during the design process. We mainly considered data about environmental collaboration in design, e.g., the use of designers for improving the final quality of the design activities. In fact, in six cases out of nine, companies collaborate with supply chain partners in the design phase to ensure that the building will comply with sustainability requirements. In particular, cases 1–6 involve suppliers in the LCA analysis of the building, as well as in finding design solutions that ensure the use of, e.g., recyclable materials. Interestingly, case 4 tries to implement sustainable practices in those projects where it is involved in the design phase by the client, and pushes other supply chain partners to do the same.

On the contrary, the level of environmental collaboration in purchasing is quite poor, given that all of the companies raised a monitoring approach. For example, case 1 mentioned their consideration of sustainability parameters in the supplier qualification phase for including the new supplier into the supply base; conversely, the company is not interested in helping the supplier to improve the performance in a collaborative way. The only exception is the environmental collaboration with competitors to improve supply chain sustainability performance: for example, cases 5 and 6 plan to set the project to share with selected competitors their sustainable supplier selection criteria and ratings, as well as to develop a code of conduct to share with sub-contractors.

As for governance, in all of the cases there is no environmental collaboration in place, except for “sustainability oriented partnership”. For example, case 1 is an Italian Green Building Council member and supports the European Union Sustainable Energy Campaign and the WWF Global Forest and Trade Network. For the other practices, companies mentioned an internal management of those aspects, without either monitoring or collaborating with suppliers, due to the intrinsic nature of those practices.

On the other hand, different levels of supply chain control can be spotted in the construction industry, based on the allocation of responsibilities of the main processes, i.e., design, purchasing and building. The level of control is considered as “high” when all planning phases are controlled directly by the company, and “low” when at least one planning phase is not directly controlled by the company. As a matter of fact, just half of our sample used to control planning activities (namely cases 1–3, and 6); all of the remaining cases would delegate outside not only the execution of activities, but also the planning activities, either totally (cases 4, 7–9) or partially (case 5). In companies with high levels of control, internal teams would cover the design, purchasing, and building planning, even if execution activities would be performed by external teams. In these cases, the company would play the role of coordinator of external partners involved in project performing.

4.2.4. Discussion

Figure 2 addresses important considerations about the variables affecting the sustainability approaches. Non-sustainable companies have a traditional approach towards environmental collaboration in design, as well as control, along the processes. These companies are primarily focused on internal processes with a clear attention towards standard performance metrics, such as cost. These companies are traditional and not interested in modifying their processes and practices based on external parties: for the same reasons they do not have a clear attention towards sustainability out of regulation.

Partially-sustainable companies would present environmental collaboration based just on information sharing with other parties. In fact, in partially sustainable companies, sharing of data, as well as plans, is pursued, but without moving towards an integration of practices and processes. On the one hand, information sharing is used because attention towards the whole supply chain is a good lever for improving the internal company's performance [10,15], as well as its sustainability profile. Indeed, an adequate level of sustainability could be obtained only through a sustainable supply chain [68,86] and so a certain level of information sharing is necessary to improve these performance metrics. On the other hand, partially sustainable companies do not have a homogeneous behaviour in terms of level of control along the chain. In fact, cases 4 and 5 are not interested in controlling the planning activities of the main processes, while cases 6 and 3 show a high extension of control along all of the processes, thereby increasing the level of control of the supply chain, although without a clear integration with partners.

In this respect, our case studies suggest that it is not enough either that one of the companies of the supply chain has a strong strategic orientation towards sustainability for that company to be fully sustainable, or to keep the control of the planning phase of design, procurement and building. In fact, fully sustainable cases are those that have not only a strategic orientation towards sustainability and not only a high level of control of processes, but also a full collaboration with other parties. This indicates that simply sharing data is not sufficient; rather, it is necessary to integrate procedures and processes to ensure that all of the partners are aligned and are pursuing the same goals. A statement of case 2's technical manager supports this conclusion: "*Developing long-term relationships with supply chain partners is fundamental to pursue a sustainable strategy*".

Based on this consideration, we could propose the following RP:

RP4: In the construction industry, a fully sustainable approach would be enabled by a high level of control of the processes and would necessarily require a full collaboration with external partners.

5. Conclusions and Directions for Future Research

This paper has investigated the topic of environmental sustainability in the construction industry, with particular attention to the role of environmental collaboration in achieving sustainability. Environmental sustainability is acknowledged as one of the most important performance-related issues within the construction industry, due to the high impact of this industry on environmental and social performance. Nonetheless, the focus of many construction companies is still just on the implementation of practices oriented to minimize the cost and improve the quality of the building. In this vein, this paper aimed at identifying the main approaches followed by construction companies for introducing sustainability practices in the procurement, design, and governance process (thus focusing on the whole supply chain), as well as of exploring the main variables that can influence these approaches. Through the development and analysis of nine case studies, targeting Italian companies, we have identified three main sustainability approaches, which differ in both the strategic orientation towards sustainability and the level of implementation in design, purchasing, and governance processes. These approaches are: fully sustainable, partially sustainable, and not sustainable. By analysing these approaches, we found that the strategic orientation towards sustainability could discriminate sustainable companies versus non-sustainable ones, but is not sufficient for discriminating between a partially sustainable and a fully sustainable approach. Thereby, we have identified variables driving the adoption of these approaches. In particular, the adoption of a sustainability approach does not seem to be affected by either the company size or the use of ICT tools. On the contrary, a supply chain variable conditions the adoption of a sustainability practice, and specifically full collaboration along the supply chain is necessary for reaching a fully sustainable behaviour.

We think these results are innovative from both a practitioner and researcher point of view. For the former, this paper would help managers in understanding the critical choices for reaching a fully-sustainable behaviour in the case of a strategic orientation towards sustainability, without wasting both money and time in investments and projects oriented to irrelevant variables (e.g., ICT tools). For the latter, this paper would enrich the theoretical knowledge about sustainability, by means of an empirical analysis in an industry where the issue of sustainability is crucial, although quite unexplored. This paper shows that for this industry as well, sustainability is definitively not a matter of single company but a matter of supply chain. On the other hand, in an industry where the design process is critical and strategic, it is not sufficient to foster sustainability at the supply chain level. Conversely, environmental collaboration between companies is necessary in the design stage, to foster sustainability. Hence, this paper reinforces theories about the importance of collaboration for enhancing sustainability and, more precisely, it stresses the importance of the alignment between the supply chain and design processes for achieving performance improvement, also in terms of sustainability.

This paper also opens new opportunities for further research. First, it would be interesting to replicate this study with a wider sample for testing, with statistical analyses, the research propositions derived from our work, thereby increasing the generalizability of the results. Moreover, this study could be replicated in other countries, to assess whether the results are dependent on industry-specific factors, rather than country specific factors.

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