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DEVELOPING DYNAMIC CAPABILITIES TO MEET SUSTAINABLE DEVELOPMENT CHALLENGES

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Dynamic capabilities are recognized as key factors for the adaptation of the firm to its changing environment. For two decades, a new pressure has been added on the shoulders of firms: they have to integrate sustainable development considerations in their strategy. This paper explores the impact of those new sustainability requirements on the dynamic capabilities that a firm should develop and sustain to remain competitive in turbulent environments. In particular, which new innovation capabilities are required to integrate environmental, social and financial objectives? To answer this question, we first consider the dynamicity levels identified in the literature in relationship with the turbulence of the firm's environment and we study what level is required for which type of sustainable innovation. Secondly, we look at the three fundamental natures of dynamic capabilities (sensing, seizing, transforming) and identify typical new requirements coming from sustainability challenges. We apply this reflection to Green IT innovations.

Keywords: Sustainable innovation; dynamic capabilities; evolution; stakeholders.

Introduction

The literature concerning dynamic capabilities is young and growing. Researchers try to understand the adaptation of firms to continuously more dynamic environments. One of the factors influencing the evolution of markets and technologies are the increasing ecological and social requirements. Firms are supposed to meet legal or societal norms that are more and more important. If some firms consider that those norms are constraints reducing their innovation space, other firms view in those changes new opportunities to develop sustainable competitive advantages. Some studies have even demonstrated a increase in the performance of firms when they take into account sustainability issues. Firms that go in this direction integrate in their strategy corporate responsibility considerations. This leads them to

develop strong relationships with their stakeholders in order to create value for and through them (Freeman *et al.*, 2004), as they are key to assimilate environmental and societal challenges and to favor a indispensable systemic change both internally and externally. As a matter of fact, the environmental and social challenges go well beyond the firm's borders (Berman *et al.*, 1999).

Such a change in the strategic thinking of the firm does not only question the resource portfolio of the firm, but also the way the firm adapts to change requirements coming from society, especially as those requirements make the current business model hard to sustain. Firms have thus to enact dynamic capabilities to improve and renew their resource base. Even further, they are pushed to re-think their innovation process, i.e., the methods they use to build new resources and competences.

In this paper, we try to understand what changes in the management and generation of dynamic capabilities appear because of societal challenges. For clarity purpose, we focus our analysis on environmental challenges. In this context, we look at the impact of stakeholders' integration in the strategy. In the next section, we remind the basic assumptions on which the literature about dynamic capabilities is built and we define the concept of dynamic capabilities. After that, we discuss a possible hierarchy of dynamic capabilities. We make the link between this hierarchy and innovation levels. This leads us to analyze what level of dynamic capabilities should be mobilized when creating sustainable innovations. Then, we remind Teece's (2007) classes of dynamic capabilities and show the importance of each of those classes in sustainable innovations. To illustrate this typology, we use examples from Green-IT innovations. Finally, we conclude and propose research perspectives in this field.

Theoretical Background

What are dynamic capabilities?

Dynamic capabilities refer to "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece *et al.*, 1997). They are rooted in the resource-based view of the firm (Penrose, 1959; Barney, 1991). Following this theory, a firm builds a competitive advantage by applying creatively its valuable resources. To sustain this competitive advantage, the firm has to focus on resources that are heterogeneous in nature and not perfectly mobile (Peteraf, 1993). The resources that help a firm to build a sustained competitive advantage own four typical characteristics: they are valuable, rare, inimitable and non-substitutable (VRIN resources) (Barney, 1991).

Researchers in the RBV theory also introduced the concept of capability (Amit and Schoemaker, 1993). While resources can be traded and are subsequently

not specific to the firm, capabilities cannot be transferred easily. They are firm-specific as they were built progressively by the firm through experiences and learning. They are used by the firm to mobilize resources, increasing their productivity. They are the firm's capacity to deploy resources (Amit and Schoemaker, 1993). They can be considered as competences or routines that the firm has developed in time and that help it to build a competitive advantage through a better deployment of resources. Among those, some are core competences leading to competitive advantage.

When looking at highly volatile environments, researchers identified specific capabilities allowing firms to create new products and processes and to face changing environments (Helfat, 1997; Teece *et al.*, 1997). Dynamic capabilities are necessary in turbulent contexts, where the usual competences and routines are no more adapted or could be challenged. New competences have to be built. Rindova and Taylor (2002) talk of a micro-evolution, through which the management capabilities are upgraded, and a macro-evolution, leading to reconfigure market competencies. Dynamic capabilities are thus capabilities that "operate to extend, modify or create ordinary (substantive) capabilities" (Winter, 2003). They give the organization the capacity "to purposefully create, extend or modify its resource base" (Helfat *et al.*, 2007), where the term *resource* refers here to the broad sense of Barney (1991), including all the elements allowing the firm to generate rents. All dimensions of dynamic capabilities reminded before are summarised in the following definition that we borrow from Noori *et al.* (2012): "the ability of the organization to continuously recognize, integrate, and leverage resources and connect them to the changing environment in order to create value."

The literature concerning dynamic capabilities is rather new and includes different research trends. Schreyöegg and Kliesch-Eberl (2007) identified three theoretical approaches to dynamic capabilities: the radical dynamization approach,

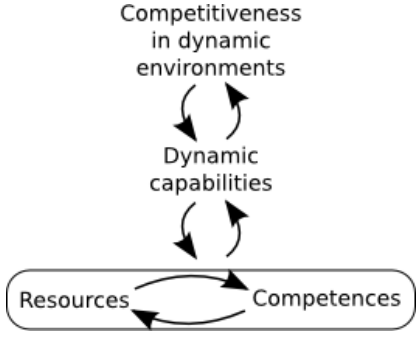

Fig. 1. Resources, competences, capabilities and competitiveness.

the integrative approach, and the innovative routine approach. They show that those approaches share the hypothesis that a dynamization of organizational capabilities is necessary to face changing environments. However, the proposed dynamization mechanisms differ from one approach to the other, and are contradictory on some points, some authors reducing dynamic capabilities to innovation routines, while others consider them as the product of ad hoc regimes. Dynamic capabilities lack thus at an operational definition. However, the continuously growing literature on this topic demonstrates the interest for a better understanding of firm's adaptation skills in fast-moving environments.

For the purpose of our analysis, we chose to use three contributions that try to unveil the reality of dynamic capabilities: Ambrosini *et al.* (2009) view of a three-level resource-building process, that we link with Ellonen *et al.* (2009) links between innovation levels and the renewal of capabilities, and Teece's (2007) definition of three classes of dynamic capabilities.

Sustainable innovation

In this paper, we use the expression *sustainable innovation* for innovations integrating environmental objectives. Those are also called *eco-innovations* or *green innovations*. Researchers and practitioners have identified three levels of sustainable innovations. At the macro-level, sustainable innovations concern the whole economy of a country, of an economic block or even at a global level. At the meso-level, sustainable innovations impact a sector, a supply chain, a region or a product system. Finally, at the micro-level, sustainable innovations cover a product or a service, a process and a given company.

As other innovations, environmental innovations are produced by individual firms and, in case of success, pervade society progressively from this micro-level. This success is the result of an efficient combination of market understanding (market pull) and technology competences (technology push). However, the dynamics behind sustainable innovations is more complex (Horbach *et al.*, 2011). As a matter of fact, regulation aspects also enter into account, as other actions (incentives, taxation) from governments. Beyond a pure response to legal requirements, firms can also integrate environmental considerations in their strategy, considering that they can position themselves as leaders in green technologies, for instance. There is thus a gradation in the environmental impact of innovations following the level of integration of sustainability issues in the innovation strategy of firms. This level of integration will also impact the means firms invest to change the innovation process in order to reach environmental effects. Those means can vary from a light process adaptation to a huge investment in a cultural change affecting the whole organization and, subsequently, the

capabilities needed in the innovation process. Sustainable innovations are thus innovations that integrate environmental challenges at various degrees, in terms of scope, goal and means.

A last point that we wanted to underline in this sub-section is that environmental innovations necessarily involve multiple stakeholders. Their systemic nature forces firms to integrate elements beyond their frontiers (van Kleef and Roome, 2007). As a matter of fact, environmental impacts are global. Moreover, best environmental efficiency requires the implication of all concerned stakeholders in the supply chain, from suppliers (who should respect environmental conditions) to customers (who should use the product or service in the best conditions). Innovation evaluation methods taking into account environmental challenges integrate *de facto* external stakeholders (e.g., Life Cycle Assessment, Cradle-to-Cradle certification).

Hierarchy of Dynamic Capabilities and Levels of Innovation

Theoretical background

Ambrosini *et al.* (2009) introduce a hierarchy of dynamic capabilities. They propose to consider that the required dynamic capabilities are not the same following the level of turbulence of the environment in which the firm evolves.

The first level is called *incremental*. Companies in relatively stable environments continuously improve their resources and competences. Incremental dynamic capabilities are relatively simple and iterative. They can be relatively stable in the firm, as quality management processes for instance. The resource stock is not really changed, but it is updated and improved to sustain existing competitive advantage.

The second level is called *renewing*. Following the authors, it corresponds to the mainstream definition of dynamic capabilities in the literature. When changes in the environment erode the resource-based advantages of the firm, those have to be renewed. This renewal is of a different order to incremental dynamic capabilities. New resources are created or new resource combinations are implemented. Moreover, the dynamic capabilities developed to face change are progressively integrated in the firm through the accumulation of experience.

The third level of dynamic capabilities identified by Ambrosini *et al.* (2009) is called *regenerative*. When existing dynamic capabilities are no more relevant to renew the resource base in turbulent environments (called *hyper environments* by the authors), the firm has to re-think the processes used to create, extend or recombine resources. Change practices are questioned and the firm has to evolve to new dynamic capabilities that are more adapted to new environmental conditions.

Regenerative dynamic capabilities do not operate directly on the resource base, as other dynamic capabilities, but on dynamic capabilities at the incremental and renewing levels, which has indirectly an impact on the resource base. Regenerative dynamic capabilities require sometimes to go beyond the organization's frontiers to import new change practices that are urgently needed.

This hierarchy of capabilities can be compared to levels of innovation as they were identified for long by the innovation and new product development researchers (Abernathy and Clark, 1985; Danneels, 2002). As a matter of fact, innovation can more or less challenge competences, both technologically and commercially, and require adapted or even different capabilities. Ellonen *et al.* (2009) studied the link between innovation levels and dynamic capabilities. They used the following classification of innovations, borrowing from Abernathy and Clark (1985) (an alternative classification, based on similar criteria, can be found in Markides and Geroski (2005): (1) *regular innovation* (also called incremental innovation) that sustains the existing competitive advantages of the firm, improving existing (technological) competences to satisfy the current customer base of the firm; (2) *revolutionary innovation* (also called strategic innovation) where existing competences are challenged but market knowledge can still be applied; (3) *niche creation* (also called major innovation) where the (technological) competences of the firm are applied to totally different customers; and (4) *architectural innovation* (also called radical innovation) where both technological and market competences have to be renewed.

Figure 2 makes the link between the hierarchy of dynamic capabilities and the innovation levels. It shows that regenerative dynamic capabilities are generally not considered in the innovation literature. However, the increasing complexity of innovation leads firms to go beyond the boundaries of the organization to find support to find complementary knowledge, calling increasingly for open innovation opportunities. The vertical arrow on Fig. 2 represents this evolution. Firms do not only have to renew their resources and competences to face continuously changing environments, they have to rethink their dynamic capabilities themselves.

When sustainability has to be taken into account in the innovation process, what level of dynamic capabilities are required? This is what we shall study in the following sub-section.

Implications for sustainable innovation

The importance of the integration of environmental aspects in the innovation process varies. Kauffeld *et al.* (2009) propose three levels of green integration. We use their terminology and analyse at each level the needs for dynamic capabilities. We also make the link with the transition paths of sociotechnical systems as they were introduced by Geels and Schot (2007).

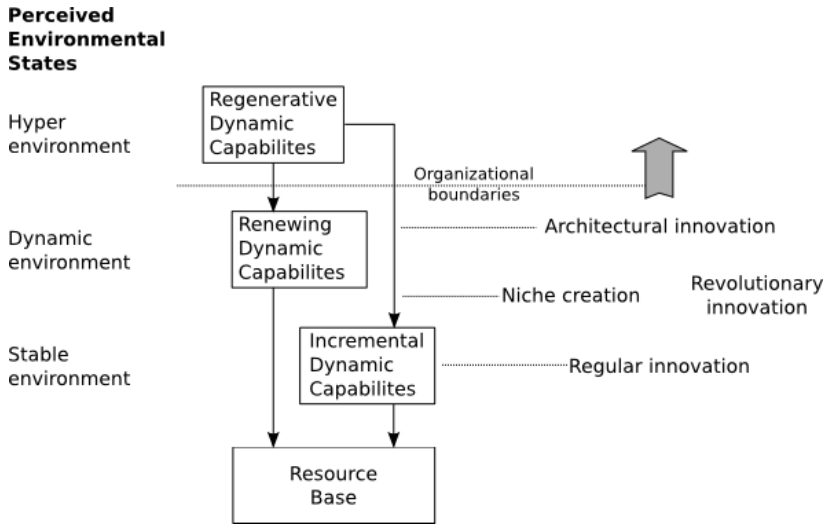

Fig. 2. Dynamic capabilities hierarchy and innovation levels.
Source: Ambrosini *et al.* (2007) and Ellonen *et al.* (2009).

Responsible green

The company implements measures and reporting to the government or to partners in order to demonstrate its compliance with sustainable requirements. This level is the less developed. The firm has no intention to change if it is not required. Green adaptations will be implemented to products, services and processes if there is a demand from customers or because of legal requirements. The level of dynamic capabilities that are mobilized in this context is clearly basic: incremental dynamic capabilities help managers to improve products in relationship with what they detect as new needs or new trends in their environment. This is typically what Geels and Schot (2007) identified as a "transformation" transition pathway, in which established economic actors adjust their practices to answer to outside pressure. If existing technologies do not allow meeting external expectations, this can even lead to another transition pathway, called "technological substitution," from which newcomers can benefit if they can develop innovative technologies that are better adapted to new environmental expectations.

Efficient green

At this level, the company engages in green initiatives targeting cost reduction, efficiency improvement and waste reduction, as those green objectives provide revenue opportunities. The focus of the green strategy is internal. It extends quality

management principles, integrating green criteria of evaluation. This can lead to significant process innovations, where new technologies are integrated to ensure energy savings or waste re-utilization, for instances. Renewing dynamic capabilities are thus possibly necessary, in the context of revolutionary process innovations. We are typically in a "reconfiguration" transition pathway (Geels and Schot, 2007). Established actors adopt component innovations provided by suppliers, as those innovations are linked to their processes and can generally not been developed in-house. The functional and economic reasons are at the core of these reconfigurations, but they also impact, sometimes deeply, skills and practices.

Differentiated green

The company has elevated green strategy to a core strategy, using a "green lens" (Kauffeld *et al.*, 2009) for both the development of new competences and the improvement of existing ones; this green orientation is integrated in brand management and communication; the company manages explicitly the trade-offs between the growth and sustainability objectives. The firm does not only try to improve the existing value chain, it uses green reflections to open new business opportunities. Generally, the firm was already a green efficient company, and it decided to go one step further. Such a transition requires important investments and the development of new capabilities, for which a new vision of markets and technologies is necessary. Kauffeld *et al.* (2009) identified the following characteristics of those *differentiated green firms*:

- They elevate sustainability to a core business strategy (…)
- They embed green in their innovation efforts (…)
- They view the entire product life cycle through the green lens (…)
- They consider green as they make major decisions (…)
- They integrate sustainability into corporate and brand marketing and messaging

Such a differentiation through green positioning requires the mobilization of regenerative dynamic capabilities, allowing to re-new other levels of dynamic capabilities. In particular, going beyond the frontiers of the firm seems to be unavoidable in environmental innovations. Adopting a perspective integrating entire product life cycle leads necessarily those firms to collaborate with suppliers and customers, and even further in the supply chain. Innovation has *de facto* to be collaborative. Moreover, the location of green preoccupations at the strategic level asks for a clear understanding of customers' viewpoints on this question in order to be able to use green strategy as a competitive advantage (Mariadoss *et al.*, 2011). New customers segments, having higher awareness of

green challenges, can also be associated and captured in this context. At such a level, which can be assimilated to "de-alignment and re-alignment" transition pathway (Geels and Schot, 2007). If established firms do not evolve in a radical way, they are faced with competition of new entrants who anchor their business in the requirements of society.

Sensing, Seizing and Transforming

Theoretical background

Teece (2007) identified three classes of dynamic capabilities: sensing, seizing and transforming capabilities. Table 1 summarizes the key elements characterizing those capabilities.

Table 1. Dynamic capabilities: Classes, nature and micro-foundations.

Class	Nature	Micro-foundations	Actions
Sensing	Discovering and creating opportunities	Cognitive and creative capacities of individuals	Scanning and monitoring internal and external technological developments
		Organizational processes as R&D activities, networking	Assessing existing or latent customer needs
Seizing	Addressing opportunity through new products, processes, or services	Selecting product architectures and business models	Determining technology and product architecture
			Designing revenue architectures
			Selecting target market
			Building mechanisms of value capture
		Selecting enterprise boundaries to manage complements and "control" platforms	Analyzing: — Appropriability regimes — Complementary assets — Relative positioning — Phase in industry development
			Assessing the systemic nature of products/services
			Evaluation of firm boundaries in this context
		Selecting decision-making protocols	Recognizing inflexion points and complementarities

Table 1. (*Continued*)

Class	Nature	Micro-foundations	Actions
			Avoiding decision errors and anti-cannibalization fears
			Demonstrating leadership
			Effectively communicating
		Building loyalty and commitment	Recognizing non-economic factors, values, and culture
Transforming	Aligning continuously specific tangible and intangible assets	Decentralizing	Adopting loosely coupled structures
			Embracing open innovation
			Developing integration and coordination skills
		Co-specializing	Managing strategic fit so that asset combinations are value enhancing
		Governance	Achieving incentive alignment
			Minimizing agency issues
			Checking strategic malfeasance
		Knowledge management	Blocking rent dissipation
			Learning
			Knowledge transfer
			Know-how integration
			Achieving know-how and IP protection

Source: Teece (2007).

Implications for sustainable innovation

Sensing capabilities

Sustainable innovations, as we have discussed earlier, require the integration of internal and external stakeholders. As a matter of fact, those innovations are often collective. For instance, green energy solutions depend on the cooperation between governments, specialised technological firms, energy providers and distributors, and sometimes the citizens. Hence, to develop environmental innovations, firms need sensing capabilities at the technological level, at the market level but also at the environmental level. They have to understand the evolution of green awareness and requirements among existing and emerging market segments. They must look at new technological opportunities with a green lens. And they must

take into account the emergence of environmental rules and practices, anticipating them to keep their leadership position.

Seizing capabilities

Once opportunities are detected and assessed, the innovation process can be launched in order to design new products, processes or services that meet some environmental objectives. If we look at the micro-foundations of *seizing* as proposed by Teece (2007) and reminded in Table 1, seizing capabilities appear as particularly important in environmental innovations.

- Selecting product architectures and business models: First, product choice has to integrate environmental dimensions. For this purpose, new product development methods have to be developed (for instance, life-cycle assessment). Secondly, new business models have to be built, capturing value from environmental quality of new products, services or processes. Those business models require to associate key stakeholders impacting or being impacted by the environmental performance.
- Selecting enterprise boundaries to manage complements and "control" platforms: A lot of environmental innovations are complex architectures, to which multiple actors contribute, either as providers, as consumers or as regulators. A kind of industrial ecosystem is created where the role of each stakeholder is important to guarantee the environmental efficiency of the system.
- Selecting decision-making protocols: Tools to help decision-making when building eco-innovations exist. They help managers to orient their choices and to manage the trade-offs between different criteria (economic, social, environmental, for instance). The issue here is to find ways to manage collective decision-making, as many stakeholders can be involved in the building of the system. Rotating decision-making (or rotating leadership) can offer a solution to avoid both lack of involvement of some actors and time lost in consensual discussions.
- Building loyalty and commitment: Engagement in environmental innovation requires the motivation of all stakeholders, internally as externally. People in the company must understand what their contribution to a broader strategic perspective is. Seeing how their contribution enters into account in a complex innovation architecture is a very important motivation factor.

Transforming capabilities

Taking into account the chosen solution and the needs for change it implies, the firm has to transform itself to guarantee the coherence between its strategy and

the new assets. Teece (2007) evokes decentralising, co-specialising, adequate governance and knowledge management as micro-foundations of this transformation. Once more, such dynamic capabilities are clearly required in sustainable innovation. At all levels of the organization, people must integrate green thinking in their practices and in their creative proposals to improve the organization. This goes also beyond the frontiers of the organization: cooperation choices, inter-organizational learning and networking have to target better environmental performances.

Illustrations from Green-IT and IT-for-Green Innovations

To illustrate how dynamic capabilities intervene at different levels of sustainable innovation, we consider examples from the IT industry. This industry has invested a lot in the past decade in new opportunities raised by environmental challenges, as IT can provide solutions for numerous other businesses. In such contexts, researchers and practitioners tend to use the expression *IT-for-Green* (Faucheux and Nicolaï, 2011), as IT is used to support the greening of other businesses. The expression *Green-IT* is used when products and services are themselves the object of environmental innovations. Both *IT-for-Green* or *Green-IT* types will be present in the following illustrations.

Responsible green

We have studied a Belgian semi-public company whose mission is to collect non-recyclable waste to burn or bury them. All organizations of this type are faced with EU legal requirements concerning their solid and gaseous emissions. Belgian authorities have asked that regular reporting of emissions are automatically transmitted to a regional database, in order to both control the compliance with legal levels and to manage potential risks for the local population. To meet this demand, the waste management company had to install filters and sensors as well as an information system with direct synchronization with the regional database. Such installations did not change the core business of the company. Some new competences had to be acquired by the personnel to use efficiently the information system and some processes had to be adapted to fit with the needs of the monitoring system. However, none of the dynamic capabilities listed by Tidd (2007), as they are described in the previous section, had to be mobilized. On the contrary, from the sensor and IT supplier part, components meeting the legal requirements had to be created and installed. Their level of sustainable innovation is of course higher. At a systemic level, this project follows "transformation" transition pathway (Geels and Schot, 2007).

Efficient green

We also studied the Belgian subsidiary of a chemical company specialised in the production of mineral fertilizers. The highest cost they have are due to energy consumption. For them, minimizing this cost is vital to maintain their competitiveness. They completely re-thought their production process in order to be able to control energy waste at each step through IT-supported methods and tools. Those are still evolving, as alternative energy source in concertation with other companies in the neighborhood (biomass, solar, etc.), have to be integrated in the production cycle. The choices of those methods and tools as well as the reengineering of processes requiredeveloping sensing capabilities. Competences have to be renewed to fit with radically new processes. Human resources have been trained to raise their awareness concerning best practices in terms of energy consumption. However, the core business of the company was not radically affected by this project. Nevertheless, the environmental awareness of the personnel led to interesting proposals of new sustainable practices emerging from human resources. In this particular case, a cultural change seems to invade the company, beyond the initial energy-efficiency objective. The company follows a "reconfiguration" transition pathway (Geels and Schot, 2007).

Differentiated green

In the previous example, the cultural evolution of the company could lead to a strong environmental positioning of the firm, integrated in its core strategy. Actors leading big projects as *smart cities* or *smart mobility* projects think that they can differentiate from competitors through a strategy focusing on environmental opportunities. Firms involved in those projects try to build radically new concepts of commodities that would be more environment-friendly. Those projects are generally complex and require the association of multiple actors having complementary competences. Those projects combine IT for green and Green-IT. As a matter of fact, IT is not only used to build greener processes. IT itself is questioned and its products and services are built integrating green criteria (energy consumption, better materials, etc.) Those projects are ambitious and require a totally different way to mobilize competences, resources and dynamic capabilities, being creative and cooperative as complex new systems have to be designed. In fact, if all actors involved in the project (government, citizens (users), companies) are not really convinced that investments in this direction are worthy, the ambition of such projects leads them to death before they even started. Firms engaging in such projects must thus be able to scan and assess the

motivation and maturity of their partners: are future users ready for new life-styles? Are local authorities inclined to invest in such projects? etc. Moreover, those projects are complex both concerning their organization and the technologies they involve. The selection of the architecture, the integration of all contributions, the decision-making processes during the project and the commitment of all stakeholders are all of prime importance to progress to success. If those elements are also required in collaborative innovations that do not focus on environmental aspects but that involve, the integration of the green dimension makes them still more crucial and complex. All dynamic capabilities described by Teece (2007) have to be stimulated in such context. The community involved in such ambitious project follows a "de-alignment/re-alignment" transition pathway (Geels and Schot, 2007), anchoring their collective innovations in environmental thinking.

Summary table

Table 2. Levels of sustainable innovation (SI) and impact on dynamic capabilities.

Level of SI	Level of DC	Transition pathway	Types of dynamic capabilities	Involved actors
Responsible green *Ex. Waste management organisation*	Incremental	Transformation Technological substitution	Sensing	Organization and technology supplier (s); legal authorities
Efficient Green *Ex. Fertilizer company*	Renewing	Reconfiguration	Sensing	Organization and technology supplier (s); partners
Differentiated green *Ex. Smart cities*	Regenerative	De-alignment / Re-alignment	Sensing, Seizing, Transforming	Stakeholders; community; government

Conclusion

In this paper, we wanted to make the link between sustainable innovation and dynamic capabilities. Looking at the levels and natures of capabilities as they were identified in the literature, we have shown that the intensity of the green strategy has an impact on the importance of capabilities dynamization. The more a firm

integrates environmental considerations in its strategy, the more existing competences, and resources but also dynamic capabilities are questioned. If they want to be successful in environmentally innovative projects, firms have to develop new dynamic capabilities integrating environmental dimensions. The more their integration of environment in their innovation strategy is high, the more diverse dynamic capabilities, able to sustain a total transformation of the firm, are necessary. In particular, firms have to develop competencies to open to stakeholders as the evolution toward radical societal changes is systemic and must be supported by all concerned actors.

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