Received 21 December 2020
Revised 8 June 2021
Accepted 10 November 2021

SIPOC-OI: a proposal for open innovation in supply chains

Thais Assis de Souza
Department of Business and Administration, Universidade Federal de Lavras, Lavras, Brazil and
Laboratoire Génie Industriel (LGI), CentraleSupelec, Gif-sur-Yvette, France
Guilherme Alcântara Pinto
Laboratoire Génie Industriel (LGI), CentraleSupelec, Gif-sur-Yvette, France
Luiz Guilherme Rodrigues Antunes
Faculty of Economic and Management, Universidade de São Paulo, São Paulo, Brazil, and
André Grützmann
Department of Business and Administration, Universidade Federal de Lavras, Lavras, Brazil

Abstract

Purpose – Regarding the premises of open innovation (OI) in terms of knowledge sources, this paper aims to discuss how to manage the existing sources of knowledge in supply chains.
Design/methodology/approach – An integrative review was developed focusing on studies related to supply chain and OI, seeking to understand the relationships between them, supporting the innovative discussion.
Findings – The SIPOC-OI was proposed as a tool to support the management of knowledge sources present in the supply chain, promoting efficiency to the company and improving its innovative capacity.
Research limitations/implications – The conceptual proposal should be empirically verified to understand the management tool's obstacles and benefits for a company's innovation performance. Additionally, it would be useful to understand the results of this proposal in the relationships between agents of the chain, as well as the direction (inbound, outbound or coupled). Additionally, relevant points were highlighted as future agendas.
Practical implications – The point of view based on OI treats the collaboration's aspects and its benefits to agents, which becomes an essential factor in improving the entire chain's integration and performance.
Originality/value – The analysis of the flow of knowledge in supply chains from an OI perspective is an innovation in theory. Besides, the multidisciplinary proposal is expressed in the framework developed as it is based on a tool from engineering. Supply chain competencies/mindset is important to develop OI as well as is the contrary – there is a mutual practical and theoretical relevance between the integration of the concepts.

Keywords Supply chain, Open innovation, SIPOC, Integrative review, Innovative capacity
Paper type Literature review

The authors thank the Federal University of Lavras and the National Council for Scientific and Technological Development (CNPq) for their support in conducting and disseminating the research.

Innovation & Management Review
Vol. 20 No. 1, 2023
pp. 76-93
Emerald Publishing Limited
2515-8961
DOI 10.1108/INMR-12-2020-0182

1. Introduction

Innovation is well known as an essential driver of growth and economic development. However, new relational, environmental, social, political and institutional changes have challenged this concept (Martinez *et al.*, 2014).

In this setting, players face the need to create and expand relationships, resulting in more porous borders between organizations, leading to a path where competitive advantages which combine internal and external knowledge sources become essential (Mention, 2011; Bravo *et al.*, 2017). Thus, innovative performance is related to networks and connections, highlighting a character of interaction (Laursen & Salter, 2006), which leads to the open innovation (OI) concept.

The new scenario no longer works based on simple planning, as in chess games; it is impossible to operate based on expectations of stabilities and certainties. The demand turns to search for new external paths (Chesbrough, 2012).

OI emphasizes the importance of inbound and outbound knowledge flows. The main idea is not new as it uses different approaches to innovation management, such as cooperation in research and development (R&D), market orientation and supply chain management (SCM) (Chesbrough, 2006; Trott & Hartmann, 2009; Cruz-González *et al.*, 2015).

According to EUROSTAT (2013), between 2008 and 2010, one in four innovative European companies worked cooperatively with research institutes and other enterprises. EUROSTAT 2008 data showed suppliers (17%) as one of the primary external sources (Mention, 2011). Suppliers are one of the knowledge sources in supply chains; thus, it encompasses collaboration among agents as a fundamental factor in improving integration and performance throughout the chain (Lee & Schmidt, 2016; Mukundan & Thomas, 2016).

There is still a gap in the literature on how organizations can effectively promote, create and maintain relationships between partners (Veldhuizen *et al.*, 2013). Considering supply chains are inserted in a more complex context since such chains are composed of different organizations, this objective can be even more critical. It is fundamental to develop "mechanisms to source, share, filter, and evaluate external knowledge" (Enkel, Bogers, & Chesbrough, 2020, p. 165).

In this regard, how can one manage the existing knowledge sources in supply chains? Aiming to answer this question, we have developed an integrative review focusing on studies that sought to understand the relationships between supply chain and OI. This methodological choice was intended to support the development of a framework capable of upholding a reflection on the establishment of the knowledge sources management and making efficient the company's innovative capacity inserted in this system. This proposal aims to cover the gaps in the literature, which points out the need to expand the level of analysis of OI beyond the company (West *et al.*, 2006; van de Vrande *et al.*, 2010; Bogers *et al.*, 2016).

According to Schmelzle and Tate (2017), it is necessary to understand how SCM can support and promote innovation through (and to) its agents. In this sense, mechanisms to drive innovation from openness require examining the context and project (Enkel *et al.*, 2009; Huizingh, 2011; Brem & Tidd, 2012). Thus, in the case of a supply chain, the mechanism must be adapted to its specificities.

Overall, this article presents four sections, besides this introduction. The following section presents the theoretical background. Subsequently, we present methods, procedures, results and discussion. At last, we present the final considerations.

2. Theoretical background

2.1 Supply chain

Scholars and experts define *supply chains* as a network composed of three (or more) entities that can be organizations (legal entities) or individuals. The idea of a network is expressed by

the direct involvement between actors and between actors and flows of finances, products, services or information (Zimmermann *et al.*, 2016). As stated by Carter *et al.* (2015), this arrangement and its upstream and downstream flows are expressed by nodes (actor decisions) and links (transactions).

A generic supply chain model comprises four agents – supply, manufacturing, distribution and consumers (Beamon, 1999) – representing a sequence of related transactions that reflect stages of value creation (Lazzarini *et al.*, 2001). The interrelated business processes aim to increase operational efficiency and profitability towards a favorable competitive position for the agents and the chain (Beamon, 1998; Min & Zhou, 2002). Figure 1 shows the supply chain in the form of a generic process.

Given this set of components, one must manage the flows from the supplier to the customer. At this point, SCM is a strategic orientation that seeks synchronism and convergence of intra-firm and interfirm processes towards the goal of value creation (Chen & Paulraj, 2004). This managerial approach requires cooperative, shared and integrative efforts and alignment of goals and improved communication (Zimmermann *et al.*, 2016).

SCM addresses the managerial role of coordinating and integrating the parts of the chain by organizing flows of information, decisions and products in an innovation-oriented manner. The aim is to minimize transaction costs, optimize production flows and capture value (Lazzarini *et al.*, 2001; Min & Zhou, 2002).

Several changes have occurred in the 20th and 21st centuries regarding the market, access to knowledge and development of technologies, representing structural and paradigm changes (Chesbrough, 2003, 2012). This complexity situates SCM as a source of competitive advantage as vital as the competitiveness of a single company, increasing its importance (Lee, 2002; Toth & Fertő, 2017).

Scholars and experts define a company's positioning according to its activity, resources and relationships. Thus, the business definition also depends on interacting and mobilizing resources (Brito & Roseira, 2005), mainly when these resources are allocated and assembled for innovation development and the maintenance of the chain's competitive advantage.

Min and Zhou (2002) advised that managers must understand the chain's drivers and their limitations and decision variables. According to the authors, there is a risk of failure in the exchange drivers' supply and demand information quality. The limiting components are capacity, service conformity and the size of the demand, and decision variables are the location, allocation, network structure, number of installations and pieces of equipment, number of stages (agents), service sequence, volume, level of inventory and need for workforce and outsourcing.

Companies face a scenario where many products have shortened lifecycles amid growing outsourcings. Corporations have been designing and developing businesses globally, and

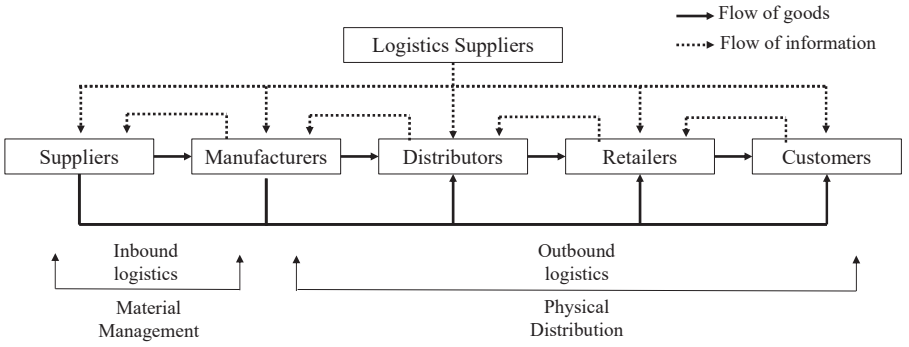


Figure 1.
Generic supply chain

Source(s): Min and Zhou (2002)

technology has continually advanced. SCM is becoming more sophisticated (Lee, 2002), so partners change their isolationist stances (Dahlander & Gann, 2010). As Chesbrough (2012) discussed, the search for new external paths can impact the whole chain regarding decision-making processes.

2.2 Open innovation

Scholars and experts have raised the concept of OI as an umbrella that connects different theoretical and practical innovation management approaches (Huizingh, 2011). The central premise of "openness" is related to finding and exchanging knowledge inside and outside companies, making it possible to expand the opportunities available from external sources (Chesbrough, 2003; Laursen & Salter, 2006; Dahlander & Gann, 2010).

Knowledge management becomes essential since individual, organizational and interorganizational knowledge determine a company's innovative capacity. The business model operationalizes it, following market dynamics to adapt its knowledge structure (Lichtenthaler & Lichtenthaler, 2009; Wallin & von Krogh, 2010). Business models focus on creation, capture, generation and delivering value; by the OI's lens, it no longer focuses on internal R&D as the only strategic asset. Companies are, therefore, characterized by porous borders that, well developed, allow opportunities to be present in other markets (Chesbrough, 2003).

In practice, according to Huizingh (2011), entrepreneurs can trace two types of OI: inbound and outbound. Inbound concerns the internal use of external knowledge (an outside-in process); outbound, on the other hand, is related to an inside-out process, which favors the external use of knowledge from another company (Lichtenthaler, 2015). According to Dahlander and Gann (2010), these typologies relate to the interaction of pecuniary or nonpecuniary activities. From this perspective, the authors discussed acquisition and trade as types of inbound innovation and sales and advertising as outbound types. In a similar vein, based on relationships, Gassmann and Enkel (2004) presented the coupled as the combination of input and output knowledge.

Knowledge management is a process to operationalize value creation and sharing. It is essential to promote stable interaction, explore potential knowledge sources of different organizations, aggregate value to technical and commercial aspects and involve agents appropriately in the strategic definition (Paci *et al.*, 2010). Thus, companies must adopt dynamic resourcefulness to develop their knowledge capabilities to profit from OI while minimizing the costs involved in boundary decisions (Zajac & Olsen, 1993; Lichtenthaler & Lichtenthaler, 2009).

As several aspects that influence the adoption of OI actions, Gassmann and Enkel (2004) highlighted the speed of the industry, product architecture, knowledge intensity and type of competitiveness. Thus, innovation decisions must consider developing innovative activities, including when, how, with whom and for what purpose (Huizingh, 2011).

Emphasizing innovation as imperative in the current context of knowledge fragmentation and specialization (Legenvre & Gualandris, 2018) and explicitly addressing the "with whom" question, we can mention the following knowledge sources:

(1) Universities and research centers (Laursen & Salter, 2006; Martinez *et al.*, 2014; Cruz-González *et al.*, 2015),

(2) Innovation intermediaries (Martinez *et al.*, 2014),

(3) Government agencies (Martinez *et al.*, 2014),

(4) Customers (Martinez *et al.*, 2014; Cruz-González *et al.*, 2015; Legenvre & Gualandris, 2018),

(5) Suppliers (Laursen & Salter, 2006; Martinez *et al.*, 2014; Cruz-González *et al.*, 2015; Legenvre & Gualandris, 2018),

(6) Consumers/users (Martinez *et al.*, 2014),

(7) Competitors (Laursen & Salter, 2006; Martinez *et al.*, 2014; Cruz-González *et al.*, 2015; Legenvre & Gualandris, 2018) and

(8) Companies that operate in other industries (Martinez *et al.*, 2014).

Conceptually, OI proposes taking the company as the point of analysis. However, West *et al.* (2006) suggested other levels of analysis: individual, peer, business unit, innovation ecosystems/communities, national innovation systems, clusters and industry-level analysis (West *et al.*, 2006; van de Vrande *et al.*, 2010; Bogers *et al.*, 2016). The focus of this work is the supply chain.

3. Methodological procedures

The authors have developed this paper through an integrative review to support the search, organization and analysis of evidence from the supply chain literature related to OI. An integrative review enables references of a specific research topic to be identified and data to be summarized and analyzed, highlighting relevant aspects to substantially contribute to the literature (Beyea & Nicoll, 1998; Torraco, 2016).

Errors and biases are likely to occur in the review development process. The authors must focus on searching, extracting, synthesizing, analyzing and interpreting sources to provide reliable and accurate results (Whittemore & Knafl, 2005). To this end, we have developed this article with peer review at all stages.

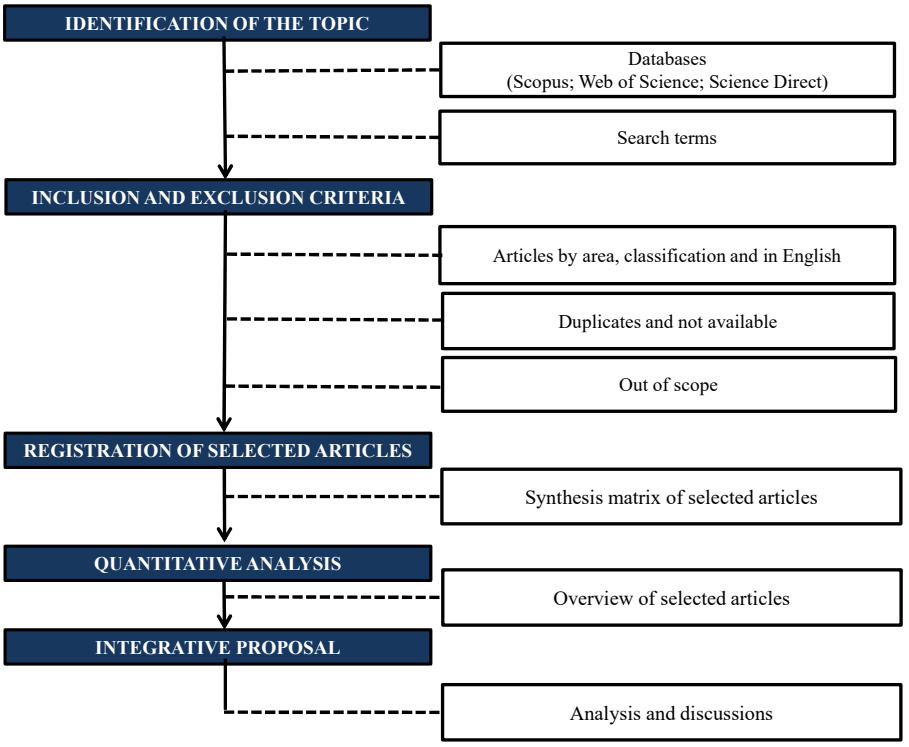
Russel (2005) indicates stages of an integrative review: formulating the problem, systematically searching articles, evaluating data, analyzing data and conducting the interpretation to build the results. Based on Russel's work and considering the stated objectives, the integrative review will follow the steps shown in Figure 2.

The steps are detailed below.

(1) *Identification of the topic*. The choice of Web of Science (WoS), Scopus and Science Direct as search databases. "All years" was the reference period for the search, and the terms were "open_innovation*" and "supply chain," using underline and quotation marks to refine results. The search resulted in 178 papers: 30 in Scopus, 65 in WoS and 103 in Science Direct.

(2) *Inclusion and exclusion criteria*. The first criterion was selecting the areas of management, business, economics and accounting, returning in 109 articles: 56 in Scopus, 42 in WoS and 11 in Science Direct. From this selection, only documents as "article" or "review" published in English were listed, which resulted in 73 articles: 29 in Scopus, 33 in WoS and 11 in Science Direct (maintained). There were 17 duplicated papers, and two papers were not available, leading to their exclusion. Analyzing the scope of the remaining 54 articles led to the exclusion of another 26 papers. Thus, we selected 28 items for registration and subsequent analysis. We have developed this step based on peer review to reduce bias.

(3) *Registration of selected articles*. After an in-depth reading and analysis, we plotted the selected papers in a synthesis matrix. The topics of synthesis matrix were as follows: search database, journal, author, year of publication, title, related country, keywords, research problem, objectives, central theme, sector of the chain studied, theoretical background, methodology, the chain's composition, the relationship among chain's components, knowledge (sources and means of exchange), reference to OI, the relationship between supply chain and OI, contribution to review, gaps for future studies, research limitations and relevant general observations identified.



Source(s): Prepared by the authors

Figure 2.
Methodological steps

(4) *Quantitative analysis*. We based this step on the data collection regarding the publication year, authors and the central theme. The objective was to categorize and describe the sample and thus support the qualitative and integrative analysis. We present the main discussions in topic 4.1 as a quantitative overview of the selected papers.

(5) *Integrative proposal*. We developed this step as the data extraction from the papers: objectives, central thematic, sector of the chain, theoretical background, gaps and limitations, as well as other information that could be important for this paper's objective. Based on these data, we focused the analysis of selected papers on comparisons and complementarities aiming to develop a theoretical discussion capable of supporting the proposition of a framework for the knowledge management of sources in the supply chain. We present this step's results in topic 4.2.

4. Results and discussion

4.1 Supply chains and open innovation: a quantitative overview of the literature

After identifying the theme, setting the inclusion and exclusion criteria, and organizing the synthesis matrix, it was obtained a quantitative overview of the field from the selected studies based on a total of twenty-eight articles for analysis, dating between 2010 and 2018. These are presented on Table A1.

After 17 years of Chesbrough's seminal work (Chesbrough, 2003), there has been growth in publications considering the chain as a system composed of knowledge sources from the

perspective of openness. We have seen the change from company level to interorganizational levels focusing on supply chain in one paper in 2010 and five in 2018. Among the authors, only Bravo, Moreno and Llorens-Montes were present in the sample with more than one article (2016, 2017 and 2018).

The study found 24 different journals, being two publications in *Industrial Marketing Management* and three in the *International Journal of Operations and Production Management*, both specific to the industrial field. Among the themes addressed in the papers, the discussion on the impact on chain performance is central. Besides the focus on OI in supply chains, there were discussions on the following factors:

(1) How OI approach influences in new service and product development projects (Hsieh & Tidd, 2012; Cruz-González *et al.*, 2015)?

(2) Intermediary networks as sources for OI (Billington & Davidson, 2013);

(3) Effects of OI on innovation performance (Martinez *et al.*, 2014);

(4) The link between OI, supply chains and trust (Shamah & Elssawabi, 2015; Bravo *et al.*, 2017) as well as commitment and competence (Bravo *et al.*, 2017);

(5) Specificities and benefits of OI for different plant sizes, specifically to small and medium-sized enterprises (SMEs) (Vahter *et al.*, 2014; Brunswicker & Vanhaverbeke, 2015);

(6) The link between power asymmetry, absorptive and desorptive capacities (Bravo *et al.*, 2016);

(7) Contractual relationship issues (Lo Nigro, 2016);

(8) Co-patent and the relation to market value (Lv, Zeng, & Lan, 2018);

(9) Innovation sourcing and its relation to innovative performance (Schmelzle & Tate, 2017; Legenvre & Gualandris, 2018);

(10) Purchasing as a way to achieve excellence in innovation sourcing (Legenvre & Gualandris, 2018);

(11) Management of organizational knowledge boundaries (Wilhelm & Dolfsma, 2018);

(12) The link between desorptive capacity, organizational ambidexterity and supply chain competence (Bravo *et al.*, 2018);

(13) Collaboration aspects considering supply chains as sources to OI (Mukundan & Thomas, 2016);

(14) Open source chain management software and performance (Boehmke & Hazen, 2017);

(15) Context particularities, such as the Chinese (Lau, Lee, Lai, & Lee, 2018) and Iranian (Arabshahi, Arabshahi, & Zaafarian, 2014);

(16) Sector specificity aspects, such as food chain (Beckeman, Bourlakis, & Olsson, 2013; Bigliardi & Galati, 2013; Toth & Fertő, 2017);

(17) Large-scale system integrator (LSSI) which is related to value chain and focal firms (van Blokland *et al.*, 2012);

(18) Environmental issues in terms of carbon emission along the supply chain (Koh *et al.*, 2013);

(19) Value generation through OI according to the types of integration (joint venture, development alliance and independent suppliers) (Erzurumlu, 2010);

(20) The innovation process with suppliers and customers involvement (Lee & Schmidt, 2016);

(21) Innovative supply chain models based on OI platform considering users as knowledge sources (Bendavid & Cassivi, 2012) and

(22) Changes in the digital era and the influences on buyer–supplier relationships (Obal & Lancioni, 2013).

Although not all papers explained their methodologies, there were 13 surveys and nine theoretical essays. Case studies accounted for eight publications, one systematic review and one literature review. Some articles used more than one methodology.

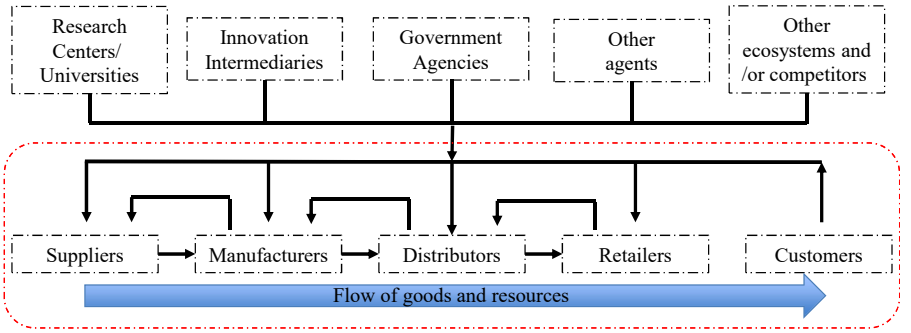
The works did not provide details about the chain agents or their relationships. Some articles focused on specific sectors such as convenience stores, aerospace, high technology, software, agricultural production and oil. Some segments were subject to more than one article, such as food (five studies), automotive (two studies) and SMEs (two studies).

Therefore, the literature presents a gap in discussing the roles and relationships in the supply chain. The next step seeks to propose a tool to operationalize knowledge management.

4.2 Integrative proposal: the SIPOC-OI

How can OI be seen in supply chains? The central concept of OI in the supply chain describes the members of the chain with porous borders, a feature which allows us to place organizations as useful knowledge sources for the innovation process (Martinez *et al.*, 2014; Cruz-González *et al.*, 2015; Toth & Fertő, 2017; Wilhelm & Dolfsma, 2018). Considering general OI dimensions, the knowledge sources, the knowledge management, the collaboration, the value creation processes and the dynamic capabilities, in this paper, we reformulated the supply chain model with an openness approach: the open supply chain (OSC) (see Figure 3).

According to Martinez *et al.* (2014), firms need to expand relationships beyond partners embedded in their OI ecosystems. To the authors, closed collaboration within a chain can restrict opportunities stemming from other channels. Thus, at this point, based on the papers' review, we described and expanded the logistics providers presented in Figure 1 to other knowledge sources as useful for agents of the OSC: research centers and universities (Martinez *et al.*, 2014; Cruz-González *et al.*, 2015; Toth & Fertő, 2017), innovation



Source(s): Prepared by the authors

Figure 3. Open supply chain (OSC)

intermediaries (Martinez *et al.*, 2014), government agencies (Martinez *et al.*, 2014), companies operating in other sectors and competitors – whether from the chain or agents of the chain (Martinez *et al.*, 2014; Cruz-González *et al.*, 2015; Wilhelm & Dolfsma, 2018).

Based on the articles of Martinez *et al.* (2014), Brunswicker and Vanhaverbeke (2015), Shamah and Elssawabi (2015) and Lo Nigro (2016), innovation is a process that involves creativity and other issues inherent to the organization, composed of steps from ideation, concept development to commercialization. Customers act as a knowledge source, but do not commercialize innovations, which justifies the upstream direction.

Furthermore, it is necessary to highlight that, as Wilhelm and Dolfsma (2018) stated, it would be unrealistic to claim that all chain agents have the same level of border permeability. Each agent has its internal specificities, and these have a strong influence on the agent's objectives and actions, which influences the capacity for openness.

According to Hsieh and Tidd (2012), the open process concept goes beyond the number of external sources – it requires a qualitative consideration of the external transactions that reckon the intensity of the interactions and the mechanisms related to knowledge sharing. Companies must consider their internal and external context and define a collaborative architecture to detail their innovative performance (Martinez *et al.*, 2014; Schmelzle & Tate, 2017). Following Cruz-González *et al.* (2015) and Bravo *et al.* (2016), it is not enough to access and acquire external knowledge, and people must understand OI as a disjointed phenomenon of business realities. Therefore, the openness process must be rooted in management and coordination structures so that the acquired knowledge is assimilated, absorbed and integrated into its innovation context in the sense of creating value.

In this sense, how can openness be operationalized and managed? In this paper, we based the proposal on a practical tool of the engineering process: the SIPOC (Figure 4).

The SIPOC (suppliers, input, process, output and customers) tool is a diagrammatic representation of critical elements that improve processes (Parkash & Kaushik, 2011). Through the representation as a flow/chain, the SIPOC enables the mapping of existing activities and identifying fundamental aspects of the process (Dirgo, 2006). Yang and El-Haik (2003) stressed that this flow of SIPOC could be of materials, resources or information.

Following the proposal of this article, the focus will be on the flow of information, here treated as knowledge. Like materials, knowledge is user-oriented (user/customer). It has functionalities, provides sources for performance and is developed through cycles (from the supplier to the customer).

As previously highlighted, this paper's general dimensions of OI are knowledge sources, knowledge management, collaboration, value creation and dynamic capabilities. By combining these with the supply chain's premises, we developed the SIPOC-OI framework (Figure 5) as an analytical tool to operationalize the OSC's (Figure 3) knowledge management.

The SIPOC-OI can support its management by considering the OSC's elements in terms of knowledge sources. The central premise is structuring a SIPOC-OI for each new knowledge source identified to support the knowledge management. Thus, using SIPOC-OI will improve the processes for searching, identifying, acquiring, processing and using external knowledge. Additionally, it is possible to understand the relationships' scope better, strengthen them and create new ones, thereby supporting the defining of strategies and creating a knowledge integration competency. The scenario described above supports the improvement of dynamic

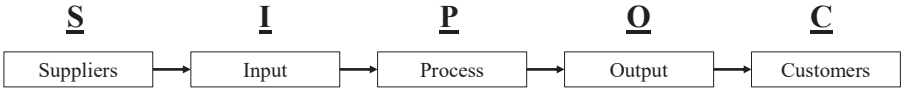
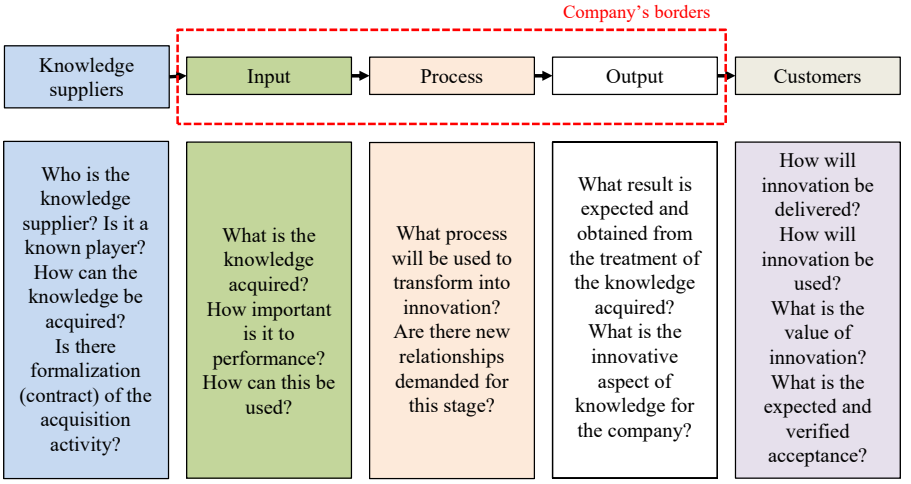


Figure 4.
SIPOC diagram

Source(s): Prepared by the authors based on Parkash and Kaushik (2011)



Source(s): Prepared by the authors

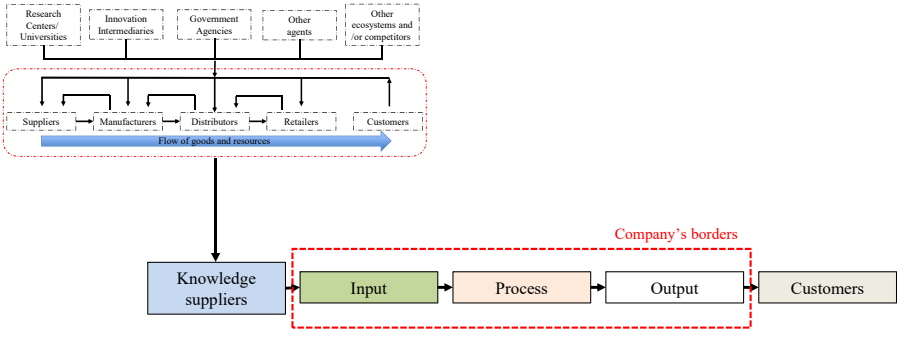
Figure 5.
SIPOC-OI

capabilities and supports the process of value creation and sharing for the whole chain based on collaboration.

SIPOC-OI uses the databases in their generic form (SIPOC) considering the OSC's structure. We do not consider any OSC agent as a knowledge source, and we do not consider customers due to this proposal's focus on innovation (commercialization) and management processes (legal sources). Consumers are nonlegal sources.

We based the SIPOC-OI's operationalization on guiding questions for each element. Regarding "knowledge suppliers," the purpose is to identify the knowledge source, including the form of acquisition, to collect pertinent information that could strengthen the relationship and expand sources of opportunities. At this stage, the willingness to collaborate and the companies' porous borders are essential factors. Figure 6 represents an example of this first stage regarding the link between SIPO-OI and OSCs.

The "input" is the first stage within the company and is related to the knowledge management process and value generation. It concerns the acquired knowledge and defines its importance to the innovation process to positively influence performance. Thus, "input" is



Source(s): Prepared by the authors

Figure 6.
The OSC and the SIPOC-OI

the stage directly related to the consolidation of the interaction between the supply chain's agents. Next is the "process" concerning the transformation of knowledge according to the organization's innovation specificities. This process adds value to the knowledge by understanding the demands of new relationships (if these exist) to achieve the objective of generating output. Regarding the "process," the selected articles indicated cross-functional teams as essential mechanisms for systematizing the sharing and processing of knowledge (Bendavid & Cassivi, 2012; Hsieh & Tidd, 2012; Bigliardi & Galati, 2013; Brunswicker & Vanhaverbeke, 2015; Cruz-González *et al.*, 2015; Mukundan & Thomas, 2016; Schmelzle & Tate, 2017; Legenvre & Gualandris, 2018).

As the last element in the company, the "output" refers to the process' results. It is necessary to define the expectations and evaluate the results. Additionally, it is essential to consider the innovative aspect, which we will define upon analyzing the subsequent step.

Regarding "customers," it considers what value will be delivered, how it will be delivered, the expectation concerning acceptance and the understanding of the present acceptance. If the customers accept the commercialization of the acquired, processed and assimilated knowledge, this indicates an innovation for the company, and consequently, it can positively influence the whole OSC.

Those aspects reinforce the entire OI process (search, identification, acquisition, processing, assimilation/utilization and commercialization) in line with the company's goals, strategies and other specificities. We based this argument on the works of Bravo *et al.* (2016), Bravo *et al.* (2017) and Toth and Fertő (2017). Thus, performance leads each agent to strengthen the OSC's competitive position. Accordingly, OI (exploration and exploitation) increases the company's internal competence and the entire OSC after reducing its flow times. Stakeholders must build up reciprocity within relationships, and it corresponds to the OI collaborative aspect and the proposal to operationalize SIPOC-OI knowledge management.

Another fundamental capacity regarding OI is the absorptive capacity (Hsieh & Tidd, 2012; Billington & Davidson, 2013; Martinez *et al.*, 2014; Vahter *et al.*, 2014; Brunswicker & Vanhaverbeke, 2015; Cruz-González *et al.*, 2015; Bravo *et al.*, 2016, Bravo *et al.*, 2018; Schmelzle & Tate, 2017; Toth & Fertő, 2017). Absorptive capacity concerns identifying, absorbing and using external knowledge, generating dynamic capacities and promoting success in relationships. As a company's performance influences the entire chain's performance, developing this capacity becomes imperative in supply chains.

4.3 Final discussions and future agenda

Chesbrough (2020) mentions crucial points by revisiting the OI concept 17 years after the first theoretical proposals. For OI to progress, generating efficient results, it is necessary to establish ecosystems for innovation and achieve it. Companies inserted in this environment must design specific processes and mechanisms to identify, share, transfer and adapt external knowledge and the existing knowledge flows. The crucial point is that OI means more than identifying useful knowledge sources; its advancements are related to additional expansion, integration, collaboration, engagement and various relationships and partnerships. By explicitly addressing the supply chain's agents, they become rich external knowledge sources for innovation in products, services or processes (Schmelzle & Tate, 2017).

This paper stands out the need to develop strategies and tools to manage and coordinate the OI's process based on the supply chain's aspects (Bigliardi, Bottani, & Galati, 2010; Dziurski & Sopińska, 2020; Enkel *et al.*, 2020; Pihlajamaa, 2021). These strategies and tools development revealed as highly necessary because not all organizations hold the capabilities to capture, share and translate acquired knowledge into value, aligned to Chesbrough (2020).

In this sense, this paper presents an original character by discussing new sources for OI by proposing a tool for operationalizing knowledge flows. The primary purpose for proposing

the SIPOC-OI is related to a better knowledge sources' identification, utilization and developing in the OSC. The proposal, as mentioned above, helps create a system to support the knowledge convergence into values and capacities, promoting relational processes with positive results avoiding cost increases or losing internal knowledge. Thus, entrepreneurs and managers should focus the relational capacity of companies on their strategies.

Considering the OSC framework, the SIPOC-OI can efficiently monitor the changes and opportunities, promote the roadmap definitions, increase responsiveness, expand the existing knowledge sources (internal and external) and increase the innovative capacity based on integration, collaboration, transparency, strategy and effectiveness.

A future agenda of studies can support further advancements:

(1) The SIPOC-OI empirical verification: it can provide an understanding of the management tool's obstacles and the benefits for the company and the OSC in terms of innovative performance;

(2) The SIPOC-OI application and analysis of the agents' relationships considering the flow direction (inbound, outbound or coupled);

(3) Industry 4.0: it can consider related aspects such as smart manufacturing and smart logistics;

(4) The activities are different for different networks and integration levels; consequently, the knowledge involved will differ. How and how much does it impact knowledge management in OSCs? How are particularities incorporated into the SIPOC-OI?;

(5) Contextual specificity: how is an OSC designed in different contexts (national, structural or sectorial terms)? and

(6) Growing areas: analysis of the SIPOC-OI and its potential use in growing areas, such as global value chains and digital supply chain (DSC). Besides, it can be interesting to analyze how define an OSC in such structures.

5. Conclusions

This article aimed to discuss managing the existing knowledge sources in supply chains. For this, we developed an integrative review that allowed the development of the SIPOC-OI. The proposed tool aims to support the management of knowledge sources present in the supply chain, promote company efficiency and improve its innovative capacity.

From the research organization and the in-depth analysis of the articles, we highlighted and reflected on the crucial issues. Such highlights and reflections guided the use of the SIPOC framework. This framework proved to be applicable to fill the gaps, enabling a reasoned discussion and the creation of a mechanism for managing external knowledge sources available to companies inserted in supply chains.

This paper's originality comes from uniting concepts for analysis. When analyzing the 28 papers collected for review, we did not find an explicit discussion on the link between supply chain and OI. Thus, the analysis of the knowledge's flow in the supply chain from the perspective of OI is a theoretical innovation effort. The proposition of a supply chain from the perspective of OI (OSC) brings the latest look at the chain's layers and how they can absorb innovation and create value. Supply chain competencies/mindset is essential to developing OI, as well as is the opposite – there is a mutual practical and theoretical relevance between the concepts' integration.

The lack of empirical evidence is a limitation of this study. In terms of managerial contributions, the proposed framework can allow the development of innovations in the chain

reliably and creatively, looking beyond organizational boundaries. Therefore, from the perspective of OI, the aspects of collaboration and its benefits for its agents become factors that can improve the entire chain's integration and performance. Moreover, this proposal can increase the chain's internal competencies and anchor the company's absorbing capacity and all chain agents.

It is worth highlighting that the supply chain's relationships influence value creation, but the value created results from the interactions, processes and flows. In this sense, by putting in operation and analyzing the supply chain through the SIPOC-OI, it is possible to systematize the value creation, resulting in socio-environmental, economic and commercial improvements.

References

Arabshahi, G., Arabshahi, M., & Zaafarian, R. (2014). A study on how open innovation influences on supply chain behavior. *Uncertain Supply Chain Management*, *2*(4), 271–274.

Beamon, B. M. (1998). Supply chain design and analysis: Models and methods. *International Journal of Production Economics*, *55*(3), 281–294.

Beamon, B. M. (1999). Measuring supply chain performance. *International Journal of Operations and Production Management*, *19*(3), 275–292.

Beckeman, M., Bourlakis, M., & Olsson, A. (2013). The role of manufacturers in food innovations in Sweden. *British Food Journal*, *115*(7), 953–974.

Bendavid, Y., & Cassivi, L. (2012). A "living laboratory" environment for exploring innovative RFID-enabled supply chain management models. *International Journal of Product Development*, *17*(1–2), 94–118.

Beyea, S. C., & Nicoll, L. H. (1998). Writing an integrative review. *AORN Journal*, *67*(4), 877–880.

Bigliardi, B., & Galati, F. (2013). Models of adoption of open innovation within the food industry. *Trends in Food Science and Technology*, *30*(1), 16–26.

Bigliardi, B., Bottani, E., & Galati, F. (2010). Open innovation and supply chain management in food machinery supply chain: A case study. *International Journal of Engineering, Science and Technology*, *2*(6), 244–255.

Billington, C., & Davidson, R. (2013). Leveraging open innovation using intermediary networks. *Production and Operations Management*, *22*(6), 1464–1477.

Boehmke, B. C., & Hazen, B. T. (2017). The future of supply chain information systems: The open source ecosystem. *Global Journal of Flexible Systems Management*, *18*(2), 163–168.

Bogers, M., Zobel, A. K., Afuah, A., Almirall, E., Brunswicker, S., Dahlander, L., . . ., & Wal, A. L. J. T. (2016). The open innovation research landscape: Established perspectives and emerging themes across different levels of analysis. *Industry and Innovation*, *24*(1), 08–40.

Bravo, M. I. R., Moreno, A. R., & Llorens-Montes, F. J. (2016). Supply network-enabled innovations. An analysis based on dependence and complementarity of capabilities. *Supply Chain Management: An International Journal*, *21*(5), 642–660.

Bravo, M. I. R., Moreno, A. R., & Llorens-Montes, F. J. (2017). Open innovation in supply networks: An expectation disconfirmation theory perspective. *Journal of Business and Industrial Marketing*, *32*(3), 432–444.

Bravo, M. I. R., Moreno, A. R., & Llorens-Montes, F. J. (2018). Examining desorptive capacity in supply chains: The role of organizational ambidexterity. *International Journal of Operations and Production Management*, *38*(2), 534–553.

Brem, A., & Tidd, J. (2012). *Perspectives on supplier innovation: Theories, concepts and empirical insights on open innovation and the integration of suppliers* (*18*, p. 692). London: Imperial College Press.

Brito, C., & Roseira, C. (2005). A model for understanding supply chain networks. *Journal on Chain and Network Science*, *5*(2), 55–63.

Brunswicker, S., & Vanhaverbeke, W. (2015). Open innovation in small and medium-sized enterprises (SMEs): External knowledge sourcing strategies and internal organizational facilitators. *Journal of Small Business Management*, *53*(4), 1241–1263.

Carter, C. R., Rogers, D. S., & Choi, T. Y. (2015). Toward the theory of the supply chain. *Journal of Supply Chain Management*, *51*(2), 89–97.

Chen, I. J., & Paulraj, A. (2004). Towards a theory of supply chain management: The constructs and measurements. *Journal of Operations Management*, *22*(2), 119–150.

Chesbrough, H. W. (2003). The era of open innovation. *Sloan Management Review*, *44*(1), 35–41.

Chesbrough, H. W. (2006). Open innovation: A new paradigm for understanding industrial innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm* (pp. 1–27). Oxford: Oxford University Press.

Chesbrough, H. W. (2012). *Inovação aberta. Como criar e lucrar com a tecnologia*. Porto Alegre: Editora Bookman.

Chesbrough, H. W. (2020). *Open innovation results: Going beyond the hype and getting down to business* (p. 201). Oxford: Oxford University Press. páginas.

Cruz-González, J., López-Sáez, P., & Navas-López, J. E. (2015). Absorbing knowledge from supply-chain, industry and science: The distinct moderating role of formal liaison devices on new product development and novelty. *Industrial Marketing Management*, *47*, 75–85.

Dahlander, L., & Gann, D. M. (2010). How open is innovation? *Research Policy*, *39*(6), 699–709.

Dirgo, R. (2006). *Look forward beyond Lean and six sigma: A self-perpetuating enterprise improvement method*. Florida: J. Ross Publishing.

Dziurski, P., & Sopińska, A. (2020). Does industry matter? Drivers and barriers for open innovation in high-tech and non-high-tech industries-evidence from Poland. *International Journal of Management and Economics*, *56*(4), 307–323.

Enkel, E., Bogers, M., & Chesbrough, H. (2020). Exploring open innovation in the digital age: A maturity model and future research directions. *R&D Management*, *50*(1), 161–168.

Enkel, E., Gassmann, O., & Chesbrough, H. (2009). Open R&D and open innovation: Exploring the phenomenon. *R&D Management*, *39*(4), 311–316.

Erzurumlu, S. (2010). Collaborative product development with competitors to stimulate downstream innovation. *International Journal of Innovation Management*, *14*(4), 573–602.

EUROSTAT (2013). *Science, technology and innovation in Europe 2013 edition*. Eurostat European Comission, Luxembourg: Publications Office of the European Union, 141 p. Available from: https://ec.europa.eu/eurostat/documents/3930297/5969406/KS-GN-13-001-EN.PDF

Gassmann, O., & Enkel, E. (2004). Towards a theory of open innovation: Three core process archetypes. In J. F. Gomes, & P. Palma (Eds.), *R&D Management Conference 2004 (RADMA): Managing people and managing R&D* (pp. 1–18). Sesimbra.

Hsieh, K. N., & Tidd, J. (2012). Open versus closed new service development: The influences of project novelty. *Technovation*, *32*(11), 600–608.

Huizingh, K. R. E. (2011). Open innovation: State of the art and future perspectives. *Technovation*, *31*(1), 2–09.

Koh, S. L., Genovese, A., Acquaye, A. A., Barratt, P., Rana, N., Kuylenstierna, J., & Gibbs, D. (2013). Decarbonising product supply chains: design and development of an integrated evidence-based decision support system–the supply chain environmental analysis tool (SCEnAT). *International Journal of Production Research*, *51*(7), 2092–2109.

Lau, A. K., Lee, L. W., Lai, K. H., & Lee, P. K. (2018). Adopting an open innovation program with supply chain management in China: A case study. *Engineering Management Journal*, *30*(1), 24–41.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal*, *27*(2), 131–150.

Lazzarini, S., Chaddad, F., & Cook, M. (2001). Integrating supply chain and network analyses: The study of netchains. *Journal on Chain and Network Science*, *1*(1), 07–22.

Lee, H. L. (2002). Aligning supply chain strategies with product uncertainties. *California Management Review*, *44*(3), 105–119.

Lee, H. L., & Schmidt, G. (2016). Using value chains to enhance innovation. *Production and Operations Management*, *26*(4), 617–632.

Legenvre, H., & Gualandris, J. (2018). Innovation sourcing excellence: Three purchasing capabilities for success. *Business Horizons*, *61*(1), 95–106.

Lichtenthaler, U. (2015). A note on outbound open innovation and firm performance. *R&D Management*, *45*(5), 606–608.

Lichtenthaler, U., & Lichtenthaler, E. (2009). A capability-based framework for open innovation: Complementing absorptive capacity. *Journal of Management Studies*, *46*(8), 1315–1338.

Lo Nigro, G. (2016). The effect of early or late R&D inbound alliance on innovation. *Journal of Business Research*, *69*(5), 1791–1795.

Lv, D. D., Zeng, P., & Lan, H. (2018). Co-patent, financing constraints, and innovation in SMEs: An empirical analysis using market value panel data of listed firms. *Journal of Engineering and Technology Management*, *48*, 15–27.

Martinez, M. G., Lazzarotti, V., Manzini, R., & García, M. S. (2014). Open innovation strategies in the food and drink industry: Determinants and impact on innovation performance. *International Journal of Technology Management*, *66*(2–3), 212–242.

Mention, A. L. (2011). Cooperation and co-opetition as open innovation practices in the service sector: Which influence on innovation novelty? *Technovation*, *31*(1), 44–53.

Min, H., & Zhou, G. (2002). Supply chain modeling: Past, present and future. *Computers and Industrial Engineering*, *43*(1–2), 231–249.

Mukundan, R., & Thomas, S. (2016). Collaborative and open innovation: Supply chain planning as an effective source. *International Journal of Indian Culture and Business Management*, *12*(1), 128–140.

Obal, M., & Lancioni, R. A. (2013). Maximizing buyer–supplier relationships in the digital era: Concept and research agenda. *Industrial Marketing Management*, *42*(6), 851–854.

Paci, A. M., Lalle, C., & Chiacchio, M. S. (2010). Knowledge management for open innovation: Collaborative mapping of needs and competencies. *Journal of Knowledge Management Practice*, *11*(1), 1–08.

Parkash, S., & Kaushik, V. K. (2011). Supplier performance monitoring and improvement (SPMI) through SIPOC analysis and PDCA model to the ISO 9001 QMS in sports goods manufacturing industry. *LogForum*, *7*(4), 1–15.

Pihlajamaa, M. (2021). What does it mean to be open? A typology of inbound open innovation strategies and their dynamic capability requirements. *Innovation*, 1–24. doi:10.1080/14479338.2021.1907192.

Russell, C. L. (2005). An overview of the integrative research review. *Progress in Transplantation*, *15*(1), 8–13.

Schmelzle, U., & Tate, W. L. (2017). Integrating external knowledge: Building a conceptual framework of innovation sourcing. *Transportation Journal*, *56*(4), 477–512.

Shamah, R. A. E., & Elssawabi, S. M. (2015). Facing the open innovation gap: Measuring and building open innovation in supply chains. *Journal of Modelling in Management*, *10*(1), 50–75.

Torraco, R. J. (2016). Writing integrative literature reviews: Using the past and present to explore the future. *Human Resource Development Review*, *15*(4), 404–428.

Toth, J., & Fertő, I. (2017). Innovation in the Hungarian food economy. *Agricultural Economics-Zemedelska Ekonomika*, *63*, 43–51.

Trott, P., & Hartmann, D. (2009). Why "open innovation" is old wine in new bottles. *International Journal of Innovation Management*, *13*(4), 715–736.

Vahter, P., Love, J. H., & Roper, S. (2014). Openness and innovation performance: Are small firms different? *Industry and Innovation*, *21*(7–8), 553–573.

van Blokland, W. B., Fiksiński, M. A., Amoa, S. O. B., Santema, S. C., van Silfhout, G. J., & Maaskant, L. (2012). Measuring value-leverage in aerospace supply chains. *International Journal of Operations and Production Management*, *32*(8), 982–1007.

van de Vrande, W., Vanhaverbeke, V., & Gassmann, O. (2010). Broadening the scope of open innovation: Past research, current state and future directions. *International Journal of Technology Management*, *52*(3–4), 221–235.

Veldhuizen, M., Blok, V., & Dentoni, D. (2013). Organisational drivers of capabilities for multi-stakeholder dialogue and knowledge integration. *Journal on Chain and Network Science*, *13*(2), 107–117.

Wallin, M. W., & von Krogh, G. (2010). Organizing for open innovation: Focus on the integration of knowledge. *Organizational Dynamics*, *39*(2), 145–154.

West, J., Vanhaverbeke, W., & Chesbrough, H. (2006). Open innovation: A research agenda. In Chesbrough, H., Vanhaverbeke, W., & West, J. (Eds.), *Open Innovation: Researching a New Paradigm* (pp. 285–307). Oxford: Oxford University Press.

Whittemore, R., & Knafl, K. (2005). The integrative review: Updated methodology. *Journal of Advanced Nursing*, *52*(5), 546–553.

Wilhelm, M., & Dolfsma, W. (2018). Managing knowledge boundaries for open innovation–lessons from the automotive industry. *International Journal of Operations and Production Management*, *38*(1), 230–248.

Yang, K., & El-Haik, K. Y. B. (2003). *Design for six sigma: A roadmap for product development* (624 p.). The McGraw-Hill Companies.

Zajac, E. J., & Olsen, C. P. (1993). From transaction cost to transactional value analysis: Implications for the study of interorganizational strategies. *Journal of Management Studies*, *30*(1), 131–145.

Zimmermann, R., Ferreira, L. M. D., & Moreira, A. C. (2016). The influence of supply chain on the innovation process: A systematic literature review. *Supply Chain Management*, *21*(3), 289–304.

Corresponding author
Thais Assis de Souza can be contacted at: assis.sthais@gmail.com

Appendix

Table A1. Selected papers

Base	Journal	Author	Year	Title	Central theme
WoS	Technovation	Hsieh and Tidd	2012	Open vs closed new service development: The influences of project novelty	New services in R&D
WoS	*International Journal of Operations and Production Management*	Beelaerts van Blokland, Fiksiński, Amoa, Santema, van Silfhout and Maaskant	2012	Measuring value-leverage in aerospace supply chains	large-scale system integrator (LSSI)
WoS	*International Journal of Technology Management*	Martinez, Lazzarotti, Manzini and García	2014	Open innovation strategies in the food and drink industry: Determinants and impact on innovation performance	Effects of open innovation on innovation performance
WoS	*Industry and Innovation*	Vahter, Love and Roper	2014	Openness and Innovation Performance: Are Small Firms Different?	Artificial intelligence in small businesses
WoS	*Industrial Marketing Management*	Cruz-González, López-Sáez and Navas-López	2015	Absorbing knowledge from supply-chain, industry and science: The distinct moderating role of formal liaison devices on new product development and novelty	Development of new products
WoS	*Journal of Modelling in Management*	Shamah and Elssawabi	2015	Facing the open innovation gap: measuring and building open innovation in supply chains	Open innovation in supply chains
WoS	*Journal of Business Research*	Lo Nigro	2016	The effect of early or late R&D inbound alliance on innovation	Design contract
WoS	*Int. J. Indian Culture and Business Management*	Mukundan and Thomas	2016	Collaborative and open innovation: supply chain planning as an effective source	Collaborative OI
WoS	*Transportation Journal*	Schmelzle and Tate	2017	Integrating External Knowledge: Building a Conceptual Framework of Innovation Sourcing	Innovation sourcing
WoS	*Supply Chain Management: An*	Bravo, Ruiz-Moreno and Llorens-Montes	2016	Supply network-enabled innovations. An analysis based on dependence and complementarity of capabilities	Open innovation that increases competitiveness in the supply chain context
WoS	*Journal of Agricultural Economics*	Toth and Ferto	2017	Innovation in the Hungarian food economy	Food economy
WoS	*Business Horizons*	Legenvre and Gualandris	2018	Innovation sourcing excellence: Three purchasing capabilities for success	Purchasing as a way to achieve excellence in providing innovations
WoS	*Journal of Engineering and Technology Management*	Lv, Zeng and Lan	2018	Co-patent, financing constraints, and innovation in SMEs: An empirical analysis using market value panel data of listed firms	Co-patent
WoS	*International Journal of Operations and Production Management*	Wilhelm and Dolfsma	2018	Managing knowledge boundaries for open innovation – lessons from the automotive industry	Management of organizational knowledge limits

(*continued*)

Table A1.

Base	Journal	Author	Year	Title	Central theme
WoS	*International Journal of Operations and Production Management*	Bravo, Ruiz-Moreno and Montes	2018	Examining desorptive capacity in supply chains: the role of organizational ambidexterity	Desorptive capacity and impact on performance and competitiveness
WoS	*Engineering Management Journal*	Lau, Lee, Lai and Lee	2018	Adopting an Open Innovation Program with Supply Chain Management in China: A Case Study	Changing SCM and NPD practices to make open innovation in China
Scopus	*Global Journal of Flexible Systems Management*	Boehmke and Hazen	2017	The future of supply chain information systems: the open source ecosystem	Open source SC management software
Scopus	*Production and Operations Management*	Lee and Schmidt	2016	Using Value chains to enhance innovation	Consumer and supplier involvement in the innovation process
Scopus	*Journal of Small Business Management*	Brunswicker and Vanbaverbeke	2015	Open Innovation in small and medium-sized enterprizes (SMEs): External Knowledge sourcing strtegies and internal organizational facilitators	External knowledge sourcing in SMEs
Scopus	*Uncertain Supply Chain Management*	Arabshahi, Arabshahi, Zaafarian	2014	A study on how open innovation influences on supply chain behavior	SCM e OI
Scopus	*Production and Operations Management Society*	Billington and Davidson	2013	Leveraging Open Innovation Using Intermediary Networks	Operational routines for acquiring and integrating new ideas
Scopus	*British Food Journal*	Beckeman, Bourlakis and Olsson	2013	The role of manufacturers in food innovation in Sweden	Innovation in the food sector
Scopus	*International Journal of Production Research*	Koh *et al.*	2013	Decarbonizing product supply chains: design and development of an integrated evidence-based decision support system – the supply chain environmental analysis tool (SCEnAT)	Carbon emission assessment throughout SC
Scopus	*Int. J. Product Development*	Bendavid and Cassivi	2012	A "living laboratory" environment for exploring RFID-enabled supply chain management models	-
Scopus	*International Journal of Innovation Management*	Erzurumlu	2010	Collaborative product development with competitors to stimulate downstream innovation	Value generated for the links in the production chain according to the level of integration
SD	*Industrial Marketing Management*	Obal and Lancioni	2013	Maximizing buyer-supplier relationships in the Digital Era: Concept and research agenda	Buyer-supplier relationship and changes in the digital age
SD	*Trends in Food Science and Technology*	Bigliardi and Galati	2013	Models of adoption of open innovation within the food industry	OI practices in the food sector

Source(s): Prepared by the authors