



Contents lists available at ScienceDirect

## Journal of Cleaner Production

journal homepage: [www.elsevier.com/locate/jclepro](http://www.elsevier.com/locate/jclepro)

## An analysis of the interplay between organizational sustainability, knowledge management, and open innovation

Cátia Milena Lopes <sup>a,\*</sup>, Annibal Scavarda <sup>b</sup>, Luiz Fernando Hofmeister <sup>c</sup>,  
Antônio Márcio Tavares Thomé <sup>d</sup>, Guilherme Luís Roehe Vaccaro <sup>a,e</sup>

<sup>a</sup> Graduate Program in Production Engineering and Systems, UNISINOS – Universidade do Vale do Rio dos Sinos, São Leopoldo, Brazil

<sup>b</sup> Graduate Program in Production Engineering, UNIRIO – Federal University of the State of Rio de Janeiro, Rio de Janeiro, Brazil

<sup>c</sup> Graduate Program in Regional Development, UNISC – University of Santa Cruz do Sul, Santa Cruz do Sul, Brazil

<sup>d</sup> Industrial Engineering Department, PUC – Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil

<sup>e</sup> Graduate Program in Business and Management, UNISINOS – Universidade do Vale do Rio dos Sinos, São Leopoldo, Brazil

## ARTICLE INFO

## Article history:

Received 1 December 2015

Received in revised form

11 October 2016

Accepted 16 October 2016

Available online xxx

## Keywords:

Organizational sustainability

Knowledge management

Open innovation

Sustainable innovations

## ABSTRACT

Organizational sustainability increasingly focuses on how to manage new knowledge of ideas and practices that can expand business. Open innovation plays a key role towards effective strategic sustainable management. Through open innovation, companies can leverage knowledge management to an asset that promotes sustainable innovations that influence back organizational sustainability. This paper explores the case of a Brazilian family-owned company of rubber products, operating in the sectors of health, education, and coatings, which based on organizational sustainability uses knowledge to develop open innovation aiming to promote sustainable innovations. The methodology is an exploratory single case study research based on informal observation, semi structured interviews with key informants, and focus group discussions. The case study's results explore in depth the company's experience in adopting the strategic organizational sustainability using knowledge management and open innovation to promote sustainable innovations in accordance with the model of the Organization for Economic Cooperation and Development for eco-innovation, acting as a driver for significant changes in the organization's culture in organizational sustainability.

© 2016 Elsevier Ltd. All rights reserved.

### 1. Introduction

Survival is the goal any organization. Under the perspective of an environment of limited resources, competitiveness arises as well as the search for new strategies for organizational sustainability (Buys et al., 2014). The concept of sustainability refers to the triple bottom-line (TBL) of environmental, social, and economic concerns of one organization, which affect present and future generations (Elkington, 1994).

The incorporation of organizational sustainability in the business environment incurs into awareness of the environmental, social, and economic capitals of the enterprise (Kucukvar et al., 2014). On the one hand, it may lead to increased opportunities

through governmental and consumers support. In this sense, organizational sustainability may act as a source of opportunities for companies to remain competitive (Gimenez et al., 2012). On the other hand, sustainability is still understood as an economic externality – or as a cost – infringed by effective legal enforcement (Porter and Van der Linde, 1995). In this sense, there is still lack of sufficient knowledge on how to incorporate social and environmental aspects in the organizational core business or how to overcome existing barriers and encouraging companies to fully deploy sustainability in business processes (Nidumolu et al., 2009).

For organizational sustainability company should focus its efforts on knowledge management and innovation (García-Álvarez, 2015; Gaziulusoy et al., 2013). Innovation grounded on knowledge and environmental, social, and economic criteria enables the creation of a sustainable basis for competitiveness in organizations (Buys et al., 2014). In other words, innovative skills generated by knowledge can play an essential role for organizational sustainability (Sanders and Linderman, 2014). The development of sustainable new products adds layers of complexity to the traditional

\* Corresponding author.

E-mail addresses: [catia.milena.lopes@gmail.com](mailto:catia.milena.lopes@gmail.com) (C.M. Lopes), [annibal.scavarda@unirio.br](mailto:annibal.scavarda@unirio.br) (A. Scavarda), [hofmeister008@yahoo.com.br](mailto:hofmeister008@yahoo.com.br) (L.F. Hofmeister), [mt@puc-rio.br](mailto:mt@puc-rio.br) (A.M.T. Thomé), [guilhermev@unisinos.br](mailto:guilhermev@unisinos.br) (G.L.R. Vaccaro).

new product development process, but is equally a potential source of gains for the economy, society, and people (Thomé and Scavarda, 2015; Thomé et al., 2016).

While innovation is recognized as a way to achieve improved performance and leadership (Schumpeter, 1934), the need for rethinking the models of closed innovation began with the changes occurred mainly after the World War II (Chesbrough, 2003). The rising costs of technology development and the reduction in the life cycle of the products changed the way of doing business and proposed a new competition format (Rogbeer et al., 2014). Concurrently, companies seek an increased ability to deal with uncertainties (Hallstedt et al., 2013) and to keep up with fast changes in the market (Buys et al., 2014), being impelled to navigate through a dynamic market driven by knowledge.

This knowledge, nevertheless, may be out of the companies' boundaries (Gaziulusoy et al., 2013). For enhancing their chance of success in that intent, companies should not depend solely on their own planning areas and internal development of new goods and services (Hallstedt et al., 2013). By creating advantage from external sources of technology and innovation, companies may boost domestic growth (Hellström et al., 2015). Open innovation assumes that knowledge that promotes innovations lies anywhere in a company's value chain (Chesbrough, 2003). Therefore, a path towards innovation consists on opening the company's doors to ideas (Kian et al., 2015), coming from the external stakeholders, like research centers, universities, suppliers, and customers (Chesbrough and Schwartz, 2007). Open innovation is a breakdown of values, in which knowledge starts to be acquired through partners, that is, together they acquire the necessary skills to generate innovation and knowledge due to their complementarity (Chesbrough, 2006). In this sense, open innovation is in line with knowledge management (Zemaitis, 2014), which involves the use of mechanisms that help companies to manage knowledge as an asset that promotes business development (Seethamraju and Marjanovic, 2009), i.e., innovation that generates learning and knowledge sharing may assist the development of companies (Cui et al., 2015).

The integration of knowledge management into business processes aims not only to protect the intangible assets of a company (Lee and Suh, 2003), but also to develop and to take advantage of the assets, stimulating the creation of more adapted goods and services to customers' needs and increasing competitiveness (Nissen, 2005). Business processes are the main linking elements between the work and skills of members of an organization and the wishes of their customers (Seethamraju and Marjanovic, 2009), becoming also instruments for the implementation and formalization of knowledge management in the company and for the accomplishment of its potential benefits (García-Álvarez, 2015). To the extent that knowledge becomes an essential and strategic asset, organizational success increasingly depends on the company's ability to produce, gather, store, and disseminate knowledge.

Despite the recognized need for sustainable organizational and its influences on knowledge management and open innovation, there is a paucity of theoretical model and case study research on the interplay of organizational sustainability, knowledge management, and open innovation (Lütkemeyer Filho et al., 2014). Within this context, this paper aims to answer two related research questions (RQ):

RQ1 – Whether organizational sustainability, knowledge management, and open innovation are intertwined?

RQ2 – Whether organizational sustainability, knowledge management, and open innovation interact in practice in a real world environment?

More specifically, the study aims at examining the interrelation processes between organizational sustainability, knowledge

management, and open innovation and their practice in a large-sized Brazilian family-owned company operating in the rubber product industry. The turn toward a less impacting production model may ensure firms important economic gains by spurring sustainable innovations aimed at reducing environmental impacts while providing economic benefits (Nidumolu et al., 2009). Green innovators fuel their innovation effort through inter-organizational relationships more intensively than other innovators (De Marchi and Grandinetti, 2013).

The next section presents organizational sustainability, knowledge management and open innovation and it offers a research model relating organizational sustainability to knowledge management and open innovation. The research methods follow. The section four present the case study description. The section five analysis of the case study. The final section contains the conclusions.

## 2. Theoretical background

This section presents some key concepts about organizational sustainability, knowledge management, and open innovation, viewed through the absorptive capacity theory and the lenses of eco-innovation, and then it presents the model.

### 2.1. Organizational sustainability

Sustainability is a recent and comprehensive issue for the economy, the companies, and the population, being considered a systemic concept (Buys et al., 2014) related to the continuity of economic, social (including cultural), and environmental issues (Ribeiro et al., 2015). The United Nations' Brundtland Report defined sustainable development as “[...] the one that meets present needs without compromising the ability of future generations to meet their own needs” (Longoni et al., 2014). Sustainability is a manner of driving civilization in order to the society and its members (companies included) preserve biodiversity (Faisal, 2010) and natural ecosystems, planning and acting to achieve the indefinite maintenance that can fill their needs and express their greatest potential in the present (Lee and Saen, 2012).

In the economic perspective, the circular economic term has emerged as an alternative to replace the linear business model of innovation. It is a movement that strives for sustainably restructuring economic systems, based on the replacement of disposals and on the removal of the system “take, make, and dispose” (Lieder and Rashid, 2016). In the circular economic processes, the optimization of products takes place in multiple cycles of disassembly and reuse, elimination of waste throughout the various life cycles, and use of products and their components. The discovery of new ways to ensure the quality of life for current and future generations, eliminating the negative impacts caused by the different effects of technology, motivates companies to adhere to the circular economy (Ghisellini et al., 2016).

In business terms, organizational sustainability basis is not only the economic pillar, but also the social and environmental pillars. These three pillars should be transverse to the company (Infante et al., 2013). Therefore, there seems to be a reasonable degree of consensus on the effectiveness of the triple bottom line concept as the guide of sustainable organizational management (Heikkurinen and Bonnedahl, 2013). Adopting a critical perspective, Faisal (2010) showed that in the organizational level, the concept has received different meanings, but, if carried to its last consequences, its adoption may even question the very own business objectives of companies.

The criteria to evaluate and access the interrelated concepts of economic, social, and environmental sustainability are borrowed

from Labuschagne et al. (2005). Economic sustainability comprises financial health, economic performance, potential financial benefits, and trading opportunities of the company. Social sustainability covers the areas of internal human resources, external population, stakeholder participation, and macro social performance (i.e., external economic impacts of the business initiative and the contribution for the improvement of the environment at a community, regional, or national levels). Environmental sustainability encompasses air, water, land, and mineral resources.

New product development related to organizational sustainability encompasses eco-innovation. The concept of eco-innovation relates to organizational sustainability and circular economies. It is a relatively new concept and one of its first uses comes from Fussler and James (1996). It is rooted in recent discussions and concerns about environmental impacts. A historic perspective of the evolution of sustainability in product development may be found in Lütkemeyer Filho et al. (2014). Eco-innovation, similarly to innovation as a whole, considers the addition of value to the business and the customer emanated from new product or processes, but with the difference that the benefit should equally reduce significantly the environmental impacts of the innovation. The definition of eco-innovation is, therefore, very general and various types of innovations can be considered as eco-innovations (Ghisetti et al., 2015). Rennings (2000) reported two significant aspects of eco-innovation: firstly this type of innovation is not an open concept, because it represents innovation that emphasizes explicitly the reduction of the environmental impacts; secondly it can also be applied to social and institutional structures.

According to the Organization for Economic Co-operation and Development (OECD, 2009), eco-innovation is an innovation that results in reduced environmental impacts. The scope of eco-innovation can go beyond the conventional limits of the organization to innovate in order to cause changes in socio-cultural norms and institutional structures. As a reinterpretation of creative destruction theory of Schumpeter (1942), the long-term survival of the economic system depends on its ability to create and maintain sustainable economic processes, which involve the creation of value and satisfaction of current needs without compromising the needs of future generations (Ghisetti et al., 2015). To Rennings (2000) the eco-innovation movement is still developing ideas, behaviours, products, or processes that contribute to the reduction of environmental damage or to achieve sustainable goals. In summary, eco-innovation is generally similar to other types of innovation, but with two important points. First point, eco-innovation results in reduction of intentional or unintentional environmental impacts. Second point, the scope of eco-innovation can go beyond the conventional innovative boundaries and it can involve broader social arrangements that trigger changes in socio-cultural norms and existing institutional structures (OECD, 2009). Also, existing approaches may be classified as eco-efficient or eco-effective (Lütkemeyer Filho et al., 2014): eco-efficiency seeks to reduce environmental impacts (Dyllick and Hockerts, 2002; Fiksel, 1996; WBSCD, 2000), whereas eco-effectiveness seeks to mimic natural biological cycles (Braungart et al., 2007; Stahel, 2010).

Eco-innovation is based on three keys elements: targets, mechanisms, and impacts (OECD, 2009):

- Targets refer to the basic focus of eco-innovation, categorized under: products (both goods and services); processes, like a production method or procedure; marketing methods, associated to the promotion and pricing of products and to other market-oriented strategies; organizations, like the structure of management and the distribution of responsibilities; and cultural values in the institutions.

- Mechanisms relate to the methods by which the changes in the eco-innovation targets take place or are introduced. They are associated with whether the changes are technological or non-technological in nature. Four basic mechanisms are identified: modification, redesign, alternatives, and creation, comprising the design and introduction of entirely new products, processes, procedures, and organizational and institutional settings.
- Impacts refer to the eco-innovation's effects on environmental conditions across their life cycles. They depend on the combination of the innovation's targets and mechanisms. From an analytical perspective, the assessments of these impacts help to identify the eco-innovation. In addition, from a practical point of view, they are important to show that the eco-innovation improves overall environmental conditions. However, the impact assessments of eco-innovation require extensive knowledge and understanding of the innovation and its contextual relationship.

Table 1 depicts case studies results from the literature classified by OECD (2009) according to the elements of targets and mechanisms.

Organizations might maintain their competitiveness by investing in leveraging the culture in order to strengthen knowledge. Knowledge can stimulate the organizations to innovate by learning from their outside. Organizational sustainability can promote knowledge management and open innovation.

## 2.2. Knowledge management and open innovation

Paraphrasing Alavi and Leidner's (1999) previous work in knowledge management, knowledge is defined as a justified personal belief that increases an individual's capacity to take effective action. Regarding knowledge management, it is the process of capturing, distributing, and effectively using knowledge (Davenport, 1994). Knowledge management constitutes the basis of companies' capabilities construction, underlying the performance of organizational and management processes (Dow and Pallaschke, 2010). The knowledge basis that results from the information about customers, markets, competition, and future technologies is the core ingredient of product development and operations management systems (López-Nicolás and Meroño-Cerdán, 2011). Most times the knowledge required to the formation of productive capabilities is already available in the company, but the process for its mobilization is inefficient. One explanation for this is the lack of a strategy for knowledge management, particularly with regard to its integration with production activities (García-Álvarez, 2015).

Knowledge management, understood on the extent of its processes, lays in the following intervention levels (Donate and Guadamillas, 2011): the strategic approach to the management of organizational knowledge; its content and structure; its instruments, tools, practices, and systems; and its organizational and management processes (Lee and Suh, 2003). It becomes key when relating to sustainable innovations, since internal Research and development (R&D) activity is critical for the development of sustainable innovations, even more than for non-environmental innovations (Horbach, 2008; Rennings et al., 2006), when performed on a continuous basis (De Marchi, 2012; De Marchi and Grandinetti, 2013). Under this context, firms need an adequate internal knowledge base to address environmental concerns affecting their activities (De Marchi and Grandinetti, 2013).

The organizations also attempt to develop knowledge from outside their borders. They should be open to other management possibilities in addition to their internal ones. Organizations might innovate from the outside. Knowledge management can trigger open innovation. Successful organizations owe their results mainly to competitive advantages that their innovative capabilities created

(Chesbrough and Schwartz, 2007). Competitive advantage is the ability organizations have to create greater economic value than their direct competitors can. This economic value, in turn, is the result of the difference between the benefits received by the customers, who purchase goods and services of a certain company, and the total cost of these products (Gaziulusoy et al., 2013). When innovations lead companies to accomplish what no other companies have made or to realize this ability more competently, they then have a source of competitive advantage.

Innovation is not just a process of creation of new technologies or, simply, invention. The need for a new innovative format stems from the difficulty that organizations (Niehaves, 2010) have to innovate through their own (internal) efforts (Jones and Linderman, 2014), since the traditional model of innovation posits a preferential use of resources and knowledge (Madrigal-Sánchez and Quesada-Pineda, 2012) arising from their own organizations.

Under the perspective of open innovation, knowledge is the masterpiece of the whole process. In particular, external knowledge flows, whether of a tacit or explicit type are paramount (Kim et al., 2015). Open innovation establishes the flow of internal and external information of organizations (Wang et al., 2015). The concept evolves in time and a brief chronology of its evolution is in Table 2 (Saebi and Foss (2015)). The connection with sustainable innovations arises when observed that internal investments in green-specific resources are major enhanced towards the introduction of eco-innovations by knowledge and competences coming from network partners (Andersen, 2002; Mancinelli and Mazzanti, 2009; De Marchi and Grandinetti, 2013).

According to De Marchi and Grandinetti (2013), in the context of Italian manufacturers, the higher relational dimension of green innovation development is verified for the recourse to external knowledge to develop innovations internally, namely using to a higher degree external sources of information, acquiring R&D from external firms, and co-developing innovation; these three strategies to access external knowledge are not necessarily jointly activated. Also, green innovators draw information from and cooperate with a larger value network than non-green innovators. In summary, according to the authors, high green innovators are those interacting the most with external organizations in the attempt to develop new innovations.

If, in a given context, sustainability is a key driver for innovation (Nidumolu et al., 2009), then, sustainable innovations arises as a concept of hard or soft innovation that is related to green products or processes, including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs, or corporate environmental management (Chen et al., 2006). This orientation may be achieved through self-awareness (Hart and Milstein, 2003; Nidumolu et al., 2009) or through external pressures (Porter and Van der Linde, 1995; Chen, 2008; Chen et al., 2012).

In recent years both concepts, open innovation and sustainable

innovations, have become an increasing part of the business models of several companies. The open innovation model formally was brought to light in 2003, with Henry Chesbrough, based on a concept of open ideas funnel. The funnel pictures a model of innovation in which an open environment embraces external opportunities, allowing the organization to exploit other technologies, ideas, features, strategies, and opportunities. Sustainable innovations was an evolving concept since the 1960s, with Carson (1962), Lovelock (1974) and Meadows et al. (1972), based on concepts discussed since the XVIII century, as in the works of Robert Malthus and Adam Smith.

Kian et al. (2015) summarized the evolution of open innovation as a strategic process of continuous reinvention of the business and of creation of new business concepts. More specifically, open innovation proposes an approach to coordinate processes of research, development, and innovation in companies, based on an integrated horizontal concept (Saebi and Foss, 2015). In a complementary view, open innovation is equally referred as the ability to minimize the costs, by outsourcing research results conducted by the company (Niehaves, 2010). By using open innovation, the company may make better use of the results of research and development applied in its product portfolio, transferring technology to third companies or through spinoff companies, to reach new markets and significant results. Substantive changes occur in the evolution of the companies, when it moves from one model of closed to open innovation (Wang et al., 2015).

### 2.2.1. Absorptive capacity theory

Absorptive capacity assists knowledge management in promoting open innovation. Zahra and George (2002) reviewed the literature on the absorption capacity concept and redefined it as a set of organizational routines and processes, by which companies acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capacity. These four dimensions enable the company to reconfigure its resource base and to adapt to market changes in order to achieve a competitive advantage. The key idea behind this concept is that all four dimensions of absorptive capacity are composed of social interactions and therefore are affected by the interaction of social and environmental integration mechanisms (Todorova and Durisin, 2007), including the integration among organizations. Open innovation ability to promote recognition of the value of new internal or external information, to assimilate it, and to apply it for commercial purposes link directly with the absorptive capacity of firms (Cohen and Levinthal, 1990). The concept of knowledge absorption capability is, thus, key to understanding the success of open innovation, which relies on external knowledge.

In accordance with Cohen and Levinthal (1990), the ability to evaluate and to use external knowledge is a function of the source of knowledge, the level of related prior knowledge, and the ability to take ownership of this external knowledge (Todorova and

**Table 1**  
Case studies on eco-innovation classified by targets and mechanisms.

Targets	Mechanisms			
	Modification	Re-design	Alternatives	Creation
Institutions				Vélib - Bicycle sharing
Organizations & marketing methods			Xerox - managed print services; IBM - energy management services.	
Processes & products	Yokogawa Econo-pilot; Michelin energy saving tyres; Sharp recycling of LCDs; Advanced high strength steel	The BMW group product improvements by Efficient Dynamics; Loremo structurally redesigned car	Toyota photocatalytic paint at plants; Corex/Finex - direct smelting reduction; BMW/Toyota Hybrid propulsion	

Note: Case studies situated between two categories are placed in the dominant category according to OECD's typology.



**Table 2**  
Concepts of Open Innovation in chronological order.

Authors	Concepts of open innovation
Chesbrough (2003)	It involves the processes of acquiring external knowledge and exploiting internal knowledge externally.
Gassmann and Enkel (2004)	It means that the companies needs to open up their solid boundaries to let the valuable knowledge flow in from the outside in order to create opportunities for cooperative innovation processes with partners, customers, and/or suppliers. It also includes the exploitation of ideas in order to bring them to market faster than the competitors.
Chesbrough (2006)	It assumes that the companies can and should use internal and external ideas and paths to market as they look to advance their technologies.
West and Gallagher (2006)	It is systematically encouraging and exploring a wide range of internal and external sources for innovation opportunities, consciously integrating this exploration with firm capabilities and resources, and broadly exploiting those opportunities through multiple channels.
Freel (2006)	It has as primary benefit that it enhances the likelihood that companies will achieve business growth as a result of incremental sales from new products or production technologies.
Dittrich and Duysters (2007)	It is referred to as open, because the boundaries of the product development funnel are permeable. Some ideas from innovation projects are initiated by other parties before entering the internal funnel; other projects leave the funnel and are further developed by other parties.
Perkmann and Walsh (2007)	It can be regarded as resulting from distributed inter-organizational networks, rather than from single companies.
Terwiesch and Xu (2008)	It is in the context that a rapidly growing number of innovation processes relies on the outside world to create opportunities and there is a selection between these alternatives for further development.
Huang et al. (2010)	It leads to business growth by permitting companies to leverage more ideas from a variety of external sources.
Huizingh (2011)	It has as basic premise opening up the innovation process. One of its most often used definitions is the use of purposive inflows and outflows of knowledge to respectively speed internal innovation and expand the markets for external innovation.
Kim et al. (2015)	It complements internal research and development with the innovation sources which often come from similar external technology domains.

Durisin, 2007).

Cohen and Levinthal (1990, p. 135) highlighted the potential role of forms of absorbcency that are externally arranged. Arbussa and Coenders (2007) showed that the ability to identify the external environment does not involve complex scientific or technological knowledge, but knowledge about the technology at the user level and knowledge of business trends. The learning ability depends on the knowledge base, the organizational structure, and the dominant logic between organizations. Prior knowledge in a company must meet two criteria to identify and value new external knowledge: a similar knowledge base between the receipt and transfer organization and a partial diversity to use the new expertise. In other words, it is the expression of the cognitive structure of the receiving organization, or rather of the patrimony of knowledge that it has accumulated over time (Zahra and George, 2002).

### 2.3. A model for the interplay between organizational sustainability, knowledge management, and open innovation

A model summarizing the approach guiding the case study, based on the previous sections on organizational sustainability, knowledge management, and open innovation, is presented in Fig. 1. It depicts a model representing a company's strategy to focus on organizational sustainability, open innovation, and knowledge management to promote sustainable innovations at the level of depicted organizational targets as organizations & marketing methods (O&M) and processes & products (P&P).

Sustainable innovations may be considered as firms for which the absorptive capacity, including the transformational capability, is a core competence (Gluch et al., 2009; De Marchi and Grandinetti, 2013), at least from evidence from the European context. The more relevant environmental impacts are to an organization, the higher the effort it will exert to develop sustainable innovations. Previous studies show that high sustainable innovations seek benefit from such contextual constraints by given high importance to external knowledge sources and that are most likely to engage both in R&D activities and in cooperative agreements (De Marchi and Grandinetti, 2013; Gluch et al., 2009; Nidumolu et al., 2009; Braungart and McDonough, 2013).

The organization with open innovation, through knowledge management assisted by absorptive capacity management, can

envison ideas into sustainable innovations, taking advantage from new technologies, stakeholders, and resources that lead to effective and rapid results. The entrepreneurial capacity of the organization, strengthened processes, and products that aim for greater strategic competitiveness may lead to the organization's economic sustainability. Nevertheless, focus on environmental, social, and economic aspects of sustainability may generate trade-offs with the previous perspective, leading to sustain strategic decisions based on grater good instead of on short-term profit.

Organizational sustainability advantages to direct a more flexible organization, higher performance (Agha et al., 2012), through new technologies, and innovative O&M and P&P (Davenport, 2013). The organizational model needs to have clearly defined three dimensions: structure, governance, and core business (Carayannis et al., 2015; Dosi et al., 2008; Schaltegger et al., 2012). This new model of sustainable inter-relates to organization the promotion of knowledge management (through research and people engagement for change) and open innovation (through network collaboration, exchange of ideas, and sharing technology).

This relation implies an organization's business model must define specific aspects related to core business, its structure and inter-relations, and its governance: (i) its mission/vision or set of incremental strategies for organizational direction; (ii) the structure and inter-relations of its organizational units and external sources to carry out these activities; and (iii) the governance of its transactions (the mechanisms to control its organizational units and links between its units and external sources).

This concept integrating organizational sustainability, knowledge management, and open innovation adopts a business model perspective, integrating structure, practices, and open capabilities, which until now have been treated separately. This model allows differentiating business designs for different organizational sustainability focused on sustainable innovations. Organizational sustainability can contribute to knowledge management and knowledge management can also contribute to organizational sustainability, the same thing between organizational sustainability and open innovation, between knowledge management and open innovation, and between organizational sustainability and sustainable innovations. Because of the design of this research that is analysing sustainable innovations as results of knowledge management and open innovation, by definition it is not presenting

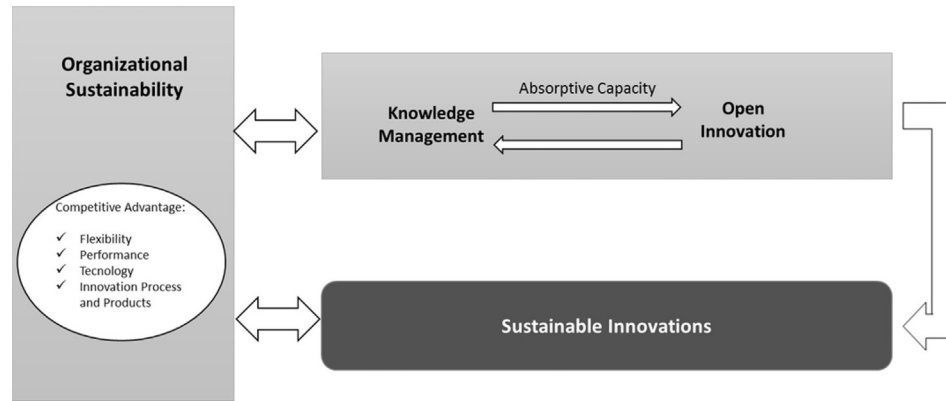


Fig. 1. A model for organizational sustainability, knowledge management, and open innovation.

knowledge management and open innovation being results of sustainable innovations.

Anyway, it is not the intention of this research study to make any causal analysis investigation. The goal of this research study is just to analyse the interaction between organizational sustainability, knowledge management, and open innovation. It is an exploratory study and it will hopefully serve as support for more studies about organizational sustainability, knowledge management, and open innovation. Future research study can analyse their correlations or causalities. Future research studies can investigate metrics that could quantitatively understand these correlations and causalities. The next section describes the research methods.

### 3. Research methods

This research is an exploratory single case study. As such, it “uncovers areas for research and theory development” and uses in-depth field observation (Voss et al., 2002, p.198). Single case studies are less prone to generalizations or external validity of findings than multiple case study research. In addition, if not properly analysed it may induce bias like “misjudging the representativeness of a single event and exaggerating easily available data” (Voss et al., 2002, p. 203). In this sense, the analysis of a single case might be a limitation, but it is equally strength of the research design, as it sacrifices generalizability in favour of more in-depth analysis than it is possible to obtain from multiple case studies. However, it is an appropriate method, as case study research is particularly suited to answer questions as “why and how” in the context of processes occurring in a real life environment, where the observer has no control over the events and the observer attempts to understand, systematize, and analyse the facts (Yin, 2009). It is equally well adapted to exploratory research and for theory building in new and emergent research areas (Voss et al., 2002).

In order to circumvent the inconveniences of single case research, the design of the study followed the components of case study research recommended by Yin (2009, p. 27). First, the case aims to answer specific research questions or propositions (if any). RQ1 and RQ2 described in the introduction of this paper intend to understand how organizational sustainability, knowledge management, and open innovation interact in theory and in practice. This research uses the OECD (2009, p.89) analytical model, because this model provides a useful comparative tool to analyse single case study research on open innovation, as it provides a basis for an initial assessment of external validity of findings from in-depth single case research.

Second, it defines clearly the unit of analysis. In the present study, the Brazilian business unit of a family-owned large sized

rubber products company is the unit of analysis. The choice of the company was due to it being one of the leaders in its segment in Brazil and because of its attempts to integrate organizational sustainability, knowledge management, and open innovation as a business model. Currently, it produces rubber products for the domestic Brazilian market and it exports to the Latin America, the United States, and Europe. In the last eight years, the company aims to change its business vision, to promote sustainability and to protect future generations, developing actions that contribute to sustainable development. The choice of the unit of analysis responded to a theoretical sampling answering to the five predicaments of a sampling plan in case research from Miles and Huberman (1994). It is relevant to the conceptual frame, demonstrates the phenomena under study, enhances generalizability of findings, and is feasible and ethical to collect data.

Third, field observation uses a model linking data to the research questions (or propositions, if any), as in the logical model applied to the case study research described in the previous section.

Fourth, it uses clear criteria to interpret the findings. The case study examines the processes of organizational sustainability, knowledge management, and open innovation as an intertwined system. The data analysis follows Wacker's (1998) four steps for theory building, consisting of definition of variables, limiting the domain, framework or model building, and analytical empirical support (Voss et al., 2002). The definition of the variables and the analytical model are in Section 2. Empirical support is in the analysis of Section 4.

#### 3.1. Data collection and analysis

Data collection was based on the previously presented model. The use of different methods was followed to ensure triangulation and enhance validity and reliability of findings (Yin, 2009). An organization with 92 years of existence in the sector of rubber artefacts and tire repairs was selected as source, due to its differentiation as a sustainable player within a sector known as delayed in sustainable initiatives. The company was pioneer in the rubber segment in systematically adopting both a sustainable organizational model and open innovation in Southern Brazil.

Initially, non-participant observation, informal conversations, formal interactions, and the revision of company's documents provided information about the company's context, structure, governance, and history. Then, a guide for orienting data collection through focus group discussions was defined as in Table 3.

The researchers conducted five focus group sections, during the period of August to November 2015. The focus group sections followed the funnel model of questioning, starting with open-ended

and more general questions, narrowed to more specific questioning as the discussions evolved. Participants were one manager, two supervisors, three coordinators, three analysts, and five production assistants. The selection of respondents aimed to ensure a contradictory debate from such a diversified array of functional areas. It equally provided for a balanced view of the structure, governance, and core business of the company, as in the model described in Section 2.3.

The researchers discussed the list of topics and validated the data collected with management strategic positions in the company through interviews. The arising topics were classified according to the dimensions of the previously proposed model. Data analysis was conducted through content analysis protocol (Bardin, 2009).

### 3.2. Case limitations

This research presents the limitations associated to a single case study, thereby analysed as the company developed its organizational sustainability strategies, knowledge management, and open innovation to develop sustainable innovations actions. Other research studies may lead do different results, since path dependency is key to analyse organizational cases. The selected company is differentiated from competitors in its segment, but no explicit information on economic performance in relation to competitors was analysed in order to ensure the company is innovative in the sense of innovation performance (Esslinger, 2011). Another limitation of this research study is related to internal factors found in the company during data collection and analysis: the company was in the middle of an 8-year plan aiming at changing its business focus, leaving the black rubber lines and seeking to develop products for the health sector. This process may have affected the capacity of collecting information, since it took to develop new suppliers, new market niche where the company had no experience.

The next section describes the case study.

## 4. The case study description

The company as mentioned before has 92 years of experience, being currently in the second level of family succession. Two brothers established the company in 1924 to produce rubber artefacts and tire repairs. It produced the first eraser in 1938, which remains a reference in the market until today. Throughout its existence several products marked the history of the company, like tennis balls and individual boats with survival kit for the soldiers of the World War II. The company also pioneered the implantation of production lines for manufacturing rackets and rubber footwear. In 1990 the business units were restructured in production lines for school, body care, and rubber laminated products.

In 2007 the company conducted a survey to evaluate the positioning of its units in the market and it decided that the brand needed to update according to the contemporary values of society. In 2009 it made an institutional commitment to unite people and organization for the creation of sustainable solutions in the rubber products industry, which led the company to impose supply constraints restricting purchases from productive processes related to tobacco and weaponry industries. In the words of one of its managers:

“The current situation reflects a lot about the way we act, mainly because we know that each activity we do to achieve our goals has implications for the people and the world we live. Because of this, we have evolved our strategic area of action for well-being, understanding that the welfare goes from the individual to the

collective, from the parts to the whole, and from competition to cooperation and we set the goal: the world in a good way for all of us.”

In the regional development model wherein the company is, it is considered by other stakeholders (municipalities and civil associations) as adding strategic advantages to the region and to its federative state, characterized by low economic power and industrialization: the company differs from other organizations for being a pioneer, in the rubber segment, in implanting both a sustainable organizational model and open innovation. As an example, the company has a social project focusing on sustainable open innovation for environmental rehabilitation and better use of natural resources, protecting the regions' fauna and flora. Sustainable practices and innovation occurs through the interaction between the company and the indigenous people farming rubber trees.

## 5. Analysis of the case study

This section presents the analysis of the case study. It is based on a search for patterns of data within the case and comparisons with a model of Fig. 1, seeking for empirical validation of findings and theory building. The organizational sustainability strategy drove towards the open innovations dimensions, considering the model of the results in the three key perspectives of eco-innovation: targets, mechanisms, and impacts.

### 5.1. Targets: the strategies that maximize organizational sustainability

The issue of sustainability is present in the declarations of mission, vision, and values of the company, as well as in its management system, based on the three pillars of environmental, social, and economic sustainability. The interviews and the analysis of documents attest that the concept of sustainability is well implemented, reflecting the way its founders comprehended sustainability and how it strives to perpetuate sustainability as an organizational value.

According to the model proposed in Fig. 1, strategic objectives of the company, targets (according to eco-innovations' perspective), gear towards the dimensions of sustainable development, and intend to support its actions and decisions under strategic, tactical, and operational levels. These targets define the content, that is, the set of elementary activities requested by the organizational context, as follows:

- Attention to non-renewable inputs: inputs arising from natural resources that cannot be produced, regenerated, or reused on a scale capable of sustaining their rates of use, or cannot be produced by humans should be reduced. The company monitors and quantifies efforts, sorting all their inputs on tracks ranging from 0% to 100%, the first being the least renewable and the last the most renewable;
- Carbon neutral company: it produces annual reports on its carbon emissions. The company publicly declares its commitment to provide emissions management throughout prevention, correction, and compensation to achieve the goal of becoming “carbon neutral;”
- Imports and local income generation: the company intends to monitor the process of reduction and gradual replacement of imports by domestic production, increasing the generation of jobs and income. These directions are aligned with the process of research and development of new products or business to the

**Table 3**  
Guidelines for focus group discussions by theoretical model's dimensions and constitutive elements.

Open-ended questions about	Model's dimensions	Constitutive elements
All employees know the direction, objectives, and targets of the rubber industry	Governance	Promotion of ideas
The management model in the rubber industry is decentralized	Structure	–
There is openness to employees expression of their opinions	Governance	Engagement of people
There is an organizational culture well defined and clear	Structure	–
There is a communication process within the company	Structure	Network collaboration
There is a communication process with its partners	Structure	Network collaboration
All employees understand the methodology of open innovation	Governance	Engagement of people
The rubber industry is in accordance with the open innovation literature	Structure	Network collaboration/new ideas and technology
There are indicators that measures the development promoted by open innovation	Governance	Promotion of ideas
The rubber industry's open innovation model provides the promotion of the management of both internal and external knowledge	Structure	Inspire KM
The open innovation model is linked to the strategic planning of the industry	Governance	–
The open innovation model is linked to the sector's sustainability	Governance	Network collaboration
There is a consensus of the importance of knowledge management	Governance	Engagement of people
The open innovation contributes to the generation of new knowledge	Core business	New Ideas and technology
The knowledge generated is shared between the partners	Structure	Network collaboration
There are main drivers that the rubber industry is addressing regarding sustainability	Governance	Sustainable competitive advantages
There are practices carried out in the industry to reduce the impacts on sustainability	Core business	Sustainable competitive advantages
There are changes in inputs, products, and processes for open innovation focused on sustainability	Core business	Sustainable competitive advantages
The rubber industry is reaching the goals set	Structure	Sustainable competitive advantages
There are the difficulties that the industry is suffering	Structure	Sustainable competitive advantages

company, in order to ensure the promotion of the social and economic development in the region;

- Restriction of tests with living organisms: the company restricts relationships to organizations that have in their portfolio products that require tests of such nature in any stage of their production processes;
- Difference between the lowest and the highest salary limit: it aims to encourage that remuneration policies and performance, jobs, and salaries in the company contribute effectively to a better distribution of income and reduction of social inequalities;
- Restrictions to market: it is intended to make public to all stakeholders that the company does not perform any business involving processes related to the production of tobacco, weapons exports, alcohol, gambling, pesticides, or productive processes imposing mistreatment of animals. This positioning confirms the company's strategic vision to act strictly for the well-being of the species; and
- Culture alignment efforts: they are represented in internal programs and they create an expectation to employees that the company does not work with the same pace for results than other industries in the market; however, direct observation does not confirm alignment, as it shows an accelerated search for financial results in the day to day work, as in any other organization.

The targets proposed by the company aim at environmental, social, and economic gains, according to eco-innovation. With respect to product development, the results point to a motivating role of new products development, positioning it strategically and seeking to act as a vehicle of change. The company, through monitoring of established key indicators, analyses each one of the target outlined previously. When the target is not within acceptable limits, corrective actions are undertaken.

### 5.2. Mechanisms and impacts: the dimensions of open innovation in the company and their repercussions

The company was a pioneer in the adoption of open innovation. A key factor in the change of strategic behaviour, especially

organizational learning, is the mechanism for the organization to diversify its product lines. In the early 1970s it diversified production to school and sport areas. The company focuses of production were on tennis balls and accessories, for which the main raw material was the natural rubber extracted from the rubber tree latex of the Amazon rainforest in Brazil. At that time the company already had a concern to generate mechanisms that interacted with customers, industries, athletes, and general users of its products.

“[...] In relation to the main raw material of the company, most of our rubbers are from the domestic market. The organization has a strategic project of natural rubber. The objective of this strategic project is to rescue and protect the natural rubber production in the Amazon rainforest, thereby also contributing to sustainability, preservation of the economy, and the livelihoods of indigenous and native communities, assisting in the protection of local flora and fauna of the Amazon ecosystem.” (focus group 3)

Over the years, the company added new products to the school line. This required developing the mechanisms that contribute to the production of differentiated products through the acquisition of new machines (technology), new studies of production and consumer trends, and market acceptance, which included the interaction with customers, in accordance with the model of Fig. 1. However, the company went one-step further in this direction. It interacted with open innovation in relation to schools in the region and in the country. There was a broad discussion about its products, with directors of schools, educators, health professionals, and students in general. Meanwhile, as observed, the process was a strategic tool of social interaction and marketing, allowing the innovation of its products and production methods.

The purpose was to improve the care and quality to the customer, in order to improve the development of new products, to promote a continuous improvement of its services, to increase the efficiency of its processes and operations, and to increase the benefit of the products. The company considers the open innovation as a mechanism for flow of ideas in a broad sense, including the interaction among the stakeholders and the enhancement of the quality offered to clients. The trend towards new and more



sustainable products increased the need for interaction between organizational and social agents and aimed at smaller impacts on the environment following the life cycle of the product, disposal, collection, return, reuse, and reverse logistics. A striking evidence of this line of thinking about organizational sustainability is the import of synthetic rubber, which affects less the environment and links directly with the issues of deforestation and the preservation of the world flora.

The company operates now in Brazil and in the Mercosur trade bloc. It expanded its businesses for the production of medical and physical therapy articles, like kneepads, anklets, slings, and physiotherapy protectors. It is also providing rubber seals and carpets for the automotive and aviation lines.

For a better handling of the model, the company works with open innovation at three different spheres of interaction: education and health, the project “diversity on the streets”, and collaboration. According Fig. 2, open innovation allowed the company to organize the three sphere of interaction, which main purposes are the stimulation of ideas and the development of new products and operations.

According to the company, the first sphere is education and health. With the mechanism design of interaction and open innovation, the company can rethink its ideas and the production of rubber products in the sectors of health and education. Among impacts generated, the company participated in the discussions about the development of new production techniques, new suppliers, and new supply chain that aim to value collaboration in integrated logistics and respect their clients and society.

For the company, knowledge management provides a different culture, where personnel engagement is a differential for knowledge.

The second sphere for the company is the project “diversity on the streets,” which aims at accessibility themes, social inclusion, and diversity. After the maturing process in the company, open innovation encompasses a wide range of active listeners. Open innovation addressed by the company allows a semi-annual meeting, where the community and the various sectors of society discuss new product development (impact). Design and build of products aim at the participation of society’s ideas, respecting the diversity and the general needs of the population, regardless of gender or social class. The goal is also to assist in the formation of several discussion groups for people who have common interests and who together create new social solutions that meet the needs of the majority.

“[...] there must be, at some point, a form of society’s awareness in defining the things that are important after all. The company will not stimulate conscious consumption and lower greenhouse gas emission values, if the consumer does not change his or her concepts and the way to consume, to buy, and to live.” (focus groups 1 and 5)

Still in the open innovation process, there is a mechanism called the laboratory of innovation and social discussion. This allows the electronic integration between the company and other partners through regular meetings. The company strategy is to use integrated structures, practices, and open innovation capabilities. The model demonstrated a different business model for different open innovation strategies focusing on sustainability, creating positive impacts for the company.

The third sphere in the company also has a project called “collaboration,” where a public call is made through different media channels, seeking collective and collaborative mobilization, debate of ideas, and general innovations about new products to improve the quality of life for people with physical limitations and

reduced mobility. In the company, all employees have time and voice in open innovation meetings, where specific suggestions for improvements are rewarded on a regular basis. Later, open innovation extends to suppliers. They are contacted frequently and meetings to open innovation with all suppliers are regularly scheduled.

The supply chain and reverse logistics are other topics of discussion. The company has a clever system of cleaning at the production line where little of the waste is lost. A cleaning is carried out collecting even the smallest pieces and rubber particles, which are then gathered in a boiler. After heating the waste and leftovers of production, the rubber comes back to its natural state of chemical league and becomes a single mass ready to be uploaded as raw material. The requirement is that the thought of recycling and low environmental impacts are also passed on to suppliers and that they understand the environmental and organizational policy. Suppliers also have ideas, improvements, and innovations in the process between raw material and production, which gain prominence in supply. For the company, open innovation provides significant impacts, a connection between network collaboration transforming new ideas from the external point of view. This process favours the company to contribute innovative strategies, generating results across the network.

Other matters are also discussed in the management strategy at the level of new products planning, as using a few toxic products and low environmental impacts. The company also takes advantage of open innovation to discuss ideas about collecting points distributed for discarded products. The design and development of new products have large financial investment and new studies for production of more sustainable products, based in green marketing and eco-design.

Focusing on the environment, the debate about open innovation also allowed these discarded products collection points to be sources of environmental awareness, especially in meetings among company, experts in the field of education, school supplies stores, teachers, and students. One of the basic requirements of open innovation taken seriously by the company as a diffuser of organizational sustainability is to maximize the use and the implementation of external and internal ideas.

“[...] by positioning management, it generates different attitudes that become references and those references help people to be inspired. In search of its own transformation, then, if the company can through its positioning be something that inspires other people, they will have harmony in relationship with other people and organizations.” (focus group 4)

Research and innovation have become a tireless search aiming at quality, diversity, and sustainability.

“[...] the biggest challenge is how to maintain the current structure of the organization and to offer products and services that cause increasingly less negative impacts on the environment and society or, even more that they begin to develop significant impacts on the society and the planet.” (CEO)

In summary, targets, mechanisms, and impacts converge to the promotion of organizational sustainability through the lenses of open innovation.

### 5.3. Final analyses

The targets and mechanisms of open innovation for sustainability reflected the process and product orientation of the

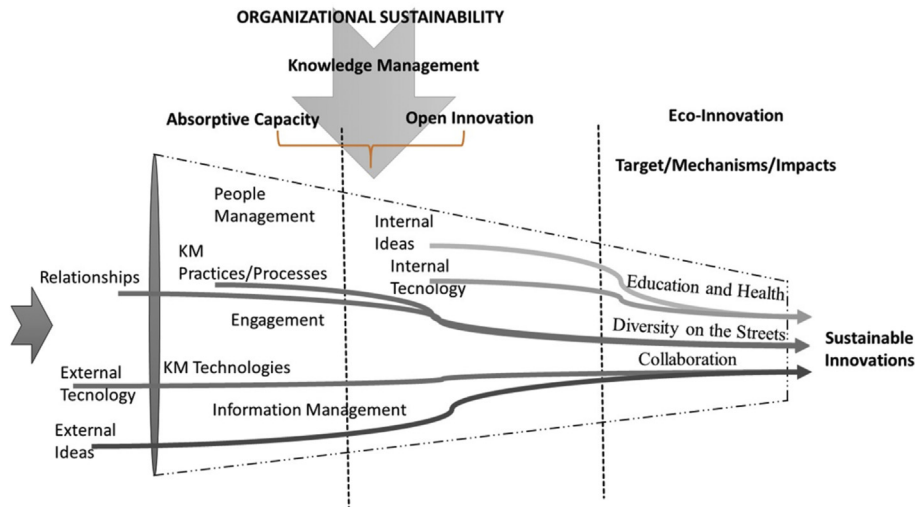


Fig. 2. Open innovation process for sustainability at the case company.

company. For the company, the impacts minimized by strategic interaction and logistics are to guarantee that the raw materials link the ecology with social awareness. Suppliers expose their ideas and studies in relation to raw materials and the supply chain. Deliveries of renewable resources that are more agile and less detrimental to sustainability are also discussed.

“[...] I think that if we start from renewable sources, in the future they will no longer be renewable and thus, in fact, what we are researching and talking enough about is how to review the issue that products and all that we produce is even relevant to people and the world.” (focus group 5).

In this sense, there are also discussions in the company about renewal of the fleets and the use of less polluting fuels. Some indications of environmental impacts exist related in particular to the rescue and the protection of the natural rubber production in the Amazon rainforest and to the on-going discussions about the renewal of the fleets with the use of less polluting fuels. However, the company is largely process oriented as reflected by the paucity of impact indicators and management attitudes towards assessing and evaluating impacts.

Table 4 depicts the positioning of targets and mechanisms in the OECD's (2009) analytical model for eco-innovation.

There is an evolution of the model of the dimensions associated with Depicted organizational targets and mechanisms. Thus there has been a ramp starting from the ideas modification toward creation. As OECD's (2009) there is a ramp initiatives, where companies start by more easy changes such as modification of P&P to the organizational maturity where it can through O&M develop strategies with a high potential for environmental and organizational benefits.

With this re-design becomes the access door to the creation of new ideas and fostering the renewal of organizational learning. As a result of this process of opening and create new alternatives that allow greater interaction between the actors involved and synergy, creating the form of solutions previously not noticeable. So Fig. 2 shows an evolution, organizational strategic thinking and sustainable innovations actions that allow the combination of technological change and substantial results in the processes/organizational knowledge.

## 6. Conclusions

This paper reviewed the theoretical underpins of the interplay of organizational sustainability, knowledge management, and open innovation, offering a novel model to analyse the contributions of organizational sustainability, knowledge management, and open innovation. The organizational survival depends directly on the actions of the creation of new ideas and innovation cycles, and these besides being developed, allowing interaction among stakeholders. Thereby resulting in technology and integrated changes focused on organizational development of production processes, products and new knowledge (internal and external), allowing the sustainable innovations actions of new products and processes.

Open innovation is summarized as a strategic and continuous process of research, development, and innovation of the business in companies, that reaches beyond the company's boundaries to suppliers, customers, and the community. In order to foster open innovation, companies often resort to organizational routines and processes to acquire, assimilate, transform, and exploit knowledge, which is portrayed in this study as the essential concept of absorptive capacity. Through the lenses of absorptive capacity theory (e.g., Zahra and George, 2002), open innovation enriches from knowledge management or from the processes of “capturing, distributing, and effectively using knowledge” (Davenport, 1994).

The study offers a model linking knowledge to open innovation through absorptive capacity and driving to the competitive advantages of flexibility, company's performance and innovative processes and products, seeking to extend the view on the subjects, as indicated in similar case and survey studies found in the literature (Gluch et al., 2009; De Marchi and Grandinetti, 2013). The proposed model includes sustainable competitive advantages in an integrated conceptual manner for organizational sustainability, through knowledge management and open innovation. Organizational sustainability is understood in a broad sense including the environmental, social, and economic impacts of the company businesses and production processes and products. The model posits to apply to the content of activities, structure, and governance of a company.

The model leads to a rigorous exploratory single case study research of a Brazilian company in the rubber products industry. Despite its rigor, single case studies have the limitation of low generalizability (or external validity) and might be prone to exaggerate results obtained from easily obtainable data or from single

**Table 4**  
Positioning of eco-innovation in the company by targets and mechanisms.

Model dimensions	Depicted organizational targets	Mechanisms				Key aspects
		Modification	Redesign	Alternatives	Creation	
Core business	O&M	Difference between the lowest and the highest salary limit; restrictions to unethical markets.	Eco design and green marketing.	Project “diversity in the streets.”	New niche products for health line. Management focused on participative leadership.	Results from the interaction of organizational sustainability, open innovation, and knowledge management in practice in a real world environment.
	P&P		Collecting points for discarded products.		New raw materials, lower environmental impact	
Structure and inter-relations	O&M	Cultural alignment in non-economic sustainability.		Open innovation debates including customers and suppliers. Laboratory of innovation and social discussion.		
	P&P			Open collaboration by public calls.		
Governance	O&M	Non-renewable inputs reduction.	Use of synthetic rubber.			
	P&P	Use of fewer toxic products. Recycling of rubber left over from production.	New product development; new product lines (expansion to education and health). Capacity absorptive			
Key aspects		Knowledge management		Open innovation	Organizational sustainability	

influential respondents. This study attempts to circumvent this recognized limitation by triangulation of direct observation, semi-structured questionnaires, and focus group discussions with multiple informants, as well as by comparison of results with other single case study research from the literature. The unit of analysis was chosen based on theoretical sampling (Voss et al., 2002) that was relevant to the model, generalizable to other settings in similar companies, feasible and ethical to collect data. Observer bias was constrained by an attempt to answer research questions, applying a model for data collection and a systematic search for within case patterns for theory building.

In answering “RQ1 – Whether organizational sustainability, knowledge management, and open innovation are intertwined?” this study posits that open innovation establishes the flow of external information of the organization and is intertwined with organizational sustainability through knowledge management, viewed through the backdrop of absorptive capacity theory and eco-innovation.

The observed targets for sustainable practices were attention to non-renewable inputs, a carbon neutral policy, promotion of local production and income generation, restrictions to tests on living organisms, salaries equity, restrictions to unethical businesses (e.g., weaponry and tobacco production), and to a lesser extent being less economic results-oriented than its competitors (described in the case as culture alignment). It becomes evident that organizational sustainability, knowledge management, and open innovation are drivers for the achievement of sustainable innovations.

The case company seeks sustainable innovations design to attend the expectations and needs of its customers by investing in research, innovation, stakeholders, and new product development through continuous improvement. The leaders of the company believe that through their existing strategic tools/mechanisms in

the conduct of their business, including open innovation, they can make large-scale gains in production and sales, because of the acceptance of the products by the customers, who share and gain from new ideas and perspectives.

The open innovation mechanisms promote external organizational knowledge adding to internal interaction with organizational knowledge more to the value chain. In order to enhance innovation, the studied company opened its doors to ideas that come from the external environment (Chesbrough, 2003), their customers, suppliers, community, and employees. Also open innovation enabled breaking previous paradigms where the closed innovation became an obsolete and precarious front for business organizational sustainability.

In answering “RQ2 – Whether organizational sustainability, knowledge management, and open innovation interact in practice in a real world environment?”, results of case studies from the literature review show a large concentration of eco-innovation on products and processes with few targets at the organizational and institutional levels. However, in the case of this study the use of open innovation placed the initiatives of organizational sustainability upper in the scale of targets, with several examples of organizational and marketing targets, in addition to initiatives geared at product and process targets alone.

The relational nature of open innovation placed the mechanisms for eco-innovation in this case study in the categories of the more elaborated mechanisms of re-design and alternatives, going beyond the simpler mechanisms of modification of existing processes. In the case company, open innovation seems to act as an accelerator of eco-innovation. However, there was little or no evidence of direct monitoring of sustainability impacts.

The theoretical contribution of this study is four-fold. First, it is among the first of its kind to offer a literature review aiming at

integrating the concepts of organizational sustainability, knowledge management, and open innovation. Second, it proposes a simple model relating organizational sustainability, knowledge management, open innovation, and sustainable innovations through the lenses of absorptive capacity theory and eco-innovation. Third, it summarizes a model synthesizing the sustainable competitive advantages emanated from an integrated knowledge management and open innovation approach in a research model. Fourth, it places open innovation on the realm of the main stream of OCDE's (2009) eco-innovation research on targets, mechanisms, and impacts of organizational sustainability.

There are three broad lessons for practice. A first practical implication is that the strategies to propel the generation of knowledge and open innovation should be the focus, the target of similar companies, since companies can no longer depend only on its own internal areas, requiring oxygenate through external sources of technology, knowledge, or innovation to boost domestic growth. The second practical implication is the mechanisms of active involvement of suppliers, customers, and communities derived from the strategic focus on sustainability and open innovation; these are effective drivers to gain market-share and maintain the client basis. The third implication is the road map to expand from a product and process based target to organizational and marketing methods and ultimately to institutional arrangements (e.g. associations and policies), as well as from mechanisms of modification to re-design, to alternative arrangements, and to the creation of radically new mechanisms to shape eco-innovation.

Looking ahead, the company should consider investing in mechanisms that manage new ideas, concepts, and research that enable integration with the different links in the value chain. In addition, it should stimulate and monitor the impacts of new ideas with customers, suppliers, and employees, enabling greater communication with universities, users of other products, and political entities. It should promote the integration and diversification of social groups and the press, searching for new partners or strategic alliances. In the future, researchers should look for a deeper understanding of the benefits generated by the association between organizational sustainability, knowledge management, open innovation, and sustainable innovations and the researchers could analyse their correlations or causalities. Also create indexes and measurement of parameters of the results of sustainable innovations and that promotes continuous improvement of processes and products. Future research studies can analyse other organizational environments to identify how other organizations are positioning themselves in the face of the challenge of developing sustainability with the support of open innovation, interplay with the generation and management of knowledge.

## Acknowledgements

The authors equally acknowledge the support of the following Brazilian agencies: CAPES, CNPq, FAPERJ, and FAPERGS.

## References

- Agha, S., Alrubaiee, L., Jamhour, M., 2012. Effect of core competence on competitive advantage and organizational performance. *Int. J. Bus. Manag.* 7 (1), 192.
- Alavi, M., Leidner, D.E., 1999. Knowledge management systems: issues, challenges, and benefits. *Commun. Assoc. Inf. Syst.* 1 (7), 1–37.
- Andersen, M.M., 2002. Organising interfirm learning: as the market begins to turn green. In: de Bruijn, T.J.N.M., Tukker, A. (Eds.), *Partnership and Leadership: Building Alliances for a Sustainable Future*. Kluwer, Dordrecht, pp. 103–119.
- Arbussa, A., Coenders, G., 2007. Innovation activities, use of appropriation instruments and absorptive capacity: evidence from Spanish firms. *Res. Policy* 36 (10), 1545–1558.
- Bardin, L., 2009. *Análise de Conteúdo*. Lisboa, Portugal; Edições 70, LDA.
- Braungart, M., McDonough, W., 2013. *The upcycle: beyond sustainability – designing for abundance*. North Point Press, New York.
- Braungart, M., McDonough, W., Bollinger, A., 2007. Cradle-to-cradle design: creating healthy emissions. *J. Clean. Prod.* 15, 1337–1348.
- Buys, L., Mengersen, K., Johnson, S., Buuren, N.V., Chauvin, A., 2014. Creating a sustainability scorecard as a predictive tool for measuring the complex social, economic and environmental impacts of industries, a case study: assessing the viability and sustainability of the dairy company A. *J. Environ. Manag.* 133, 184–192.
- Carayannis, E.G., Sindakis, S., Walter, C., 2015. Business model innovation as lever of organizational sustainability. *J. Technol. Transf.* 40 (1), 85–104.
- Carson, R., 1962. *The Silent Spring*. Houghton Mifflin, Boston.
- Chen, Y.S., 2008. The driver of green innovation and green image. *J. Bus. Ethics* 81, 531–543.
- Chen, Y.S., Chang, C.H., Wu, F.S., 2012. Origins of green innovations: the differences between proactive and reactive green innovations. *Manag. Decis.* 50 (3), 368–398.
- Chen, Y., Lai, S., Wen, T., 2006. The influence of green innovation performance on corporate advantage in Taiwan. *J. Bus. Ethics* 67 (4), 331–339.
- Chesbrough, H., 2006. *Open Innovation: A New Paradigm for Understanding Industrial Innovation*. Open Innovation: Researching a New Paradigm. Oxford University Press, Oxford.
- Chesbrough, H., Schwartz, K., 2007. Innovating business models with co-development partnerships. *Res. Technol. Manag.* 50 (1), 55–59.
- Chesbrough, H.W., 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press, Boston, MA.
- Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning and innovation. *Adm. Sci. Q.* 35 (1), 128–152.
- Cui, T., Ye, H., Teo, H.H., Li, J., 2015. Information technology and open innovation: a strategic alignment perspective. *Inf. Manag.* 52 (3), 348–358.
- Davenport, T.H., 2013. *Process Innovation: Reengineering Work through Information Technology*. Harvard Business Press.
- Davenport, T.H., 1994. Saving IT's soul: human centered information management. *March-April Harv. Bus. Rev.* 72 (2), 119–131.
- De Marchi, V., 2012. Environmental innovation and R&D cooperation: empirical evidence from Spanish manufacturing firms. *Res. Policy* 41 (3), 614–623.
- De Marchi, V., Grandinetti, R., 2013. Knowledge strategies for environmental innovations: the case of Italian manufacturing firms. *J. Knowl. Manag.* 17 (4), 569–582.
- Dittrich, K., Duysters, G., 2007. Networking as a means to strategy change: the case of open innovation in mobile telephony. *J. Prod. Innov. Manag.* 24 (6), 510–521.
- Donate, M.J., Guadamillas, M.J., 2011. Organizational factors to support knowledge management and innovation. *J. Knowl. Manag.* 15 (6), 890–914.
- Dosi, G., Faillo, M., Marengo, L., 2008. Organizational capabilities, patterns of knowledge accumulation and governance structures in business firms: an introduction. *Org. Stud.* 29 (8–9), 1165–1185.
- Dow, R.M., Pallaschke, S., 2010. Managing knowledge for spacecraft operations at ESOC. *J. Knowl. Manag.* 14 (5), 659–677.
- Dyllick, T., Hockerts, K., 2002. Beyond the business case for corporate sustainability. *Bus. Strategy Environ.* 11, 130–141.
- Elkington, J., 1994. Towards the sustainable corporation: win-win-win business strategies for sustainable development. *Calif. Manag. Rev.* 36 (2), 90–100.
- Esslinger, H., 2011. Sustainable design: beyond the innovation driven business model. *J. Prod. Innov. Manag.* 28, 401–404.
- Faisal, M.N., 2010. Analysing the barriers to corporate social responsibility in supply chains: an interpretive structural modelling approach. *Int. J. Logist. Res. Appl.* 13 (3), 179–195.
- Fiksel, J., 1996. *Design for Environment*. Total Quality Environmental Management. John Wiley & Sons, Inc.
- Freel, M., 2006. Patterns of technological innovation in knowledge intensive business services. *Ind. Innov.* 13 (3), 335–359.
- Fussler, C., James, P., 1996. *A Breakthrough Discipline for Innovation and Sustainability*. Pitman Publishing, London, UK.
- García-Álvarez, M.T., 2015. Analysis of the effects of ICTs in knowledge management and innovation: the case of Zara Group. *Comput. Hum. Behav.* 51 (PartB), 994–1002.
- Gassmann, O., Enkel, E., 2004. In: *Proceedings of the R&D Management Conference (RADMA)*. Lisbon.
- Gaziulusoy, A.I., Boyle, C., McDowall, R., 2013. System innovation for sustainability: a systemic double-flow scenario method for companies. *J. Clean. Prod.* 45, 104–116.
- Ghisellini, P., Cialani, C., Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *J. Clean. Prod.* 114, 11–32.
- Ghisetti, C., Marzucchi, A., Montresor, S., 2015. The open eco-innovation mode. An empirical investigation of eleven European countries. *Res. Policy* 44 (5), 1080–1093.
- Gimenez, C., Sierra, V., Rodon, J., 2012. Sustainable operations: their impact on the triple bottom line. *Int. J. Prod. Econ.* 140 (1), 149–159.
- Gluch, P., Gustafsson, M., Thuvander, L., 2009. An absorptive capacity model for green innovation and performance in the construction industry. *Constr. Manag. Econ.* 27 (5), 451–464.
- Hallstedt, S.L., Thompson, A.W., Lindahl, P., 2013. Key elements for implementing a strategic sustainability perspective in the product innovation process. *J. Clean. Prod.* 51, 277–288.
- Hart, S.L., Milstein, M.B., 2003. Creating sustainable value. *Acad. Manag. Exec.* 17 (2), 56–69.



- Heikkurinen, P., Bonnedahl, K.J., 2013. Corporate responsibility for sustainable development: a review and conceptual comparison of market- and stakeholder-oriented strategies. *J. Clean. Prod.* 43, 191–198.
- Hellström, A., Lifvergren, S., Gustavsson, S., Gremyr, I., 2015. Adopting a management innovation in a professional organization: the case of improvement knowledge in healthcare. *Bus. Process Manag. J.* 21 (5), 1186–1203.
- Horbach, J., 2008. Determinants of environmental innovation: new evidence from German panel data sources. *Res. Policy* 37 (1), 163–173.
- Huang, T., Wang, W.C., Ken, Y., Tseng, C.Y., Lee, C.L., 2010. Managing technology transfer in open innovation: the case study in Taiwan. *Mod. Appl. Sci.* 4 (1), 2–11.
- Huizingh, E.K., 2011. Open innovation: state of the art and future perspectives. *Technovation* 31 (1), 2–9.
- Infante, C.E.D.D.C., de Mendonça, F.M., Purciconio, P.M., Valle, R., 2013. Triple bottom line analysis of oil and gas company A with multicriteria decision making. *J. Clean. Prod.* 52, 289–300.
- Jones, J.L.S., Linderman, K., 2014. Process management, innovation and efficiency performance: the moderating effect of competitive intensity. *Bus. Process Manag. J.* 20 (2), 335–358.
- Kian, T.S., Fauziah, W., Yusoff, W., 2015. Motivation and promotion opportunity of academic citizens towards open innovation: proposed model. *Proc. Soc. Behav. Sci.* 204, 29–35.
- Kim, B., Kim, E., Foss, N.J., 2015. Balancing absorptive capacity and inbound open innovation for sustained innovative performance: an attention-based view. *Eur. Manag. J.* 34 (1), 80–90.
- Kucukvar, M., Egilmez, G., Tatari, O., 2014. Sustainability assessment of U.S. final consumption and investments: triple-bottom-line input–output analysis. *J. Clean. Prod.* 81, 234–243.
- Labuschagne, C.L., Brent, A.C., van Erck, R.P.G., 2005. Assessing the sustainability performance of industries. *J. Clean. Prod.* 13, 373–385.
- Lee, H.S., Suh, Y.H., 2003. Knowledge conversion with information technology of Korean companies. *Bus. Process Manag. J.* 9 (3), 317–336.
- Lee, K.H., Saen, R.F., 2012. Measuring corporate sustainability management: a data development analysis approach. *Int. J. Prod. Econ.* 140 (1), 219–226.
- Lieder, M., Rashid, A., 2016. Towards circular economy implementation: a comprehensive review in context of manufacturing industry. *J. Clean. Prod.* 115, 36–51.
- Longoni, A., Golini, R., Cagliano, R., 2014. The role of New Forms of Work Organization in developing sustainability strategies in operations. *Int. J. Prod. Econ.* 147 (PartA), 147–160.
- López-Nicolás, C., Meroño-Cerdán, A.L., 2011. Strategic knowledge management, innovation and performance. *Int. J. Inf. Manag.* 31 (6), 502–509.
- Lovelock, J., 1974. Atmospheric Homeostasis by and for the Biosphere: the Gaia Hypothesis. <http://www.jameslovelock.org/page34.html>. Cited on 30 mar 2013.
- Lütkemeyer Filho, M., Vaccaro, G., Moraes, G.L.R., 2014. A historical perspective of sustainable approaches for product development. In: Proceedings of the 8<sup>th</sup> International Conference on Industrial Engineering and Industrial Management – XVIII Congreso de Ingeniería de Organización – XX International Conference on Industrial Engineering and Operations Management – International IIE Conference 2014 (Málaga).
- Madrigal-Sánchez, J., Quesada-Pineda, H., 2012. Innovation: case study among wood, energy and medical firms. *Bus. Process Manag. J.* 18 (6), 898–918.
- Mancinelli, S., Mazzanti, M., 2009. Innovation, networking and complementarity: evidence on SME performances for a local economic system in North-Eastern Italy. *Ann. Reg. Sci.* 43 (3), 567–597.
- Meadows, D.H., Meadows, D.L., Randers, J., Behrens, W.W., 1972. *Os Limites Do Crescimento [Limits to Growth]*, first ed. Perspectiva, São Paulo.
- Miles, H., Huberman, M., 1994. *Qualitative data analysis: a sourcebook*. Sage Publications, Beverly Hills, CA.
- Nidumolu, R., Prahalad, C.K., Rangaswami, M.R., 2009. Why sustainability is now the key driver of innovation. *Harv. Bus. Rev.* 87, 25–34.
- Niehaves, B., 2010. Open process innovation: the impact of personnel resource scarcity on the involvement of customers and consultants in public sector BPM. *Bus. Process Manag. J.* 16 (3), 377–393.
- Nissen, M.E., 2005. Experimental assessment of an innovation knowledge system for decision support. *Bus. Process Manag. J.* 11 (5), 444–475.
- OECD (Organisation for Economic Co-operation and Development), 2009. *Eco-innovation in Industry: Enabling Green Growth*.
- Perkmann, M., Walsh, K., 2007. University–industry relationships and open innovation: towards a research agenda. *Int. J. Manag. Rev.* 9 (4), 259–280.
- Porter, M.E., Van der Linde, C., 1995. Toward a new conception of the environment-competitiveness relationship. *J. Econ. Perspect.* 9 (4), 97–118.
- Renning, K., 2000. Redefining innovation—eco-innovation research and the contribution from ecological economics. *Ecol. Econ.* 32 (2), 319–332.
- Renning, K., Ziegler, A., Ankele, K., Hoffmann, E., 2006. The influence of different characteristics of the EU environmental management and auditing scheme on technical environmental innovations and economic performance. *Ecol. Econ.* 57 (1), 45–59.
- Ribeiro, I., Kaufmann, J., Schmidt, A., Peças, P., Henriques, E., Götze, U., 2015. Fostering selection of sustainable manufacturing technologies – a case study involving product design, supply chain and life cycle performance. *J. Clean. Prod.* 112, 3306–3319.
- Rogbeer, S., Almahendra, R., Ambos, B., 2014. Open-innovation effectiveness: when does the macro design of alliance portfolios matter? *J. Int. Manag.* 20 (4), 464–477.
- Saebi, T., Foss, N.J., 2015. Business models for open innovation: matching heterogeneous open innovation strategies with business model dimensions. *Eur. Manag. J.* 33 (3), 201–213.
- Sanders, J.L., Linderman, K., 2014. Process management, innovation and efficiency performance. *Bus. Process Manag. J.* 20 (2), 335–358.
- Schaltegger, S., Lüdeke-Freund, F., Hansen, E.G., 2012. Business cases for sustainability: the role of business model innovation for corporate sustainability. *Int. J. Innov. Sustain. Dev.* 6 (2), 95–119.
- Schumpeter, J.A., 1934. *The Theory of Economic Development: an Inquiry into Profits, Capital, Credit, Interest and the Business Cycle*. Harvard University Press, Cambridge, Mass.
- Schumpeter, J.A., 1942. *Creative Destruction - Capitalism, Socialism and Democracy*. Harper, New York, NY.
- Seethamraju, R., Marjanovic, O., 2009. Role of process knowledge in business process improvement methodology: a case study. *Bus. Process Manag. J.* 15 (6), 920–936.
- Stabel, W., 2010. *The Performance Economy*, second ed. Palgrave Macmillan, London.
- Terwiesch, C., Xu, Y., 2008. Innovation contests, open innovation, and multiagent problem solving. *Manag. Sci.* 54 (9), 1529–1543.
- Thomé, A.M.T., Scavarda, A., 2015. A systematic literature review of design manufacturing integration for sustainable products. *Chem. Eng. Trans.* 45, 691–696. <http://dx.doi.org/10.3303/CET1545116>.
- Thomé, A.M.T., Scavarda, A., Ceryno, P.S., Remmen, A., 2016. Sustainable new product development: a longitudinal review. *Clean. Technol. Environ. Policy*. <http://dx.doi.org/10.1007/s10098-016-1166-3>.
- Todorova, G., Durisin, B., 2007. Absorptive capacity: valuing a reconceptualization. *Acad. Manag. Rev.* 32 (3), 774–786.
- Voss, C., Tsikriktsis, N., Frohlich, M., 2002. Case research in operations management. *Int. J. Op. Prod. Manag.* 22 (2), 195–219.
- Wacker, J.G., 1998. A definition of theory: research guidelines for different theory building research methods in operations management. *J. Op. Manag.* 16 (4), 361–385.
- Wang, C.H., Chang, C.H., Shen, G.C., 2015. The effect of inbound open innovation on firm performance: evidence from high-tech company A. *Technol. Forecast. Soc. Change* 99, 222–230.
- West, J., Gallagher, S., 2006. Challenges of open innovation: the paradox of firm investment in open-source software. *R&D Manag.* 36 (3), 319–331.
- World Business Council for Sustainable Development (WBSCD), 2000.
- Yin, R., 2009. *Case Study Research*. Sage Publications, Beverly Hills, CA.
- Zahra, S., George, G., 2002. Absorptive capacity: a review, reconceptualisation, and extension. *Acad. Manag. Rev.* 27 (2), 185–203.
- Zemaitis, E., 2014. Knowledge management in open innovation paradigm context: high tech sector perspective. *Proc. Soc. Behav. Sci.* 110, 164–173.