



Methodological Transition Towards Sustainability: A Guidance for Heterogeneous Industry

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Abstract. No matter the sector, type, or philosophy of companies, there is strong evidence of sustainability awareness and environmental proactivity in industry. However, heterogeneity of firms shows that undertaking environmental actions may be a major challenge, where success is not guaranteed. This is a central issue for the ecological transition of industry and, unfortunately, it is an issue that cannot be tackled by a unique perspective. Still, for a transition occur, at least an initial and an envisaged state should be defined; and a procedure for transition between both must be formalized. In this sense, the literature provides methods to define, yet not to enhance the ecological states of firms, exposing a critical inattentiveness in the process for transformation and, in industrial diversity. To establish the foundation for dealing with these issues, this paper first synthesizes these methods—which showed a strong alignment to Information science and strategic sustainability, and proposes a matrix for transition, composed of an informational and ecological dimension. Later, this matrix is used to propose and fuel a preliminary methodology delineated by different firms. Both are oriented to guide the ecological transition of all kind of companies.

Keywords: Sustainability · Environment · Transition · Strategy · Information Science · Data · Information · Knowledge · heterogeneity

1 Introduction

Sustainability emerges, not through fixed definitions of the concept, but through its interpretation and its continuous practice [1]. Nowadays, a sustainability mindset is being adopted progressively and is gaining momentum, as increasing organizations embark on their sustainable transitions in different ways. As a result, significant improvements in the economic, environmental and social contexts are evidenced around the world. In France, for example, the industrial sector has reduced approximately 40% of its Greenhouse Gas (GHG) emissions over the last three decades [2]. Although the credit of this notable achievement is due to several factors, there are specific sectors, such as those of the mining, chemical and metallurgical that reported significant advancements. This suggest that sectors and firms are dissimilar and embrace sustainability differently, so much, so that the orchestration of their environmental actions merits more investigation. Indeed,

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there is evidence that sustainability goals (e.g., resources efficiency or decarbonization [3]), challenges (e.g., globalization or innovation [4]), and key capabilities (e.g., in traditional or new technologies [5]) differs from one sector to another and from one company to another.

In the face of such heterogeneity (which is surely replicated worldwide [6]), environmental initiatives may not be successful [7], or strategic sustainability and initial steps may not be clear [8]. These issues are critical for the transformation of industry and must be tackled by adopting a comprehensive posture to avoid resource waste. Pragmatism (and later own research) suggest that hard beginnings and hesitation are expected, especially when a long-term vision is not clear [8], and when operative process are not synchronized [5].

Nevertheless, firms confront the challenge of embarking on their ecological transitions without a framework that prevent them from failing, or that facilitate tracing the transformation process in a holistic way. Pragmatically, for a transition to happen, current and envisaged states need to be recognized, and transition means between them need to be established at least. In this sense, measuring the ecological state of firms gets significance, and knowing the dynamics of change become fundamental for materializing environmental agendas. Accordingly, several authors abstract those key features that defines representative states, but they only arrange these states in rigid sequences, according to different domains. Thus, available models help to recognize, yet not to enhance the ecological position of firms [9]. In addition, they fall short regarding heterogeneity of firms [6, 10].

In the light of this complex reality, this work aims to give an answer to the following question: “how to guide efficiently heterogeneous firms into their successful transitions towards sustainability?”.

On the other hand, previous research exposes the strong ties and paradoxes between sustainability and different facets of Information and Communication Technologies [11], especially data [12]. For example, data circulating along cloud-based IT architectures may generates environmental damage (especially when uncontrolled service propagation occurs [13]), but data may also nourish industry transformation [9] and environmental performance [14, 15]. Here, we not only advocate for the pros of data, but also hypothesize that the collection of appropriate data, its transformation into information and its further exploitation, altogether are vital for ecological evolution. Accordingly, this work synthesizes key aspects found in literature so that they (1) be related in a transition model and (2) fuel a guidance method. This is of particular interest for ensuring the success of environmental initiatives and the strategic sustainability of all kind of companies.

The rest of the article is organized as follows. Section 2 present the research methodology adopted to answer the aforementioned research question. Section 3 presents our results that generate a transition matrix, proposed in Sect. 4, and a guiding methodology, proposed in Sect. 5. Section 6 reports ongoing and future work and concludes this article.

2 Research Methodology

The research methodology followed in this work is composed of two parts. The first part consists in a systematic review of the literature and the second part consists in a qualitative research. In the first part, we are interested in methods that help to construct,

assess or guide the ecological transition of firms. Because the concept of environmental transition is complex —difficult to be abstracted in single keywords and mandatory to be tackled from different perspectives, this part covers the systematic review of four bodies of literature, organized as follows:

- Assessment methods for environmental maturity
- Assessment methods for environmental awareness
- Assessment methods oriented to ecological performance
- Methods oriented to stablish environmental roadmaps

In this way, the first two cover methods focused on recognition of ecological states, and the last ones cover methods (researched in academy and advisory praxis) used in the dynamics of change (both for implementing environmental projects and for assessing the successful of such initiatives). Figure 1 describes the simplified selection process of methods based on the Preferred Reporting Instrument for Systematic Reviews and Meta-Analysis (PRISMA) (a methodology designed to report, in a transparent way, the followed steps and the obtained results in systematic reviews [16]).

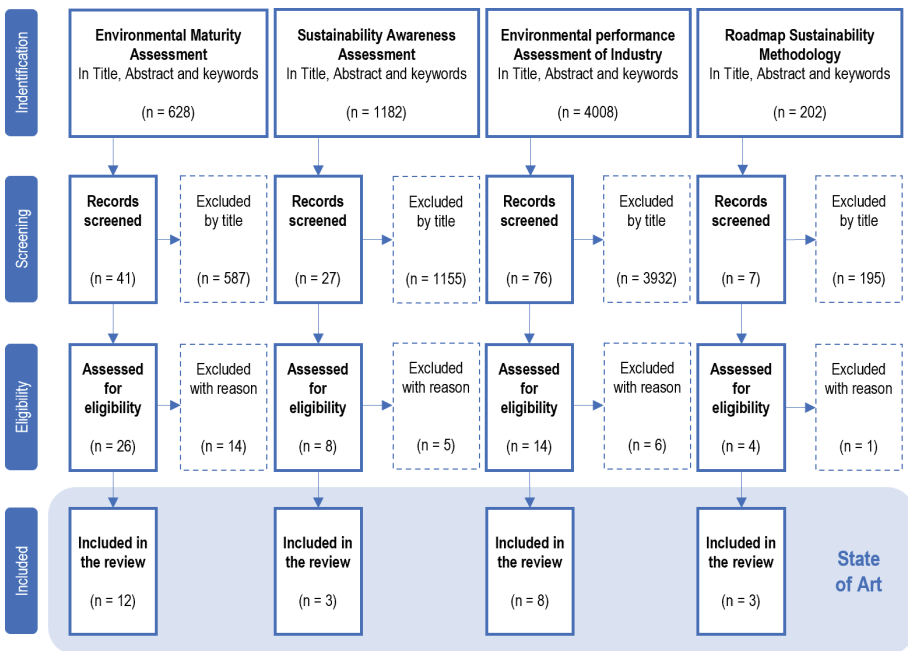


Fig. 1. Systematic Literature Review process of the four bodies of literature that define ecological transition

As observed, the Systematic Literature Review process was conducted in four steps. In the first step, each keyword group (e.g., Environmental Maturity Assessment) is searched by title, abstract and keywords in Web of Science. In the second step, the results are screened by title, keeping only instances that suggest the introduction of

methodologies. In the third step (eligibility), works oriented to very specific sectors or firms are excluded, and the abstracts of remaining peer-reviewed works are read. Only those validated empirically are included for full lecture. This process allows to establish the State-of-Art, which will be later analyzed in Sect. 3.1 to propose a transition model deductively, in Sect. 4.

In the second part, we are interested in inquiring into the heterogeneity of firms to construct a flexible methodology for ecological transition. Figure 2 shows the design of this investigation according to the research methodology proposed by Maxwell, J. [17].

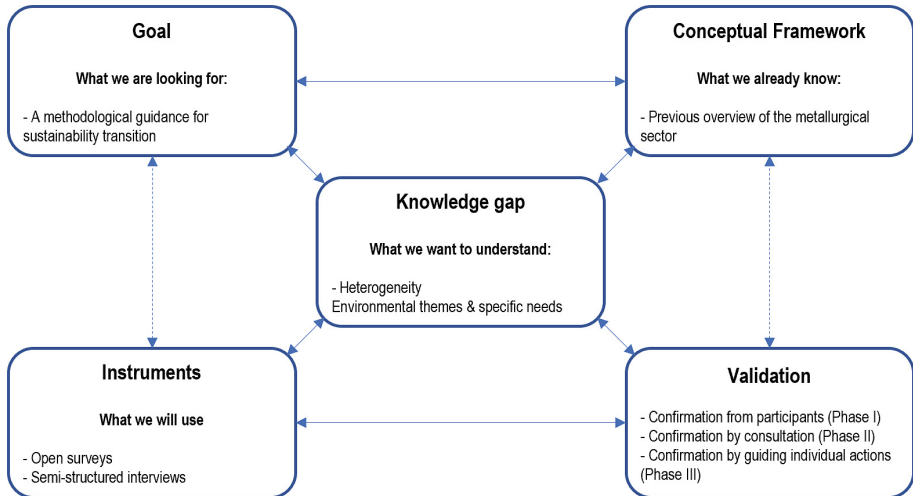


Fig. 2. Design of the qualitative research. Validation may require revisiting the conceptual framework and additional instruments may be applied, according to the goal of the study.

Starting from previous knowledge that introduces the diverse nature of ecological attempts of companies in the metallurgical sector [5], we define our goal oriented to find key concepts to construct a methodology for guiding heterogeneous companies in their ecological transition. To achieve this goal, we aim to get comprehension of two aspects. Firstly, we want to understand heterogeneity in terms of products and/or services, achievements, ongoing environmental actions and impact hotspots (which will establish the current state of a firm); and in terms of environmental objectives. Secondly, we aim to understand the usual ecological themes and specific needs of enterprises.

The first aspect is covered by semi-structured interviews and the second aspect is covered by an open survey lunched in industrial workshops. This qualitative research is conducted within the UIMM industrial network at the French region of Ain, in the context of the ACCEL4.0 project [18]. Industrial members belonging this consortium validate this investigation in three phases: a first phase (phase I), in which synthesized results from open surveys and semi-structured interviews are reviewed; a second phase (phase II), in which preliminary versions of the envisaged methodology are discussed; and a third phase (phase III), in which application of our methodology is tested, under

the context of individual projects. This work presents the results of the first phase that produce a preliminary version of the guiding methodology, presented in Sect. 5.

3 Results

3.1 Key Findings from the State-of-Art

From the State-of-Art showed in Fig. 1, Maturity- and Indicators-based models are dominant. Very few contributions under alternative approaches are found (e.g., Sustainable Business Models [19]), although not in the four bodies of literature. With the exception of Ngai, E., et al. [20], who offer the concept of “maturation levels” and Vasquez, J., et al. [21], who offer a transitional routine based on the fulfilment of “characteristics”; Maturity Models (including variants) and Indicators-based approaches (which we later considered as a vehicle for assessing maturity) only allow positioning companies in environmental levels. In other words, they show the “you are” and “you should be”, but they fall short in guiding the transition from one maturity level to the other (that is, the “how to enhance”). Added to this, the “you should be” is established in function of rigid roadmaps, rather than appropriate strategy [8].

On the other hand, the literature review highlighted quite similar postures from very different authors. These similarities have to do with environmental aspects, usually interpreted in impact categories (e.g., global warming or resources depletion) and the circulating information used to estimate and reduce the environmental damage in each level of maturity. Indeed, with few exceptions, the majority of authors reveals clearly (1) the relevance of data collection, (2) the inevitable information treatment and (3) the automatization means, for dealing with impact categories. Besides, a subjacent tendency related to environmental initiatives, modification of processes and strategy is perceived in most of operational aspects (here, also, the notion of data and information flow persists, although more subtly (e.g., in the structural enablers studied by Güngör, B., et al. [22] or in the policy domain studied by Eisner, E., et al. [6])).

This tendency describing initiatives, processes and strategies aligns with the explicit evolution evidenced and promoted in the scarce literature of environmental advisory. Certainly, experience from consultors [8] and representative case studies [23] suggest that ecological initiatives evolve from a tactical sustainability (unrelated actions or isolated initiatives), to a strategic sustainability (new sustainable business models) driven by the change of transversal core processes of companies (process sustainability).

Aligned with this, Chofreh, A. G. & Goni, F. A. [24] suggest that a strategical level (top management activities), a tactical level (mid-level management activities) and an operational level (supervisory activities) form a decisional paradigm usually adopted in the design and implementation phase of sustainability roadmaps. Based on this, they later proposed a framework for the design of Sustainability Environmental Resource Planning implementation covering relevant aspects for all industrial sectors, including sustainability indicators and tactical, operational and strategic management [25].

The supplementary material that accompanies this work summarizes these key aspects and includes more works, that align to these findings in an implicit or explicit way. Together, they allow the construction of two generic Maturity Models that generate a transition Matrix, proposed in Sect. 4.

3.2 Results from the Qualitative Research

Initially, the open surveys were distributed during industrial workshops and putted online to everyone during seven months. The responses of nine companies belonging to different sectors were analyzed to identify common themes regarding ecological transition. From this, it was found that 5 of 9 enterprises require support in environmental impact estimation and environmental impact reduction (including eco innovation and eco design). Also, 4 of 9 enterprises require assistance in strategic sustainability and training (including environmental education, raising internal awareness and coaching). These results coincide with certain groups of aspects saw in literature (such as performance enablers, human factors, top management, product lifecycle or business models).

Subsequently, 5 enterprises participated in semi-structured interviews. The statements of participants were analyzed systematically to identify specific needs regarding impact estimation, eco innovation, strategic sustainability and training; all in the context of certain aspects that characterize the current state and ecological objectives of their companies. Figure 3 illustrates an instance of a specific need (dotted arrow) that must be fulfilled to achieve a specific objective from a current state, all in the context of a common theme.

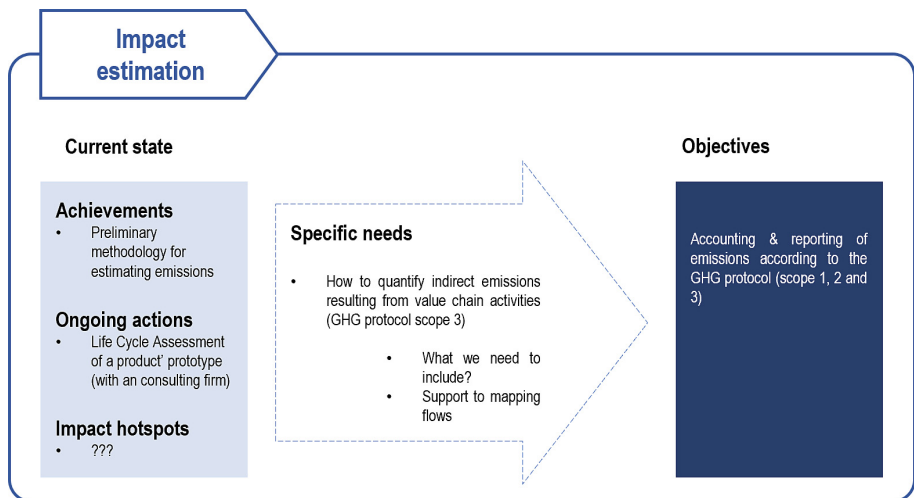


Fig. 3. A specific need of a company in the context of the environmental theme “impact estimation (Type of product is not shown due to confidentiality reasons).

Importantly, doubts and high uncertainty related to strategic sustainability was evidenced in some companies.

4 Matrix for Ecological Transition

Figure 4 synthesizes the central aspects of the literature presented in Sect. 3.1. Figure 4 (right) shows a simplified Maturity Model composed of n environmental and n operational aspects in lines, and only three maturity levels in columns, which are a synopsis

of maturity levels in terms of tactical sustainability (initiatives), process sustainability (changes in transversal core processes) and strategic sustainability (Sustainable Business Models). We call this synopsis the ecological dimension. On the other hand, Fig. 4 (left) shows a simplified Maturity Model composed of the same environmental and operational aspects in lines, but with a synopsis of maturity levels related to data collection, Information and Knowledge. This abstraction reflects the central role of information for the maturity evolution of operational and environmental aspects of firms, evidenced in literature. We call this synopsis the informational dimension.

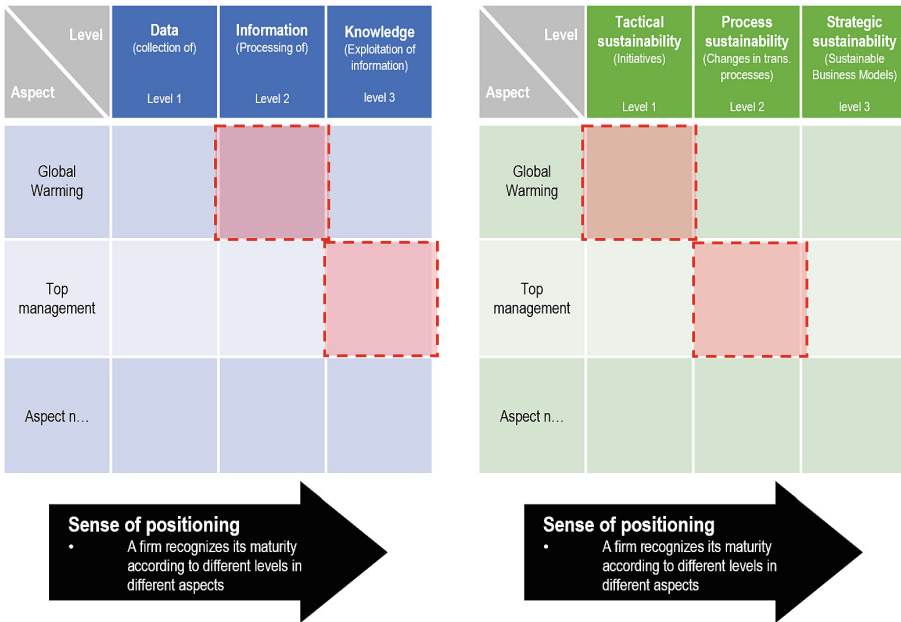


Fig. 4. Dissection of Maturity Models according to the informational and ecological dimensions. The “Global Warming” and “Top management” cells are provided randomly, only for illustrate an instance of an environmental an operational aspect.

Within these two dimensions, a company can recognize its maturity according to different levels in different aspects. For example, it may process information from data related to emissions to apply a particular tactic to reduce its global warming damage, or use previous information from top management to apply changes in transversal processes to solve several hotspots reported in its environmental reports. As observed in the simplified models above, a company can evolve only horizontally in both dimensions, and independently from one environmental or operational aspect to another (as red boxes suggest). In this sense, the idea of Maturity Models promoted so far by literature is recognizing the position of an enterprise within a level-based roadmap, neglecting the transitional procedure from one level to another. In this work, we believe that this transitional procedure happens simultaneously in both the ecological and informational dimensions, as suggested by our proposed transition Matrix showed in Fig. 5.

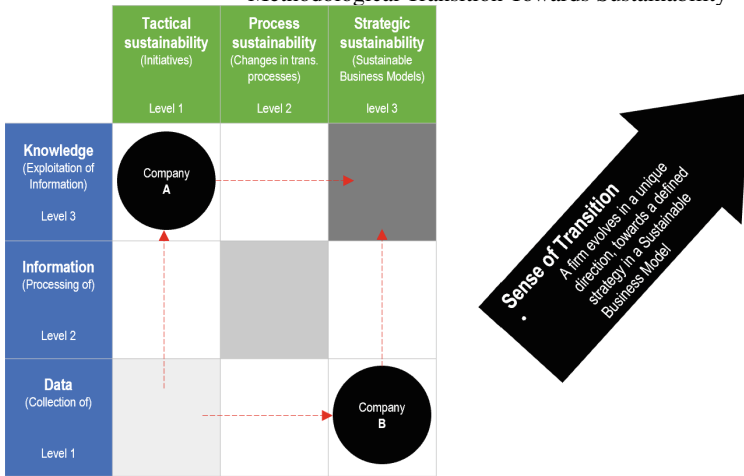


Fig. 5. Matrix for ecological transition of firms

Indeed, our main hypothesis here is that mature firms in the informational dimension (e.g., Company A) have a significant potential to accelerate their evolution in the ecological dimension because both, information or knowledge, can be used for replanning transversal processes or business models, to allow sustainability. Likewise, mature firms in the ecological dimension (e.g., Company B) have a significant potential to accelerate the materialization of their sustainable agendas, if they collect key data to generate and exploit information. In this sense, we bet on a transition model, whose main dynamic aligns environmental and operational aspects in a unique sense towards a defined strategy in a Sustainable Business Model (as showed by the gray boxes, along the diagonal).

To validate this hypothesis, we will conduct in a further work a diagnostic of firms that includes our matrix. This diagnostic will be carried out within the ACCEL4.0 project and it will consist of an iterative diagnostic of the firms’ maturity in the ecological and informational dimensions. This diagnostic step is included in the step 4 of a proposed methodology, described in Sect. 5.

5 Methodology for Guiding Ecological Transition

The Maturity Matrix above is an abstraction which is coupled with a methodology oriented to facilitate the construction of environmental roadmaps, towards sustainability (presented in Fig. 6).

Because the results of our qualitative research show high heterogeneity of companies (not only in terms of activity, needs and size, but also in terms of objectives in different themes) this methodology must to be the most flexible to adapt to specific goals; and the most generic to adapt to all types of firms. In this sense, the first step conducts an evaluation of the current state of a firm, considering its global strategy and all its distinct features (specially its short-, mid- and long-term goals and needs). From this, one or many environmental actions can be projected, and the second step —Training, covers the development of necessary skills related to these actions (it may also include raising awareness of sustainability and digital maturity). Then, the methodology classifies environmental actions in two interrelated categories: environmental actions oriented to

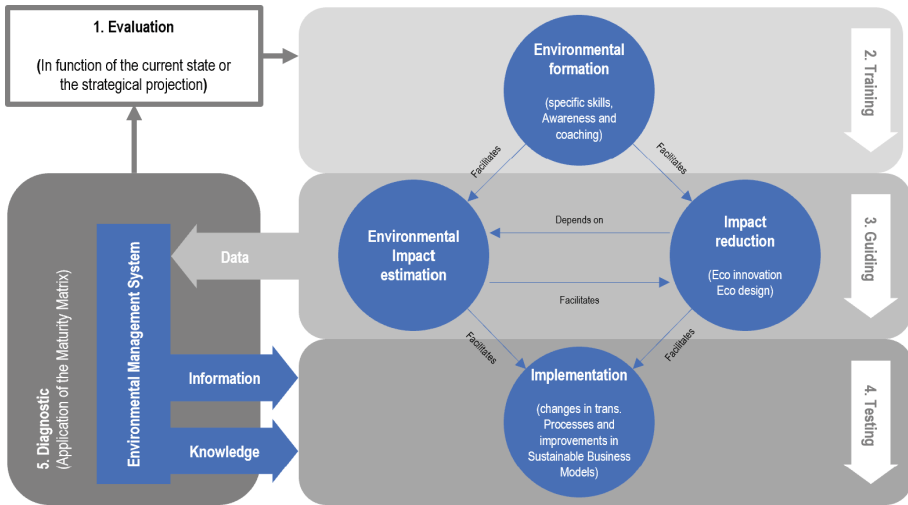


Fig. 6. The proposed methodology for guiding and stablishing flexible roadmaps for ecological transition

impact estimation and environmental actions oriented to impact reduction (including eco design and eco innovation). Guidance for both categories is provided in a third step (guidance). Also, factual data is identified and collected systematically on the way, so that information or knowledge can be generated (manually or automatically) in an environmental management system, and used to modify transversal processes or business models in a four step (implementation). As observed, a firm may start anywhere and skip some steps, but not step five (in which transition is reviewed and confronted to the strategy of the company, closing the loop).

In the first iteration, step five (diagnostic) allows getting a level position in our Matrix and step five and four together allow making a level transition. From this, new iterations may be needed if incomplete maturity is evidenced in the transition Matrix, according to the strategy of the enterprise.

6 Conclusion and Further Work

In recent years, awareness and proactivity allowed significant advancements in reducing the environmental impact of industry. However, embarking in the ecological transition may be complex, as enterprises are heterogeneous and as they embrace sustainability in different ways. This is a crucial aspect that must be studied to avoid failure and hesitation, especially, when first attempts towards sustainability are made. Thus, in this work we intend to give an answer to “how to guide efficiently heterogeneous firms into their successful transitions towards sustainability?” and we organize our investigation in two parts. In the first part, we study the available literature that defines, from our perspective, ecological transition. In the second part, we conduct a qualitative research to understand heterogeneity of enterprises. From the State-of-Art, we find that current methods help firms to recognize their environmental states, but hardly help them to enhance their positions to further states. Also, we observe an evident closeness of these methods

to Information science and strategic sustainability. From the qualitative research, we find that firms plan their ecological transition under the context of training, strategic sustainability, estimation and reduction of environmental impacts. Also, we observe a high variability in specific needs regarding these environmental themes, and an unclear long-term vision in some cases.

The results of the first part of our investigation allow to construct a matrix that abstracts the dynamics of change of ecological transition in two dimensions: the informational and the ecological dimensions. From this, we formulate a hypothesis that links both dimensions. The results of the second part of our investigation (phase I) allow to construct a preliminary version of a methodology for guiding the ecological transition of heterogeneous firms.

Ongoing work is been made to start the phase II of our qualitative research. This work includes the preliminary validation (or redesign) of the proposed methodology, and the evaluation of the current states and strategies of three companies. Simultaneously, assisted planning of concrete actions in the training, guiding or testing steps will be made, all in the context of their specific needs reported in phase I. Results of phase II will allow the beginning of phase III, in which we will test iteratively our proposed methodology and matrix, in the context of individual projects. In this way we expect to answer the research question that led this work and validates our hypothesis.

7 Relationship with the SPI Manifesto

One of the major problems and challenges of industry nowadays are its contribution to the accelerated degradation of our environment and its ecological transition. The SPI manifesto [26] is inherently linked with transition and change, and requires organizations to perpetual improvement in three steps: identify relevant problems and recognize the need for transformation (unfreezing), find and implement solutions (moving); and make correspondent changes a permanent part of how companies work (freezing). In this sense, the **“ecological”** and **“informational dimensions”** revealed in this work unfreeze heterogeneous businesses, and urge to change their current states. Then, our **“matrix for transition”** moves companies along a comprehensive and ecological transition of states, fuelled by the collection of key data and exploitation of useful information. Finally, our **“close-looped-based methodology”** makes permanent the improvement, in an ever-changing strategic sustainability.

Data Availability Statement. The authors declare that the data supporting the findings of this study are available within the paper, its reference section and its supplementary information, which is available online, or from the corresponding author on reasonable request.

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