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# Open Innovation in Agrifood Chain: A Systematic Review

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**Abstract:** Despite the practice of open innovation being consolidated, scientific publications are still limited, particularly when related to agribusiness. Through bibliometric technique and content analysis, this study aimed to analyze the state of the art on the subject, explaining the development of open innovation in agribusiness and highlight future research opportunities. The risk of sharing valuable knowledge is the main barrier to adoption. For mitigate it, there is a need for internal organizational changes, the support of communication tools and an intellectual property model that encourage knowledge sharing. Open innovation is a field that needs to be explored in different links in the chain, locations and contexts, in order to help ensure that organizations can benefit from this strategy.

**Keywords:** food industry; partnerships; property rights; university; company; research and development.

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## Introduction

The current agribusiness scenario is influenced by a variety of factors, such as the growth of the world population (Food and agriculture organization of the United Nations [FAO], 2009), the intense economic competition (Läpple, Renwick & Thorne, 2015), the limitation of fossil resources (Preschitschek, Curran & Leker, 2011) and the climate changes and their possible effects on food security (Knickel, Brunori, Rand & Proost, 2009). Under these conditions, there is a need to increase the production of food, fiber and energy with greater efficiency in the use of available resources. To achieve this goal, it is essential that organizations of this sector promote innovation throughout their supply chains (Roucan-Kane, Gramig, Widmar, Ortega & Gray, 2013).

The revolutions in information and communication technology have reduced marketing and coordination costs and allowed organizations to establish more complex and efficient relationships (Organisation For Economic Co-Operation And Development [OECD], 2014). Consequently, the way innovations are designed, developed and marketed was also affected.

An increasingly evident practice is the open innovation, by offering opportunities to generate shorter innovation cycles of products, services and techniques (Grieve, Bushell, Lant, Georghiou, & Malik et al., 2009), reduced R&D costs, in addition to meeting the shortage of resources (Gassman & Enkel, 2004). This concept admits that knowledge is very widely available and that organizations must use the external environment to complement the assets needed to generate innovation (Chesbrough & Bogers, 2014), at the same time that may externalize internal results of R&D that are inconsistent with their current business model (Gassman & Enkel, 2004).

Notwithstanding, the transition to the opening of the innovation processes involves considerable management challenges for organizations, such as the transformation of business models (Saebi & Foss, 2015), the implementation of new types of R&D management structures (Chiaroni, Chiesa & Frattini, 2010) and the cultural shift to a vision more oriented towards the external environment (Huston & Sakrab, 2006). Still, recent academic studies and the practical business discussion highlight the collaborative nature of innovation activities, as in a systemic world, almost all of these are generated by cooperation between different actors (Mäkimattila, Melkas & Uotila, 2013), positively impacting the final performance (Omta & Fortuin, 2013).

Open innovation can represent a new paradigm for the development of agribusiness (Dong, Yang, Bai, Wang & Zhang, 2013), therefore, it is assuming increasing importance in theory and in practice (Gassman & Enkel, 2004). However, empirical scientific evidence on agrifood chains are still scarce (Sarkar & Costa, 2008; Bigliardi & Galati, 2013). Since no review synthesizing the subject in this sector was identified, this study aims to present the state of the art on open innovation in agribusiness, identifying how it is adopted, the factors that influence this process and future research possibilities.

## Open innovation

Chesbrough (2003) first used the term open innovation when identifying erosion factors that undermine the traditional model of R&D. According to the author, increased mobility of employees, more qualified universities, the decline of the US hegemony and the increased start-ups access to venture capital changed the conditions under which the organizations innovate. To these, Chesbrough and Bogers (2014) added the expansion of the Internet and social media, which increased the access and the sharing of knowledge.

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As a result, a new paradigm is imposed on organizations: open innovation. An innovation process based on the purposeful management of knowledge flows within the limits of the organization, supported by financial incentives or not, which should be aligned with the business model of the same (Chesbrough & Bogers, 2014). This model is more dynamic and less linear, because innovations are based on capturing external knowledge assets through cooperation; as well as on the outsourcing of assets that are not part of the core business and that will be better developed and marketed by others (De Backer, Lopez-Bassols & Martinez, 2008).

Significant implications result from this recent conception and can be seen in the representation of Chesbrough, Vanhaverbeke and West (2006) of the organization as a funnel. One can check the permeability of the organization's boundaries, which is willing to acquire and make knowledge available externally, in order to generate greater value for the innovations, through the current market, new markets or new businesses.

The distinct forms of this practice are based on the direction of flow of knowledge across the organization's boundaries, which may occur from the outside in - inbound - or from the inside out - outbound (Gassman & Enkel, 2004). Those of the first type occur in relationships established with external actors in order to access technical and scientific knowledge that will improve innovation performance internally (Chiaroni et al., 2010).

In the case of inbound practices, organizations can access these resources through various collaborative and contractual agreements, involving organizations and individuals with relevant knowledge to complement the internal efforts of R&D (Von Hippel, 2005). Some mechanisms include the acquisition of licenses of intellectual property rights, research programs with universities, foundation of start-ups with other companies, crowdsourcing, competitions and tournaments and collaboration with links in the supply chain and the community (Chesbrough & Bogers, 2014).

On the other hand, the results of investments in R&D can generate spillovers, ie, knowledge assets, from which the company has no capacity to benefit or that are not compatible with its current business model (Chesbrough & Bogers, 2014). In the open innovation view, these spillovers are transformed into inputs and outputs that can be managed through outbound processes.

In other words, organizations can create channels for this knowledge, that would be useless or not used internally, to be transferred to external partners (Maarse & Bogers, 2012; Chesbrough & Bogers, 2014). The sale or donation of intellectual property rights and technology licensing, corporate incubators, joint ventures and alliances are some of the examples by which this practice can be achieved (Chesbrough & Garman, 2009).

Moreover, inbound and outbound flows can occur simultaneously, combined to generate and/or market an innovation cooperatively (Enkel, Gassmann & Chesbrough, 2009; Chesbrough & Bogers, 2014). The process known as couple open innovation involves two or more partners who purposefully manage mutual knowledge flows, developing innovation and/or marketing activities jointly (Bogers, Bekkers & Granstrand, 2012).

Although involving knowledge flows in both directions, the application in the form of technologies can be performed in different ways. That is, the dual processes can be further classified as bidirectional, when only one partner develops innovation (Gassman & Enkel, 2004), or co-creation, when this is done in a shared way (Piller & West, 2014). This combination of processes "from the inside-out" and "from the outside-in" can be implemented through strategic alliances, joint ventures, consortia, networks, ecosystems and innovation platforms (Chesbrough & Bogers, 2014).

Open innovation represents an innovation in itself, first adopted by the industries referred to as high-tech, such as information technology and pharmaceuticals (Gassman & Enkel; Chesbrough, 2010). However, gradually it has also been used as a strategy of the so-called mature and traditional industries (Chesbrough & Crowther, 2006), such as the case of agribusiness.

### Bibliometric analysis

The studies were collected from the ISI Web of Science, Scopus and Science Direct databases. The search resulted in 37 studies in English, being 23 articles, 1 book, 4 book chapters, 4 conference papers, 1 review conference and 4 reviews (Table 1). Despite the small number, the evolution of publications since 2006 signals the growing discussion on the subject. The reviews on the food industry and the development of functional foods are highlighted.

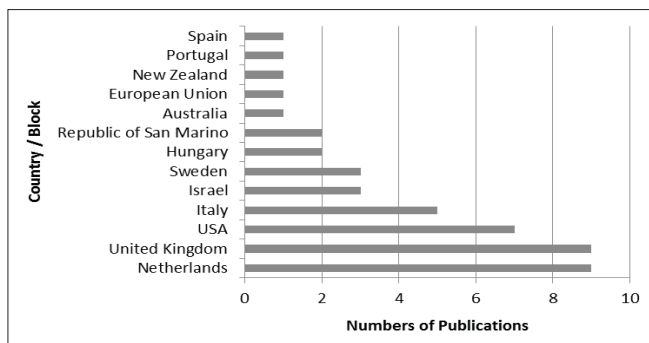
**Table 1.** Open innovation studies in agrifood chain.

Author(s)	Year	Document Type	Study Object
Juriaanse	2006	Conference paper	Food Industry
Sarkar & Costa	2008	Review	Food Industry
Fortuin & Omta	2009	Article	Food Industry
Grieve, Bushell, Lant, Georgiou & Malik	2009	Conference paper	Agri-eletronics
Siedlok, Smart & Gupta	2010	Article	Nutraceuticals
Bellairs	2010	Article	Food Industry
Wolfert, Verdouw, Verloop & Beulens	2010	Article	Agri-food SME's
Top, Koenderink & Rijgersberg	2010	Book Chapter	Agri-food Supply Chain
Traitler, Watzke & Saguy	2011	Article	Food Industry
Enzing, Pascucci, Janszen & Omta	2011	Article	Food Industry

Saguy	2011	Article	Agri-food companies
Petroni, Venturini & Verbano	2012	Article	Food Industry
Kumar, Boesso, Favotto & Menini	2012	Article	Food Industry
Thornblad & Hedner	2012	Article	Agriscience Companies
Klerkx & Nettle	2013	Article	Dairy production
Beckeman, Bourlakis & Olsson	2013	Article	Food Industry
Filieri	2013	Article	Food Industry
Di Guardo & Castriotta	2013	Article	Agri-food sector
Martinez	2013	Article	Restaurant
Roucan-Kane, Gramig, Widmar, Ortega & Gray	2013	Article	Food Industry
Moskowitz & Saguy	2013	Article	Fertilizers
Caudill	2013	Book Chapter	Food and Beverage Industry
Martinez	2013	Book Chapter	Beverage Industry
Wognum & Curran	2013	Book Chapter	Agri-food sector
Dries, Pascucci, Török & Tóth	2013	Conference paper	Beverage Industry
Saguy, Singh, Johnson, Fryer & Sastry	2013	Conference Review	Food Industry
Martinez	2013	Book	Food and Beverage Industry
Bigliardi & Galati	2013	Review	Food Industry
Khan, Grigor, Winger & Win	2013	Review	Functional Food
Omta & Fortuin	2014	Article	Food and Beverage Industry
Chesbrough, Kim & Agogino	2014	Article	Agri-food sector
McAdam, McAdam, Dunn & McCall	2014	Article	Artisan Bakeries
Dries, Pascucci, Torok & Tóth	2014	Article	Beverage Industry
Ruitenburt, Fortuin & Omta	2014	Article	Seeds
Pellegrini, Lazzarotti & Manzini	2014	Article	Food and Beverage Industry
Saguy & Sirotinskaya	2014	Review	Food Industry
Bombaywala & Riandita	2015	Conference paper	Food Industry

The results showed a certain concentration of the studies regarding the geographical distribution, in which Europe stands out (Figure 1). Either when mentioned by a member country or by several countries inserted in the European Union bloc, the continent is portrayed in almost 90% of the work.

**Figure 1. Worldwide geographical distribution of open innovation studies in agrifood chain.**



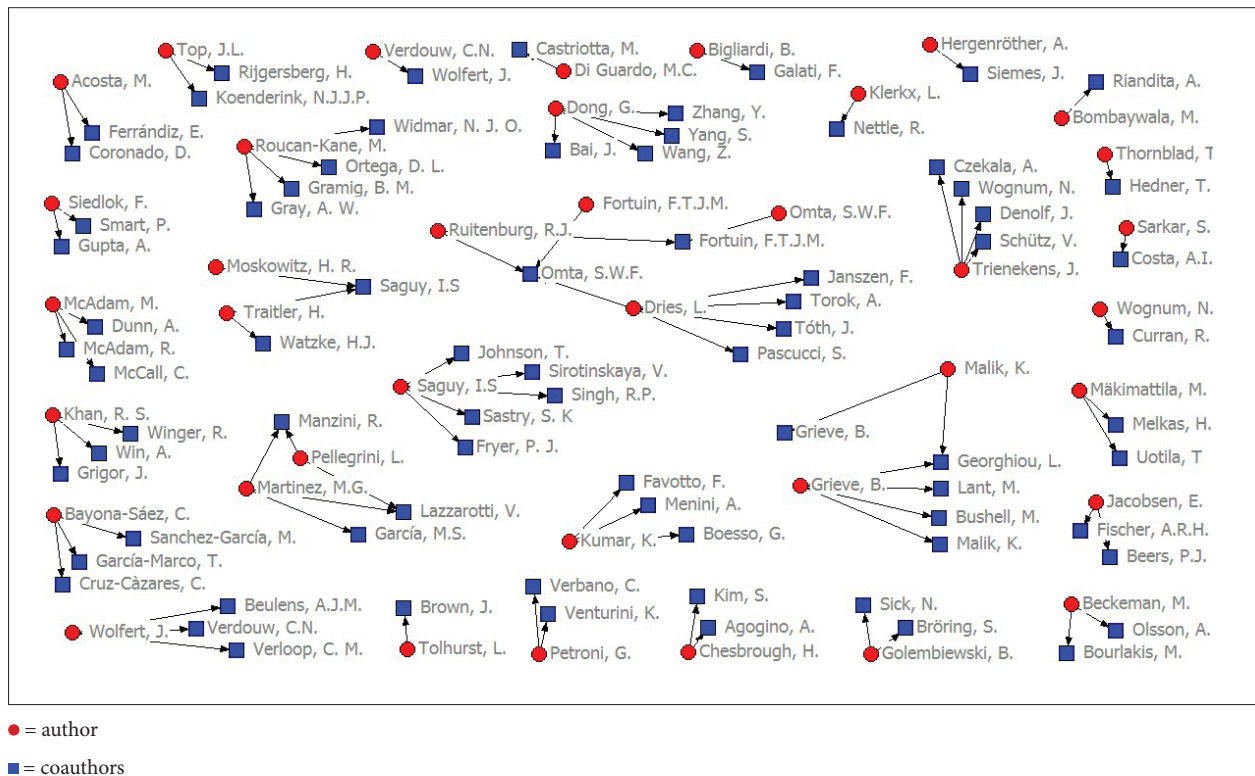
This can be explained by the existence of traditional research centers in the agribusiness area, which can be confirmed by analysis of the

institutions in which the authors are allocated. In relative numbers, the researchers of the Dutch Wageningen University were the ones who participated most in the studies identified. In this sense, The Hebrew University of Jerusalem, from Israel, and the University of Kent, UK, also stand out.

Later, one can observe the contribution of North America, which can be supported by the presence of Professor Henry Chesbrough of the University of California, who coined the term open innovation, being the executive director, founder of the Center for Open Innovation and lead author of one of the selected articles. Asia and Oceania were also represented, however, no study was identified in Africa and South America, important global agribusiness markets.

The authorship of publications is diverse: although five authors have published alone, a significant part of the work was carried out between two and four researchers. The representation of the authorship network displays the most complex connections to the center, among which stand out Saguy and Dries, working with five co-authors, and Grieve, as the author of four papers and co-author of another (Figure 2). Considering the contemporary theme of the discussion, it is believed that this configuration features that research groups are still being structured.

Figure 2. Authors' network representation of selected studies.



Despite some literature searches (Juriaanse, 2006; Siedlok, Smart & Gupta, 2010; Moskowitz & Saguy, 2013), most studies have sought to identify and understand the practice of open innovation through empirical studies. Therefore, surveys (Dries, Pascucci, Torok & Toth, 2014; Pellegrini et al., 2014) and interviews with managers (Beckeman, Bourlakis & Olsson, 2013; Ruitenburt, Fortuin & Omta, 2014) were conducted, but a significant part was based on single or multiple case studies (Hergenröther & Siemes, 2010; Remon, 2011; Thornblad & Hedner, 2012; Klerkx & Nettle, 2013).

It is noted that the empirical evidences have a significant focus on the manufacturing industry, specifically of food and beverage. This may be related to the proximity of this link to the final consumers, which enables the early identification and fulfillment of their demands. Nonetheless, some new trends emerge inside and outside the industry, such as functional and nutraceutical foods and food services, respectively.

Functional and nutraceutical foods are increasingly becoming the focus of R&D activities in the food industry. Notwithstanding, this process is complex and its success depends on factors other than those of the traditional food product development (Khan et al., 2013). They require high levels of systemic innovation, that is, besides the inter-organizational level, an inter-industrial and inter-institutional

convergence and a sector reorientation process (Siedlok, Smart & Gupta, 2010). Thus, this new segment results from the convergence of the food, chemical and pharmaceutical industries, which in turn requires the integration of technologies, markets and value proposition (Bröring, 2013).

But, in general, the food and beverage industry is in transition, still starting the opening of innovation processes (Pellegrini, Lazzarotti & Manzini, 2014). The fact of involving an increasing number of chain actors to meet the needs of consumers, increasingly heterogeneous (Bigliardi & Galati, 2013), makes it a complex and dynamic system, based on a number of vertical and horizontal relationships (Sarkar & Costa, 2008).

### Partnerships

In line with the amount of studies applied in the food industry, the adoption of open innovation has shown to be facilitated in this link, either with their suppliers (Dries, Pascucci, Torok & Toth, 2012), with the final consumer (Moskowitz & Saguy, 2013) or with both (Dries et al., 2014). The success of innovation in the market is the main benefit attributed to these types of partnerships, as it enables the product development process to better capture the expectations of consumers (Dries et al., 2012; Moskowitz & Saguy, 2013; Dries et al., 2014).



Organizations must recognize the strategic role of the involvement of the end consumer in their innovation activities. This can spontaneously provide valuable, original and feasible ideas that can initiate or accelerate the innovation of products and services (Filiéri, 2013). In particular, their integration in the initial design phase is a market orientation, which has generated higher quality products (Omta & Fortuin, 2013). In contrast, innovations have been more incremental, due to the dependence that arises from the contributions of consumers (Omta & Fortuin, 2013). Thus, it is crucial for organizations to ally themselves to other types of partners simultaneously, since the extent of their links with the external environment can extend the possibilities of innovation.

Among these alternatives, one occurs between private companies and universities. For example, the alliance between Syngenta and the University of Manchester, which is directed to the development of technologies for precision agriculture, the “agri-eletronics” (Grieve et al., 2009). The university can benefit from the ability to attract more financial resources, even with the spin-outs that can be licensed, in addition to the academic insights into business strategies; on the other hand, intellectual property rights restrictions may prevent publications (Malik, Georgiou & Grieve, 2011).

The long-term interactions between scientists in the company and in the academy allow access to broad expertise and technological combinations still missing, whose results can lead to new markets; but if the practice is not accommodated by the culture of the organization, it can restrict the intrapreneurship and generate conflicts, especially if there are multiple external partners (Malik, Georgiou & Grieve, 2011).

Hence, it is clear that these alliances can be realized in a productive, but still challenging, model of open innovation. It is essential to create a relationship of mutual trust, which runs through the change of some paradigms, such as the reformulation of the old system of learning and the involvement of students, the reflection on the role of the industry and the awareness of social responsibility of both parties (Saguy, 2011).

### Factors influencing the opening of the innovation process

The main drivers of open innovation can be summarized to technological and market pressures. As a consequence, the need for a technology that does not exist demands from the organization an appropriate architecture for collaboration with external actors, able to access and integrate this knowledge (Martinez, Lazzarotti, Manzini & Sánchez García, 2014). As for the pressures exerted by consumer demand, they can be answered by the communication between the areas of R&D and marketing (Fortuin & Omta, 2009).

Some agribusiness companies that have resisted the opening of their innovation activities obtained as a result more incremental innovation at the expense of the ability to generate more significant advances in their products (Bayona-Sáez, García-Marco & Sanchez- García, 2013). The cases reported by Beckeman, Bourlakis and Olsson (2013)

confirm that, when developed internally, the resulting innovations were mostly incremental and with invisible benefits to the consumer, such as the reduction of costs and production time.

Enzing et al. (2011) attested that the involvement of different actors related to technology and market impacts positively on the performance of new products in the short and long term, but its effect was not seen in the improvement of existing products. This corroborates other evidence in the literature, which attach greater degree of innovation radicalness when the product development is conducted openly (Bayona-Sáez et al., 2013); mainly if driven by dual processes, in which there is mutual exchange of knowledge between partners, which resulted in greater number of innovations, reflecting directly the growth of organizations (Brink, 2014).

As mentioned, there are different patterns of knowledge acquisition and these may vary according to the sector, place of origin and, especially, the size of the organization (Acosta, Coronado & Ferrándiz, 2013). In agribusiness, while large companies often prospect innovations, small and medium-sized enterprises position themselves in a reactionary way; only a small part of these innovate successfully, which is possible by adopting the open innovation model (Kumar et al., 2012).

Notwithstanding, regardless of their size, organizations are challenged by the primary internal changes to accommodate this practice. In addition to a new structure of R&D, network or matrix organizational models emerge, together with professionals that integrate scientific knowledge and entrepreneurial expertise, the T-men; and as a result, techniques for managing people also tend to change (Petroni et al., 2012).

Regarding the establishment and maintenance of partnerships with external actors, organizations may have to deal with technical and perspective barriers (Bombaywala & Riandita, 2015). The lack of technological expertise among partners, possible legal requirements and the difficulty of predicting future needs for the development of innovation are some technical elements; yet the skepticism about new technologies and conflicts of interest can generate perspective barriers, the lack of confidence being the most imperative (Bombaywala & Riandita, 2015).

This lack is closely related to the inherent risk of knowledge sharing (Bigliardi & Galati, 2013) and often prevents organizations from making use of the opportunities to open their R&D activities (Beckeman, Bourlakis & Olsson, 2013). So there is a tension on the part of organizations, between the urge to open and to benefit from external knowledge and the will to remain closed, preventing others to make use of strategic knowledge.

In this sense, information systems technologies represent valuable tools to integrate the actors and enable transparency of products and processes (Trienekens, 2008). Similarly, mechanisms of protection of intellectual property, be they formal or informal, can protect organizations, although generally they are expensive or limit flexibility and creativity (Ruitenburt et al., 2014).

Since, along with communication, intellectual property protection mechanisms influence the level of trust in the partnership, which is positively related to innovation performance (Saguy & Sirotinskaya, 2014), these elements must be negotiated and balanced in order to facilitate the advancement of the relationship (Oguamanam, 2013). With this, the new intellectual property model should not only consider the financial returns, but allow greater sharing of rights rather than the accumulation of these as a form of protection; besides creating value for the licensing of unused technology or the sale of ancillary patents (Saguy & Sirotinskaya, 2014).

Finally, another key aspect that could represent an incentive or a barrier to the adoption of open innovation is related to the institutional environment, essential for actors to play their role effectively (Klerkx & Nettle, 2013). This is manifested by the reduction of technical and regulatory risks, the clear communication of requirements, procedures, expectations and regulatory processes and the creation of funding programs (Roucan-Kane et al., 2013), especially when it comes to small and medium-sized companies, whose resources are scarcer (Khan et al., 2013).

Despite the government's participation in partnerships between companies and research institutions being fundamental in agrifood chains (Wolfert, Verdouw, Verloop & Beulens et al., 2010; Roucan-Kane et al., 2013), public policies to encourage innovation are still scarce (Dong, Yang, Bai, Wang & Zhang, 2013). In this sector, policy makers can act relevantly, raising awareness and encouraging their adoption; financing projects that include issues such as food safety, animal welfare and sustainable use of resources; ensuring compliance with legislation; and supporting the harmonization of relevant international standards for the regulation of innovations (Verdouw & Wolfert, 2010).

## Conclusions

Organizations from various sectors are increasingly opening their innovation processes, streamlining their R&D activities with the expectation of better results. By being more widely consolidated in the areas of information and communication technology, it was considered appropriate to present the state of the art on open innovation in agribusiness, analyzing how this is adopted and the factors that influence this process.

The challenges of agribusiness today demand more complex and systemic innovations that can be achieved through more open processes of product development. Nevertheless, despite the socio-economic importance of the sector to the world, it was found that the scientific publications in the area are incipient and research groups are still being structured.

The phenomenon is reported in empirical studies mainly in the food and beverage industry, where partnerships proved to be facilitated between different actors in the supply chain. On the other hand, some difficulties were related between input suppliers and the academy, especially regarding intellectual property rights.

In general, the main barrier in establishing innovation alliances refers to the inherent risk of knowledge sharing, which creates a lack of trust between partners. Proof of this is that no study was identified reporting outsourcing processes of knowledge assets, which would be unused or underused internally. This is a valuable opportunity for the organizations in the sector to create value, but which may be being ignored by managers.

To assuage the fear of the organizations regarding the exposure of strategic internal resources, communication tools and a new intellectual property protection model are critical, which should encourage the sharing of rights and foster cooperation among stakeholders. Internally, it is also necessary for the organization to create a collaborative design that is receptive to external links. This includes some changes both in the hierarchical and in the R&D structure, in addition to new professional profiles that must be managed differently.

The external environment is another aspect that significantly influences the development of innovation through regulatory elements and the targeting of goods and services to be created through requirements and financing tools. This latter mechanism is especially important for small and medium-sized enterprises, whose financial resources are often scarce.

Several studies indicate considerable advantages for organizations that use open innovation as a strategy, which led to more innovations and with greater radicalness. Although considering that the products and services resulting from interactions between different actors have higher chances of market success, there are no quantitative measures comparing the performance of these in relation to those which are internally generated, whether in terms of tangible or intangible assets.

Thus, the field of open innovation lacks empirical research that attempts to understand and measure the possible benefits and harms of this practice and in different links of the chain, locations and contexts. As a result, these studies can help organizations benefit from this strategy and create the innovations necessary for the development of agribusiness in all its breadth.

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