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Be Sustainable to be Innovative;
The Need for Innovation Reconcilement

Resource, Capability, Process Settings

PhD Thesis

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Abstract

Despite sustainability's recognized importance for the last decade(s), practitioners and academicians yet question whether existing paths of businesses are sufficient. Accordingly, innovation has emerged recently as a path for businesses to enhance sustainability. As the director of IMD's Global Center for Sustainability Leadership (CSL) stated: *"Business has entered a challenging new world full of opportunities for strategic innovation, and sustainability will be a major driver of these opportunities into the future."*

Of this, valuable insights drawn from the prior research and practice present business cases where sustainability priority and adoption of its action programs leads perceiving innovation as a priority and adoption of innovation programs – or vice versa. However, there is a lack of investigation on their bidirectional relationship on a generalizable sample of firms, and not only specific cases. Thus, primarily this study intends to test the bidirectional relationship between sustainable development and innovation management on a generalizable large-scale empirical investigation – through a survey methodology with around 850 respondents from 22 countries. The results reveal on a generalizable sample of firms, that sustainability priority acts as an antecedent of innovation priority. While, on the adoption of relevant programs and performance, sustainable development and innovation management correlate positively and significantly. We further explore this relationship –through the similar method- on the supply chain level to propose a more comprehensive view, due to the proposed critical role of supply chain in this matter. The results show that, a positive and significant correlation exists between firm's adoption of sustainability/innovation programs and the integration of multi-actor supply chain (supplier-internal-customer).

The proven generalizable correlation of sustainable development and innovation management motivated this PhD dissertation to extend its scope by exploring strategic innovations particularly aimed at sustainability. The prior research and the surge of business initiatives on innovations aimed particularly at sustainability, peruse the development of new products/services with the guiding foundations of environmental, social, and economic goals. Despite the increasing interest in developing these initiatives by businesses, their management seems to be quite challenging and complex. Even though, innovation theories/frameworks can be applicable to support businesses facing the challenges, based on previous studies, we argue that the particular context of sustainability brings forward for businesses a number of peculiarities compared to the conventional forms of innovation. As the director of IMD's Global Center for Sustainability Leadership (CSL) stated: "*Innovation for sustainability is more dynamic than innovation per se, since people working in this area have to be incredibly flexible to take account of the numerous drivers in play."*

Preceding insights, on sustainability context's peculiarities in innovations, offer the need of conventional innovation adjustment in terms of its required capabilities, external cooperation and the project process. Accordingly, to build the further steps of this Ph.D. work, we investigated innovations aimed particularly at sustainability to explore which and how conventional innovation resources, capabilities and process' elements require reconcilement in the particular context of sustainability. To achieve the aim, a qualitative multiple case study method is adopted – in total 25 cases are studied. The results show that when conventional innovative firms attempt to develop innovations aimed

particularly at sustainability, they need to reconcile their exploration/exploitation innovation capabilities through incorporating and aligning internal and external sources with a systemized sustainability orientation. These innovation resources and capabilities are hypothesized to require more crucial adjustment, for sustainability context, compared to the other innovation capabilities e.g. R&D, symbolic capital growth and/or knowledge formalization. Finally, in terms of the process elements, the approach towards user involvement and process cycle are identified, based on studied cases, as the main drivers of process difference between innovations aimed particularly at sustainability and conventional forms of innovation. Furthermore, the results show that a distinction needs to be made between different innovations. In this regard, the already possessed open innovation capabilities of conventional innovative firms may not require critical reconcilement for developing an innovative product or service for sustainability. However, developing innovative product-service system in particular context of sustainability require all projects' actors to reconcile their already established open innovation capabilities or, if not already possessed, build them collaboratively. In a similar vein, critical process adjustments are required for developing innovative product-service system for sustainability.

This study complement the research frontiers on sustainability by proposing new foundations in further understanding its relationship with innovation management. Further, this work contributes to multi-disciplinary theoretical domains including capability view and open innovation by empirically testing innovation resources and (open) innovation capabilities in multiple innovation cases targeting specifically at sustainability. From practitioners'' point of view, this PhD dissertation propose managers the opportunity of being innovative through being sustainable. In this regard, we support managers to build/leverage their conventional innovation resources, capabilities and process to develop successful innovations for sustainability.

The dissertation includes first, the cover chapter -illustrating the multi-level frame of the research, theoretical background, methodological approach, summary of paper portfolio, discussion and contributions, and limits and direction for future research.

Keywords: Sustainable Development, Innovation Management, Sustainability Oriented Innovation, Resource Based View, Capability View, Development Process, Multi-methodological Approach, Survey Method, Case Study Method.

Resumen

A pesar de la reconocida importancia de la sostenibilidad durante la última década, los profesionales y académicos se preguntan aún si las vías existentes de negocios son suficientes. En consecuencia, la innovación ha surgido recientemente como un camino para las empresas para mejorar la sostenibilidad. Como señaló el director del Centro Global para el Liderazgo de Sostenibilidad (CSL por sus siglas en inglés) de la IMD: "Los negocios han entrado en un desafiante nuevo mundo lleno de oportunidades para la innovación estratégica, y la sostenibilidad será el principal impulsor de estas oportunidades en el futuro".

De esto, los valiosos conocimientos extraídos de la investigación y la práctica previas presentan casos de negocios en los que la prioridad de la sostenibilidad y la adopción de sus programas de acción conducen a percibir la innovación como una prioridad y a la adopción de programas de innovación o viceversa. Sin embargo, hay una falta de investigación sobre su relación bidireccional en una muestra generalizable de empresas, y no sólo casos específicos. Por lo tanto, este estudio pretende principalmente probar la relación bidireccional entre el desarrollo sostenible y la gestión de la innovación en una investigación empírica generalizable a gran escala, a través de una metodología de encuestas con alrededor de 850 encuestados de 22 países. Los resultados revelan en una muestra generalizable de empresas, que la prioridad de la sostenibilidad actúa como un antecedente de la prioridad de la innovación. Si bien, en la adopción de programas y resultados relevantes, el desarrollo sostenible y la gestión de la innovación se correlacionan positiva y significativamente. Más adelante exploramos esta relación -a través del método similar- en el nivel de la cadena de suministro para proponer una visión más completa, debido al papel crítico propuesto de la cadena de suministro en esta materia. Los resultados muestran que existe una correlación positiva y significativa entre la adopción por la empresa de programas de sostenibilidad / innovación y la integración de la cadena de suministro de múltiples actores (proveedor-interno-cliente).

La demostrada correlación generalizable del desarrollo sostenible y la gestión de la innovación motivó esta tesis doctoral para ampliar su alcance mediante la exploración de innovaciones estratégicas orientadas especialmente a la sostenibilidad. La investigación previa y la oleada de iniciativas empresariales sobre innovaciones orientadas especialmente a la sostenibilidad, examinan el desarrollo de nuevos productos / servicios con las bases rectoras de los objetivos ambientales, sociales y económicos. A pesar del creciente interés en el desarrollo de estas iniciativas por parte de las empresas, su gestión parece ser bastante desafiante y compleja. A pesar de que las teorías / marcos de innovación pueden ser aplicables para apoyar a las empresas que se enfrentan a estos retos, basándonos en estudios previos, argumentamos que el contexto particular de la sostenibilidad trae a las empresas una serie de peculiaridades comparadas con las formas convencionales de innovación. "La innovación para la sostenibilidad es más dinámica que la innovación per se, ya que las personas que trabajan en esta área tienen que ser increíblemente flexibles para tener en cuenta a los numerosos impulsores en juego", dijo el director del CSL de IMD.

Antecedentes previos, sobre las peculiaridades del contexto de sostenibilidad en las innovaciones, ofrecen la necesidad del ajuste convencional de la innovación en términos de sus capacidades requeridas, la cooperación externa y el proceso del proyecto. En consecuencia, para construir los pasos adicionales de este doctorado. Investigamos las innovaciones dirigidas particularmente a la sostenibilidad para explorar qué y cómo los recursos de innovación convencionales, las capacidades y los elementos del proceso

requieren reconciliación en el contexto particular de la sostenibilidad. Para lograr este objetivo, se adopta un método cualitativo de estudio de casos múltiples, en total se estudian 25 casos. Los resultados muestran que cuando las empresas innovadoras convencionales intentan desarrollar innovaciones orientadas particularmente a la sostenibilidad, necesitan conciliar sus capacidades de innovación de exploración / explotación mediante la incorporación y alineación de fuentes internas y externas con una orientación sistematizada de sostenibilidad. La hipótesis es que estos recursos y capacidades de innovación requieren un ajuste más crucial, para el contexto de sostenibilidad, en comparación con otras capacidades de innovación, por ejemplo, I + D, crecimiento simbólico del capital y / o formalización del conocimiento. Por último, en cuanto a los elementos del proceso, se identifica el enfoque hacia la participación de los usuarios y el ciclo del proceso, a partir de los casos estudiados, como los principales impulsores de la diferencia de procesos entre innovaciones orientadas particularmente a la sostenibilidad y las formas convencionales de innovación. Además, los resultados muestran que es necesario distinguir entre diferentes innovaciones. En este sentido, las capacidades de innovación abierta ya poseídas por las empresas innovadoras convencionales pueden no requerir reconciliación crítica para desarrollar un producto o servicio innovador para la sostenibilidad. Sin embargo, el desarrollo de un sistema de producto-servicio innovador en un contexto particular de sostenibilidad requiere que todos los actores de los proyectos concilien sus capacidades de innovación abierta ya establecidas o, de no ser así, construirlas de manera colaborativa. En una línea similar, se requieren ajustes críticos del proceso para desarrollar un sistema innovador de producto-servicio para la sostenibilidad.

Este estudio complementa las fronteras de la investigación sobre la sostenibilidad al proponer nuevas bases para comprender mejor su relación con la gestión de la innovación. Además, este trabajo contribuye a dominios teóricos multidisciplinarios que incluyen la visión de la capacidad y la innovación abierta al probar empíricamente los recursos de innovación y las capacidades (abiertas) de innovación en múltiples casos de innovación dirigidos específicamente a la sostenibilidad. Desde el punto de vista de los profesionales, esta tesis doctoral propone a los directivos la oportunidad de ser innovadores mediante el ser sostenibles. En este sentido, apoyamos a los gerentes para desarrollar / aprovechar sus recursos de innovación convencionales, capacidades y procesos para desarrollar innovaciones exitosas para la sostenibilidad.

Palabras clave: Desarrollo sostenible, Gestión de la innovación, Innovación orientada a la sostenibilidad, Visión basada en recursos, Visión de capacidades, Proceso de desarrollo, Enfoque multi-metodológico, Método de encuesta, Método de estudio de caso.

Disclaimer

Some parts of this PhD Thesis have already been published or under review process as:

- Sarah Behnam, Raffaella Cagliano, (2016). Be Sustainable to Be Innovative: An Analysis of Their Mutual Reinforcement. Sustainability, 9(1), 17.
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- Sarah Behnam, Raffaella Cagliano. Are Innovation Resources and Capabilities Enough to Make Businesses Sustainable? An Empirical Study on Leading Sustainable Innovative Firms. Under revision under *International Journal of Technology Management* Journal.

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1. INTRODUCTION

According to a survey on 2008, 60% of firms take sustainability into account in developing and marketing new products (McKinsey and Company, 2008). Passively heated houses, solar cells, organic food, fair trade products, hybrid cars and car sharing are typical examples. Innovation and sustainable development play a crucial role in nowadays management of businesses (Belz, et al., 2010). As the director of IMD's Global Center for Sustainability Leadership (CSL) stated:

> "Business has entered a challenging new world full of opportunities for strategic innovation, and sustainability will be a major driver of these opportunities into the future…. Innovation for sustainability is more dynamic than innovation per se, since people working in this area have to be incredibly flexible to take account of the numerous drivers in play."

They have been claiming that solution-oriented innovation for sustainability is the new framework of the world's leading companies to find new ways to improve performance through innovation in all three dimensions of sustainable development: environmental, social, and economic. For example, in the automotive industry, BMW (leader in the Dow Jones Sustainability Index) created strategy to develop sustainable, visionary concepts for mobility in 2007. It shapes BMW's future by introducing innovation for zero-emission vehicles. While, Toyota, is taking things a step further in building its future strategy by applying electric cars. As in examples, the innovation is not necessarily a new product, but also encompasses new services (e.g. new ways to communicate products) and/or new infrastructure (using internet tools to learn from the consumers), if not new business models (Rethinking of the way of business).

Building on these premises, the overall Ph.D. path has been driven by willing to explore innovation and sustainability relationship in businesses and accordingly, innovative approaches towards sustainable development. In particular, the overall objective is to understand the interlink between sustainability and innovation in businesses, and if there exists an interlink, how sustainability should be incorporated in conventional forms of innovations.

Prior research on the interrelationship between sustainability and innovation primarily generate strong evidences on whether, why and how sustainability and innovation are interlinked in firms. Of whether, extensive practical cases are documented when firms' innovation orientation did act as an enabler of sustainability enhancement (e.g. Hart, 1995; Hansen, et al., 2009) or sustainable firms being able to become highly innovative (Hansen et al., 2009). The existence of these cases are documented as innovation ability in bringing non-economic gains (Bos-Brouwers, 2010), sustaining innovation strategies (Van den Hove, et al., 2012), or because sustainability as a strategic goal requires rethinking the business (Nidumolu et al., 2009).

In doing so, innovative firms need to include sustainability in their agenda strategically and objectively (De Medeiros, et al., 2014; Gmelin and Seuring, 2014) or should be a touchstone for innovation strategies (Nidumolu, et al., 2009). We can conclude that innovation and sustainability orientation have been/should be correlated (Seebode et al., 2012). However, the correlation is seen in proactive firms/best practices and whether sustainability and innovation propensity are interrelated on a generalizable sample of firms is still remains lacking. Thus, the first course of this PhD work aims at primarily test the following hypothesize:

H1: Sustainability propensity correlates positively with innovation propensity.

Moreover, OM Literature provides extensive evidences that sustainability (e.g. Adamczyk et al., 2009) or innovation propensity (e.g. Preuss, 2007) leads to higher performance through adoption of their relevant practices and mechanisms, while prior research on the sustainability and innovation interrelationship lack consideration on their performances (Pujari, 2006). Therefore, we further hypothesize as the following:

H2: Sustainability performance correlates positively with innovation performance.

However, in regards to adoption of relevant practices and mechanisms, Gualandris and Kalchschmidt, (2014) show the casual relationship of firms' adoption of innovation mechanisms on their adoption of sustainability practices. However, more but still not sufficient studies show correlation effects between firms' effort on adoption of sustainability practices and innovation mechanisms (Chapas et al., 2010; Gmelin and Seuring, 2014). To give a deeper understanding on the existing inconsistency, aligned with majority of investigations, we hypothesize:

H3: Putting effort on adoption of sustainability practices correlates positively with the effort on adoption of innovation coordination mechanisms.

Scholars advance the debate on the relationship between adoption of sustainability practices and innovation mechanisms by identifying its influencing factors. Prior research identifies supplier integration (e.g. Geffen and Rothenberg, 2000), and cross-functional coordination as positive influencing factors on adoption of sustainability practices and innovation mechanisms (e.g. Petala et al., 2010). However, there are both positive and negative evidences on the relationship between customer integration and adopting sustainability practices and innovation mechanisms (e.g. positive: Yoon and Tello, 2009; negative: Gualandris and Kalchschmidt, 2014). The reason behind contrasting results could be due to the fact that supply chain elements effect each other but prior investigations on the relationship between supply chain integration and adoption of sustainability practices and innovation mechanisms, seem to be disjointed, thus require an integrated perspective (e.g. Flynn et al., 2009). Therefore, this Ph.D. work advance the debate by examining interrelationship between adoption of sustainability practices, innovation mechanisms and supplier-internal-customer integration by specifying a model to test following hypothesis:

> H4: Supplier-internal-customer integration correlates positively with putting effort on adoption of sustainability practices
>
> H5: Supplier-internal-customer integration correlates positively with putting effort on adoption of innovation mechanisms.

As a result of the correlation between sustainability and innovation in firms and its supply chain, a growing business initiative, accordingly academic investigations, has emerged where firms establish strategically innovations particularly aimed at sustainable development (Dangelico and Pujari, 2010). In this PhD work, we adopt the terminology of "sustainability oriented innovation (SOI)" for these initiatives, defined as the development of new products, processes, and/or management systems, where environmental, social, and economic goals are their foundations (Hansen et al., 2009). Sustainability oriented innovations have increasingly and extensively gained attention both from academicians and practitioners (Pujari et al., 2003). However, it is challenging for firms to incorporate sustainability in their innovations (e.g. Ketata et al., 2015; Pujari, 2006; Petala, et. al., 2010). Thus, SOI is argued extensively to be more complex compared to conventional forms of innovation, thus, possess its own peculiarities. Prior investigations on SOI peculiarities, focus on various perspectives ranging from differences in capability development (e.g. Van Kleef and Room, 2007; Chen, 2008; Yarahmadi and Higgins, 2012), external/internal cooperation/coordination (e.g. Pujari, 2006;

Van Kleef and Room, 2007), new product/service development process (e.g. Hall and Vredenburg, 2012; Carrillo-Hermosilla et al., 2009) or even hybrid models of the perspectives (external cooperation capability in Sharma and Vredenburg, 1998).

We can hypothesize the required resources and capabilities for SOIs, according to the innovation literature (e,g, Lichtenthaler, U., and Lichtenthaler, E. 2009) to human, organizational, Inter and intra-relational and symbolic capital -resources- and internal exploration and exploitation, external exploration and exploitation and retention -capabilities. However, prior research proposes sufficient reasoning that SOIs may require adjusted innovation capabilities but have not investigated the comprehensive set of resources and capabilities (e.g. Zahra and George, 2002) encompassing both social and environmental perspectives (e.g. Horbach et al., 2012). Therefore, the objective of the next study is to answer the following research question:

> RQ a. Which innovation resources and capabilities should be adjusted by firms for particular innovations aimed at sustainability?

The results of this study confirms the criticality of incorporating broadly and deeply various actors in the SOI initiatives (e.g. Pujari, et al., 2003). This is why, in the next phase of this PhD, we investigate deeper the external integration capability by applying open innovation framework (Lichtenthaler, U., and Lichtenthaler, E. 2009). Four subsets of capabilities for integrating external actors in conventional forms of innovations are identified including networking (Perks and Moxey, 2011), competence mapping (Kazadi et al., 2016), relational (Van Lancker et al., 2015), and desorptive capacity (Hillebrand and Biemans, 2004). However, in addition to sustainability context peculiarity, the outcome characteristics effect the external actors' integration (e.g. Carrillo-Hermosilla et al., 2010). Thus, subsequently, this Ph.D. work tries to answer the following research question:

> RQ d. Which open innovation capabilities should be reconciled by firms for particular innovations aimed at sustainability depending on the radicalism and the product/service combination of the output?

Despite the fact that adjusting open innovation capability can support business in coping with the challenges of incorporation of diverse actors in the SOI projects, it will pose some differences in the SOI process compared to conventional forms of innovations in terms of partnership and process cycle (e.g. Hallenga-Brink and Brezet 2005). Analyzing empirically

the proposed drivers of SOI process differences -compared to conventional innovations- in both environmental and social innovations is would help academics and practitioners to understand their relative force and accordingly the more critical drivers, suggesting the primary areas where adjustment is needed in conventional innovation processes to adapt to SOI process. Thus, we extend the previous explorations by answering to the following research question:

> RQ c. How does the innovation process for sustainability differ from conventional innovation processes in terms of involved partnership and process cycle depending on the radicalism and the product/service combination of the output?

While, the hypotheses are tested through a survey analysis, the research questions are answered through case study research perspective to gain the deep insights on the specific cases and practical examples to understand the peculiarities of sustainability oriented innovations compared to conventional forms of innovations, from diverse perspectives. Relevance for practitioners have been a clear objective of the Ph.D. path – as obvious by developing empirical studies-, but taking always for granted the essentiality of a rigorous research approach with strong theoretical foundations. Table 1 summarizes the five empirical analysis of this PhD dissertation.

TABLE 1. The link between research questions and the empirical settings

Empirical Setting	Unit of analysis	Analysis Perspective	Provided dataset	Approach Method	Focus		Answering focus to the RQ					Relevance to the RQ				
					Sustainability & Innovation relationship	Sustainable& Conventional Innovation	H1-H3	RQb	RQc	RQd	RQe	H1-H3	RQb	RQc	RQd	RQe
1	Firm	Firm	The International Manufacturing Strategy Survey 2013.	Quantitative/ Survey	***		***					***	**			
2		Supply chain			***			***				**	***			
3	Firm	Firm	Independent research.	Qualitative/ Case Study		***			***					***	**	
4	Project	Firm/ Project	Independent research.			***				***				**	***	
5	Project	Firm/ Project	Eu-Innovate Project.			****					***			*	*	***

2. THEORETICAL FRAMEWORK

In social science research, a theoretical framework shows several aspects, including what important to be considered, gaps in the existing literature and a source of cross fertilization of connected fields (Parsons, 1938). Thus, this chapter aims at highlighting the substantial aspects of the related fields that are beneficial in understanding the dynamics of innovation and/for sustainability. This chapter, therefore, serves as an analytical basis and theoretical lens to interpret the applied empirics in this dissertation.

The sustainability approach has gained extraordinary attention in the recent decades. The concept of sustainability was introduced in the Brundtland Commission (WCED,1987). Sustainability concept, -or "triple bottom line" approach introduced by Elkington (1997)- relates the organization to the interrelated environmental, economic and social dimensions. We treat sustainability as a dynamic and unfolding concept that is achieved over time rather dichotomously (sustainable/not sustainable) (Adams et al., 2015). In a similar vein, according to the recent comprehensive reviews of the topic (e.g. Adams et al., 2015), previous work often focused purely on environmental aspect and overlooked the social dimension of sustainability. The reason why, following Ketata, et al., (2015) and Adams et al., (2015), a broad perspective for the definition is chosen to include also social issues.

The literature highlights numerous benefits for sustainability incorporation to businesses' operations including: return on investment and increased sales (e.g. Fierman, 1991); enhanced competitiveness (Porter and van der Linde, 1995); improved image/reputation concerns (Engleberg, 1992); stakeholder satisfaction, meeting legal requirements, and internal organizational improvements (Ranganathan and Willis, 1999; Dunphy et al., 2003).

Given the multi-dimensional character of sustainability issues, prior research has focused on diverse issues that have been or should be addresses in the introduction of sustainability in businesses (Starik and Rands, 1995). To name a few at the organizational level, quite extensive studies provide in-depth investigations on why firms do/should react to sustainability concerns, what is/should be the sustainability considerations' application in strategic management and firms' capabilities and the influence of individual/contextual factors on decisions to embrace sustainability concerns, etc. These issues have been investigated through diverse theoretical

frameworks including: The resource-based view looking at gaining and maintaining competitive advantage as the outcome of organizational capabilities result from a proactive sustainability strategy (e.g. Aragon-Correa and Sharma, 2003; Hart, 1995); Institutional theories looking at how organizations become more associated with the institutional environment (e.g. Bansal and Roth, 2000); theories of planned behavior (e.g. Cordano and Frieze, 2000), etc.

One of the extensive debates, aligned with this study's purpose, is how firms do/should consider sustainability in operations and developing products/services (e.g. Charter and Tischner, 2001) and also deal with increasing recent competitive scenarios. Managers have been raising questions whether existing paths of businesses are able to do so (Seebode, et al., 2012; Nidumolu et al., 2009; Adams, et al., 2015). As a response, innovation is seen to be an effective approach for enhancing sustainability while meeting the recent competitive scenarios (e.g. Dangelico and Pujari, 2010; Horn and Brem, 2013).

Schumpeter (1939) defined innovation in any form of new products, processes, methods, markets, supply sources, which economy expansion is directly dependent on it. Innovation concept has been extensively evolved further (for instance to new business models e.g. Boons et al., 2013; Schneider and Spieth, 2013). However, the common core perspective - novelty and change - for economic progress has been preserved. An effective and successful innovation must achieve a noticeable change from previous product, process, service or business model (Harper and Becker, 2004). The novelty of innovation is mainly considered for the adopting/developing unit (Bhaskaran, 2006). Similar to several previous studies, (e.g. Kemp and Pearson, 2008), our notion of innovation is related to the change and novelty to the firm as an institutional context. This is appropriate because innovativeness is highly context-dependent (meaning that novel for a certain group may be completely commonplace for another group) (Morand, 2008). Thus, in this study, we adopt the similar conceptualization, where innovation can be considered as any new product, process, service or business model novel to the business/operational unit.

Innovation ability is proved in leading many advantages for businesses including: competitiveness (Porter, 1985); profitability and increased productiveness (Guinet and Pilat, 1999); enhanced market shares, operational efficiency and reputation (Abernathy and Clark, 1985; Cooke and Mayes, 1996), etc.

To provide a comprehensive theoretical framework, aligned with our purpose, a structured literature review was conducted by using organized and diverse methods to identify, select, and critically assess literature searches (Tranfield et al., 2003; Jones, 2004). We applied structured review to ensure high analytical objectivity. However, for the purpose of this study, and due to various terminologies applied as sustainability or innovation, in addition to a keyword search, other methods are implemented (e.g. identifying relevant papers from well-referenced review papers applying each terminology -Table 2). The steps of the literature review are provided (Figure 1).

FIGURE 1. Literature Review Steps

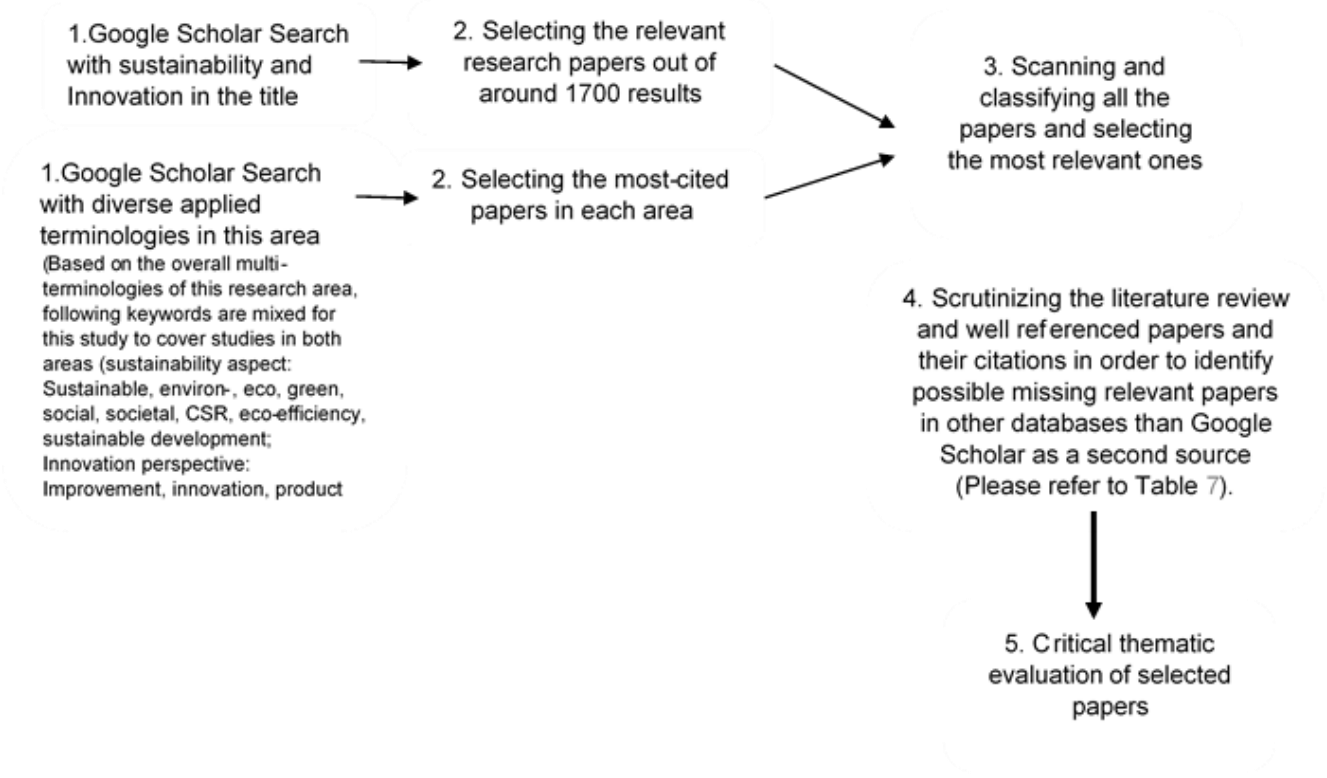


TABLE 2. Literature review papers used in identification of additional papers

Area	Papers/database(s)	Key Findings	Ref
Environmentally sustainable product innovation	67 papers in 32 Peer Reviewed Journals	Four main critical success factors for environmentally sustainable product innovation	De Medeiros, et al., 2014
Environmental new product development	ENPD and NPD literature	Incorporation of environmental issues in NPD increases the complexity.	Berchicci and Bodewes, 2005
Green Product Development	325 (business) 150 (Engineering) 232(Policy)	Building a multidisciplinary research agenda on the topic.	Baumann, et al., 2002

Sustainable Innovation	Sustainable Innovation Conferences 2003–2006 (by the Centre for Sustainable Design)	Building a research agenda on the topic.	Charter and Clark, 2007.
Sustainability oriented innovation	127 articles.	Present a model to help understand different types and phases of SOI in companies.	Adams et al., 2015
Sustainability oriented innovations in SMEs	Interdisciplinary systematic review of 84 key journal articles from 1987 to 2010.	Identifying the different types of SME strategic sustainability behavior and innovation practices and the critical factor (interaction with externals). Showing strong eco-innovation literature but few SOI literature.	Klewitz and Hansen, 2014
Sustainable Innovation and Open innovation	33 papers, as being related to sustainable open innovation.	Showing that while the concept of open innovation can be an appropriate approach for sustainable innovation few studies investigate SOI through open innovation lens.	Perl-Vorbach, et al., 2014.
Capabilities for sustainable development in terms of innovation	Dutch library databases.	Showing that innovation for sustainability requires the active involvement of a broader and more diverse network of actors.	Van Kleef and Roome, 2007
Environmental Innovation in SMEs.	The most relevant contributions of the economic literature.	Identifying the factors driving scarce development in the SMEs in respect to their environmental	del Brío, and Junquera, 2003

The review of the literature reveals a twofold, but interlaced approaches in prior investigations on sustainability and innovation. First, approaches considering sustainability and innovation as related but autonomous strategies in businesses. While, the second approach investigate particular innovation strategies/practices which are aimed at and/or enhance at least one dimension of sustainability. In doing so, a unified strategy/practice of sustainable innovation would be occurred (e.g. IKEA established a new functional department of sustainable innovation). While particular innovations for sustainability -second approach- is argued to be the result of sustainability and innovation interrelationship -first approach- (Dangelico and Pujari, 2010). In the case of IKEA, the business had been proactive towards both sustainability and innovation for decades before establishing a particular strategy/department for sustainable innovations. This is why, we argue that the prior academic investigations can be classified as two but interlinked approaches. In the next sections, respectively, a thorough theoretical

framework of each of the above approaches is provided in relation to the multi-level research questions of this Ph.D. work.

2.1 Sustainability and innovation as two related but autonomous business initiatives

Prior research on the interrelationship between sustainability and innovation primarily generate strong evidences on whether, why and how sustainability and innovation are interlinked in firms. Subsequently, studies have been investigating factors influencing positively or negatively the sustainability and innovation interrelationship.

Regarding whether sustainability and innovation are interlinked, extensive practical illustrations are documented where firms' innovation orientation did act as an enabler of achieving sustainability enhancement in businesses (e.g. Hart, 1995; Vredenburg and Westly, 1997; Hart and Milestein, 1999; Senge and Carstedt, 2001; Hall and Vredenburg, 2003; Hansen, et al., 2009). In a similar vein, extensive sustainable firms being able to become highly innovative, bring forward a broad understanding that the sustainability orientation would propose meaningful opportunities for enhancing innovativeness (Hansen et al., 2009) leading to act as the driver for establishing innovation strategies (Noci and Verganti, 1999). This argument emerges from two lines of reasoning. First and more critical, sustainability introduces additional contemporary visions for new business opportunities (Hart, 1997; Day, 1998). Second, sustainability regulations push businesses to enhanced innovativeness (Preuss, 2007; Hockerts & Morsing, 2008). In this regard, Sustainability has been seen as an innovative and change force which generates new products and processes challenging existing practices in firms (Blum-Kusterer and Hussain, 2001). Porter (1991, p. 96) contended that vigorous sustainability strategies would trigger innovation, stating: properly constructed regulatory standards, which aim at outcomes and not methods, will encourage companies to re-engineer their technology". Porter and van der Linde (1995), demonstrate multiple cases where sustainability orientation lead to enhanced innovativeness in products and processes.

Answering to the why question, diverse reasons are provided by the previous studies. First, because innovations are able to bring beyond economic gains for businesses including social and environmental benefits (Bos-Brouwers, 2010; Larson, 2000). Second, because innovation strategies cannot sustain long-term without being merged with sustainability strategic orientation (Van den Hove, et al., 2012; Hall, 2003). Finally, because sustainability as a

strategic goal requires rethinking the products, technologies, services, processes and business models (Nidumolu et al., 2009).

To answer the how question, scholars argue that the innovative firms need to include sustainability in their agenda strategically and objectively (De Medeiros, et al., 2014; Gmelin and Seuring, 2014) to be able to go beyond only achieving sustainability enhancement but rather evolving into proactive/highly sustainable firms (Pujari, 2006) and sustaining their sustainability enhancement (e.g. Koebel, 1999). Others even claim that sustainability orientation should be a touchstone for innovation strategies because becoming sustainable can lower the businesses' costs and increase revenues -which is the goal of innovation- that yields both bottom-line and top-line returns (Nidumolu, et al., 2009).

We can conclude that, either perspective adopted, innovation and sustainability orientation/strategies can/should reinforce each other (Seebode, et al., 2012; Adams, et al., 2015; Steiner, 2008; Pujari et al., 2003). The result in many cases is both sustainability and innovation performance enhancement (Porter, 1991). But more importantly, the result would be able to contrast the superficial changes to products/services for sustainability (Pujari, 2006), but achieving competitiveness (Porter and van der Linde, 1995) and challenging the initial perspective on inevitable environmental/social trade-offs with economic competitiveness (Parkinson, 1990; Porter, 1991; Makeower, 1993). Thus, what is sufficiently explored is whether, why and how sustainability and innovation propensity/orientation/strategies enable or reinforce each other when a firm is proactive towards at least one of them through demonstrating successful cases. What is not sufficiently explored is whether sustainability and innovation propensity are correlated covering not only the best practices or proactive firms but a generalizable sample of firms. Thus, in the first course of this PhD work to understand the inter-relationship between sustainability and innovation in firms. Thus, primarily, we hypothesize as following:

H1: Sustainability propensity correlates positively with innovation propensity.

Moreover, OM Literature provides extensive strong evidences on sustainability or innovation propensity leading to the enhanced res

pective performances -with the (partial or full) mediating role of adoption of their relevant practices and mechanisms- (sustainability e.g. Adamczyk et al., 2009; Hansen et al., 2009; Innovation e.g. Preuss, 2007; Roth, 2009). While OM literature highlights the critical role of

examining performance in operational studies, prior research on the sustainability and innovation interrelationship lack consideration on their performances (Pujari, 2006) to be able to fully comprehend how innovation and sustainability would contribute to one another (Steiner, 2008). Because, sustainability (Wagner & Schaltegger, 2003) and innovation (Cooper, 2001; Zhang & Doll, 2001; Totterdell et al., 2002) have been approved as the key to business success, but previously business success had been quantified mostly with economic perspective (Hansen et al., 2009). The socio-environmental impacts of businesses include both non-market outputs (process improvements e.g. through pollution reduction) as well as market outputs through product innovation (Ottman, 1994). It is believed that ultimately the contribution will be achieved only if a viable new product is provided (Pujari et al., 2003). Similarly, such products can sustain long-term success in the market by their eco-performance (Maxwell & van der Vorst, 2003; Hall, 2003; Fuller and Ottman, 2004; Pujari & Wright, 1999a,b). Currently and increasingly, non-economic aspects of business success have become the issue for managing innovation (e.g. Preuss, 2007; Roth, 2009) greatly influenced by the vision of sustainable development (Adamczyk et al., 2009; Hansen et al., 2009; Fitzgerald et al., 2006) leading to an enhanced market position (Elkington, 1998). Thus, in this study, non-economic performance of firms is scrutinized for the link between sustainability and innovation. Based on previous studies, sustainability performance will be enhanced through new product development in two approaches: either by regular plans of sustainability improvement in all products of a firm; or by designing a new product specifically aiming at sustainability improvement (Pujari et al., 2003). In this study, we argue that the first approach is concerned with the fact that innovation performance can enhance sustainability performance (May et al., 2012; Endris et al., 2011). However, the second approach is when firms design a new sustainable product with clear objective. In this regard, the more proactive the firm is towards sustainable development, the more innovative products will be developed (Charter, 2006). In this regard, sustainability performance includes company level socio-environmental impacts and not that product's socio-environmental impacts (Peattie, 1995). Thus, we hypothesize the fact that if sustainability and innovation are mutually reinforced in firms' operations, their performances are correlated positively. To do so, we target firms globally, because as stated in the systematic reviews of the topic (e.g. Adams, et al., 2015), the geographical distribution of studies shows global interest in the topic, though less than one-third of the studies adopted a multi-country focus. Therefore, we hypothesize as the following:

H2: Sustainability performance correlates positively with innovation performance.

In regards to the operational interrelationship between sustainability and innovation adoption of relevant practices and mechanisms, few evidences have been documented. In this regard, Gualandris and Kalchschmidt, (2014) show the casual relationship of firms' adoption of innovation mechanisms on their adoption of sustainability practices. However, more but still not sufficient studies show correlation effects between firms' effort on adoption of sustainability practices and innovation mechanisms (Chapas et al., 2010; Gmelin and Seuring, 2014). In this regard, sustainability propensity has shown to lead increased sustainability performance with the mediating role of putting effort for adoption of sustainability practices (Adamczyk et al., 2009; Hansen et al., 2009; Fitzgerald et al., 2006; Koe et al., 2014). On the other hand, in terms of innovation management, Cooper, (1994) argues that innovation requires a coordination mechanism. In this regard, previous scholars argue that innovation propensity improves innovation performance with the mediating role of putting effort for coordination mechanisms of innovation development and manufacturing processes (Preuss, 2007; Roth, 2009). Thus, previous studies propose firms putting effort for adoption of sustainability practices and adoption of action programs to coordinate new product development and manufacturing processes as operational constructs of sustainability and innovation (Chapas et al., 2010; Gmelin & Seuring, 2014). To give a deeper understanding on the inconsistency in the few studies on the relationship between adoption of sustainability practices and innovation mechanisms, aligned with majority of evidences, we hypothesize:

> H3: Putting effort on adoption of sustainability practices correlates positively with the effort on adoption of innovation coordination mechanisms.

Scholars advance the debate on the interrelationship between adoption of sustainability practices and innovation mechanisms by exploring the influencing factors. A systematic review of the literature has been conducted for analyzing the role and importance of supply chain for sustainability and innovation. In this regard, four main databases, namely: Scopus (for innovation), IEEE, Science Direct and Web of Science (for sustainability), have been selected for the literature review. However, due to the broad and diverse terminologies used for the supply chain integration, we use a general keyword (stakeholder which can include any internal and external actor influencing/involving in the business) is chosen to identify as many as possible the potential papers. Targeting sustainability literature, the search on three databases (IEEE and Science direct (with key words of sustainability and stakeholder in the abstract) and Web of Science (with key words sustainability and stakeholder in the title)) resulted in 118 journal papers. Initial screening based on the journals and topics, bring about 38 potential

relevant studies. By reading the abstracts, 7 studies were selected finally as relevant papers to this study. In regards to innovation literature, due to identification of numerous paper (more than 1000), a more limited keyword was chosen in titles/abstracts/keywords (stakeholder involvement + innovation process). Within the result of the search (70 papers), based on the relevance of journals and topic, 22 potential relevant papers have been selected. By reading the abstracts, finally 7 papers were selected as the related paper to this study. Fourteen selected papers have been scrutinized for understanding the theories in use for the role of supply chain in innovation or sustainability. In addition to the above systematic review, all papers including sustainability and innovation in their title (on Google Scholar), was assessed to identify the relevant papers for the purpose of this study (20 papers).

The reviews of the literature show that supply chain relationships can play a critical role in synergizing the effect of innovation and sustainability (Senge & Carstedt, 2001; Arnold, 2011; Wagner, 2009). The review of the literature shows extensive body of knowledge on supplier and/or customer integration for sustainability and/or innovation, recognizing the necessity of building close, interactive relationships with key customers and suppliers (e.g. Flynn et al., 2009). Majority of the studies, clarify the role of suppliers in enhancing the firm's ability to incorporate sustainability issues in product development (e.g. Lee and Kim, 2011; Geffen and Rothenberg, 2000; Verghese and Lewis, 2007; Achterkamp & Vos, 2006; Wenyu et al., 2012; Heikkurinen, & Bonnedahl, 2013). In particular, previous studies argue that deeper and closer partnerships with suppliers enhance sustainability on supply chain level (Yarahmadi and Higgins, 2012). Moreover, suppliers have been targeted mainly as a source of new insight on sustainable product and process development (Yarahmadi and Higgins, 2012). Indeed, Simpson et al., (2007) showed that information on new sustainable technologies can be found within supplier relationships, and thus they can drive sustainable process innovations (Simpson et al., 2007).

In a similar vein, within the supplier network, customer integration also seems to act critically in driving businesses towards sustainability and innovation (Yoon and Tello, 2009). In particular, Scholars underline mainly how customer act as one main diver of sustainability for firms (Wong, et al., 1996; Sheth, 2011). In other words, as Gonzales-Benito and Gonzales-Benito, (2006) claimed that if the business realize customers' sustainability needs, they put effort in implementing proactive sustainability actions. Others go even beyond by showing that customer interests are closely aligned with the interests of many other stakeholders, and thus, a strong customer integration seriously empower both the efficiency and the effectiveness of

sustainability efforts (Sheth, 2011). In contrast, some investigations show that customer integration make firms' innovation effort more challenging (a possible hindering factor) in relation to sustainable development (Wagner, 2009). Alternatively, Gualandris and Kalchschmidt, (2014) show that firms' innovativeness negatively and significantly moderates the effect customer has on sustainable process management. However, some scholars link customer and supplier integration, by claiming that customers not only demand the focal company but also the suppliers to be sustainable compliant (Delmas and Montiel, 2007), thus suppliers are increasingly pushed to innovate to reach the customers' needs.

Finally, cross functional coordination between departments, labelled as internal integration, is seen to be a necessary element in how adoption of sustainability practices can mutually benefit (from) new product development mechanisms (e.g. Boks, 2006; Petala et al., 2010; Sullivan and Ehrenfeld 1992/93; Charter & Tischner, 2001). In this regard, Pujari and Wright, (1996) show that the integration of environmental concerns with other functional areas, of within NPD process, is necessary in utilizing the most of synergetic effects of sustainable development and innovation management. In a more individual perspective, Liu et al. (2010) argue that employees' knowledge can enhance firm's sustainability capacity. Henriques and Sadorsky (2007) further stated that the pressure from employees is a significant determinant whether and how the firm is committed to sustainability issues.

To conclude, literature review proposes strongly the positive and significant role of supplier and internal integration on adoption of sustainability practice and/or innovation mechanism (Van Bommel, 2011; Pujari et al., 2003; Geffen, 1997; Rothenberg, 1999), while there exist contrasting results on the effect of customer integration (e.g. Yoon and Tello, 2009; Gualandris and Kalchschmidt, 2014). Despite strong insights dawn from these studies and the relevance of supplier-internal-customer integration, they seem to be disjointed (e.g. Flynn, et al., 2009). Thus, more recently a systematic and holistic approach to supplier-customer-internal integration emerged (Lambert and Cooper, 2000; Flynn et al., 2009; Wisner and Tan, 2000; Zhao et al., 2008). We argue that the unidimensional approach towards supply chain integration could be the reason behind some inconsistency in the results of previous studies, because supplier, internal and customer integration correlate with each other (e.g. Das et al., 2006; Devaraj et al., 2007; Germain and Iyer, 2006).

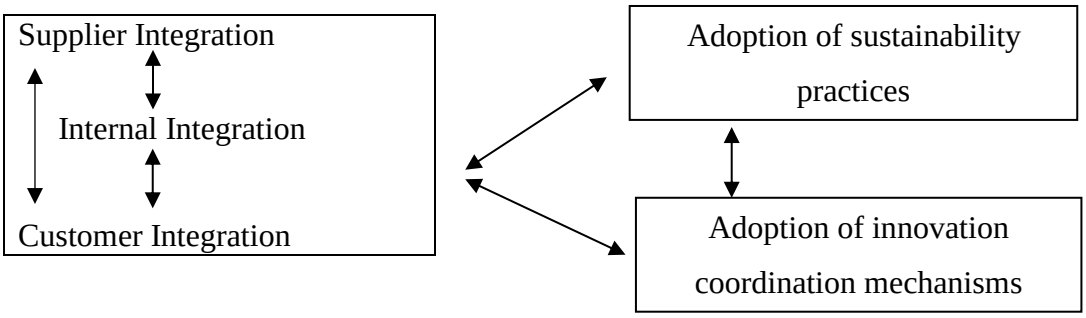
As obvious from above, but even few contrasting results of previous studies, there is a need to explore how sustainability and innovation are interlinked through a generalizable method, from

the supply chain interactions' perspective (including both upstream and downstream actors). Recently, scholars argue that to consider supply chain integration, internal aspect of focal firms should also be considered as a key element in supply chain integration (e.g. Boks, 2006; Petala et al., 2010; Sullivan and Ehrenfeld 1992; Charter and Tischner, 2001) through a holistic view (Flynn et al., 2009). By applying the definition of integration (by Webster's 1966) to supply chain partners, holistic supply chain integration is defined "as the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organization processes" (Flynn et al., 2009, p. 59). The goal of integration has often been to achieve effective and efficient flows of products/services, money, information, and decisions, in order to obtain the optimal value for the customer cheaper and faster (Bowersox et al., 1999; Frohlich and Westbrook, 2001; Naylor et al., 1999). However, extant studies have been scrutinizing supply chain integration for sustainability and/innovation in unidimensional approach (Paulraj et al., 2008; Mabert and Venkataramanan, 1998; Spekman et al., 1998; Fawcett and Magnan, 2002) either by their dyadic relationships (Lee and Whang, 2001) or treating them as a single system (Vickery et al., 2003; Naylor et al., 1999; Bowersox and Morash, 1989; Hammer, 1990; Stevens, 1989). Instead, looking at upstream-internal-downstream relationships -supplier, internal, customer - though a holistic approach is a relatively new research stream (Flynn et al., 2009). This Ph.D. work by further testing the role of supply chain integration on the firms' sustainability and innovation effort fill several gaps: first, by investigating supply chain integration considering internal and external views through a holistic approach; Second, investigating deeply the synergetic effects of sustainability and innovation cube with supply chain integration, by a global generalizable methodological approach. Because as stated in the systematic reviews of the topic (e.g. Adams, et al., 2015), the geographical distribution of studies shows global interest in the sustainability and innovation interlink, though less than one-third of the studies adopted a multi-country focus (to name the few e.g. the European survey carried out by Wagner, 2008). In particular, the following hypothesis are formulated to be tested:

> H4: Supplier-internal-customer integration correlates positively with putting effort on adoption of sustainability practices
>
> H5: Supplier-internal-customer integration correlates positively with putting effort on adoption of innovation mechanisms.

We specified a model to answer to the test the fourth and fifth research questions (Figure 2).

FIGURE 2. Specified model for the correlation between supply chain integration, sustainability and innovation



The findings from testing the hypotheses, based on evidence from more than 850 firms in more than 20 countries, confirm the synergetic effect between all elements of the model. As a result of the confirmation, in the second course of this Ph.D. work, we focus on the second approach in literature, investigating management of particular innovations aimed at and/or enhance -at least one dimension of- sustainability as a unified business initiative. As we previously argued, we believe the particular innovations for sustainability is the result of sustainability and innovation positive correlations in diverse perspectives. Thus, in the next section, a thorough theoretical framework of each of the second approach is provided in relation to the other multi-level research questions of this Ph.D. work.

2.2 Innovations aimed at sustainability as a unified business initiative

The primary literature screening on the innovations for sustainability, shows that despite the growing interest of these type of initiatives in businesses, yet, there is no quite precise unified terminology for that. This could be due to the multi-dimensional nature of sustainability and innovation concepts (Charter and Clark, 2007). A list of different applied terminologies for almost similar concept is provided (Table 3).

TABLE 3: Applied terminologies for innovations aimed at sustainable development

Examples of related terminologies	Some Reference
Sustainability related innovation	Wagner, and Llerena, 2008
Sustainability driven innovation ‘the creation of new market space, products and services or processes driven by social, environmental or sustainability issues.’	Hall and Vredenburg, 2003; Keeble et al., 2005.
Sustainable Innovation: Innovations in which the renewal or improvement of products, services, technological or organizational processes not only delivers an improved economic performance, but also an enhanced environmental and social performance, both in the short and long term.	Bos-Brouwers, 2010; Hockerts, 2003

Sustainable-oriented New Product Development	Gmelin and Seuring, 2014
Sustainability-led innovation	Seebode, et al., 2012
Sustainable development innovation	Hall, 2002
CSR driven innovation	Hockerts, et al., 2008
Eco-Innovation: The process of developing new products, processes or services which provide customer and business value but significantly decrease environmental impact.	Fussler and James, 1996.
Environmentally sustainable product innovation: The development of products or technologies that are both market-oriented and cause the minimal environmental impact possible	Maxwell and van der Vorst, 2003; De Medeiros, et al., 2014; Kemp and Arundel, 1998
Environmental New Product Development	Berchicci and Bodewes, 2005
Green Product Innovation	Dangelico and Pujari, 2010
Social Innovation	Mulgan, et al., 2007

As mentioned in the literature review method explanations, we identify the most cited papers applying any terminology to fully grasp the prior research on the topic. The literature review shows that within the related multidisciplinary research streams around the topic, eco/green-innovation/product development has been more extensively investigated (Klewitz and Hansen, 2014) which focus solely on environmental issues mainly at new products/services development (To name a few, e.g. Pujari, 2006; Pujari et al., 2003, 2004; Foster and Green, 2002; Azzone and Noci, 1996; Hart, 1997; Conway and Steward, 1998). However, product environmental innovations are almost public-policy induced or market-oriented (Hall and Vredenburg, 2003) thus include fewer disruptive innovation (e.g. remanufactured products, recycled content (Pujari, 2006). This is why, following Ketata, et al., (2015) and Adams, et al., (2015), a broad perspective for the definition is chosen to include also social issues. In this PhD work, sustainability oriented innovation (SOI) is defined as the establishment of new products, processes, and/or management systems, where environmental, social, and economic goals are their foundations (Hansen et al., 2009). Also, compared to other terminologies covering social aspects (e.g. sustainable innovation), "sustainability oriented innovation (SOI)" has been chosen because the focus is on innovations which are intended to contribute to sustainable development, independent from the actual sustainability performance of business. Alternatively, we could have focused on the the actual sustainability impact of innovations. Focusing on the sustainability performance has a clear drawback to decide which innovation projects, in practice, actually enhance sustainability performance of the entire business (VINNOVA, 2001). For instance, CFCs were highly-innovative technological solution in the

1920s, however, decades later it is discovered to harm the ozone layer. Thus, it was replaced by HFCs, which turns out to have a powerful effect on the Earth's climate. That's why, this study focuses on the intention of the innovators despite of its own drawback in becoming mixed up with other motivations such as cost-cutting efforts or continuous quality improvement - business or consumer- oriented benefits (Rennings and Zwick, 2002).

Sustainability oriented innovations have increasingly and extensively gained attention both from academicians and practitioners. As Pujari et al., (2003) noticed, by carrying out a survey analysis of UK firms, a notable ''paradigm shift'' is present towards sustainability oriented innovation development into the entire innovation process. Also, according to the 2015 Responsible Business Summit, 30% of the investigated practitioners' community stated that SOI is the most exciting opportunity for their organizations over the next five years. Innovation aimed at sustainability is accepted in 95% of the surveyed practitioners as a significant source of business value (Keeble et al., 2005). On the other hand, from academicians' point of view, an increasing number of academic conferences and journals' special issues are illustrating the increasing attention around SOI theme (e.g. to name some, the 11th International Conference of the Greening of Industry Network {held in San Francisco, USA, on 12–15 October 2003}, around the theme of Innovating for Sustainability which is also related to the special issue of "Business Strategy and the Environment" Journal focusing on the diverse interpretations of innovation and their impacts on the different strands of sustainability; 11 special Issues of "Sustainability" journal e.g. on "Innovation and Environmental Sustainability", 2011 and "Sustainability and Open Innovation Capabilities of Firms for Value Chain Development", 2016; Special issue of "International Journal of Innovation Management" on "Innovation for Sustainable Economy and Society", 2015 and "Innovating in Global Markets: Challenges for Sustainable Growth", 2014 and "Sustainability in Innovation", 2012; 3 special issues of "Journal of Cleaner Production" on "Sustainable Innovation and Business Models", 2013 and "Environmental innovation", 2003 and "Green and Sustainable Innovation for Cleaner Production in the Asia-Pacific Region", 2016; Special issue of "international journal of business in society" on "Entrepreneurship and Sustainable Innovation", 2016; etc.).

As seen from the very high number of special issues on the topic, the investigations of sustainability oriented innovation have been carried out from various perspectives. To name the most well-known perspectives, prior research has focused extensively on the drivers (e.g. Wagner and Llerena, 2008; Yoon and Tello, 2009; Blowfield et al., 2008), benefits (e.g. Kiron, et al., 2013) and the importance of SOIs regarding the regulations, environmental concerns and

business competitiveness (financial and market drivers) (Dangelico, and Pujari, 2010; Charter and Clark, 2007). The results show different benefits and drivers including regulatory compliance (Dechant and Altman, 1994), competitive advantage (Porter and Van der Linde, 1995), stakeholder pressure (Baya and Gruman, 2011), social legitimacy and reputational enhancement (Boiral, 2007, Kesidou and Demirel, 2012), and moral consciousness (Bos-Brouwers, 2010). Second, there are many studies on development of application tools and methodologies in this area, e.g. 'cradle to cradle' protocol; development of an external advisory board, workshops; in-house product-related environmental evaluation procedures and customized tools. Third, sustainable product development and design (SPDD) has been studied quite widely which focuses mainly on the systematic incorporation of life-cycle sustainability/environmental considerations into product/service design as well as eco-design (e.g. Huber, 2008; van Hemel and Cramer, 2002). Japanese firms are progressively implementing eco-design initiatives as part of a broader plan between industry and government for an international competitive issue (Cortez and Cudia, 2010). Fourth, development of new business models for sustainability with the system level focus is an increasing area of academic discussion. In this regard, a body of knowledge focus on sustainability oriented business models, including transformative/transition regimes innovations for sustainability (Leach, et al., 2012, Hargreaves et al., 2013), sustainable Product-Service-Systems (PSS) by implementing non-material services compared to targeting only physical products (e.g. Charter and Tischner, 2001; Tukker and Tischner, 2006).

Finally, prior research, more related to this PhD work, have been investigating the barriers and challenges in the development of innovation for sustainability (e.g. Seebode, et al., 2012; Vasilenko, and Arbačiauskas, 2012). Because innovation, by nature, is a complex area while sustainability presents its own complexities and uncertainties. Previous studies propose some of the obstacles including organizational (lack of capability building), market and financial issues and policy (Rehfeld, et al. 2007), conceptual (lack of coherence in defining and conceptualizing with variety of concepts leading to lack of common language between practitioners and academicians and lack of insights into solutions (Dangelico and Pujari, 2010; Adams, et al., 2015; Perl-Vorbach, et al., 2014). One of the possible ways to face some of the challenges is proposed to form sustainable innovation networks because both sustainability and innovation require the engagement of a variety of players and developing networks (e.g. Steiner, 2008). Views on network/stakeholder management, knowledge management/absorptive capacity for learning is the majority of research papers in this area

(Seebode, et al., 2012; Correia de Sousa, 2006). Following is provided a detailed review of literature.

The review of the literature on SOI development shows that despite increasing attention emerges towards SOI development, though it is quite challenging for firms to incorporate sustainability in their innovations remaining economically competitive (e.g. Ketata et al., 2015; Pujari, 2006; Petala, et. al., 2010; Berchicci and Bodewes, 2005). This is why, many failures (e.g. 'EarthLight' compact florescent light bulbs from Philips, GM's first electric car EV-1, and Whirlpool's CFC-free refrigerator) are noticeable, despite of some success cases (e.g. PandG's Lenor concentrated fabric softner, and ARCO's environmentally reformulated gasoline) (Pujari, 2006). Facing this challenge successfully to create a 'win-win' solution, or to at least face the raised trade-offs, make SOI development more complex and risky compared to conventional approaches (e.g. Sharma and Vredenvurg, 1998; Hansen et al., 2009). In this regard, Hall and Vredenburg (2003) showed that few firms invest heavily on SOI development. Because it possesses higher complexity due to a wider range of stakeholders and ambiguity due to their possible contradictory needs (Hall and Vredenburg 2003). The complexity of the generation of SOI development becomes even more complex about the possible negative effects that, are in addition to the usual positive effects (Steiner, 2008). Lenox and Ehrenfield (1997) find that when sustainability is incorporated in innovations, it is more likely to be hampered by organizational barriers than technical/process barriers compared to the conventional forms of innovation.

Therefore, SOI is argued to be more complex compared to conventional forms of innovation, thus, possess its own peculiarities. However, as Pujari et al., (2003) claimed, there is more synergy than conflict. That is why, SOI investigations can/should be studied through innovation theories/frameworks (Pujari, 2006). Pujari, (2006) claimed the effective integration of SOI and innovation paradigms could be one of the key challenging benefits for both academics and practitioners.

Prior investigations on SOI peculiarities, focus on various perspectives ranging from differences in capability development (e.g. Van Kleef and Room, 2007; Chen, 2008; Yarahmadi and Higgins, 2012), external/internal cooperation/coordination (e.g. Pujari, 2006; Van Kleef and Room, 2007), new product/service development process (e.g. Hall and Vredenburg, 2012; Carrillo-Hermosilla et al., 2009) or even hybrid models of the perspectives (external cooperation capability in Sharma and Vredenburg, 1998).

Regarding SOI capability building, the resource-based view (RBV) of the organization serves as a theoretical lens for achieving/maintaining competitive advantages by analyzing the role of intangible resources (Teece, 2007; Barney, 1991; Hamel and Prahalad, 1990; Wernerfelt, 1984) and organizational capabilities (Hofer and Schendel, 1978; Hamel and Prahalad, 1990; Ulrich and Lake, 1991). Seebode, et al., (2012) look at SOI capability development from knowledge management perspectives. They claim that SOI, by its nature, includes diverse knowledge components (e.g. new regulatory/public conditions in addition to the required knowledge for conventional innovation such as new technologies/markets) (Seebode, et al., 2012). Thus, they need the capability to acquire, assimilate and exploit new knowledge. Alternatively, Zahra and George, (2002) show that innovative businesses need to enhance their absorptive capacity for handling the new knowledge components of sustainability. Kleindorfer et al., 2005 defined this development of capabilities that a competitor would be unable to copy (quickly) as the "first-mover" advantage for SOIs. They suggest that the capability development is the primary step for businesses to be able to learn for further improvements (Womack, et al., 1990). For instance, Toyota's hybrid petrol-electric car took the advantage of first-mover compared to few sustainable technologies of Ford Motors, General Motors, Mercedes, and Porsche. Also, 3M elimination of solvents by coating products with water-based solutions took the advantage over 3M competitors. These examples gained a first-mover advantage, thanks to the built/enhanced capabilities over competitors who followed similar initiatives much later (Kleindorf et al., 2005). In particular, Nidumolu, et al., (2009) show how sustainability initiatives of 30 large corporations go through five distinct stages of change which they must develop new capabilities to face the challenges and take advantage of innovation opportunities in each stage {Stage 1) Viewing Compliance as Opportunity requires the competence to work with other companies; 2) Making Value Chains Sustainable requires the capability to redesign operations and ensure suppliers and retailers become more sustainable; 3) Designing Sustainable Products and Services requires the competence to identify measurements of the sustainable outputs and to generate real public support; 4) Developing New Business Models requires the capacity to understand consumers, their needs and how partners can enhance the value creation; 5) Creating Next- Practice Platforms requires the knowledge of how firms' practices affect business ecosystems and industries to be able to synthesize new business models}.

To conclude, previous studies propose sufficient reasoning that SOIs may require adjusted innovation capabilities. Extant previous research corroborates the resource-based view as an applicable theoretical lens for studying resources and capabilities in achieving a specified

purpose. However, extensive innovation studies are applicable to hypothesize the required resources and capabilities for sustainability oriented innovations. The resource-based view refers to intangible resources as critical drivers of performance (Villalonga, 2004), meaning a firm's endowment of resources leads its competitive advantage over time (Wernerfelt, 1984; Rumelt, 1984; Barney, 1991). Intangible resources are difficult to assess from an accounting viewpoint, but should be recognized and deployed to achieve competitive success. According to the pioneer studies with comprehensive analysis of intangible resources (e.g. Hall, 1992), intangible (invisible) resources typically range from know-how to networks and reputation. In this regard, the know-how of the organization can be drawn from both individuals or the organization. Individual know-how, typically called as human capital, is assessed mainly by the level of professional development and employees' new skills and knowledge in firms (Bontis et al., 1999). While organizational know-how, called as organizational capital, refers to various perspectives of the organization including business philosophy/working style and institutionalized knowledge/experience, (Hall, 1992). Business philosophy and working style considers the critical principles that determine the formation and operation of a business. On the other hand, institutionalized experience/knowledge refers to the past experience of firms which leads to enhanced know-how to do better in future. The other key element (networks) is referred mainly to relational capital, which is divided into inter and intra-organizational relations. While inter-organizational resources consider mainly the commitment, participation, and internal collaboration, the intra-relational capital is dealing mainly with the structure of company-stakeholder relationships (Salman and Saives, 2005). Finally, symbolic capital is mainly related to the reputation of the organization (Hall, 1992).

On the other hand, we define capabilities as a firm's capacity to deploy resources for some purpose. "[They] can abstractly be thought of as 'intermediate goods' generated by the firm to provide enhanced productivity of its Resources" (Amit and Schoemaker, 1993, 35). According to innovation studies, firms should be able to open up their innovations externally (Chesbrough, 2006) as well as devoting investments internally (Chesbrough, 2003; Dyer et al., 2004). In this regard, previous studies emphasize strongly the necessity of integrative perspectives where firms build strongly on external transactions to extend the internal bases (Lichtenthaler & Lichtenthaler, 2009; Argote et al., 2003). However, knowledge management research is often limited to specific internal knowledge processes, e.g. knowledge creation or exploitation (Grant, 1996; Nonaka, 1994). On the other hand, absorptive capacity is an effective theoretical lens, however it focuses mainly on utilizing external insights inside the firm (Cohen and

Levinthal, 1990). More recently, the concept of combinative capability relates external knowledge accumulation to the necessity of merged internal collborativeness (Gebauer et al., 2012). The proven need of integrative perspective leads us to initiate our theoretical framework based on the developed capability-based frameworks for innovation considering both inside and outside organizational boundaries (e.g. Lichtenthaler & Lichtenthaler, 2009).

Regarding the internal factors, the importance of R&D for innovations has been proved extensively by previous studies especially from the technological perspective (e.g. Guan & Ma, 2003). Neely & Hii, (1998) argued that R&D is the key input for linear model innovations which takes for granted the market as a ready platform for the innovation output. Apart from R&D, regarding other internal factors associated with capabilities for innovation, previous studies mainly proposed how organizational structure and autonomy/level of centralization may affect firms' openness toward new approaches, called innovative capacity (Neely & Hii, 1998). In this regard, previous studies mainly show the effect of organizational structures, designs and incentives for reacting to environment changes (Hilliard, 2006) through firms' dynamic capability (Teece et al., 1997; Teece, 2007).

Previous studies, however, argue the absolute need of considering external sources for more complex innovations (Neely & Hii, 1998). The extensive studies on the external collaboration and building networking capability is discussed mainly in open innovation literature (Chesbrough, 2006). Open innovation is defined as "a distributed innovation, based on purposively managed knowledge flows across organizational boundaries" (Chesbrough & Bogers, 2014, p. 12).

Lichtenthaler, & Lichtenthaler, (2009), based on extensive body of studies, distinguished capabilities for innovation development into three main categories: exploration (knowledge/opportunity creation), exploitation (knowledge/opportunity application) and retaining knowledge over time. Exploration and exploitation have been scrutinized through diverse theoretical perspectives, mainly knowledge management and organizational learning. Exploration capability is defined as the businesses' ability to attract new ideas, while exploitation relates to implementation of the attracted new idea (e.g. Ketata, et al., 2015; Cohen & Levinthal, 1990; Seebode et al., 2012). The proposed routines for opportunity exploration capability typically include frequent opportunity recognition and new ideas' absorption, assimilation and idea reconfiguring and adjustment to the existing firm (Cohen & Levinthal, 1990; Teece, 2007). Finally, firms' ability to retain and formalize knowledge is discussed

widely in innovation literature (Menzies, 1999; Cohen & Levinthal, 1990; Gebauer et al., 2012). Knowledge formalization relates mainly to methods and techniques for knowledge maintenance in businesses over time and their ability in reactivating the knowledge where necessary. Following, the hypothesized capabilities are summarized (Table 4).

TABLE 4. The hypothesized capabilities according to innovation theories

	EXPLORATION	**EXPLOITATION**	**RETENTION**
INTERNAL	Research and Development Internal organizational factors: - Organizational Structure and autonomy - Enterprise procedures, designs, and incentives Internal collaboration; Cross-functional and participative functions		Knowledge Formalization: - Knowledge maintenance and reactivation -Knowledge systemization Continuous re-alignment
EXTERNAL	Knowledge acquisition & recognition through socialization: -Stakeholder integration, dialogue, collaboration (relationship, communication style, stakeholder flexibility, openness to change by external views)	Assimilative, transformative and exploitative learning process and focus for knowledge assimilation, transformation, and application.	

Despite the proposed comprehensive framework of required capabilities for innovation, as mentioned before, when sustainability is in the framework of the innovation objective, it may bring peculiarities. Previous studies investigated some aspects of the hypothesized capabilities in sustainability oriented innovations. However, in order to fully comprehend the existing literature on SOI capabilities, due to many terminologies used (Ketata et al., 2015), attention was given not only to studies clearly applying the terminologies of sustainability and innovation (e.g. Hall and Vredenburg, 2003; Ayuso et al., 2011), but also the ones stating similar terminologies such as eco/green innovation, etc (e.g. Senge and Carstedt, 2001; Bakhtina, 2011).

Regarding the internal exploration and exploitation, Müller and Siebenhüner, (2007) shows that R&D and technological development may address only one part of the change towards sustainability. Additionally, firms should establish sustainability-related research (improvements of cognitive knowledge about sustainability solutions) and enhance sustainability oriented learning processes (Müller and Siebenhüner, 2007). In a similar vein, previous studies show that enterprise structure may leverage indirectly the internal exploitation of SOI opportunities by supporting internal communications. This is aligned with studies on dynamic capability perspective where organizational structure act as facilitator in innovation

opportunity seizing (Wu et al., 2013). Indeed, the necessity of extensive internal collaboration is argued in previous studies for the particular context of sustainable development (e.g. Barratt, 2004). Firms can enhance internal collaboration through various proposed means including employee engagement, idea management, empowerment and training.

On other hand, when it comes to capabilities for external exploration and exploitation, contemporary scholars relate open innovation approaches to integration of interest groups to enlargement and exploitation of a firm's sustainability (Perl-Vorbach et al., 2014). In general, sustainability specific related opportunities, by nature, forces firms to learn new approaches around the core searching, selecting and implementation (Seebode et al., 2012). "In particular, they need capability (and enabling tools and methods) to acquire, assimilate and exploit new knowledge and to work at a systems level" (Seebode et al., 2012, pp. 197). In this regard, extant research suggests that SOIs require higher emphasis compared to conventional forms of innovation, on capabilities for external collaborations (Adams et al., 2012; Carrillo-Hermosilla et al., 2010; van Kleef & Roome, 2007). Based on a comprehensive review, Van Kleef and Roome (2007) argue that SOI requires active integration of a broader and more diverse network of actors, especially non-conventional ones, including customers, NGOs, and other stakeholders such as people involved locally (Gable and Shireman, 2004; Ketata, et al., 2015). Finally, previous studies on resources and capabilities needed in SOI context, bypass knowledge retention capabilities.

To conclude, despite broad exploration of resources and capabilities for innovations, previous studies have argued that sustainability context of SOIs bring peculiarities compared to conventional forms of innovation (Sarkis et al., 2010; Ketata, et al., 2015) by its multidimensional objectives (Foxon and Andersen, 2009; De Marchi, 2012) for addressing sustainability targets beyond generating only revenues (Adams et al., 2012).

Accordingly, SOIs may require similar capabilities with different emphasis (Van Kleef and Roome, 2007; Ketata, et al., 2015). Moreover, given the SOI peculiarities mentioned above, empirical investigations that examine resources and capabilities for innovations aimed at sustainability are sparse. Therefore, research is needed on managing resources and capabilities when innovation is aimed at sustainable development. Based on the combined insights from resource based view and capability view for innovations, this study examines intangible resources and capabilities for particular context of "sustainability oriented innovations". However, within the few documented studies on SOI capability, previous research has almost

entirely focused only on one of the organizational capabilities (e.g. absorptive capacity in Ketata, et al., 2015; internal knowledge generation in Lane et al., 2006; Zahra and George, 2002) and focus mainly on environmental issues (e.g. environmental/green/eco-innovation in Horbach et al., 2012; Kesidou and Demirel, 2012). Therefore, there is a lack of empirical studies with the integrative capability perspective for innovations aimed particularly at sustainable development (e.g. Ayuso et al., 2006; Dangelico et al. 2013; Adams et al., 2015; Ketata, et al., 2015). This is especially important to be investigated, because to add sustainability in traditional innovations, businesses may require adjustment the most critical capabilities primarily.

> RQ a. Which innovation resources and capabilities should be adjusted by firms for particular innovations aimed at sustainability?

The results of this study confirms the criticality and benefits of incorporating broadly and deeply various actors in SOI initiatives (e.g. Pujari, et al., 2003; Gmelin and Seuring, 2014; Pujari, 2006; Bos-Brouwers, 2010; Charter and Clark 2007; Sharma and Vredenburg, 1998). In addition, in many (sustainability-oriented) innovations, various actors are incorporated (Sharma & Vredenburg, 1998). The benefits, reported by the literature, are: providing lacking or new insights over a wide range of areas –e.g. technical, technological or sustainable (Ayuso et al., 2006; Hansen et al. 2009; Laperche & Picard 2013); enhancing strategic orientation of firms towards sustainable development (Ayuso et al., 2011; Sharma & Henriques, 2005; Van Kleef and Roome, 2007); promoting sustainable behavior in the involved actors (mainly in users (Jelsma, 2003; Lockton et al., 2008) or suppliers (Carter & Rogers, 2008)); finally, benefiting stakeholder satisfaction, trust, and commitment (Grafé-Buckens & Hinton, 1998; Strong et al., 2001). Thus, in the next step of this Ph.D. work, we focus on external incorporations' capability development to explain the detailed peculiarities of specific SOI projects.

To have a more precise literature review on the external incorporations' capability, a multi-terminology multi-disciplinary approach was applied. More generally, and more applied in sustainability literature, it can be called as stakeholder integration when stakeholder is any actor involved in a project, ranging from individual and groups to whole organizations. Thus, stakeholders can come from both within or outside of the organization's boundaries. The definition is close to Freeman and Evan's (1991), Hill and Jones' (1992), and Cornell and Shapiro's (1987), where stakeholders are contractors or participants in exchange relationships.

With this definition, as Wayne, 2012 claimed, stakeholder integration in innovations are analogous organizational constructs with open innovation (Wayne, 2012). On the other hand, strong evidences and body of knowledge on actors involving in innovations is drawn from open innovation literature. Open innovation is defined as "a distributed innovation, based on purposively managed knowledge flows across organizational boundaries" (Chesbrough & Bogers, 2014, p. 12). Drawn from all perspectives, we can conclude that while integrating diverse entities are quite advantageous for businesses, they face abundant challenges and complexity in doing so (Keskin et al., 2013). As a consequence, businesses must develop organizational capabilities to be able to face the challenges (Sharma & Vredenburg, 1998; Van Kleef & Roome, 2007; Huizingh, 2011).

The review of the literature shows that firms should be able to open up their innovations externally (Chesbrough, 2006) as well as devoting investments to align external acquisitions internally (Chesbrough, 2003; Dyer et al., 2004). While knowledge management research is often focused on specific internal knowledge processes, e.g. knowledge creation or exploitation (Grant, 1996; Nonaka, 1994), absorptive capacity focuses mainly on utilizing external insights inside the firm (Cohen and Levinthal, 1990). More recently, the concept of combinative capability relates external knowledge accumulation to the necessity of merged internal collaborative (Gebauer et al., 2012). As applied in previous studies, we base our work on Lichtenthaler & Lichtenthaler, (2009) who merged different perspectives to advance towards an integrative perspective of capability-based framework for open innovation processes, which considers knowledge exploration, retention, and exploitation – based on the classic evolutionary model of variation–selection–retention (Campbell,1960). They also differentiate the capabilities according to the internal and external boundaries of the organization (Lichtenthaler & Lichtenthaler, 2009). However, due to the purpose of this phase of the study, for understanding the external incorporations' capabilities, we itemized more in depth only on the proposed external exploration, exploitation and retention. External knowledge exploration explains the acquisition of knowledge from external sources (Lane et al., 2006), i.e. externally generating new intuitions, and selection (Zollo and Winter, 2002). While, external knowledge exploitation encompasses the replication of new approaches in different contexts and their application in different settings (Zollo and Winter, 2002). Finally, external knowledge retention describes the possibility of incorporating knowledge on interfirm relationships, which represent the external knowledge base. They suggest absorptive, connective and desorptive capacity for the external exploration, exploitation and retention, subsequently (Lichtenthaler and

Lichtenthaler, 2009). Absorptive capacity originally is defined as recognizing, assimilating, and applying external knowledge. Thus, relying only on external exploration is not enough for successful external acquisition (Lichtenthaler, 2009). However, aligned with Lichtenthaler and Lichtenthaler, (2009), "we define absorptive capacity as a firm's ability to explore external knowledge" (p. 1319). The review of the literature shows that firms to be able to explore externally and build the absorptive capacity, need the ability to attract external entities (networking capability) and map their competences (competence mapping capability). Networking capability is defined as firm's ability to attract external actors to be engaged in an innovation project with the leading firm (Perks & Moxey, 2011). Kazadi et al., (2016) argue that businesses require more elaborated type of networking capability when integrating a diverse range of actors, especially with non-business actors for non-financial goals. On the other hand, competence mapping capability is defined as "a firm's ability to produce an explicit overview of the different competences present in each of its different stakeholders" (Kazadi et al., 2016, p. 534). They argue that when a stakeholder is far from the leading firm's business, identifying the competences of each stakeholder would be much more challenging and complex (Kazadi et al., 2016).

The suggested capability for external exploitation (Connective Capacity) refer to the relationships of the actors and a firm's ability to retain knowledge in interfirm relationships (Lichtenthaler and Lichtenthaler, 2009). Thus, it encompasses elements of relational capability -mainly aligned with our definition of actors' involvement in a project (Lorenzoni and Lipparini, 1999) or alliance capability -refers mainly to the long-term interfirm relationships (Kale and Singh, 2007). Relational Capability is defined as organization's ability to manage relationships with involved actors in projects by building an innovation network (Capaldo, 2007). Mitrega et al. (2012) suggest a combination of relationship initiation, relationship development and relationship termination. The common issue in the definitions is the relationship capability (Capaldo, 2007; Lorenzoni & Lipparini, 1999). However, it is argued that if involved actors are required to have an active and positive relationship with each other (not limited to dyadic relationships), additional relational capabilities are required. Some studies recognized relational capability as the key element of stakeholder integration (e.g. Van Lancker et al., 2015).

Finally, desorptive capacity refers to a firm's ability of external knowledge retention, which is executed by internal knowledge applied in the boundaries of the organization (Lichtenthaler, 2007). The rational lies in the fact that after identifying external knowledge exploitation

opportunities, a firm has to accommodate the knowledge internally (Rivette and Kline, 2000). This capability refers to the firm's ability to select, engage, empower, and align relevant internal actors to external acquisitions in a project (e.g. Hillebrand & Biemans, 2004 & 2003). The majority of innovation studies on internal cooperation have focused on the cooperation between functions (e.g. Griffin & Hauser, 1996), especially in new product development (Hillebrand & Biemans, 2004). However, desorptive capacity is very hard to be achieved by businesses and is proven not to have a single best solution, while "a contingency approach appears to offer the best chance of success" (Hillebrand & Biemans, 2004, p. 736).

To conclude, elaborated on the prior open innovation research, four capabilities can be identified as the fundamental components of external actors' incorporation in open innovation projects – namely: networking, competence mapping, relational and desorptive capabilities/capacities.

On the other hand, the review of literature on sustainability oriented innovation shows limited documented evidences on external actors' incorporation. Among them, Ayuso et al. (2006) qualitatively conceptualize stakeholder integration capability for SOIs in two constructs: stakeholder dialogue and stakeholder knowledge integration – referring to the relational capability. Further, the author relates the relational capability to desorptive capacity by showing quantitatively that actors' knowledge must be managed by the business internally to be converted into new ideas (Ayuso et al., 2011). Building on this conceptualization, Veldhuizen et al. (2012) show how desorptive capacity can act as a driver of relational capability.

Further, some scholars investigate external actors' integration capability in green/sustainable new product development. In this regard, Dangelico et al., (2013) suggest that external actors' integration capability for green new product development should encompass creation of collaborative networks with actors along and beyond the supply chain, and include acquisition of technical sustainability-specific knowledge. On the other hand, Driessen and Hillebrand (2013) identify coordination and prioritization mechanisms –refers to relational capability. They suggest that integrating disparate type of actors (market and non-market) require organizations to build more elaborated capabilities to overcome the possible complexity. Thus, the few studies on external actors' incorporation capability in the SOI context have focused mainly on relational, with its relation to desorptive capabilities, thus not fully covering the suggested capabilities by (open) innovation literature.

As mentioned before, it is argued here that despite the fact that SOI is argued to possess its own context peculiarities compared to conventional forms of innovation, as Pujari et al., (2003) claimed, there is more synergy than conflict. That is why, innovation theories and frameworks can/should support the investigations of SOI projects and the effective integration of these paradigms could be one of the key challenging benefits for both academics and practitioners of both fields (Pujari, 2006). A comprehensive investigation of external actors' incorporation capability in the SOI context, from open innovation theories, is necessary because it can highlight the peculiarity of this context (Adams et al., 2012; Carrillo-Hermosilla et al., 2010; Van Kleef & Roome, 2007), supporting firms to be able to reconcile their open innovation capabilities for the specific context of sustainable development. The argument is also confirmed by the innovation literature that states that the effectiveness of collaboration for innovation depends on the context (Huizingh, 2011). Thus, an empirical analysis, based on open innovation framework -comprehending all proposed subset capabilities-, is lacking to fully clarify the capability for SOI.

However, for the explanatory purpose of this step of the Ph.D work, according to the prior innovation, external actors' integration capability can be dependent on the innovation characteristics (e.g. Carrillo-Hermosilla et al., 2010). In particular, two main aspects have been reported to be relevant: first, the combination of product and services (Carrillo-Hermosilla et al., 2010); second, the extent of the innovation radicalism (Tukker and Butter, 2007). Regarding the former, it has been argued that the way in which the combination of products and services create value stresses the relevance of the entire supply chain perspective (Linton et al., 2007) leading to affect the level and/or the nature of partnerships. This is specifically seen in the literature, where product development studies emphasize more on networking capability compared to other suggested capabilities (Dangelico et al., 2013; Driessen and Hillebrand, 2013). Additionally, different actors – called as "a value network" - are needed to create added value in developing the product-service system compared to being limited only to the value chain (Könnölä and Unruh, 2007).

Concerning the level of radicalism, for the purpose of this Ph.D. work we distinguish between radical and incremental changes (Freeman and Perez; 1988) which are brought about by the SOI project (Carrillo-Hermosilla et al., 2010):

-Incremental changes refer to gradual modifications that preserve existing production systems creating added value in the existing system.

-Radical changes, in contrast, are discontinuous changes that seek the replacement of existing components or entire systems.

It is argued that the incremental modifications are developed mainly in the existing networks while radical changes seek the creation of new networks while creating added value (Carrillo-Hermosilla et al., 2010). However, various terminologies have been proposed to discern the level of "radicalism" of innovations (e.g. Christensen (1997) distinguishes between sustaining innovations and disrupting innovations). Disruptive sustainable manufacturing initiatives such as closed-loop production arises through a dynamic interaction with diverse actors, which affect the innovation process (Carrillo-Hermosilla et al., 2010). It is also important to notice that, the two dimensions that characterize innovation types are argued to be interconnected in a way the more systemic changes generally embody higher level of radicalism (OECD, 2009).

To conclude, there is a lack of empirical analysis on comprehensive open innovation framework capabilities for particular innovations aimed at sustainable development. Moreover, the capability framework was argued to be dependent on radicalism level and product/service combination characteristics of the output. Thus, this study attempts to answer following research question:

> RQ b. Which open innovation capabilities should be reconciled by firms for particular innovations aimed at sustainability depending on the radicalism and the product/service combination of the output?

Based on the literature review, we anticipate that the open innovation capability-based framework is an appropriate lens for SOI investigation, however SOI context bring forward different emphasis on certain types of capabilities, depending on the radicalism and product/service combination of the outcome.

Despite the fact that adjusting open innovation capability can support businesses in coping with the challenges of incorporation of diverse actors in the SOI projects, it will pose some differences in the SOI process as well compared to conventional forms of innovations. According to a survey of eighty proactive firms towards sustainable development, practitioners have experienced uncertainties of their own ability to do this (OECD, 2000). Of this, it is argued that the contribution can be obtained through certain external partnerships (e.g. Hall & Vredenburg, 2012). One of the key needs for partnerships generally comes from the lack of companies of the right knowledge and/or access to the right resources. Of this and particularly

for sustainability oriented innovations, Hall and Vredenburg, (2012) focus especially on the impact of sustainability-related secondary stakeholders (e.g. environmental groups, safety advocates, anti-globalization activists among others). They claimed that conventional innovation approaches mostly ignore these type of stakeholders while many of them play a vital role in sustainable development initiatives. OECD (2000), suggests public-private partnerships as a common and necessary type of collaborations for sustainability oriented innovations. Also users are argued to "play a key role not only in applying innovations but also in identifying, making improvements and developing new innovations" (Carrillo-Hermosilla et al., 2009, pp. 1078). In order to intensively involve these external partners -which could be far from routine organizational context- in the innovation process, firms are required a special adjustments or methodologies (e.g. lead user methodology (Urban and Von Hippel, 1988)) to identify them and communicate accordingly. These partners differ from ordinary external partnerships that they derive significant benefits to sustainability dimension of the innovation (Carrillo-Hermosilla et al., 2009). One of the reason is to be able to anticipate the acceptance of SOIs in the market by better understanding their needs, references and behaviors (Carrillo-Hermosilla et al., 2010). It has been seen that users mostly involved as innovators and/or co-developers (Rondinelli & London, 2003).

The particular partnership of sustainability oriented innovations poses differences in the process as well. Classical assumption in conventional innovation process is the existence of logical flow of decision making activities - meaning that each phase is the logical follow-up of the former phase (Hallenga-Brink & Brezet, 2005). In this regard, Roozenburg & van Eekels, (1991) proposed a process model for innovations with logical flow, Hallenga-Brink and Brezet (2005) suggest a different process model for SOI. In particular, they propose a diamond process model for new sustainable product-service system (Hallenga-Brink & Brezet, 2005), differentiating it from conventional innovation process. The basic idea behind the diamond model is twofold: first, the early phases of the process are not linear but chaotic instead, resulting in continuously jumping from one field to one or more others in each phase of the process. Second, the final stages of the process result in a converging process in which all pieces of the puzzle come together and a joint efforts have to be made to release the sustainability oriented innovation as a tangible outcome for the market. The whole process in itself is a diverging–converging process, the reason why it is called diamond (Hallenga-Brink & Brezet, 2005).

However, the extent or type of discrepancy in the sustainability oriented innovation process can be argued to be dependent of the outcome's characteristics including the combination of product and services (Carrillo-Hermosilla et al., 2010) as well as the extent of outcome radicalism (Tukker and Butter, 2007). Regarding the former, it has been argued that the way the combination of the products and services create value may play a crucial factor in the innovation process (Stahel and Jackson, 1993). The change from developing specific new sustainable product or service to deliver a product-service system modifies the innovation process and also the perception of the users' relation (Carrillo-Hermosilla et al., 2010). In fact, the definition of product-service system is focused mainly on the delivery of a function to users that is a combination of product and services which jointly are capable of fulfilling customers' needs (Goedkoop et al., 1999). Moreover, the product service dimension of (sustainability oriented) innovation stresses the relevance of the entire supply chain perspective during the production, consumption, customer service and post-disposal of products (Linton et al., 2007). This perspective may affect the level and/or the nature of partnership in the innovation process. Accordingly, different actors – a value network - are needed to create added value in developing the product-service system rather than value chains (Könnölä and Unruh, 2007).

Concerning the level of radicalism, incremental changes refer to gradual and continuous modifications that create added value in the existing system. However, radical changes, are discontinuous changes that seek the replacement of existing practices and the creation of new networks while creating added value. Particularly for sustainability initiatives, the need for radical change or system innovations has often been considered key to meet the challenging sustainability demands (e.g. mitigating climate change) (e.g. Tukker and Butter, 2007).

However, the majority of previous studies on SOI process peculiarities stand either conceptual or focus on one driver of process differences. Therefore, analyzing empirically all proposed drivers of SOI process differences -compared to conventional innovations- in both environmental and social innovations is lacking. Studying these drivers comprehensively help academics and practitioners to understand their relative force and accordingly the more critical drivers, suggesting the primary areas where adjustment is needed in conventional innovation processes to adapt to SOI process.

In addition, according to the innovation literature, the characteristics of the output can affect the innovation process which is overlooked in the majority of the previous studies. Thus, the final phase of this Ph.D. dissertation addresses these gaps by empirically scrutinizing all the

proposed drivers of SOI process differences -compared to conventional innovations- as well as depending on the output characteristics. In particular, the following research question guides this phase of the work:

> RQ c. How does the innovation process for sustainability differ from conventional innovation processes in terms of involved partnership and process cycle depending on the radicalism and the product/service combination of the output?

3. METHODOLOGICAL APPROACH

3.1 Quantitative and qualitative methods adopted

Addressing the aim of this Ph.D. dissertation, the methodological approach is based on multi-methodological ways, combining quantitative and qualitative methods. Quantitative and/or qualitative research methodologies have been applied rigorously in order to understand the phenomenon under inquiry. Testing the hypotheses are carried out through survey methodology. The survey method was chosen mainly to ascertain large populations' information with an accurate level. In these studies, survey method was applied to map the interrelationship and causal links between specific variables of sustainable development and innovation management. The details about the survey design, implementation and data gathering/analysis are described in the following section (see section 3.2). Yet, the research questions are answered based on case study methodology. Case study method has been applied mainly due to the nature of the phenomenon under inquiry, which is SOI peculiarities compared to conventional forms of innovations from varied perspectives. The main focus, as typically, is to answer 'how/which' questions, covering contextual conditions (Yin, 2003). The details about the case study design, implementation and data gathering/analysis are described in the following section (see section 3.3).

3.2 Survey

A survey research methodology is congruent with the aim of the quantitative studies of this Ph.D. work. Because although OM literature is quite rich on each of the constructs of sustainability and innovation, previous studies show conflicting results on how they interlink which needs to be tested empirically and comprehensively on a generalizable scale. Moreover, a survey research methodology is aligned with other studies published in managerial literature on sustainable development (Searcy, 2012; Gimenez et al., 2012; Crowe, and Brennan, 2007).

A survey research methodology is congruent with the aim of testing the hypotheses, because although OM literature is quite rich on each of the constructs of sustainability and innovation which the interrelationships need to be tested empirically and comprehensively on a generalizable scale. Moreover, a survey research methodology is aligned with other studies

published in managerial literature on sustainability practices and performance (Searcy, 2012; Gimenez et al., 2012; Crowe, & Brennan, 2007).

To test the research hypotheses of the study, we used data collected in the sixth edition of the International Manufacturing Strategy Survey (IMSS VI), a research project carried out in 2013-2014 by a global network. The IMSS project, originally launched in 1992 by the London Business School and Chalmers University of Technology, studies manufacturing and supply chain strategies within the assembly industry (ISIC 25-30 classification) through a detailed questionnaire administered simultaneously in many countries by local research groups. The questionnaire investigates the strategies and activities performed at the plant level, so the target respondent is operations, manufacturing, general or technical managers of the company. Following, the questions supporting this study are reported. Responses have been gathered in a unique global database (Lindberg et al., 1998). The sample consists of 931 manufacturing plants from 22 different countries, with an average response rate of 36 percent (Table 5). Data has been collected from May 2013 to March 2014. Firms have been selected through three different ways: convenience sampling, random sampling and firms which participated in previous versions of the surveys.

The distribution of the sample, in terms of country and valid response rates are shown in Table 6.

TABLE 5. Survey firms' descriptive data

	Number of firms contacted	***Number of firms agreed to participate***	***Number of responses***	***Valid responses in the final release***	***Agreement rate***	***Valid Response rate (on contacted firms)***	***Valid Response rate***
TOTAL	7167	2586	1003	931	36.1 %	13.0 %	36.0 %

TABLE 6. Survey sample descriptive data

Country	***N***	***%***	***Valid Response rate (on contacted firms)***	***Valid Response rate***
Belgium	29	3.1	25.9 %	65.9 %
Canada	30	3.2	20.4 %	33.7 %
China	128	13.8	26.1 %	79.2 %
Denmark	39	4.2	12.6 %	30.2 %
Finland	34	3.7	6.2 %	40.5 %
Germany	15	1.6	9.7 %	23.4 %
Hungary	57	6.1	17.6 %	26.8 %
India	91	9.8	18.2 %	19.9 %

Italy	48	5.2	17.0 %	35.0 %
Malaysia	14	1.5	5.6 %	46.7 %
Netherlands	49	5.3	14.8 %	51.0 %
Norway	26	2.8	23.6 %	53.5 %
Portugal	34	3.7	26.0 %	65.4 %
Romania	40	4.3	8.0 %	21.5 %
Slovenia	17	1.8	6.7 %	34.0 %
Spain	29	3.1	11.3 %	12.9 %
Switzerland	30	3.2	15.8 %	37.0 %
Taiwan	28	3.0	5.6 %	48.3 %
USA	48	5.2	3.2 %	75.0 %
Japan	82	8.8	48.0 %	82.0 %
Sweden	32	3.4	17.3 %	19.9 %
Brazil	31	3.3	15.9 %	73.8 %
TOTAL	**931**	**100.0**	**13.0 %**	**36.0 %**

The quality of the global database has been checked for all respondents. Cases with more than 60% of answers missing were deleted. In addition, for questionnaires gathered on paper, some fault-proof methods have been used for data consistency. Non-response and late-response bias have been checked for all the countries' database except for few cases: Hungary, around half of Norway cases and Germany. In case of German cases, it has not been checked only for non-response rate mainly because availability of economic performance is not mandatory especially for medium sized companies. In the second step, the quality of the database corresponding to this study have been checked. Missing data replacement carried out in two steps: first, if one complete construct is missing in a respondents' answer, the whole respondent was eliminated. The remaining sample size is 860 respondents. Then, within these respondents, the missing values were replaced with mean of the series (Downey & King, 1998). Finally, for respondents whom their missing values were replaced, the coherency with the other answers of the construct have been checked for final reliability analysis of the data.

Data have been tested primarily for normality check by Skewness and Kurtosis tests. The results reveal that the normality assumption is rejected for all of the variables with few exceptions in variables only if Skewness or kurtosis test is considered individually. Even though the samples are ordinal and shown to be non-normal, the *maximum likelihood (ML)* is considered despite its assumption of continuous and normal sample since west, et al., (1995) content that, treating ordinal data as continuous will result in negligible underestimation of path coefficients, factor loadings and correlations.

We did not control for industry, because the sample of the IMSS survey is being restricted to what is called as “assembly industries” (ISIC 28-35), meaning that the examined industries are already homogeneous in nature. Following is provided the Summary statistics of the dataset and its normality test.

TABLE 7. Summary statistics of the survey dataset and its normality test

Skewness/Kurtosis tests for Normality

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	joint adj chi2(2)	joint Prob>chi2
sustpropen~1	860	0.0096	0.0000	23.94	0.0000
sustpropen~2	860	0.3913	0.0000	30.56	0.0000
sustpropen~3	860	0.0002	0.0000	30.75	0.0000
innpropens~1	860	0.0022	0.0000	23.70	0.0000
innpropens~2	860	0.0000	0.0186	33.56	0.0000
sustefforт1	860	0.0000	0.0000	.	0.0000
sustefforт2	860	0.0009	0.0000	.	.
sustefforт3	860	0.7346	0.0000	.	0.0000
sustefforт4	860	0.0483	0.0000	42.19	0.0000
sustefforт5	860	0.0044	0.0000	73.47	0.0000
sustefforт6	860	0.0001	0.0000	34.74	0.0000
sustefforт7	860	0.5827	0.0000	60.01	0.0000
npdefforт1	860	0.0437	0.0012	13.31	0.0013
npdefforт2	860	0.0196	0.0000	24.53	0.0000
npdefforт3	860	0.0328	0.0000	19.52	0.0001
npdefforт4	860	0.2507	0.0000	60.14	0.0000
npdefforт5	860	0.2396	0.0000	.	0.0000
npdefforт6	860	0.0072	0.0000	38.12	0.0000
npdefforт7	860	0.0193	0.0000	38.79	0.0000
innperform~1	860	0.0018	0.0000	73.47	0.0000
innperform~2	860	0.2368	0.0000	37.00	0.0000
socsustper~1	860	0.2195	0.0005	12.65	0.0018
socsustper~2	860	0.0133	0.0000	41.69	0.0000
envsustper~1	860	0.0000	0.3416	20.09	0.0000
envsustper~2	860	0.0000	0.5724	39.44	0.0000

Variable	Obs	Mean	Std. Dev.	Min	Max
sustpropen~1	860	3.25814	1.045915	1	5
sustpropen~2	860	3.028488	1.112189	1	5
sustpropen~3	860	3.406395	1.11567	1	5
innpropens~1	860	3.253488	1.079624	1	5
innpropens~2	860	3.622674	1.041518	1	5
sustefforт1	860	3.261047	1.413656	1	5
sustefforт2	860	2.615698	1.472977	1	5
sustefforт3	860	2.867442	1.190958	1	5
sustefforт4	860	3.077326	1.158613	1	5
sustefforт5	860	3.109302	1.205211	1	5
sustefforт6	860	3.374419	1.124361	1	5
sustefforт7	860	2.749419	1.168688	1	5
npdefforт1	860	3.324419	1.011279	1	5
npdefforт2	860	3.192442	1.08294	1	5
npdefforт3	860	3.059884	1.061643	1	5
npdefforт4	860	3.024419	1.166314	1	5
npdefforт5	860	2.979651	1.236049	1	5
npdefforт6	860	3.247093	1.147576	1	5
npdefforт7	860	3.141279	1.140627	1	5
innperform~1	860	3.073837	1.007574	1	5
innperform~2	860	3.201163	1.010249	1	5
socsustper~1	860	2.887791	.9467313	1	5
socsustper~2	860	3.252326	.9457	1	5
envsustper~1	860	2.572093	.9331748	1	5
envsustper~2	860	2.802907	.9349274	1	5

Operational Constructs

In order to test the abovementioned hypotheses, following constructs have been designed:

- Innovation propensity
- Sustainability Propensity
- Innovation effort
- Sustainability effort
- Innovation performance
- Sustainability performance
- Internal integration
- Supplier integration
- Customer integration

The variables (observed variables) of all constructs (latent variables) were grounded based on previous research studies. All attributes are measured by Likert scale 1 to 5. In particular, for propensity, respondents were asked to rate the importance of offering related attributes to win orders from their major customers (1 = Not important to 5 = Very important). In sustainability

and innovation effort, respondents were asked to rate the level of putting effort on action programs related to different attributes of each construct in the last 3 years (1=None to 5=High). In innovation and sustainability performance, respondents were asked to rate the level of manufacturing performance which has changed over the last three years (1=decrease -5% or worse, 2= stayed about the same -5% to 5%, 3=slightly increased +5 to +15 %, 4= increased =15 to 25%, 5=strongly increased +25% or better).

Innovation has been categorized in the literature with differentiation mainly between product and process (Gritti & Leoni, 2012), radical (Hult et al., 2004) and incremental (Jay & Arnold, 1993). In this study, firms' propensity towards innovation is focused only on the operational product innovation, taking into account both incremental and radical innovations (respectively offer new products more frequently and more innovative products) (Miller & Roth, 1994). Similarly, sustainability propensity is measured based on more environmentally sound products and processes (Gimenez et al., 2012), higher contribution to the development and welfare of the society and more safe and health respectful processes (Maxwell & Van der Vorst, 2003).

Sustainability effort has been measured also from operational point of view, by the level of effort putting for action programs: environmental certifications such as EMAS or ISO 14001 (Kitazawa & Sarkis, 2000; Russo, 2009), Energy and water consumption reduction programs (Sarkis, 1998) and Pollution emission reduction and waste recycling programs (Klassen & Whybark, 1999), social certifications such as SA8000 or OHSAS 18000 (Longo & Bonoli, 2005), formal sustainability oriented communication, training programs and involvement (Daily & Huang, 2001), formal occupational health & safety management system (Longo & Bonoli 2005; Jamali, 2008) and work/life balance policies (Longo & Bonoli, 2005). Similarly for innovation, attributes include informal mechanisms, such as direct, face-to-face communication, informal discussions, ad-hoc meetings, design integration between product development and manufacturing through e.g. platform design, standardization and modularization, design for manufacturing, design for assembly, organizational integration between product development and manufacturing through e.g. cross-functional teams, job rotation, co-location, role combination, secondment and co-ordinating managers, technological integration between product development and manufacturing through e.g. CAD-CAM, CAPP, CAE, Product Lifecycle Management, integrating tools and techniques, such as Failure Mode and Effect Analysis, Quality Function Deployment, and Rapid Prototyping, communication technologies such as teleconferencing, web-meetings, intranet and social media, forms of

process standardization, such as a stage-gate process, design reviews and performance management (Paashuis & Boer, 1997).

Finally, operational performance of innovation includes product customization ability and new product introduction ability. On the other hand, sustainability performance measures by materials, water and/or energy consumption (Rao, 2002), pollution emission and waste production levels (Zhu & Sarkis, 2004; Rao & Holt, 2005), workers' motivation and satisfaction (Gimenez et al., 2012; McKenzie, 2004) and health and safety conditions (Pagell & Gobeli, 2009; Maxwell et al., 2006). Following is provided the Questionnaire for this study.

TABLE 8 a-b-c-d. The survey questionnaire (Subsequently for firms' propensity, sustainability and innovation effort and performances)

Consider the importance of the following attributes to win orders from your major customers					
	Importance in the last three years				
	Not important			**Very important**	
Offer new products more frequently	1	2	3	4	5
Offer products that are more innovative	1	2	3	4	5
More environmentally sound products and processes	1	2	3	4	**5**
Higher contribution to the development and welfare of the society	1	2	3	4	5
More safe and health respectful processes	1	2	3	4	5

Indicate the effort put in the last 3 years into implementing, action programs related to:					
	Effort in the last 3 years				
	None				**High**
Environmental certifications (e.g. EMAS or ISO 14001)	1	2	3	4	5
Social certifications (e.g. SA8000 or OHSAS 18000)	1	2	3	4	5
Formal sustainability oriented communication, training programs and involvement	1	2	3	4	5
Energy and water consumption reduction programs	1	2	3	4	5
Pollution emission reduction and waste recycling programs	1	2	3	4	5
Formal occupational health and safety management system	1	2	3	4	5
Work/life balance policies	1	2	3	4	5

Indicate the effort put in the last 3 years into implementing, action programs to coordinate your new product development and manufacturing processes, related to:					
	Effort in the last 3 years				
	None				**High**
Informal mechanisms, such as direct, face-to-face communication, informal discussions, ad-hoc meetings	1	2	3	4	5

Design integration between product development and manufacturing through e.g. platform design, standardization and modularization, design for manufacturing, design for assembly	1	2	3	4	5
Organizational integration between product development and manufacturing through e.g. cross-functional teams, job rotation, co-location, role combination, secondment and co-ordinating managers	1	2	3	4	5
Technological integration between product development and manufacturing through e.g. CAD-CAM, CAPP, CAE, Product Lifecycle Management	1	2	3	4	5
Integrating tools and techniques, such as Failure Mode and Effect Analysis, Quality Function Deployment, and Rapid Prototyping	1	2	3	4	5
Communication technologies such as teleconferencing, web-meetings, intranet and social media	1	2	3	4	5
Forms of process standardization, such as a stage-gate process, design reviews and performance management	1	2	3	4	5

How has your manufacturing performance changed over the last three years?					
	Compared to three years ago the indicator has				
	Decrease (- 5% or worse)	stayed about the same (±5%)	slightly increased (+5-15%)	increased (+15-25%)	Strongly increased (+25% or better)
Product customization ability	1	2	3	4	5
New product introduction ability	1	2	3	4	5
Workers' motivation and satisfaction	1	2	3	4	5
Health and safety conditions	1	2	3	4	5
Materials, water and/or energy consumption	1	2	3	4	5
Pollution emission and waste production levels	1	2	3	4	5

Furthermore, to understand the correlation between supply chain integration, sustainability and innovation, we further applied the supply chain integration construct. In regard to supply chain integration, some investigators have measured integration of suppliers and customers adopting combined "metascales" labelled as supply chain integration (intensity) or outward-facing supply chain strategy (Vickery et al., 2003, Rosenzweig et al., 2003; Frohlich & Westbrook, 2001). However, this study goes along with other studies which have differentiated the supplier and customer elements of integration, in order to verify their potentially discrete relationships (Narasimhan & Kim, 2002; Shah et al., 2002). This study's supplier and customer integration address information sharing (Flynn et al., 1994, Flynn et al., 1995a, Flynn et al., 1995b, Dow et al., 1999; White et al., 1999; Cagliano et al., 2003; Jamali, 2006; Hart & Sharma, 2004;

Hoffman, 2000), collaborative approaches development (Cagliano et al., 2003; Cousins, 2002; Cousins, 2005; Blomqvist & Levy, 2006) and joint decision making (Cagliano et al., 2003; Kim & Oh, 2005; Panteli & Sockalingam, 2005; Sweet et al., 2003). On the other hand, internal integration which refers to firms' employees integration are addressed by delegation and knowledge of your workers (e.g. empowerment, training, encouraging solutions to work related problems, pay for competence or incentives for improvement results), lean organization (e.g. few hierarchical levels and broad span of control) (Cagliano, et al., 2011); Open communication between workers and managers (information sharing, encouraging bottom-up open communication, two-way communication flows) (Sveiby & Simons, 2002). Accordingly, following question was applied in the survey.

TABLE 8 e-f. The survey questionnaire (Subsequently for supplier, customer and internal integration)

Indicate the effort put in the last 3 years into implementing, action programs related to external integration:					
	Effort in the last 3 years				
	None			**High**	
Sharing information with key suppliers (about sales forecast, production plans, order tracking and tracing, delivery status, stock level)	1	2	3	4	5
Developing collaborative approaches with key suppliers (e.g. supplier development, risk/revenue sharing, long-term agreements)	1	2	3	4	5
Joint decision making with key suppliers (about product design/modifications, process design/modifications, quality improvement and cost control)	1	2	3	4	5
System coupling with key suppliers (e.g. vendor managed inventory, just-in-time, Kanban, continuous replenishment)	1	2	3	4	5
Developing an international sourcing strategy (e.g. supplier scouting at the international level, develop an international purchasing office)	1	2	3	4	5
Sharing information with key customers (about sales forecast, production plans, order tracking and tracing, delivery status, stock level)	1	2	3	4	5
Developing collaborative approaches with key customers (e.g. risk/revenue sharing, long-term agreements)	1	2	3	4	5
System coupling with key customers (e.g. vendor managed inventory, just-in-time, Kanban, continuous replenishment)	1	2	3	4	5
Joint decision making with key customers (about product design/modifications, process design/modifications, quality improvement and cost control)	1	2	3	4	5
Developing an international distribution strategy (e.g., open foreign sales office, develop an international distribution network)	1	2	3	4	5

Delegation and knowledge of your workers (e.g. empowerment, training, encouraging solutions to work related problems, pay for competence or incentives for improvement results)	1	2	3	4	5
Open communication between workers and managers (information sharing, encouraging bottom-up open communication, two-way communication flows)	1	2	3	4	5
Lean organization (e.g. few hierarchical levels and broad span of control)	1	2	3	4	5

3.3 Case Studies

For the second phase of this dissertation, where the peculiarities of sustainability oriented innovation are assessed compared to the conventional forms of innovation, a qualitative, in-depth, multiple-case-study methodology was chosen. Case study is routinely applied for diverse purposes including providing description, testing theory or generating theory (Eisenhardt, 1989). In this dissertation, the case study method is used in order to provide an in-depth description of the sustainability oriented innovation practical examples, a rather under-researched phenomenon. When there is lack of previous research, a case study approach is appropriate for exploring a contemporary context, grasping a holistic view of complex instances through observation and searching for patterns (Yin, 2013). The strength of case study lies in its approach in empirically collecting context dependent knowledge with sufficient amount of details (Flyvbjerg, 2006; Lincoln, 2009; Stake, 2000). Further, qualitative data were needed because of a variety of terminologies used by practitioners and scholars in this field, and a need to develop deep insights (Alvesson and Sköldberg, 2009). The nature of firm-specific, organizational processes suggests that diverse perspectives of the sustainability oriented innovation examples is path dependent (Bos-Brouwers, 2010; Mahoney, 2000); detailed case studies were required to evaluate path-dependent processes (Mahoney, 2000). Moreover, terminologies used for this dissertation (including sustainability and innovation) are typical concepts that can be interpreted in various ways and from varying perspectives.

In particular, in order to answer the RQa - Which innovation resources and capabilities should be adjusted by firms for particular innovations aimed at sustainability? - a qualitative, in-depth, multiple-case-study methodology was chosen. Leading sustainable-innovative firms were chosen based on successful SOI projects and sustainability/innovation visions/rankings. Ultimately, based on convenient sampling, five cases were chosen. The size of the firms and the products they produced were also considered (Table 9). For data collection, interviews and observations (i.e., plant visits) were combined to offer stronger evidence of constructs and for

data validity. Interviews were conducted with each case, with the purpose of covering information from varying perspectives of sustainable development responsible, innovation manager, and operations manager. Especially regarding the smaller companies, not all three positions were present. In these cases, managers in positions responsible for SOI were interviewed using all three perspectives (Table 9). On average, two interviews were conducted per case.

TABLE 9. First Case Study-Case descriptions

	A	**B**	**C**	**D**	**E**
Country of Origin	United States	Italy	Sweden	United States	Italy
Size	Big and multinational (88,000 employees, $29.6 billion Revenue)	Small and local (20 employees, €4 million revenue)	Big and multinational (139,000 employees, €27.628 billion Revenue)	Big and multinational (69,000 employees, $18.769 billion Revenue)	Micro/small and local (10 employees, 150,000 € revenues)
Product	More than 55,000 products (e.g., adhesives, abrasives for medical products)	High-quality household products	Furniture, appliances, home accessories	Home appliances	Smart phone/earphone covers
Interviewee	Sustainability business and development manager	Sustainable development responsible & R&D manager	Environmental manager and communication responsible and shopkeeper	R&D manager for cross-category technology development and global sustainability responsible and HR manager and site manager	Entrepreneur
Used secondary data	Company website, Innovation project portfolio/examples across company branches	Company website and reports	Company (group) website, Company group report on their approach to sustainability, Company group sustainability reports	Company website and reports, company sustainability reports	Company website, company vendors' information, company report.

To gather data from interviews, a structured research protocol was developed. Several topics were discussed during interviews concerning sustainable innovation projects, including:

1. the organizations goals, programs, and processes of sustainable development and sustainability innovation;
2. two specific successful and any available unsuccessful projects' visions and goals;
3. internal and external processes of collaborative learning and development, especially weaknesses, strengths, and results.

For the interviews regarding innovation development and R&D, the following topics were discussed:

1. organizational goals and processes of innovation for sustainability;
2. use of internal R&D functions and resources;
3. the firm's orientation toward use of internal/external sources of knowledge.

For the interviews regarding operations, the following topics were discussed:

1. organization of innovation for sustainability in operations;
2. the importance and process of learning;
3. operations' practices for fostering innovativeness and sustainable innovation at the plant level;

All interviews except one (interviewee did not allow), were audio recorded and transcribed for data analysis, and analyzed through coding (Charmez, 1983). Due to the large number of questions, they were grouped and labeled as general questions, and delivered to interviewees as discussion topics prior to the interviews. Regarding the design of the questions, to understand the importance and possession of capabilities, both direct and indirect questions were asked. Concerning indirect questions, for each capability, a short checklist of building routines was designed for each question.

Interview transcripts were analyzed using coding and a qualitative interview analysis technique (Charmaz, 1983), and detailed analyses of cases and cross-case analyses were conducted. Table 3 shows how the data analysis was conducted.

TABLE 10. First Case Study-Coding scheme for each case

	Case
Dimensions of each resource or micro-foundations of each capability	
Perceived importance of resource/capability/routine SOIs (as an absolute measure and also compared to conventional forms of innovation)	
Whether the existing resource/capability/routine already developed for conventional innovations was sufficient (Suf.) or required enhancement for SOI projects (Enh.)- If enhanced, how?	
Whether the resource/capability/routine was one of the most important success factors of SOI project(s) or a limitation & challenging for the SOI success[1]	

[1] This factor acts as a validation for the results. In case a resource/capability/routine have been a success factor for SOI success, it means that its very high importance while the existing was sufficient. On the other hand, in case of being a limitation, it shows its high importance while the already developed one was not sufficient.

Perceived importance was assessed based on direct questions regarding the importance of each capability, in addition to the analysis of success factors. A scale from 1 to 3 assessed perceived importance of the capabilities, ranging from 1 (low/not important), 2 (important but not considered a success factor), to 3 ((very) important; a success factor). Detailed analysis of the cases was used to understand firm specifics, which requires investigating theories-in-use (Argyris and Schön, 1978; Mariadoss et al., 2011). Cross-case analysis and corroboration between data types were used for pattern recognition.

Subsequently, to answer to the RQ b - Which open innovation capabilities should be reconciled by firms for particular innovations aimed at sustainability depending on the radicalism and the product/service combination of the output? -, as earlier a qualitative, multiple-case study methodology was chosen. Eight SOI projects at firms in Italy and Spain were studies, with the project as the unit of analysis. The firms were selected based on their high proactive approach towards open innovation, while, SOI projects in each firm were selected based on several criteria: 1) the project should have aimed at developing an innovative output for sustainability, with the involvement of at least two actors. Actors can range from organizations to teams and/or individuals; 2) the project should have achieved a prototype or tangible outcome, and actors should have been able to finish a pre-defined milestone together. The reason behind this choice was aligned with the purpose of our study, because we examine the successful integration of actors in a project, and not the successful innovation. Tus, the project did not have to be commercialized, but rather should have reached the actors' goal (e.g., during some projects, milestones are limited to collaborative exploration/testing, and thus does not necessarily constitute commercializing the project's output to the final market). 3) projects should have been initiated fewer than 5 years before the start of the study, especially to facilitate accessibility of a project's information; 4) preference was given to projects during which individuals were also involved during development to cover possible complexities caused by integration of disparate types of actors e,g, idividuals ; and 5) preference was given to more radical and information-rich projects (Patton, 1990, p. 169), particularly those possessing rich, available, secondary data. Based on these criteria and convenience sampling, eight cases were chosen. The main outcome of each case's project is reported in Table 11.

TABLE 11. Second Case Study- Case descriptions

	DEVELOPED GOOD AND/OR SERVICE	EXPLANATION	SUSTAINABILITY ASPECT	PRIMARY STAKEHOLDERS
A	*CO_2 emissions reduction during production and distribution of beer manufacturing*	The project developed an innovative technology to improve draft beer quality and reduce its environmental impact during filling, distribution, and consumption at point of sale.	Use of recyclable containers, decreased CO_2 consumption during delivery and packaging, and replaced external air pressure instead of traditional cylinders of CO_2	A multinational beer producer (40,435 employees worldwide); users (for testing); a research institution and supplier network (only for technological development)
B	*New homogenous packaging for easy recycling*	The project introduced a new-generation packaging material for food products, with enhanced recyclability	The project developed and applied a near-zero plastic formula, leading to material homogeneity for disposal of food products' packaging	A multinational food manufacturer (14,000 employees worldwide); a user (proposing the innovative idea through the company's online platform) and professional users for testing; a research institution and the suppliers' network for technological developments
C	*Smart Energy efficiency systems for home appliances*	The project involves a smart grid system aimed at introducing new-generation, integrated home appliances for enhanced energy efficiency and reduced cost of energy consumption	The system integrates electric grids, electronic meters, renewable energy in-house production system (photovoltaic energy), and smart appliances with the energy provider's insights	A multinational manufacturer of smart home appliances (10,500 employees worldwide), one of the biggest local utility providers (approximately 2500 employees), a research institution during the entire project; users and municipality (for testing)
D	*Designing convenient home interfaces for disabled and elderly people*	The project developing a smart solution (e.g., through use of ICT) to improve the quality of life of disabled and elderly people at home	This project promotes independent and autonomous lifestyles for elderly and/or disabled people with sensorial, cognitive, or mobility problems by addressing their needs of safety and security at home	An international, non-profit research center linked to a home furniture producer; users and municipality in two designed apartments for testing; external exerts and industrial network for technological developments
E	*New car sharing initiative for cities with limited experience*	The project is a car-sharing startup founded in 2010 in a city with very low experience with car-sharing	The purpose was to become the best alternative for individuals and companies to enhance efficiency and sustainability on urban mobility with the same amount of comfort by reducing number of private cars	A local car-sharing business (fewer than 50 employees) linked to a manufacturer of electric cars; users and municipality for testing the product and enhancing the urban arrangement of electric charging points
F	*Introducing a local electric mobility infrastructure*	The project introduced and applies an ecosystem for use of electric cars in a city with low experience with electric cars.	The objective was to demonstrate electric cars as a phenomenon for users and citizens trying to change their lifestyles	A multinational mobility utility company linked with an agency of "new uses of energy"; users and municipality for enhancing an established infrastructure, goods, and services
G	*New environmental design of urban surfaces for higher air quality*	The project introduced photocatalytic materials for implantation in asphalt, pavement, and the surface of buildings for better air quality in urban areas	The purpose is for urban areas to investigate and apply preventive air pollution systems, including material and measurement methods	A research organization linked with an engineering-consultancy, a lead company in transport engineering (approximately 2,500 employees); suppliers and another research institution for testing and measuring the influence; users and municipality for testing
H	*Empowerment of local "people in need" by business and their employees*	The project introduced annual innovative projects for underprivileged people, according to needs.	Employees trained underprivileged people according to their needs and available expertise (e.g., how to save money and face economic challenges)	A multinational manufacturer (121,000 employees worldwide) of consumer goods linked with an NGO; users (i.e., underprivileged people) for understanding their needs

Since, the in-depth qualitative studies on external integrations rest on documents and interviews with the most key process participants/stakeholders, we attempted to interview at least one person from each involved actor in the projects. In three cases (C, E & G), all involved stakeholders were interviewed. In two cases (D & H), the only stakeholder who were involved but not interviewed is the user, due to the confidentiality policy. In case B, the involved actors were the user and technological partner (supporting only the formula development). Regarding the user, which were integrated through an online platform in the firm's website, we performed a content analysis of the communications on the online platform. Therefore, in six cases, we were able to interview all or key stakeholders. Regarding the other two cases (A & F), due to limitations of the cases, we interviewed only the lead company. However, to compensate the lacking interviews, rich secondary data on the involved actors were gathered.

To select interviewees from each organization, the following criteria were used: they had to take part in the project and still be working for the same company. However, users, as individuals, were interviewed based on convenience selection. Depending on the interviewee and his/her information, to collect answers to all questions, other interviewees in some cases were chosen or recommended (by the first interviewee) for further data collection. Interviews were conducted until all required information was fulfilled. Table 2 contains a list of interviewees (with durations), and sources of secondary data for each case.

TABLE 12. Second Case Study- List of interviews and sources of used secondary data

	Stakeholder	Min	Source of secondary data/Interviewee Position
A	Project's secondary data		Press company archive, 2012; Project report and online sources
	Manufacturer	45	Corporate affairs manager
			Secondary data (Online innovation reports of the branch; sustainability reports 2011 to 2014)
B	Manufacturer	20	Local marketing director
		45	Local marketing director
		50	Technical development director, packaging design, and standards director
			Secondary data (branch website; branch's report on recyclability and recycling of packaging)
	User		Secondary data (content analysis of firm-user online platform)
C	Project's secondary data		Project's website and online sources
	Involved research institution	85	Associate professor, energy department
		40	
	Energy Provider	120	Energy-provider consultant
			Secondary data (full report and presentation of the former smart grid project; project presentation; academic publications from the project)
	Manufacturer of home appliances	60	Energy and sustainability manager
			Secondary data (sustainability reports)
	End User	40	User
		30	
			Secondary data (The users' contracts; classifications; questionnaire used for feedback; presentation of users' feedbacks)
D	Project's secondary data		Project's website and online sources

	Research Institute (Project leader)	105 45	Director
			Secondary data (company's website)
E	Mobility sharing business	75	Communication director
			Secondary data (company's website)
	End User	30 30	Two customers
	International consulting firm		Secondary data (full report of 2015 customer value leadership award; company's website)
F	Electric car manufacturer	50	Project manager
			Assistant manager of electric vehicles in the innovation department
			Secondary data (corporate governance, 2014; legal documentation 2014; activity report, 2014; sustainability report, 2014; Publication of the project; project's catalogs)
	Industry partner		Secondary data (agreement; sustainable mobility report; seven latest reports on products)
	Industry network		Secondary data (industry network's electrical vehicle's report).
G	City hall	30	General director of city maintenance, utilities and transport
	The engineering-consultancy organization	55	General director of waste, water and environment branch of the department of engineering and services
	Research organization	70	Technical coordinator of scientific technical development
H	Project's secondary data		Project report and catalogues. the joint written answers to delivered general questions to be asked during the interview.
	Manufacturer	55	Group manager of external relations.
			Secondary data (company website; sustainability report)
	International NGO	55	Businesses' loyalty responsible
			Brand and fund raising director

A set of questions were developed to gather data from organizations or individuals. Accordingly, two questionnaires were designed, one for organizations/groups (either lead organizations or their partners) and one for individuals. Due to the large number of questions, they were grouped and labeled as general questions, and delivered to interviewees as discussion topics prior to the interviews. Regarding the design of the questions, we assign the perceived importance of each capability based on our synthesis of the qualitative data including direct questions regarding the relative importance of set of capabilities (the interviewee had to rank the capabilities from the very important), in addition to questions regarding the success factors of actors' integration in the project. These two questions enable to assign a scaling of the perceived importance of each capability, from 1 to 5 - 1 (not important), through 2 to 4 (important but not considered a success factor), to 5 (very important and as a success factor). We basically assess the importance of each capability to confirm our argument on the fact that innovation frameworks/theories are appropriate lens to investigate SOIs. Regarding the possession of the capability, we identify the actor (s), being capable of networking, competence mapping, relational and desorptive capabilities, through the synthesis of the qualitative data on each of the actors' roles/duties, activities and challenges. Finally, to ensure whether/how the already open innovation capability was enough or requires reconcilement for particular

sustainability context, we asked direct questions about different capabilities' conceptualizations in addition to the qualitative analysis of actors' faced challenges for integration. Basically, the way actor(s) cope with the upcoming challenge, if any, due to the particular sustainability context, supports us to assess whether the capability was required to be enhanced or modified.

The interviews were recorded and transcribed for data analysis, and analyzed through coding (Charmez, 1983). Detailed analysis of the cases was used to assess project members' perceptions regarding the importance of SIC capabilities. Single case analysis was used to examine SICs by deploying theories-in-use (Argyris & Schön, 1997). Cross-case analysis was performed by searching for similar/disparate patterns through data comparisons across all cases. Finally, corroboration of one data type through evidence from another was performed based on single and cross-case analyses. All data analysis steps were discussed continuously among the authors, and when possible, with other scholars, ensuring the reliability of data analysis. Explanations of the content of the interviews, linked with how it was used during analysis, appear in the following table.

TABLE 13. Second Case Study- Topics during interviews, linked with data analysis and theoretical background

Topics	Links to data analysis and theoretical background
Involved organization	
Explanation of the project, including drivers and the primary goals, expected outcomes, and outcome's target market for success/failure factors of the project's outcome	Ensuring the suitability of the case for the study and the progress of the project.
Detailed explanation of each phase of the project (i.e., idea generation, development, testing/validation, and commercialization)	Introduction to each phase of the project (next Q)
Stakeholder integration at each phase of the project, including who/how/when/roles/outcomes/(dis)advantages	Networking capability's importance and stakeholder's peculiarity
Information-sharing among various stakeholders; decision-making throughout the project with all stakeholders	Networking capability micro-foundations to understand the possession of the capability
Stakeholder identification and selection capability's importance and challenges	Competence mapping capability's importance
Inputs from each stakeholder during the project, including through which mechanism/with what aim	Competence mapping capability's possession and stakeholders' peculiarities
Evaluation of engagement/dialogue ability through collaboration with various stakeholders in terms of importance and challenges	Relational capability's importance and stakeholder's peculiarity
Micro-foundations for communication and relationship management	Relational capability's possession.
Departments/centers/teams/focal actors of the company involved in the project, and their roles. Co-existence of internal integration with external integration, the reasons and mechanisms	Internal involvement capability's possession
Necessity of involvement and empowerment during stakeholder integration, and the mechanisms	Internal involvement capability's importance and possession

Complexity and importance of external information for value capturing; managing increase of efficiency during information exchanges, and the mechanisms	Open questions to enhance the richness of data/collect any missing data, validating their prior responses.
Handling technological knowledge gaps between stakeholders	
The importance of each ability during each phase, and ways of enhancing them if needed; learned lessons; difficulties during projects and ways to deal with them' conflicts of interest among stakeholders; perceived need to develop new abilities during a project/any developed or improved ability-facilitating factors for stakeholder integration; influencing factors regarding how to engage actors in a project; company's orientation toward stakeholder integration; sustainability brought to a typical open innovation project	
User	
Gains and motivations from participation; method of involvement; stage of involvement; disparate expectations with reality; communication and its role; the role of other stakeholders; existence of tensions in relationships; degree of integration; description of the experience; difficulties; proposed product and its difference with traditional ones; sustainability aspects and users' perceptions; change led by involvement with users' lifestyles or perceptions of organization's or sustainable development; potential improvement points	

Finally, to answer to the RQ c - How does the innovation process for sustainability differ from conventional innovation processes in terms of involved partnership and process cycle depending on the radicalism and the product/service combination of the output? -, we used data collected as part of the EU-InnovatE project- EU-funded research project that investigates the innovative and entrepreneurial roles of end users to shape a green EU-economy. The research project has been carried out in 2014-2015 by a European network. Sustainability oriented innovation projects were selected based on several criteria: 1) the case as the company to be considered as an innovative business and the SOI project should explore an innovative product for sustainability, in particular 2) the SOI project achieved a prototype or tangible outcome without the necessity of present commercialized product/service 3) SOI projects were initiated fewer than 5 years ago, especially to facilitate accessibility of a project's information; 4) preference was given to SOI projects during which users were involved during development individually to understand peculiarities proposed by users. Within the projects' cases, this study chose twelve European cases that possess clear explanation of the conventional innovation process. To define the SOI projects, their sustainability impact intentionality is our focus (Carrillo-Hermosilla et al., 2010). An explanation of cases follows (Table 1).

TABLE 14. Third Case Study - Cases' Description

	Company Characteristics	SOI project	Product/Service Developed	Radicalism
1	German manufacturers of cars and motorcycles (Large Multinational Co.)	The first commercialized series of electric vehicles	Mix of Product/Service	Radical
2	Energy supplier based in Germany (Large Co.)	Developing smart home technologies, including a solar control system	Product	Radical
3	Spanish food retail company (Medium Co.)	Creating a new range of ecological, organic products	Product	Radical
4	Gardening tool manufacturer in Finland	Developing an indoor garden	Product	Incremental

	(Big Multinational Co.)			
5	German-based company that produces and markets frozen food (Big Multinational)	Creating opportunities for sustainable food.	Product	Incremental
6	Finnish Regional Transport company (Regional Big Co.).	Developing a demand-responsive transport (DRT) service- systems	Service	Radical
7	Netherland's branch of a furniture retailer (Big Multinational).	Developing a home waste management kit.	Product	Incremental
8	Polish Regional energy policy Provider (Big Regional Co.)	Providing 'consumers' with the individually adjusted energy management plans.	Mix of Product /Service	Radical
9	Building cooperative in Zurich (Big Regional).	Development of a new energy efficient residential quarter	Mix of Product /Service	Radical
10	Fast-moving consumer goods company (Big Multinational Co.)	Development of a socially inclusive business model addressed at reducing youth unemployment	Mix of Product/Service	Incremental
11	Bike sharing systems in the world (Big Multinational Co.)	Zero carbon bicycle sharing system	Mix of Product/Service	Incremental
12	Austria's leading electricity Provider company (Big Regional Co.).	Developing a new business Model of an e-mobility	Mix of Product/Service	Radical

To answer the research question "e", the information for the particular SOI project (the output, process and the partners) and interviewees' perception of how SOI project is compared to conventional forms of innovation are used. To select interviewees from each organization, the following criteria were used: they had to have taken part in the project and still be working for the same company. Attention was also given to the sources of available secondary data. A set of questions were developed to gather data. For the conventional innovations, discussed topics include ordinary innovation process (if and how there is a structured method) and involved typical partners. Likewise, for the SOIs, the process (its timeline and phases/activities), the involved partners and the output were discussed in the interviews. The unit of analysis is the (sustainability oriented) innovation process. The interviews were recorded and transcribed for data analysis, and analyzed through coding (Charmez, 1983). Detailed analysis of the cases was used to assess informants' perceptions regarding the different characteristics of the (sustainability oriented) innovation process.

For analyzing the process cycle, both sustainable and ordinary innovation process is categorized as either linear (if the company developed a structured method typically from exploration to testing/prototyping and development) or diamond (if the phases of the process were not in the logical flow). Moreover, attention was given to whether interviewees perceive the SOI process differently from their ordinary process. For assessing partnership, the perception of interviewees was checked to understand whether any partnership is different compared to conventional forms of innovation. In particular, to assess the presence of secondary stakeholders, NGOs, communities and activists are considered. For assessing the public-private partnership, the involvement of public authorities, communities and

municipalities is examined. Regarding users' involvement, due to case selection criteria requiring that users are involved in the SOI project, the degree/extent of the involvement and its mechanism are scrutinized. Special attention was given to detect any perceived difference in SOIs' user involvement compared to ordinary forms of innovation. Cross-case analysis was performed by searching for similar/disparate patterns through data comparisons across all cases. Finally, corroboration of one data type through evidence from another was performed based on single and cross-case analyses to increase truth-value and the traceability of data.

4. ANALYSIS AND RESULTS

4.1. Survey analysis on sustainability and innovation interrelationship

Structural equation modelling approach has been employed to test the hypotheses and to achieve interpretational clarity of relationships within constructs (Anderson and Gerbing, 1988). First, the necessary conditions for model identification were assessed. There are (p=) 25 observable variables, thus the non-redundant data points in sample variance covariance matrix is given by: p=(p(p+1))/2=325. The number of parameters to be estimated are 62 so the model has the necessary condition and can be over identified. The second tested condition is regarding to the measurement portions of the model. The first regression coefficient of each construct is constrained to 1 for establishing the scale of factors. Secondly, although data will be tested by confirmatory factor analysis in the model in order to verify the relevance of constructs based on measurements and applied measures of constructs, are adopted according to the previous studies, an exploratory factor analysis were used primarily to assess the underlying structure of each construct.

Finally, we specified two models based on our hypothesized models providing also the parameter values for significant paths. The first model (Figure 3) tests the following hypotheses:

H1: Sustainability propensity correlates positively with innovation propensity.

H2: Sustainability performance correlates positively with innovation performance.

H3: Putting effort on adoption of sustainability practices correlates positively with the effort on adoption of innovation coordination mechanisms.

Parameter values for significant paths of the model testing the above hypotheses are shown in Table 16. The overall fit for the path model was acceptable (Chi^2=263 and the final iterations are concave but not backed up). Even though the overall fitness of the model was acceptable, we used modification indices to enhance the model with respect to the theoretical considerations. Significantly, covariance between two measurements for each sustainability effort and performance were suggested: energy/material and water consumption (reduction programs) & pollution emission reduction and waste recycling programs/production level). Subsequently, further theoretical investigation of the variables shows that the correlations are

justifiable based on theoretical background because of the fact that both measurements are targeting *environmental* sustainability practices. Based on previous studies, the environmental practices may be correlated in a sense that firms with proactive environmental strategies engage typically to enhance diverse type of environmental practices (Arbuckle, et al., 1976; Brownell, et al., 2011). As a consequence, the covariance of the environmental practices is considered in the final model with improved overall fit (Chi^2=262, Table 15).

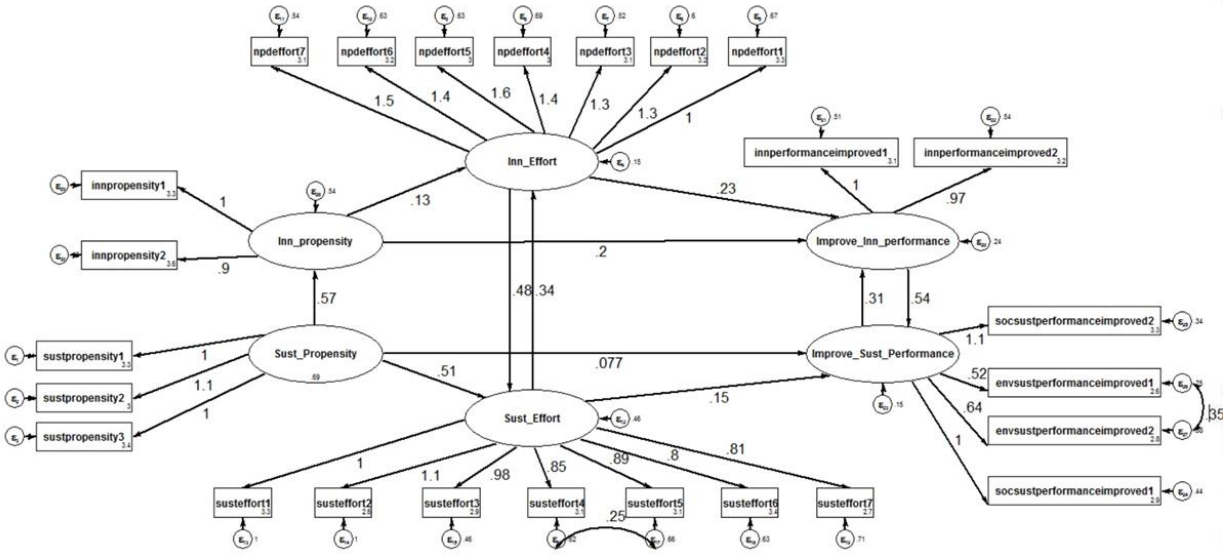
TABLE 15. Survey Analysis-Overall fit of the first model

Fit Statistic		**Value**
Population error	RMSEA	0.053
Baseline Comparison	CFI	0.938

TABLE 16. Survey Analysis-Values of the hypothesized relationships of the first model

Structural			**Co-efficient**	**P > I z I**
Innovation Effort	->	Sustainability effort	.48	.0
Sustainability Propensity	->	Sustainability effort	.51	.0
Sustainability Effort	->	Sustainability Performance	.15	.0
Innovation Performance	->	Sustainability Performance	.54	.0
Sustainability Propensity	->	Sustainability Performance	.077	.019
Sustainability Propensity	->	Innovation Propensity	.57	.0
Sustainability Effort	->	Innovation Effort	.34	.0
Innovation Propensity	->	Innovation Effort	.13	.0
Sustainability Performance	->	Innovation Performance	.31	.012
Innovation Propensity	->	Innovation Performance	.2	.0
Innovation Effort	->	Innovation Performance	23	.001

FIGURE 3. Survey Analysis - Structural Equation Model based on our second hypothesized model



The results of the analyses provide mix support of the hypotheses. As already widely proven by the literature, firm's propensity positively impacts the performance with mediating role of putting effort for practices' adoption. This is supported, in the model, with the proof of partially mediation role. Meaning that the impact of innovation/sustainability propensity on innovation/sustainability performance remains significant when the intervening mediator of putting effort is considered.

Interestingly, results show how sustainability and innovation are interlinked: H1 (Sustainability propensity correlates positively with innovation propensity) is not fully supported. In this regard, the results show that sustainability propensity impacts positively and significantly on innovation propensity only if the causal link is not considered. Meaning that if the impact of innovation propensity on sustainability propensity is considered, both propensities falls into insignificant.

Hypothesis 2 (Putting effort on sustainability practices' adoption correlates positively with the level of effort on adoption of action programs to coordinate new product development and manufacturing processes) is fully supported. This means that on the level of effort of firms for enhancing innovation or sustainability, not only innovation practices enhance sustainable development but also sustainable development lead firms to be more innovative.

Finally, Hypothesis 3 (Sustainability performance correlates positively with innovation performance) is also fully supported meaning that on the performance level of firms, both innovation and sustainability enhance each other proving the synergetic effects of them on performance level.

Subsequently, to test the following hypotheses:

> H4: Supplier-internal-customer integration correlates positively with putting effort on adoption of sustainability practices
>
> H5: Supplier-internal-customer integration correlates positively with putting effort on adoption of innovation mechanisms.

We specified a SEM model as well, in order to perform several analyses: first, the parameter values for significant paths; second, confirmatory factor analysis shows the reliability and validity of the constructs (all constructs are affirmed by confirmatory factor analysis). Regarding the first model, all the coefficient paths are shown to be significant (Table 17). The overall fit for the path model was acceptable. The chi2 test is significant ($p < 0.05$) which does not suggest a close fit. But chi2 test is highly sensitive to sample size (Chi 2 value is the minimum multiplied by N-1), thus CFI and RMSEA tests are also considered to check the

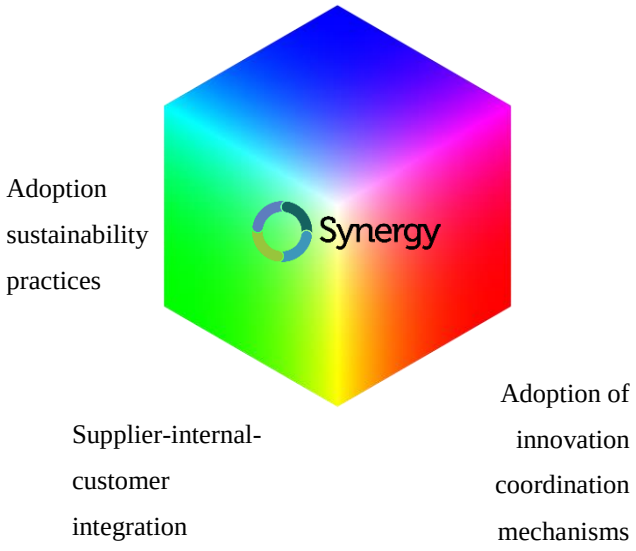
validity of the fit (Root Mean Square Error of approximation (RMSEA) is 0.059 which suggest a fair acceptable fit and finally the Comparative Fit Index (CFI) is 0.933 which also implies a good fit (Bentler & Bonett 1980) (also TLI = 0.924 and SRMR= 0.041 which is both implies a good fit).

TABLE 17. Survey Analysis- co-efficient paths of the second specified model

		Adoption of sustainability practices	Coef. .45 P = 6.03e-28	Adoption of innovation coordination mechanisms
	Supplier integration	Coef.48 P = 4.65e-28		Coef. .33 P = 2.77e-28
Coef. .55 P= 4.48e-41	Coef. .31 P = 2.78e-23			
	Internal integration	Coef. .38 P = 1.38e-21		Coef. .27 P = 1.10e-23
	Coef. .28 P = 4.33e-17			
	Customer integration	Coef. .56 P = 3.03e-28		Coef. .32 P = 2.94e-25

The results reveal the synergetic effect of firms' effort on sustainability and innovation with SCI integration. Thus, the results confirm that sustainability, innovation and SIC integration form a reinforcement cube where each construct positively affects the other, leading to generate synergetic effects when all adopted by firms (Figure 4).

FIGURE 4. Survey Analysis - Result of the second specified model



The results show the support of all relationships in the specified model. Meaning that, the more supply chain integration is, firms put more effort on sustainability and innovation activities. In return, the higher firms put effort on sustainability and innovation activities, they tend more to integrate their supply chain (supplier-internal-customer).

4.2. Case study analysis on the resources and capabilities for SOI development

In order to understand, which innovation resources should be adjusted by firms for particular innovations aimed at sustainability, each category of intangible resources (including human, organizational, relational and symbolic capital classified in the theoretical background section) has been tested empirically based on the importance level perceived by cases' managers for developing successful SOI projects (Table 18).

TABLE 18. First Case Analysis- Data results for intangible resources for SOI development

		Single cases' analysis and supporting informants' statements				
		A	***B***	***C***	***D***	***E***
Human Capital	Importance	*1*			*2*	
	Sufficient OR Enhanced[2]	*Suff.* Only necessary for understanding the global sustainability challenges	*Suff.* Similar to conventional innovations to be open to new approaches	*Suff.* Similar to conventional innovations to cope up with challenges after implementation	*Enh.* SOIs require particular human capital in terms of technical sustainable changes	*Enh.* SOIs require particular human capital in terms of technical sustainable changes
Organizational Capital	Importance	*3*			*2*	*3*
	Sufficient OR Enhance	*Enh.* A need of clear direction towards both sustainable development objectives and innovations is requisite for SOIs. Moreover, institutionalized knowledge and experience facilitates the road towards SOIs and the businesses' direction. All need to be accompanied by collaborative decision making and management style of all firms' members.				
Inter and intra-relational Capital	Importance	*3*				
	Sufficient OR Enhance	*Enh.* Employee involvement is more required for SOIs to increase exposure to new ideas through establishment of (in)formal communication channels and practices (e.g. job rotation). Higher density of relationship with mainly customers as well as suppliers and industrial partners are needed. Moreover, relations with indirect stakeholders are needed for SOI know-how acquisition.				
Symbolic Capital	Importance	*2*				*3*
	Sufficient OR Enhance	*Suff.* Similar to conventional innovations, the critical element is to provide a common acceptance of innovation, but also SOIs require this for sustainability to enhance employees' willingness (e.g. to change and internal transparency (Case C), increase employees' satisfaction (Case B)).				*Enh.* Reputation of the company for sustainability was required

[2] Whether existing resources were sufficient (Suf.) or required enhancement for any SOI project (Enh.)

Results suggest that organizational and relational capitals are requisite, intangible resources for developing SOI projects. Business philosophy is highly important perceived by all managers for successful SOI development, for formation of clear direction towards sustainable development and innovating. Firms see the importance of institutionalized experience as a driver of enhanced problem-solving ability in different directions. All cases see the importance of institutionalized knowledge to build a clear orientation towards sustainability and/or innovation. Regarding the decision making and management styles, collaborative decision making (mainly internally but also externally) with management system providing employees with a common acceptance are recognized as critical principles in cases. For instance, as the communication responsible of one of the cases mentioned:

> The most important capability of the firm for SOI development is "the attitude of the employees to have a common understanding, acceptance and approach for a project.

Regarding the relational capital, both internal and external relations are quite important in successful SOI development. Meaning very high focus on employee and departmental involvement would increase exposure to new ideas through informal and strong relationship with external partners (mainly customers as well as suppliers and industrial partners but also indirect stakeholders-e.g. mainly universities, research/national labs or centers NGOs, service provider firms, consultants, technical experts, vendors- for know-how acquisition). Internally, firms achieve "creative abrasion" through higher informal and deeper formal interactions with employees and cross-functional interfaces to enhance out-of-the-box thinking. Creative abrasion is a phrase coined by Jerry Hirshberg, founder and president of Nissan Design International and describes a culture where ideas are productively challenged. In one of the cases, employees were allowed to work a fixed percentage of working time on their own interests, called the innovation time-off program. A sustainability development manager explained:

> Our ten-percent culture has been around for many years. The challenge to R&D professionals: 10% of their overall time is reserved to pursue their own research interests, with the remainder focusing on their own challenges aligned with the division. It is also an opportunity to innovate in other areas and work across divisions, and share information and technologies across the company to solve those challenges.

Results suggest that a participative decision-making, common acceptance of the SOI necessity, fewer departmental barriers, technology- and knowledge-sharing platforms, and less hierarchical structures support firms regarding creative abrasion.

In order to understand Which capabilities should be adjusted by firms for particular innovations aimed at sustainability, the results are provided based on the hypothesized theoretical framework of capabilities for traditional innovation. The emphasis of each capability or its building routine has been tested empirically (Table 19).

TABLE 19. First Case Analysis - Data results for capability

	Capability	***Building routine***	***A***	***B***	***C***	***D***	***E***	***Cases' statements***
Internal Exploration and Exploitation	Research and Development	R&D	2 Suf.	3 Suf.	2 Suf.	3 Enh.	2 Suf.	B&A&E: Internal R&D is perceived as persuasive and important but not external R&D. D: Establishing a new local legal entity for external R&D.
		Sustainability oriented R&D	3 Enh.			2 Suf.	3 Enh.	C: Establishing a new research department on sustainable products. B&A&E: Establishing particular R&D process for sustainability mainly on the availability of materials and technology from early stages of the project.
	Internal organizational factors &	Organizational structure	1 Suff.					Cases have different type of organizational structure. A&C: hierarchical autonomy may prohibit the enhancement of internal collaborations.
		Internal collaboration, cross-functional & participative functions	3 Enh.			Suff.		A: establishing internal information sharing channels. B & C: establishing and promoting high internal daily involvement of diverse employees and departments.
External Exploration	Knowledge acquisition & recognition through socialization	Stakeholder integration, dialogue, collaboration	3 Enh.					All: not only establishing specific relationships with critical external partners (mainly suppliers), but also extending the external relationships to entities particularly related to sustainability (e.g. NGOs, research centers) A: establishing a structured user involvement for new sustainable product developments. A&C: New ideas' attraction from very diverse type of sources. A&D&E: Increase communication channels with customers because they are seen as a main source of new ideas. B&C&E: Planning frequently projects with opportunity generation/recognition. A&B: Planning multiple frequent new radical and incremental sustainable products/services/processes with company level economic objectives (versus for each project)
			3 Enh.					
External Exploitation	Opportunity Exploitation with outside view	Assimilative, transformative and exploitative learning for application	3 Enh.					All: openness to co-creation development project with external entities: Presenting the recognized opportunities to main external partners (B) and extending the involved competent external entities (B) particularly with continuous exchange of information (C&D) from early stages of prototyping (E). Establishing continuous improvement plans. D: Establishing frequent continuous structured testing processes with users A: establishing a continuous potential sustainability improvement plan for all the products

Retention	Knowledge Formalization	Knowledge formalization and systemization (maintenance and reactivation) and continuous re-alignment	2	1 Suff.	All: Knowledge maintenance and reactivation are not really feasible and economically reasonable for SOI projects because of the peculiarity of sustainability knowledge as tacit and innovation knowledge as non-replicable except for similar projects (Case B) or similar products (Case D)

Results, on internal exploration and exploitation capability, show that despite recognized importance of mainly internal R&D for (sustainable) innovations, particularly SOIs require firms to establish additionally sustainability oriented research and development processes. For example, case C established a new research department working specifically on innovative sustainable products. In a similar vein, the results on internal organizational factors - organizational structure and internal collaboration- provide interesting insights. The results show that organizational structure doesn't have any specific influence on the SOI development, however the structure may facilitate or act as barrier in enhancing internal collaborations. In this regard, we argue that democratic organizational structure and non-hierarchical autonomy may support internal collaborations and participative approaches in the organization. This is important mainly because the results show that internal collaborations are very important for SOI development and act as a primary key success factor. As the communication responsible of one of the cases mentioned:

> The most important capability of the firm for SOI development is that "a basis should be created for a new project in the co-workers to have everybody on board and not be imposed by a part of organization. Our company is very democratic and we have to have internal agreement and acceptance through internal communication for the SOI. This is necessary to be able to work internally to change the people attitude and mindset and help them for an innovative approach towards sustainability."

In particular, informants claim that higher level of internal collaborations are required when innovations are aimed at sustainable development. The reason, our cases establish frequent information channels either formally or informally to connect cross-departmental and cross-functional employees. Likewise, enhanced external partnerships is a key success factor for SOI development. In this regard, not only establishing relationships with critical external partners is necessary, but also for SOIs, this should be extended to entities particularly related to sustainability (e.g. NGOs, research centers) and users.

Next, the ability to explore and exploit externally the SOI opportunities and knowledge is perceived as critical success factors. This is especially true for SOIs because many sustainability oriented ideas are not able to be recognized through traditional approaches (market-pull or technology-push). Our cases show that these capabilities, as well as internal collaborativeness, need to be reinforced accordingly for SOI development, compared to traditional innovation. In our cases, diverse type of new ideas' sources, enhanced communication channels with customers, planning multiple frequent new radical and incremental sustainable products/services/processes support SOI external exploration capability. Regarding the external exploitation, co-creations and establishing continuous improvement plans for sustainable products/services-if not business models- can facilitate opportunity exploitation. However, knowledge formalization including maintenance and reactivation seem to be less significant in SOI capability development. In this regard, our results show that the sustainability-related know-how are often project-specific and tacit so firms should have the ability to acquire and commercialize specific knowledge for each project compared to maintaining and reactivating previous knowledge.

The results on capabilities is coherent with the findings on resources. In this regard, the enhanced sustainability-oriented R&D derives from improved organizational capital where businesses have a clear direction towards both sustainability and innovation. The structured process for sustainability research will enable improved organizational capital in terms of its institutionalized knowledge and experience. As the environmental manager of one of the cases mentioned:

> We have established a "specific research and development department as an internal R&D called sustainable innovations in the headquarter. This supports us in having a structured international sustainability direction called …. with 3 main aspects: Energy…, Social issues…, and sustainable life at home…..We have a goal to increase the sales of sustainable products, the number of sustainable products, the communication and the knowledge."

On the other hand, inter-organizational capital as a requisite resource enable businesses to build micro-foundations for enhancing internal collaborations and participative approaches. Finally, the key role of intra-organizational capital in SOI development support external exploration and exploitation.

4.3. Case Study analysis on the open innovation capabilities for SOI development

To answer the research question of Which open innovation capabilities should be reconciled by firms for particular innovations aimed at sustainability depending on the radicalism and the product/service combination of the output?, first we show cases' insights on the specific elements of open innovation framework in this study SOI projects (Table 20). Findings are presented following the capability framework of open innovation elaborated by the prior literature.

TABLE 20. Second Case Analysis-Cases' insights on the elements of open innovation capability framework

		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
	Networking								
External Exploration	Perceived importance[a]	3	2	5	4	2	5	3	4
	Who possessed the capability? (To answer the following question)	LO[b]	LO	KS[c]	KS	KS	KS	LO	KS
	Whether the already possessed open innovation capability by the actor(s) was enough (en.) or requires reconcilement (Rec.) during the SOI project (rec.). In case of the latter, how was it? (enhancement (Enh.) or modification (Mod.))	En.	En.	Rec./Enh.	Rec./Enh.	Rec./Enh.	Rec./Enh.	En.	Rec./Enh.
	Competence mapping								
	Perceived importance[a]	2	3	5	5	4	5	3	4
	Who possessed the capability? (To answer the following question)	LO	LO	KS	KS	LO	KS	LO	LO
	Whether the possessed capability for innovation is required to be reconciled during the SOI project? If yes, an enhancement was required or a modification (Enh./Mod.)	En.	En.	Rec./Enh.	Rec./Enh.	Rec./Enh.	En.	En.	En.
External Exploitation	***Relational Capability***								
	Perceived importance[a]	3	2	5	5	4	4	3	4
	Who possessed the capability? (To answer the following question)	LO	LO	KS	KS	LO	KS	LO	KS
	Whether the possessed capability for innovation is required to be reconciled during the SOI project? If yes, an enhancement was required or a modification (Enh./Mod.)	En.	En.	Rec./Enh.	Rec./Enh.	Rec./Enh.	Rec./Enh.	En.	Rec./Enh.
External Retention	***Desorptive Capacity***								
	Perceived importance[a]	4	5	5	5	5	4	4	5
	Who possessed the capability? (To answer the following question)	LO	LO	KS	KS	LO	KS	LO	KS
	Whether the possessed capability for innovation is required to be reconciled during the SOI project? If yes, an enhancement was required or a modification (Enh./Mod.)	En.	En.	Rec./Enh.	Rec./Enh.	Rec./Enh.	Rec./Enh.	En.	En.

[a] A scale from 1 (not important) to 5 (very important)
[b] The lead organization
[c] Stakeholders, including the lead organization and/or partners involved during all stages of the project

Following, the descriptive results for each element of open innovation capability framework is provided.

Networking capability: Results suggest two different patterns in the perceived organizations' ability to attract external actors to be engaged in the SOI project. From the one hand, -in cases C, D, E, F, and H-, project members saw this ability as very important and a success factor. Since key actors were collaborating throughout the whole project, all of them -not only the lead organization- contributed to identify other actors to be engaged. In these cases, all key involved actors faced extensive challenges for attracting other potential actors according to the particular sustainability context. Accordingly, they were pushed to reconcile their ability collaboratively, mainly by communicating continuously and extensively about potential partner types and the selection criteria to be used, according to the particular context of sustainability. In these cases, the project members enhance their capability mainly through engaging in various networking opportunities (Kazadi, et al., 2016; Van Kleef & Roome, 2007). The interesting result shows that in these cases, not only the lead organization but all key actors attempted to enhance networking capability collaboratively based on complementary competences. As a professor of an involved university in case C stated:

> The manufacturer and the energy provider established discussion groups in the foundation with all key actors for facing challenges (of attracting other potential actors). Thus, collaboratively, we found a valid and successful solution on how to initiate relationships with users (to be involved intensively in particular context of sustainability).

From the other hand, in cases -A, B, and G-, the involved actors – apart from the lead organization- were integrated at various stages, but the lead organization was the primary actor during all stages. Accordingly, only the lead organization was able/responsible to attract other actors to be engaged in the project. As a consequence, only the lead organization attempted to develop the best practices for attracting external actors (e.g., case H is one of the first adopters of open innovation according to the secondary data). As stated by informant of the case H:

> We (the leading organization) were able to involve the well-known "international non-governmental social development organization" …. We were able to do that thanks to our established best practices.

Competence mapping capability: Results for the competence-mapping capability suggest similar twofold pattern to networking capability. First, all involved actors who considered this ability as being very important, also faced challenges in putting in practice the processes and perceived the need of capability enhancement during the project (C, D, and E), for particularly

mapping the sustainability competences of each actor. In these cases, all actors collaboratively dealt with this challenge through sharing their previous experiences, via regular explorative meetings to identify present competencies in each partner. During these projects, actors were typically co-developing an output together from the beginning of the project, when there was no clear idea of the final outcome and the required competence from each partner. On the other hand, in the second group of projects, the lead organization identified potential actors possessing the required knowledge/asset/competence (A, B, F, G, and H). Although these leading actors identified these capabilities as important, they had not experienced many challenges during the projects, and they claimed that partners' competencies were easily recognizable, even in the sustainability context. In this regard, partners' competencies are easily recognizable because the particular requirements are clear and pre-defined from very beginning of the projects. For example, in case B, the reason behind integrating research centers was a need for waste-management technology, which was lacked by internal competences of the lead organization. In these cases, the lead organization were able to systematically evaluate diverse types of required assets, and accordingly suitable actors to be engaged, by documenting stakeholder competencies assessments (Sharma & Vredenburg, 1998).

Relational capability: Results of cross-case analysis on relational capability show that five cases (C, D, E, F, and H), perceived the importance of building trust–based relationships with continuous goal identification and discussion exercises as a success factor but also challenging. In these cases, the entire team that collaborated during all stages of the project attempted to establish continuous communication with frequent and intense decision making processes (Ayuso et al., 2006). As the assistant manager of the innovation department at case F mentioned:

> The main issue was to understand the cultural differences of the partner, as we were very different. So we spend at least 10 or 11 months in the consortium agreement to discuss collaboratively… We managed to have a very good relationship although we were very different.

Instead, in other cases, the capability seems to be important but less challenging for the lead organization who was the main responsible to manage the relationships because usually the relationships were managed formally and/or contract-based.

However, in all cases when an actor is far from a lead organization's current business –which happens often in sustainability context, e.g. NGOs, the challenges increase. In this regard, corporate affairs from case A mentioned:

> It is difficult to integrate all types of actors. We are trying to improve but it is not easy for us. Especially on sustainability projects, companies are learning how to communicate. This does not mean that we should not do but you have to find ways to communicate.

We argue that integrating actors who are far from the lead organization's business is challenging mainly for relational capability during SOI projects. The informants perceive that sustainability can facilitate relational capability building by establishing a shared sustainability-related vision. As the technical development director of case B stated:

> Projects related to sustainability are experienced in a more shared vision approach among diverse types of actors.

Desorptive Capacity: Desorptive capacity includes both the ability to select and engage internal actors, and align and empower them according to external acquisitions. Results suggest that the two abilities were perceived as extremely important in all projects. The local marketing director from case B reported:

> It is a critical success factor of the project to collaborate and align internally. If the company does not operate as a system, no project can be feasible.

The communication manager from case E mentioned:

> You have to have a good relationship with the (external partners) e.g. users, but you have to have a good team working internally on top. It's not just one factor, it's the combination of them which is a success factor.

Respondents claimed that a multidisciplinary perspective is required from various internal actors to incorporate sustainability issues during a project. Thus, engaging internal actors is fundamental because many functions in each partner should be engaged with the same perception and conceptualization of the project. The energy and sustainability manager of a home appliance manufacturer from case C mentioned:

> The difficulty of the SOI project is the need of multidisciplinary perspectives from different not only external but also internal actors in order to provide everything so that the final product functions properly.

However, aligning and empowering internal actors with stakeholders are perceived as much more challenging (cases C, D, E, and F), when the organizational differences of actors are high. When is the case, employees of all involved organizations in all project phases are required to be trained particularly and continuously in terms of the specific project. In addition, various internal actors participate intensively during network meetings. Various mechanisms are conducted by all projects for being able to manage the knowledge (e.g. designing a specific

channel such as an online platform to distribute information and outcomes systematically). As the director of the research institution (lead organization) from case D stated:

> There are shared documents… between individuals of organizations. Having done such a complex project, managing the knowledge through shared channels has led to the growth for everyone, and we all learned something both as organizations and individuals.

Also, as the assistant manager of the innovation department from case F mentioned:

> Some engineers from the other partner have been here for the whole 4 years. Then, every 2 months, the project coordination committee integrate all the stakeholders to share the updated insights. This is necessary for the project process, internal-external integration and finding solutions.

Finally, projects apply boundary teams. Boundary teams bridge disparate mindsets and languages by translating contrasting coding schemes and channel information between employees (Tushman, 1977). These mechanisms are in addition to conventional ones for enhancing the ability to integrate internal divisions (e.g., cross-functional teams, training, and social activities) (Maltz & Kohli, 2000). To conclude, all proposed capabilities are perceived as important for SOI development in all the cases. However, the emphasis on desorptive capability, for particular context of sustainability is noticeably higher compared to higher - networking, competence mapping and relational.

To conclude and drawing out findings to answer the research question - Which open innovation capabilities should be reconciled by firms for particular innovations aimed at sustainability depending on the radicalism and the product/service combination of the output?- we classified our cases into two groups. Set 1 (labelled as uni-dimensional) consists of cases A, B, G, and H, developing a new sustainable product or service that includes modification in the existing system of businesses and customers' sustainable lifestyles. Set 2 (labelled as systemic) consists of cases C, D, E, and F, aimed at developing a mix of products and services, with architectures that are expected to change dramatically the existing systems (both the business model of organizations and the lifestyles of customers.

By combining insights from findings on both research questions, the external integration capability building differs depending on the outcome characteristic. The synthesized insights suggest that project members of systemic SOIs typically face higher challenges for exploration and exploitation of sustainability issues in innovations compared to unidimensional projects' members which leads key actors to possess exploration/exploitation capabilities for the particular context of sustainability or develop a collaborative capability

together. Finally, desorptive capacity seems to require reconcilement not only for systemic SOIs, but also for unidimensional SOIs, because aligning and empowering internal functions on sustainability issues is challenging. Thus, we can conclude that all key actors of systemic SOIs should possess all open innovation capabilities, thus must develop them, if not already possessed. Differently, in unidimensional SOIs only lead organizations (should) possess the capabilities and probably enhance their established desorptive capacity according to the particular context of sustainability.

To conclude, we argue that unidimensional SOIs can be developed relying on established open innovation capabilities with reconciling mainly desorptive capacity – by aligning and empowering internal functions to the particular sustainability context. However, in systemic SOIs, a reconcilement is required in all open innovation capabilities. In regards to exploration and exploitation capabilities, all key actors should develop, if not already possessed, the capabilities or build a collaborative capability. Based on the cases, we can also suggest some mechanisms to build collaboratively the capability together including communicating continuously and extensively and engaging jointly in various networking opportunities and exploring various potential actors jointly, conducting goal identification exercises continuously, relying not only on typical information-sharing routines within boundaries of each actor but applying boundary-breaking routines. Finally, the results show that when actors have organizational differences – as is typical in the sustainability context- no matter the outcome characteristics are, the exploitation and retention capabilities are much more challenging and require reconcilement.

4.4. Case Study analysis on the process differences between SOI and conventional innovations

To answer the first part of the research question c - How does the innovation process for sustainability differ from conventional innovation processes? - single and cross case-study analysis was performed (Table 21).

TABLE 21. Third Case Analysis -Findings of single case analysis answering RQ based on the coding scheme and some examples of cases

		Partnerships			Process Cycle (D/L[3])
		Secondary stakeholders	Public-Private Partnerships	User involvement	
1	C[4]	-	When necessary	Market research method & usability design tests	L (Global research & innovation network (3 structured phases))
	SOI	Austrian mobility club	Public Funding, Public Research & Governmental associations	Field trials and Co-creation Labs	L
2	C	-	-	User testing when necessary	L(Structured "Innovation Methodology" designed by Co.)
	SOI	-	Municipality	Field Trials, online surveys, phone interviews, focus group meetings, and in-home interviews.	D (Filed trials happen at development and commercialization phases + Establish of Partnerships before exploration phase)
3	C	Non–governmental institutions e.g. food banks	-	Customer led one area of NPD by collecting customer feedbacks through online and social media and/or workshops	L (3 designed methodologies for NPD: Customer/ employee/ supplier led product development)
	SOI	Specialized groups & foundations in sustainable food	-	New approach towards user involvement with objective data through various channels	D
4	C	-[5]	-	User involvement	L
	SOI	-	-	User Involvement	L
5	C	-	Public food institutes	-	L
	SOI	Sustainability activists (Bloggers)	Public food institutes	End-users via online platforms	L
6	C	-	-	-	L
	SOI	-	Public-Private is shaping the project	Users' lifestyle shape the developed service, so multichannel involvement	D
7	C	-	-	Market Research	L
	SOI	-	-	Interactive approach towards market research	L
8	C	-	-	Market Research	L
	SOI	-	An Energy Cluster is created by the company as a platform for public institutions, local government and business partnership	Evaluation of the developed product/service from customer perspective (if relevant)	D
9	C	-	When necessary	Market Research	L
	SOI	Environmental specialists and foundations	The concept is only possible with partnership with public transportation system	Users shape the developed outcome	D (Exploration and testing phases are complementary phases)
10	C	-	-	Market Research	L
	SOI	NGOs' Collaboration shape the output to be unique	Public-Private partnership lead to gain a competitive advantage in comparison with competitors	User integration shapes the vision of innovation and entrepreneurship and fill the gap of non-existence R&D center of the company	D (Testing and exploration phases are inseparable)
11	C	-	Public authorities	Core of the business	L
	SOI		Public authorities as well as public local entities	Core of the project	D
12	C	-	When necessary	Market Research	L
	SOI	-	Public funding and the close collaboration with public charging infrastructure	User involvement shapes mainly the provided service	D (Lead user testing together with exploration phase)

Secondary stakeholder, public-private partnership are assessed based on the number of the cases that possess differences. Process cycle is assessed based on the number of cases (for each SOI or conventional) that are categorized as chaotic. Finally user involvement is assessed not only based on whether or not company is involving user but also the degree of user

[3] D stands for Diamond Model of Innovation Process versus Linear Model
[4] C stands for Conventional innovation process versus SOI which stands for Sustainability Oriented Innovation process
[5] Mainly innovations are developed based on the internal R&D with a structured approach: from large number of ideas being evaluated and tested to be prototyping through stage-gate modeling (various evaluation criteria)

incorporation (if the user involvement is only for market research (0.5 weight in scale) -if the users are shaping the final output of outcome (1.5 weight in scale). The average results are shown in Figure 5.

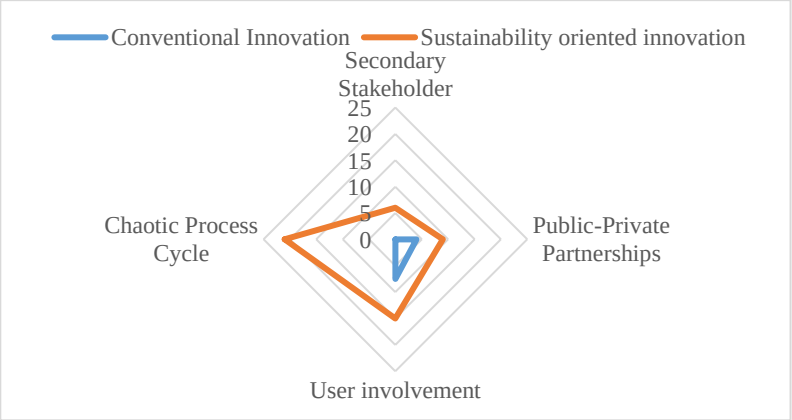


FIGURE 5. Third Case Analysis- Process disparities of conventional and sustainability oriented innovations

The results show that the majority of SOIs' differences compared to conventional forms of innovation lies in user involvement and process cycle (except cases 4 and 7). Second, public entities seem to be incorporated more in SOI projects.

For user involvement, some interviewees seem to perceive them as necessary actors who play a key role in developing or refining the final output of the SOI projects. Thus structured, various and profound mechanisms are typically used for user involvement. About process cycle, all cases were able to establish a structured and relatively linear model for conventional innovations[6]. However, they mostly perceive SOI as not being able to fit in their structured process. To sum, our results show that when innovations are aimed at sustainable development, particular external partnership should be designed. In this regard, users may be incorporated as developers, and also public entities that are far from ordinary industrial partners should be involved intensively. We can argue that the complexity brought by these external partnerships will lead to more complex process cycle of the SOI project compared to conventional innovations.

To insights from the first part of the RQ c supports us to answer fully to the RQ c – How does the innovation process for sustainability differ from conventional innovation processes in terms of involved partnership and process cycle depending on the radicalism and the product/service

[6] This can be due to that fact that our cases are mostly large companies.

combination of the output? – based on cross case-study analysis. Based on the types of innovation identified in methodology section, cases can be categorized as following:

1. Radical product-service-system development
2. Incremental product-service-system development
3. Radical product or service development
4. Incremental product or service development

The output categories have been linked to the findings on the first research question. Results are summarized in Figure 6.

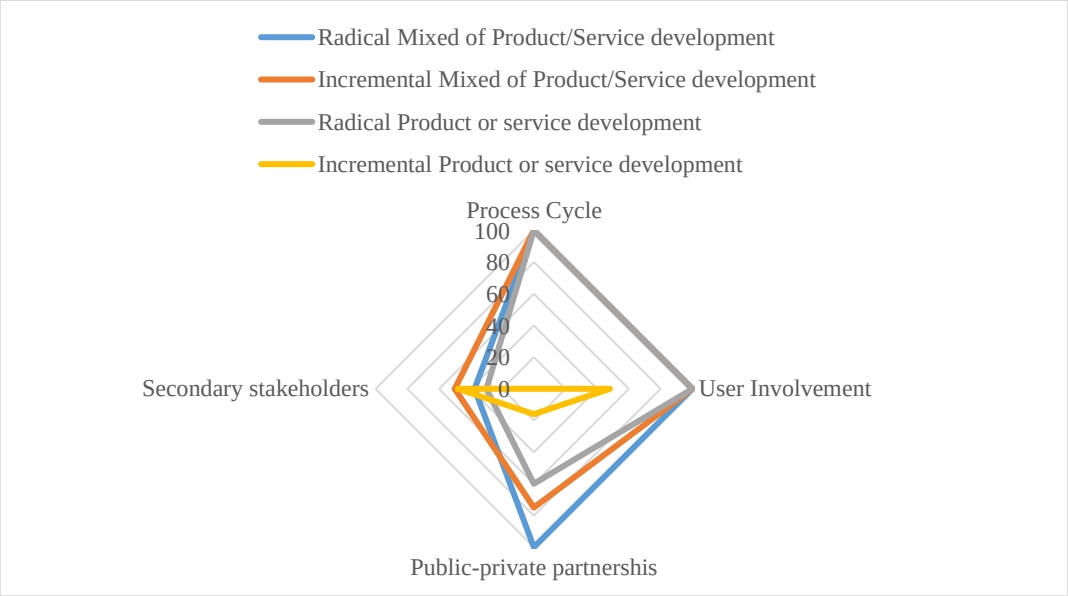


FIGURE 6[7]. Third Case Analysis- SOI and Conventional innovation process disparities depending on the outcome

Results show that the output characteristics definitely affect the process used. SOI process seem to be the most different compared to conventional forms of innovations when the output is a radical/incremental product-service-system (Cases 1, 8, 9, 10, 11 and 12). Of this, the SOI process seems to be different compared to conventional forms of innovation mainly in terms of process cycle, user involvement and public-private partnerships. Subsequently, differences are seen in new radical sustainable products or services mainly in terms of user involvement and process cycle. Based on the results, we argue that for SOI development, when the output is either a product-service system or radical, the process is more chaotic, and users are potential

[7] Assessments are based on the percentage of the cases

contributors as co-developers and shapers of the final outputs. However, when the SOI output is a product-service system, public entities may become necessary partners additionally. Finally, the SOI process for incremental product or service development (Cases 4, 5, 7) seems to be almost similar to conventional innovation processes. Based on the overall results, sustainability-related secondary stakeholders' contribution for SOIs may act as a driver of process differences compared to conventional forms of innovation not depending on the outcome characteristics but when the know-how is needed.

5. DISCUSSION AND CONTRIBUTION

5.1. Theoretical/Literature implications and contributions

The results provide apealing insights to the current debate on the interrelationship between sustainability and innovation by several means. First, our results prove that, through a survey from 850 practitioners, sustainability propensity proposes innovation opportunities for businesses (Hansen et al., 2009; Noci and Verganti, 1999), by acting as an antecedent of innovation propensity in businesses. Further, our results show that adoption of sustainability practices and performance correlates positively and significantly with adoption of innovation mechanisms and innovation performance. Thus, our results suggest that not only innovation is a driver of sustainability (e.g. Hall and Vredenburg, 2003; Hansen, et al., 2009), but they can bring mutual benefits for firms' operations and performances (Porter and van der Linde, 1995). Thus, this research reflects the relevance of the debate on the business case for sustainability (Dyllick, and Hockerts, 2002). Our results confront innovation literature by showing on a generalizable sample of firms, how innovation is able to bring forward also social/environmental benefits for businesses (Bos-Brouwers, 2010; Larson, 2000) in addition to the economic benefits.

Second, this Ph.D. work, make further suggestion to the previous studies on positive influence of supplier (e.g. Yarahmadi and Higgins, 2012), customer (e.g. Sheth, 2011) and internal (e.g. Petala et al., 2010) integration on sustainability and innovation, by showing the existence of synergetic correlations between sustainability, innovation and supply chain integration. In other word, the more integration is between supply chain actors and within the focal firm, the focal business put more effort on sustainable development and innovation management. In return, the higher firms put effort on sustainability and innovation, they tend to integrate more their supplier and customer integration and internal coordination. Finally, thanks to the adopted integrative perspective of upstream-internal-downstream of supply chain (e.g. Flynn et al., 2009), we suggest that supply chain integration should consider both external (upstream and downstream) as well as internal perspectives because these elements positively reinforce each other. This could be the reason behind contrasting results (positive and negative influences) of customer integration on innovation and/or sustainability (e.g. Gualandris and Kalchschmidt,

2014). Thus, we suggest the necessity of integrated view of supplier-customer-internal integration when firms put effort on sustainable development and innovation management.

Third, this Ph.D. work contribute to the theory and context, by showing that (open) innovation theories as an applicable lens to investigate SOIs, since the entire components of the (open) innovation capability framework, are perceived quite important in particular context of sustainability. However, our results boost SOI literature to propose when sustainability concerns are added to the innovation goals, the degree of emphasis on capabilities differ, thus sustainability context bring forward some peculiarities compared to conventional forms of innovation. This PhD work shows the SOI peculiarities from diverse perspectives. First, from the required intangible resources, the results contribute to resource-based view for achieving sustainability and innovation. Findings reveal that, for the sustainability context, businesses have to adjust organizational capital by establishing a clear direction towards sustainability (Seebode et al., 2012). Further, firms need to reconcile inter/intra-relational capital, by establishing strong internal cooperation and increasing sustainability awareness (Bettley and Burnley, 2008; Ketata et al., 2015) and accelerating emergence of diversified creative ideas from various networking interactions (de Sousa, 2006). Second, from organizational capabilities for SOI development, we suggest an additional sustainability-specific research focus taking into account newly emerging sustainability trajectories (Seebode et al., 2012). Moreover, for exploration and exploitation capabilities, our results confirm that sustainability context bring higher uncertainty (Seebode et al., 2012). Our results show that in order to cope with the higher complexities, external cooperative efforts should be managed from very diverse type of sources (De Marchi 2012; Laperche and Picard 2013) fully integrated with the internal aspects of the organization. The results adjoin value to the debates on innovation literature around the highly complex innovations that strong and diverse interactions enable reduces uncertainty in the innovations and the network value (Larson, 2000). However, the integrated internal perspective could be more relevant to the specific sustainability concept mainly for internal acceptance of sustainability concerns (e.g. Adams et al., 2015). In particular, we suggest desorptive capacity -capability to integrate internal functions for external incorporations- requires particular reconcilement for particular context of SOI development, which is aligned with contemporary research focusing on internal alignment and empowerment for external integration (e.g. Hillebrand and Biemans, 2004; Ayuso et al., 2011; Peters et al., 2011; Verona, 1999). Our findings suggest set of processes to face the challenge including cross-functional teams, training, and social activities (Maltz and Kohli, 2000). Further, we propose that the employment of people who transfer information among organizational groups

-referred to as boundary persons- (Tushman, 1977) can be beneficial to reduce the gap caused by differences in mind-sets, languages, timeframes, and norms of employees (Dougherty, 1992). Due to the recognition of SOI context as highly uncertain and complex innovation, our results are aligned with studies, demonstrating that SOI process requires particular reconcilement compared to conventional innovation processes (e.g. Hall and Vredenburg, 2012; Carrillo Hermosilla et al., 2010; Pujari, 2006). We enrich this view by showing that process cycle and user involvement are the key factors demanding adjustments in the SOI process.

Last but not least, we argue that the introduction of external incorporations and process adjustment should continue to be depending on the outcome characteristic (Carrillo-Hermosilla et al., 2010). In this regard, we suggest a differentiation of systemic SOI (developing a mixed product service system which radically changes the existing systems (Markides, 2006) where key actors collaborate/co-develop through the entire process (Perl-Vorbach et al., 2014)) and unidimensional (developing a new specific product or service within the existing system where actors are participating when required by the lead organization). Our findings contribute to the current debates on external incorporation by suggesting systemic SOIs requires key actors -not only the lead organization- to build collaboratively, if not already possessed the open innovation capabilities. However, in unidimensional SOIs, only the lead organization mainly possess/develop the capabilities. Yet, sustainability concept should be reconciled in internal alignment and empowerment even in unidimensional SOIs, by the lead organization. On the other hand, the SOI process is more different compared to conventional forms of innovation in both radical and incremental development of product-service-systems. Our cases contribute to the debate by showing that particularly during development of sustainable product-service systems and radical products or services, users are able to reshape and refine the new sustainable concepts (Arnold, 2011; Hoffmann, 2007), leading to play a role as co-creators and/or co-developers (Carrillo Hermosilla et al., 2010; Pujari, 2006). To involve users extensively, more profound, structured and various means are needed. These results are in contrast with Hoffman's (2007) abstract methods for user integration in the SOI context. We argue that abstract user involvement may be sufficient for new incremental sustainable product development, where users are involved primarily for understanding market acceptance.

To conclude, we argue that despite the fact that SOI is argued to possess its own context peculiarities compared to conventional forms of innovation in various perspectives as Pujari et al., (2003) claimed, there is more synergy than conflict. That is why, innovation theories and frameworks can/should support the investigations of SOI projects and the effective integration

of these paradigms could be one of the key challenging benefits for both academics and practitioners of both fields (Pujari, 2006).

5.2. Practical Contribution

The study provides managers with clear evidence of the necessity for sustainability propensity and endeavor for enhanced innovation in firms' operations. In other words: "Be sustainable to be innovative" to take the synergetic advantage of mutual reinforcement of adoption of sustainability and innovation practices/mechanisms to achieve higher innovation and sustainability performance. In this regard, our suggestions are mainly twofold: first, treat sustainability as a driver of innovation in operations. Second, take the integrative perspective of external supply chain integration -both upstream and downstream- with intense and relevant internal integration for improving sustainability and innovation.

Second, we suggest managers to leverage their conventional innovations' resources, capabilities and processes in order to develop SOIs. In particular, we suggest businesses to build a very clear direction and orientation towards sustainability to enhance their organizational capital. Moreover, we suggest establishing strong internal cooperation mechanisms, increasing sustainability awareness in employees, diversifying the external sources. We suggest that one of the keys to SOI success is managing external cooperative efforts fully integrated with internal aspects of the organization.

Further, we propose that conventional innovation reconcilements should depend on whether the SOI output is related to developing a mixed product service system which radically changes the existing systems (systemic) or developing a new specific product or service within the existing system (unidimensional). We suggest that firms should extensively leverage their capabilities and process especially for systemic SOIs by building additional processes, if not already possessed, in all involved actors. We suggest managers some practices to leverage their resources for SOI context including establishing an additional sustainability-specific research and development focus, cross-functional teams, training, and social activities, the employment of people who transfer information among organizational groups with the sustainability expertise (to reduce the gap caused by differences in mind-sets, languages, timeframes, and norms of employees. In a similar vein, businesses must be open to adjust their conventional innovation process in particular for SOI development, by openness towards chaotic (non-

linear) project development and building the capabilities to involve users as co-developers and establish more profound, structured and various means to do so.

6. LIMITATIONS AND FUTURE RESEARCH

While this study provides a compelling contribution to the sustainability and innovation literature and possess valuable implications for theory and practice, there are some limitations, some of which offer further research avenues.

Concerning the primary phase of the studies, conducted by survey methods, since sustainability and innovation interrelationship may also evolve over time, examining the patterns in a longitudinal study will be advantageous. Second, future studies should consider other industries, and control other contextual factors (e.g. technological complexity level of the firms). Finally, the synergetic effects of sustainability-innovation (and supply chain integration) magnifies the importance of merging other relevant research streams with operations management for enhanced sustainability and innovation performance in multidisciplinary manner (e.g. market research as in Heikkurinen and Bonnedahl, 2013; organizational coordination functionality with sustainability and innovation as in Petala et al., 2010).

On the other hand, qualitative exploratory studies offer various areas of future research including: first, the findings of the case studies relied on limited number of cases through a number of in-depth interviews with informants, triangulated with other data sources. Future research should include more cases covering more comprehensive types of SOIs which definitely will be able to extend the scope of this topic. Moreover, since limited investigations have been conducted on management of disparate type of actors (Ayuso et al., 2011), we suggest that further research should focus on how different types of stakeholders may affect the capability development especially in SOI context. Research should also focus on disparities within projects to elucidate further influencing factors. This is aligned with previous studies suggesting that dual approaches in management are worth exploring to ensure incremental sustainable improvements, as well as more systemic and radical changes in the longer term (Carrillo-Hermosilla et al., 2010). However, we propose that the dual approaches seem to be disjointed and integrative perspectives can support practitioners to differentiate properly the business initiatives. Accordingly, our results suggest that the process of developing systemic SOIs, especially in mobility and energy sector are affected by the public-private partnerships (PPP). However, the introduction of SOIs are rarely linked theoretically with public-private

partnerships (PPP) literature (Osborne, 2002) while strong evidences have been built around identifying barriers, system failures, policy and technological implications. Thus, we suggest studies on process perspective of PPP in sustainability oriented innovation systems from company perspective can be enriched in future. Methods and techniques used to manage appropriately the resources, capabilities and processes for SOI development from conventional innovation management should also be scrutinized. It should be noted that the suggested assessment of resources, capabilities and process differences for SOIs is subjective, not only because of incomplete information but also because of interpretations and the use of the graded scale of importance.

7. APPENDIX

7.1. Ph.D. Thesis Dissemination

International peer-reviewed articles

- Sarah Behnam, Raffaella Cagliano, Mercedes Grijalvo. How Should Firms Reconcile Their Open Innovation Capabilities for Incorporating External Actors in Particular Innovations aimed at Sustainable Development? Under revision under Special Issue of "Innovating for Sustainable Development", Journal of Cleaner Production.
- Sarah Behnam, Raffaella Cagliano. Are Innovation Resources and Capabilities Enough to Make Businesses Sustainable? An Empirical Study on Leading Sustainable Innovative Firms. Under revision under International Journal of Technology Management.
- Sarah Behnam, Raffaella Caglino. Sustainability and innovation cube; The role of supplier-customer-internal integration. Under revision under revision of Chapters – Innovation for Sustainability : Business transformations towards a better world..

INTERNATIONAL CONFERENCES

- Sarah Behnam, Raffaella Cagliano (27-28 Feburary 2017). Sustainable and Conventional Innovation Process Differences, 4th International EurOMA Sustainable Operations and Supply Chains Forum (SOSCF). Milan, Italy.
- Sarah Behnam, Raffaella Cagliano, (18-22 June 2016). Discrepancies between sustainable and conventional innovations; European Case Study Findings, 23rd EurOMA Conference: operations management for sustainable competitiveness, Trondheim, Norway.
- Sarah Behnam, Raffaella Cagliano, (11-12 April 2016), Discrepancies between sustainable and conventional innovations; Case Study Findings, 3rd Intl. EurOMA Sustainable Operations and SC Forum, Lancester, UK.
- Sarah Behnam, Raffaella Cagliano, (11 June 2015), Sustainability and Innovation Interlink; The Evidence from Varied Perspectives, 2nd Annual EDIM PhD conference: Research Challenges in Contemporary Management Engineering, Milan, Italy.

- Sarah Behnam, Raffaella Cagliano, Mercedes Grijalvo (11 June 2015), New Sustainable Product or Service development from the Perspective of Secondary Stakeholder Integration's Process, 2nd Annual EDIM PhD conference: Research Challenges in Contemporary Management Engineering, Milan, Italy.
- Sarah Behnam, Raffaella Cagliano, Mercedes Grijalvo, (28 June 2015), Secondary stakeholder integration in the context of new sustainable product/service development; Empirical findings of European Cases, 22nd EurOMA Conference: operations management for sustainable competitiveness, NEUCHÂTEL, Switzerland.
- Sarah Behnam, Raffaella Cagliano, (23 March 2015), Sustainability and innovation cube; The role of primary stakeholder integration, 2nd Intl. EurOMA Sustainable Operations and SC Forum, Barcelona, Spain.
- Sarah Behnam, Raffaella Cagliano, (23 June 2014), Capabilities for Sustainable Innovation: An exploratory study in the Manufacturing Industry, 21st EurOMA Conference; Operations Management in an innovation economy, Palermo, Italy.
- Sarah Behnam, Raffaella Cagliano, (12 June 2014), Sustainable innovation capabilities: An exploratory study, 1st Annual EDIM PhD conference: Research Challenges in Contemporary Management Engineering, Milan, Italy.
- Sarah Behnam, Raffaella Cagliano, (24 March 2014), Capabilities for Sustainable Innovation: An exploratory study in the Manufacturing Industry, 1st International EurOMA sustainable operations and supply chain Forum; Exploring Sustainability in OM and SCM: Setting the Research Agenda, Groningen, Netherlands.

WORKSHOPS AND SEMINARS

- Writing Skills & Theorising Research Workshop, Politecnico di Milano, Prof. Irvine Lapsley, 15th-19th April 2013, Milano, Italy.
- 5th EurOMA Summer School, Cranfield School of Management, 24th-28th June 2013, Cranfield, United Kingdom.
- EurOMA Doctoral Seminar from 20/06/2014 to 21/06/2014, Palermo, Italy.
- EU-Innovate PhD Academy from 1/09/2014 to 3/09/2014, Milan, Italy.
- EU-Innovate Workshop from 4/09/2014 to 5/09/2014, Milan, Italy.
- EurOMA Doctoral Seminar from 26/06/2015 to 27/06/2015, NEUCHÂTEL, Switzerland.
- EurOMA Publishing Workshop, 18th June 2016, Trondheim, Norway.

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