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A theoretical and methodological framework for analyzing structural and relational aspects of diffusion of innovations among organizations

Proposta de *Framework* Teórico-Metodológico para Análise dos Aspectos Estruturais Relacionados ao Processo de Difusão de Inovações entre Organizações

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RESUMO

A inovação é tida como uma das principais prioridades estratégicas das organizações, estando comprovadamente relacionada à obtenção de retornos acima da média. Num contexto em que se exige das empresas, para um desempenho superior, a estruturação de redes cada vez mais extensas e complexas, além do aumento da capacidade de inovação, deve haver também a preocupação em difundir as inovações ao longo das redes organizacionais, de forma a potencializar seus impactos sobre o desempenho global do sistema. Com isso em mente, o presente trabalho traz uma proposta de um *framework* teórico-metodológico para a compreensão do processo de difusão de inovações entre os integrantes de uma cadeia de suprimentos. Espera-se contribuir para pesquisas futuras, estruturando as bases para guiar o processo de caracterização e análise da difusão de inovações entre organizações, especificamente no que diz respeito à relação entre esse processo e os aspectos relativos à gestão de cadeias de suprimentos.

Palavras-chave: Cadeia de suprimentos. Difusão de inovações. Organização para inovação. Inovação.

ABSTRACT

Innovation is seen as a key strategic priority for contemporary organizations, being frequently related to above-average returns. The competitive environment requires companies to structure even more complex and extensive networks for a superior performance. Therefore, besides increasing their innovation capacity, they must also be concerned in spreading the innovations across organizational networks in order to maximize their impact on the system performance as a whole. This paper proposes a theoretical and methodological framework for understanding the process of diffusion of innovations among members of a supply chain. We expect to contribute to future researches on the field by presenting a guiding model for the analysis of the process of diffusion of innovations among organizations, specifically with regard to the relationships between said phenomenon, the supply chain structure and particularities of its members.

Key words: Diffusion of innovations. Innovation management. Organization for innovation. Supply chain.

1 INTRODUCTION

Innovation has often been addressed in the literature only from the perspective of the individual organization. Only recently (noticeably since the 1990s) managers have become concerned with the performance of a set of companies as a system. While acknowledging the importance of developing an open model to take advantage of the opportunities that surpass organizational boundaries, the innovation literature considers the external environment as something unstructured and immune to the influence of the organizations (Bagno, Salerno, Amato Neto & Silva, 2012, p. 2). However, as we observe the rise of an environment characterized by continuous turbulence, the insertion of the firm in inter-organization networks plays a fundamental role in maintaining their competitiveness.

In a networked society, where organizations increasingly become dependent on the performance of other players (Castells, 1999), it is necessary to direct efforts towards approaches that consider the process of innovation within supply chains and systems. It becomes important to ensure the optimization of the performance of the entire set of interdependent actors rather than the maximization of the performance of its individual components.

The competition has gradually shifted to the level of the supply chain, not only occurring solely among its members, but between systems as wholes, since value is created from the synergy between the operations of each one. Organizations now constitute collaborative networks aimed at developing innovations faster than the competition (Bowersox, Closs & Cooper, 2006; Christopher, 1992; Correa, 2010). More and more companies start to explore the capabilities of suppliers and customers in order to add more value to their outputs, to develop solutions to reduce costs and to improve the quality of products and processes (Liker & Choi, 2004).

Competitive success is strongly associated with the ability to find the optimal balance between cooperation, collaboration and competition, when joining forces to better meet the demands and needs of consumers. As stated by Davila, Epstein and Shelton (2007, p.43), the central unit of innovation does not lie in the individual, but in the networks formed by the organization – internally and externally –, which ought to enable the practice of a collaborative behavior between the parties. After all, innovation is a result of a joint effort, a continuous process of combination of ideas (Karlsson, 2010).

In addition to building innovation capabilities, there must also be the concern to spread the innovations across organizational networks. Tigre (2006) argues that, at the time of the introduction of an innovation, its impacts are limited to the scope of the innovative firm and, eventually, its customers. An innovation would only produce broad economic impact when widely disseminated among companies, sectors and regions. The more widely spread an innovation is, the greater its impact on organization and network performance.

Addressing the challenges faced by innovation management processes in an inter-organizational level, especially regarding the management of frontiers in competitive contexts that require the structuring of increasingly extensive and complex networks, we propose a theoretical and methodological framework for an in-depth understanding of the process of diffusion of innovation in supply chains.

Firstly, we present the concept of innovation and considerations about its different categories - although we do not intend to exhaust the discussion on the topic. Then, we discuss the innovation diffusion process through a brief overview of the literature and of previously conducted studies that specifically consider the process in the context of supply chains. Finally, we present our considerations about structural aspects that favor innovation and, hence, its diffusion, and we introduce the framework that we believe should enable further understanding of the phenomenon.

2 FROM IDEA GENERATION TO DIFFUSION OF INNOVATIONS

Schumpeter was responsible, in the early twentieth century, for the pioneering studies of innovations as engines of economic development. For him, the dynamics of the capitalist system was fundamentally driven by the process of "creative destruction". The introduction of new elements and the consequent stimulus to new consumer needs generate discontinuities in the current economic structure (Schumpeter, 1984). Innovations would be closely related to changes in the existing economic balance. Those able to exploit them on behalf of their organizations through effective management processes are proven to get above average returns.

Tigre (2006, p.72) states that an innovation occurs with the effective practical application of an invention. Rogers (2003, p.11), in turn, defines it as "an idea, practice or object that is perceived as new by an individual or another adoption unit". The author highlights the link between the degree of novelty and context of adoption,

pointing out that an innovation necessarily do not need to be new to the world to be considered as such. Although comprehensive, Rogers' concept does not address the issue of implementation, as does Tidd, Bessant and Pavitt's (2005), for whom innovation is the process of transforming opportunities into new ideas and to put them into practice. Therefore, innovation does not involve only the perception of a new idea. It also involves the practical use development process, requiring management efforts and capabilities driven towards its effective adoption and its exploitation for the benefit of the organization.

Therefore, the process of innovation is not limited to the activities of creation or discovery of new technologies, but it also includes the activities of management, implementation and dissemination of novelties. As pointed out by Hansen and Birkinshaw (2007), it is necessary to understand innovation as an integrated flow, similarly to Michael Porter's value chain, from idea generation to the diffusion of innovations (Figure 1).

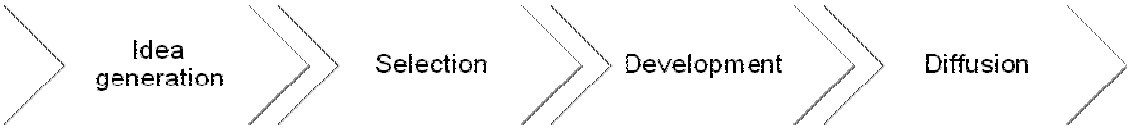

Figure 1: Innovation Value Chain.
Source: Adapted from Hansen e Birkinshaw (2007).

Indeed, the processes of innovation and diffusion cannot be completely separated, as also suggested by Tigre (2006, p.73), since very often the diffusion contributes to the innovation process itself, in that it feeds and directs the trajectory of the innovation, revealing the changing needs of the demands for technical solutions. Fleck (1993 apud Kemal, 2009) even coined the term "innofusion" to describe innovation activities that take place after the adoption of the initially planned innovation, and that occur from interactions of its technical aspects with the social context of use.

According to Teece (1980), diffusion is the process through which an innovation is spread among potential users. The origins of the studies of diffusion of innovations are found in the works of the "laws of imitation" by the French judge Gabriel Tarde, in the early twentieth century. Tarde sought to understand why some innovations were widespread while others, designed at the same time, were forgotten

(Tarde, 1903 apud Rogers, 2003). For the author, invention and imitation, and, therefore, diffusion of innovations, would constitute the fundamental explanation for changes in human behavior. The term “diffusion” was coined by European anthropologists adepts to the diffusionism, which preached that the process of introducing innovations and disseminating them was the basis of social change (Rogers, 2003).

The diffusion of innovations has important effects on the industrial structure. It is responsible for the destruction and for the creation of companies and industries because of its effects on the pace of economic growth and competitiveness among organizations and regions (Rogers, 2003; Tiger, 2006). Neoschumpterian scholars addressed the diffusion of innovations from a broader perspective, trying to explain the successive introduction of technological paradigms through the introduction and dissemination of radical innovations in the economic system (Dosi, 1982; Freeman & Perez, 1988; Perez, 1986). Discontinuities and imbalances in the economy would occur due to the adoption and diffusion of "technological revolutions" (Perez, 1986, p. 5), which, due to its strength and penetration, would act as supporters of economic growth for long periods of time. Technical progress, thus, would be the result of the diffusion of innovations in the economy, with a cyclical behavior. The adoption of new technological systems that gradually crystallize as an ideal type of organization would lead to the emergence of new industries as well as to the renewal and transformation of existing ones (Freeman & Perez, 1988; Perez, 1986)

At the organizational level, the diffusion process becomes equally important as it is closely related to the achievement of new levels of performance. Therefore, the more an innovation is widely spread, the greater its impact on organizational performance will be. This leads, consequently, to new levels of performance of the networks to which they belong.

Diffusion of innovations and technology transfer are often considered as synonyms in the literature (Stewart, 1987). However, even though they share some common concepts (Rogers, 2002), it is necessary to clarify the distinctions between the two phenomena in order to determine, accurately, about upon which points in the innovation process to act - and which aspects should be considered during the research in each one of the themes.

One of the main differences pointed by Stewart (1987) is that, while technology transfer is generally a planned process, diffusion occurs more spontaneously. Technology transfer often involves formal communication process and implementation of intellectual property, through the signing of trade or cooperation agreements. For Rogers (2002), the key question to be answered by the technology transfer process often relates to the means of commercialization of the results of R&D processes, while the diffusion would be interested in how an innovation, once available to members of a system, is disseminated and adopted by them.

Rogers (2003, p.6) defines diffusion as "the process in which an innovation is communicated through certain channels over time among members of a social system". According to the author, the diffusion process can be explained by four key elements: (i) the innovation itself, the benefits and costs involved in its adoption; (ii) the communication channels, which refers to the means through which messages flow from one individual to another; (iii) the time, which refers to the decision-making process through which an individual passes from first contact with the innovation to its adoption or rejection; and (iv) the social system in which the diffusion occurs.

The flows of communication through interpersonal networks are fundamental to understand the innovation diffusion process. They are influenced by the concepts of homophilia and heterophilia, widely employed in natural sciences studies, which determines the degree of similarity between a group of individuals (Fu, Nowak, Christakis & Fowler, 2012). Information exchange most often occurs between individuals and organizations who are homophilic – who share values, beliefs and socioeconomic status, for example –, since the communication between them would occur more intensively (Rogers, 2003).

Homophily and communication influence each other: the denser the communication flows between two individuals, the greater their tendency to become homophilic. The higher the homophilic character of the relationship, the more effective the communication. However, homophily can act as a barrier to diffusion of innovations in an inter-organizational network. In this case, the low interaction between groups with a higher status, and generally more likely to introduce new ideas, and the other elements of system, can hinder the transmission of new knowledge to those who do not possess similar position. Also, since innovation is

essentially a collaborative process (Karlsson, 2010), the existence of heterogeneous knowledge and different skill sets within the networks is an important precondition for its occurrence.

Regarding the social system, three main aspects have direct effects on the process, according to Rogers (2003): its structure, defined by the author as the formal and informal arrangements of system units; its norms, rules, values and established patterns of behavior; and its actors of influence, such as opinion leaders and change agents.

Tigre (2006, p.78), in turn, points out that the diffusion can be understood as the path of adoption of a technology. His definition focuses on the features of the innovation and other elements that influence their pace and direction. For the author, the diffusion process can be analyzed in the light of four basic dimensions, additional to those posed by Rogers (2003): the technological trajectory, which refers to the technical choices adoption during the evolutionary path of the innovation; the rhythm or rate of diffusion; the conditioning factors related to characteristics of the innovation itself and of the system in which the diffusion occurs, responsible for stimulating or restricting the adoption of the innovation; and the economic and social impacts of its dissemination.

Tigre (2006) analyses the influence of factors related to the internal context of the organization on the potential for innovation diffusion. Organizational flexibility and the cognitive capacity of its members to perceive and absorb new knowledge are key to the diffusion of new technologies. Similarly, the author highlights the role of inter-organizational factors in the process, such as the degree of concentration of the market and the degree of articulation of the production chain. While sectors that are more concentrated may make certain innovations more viable, because of economies of scale and scope provided the high production volume, more pulverized industry structures can slow the absorption of innovations, due to difficulties in accessing technical and financial resources needed to invest in new technologies.

Just as the innovation itself, which should not be seen as a linear process, but subject to intense interactivity, the diffusion process cannot be considered only through a sequential perspective. Diffusion involves a broad and complex context in which knowledge related to an innovation and the decision-making process for its

adoption occur continuously, involving different levels and actors. This means that the diffusion does not start with the generation of a new idea and ends with its implementation, but encompasses a phenomenon that permeates the daily lives of all the potential adoption units.

2.1Diffusion of innovations in supply chains

Innovations diffuse between organizations through inter-organizational networks, similar to the process observed among individuals in a social system (Walker, 1969). Rogers (2003) identifies a number of representative studies for the construction of a theory of diffusion of innovations. For our research, we analyzed Coleman, Katz & Herbert's (1957) and Walker's (1969) studies, as indicated by the author. They focus, respectively, on diffusion networks and on the diffusion among organizations. Complementarily, we searched academic databases for other studies on the diffusion of innovations in supply chains, in order to support the construction of a framework that would allow us to the achievement of the objectives of this work. The following is a summary of the most important points of each study analyzed, that guided the construction of the proposal presented later on.

Walker (1969) was interested in the means through which new government programs were spread among US federal units. The author classified the states according to a score elaborated to measure the diffusion rate in each one based on the date of adoption of 88 previously selected programs. After drafting an initial ranking, the author established correlations with socioeconomic data in attempt to identify factors that led to the existence of differences in the adoption rates of innovations by state legislation. The author concludes that larger, wealthier, more urbanized and industrialized states, with higher turnover rates in their political systems, tended to adopt new programs faster. Similarly, other studies emphasized factors such as size and availability of resources as important for innovation adoption at the organizational level (e.g. Goshal & Bartlett, 1988; Marx, 2008; Rogers, 2003).

Moreover, Walker realized that the states' behavior, with regard to the adoption of a program, was influenced by the behavior of other states considered regional references. The pioneering attitude of those states towards the adoption of an innovation would serve as a guiding parameter for decision-making about its adoption for others. Such regional references acted as opinion leaders, using

Rogers' (2003) nomenclature, and were proven to be important in explaining the rate of adoption of an innovation. Opinion leaders are individuals (or similarly, organizations) that influence the attitudes and behaviors of others. Opinion leaders serve as channels for the introduction of new ideas into a system. To do so, they must rely on a more extensive relationship network than that of their followers, in order to promote greater social participation and to allow formal and informal contact that would lead to the diffusion between elements of the system (Rogers, 2003).

Coleman et al. (1957) focused on diffusion networks, analyzing the adoption rates of a new drug by doctors working in four US cities. The analysis of prescriptions allowed to determine the dates of the first occurrences of the use of the new drug. Through interviews, the authors identified the social variables that affected the process, noting that the adoption was faster among doctors who were most deeply involved in their respective professional communities.

Through a survey of adopting periods of an administrative innovation by companies from various sectors of the US economy, Teece (1980) sought to determine if that kind of innovation would follow the same patterns of diffusion of technological innovations, which are extensively worked in the literature. The author concludes that both are subject to the same function that explains the diffusion. However, the study raises hypotheses that administrative innovations would take more time to be implemented, given that they usually require further adaptations to the context of the organization.

Ghoshal and Bartlett (1988) studied the organizational attributes that contribute to the development and diffusion of innovations processes in subsidiaries of multinational companies. The authors analyzed a set of innovation cases drawn from interviews conducted with managers of those companies, which were then related to common organizational attributes that could affect the process. The authors conducted nine case studies, whose results were complemented by surveys applied in 66 North American and European companies. They found a strong positive correlation between diffusion rates, the degree of integration between subsidiary and headquarters and the density of the existing internal and external communication networks.

Rosegger (1991) analyzed the impact of competition and cooperation on the dissemination of technologies in the automotive industry, by establishing a comparison between American and Japanese automakers. The superior performance of the automakers from Japan during the 1980s was attributed to strategic partnerships they formed with their suppliers, which enabled the diffusion of innovations among them. Such cooperative arrangements replaced the usual highly vertically integrated companies with a collaborative network and were responsible for accelerating the dissemination of technologies in the industry.

Xin Gan & Clemes. (2007), in turn, investigated a textile supply chain in a Chinese province, having found a gap in the literature regarding diffusion of innovations and supply chain integration. The application of surveys among the members of the network revealed positive correlations between the application of governance mechanisms at the chain level and the diffusion process, since they contribute to greater integration between the processes of the companies.

Greve (2008) investigated the influence of geographical factors in the diffusion of innovations in the naval sector. The author concluded that many of the innovations studied remains rare because they are not usually adopted by firms geographically distant from those who first implemented the innovation. This finding reinforces the influence of the position held by firms within inter-organizational networks on their competitiveness.

In 2011, So and Sun attempted to explain the adoption of lean manufacturing principles by 558 companies and the relationship of this process with supply chain integration, using the diffusion of innovations theory presented by Rogers. The authors concluded that the use of electronic means for information sharing and its effects on supply chain integration contributed to a higher rate of adoption of said principles. Information exchange helped to elucidate the benefits and usefulness of the innovation.

Skipper, Hanna and Cegielski (2009) revealed that the adoption of contingency plans by companies inserted in supply chains depends on internal factors such as the perception of the advantages of the innovation by potential adopters, decentralization and senior management support. Their study differs from the others

because it focused on the intraorganizational factors that affect the diffusion process at the supply chain level.

Interestingly, all the analyzed studies involved the application of quantitative methods at some stage of research, and focused in determining the trajectory of adoption of one or more particular types of innovation. The works considered, however, did not address simultaneously intra and inter-organizational structural factors that may have impacts on the diffusion process.

2.2 Organizational structure and innovation

Scholars who have studied diffusion of innovations, having organizations as units of analysis, sought to determine the reasons for firms to adopt and implement innovations at different rates, thus, focusing on the particularities of the organizations (Rogers, 2003). The diffusion and adoption of innovations depend on the company's competitive environment and its characteristics as a social system (Freeman & Perez, 1988; Rogers, 2003). Therefore, the occurrence of diffusion is highly related to the organizational context as well as the inter-organizational system in which the firms operate.

Setting up an organizational context favorable to the creation and improvement of the innovation processes depends, in addition to the adoption of an appropriate structure, on the promotion of an environment that encourages innovation and creative thinking across the firm (Tidd, Bessant & Pavitt, 2005). Although firms differ greatly from each other, it is possible to find common aspects that characterize the organizational contexts of those that stand out for their innovation capacity. Mintzberg (2003) points out that the performance of a company is related to the adequacy of its structure to particular aspects of its production process, such as size, strategy, technology and conditions of uncertainty. An effective organization would result from the adequacy of its structure to such contingency factors.

Innovation strategies are closely related to flexible and agile structures, while rigid, more conventional structures are related to strategies aimed at cost reduction and quality assurance. Marx (2008) explains that increases in the organization's innovative capacity – which would lead to the success in the introduction of innovations and the consequent effectiveness of the diffusion process (Rogers, 2003; Tigre, 2006), are favored by settings that enable continuous adaptation to changes in

the environment. Such settings are related to more organic structures, characterized by high horizontal specialization and decentralization of decision-making, which, along with a coordination based on informal communication and empowerment, contribute to higher versatility and flexibility.

With regard to the internal characteristics of the organizational structure, there seems to be a consensus that size, ease of communication and interconnectivity and senior management support are positively related to innovation capabilities, while centralized control and formalization have a negative impact (Damanpour, 1991; Marx, 2008; Mintzberg, 2003; Rogers, 2003; Tidd et al., 2005).

Rigid hierarchical structures, which prevent integration between functional areas and emphasize top-down communication, do not provide conditions for information sharing and cross-functional cooperation. These are recognized as success factors for the innovation process (Tidd et al., 2005). However, as noted by Rogers (2003), some studies show that, despite the fact that low centralization, high complexity and low formalization facilitate the beginning of the innovation process, such features can hinder the implementation, once a decision is made regarding the adoption of an innovation. This issue can be attributed to certain ambiguities commonly encountered in more flexible structures (Mintzberg, 2003), where difficulties arise from trying to combine the complex process of innovation with the overall performance of the company. Hage (1965 apud Donaldson, 1999) studies the relations between organizational formalization, efficiency and innovation rates, observing that, while a more organic structure may lead to greater innovation rates, it may also cause efficiency problems in the organization's operations, since deviations, although important to the innovation processes, can easily hamper the daily operations.

The structure of the supply chain, in turn, consists of its members, the links and the existing relationship patterns between them (Cooper, Lambert & Pagh, 1997). The interdependence between suppliers and consumers underlines the need for effective management of the relationships at the chain level. As a result, structuring communication processes and mobilizing individuals and groups have transcended the boundaries of the firm in recent years. These now also occur within organizational networks. Long-term relationships have gradually expanded towards greater

integration with suppliers, favored mainly by the emergence of new information and communication technologies. This new perspective on inter-organizational relationships encourages planning and joint problem solving, and provides greater flexibility, responsiveness and new cost reduction opportunities for everyone involved (Christopher, 1992; Liker & Choi, 2004).

McAdam and McCormack (2001) note the importance of integration of the various links of the supply chain for the competitiveness of its members. Integration occurs mainly through increased communication between business partners, and can be understood as the process of connecting entities through coordination and resources and information sharing. Child (2012, p.111), similarly, defines integration as the application of "coordination, cohesion and synergy" between different organizations working in a network with a common goal, which would be interdependent in the value creation process.

The potential for contribution of the collaboration between the supply chain members to the global performance and, consequently, to the competitiveness of the entire system, will depend on the degree of coordination achieved between their activities and interdependent processes. The alignment between the strategies of each organization leads to the consolidation of win-win relationships and to the achievement of global objectives (Cooper et al., 1997; Correa, 2010).

Within the supply chain, governance can be defined as the "management of interactions, regulatory systems, coordination and negotiation mechanisms" (Cassiolato & Lastres, 2003, p. 14) that are in effect between the members of the chain. According to Humphrey and Schmitz (2000), the governance structure consists of the relations of authority and power that determine how resources are allocated in the system. It is crucial to define the space of opportunities to reduce conflicts, to develop greater coordination between participants, and to allow the occurrence of cooperative and collaborative behavior. Governance, then, is related to the different forms of operation of the inter-relations that take place between the processes and functions that occur across firms' boundaries. It should seek for continuous improvement of system performance and dissemination of the principles and norms that guide its operations. The established governance structure may involve the use of formal or informal control mechanisms (Ferguson, Paulin &

Bergeron, 2005; Jain & Dubey, 2005), usually in the form of contracts, incentive programs and supplier assessment practices (Dolci & Maçada, 2011).

Literature (e.g. Coleman *et al.*, 1957; Goshal & Bartlett, 1988; Rosegger, 1991; So & Sun, 2011; Walker; 1969; Wejnert, 2002) has shown that integration and density of communication flows positively contribute to the effectiveness of the diffusion process. The adoption of control and coordination mechanisms in a supra-organizational level has also been found to be related to the transmission of innovations (Xin, Gan & Clemes, 2007). Thus, within the supply chain, innovation would be the result of the integration between its participants, measured by the extent and frequency of the interactions between its members, proximity to business partners and degree of information sharing. These, in turn, would depend on the use of effective communication channels and on the degree of openness of the relationships mediated by the use of governance mechanisms.

As evidenced by Karlsson (2010), successful organizations are adopting collaborative approaches to their innovation processes at an increasing rate, extending their networks to create greater value for customers, suppliers, partners and even competitors. A key feature which gives them superior performance lies in their ability to recognize not only their core competencies, but also those employed by their partners in the innovation process. For this collaboration to be possible, the factors listed above are essential for the system's performance.

2.3 Articulating the constructs: a new analytical framework for the diffusion of innovations

Innovation is a topic that involves complexity and change, making it difficult to predict the results of its application and to identify the related opportunities and threats. That is why it is fundamental to study in depth aspects of innovation management in inter and intra-organizational levels in order to use it effectively in favor of the competitiveness of organizations. Since diffusion is an essential stage of the innovation process (Hansen & Birkinshaw, 2007), it is also important to comprehend the characteristics of this particular phenomenon.

The research in diffusion of innovations begun around the 1940s, with studies focusing in a single type of innovation. The first works emerged from the research in

anthropology and sociology, reaching the area of administration and marketing during the 1960s. In 1962, Rogers launched the first edition of the book Diffusion of Innovations, motivated by the attempt to describe a single general model to guide studies in the field. Although the author (Rogers, 2003) noted a tendency towards the adoption of multidisciplinary approaches for the development of a theory of diffusion, he noted that the contributions to the field of management remained unexploited.

Existing theory and studies of diffusion usually seek to identify empirical regularities that allow to describe and eventually predict the pace of adoption of an innovation (Tigre, 2006). As noted by Rogers (2003) and Tidd et al. (2005), research in the area aims to identify on which aspects early adopters of an innovation differ from the rest, how perceived attributes of an innovation affect their rate of adoption and how the adoption curve of an innovation develops through time.

Regarding the latter, there are numerous quantitative studies in the literature aimed at obtaining formulas to characterize the behavior of the pace of adoption of certain innovations in presumed stable circumstances. To do so, the prediction model developed by Frank Bass, known as Bass diffusion model, is commonly used. It consists of a differential equation that describes the rate of adoption of an innovation over time (see Bass, 1969). It is widely used in determining diffusion rates of new durable goods products by consumers as a method of quantifying the diffusion process. The pace of adoption is usually presented graphically as an S-curve. At first, the adoption rate is low and the innovation remains restricted to a few individuals (commonly referred to as innovators). Gradually, a greater number of people adopt the innovation (early adopters), accentuating the growth curve (late-majority) until eventually it begins to decrease, turning into an asymptote, the laggards being the last to embrace the innovation (Rogers, 2003).

Tidd et al. (2005) note that quantitative models that result from analysis such as the one proposed by Bass' model are still unable to provide the necessary information for a greater generalization of the diffusion process. According to these authors, the pattern of adoption of an innovation depends on the interaction of complex factors related to its demand, as well as to its offer, in a co-evolution context, which goes far beyond the simplifications of mathematical models. Hall (2005) also recognizes that further clarification of the diffusion process requires a

broader framework beyond models that simply seek to identify the determinants of the success or failure of a particular innovation.

We found that the studies in the field remain restricted to the work of a small number of authors, especially to that of the sociologist Everett M. Roger. The proposition of a new analytical framework aims to fill this gap found in the literature, mainly in what regards the relations between intra and inter-organizational aspect.

Considering the importance of innovation as a competitive factor for organizations and for the supply chains in which they operate, it is essential to get a holistic understanding of the aspects that influence the processes related to its occurrence. Therefore, it is necessary to highlight the structural aspects that influence the phenomenon in order to substantiate the basis for the study of the relationships between the diffusion process and supply chain management, as well as of the internal factors that favor its occurrence between customers and suppliers, and among suppliers. We expect to contribute to future research on the subject, structuring the foundation to guide the characterization and analysis of the diffusion of innovations among organizations.

2.4 A framework to analyze diffusion of innovations within supply chains

The understanding of the constructs of the framework will allow to clarify the relationships between the diffusion of innovations process, the structural aspects of the supply chain under analysis and factor related to the organizational context of its members, enabling a more detailed description of the phenomenon.

We classified the constructs into two groups according to the level of the organizational analysis. The framework is illustrated in Figure 2, where C_1, C_2 e C_n represent clients and S_1, S_2 e S_n, suppliers.

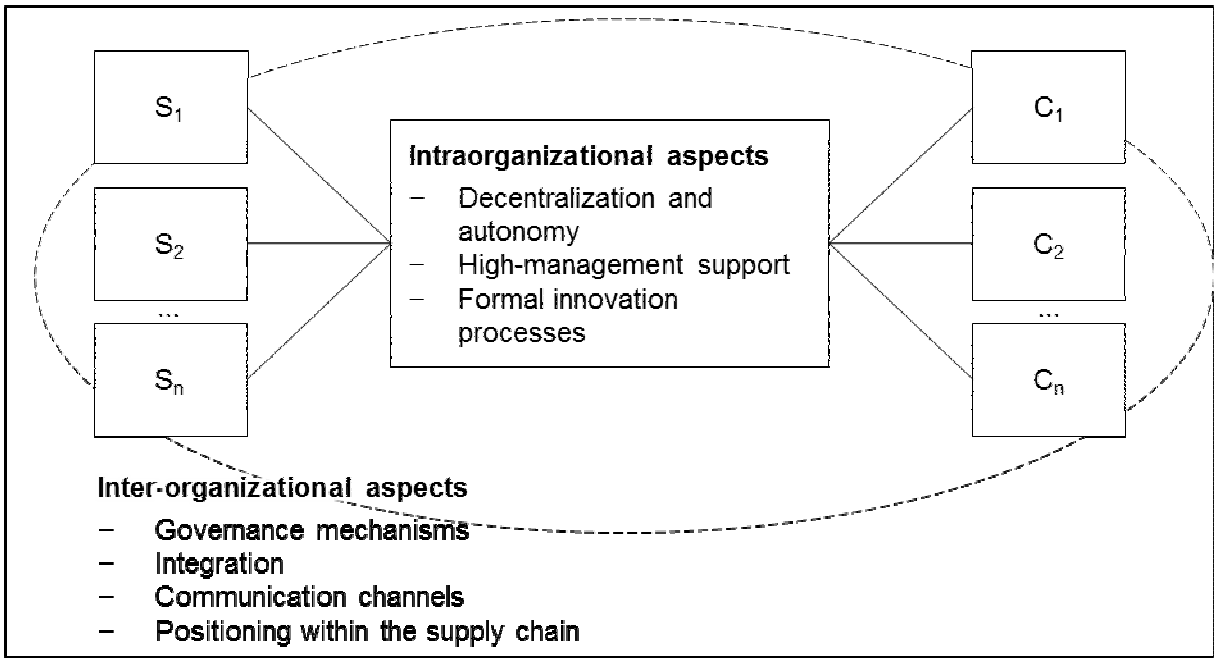

Figure 2: Framework for analyzing the diffusion of innovations process within supply chains
Source: Prepared by the authors.

The more an organization is oriented towards innovation, the higher the innovation adoption rates by their members will be. Therefore, it would be more suitable to act as a source for the dissemination of new ideas for the other elements of the system in which it operates. An organization that presents a flexible structure that encourages delegation of responsibility and tolerance to errors and that gives space to develop new ideas tend to have greater ease in transferring complex knowledge (Cummings & Teng, 2003).

Zahra and George (2002) note that, without adequate mechanisms, knowledge obtained externally will not be exploited and thus the communication of innovation will not result in adoption. At the same time, as we learn from Easterby-Smith and Lyles Tsang (2008), an organization well-equipped to spread such knowledge within its borders should also excel in absorbing external knowledge. Since it would be better able to generate new ideas, select other externally and exploit them, such organizations would contribute more significantly to the innovation diffusion process in the chain level, serving as a channel for the transmission of innovations among the different levels of the network and contributing to increase the system's innovative capability as a whole.

The intra-organizational factors detailed in Table 1 relate to the characteristics of the organizational context of each particular company, which contribute to the diffusion process at the chain level.

Aspect	Concept
Decentralization	Refers to the degree of concentration of the decision-making within the organization (Mintzberg, 2003)
Senior management support	The extent to which senior management endorses and contributes to the innovation process (Rogers, 2003; Tidd *et al.*, 2005)
Formalization	Refers to the degree of regulation of the organization members' behavior (Mintzberg, 2003)
Autonomy	Refers to the decision making regarding planning of individual work (Salerno, 1999)

Table 1: Intra-organizational aspects related to the diffusion of innovations process
Source: Prepared by the authors.

An internal organizational context oriented innovation alone is not decisive for the occurrence of diffusion flows. It is essential for the enhancement of the diffusion process that the organization is centrally positioned within the supply chain and that it relies on effective communication channels with its trading partners, while having internally sufficient resources to recognize the potential of an innovation as a competitive factor and to adapt it to a new context of use.

Within the supply chain, innovation is a product of, among other factors, the level of integration between its participants, measured by the amount and frequency of interactions with other members, the proximity to business partners and the degree of information sharing. The latter depends, in turn, on the participation in effective communication channels within the chain and on the degree of openness of the relationships determined by the adopted governance mechanisms.

The inter-organizational factors detailed in Table 2 relate to the structure of the supply chain, more specifically to supra-organizational aspects related to its members, as well as to the relationship patterns that may influence the innovation diffusion process among them.

Aspect	Concept	Studies
Governance mechanisms	Means of regulating the relationships within the supply chain (Cassiolato & Lastres, 2003)	Rosegger (1991); Xin *et al.* (2007)
Integration	Degree of coordination between inter-organizational processes and of information sharing ((McAdam & McCormack, 2001)	Goshal & Bartlett (1988); Rogers (2003); Rosegger (1991)
Communication channels	Means through which messages flow from one individual to another (Rogers, 2003).	Coleman *et al.* (1957); So & Sun (2011)
Positioning within the supply chain	Distance to the opinion leader (Rogers, 2003)	Greve (2008); Rogers (2003); Walker (1969)

Table 2: Inter-organizational aspects related to the diffusion of innovations process
Source: Prepared by the authors.

3 Final remarks

The diffusion of innovations process requires careful management: the lack of sufficient information about a particular innovation can lead to a misunderstanding of its real benefits, resulting in the adoption of technically inefficient innovations and unnecessary resource expenditures (Hall, 2005; Tidd et al., 2005). Understanding the diffusion process, according to Hall (2005), is the key to understand how innovative activities consciously conducted by organizations have the desired economic and social outcomes.

The intra and inter-organizational aspects listed in the framework we elaborated for this research work as conditions for the establishment and maintenance of communication spaces, which act as channels for the dissemination of innovations within the social system under consideration (i.e. the supply chain). The combination of factors related to the chain structure and the organizational contexts of its members determines how the process occurs, its intensity and how each company affects or is affected by the diffusion.

Besides seeking a contribution to the study of innovation as a source of competitive advantage for organizations, we aimed to contribute to this theoretical field. Specifically with regard to the relationship between the diffusion process and aspects of supply chain management and the relationships between its members as

well as to the internal factors that favor its occurrence between consumers and suppliers.

We believe that the design of the framework helps to strengthen the foundations of the research on diffusion of innovations, recognized as an important step in the innovation process. Understanding of the factors that influence the diffusion is a first step to understand the dynamics involved in the phenomenon and, consequently, to adopt an active approach in exploiting its potential benefits.

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