

Industrial synergies from “hidden structures” of knowledge. Towards the foundation of industrial ecosystems.

Sinergias industriales de “estructuras invisibles” de conocimiento. Hacia la fundación de ecosistemas industriales.

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Abstract: Industrial strategies based on industrial ecology and circular economy have populated the current industrial landscape. However, these approaches focusing on the creation of symbiotic relationship among industries have been relatively insufficiently researched. Although economically and environmentally beneficial, the process of their emergence and development remains unclear. This conceptual research advances the potential role of knowledge in the creation of symbiotic linkages through a qualitative theoretical literature research. The result is a conceptual framework combining different theoretical streams. I conclude that by using absorptive capacity constructs coupled with the principles of industrial ecosystem framed under social network analysis, the genesis of industrial ecosystem can be unearthed.

Keywords: industrial ecology; absorptive capacity; knowledge networks; circular economy.

Resumen: Las estrategias industriales basadas en la ecología industrial y la economía circular han poblado el panorama industrial actual. Sin embargo, los enfoques que se centran en la creación de relaciones simbióticas entre las industrias han sido relativamente poco investigados. Aunque económica y ambientalmente beneficioso, el proceso de su surgimiento y desarrollo sigue sin estar claro. Esta investigación conceptual avanza en el papel potencial del conocimiento en la creación de enlaces simbióticos a través de una investigación cualitativa de revisión de literatura teórica. El resultado es un marco conceptual que combina diferentes corrientes teóricas. Se concluye que, al usar constructos como capacidad de absorción junto con los principios del ecosistema industrial enmarcados en el análisis de redes sociales, el génesis de un ecosistema industrial puede ser descubierto.

Palabras clave: ecología industrial; capacidad de absorción; redes de conocimiento; economía circular.



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Sinergias industriais de “estruturas escondidas” do conhecimento.

Em direção à fundação dos ecossistemas industriais.

Resumo: Estratégias industriais baseadas na ecologia industrial e na economia circular povoaram o cenário industrial atual. No entanto, essas abordagens que se concentram na criação de relações simbióticas entre indústrias têm sido relativamente pouco pesquisadas. Embora seja econômico e ambientalmente benéfico, o processo de seu surgimento e desenvolvimento permanece incerto. Esta pesquisa conceitual avança o papel potencial do conhecimento na criação de vínculos simbióticos por meio de uma revisão qualitativa da literatura teórica. O resultado é uma estrutura conceitual que combina diferentes correntes teóricas. Conclui-se que, usando construções como capacidade de absorção juntamente com os princípios do ecossistema industrial enquadrados na análise de redes sociais, pode-se descobrir a gênese de um ecossistema industrial.

Palavras-chave: ecologia industrial; capacidade de absorção; redes de conhecimento; economia circular.

Industrial synergies from “hidden structures” of knowledge

Recycling, remediation and eco-efficiency are not sufficient (Palko, 2005). Industrialization has considerably reduced the available natural resources being nearly 30% of these unfeasible to salvage through natural means (Gore, 2006). Coupled with today's hypercompetitive environment (D'Aveni, Dagnino, & Smith, 2010) the rise of a knowledge-based economy (Grant, 1996) ephemeral competitive advantages and the rising pressures towards a more ecocentric paradigm of production (Shrivastava, 1995), industries are increasingly forming inter-firm alliances as hidden industrial structures (Hagedoorn & Schakenraad, 1990). These alliances represent links for sharing resources and knowledge to foster innovative productivity (Ahuja, Lampert & Tandon, 2008). These concerns have given impetus to a relatively new integrated management approach in industry based on industrial ecology. It advocates that these industrial systems could and should operate through symbiotic linkages among firms according to the principles that drive natural systems (Geng & Cote, 2007) whose final aim is to form industrial ecosystems. These strategies are in line with a new economic model called Circular Economy (Andersen, 2007; Saavedra, Iritani, Pavan, & Ometto, 2018; Stahel, 2010;) that aims at decoupling wealth creation from resource extraction by emulating natural cycles (Ellen MacArthur Foundation, 2012) such as interfirm symbiosis.

Although economically and environmentally beneficial, the process of emergence and development of these symbiotic linkages seem far from straightforward (Doménech & Davis, 2011a). The question of how



these industrial ecosystems are constructed remains up to date partially unanswered (Chertow, 2007). I argue that there are two approaches for addressing these questions related to industrial ecosystems. On the one hand, there are studies that focus on the flows of measurable residues or resources among firms. This stream has been taking place in the literature in form of mainly case studies where rich detailed data over the quantities of wastes exchanged, the virgin resources saved is available (e.g. Chertow, Ashton & Espinosa, 2008; Fujita, 2009; Gertler, & Ehrenfeld, 1996, 1997; Van Berkel et al., 2009; Zhu et al., 2007; Zhu & Cote, 2004). Although this body of knowledge represents an advance in industrial ecology literature, it remains focused on physical aspects leaving cavity to research the non-physical aspects of industrial ecosystems, such as knowledge, which is the second approach and focus of the present paper.

I contend that for these wastes, residues (resources) to flow from one firm to another, knowledge in form of processes, technology, patents and know-how is needed for transforming them into higher value, i.e. upcycling (McDonough & Braungart, 2013) within the context of industrial ecology literature. The impact of knowledge factors over the symbiotic linkages among industrial ecosystems' formation has been overlooked in the literature with few exceptions. Among these exceptions Ashton and Bain (2012) study the impact of trust, openness and communication on the linkages of an industrial complex in Denmark. Also, Belaire et al. (2011) analyse the flow of information and its impact over collaboration towards conservation of natural resources finding that interconnectedness among actors enhanced the collaboration and problem-solving. Finally, Walter and Schotlz (2006) focus on innovation networks and how diversity, density and knowledge integration affects its formation. In sum, these researchers have addressed the flow of information and its relevance on collaborative linkages using social network analysis. Despite the increasing use of social network analysis in recent years, which according to Doménech and Davies (2011b) provides comprehensive methodological and analytical framework to understand industrial ecosystems, these studies have ignored the role of knowledge constructs such as absorptive capacity to uncover its impact on the creation of symbiotic linkages.

Consequently, in order to abridge this gap this article addresses the following research questions:

RQ1: What is the role of firm knowledge on the establishment of interorganizational symbiotic linkages?



RQ2: How knowledge transfer and the absorptive capacity of firms, in the form of technological innovations such as processes or products can shape the formation of synergistic networks aiming towards sustainability?

RQ3: How can these linkages be encouraged in order to construct an industrial ecosystem?

To answer these three key questions, I have adopted a theoretical literature review approach as follows. First, I depart from the SWIT (sustainable wealth creation through innovation and technology) model (Scheel, 2016), which stresses the importance of technology and process identification in the construction of industrial ecosystems. Moreover, I use two of Korhonen's (2001) basic principles of industrial ecosystems to emphasize the importance of knowledge. Furthermore, I underline the role of absorptive capacity (Cohen & Levinthal, 1990) both potential (PACAP) and realized (RACAP) absorptive capacity (Zahra & George, 2002) as promoters of the construction and maintenance of symbiotic linkages. Finally, coupled with structural holes concept derived from social network (Burt, 1992; Wasserman & Faust, 1994) I argue that the creation of these linkages reduces the existence of structural holes in a network. In other words, the present research unearths the role of absorptive capacity of firms' within a network for the establishment of symbiotic linkages among firms, which in turn fosters the creation of both an industrial ecosystem and a competitive advantage to the firms involved based on cost reduction (Ehrenfeld & Chertow, 2002).

The research is broadly propelled from Ahuja et al. (2008) and Zhou and Li (2012) concerns over the still unexplored connection of the network properties and the capabilities firms need to possess to benefit from knowledge. The paper proceeds as follows. First, I review the concepts related to industrial ecology. Then I highlight its importance on industrial ecosystems formation. Moreover, I present the SWIT model that focus on the formation of these ecosystems. By listing its phases, I concentrate in the technology transfer phase where the literature regarding firms' knowledge is of great relevance. In the following section I introduce Korhonen's (2001) four principles of industrial ecosystems and highlight the importance of researching their knowledge aspect on the creation of symbiotic linkages. Additionally, I briefly review the concept of structural holes (Burt, 1992) from social network analysis in order to have an empirical measure for the evaluation of a nascent industrial ecosystem. Furthermore, I present the theoretical aspects of absorptive capacity and its subsets in order to establish a connection between these constructs



and the creation of industrial ecosystems. Likewise, social network analysis is briefly described as an important methodology that might help to unearth important characteristics of these firms and the potential synergies that could arise from knowledge transfer among them. Several propositions are offered along with a corresponding discussion. Finally, I offer possible future research avenues and conclusions.

Theoretical literature review

Industrial ecology and symbiosis

Traditional biological ecology is defined as the scientific study of the interactions that determine the distribution and abundance of organisms (Jelinski, Graedel, Laudise, McCall & Patel, 1992). In a biological ecosystem, organisms use several inputs such as water, sunlight and minerals to grow, while others feed on them and produce their own waste. These wastes are used as food for other organisms and so on, until a complex network of processes in which everything produced is used by some organism for its own metabolism is created. In the same way the attempt of industrial ecosystems is to operate through analogy that although not perfect, could mimic the best features of the biological analogue (Jelinski, et al., 1992).

The field of industrial ecology has been developing for several decades. Frosch and Gallopoulos (1989) coined the term "industrial ecosystem" which later became more known as industrial ecology. "The idea of an industrial ecology is based upon a straightforward analogy with natural ecological systems. In nature an ecological system operates through a web of connections in which organisms live and consume each other and each other's waste" (Frosch, 1992:800).

Industrial ecology is an integrated system in which the consumption of energy and materials is optimized and the effluents of one process serve as the raw material(s) or energy for another process (Frosch & Gallopoulos, 1989). One of the main branches of IE is industrial symbiosis (IS) (Chertow, 2000). IS focuses on the flow of resources through clusters of geographically proximate businesses (Chertow, 2000). To create such industrial ecosystems, I argue that the SWIT model (Scheel, 2016) can be implemented. The next section describes briefly the SWIT model and the main phases, one of which is the focus of the present research called processes and technologies identification.



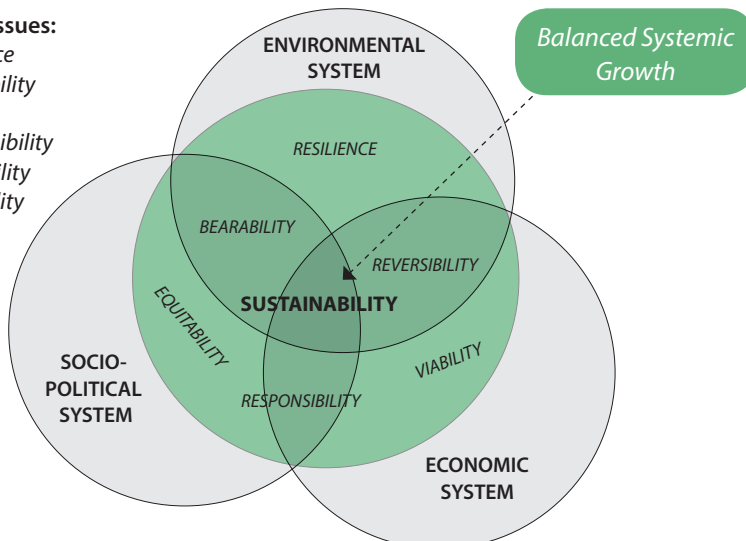
The SWIT model

The SWIT model (Scheel, 2016) has been designed based on the articulation of the systemic thinking, industrial ecology, blue economy, entrepreneurship, systemic, technological and regional innovation systems designed to create 0-emissions (Pauli, 2010) ecosystems where all the inputs of the network are transformed and remain within it through the transformation of wastes produced into higher nutrients value (economic, social and environmental) for other transformation processes within the region (Scheel, 2014). This means reverting the equation, to convert community sustainable practices and restrictions into economically competitive and socially beneficial products. The model maintains that residues are possible and feasible to transform in order to create sustainable wealth: EVA (economic value added), social welfare (jobs) and natural resilience in order to recover air, land and water resources. The SWIT has been used in a diverse array of projects of regional development based on a Plan of Technological Science and Innovation for developing countries. The articulation and balance of these three systems (environment, socio-political and economic) (Elkington, 1998) generates the emerging attributes of the ecosystem, which are: equitability, responsibility, viability, reversibility, bearable, sustainability and resilience (Fig. 1).

Figure 1. SWIT Model: Creates a sustainable business model capable to articulate and balance the multiple attributes of the regional industrial ecology system.

The Six Issues:

- Resilience
- Reversibility
- Viability
- Responsibility
- Equitability
- Bearability



Source: Adapted from Scheel (2016).



The SWIT's roadman is divided into the following phases: (a) mapping the extended value system of the industry, (b) synergy (inventory) of residues, (c) residues based regional synergies, (d) identification of economic value opportunities (business), social (quality of life) and ecological (environmental), (e) processes and technologies identification, (f) linked producer-product matrix (LPPM), (g) systems dynamic modelling, (h) start-ups' clusterization strategies and (i) systemic assembly of regional business models aiming at developing a well-articulated mechanism, replicable and effective, for the generation of an innovation cluster for multiple start-ups and business models, based on residues from the industry (Scheel, 2014). The focus is on the phase where processes and technologies must be identified, assimilate and deployed for uncovering the potential value of residues. This phase represents the crossroads of the model given that it is knowledge intensive and here the feasibility of the potential revalorization of residues is addressed. This feasibility depends on firms' ability to recognize the value of new information, assimilate it, and apply it to commercial ends, which is closely aligned with Cohen and Levinthal's (1990) absorptive capacity, a phenomenon rooted in the knowledge-based view of the firm (Grant, 1996) and in the dynamic capabilities (Teece, Pisano & Shuen, 1997).

Principles of industrial ecosystems

Korhonen (2001) states that, in order for an industrial cluster to become an industrial ecosystem, it must follow four basic principles. The first principle is called roundput. Roundput refers to the utilization of waste, material and energy in cooperation. The purpose of the principle of roundput is that residues can flow in a cascade-like fashion in order for other firms to use the wastes as feedstock. The second principle is diversity. Korhonen (2001) based on his studies of the finish forestry industry realized the importance of diversity on industrial ecosystems. Diversity is related to the need of having different types of industries operating, because this diversity allows the generation of distinct wastes around the production chain in for of sub products, residues or wastes which are potentially tradable or exchangeable between firms. The third principle is locality. Locality suggests that for the firms to cooperate and exchange residues, these must be proximate or within the region. Finally, the fourth principle is gradual change. It implies that adaptation between the firm's processes is required with respect to two factors, namely the number of residues and the times in which the generated waste can be used.

I argue that these principles can be grouped into the previously mentioned classification between measurable (physical) and difficult



to measure (non-physical) aspects of industrial ecosystems. Depending on the intangible, difficult-to-measure properties, I suggest that on the one hand, diversity and locality are properties more easily identifiable and measurable and that have received more attention in descriptive research such as cases of studies. On the other hand, roundput and gradual change are more dependent on both knowledge and capabilities of the firm. Consequently, focusing on roundput and gradual change, I consider that the knowledge-based perspective of absorptive capacity may provide new insights regarding the construction and maintenance of such industrial ecosystems narrowing, from a social network analysis point of view, the structural holes of the network.

Social network's structural holes

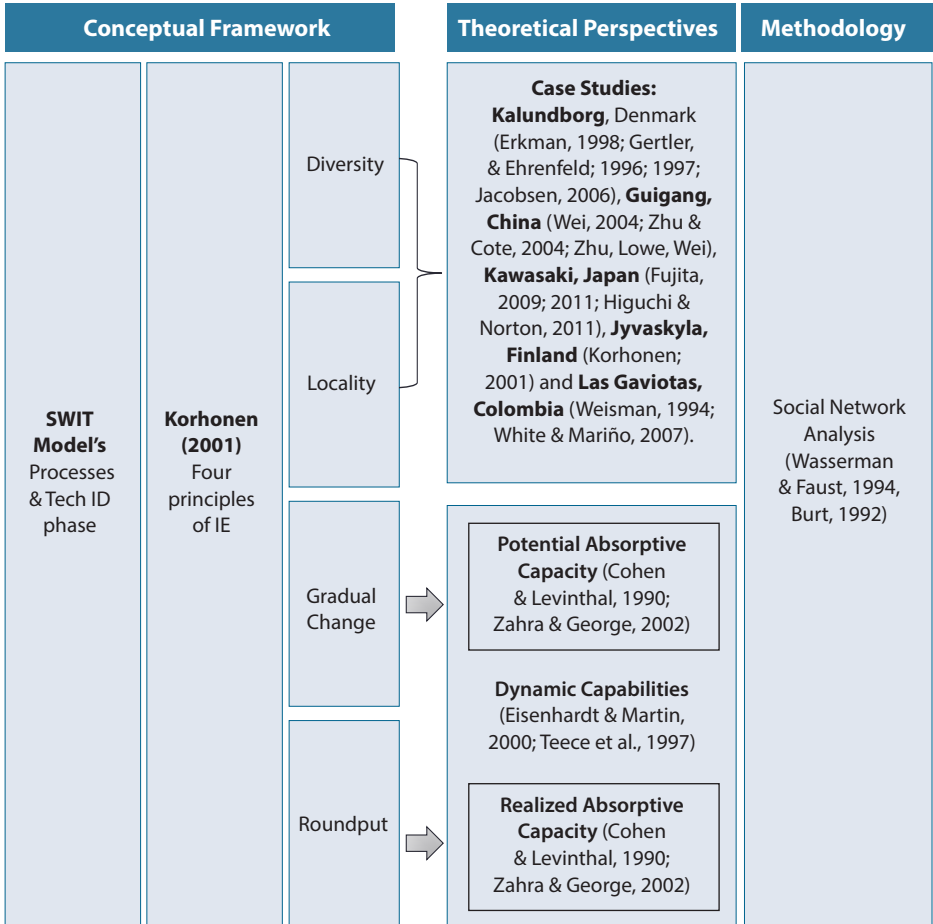
Structural holes are gaps in information flows between alters (other actors) linked to the same ego (the principal actor) but not linked each other which implies a flow of information asymmetry (Ahuja, 2000). Krackhardt (1995) argues that Burt's (1992) structural holes theory is based on the idea that actors, which in this case are firms, have a vantage position in respect to profit, interaction and transaction in contrast with its peers, "if they are connected with others who are not themselves connected or well organized" (Burt, 1992: 350). Contrasting Burt's (1992) assertion, Ahuja (2000) following Coleman (as cited in Borgatti & Foster, 2003) states that using network analysis and on the context of innovation, indirect ties and structural holes, influence the firm's subsequent innovation output. Ahuja (2000) find that collaboration networks provide benefits of resources sharing through direct ties, knowledge spillovers through indirect ties, and finally the extensive relation (lack of structural holes) fosters the development of shared knowledge. This means fine grained information transfer and joint problem solving (Ahuja, 2000) which under the industrial ecosystem lens, appears to be a compelling tool for addressing the formation of such ecosystems.

The relation of these theoretical concepts and streams is depicted in Figure 2 which I clarify in the following sections along with a detailed description of the propositions I offer.





Figure 2. Conceptual model of the creation of industrial ecosystems



Source: Author's own construction.

Theoretical framework

Absorptive capacity

Given that there are clusters (geographically proximate) of diverse firms which recently are seeking to create symbiotic linkages, one determinant factor influencing the achievement of these linkages lies within the firms’ “ability to recognize the value of new information, assimilate it, and apply it to commercial ends” (Cohen & Levinthal, 1990:128). This ability is termed as the absorptive capacity of the firm (Cohen & Levinthal, 1990). The construct of absorptive capacity is, according to Zahra and



George (2002) a dynamic capability. Although there has been numerous definition of the concept of dynamic capability (see Barreto, 2010 for a review) Teece et al.'s (1997) define it as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997:516). Accordingly, the absorptive capacity construct derives from the dynamic capabilities' perspective, which is considered a theoretical spin-off of resource-based view of the firm (Helfat & Peteraf, 2003; Teece et al., 1997). Dynamic capability perspective addresses particularly how organizations develop competitive advantages in order to cope with the high-velocity (Eisenhardt & Martin, 2000) or hypercompetitive (D'Aveni, 1994) business context. This perspective suggests that in order to maintain competitive advantages, organizations must to continually reconfigure their resources (Eisenhardt & Martin, 2000).

More specifically, absorptive capacity is considered critical for enhancing the innovative capacity of a firm. This concept has two related ideas implicit regarding the ability to assimilate information. First, the richness of pre-existing knowledge means that learning is cumulative and second, learning performance is greatest when the object of learning is related to what is already known. Absorptive capacity is both the ability to absorb and transmit knowledge (Szulanski, 1996). Additionally, a key in the process of absorptive capacity is associated with the diversity of knowledge by increasing the absorption rate of new knowledge when this is more familiar. These knowledge transfers can be intraorganizational or interorganizational. An example of the latter is the article by Davis and Eisenhardt (2011), which aims at exploring the reasons behind why some interorganizational relationships, such as collaboration, produce technological innovations whereas others do not achieve the same results.

Moreover, Cohen and Levinthal (1990) further argue that some members in a firm may assume "boundary-spanning" or "gatekeeping" roles when the useful information from external actors differ considerably from the expertise of individuals in the organization. Thus, some level of redundancy in expertise is desirable in what can be called cross-function absorptive capacities. For example, these can be the relationship among research and development, manufacturing or even marketing (Cohen & Levinthal, 1990). But this last point is not bounded to intrafirm relationships. I contend that this is also influencing interfirm collaboration thus, with an increase of redundant relationships, the flow of information regarding the usage, compositions or even the knowledge of the alternatives for wastes transformation can enhance the creation of symbiotic linkages by narrowing the structural holes of the network.



Absorptive capacity is composed by four dimensions. These are, according to Zahra and George (2002) acquisition, assimilation, transformation and exploitation. Acquisition entails the firm's capacity to recognize and obtain external knowledge. Assimilation refers to the routines within the firm that permit to analyse, process, interpret, and understand the external knowledge. Transformation implies the firm's capability to develop routines that promote the combination of both the existing and new knowledge. Finally, exploitation dimension refers to the capability to create new competencies or refine existing ones by incorporating new knowledge into its operations.

Furthermore, these four dimensions conform two subsets of absorptive capacity. On the one hand the first two dimensions conform what is called as the potential absorptive capacity (PACAP). PACAP comprises knowledge acquisition and assimilation capabilities. On the other hand, the second subset is called realized absorptive capacity (RACAP) and comprises transformation and exploitation dimensions.

Since the PACAP allows the firms to be strategically flexible while being also able to adapt and evolve in high-velocity environments (Zahra & George, 2002) I argue that this concept is closely related to the gradual change principle of industrial ecosystems. Since in order to cope with the changing environment, in this case subject to the different waste streams generated and their quantities, a firm must possess the ability to continually acquire and assimilate knowledge that allows it to transform them into a valuable input. To cope with this dynamic process of internal routines (Nelson & Winter, 2002) firms must, as stressed by Easterby-Smith, Lyles and Tsang (2008), develop the capability to learn from others in order to handle with the dynamics of competition. Moreover, Laursen and Salter (2006) provide empirical supporting the fact that firms searching externally (beyond a small number of sources) enhance their innovative performance. This discussion lead to the first proposition:

Proposition 1: *The presence of PACAP focused on the knowledge regarding transformation of wastes of into feedstock, moderates the positive relationship between gradual change and the reduction of structural holes in a potential industrial network.*

Moreover, the ability to dynamically respond to changes in the already established symbiotic linkages may be influenced by the level of PACAP of the firms as well. The principle of gradual change involves an evolution of the ecosystem. This evolution consists in the constant adaptation and



balance between inputs and outputs that must occur for the survival of the industrial ecosystem. I contend that since PACAP helps firms to scan changes in the industry therefore facilitating the deployment of necessary capabilities, (i.e. production and technological competencies) at the opportune moment (Zahra & George, 2002), then it must be a determinant of the prevalence of the symbiotic linkages, in what I call symbiotic endurance. Following this reasoning I propose:

Proposition 1b: *The presence of PACAP regarding the knowledge for transformation of wastes into feedstock has a positive relationship with symbiotic endurance.*

Moreover, I argue that RACAP, which is based on knowledge exploitation (March, 1991) and focus on knowledge transformation (Zahra & George, 2002), is linked to the principle of roundput. According to Korhonen (2001) in order to achieve roundput, a firm must possess the ability and knowledge to utilize wastes as inputs. Thus, assuming a mutual cooperative attitude between the involved parts, both the producer and the receiver of the waste must have enough RACAP in order to effectively transform and exploit the knowledge, thus overcoming the stickiness of knowledge (Szulanski, 1996).

Supporting this, Ahuja and Lampert (2001) use absorptive capacity for explaining how incumbent firms create breakthrough inventions and overcome the so-called organizational pathologies that inhibit these inventions. Finally, Hoang and Rothaermel (2010) within the alliance context, research the learning process of firms whereas Rothaermel and Alexandre (2009) assess the importance of absorptive capacity as moderating variable on technology sourcing. Consequently, as Cohen and Levinthal (1990) state, when a firm holds an adequate level of absorptive capacity, it is more sensitive to opportunities and better adapted to exploit them by combining internal and external sources of knowledge. Zahra and George (2002) argue that RACAP includes the modification of capabilities, which help firms to develop new perceptual schema or changes to existing processes. This reasoning suggests the following:

Proposition 2: *The level of RACAP of the firms moderates the positive relationship between roundput and the reduction of structural holes in a network.*

Finally, derived from these propositions, I contend that the final impact associated with narrowing the structural holes in the network would generate both beneficial impacts over environmental and financial



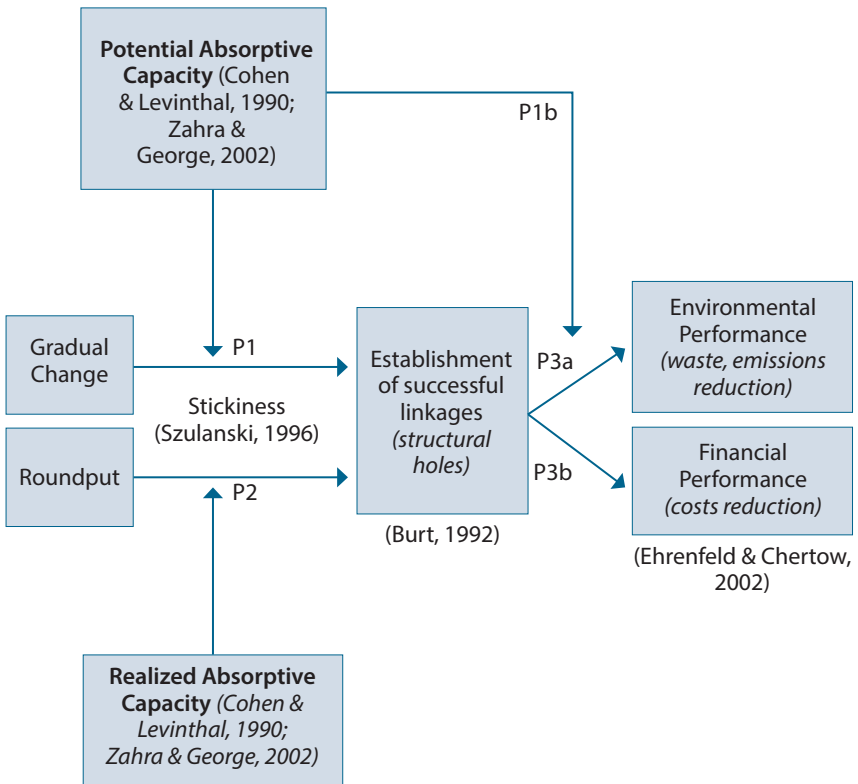
performance. In line with this reasoning Zahra and George (2002) state that both PACAP and RACAP are capabilities that enable firms to reconfigure its resource base and adapt to dynamic market conditions that eventually translates into the achievement of a competitive advantage. Accordingly:

Proposition 3a: *The reduction of the structural holes within a network has a positive relationship with environmental performance.*

Proposition 3b: *The reduction of the structural holes within a network has a positive relationship with financial performance.*

The four propositions are depicted in Figure 3.

Figure 3. Theoretical model and propositions



Source: Author's own construction.



Discussion and conclusions

Drawing on apparently disconnected theoretical streams of research, such as industrial ecology, dynamic capabilities, social network analysis, I contribute to the ongoing process of theoretical construction of industrial ecology research stream. The present research furthers the research by Kabongo & Boiral (2017) and Dubey, Gunasekaran, and Papadopoulos (2017) on the role of dynamic capabilities on the creation of industrial ecosystems. To do so, I incorporate absorptive capacity's PACAP and RACAP subsets as a new theoretical lens with potential to provide new insights regarding the more intangible and knowledge related aspects of the construction of industrial symbiotic linkages. Moreover, I propose that RACAP not only moderates the creation of linkages but also preserve them through time on what I have termed symbiotic endurance. On this basis I raise the level of analysis on absorptive capacity from individual or dyadic to a network level. In this way enriching the potential usage of this relatively new theoretical stream to other areas.

This research work intends to encourage the usage of social network analysis methodology on researching the potential collaborative network alliances that can be built based on knowledge attributes of the actors, rather than just focusing on material resources as it has been traditionally approached.

Future research is encouraged to use social network analysis to test these propositions in order to deliver an empirically account of how knowledge may influence the establishment of symbiotic linkages. The potential implications of uncovering the role of absorptive capacity may allow firms to create symbiotic alliances by focusing on knowledge stock. Moreover, at a macro level, future investigations may even inform potential public policy makers of the importance of knowledge related structures within clusters regarding the planning; construction and even the management of industrial systems intended to become industrial ecosystems. Future studies should focus on testing the propositions by exploring recent attempts to create such industrial ecosystems. One of such cases could be the so-called Circular Value Ecosystem (Aguiñaga, 2016) that the multinational company Heineken is trying to develop its newest brewery at Meoqui, Chihuahua as part of their transitioning strategy towards a Circular Economy.



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La arquitectura Inca se caracterizó por la solidez, sencillez y simetría de sus construcciones, y muchas de sus edificaciones aún se encuentran en pie, siendo Machu Picchu la más simbólica y representativa de esta cultura. Su dominio en el trabajo de la piedra, llevó a que desarrollaran diferentes técnicas para la construcción de sus templos y fortalezas, de las cuales se destacan dos por las innovaciones en sus diseños arquitectónicos, que aún resultan sorprendentes para los visitantes. La primera técnica consistía en unir grandes y pesados bloques sin necesidad de argamasa (arena, cal y agua), lo que garantiza la sismorresistencia de las edificaciones; la otra consistía en unir las piezas de piedra mediante acanaladuras, como si fueran un rompecabezas tridimensional, con tal precisión que era imposible que una hoja de papel traspasara las juntas de los muros. Las herramientas que utilizaron fueron fundamentales, pues usaban tres tipos de martillo para labrar y ajustar las piedras, fundidos con la más alta tecnología para resistir el trabajo a que eran sometidos.

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