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# DOES AGROINDUSTRY MATTER? AN ANALYTICAL FRAMEWORK OF INNOVATION AND INTERNATIONALIZATION PROCESS

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## ABSTRACT

The aim of this work is to develop an analytical framework that explores the relationship between knowledge flows, technological mastery, innovative results, organizational growth, internationalization patterns and maturity´s segmentation for Brazilian agroindustry. Much progress has been made in the theoretical understanding of technological mastery´s process, its sources, its results and its indirect implications. However, some of these works focus on manufacturing industries. In addition, some researches ignore that the development of innovative activities could occur in agroindustry. Moreover, agroindustry is generally encapsulated as commodities and low-tech, characterized by a limited opportunity for interaction of technological flows, creation of innovative activities and positive externalities for economic development. However, advances in agroindustry have increasingly been a result of science-based efforts. Therefore, this work launches a theoretical and analytical basis for examining the innovation and internationalization in agroindustry for the Brazilian context.

**Keywords:** Technological Mastery. Industrial Diversification. Innovation. Agroindustry.

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# AGROINDÚSTRIA IMPORTA? UMA ESTRUTURA ANALÍTICA DO PROCESSO DE INOVAÇÃO E INTERNACIONALIZAÇÃO


## RESUMO

O objetivo deste trabalho é desenvolver uma estrutura analítica que explora o relacionamento entre fluxos de conhecimento, domínio tecnológico, resultados inovativos, crescimento organizacional, padrões de internacionalização e maturidade de segmentação para a agroindústria brasileira. Muito progresso foi realizado para o entendimento teórico do processo de domínio tecnológico, suas fontes, suas implicações diretas e indiretas. Entretanto, alguns destes trabalhos focam primordialmente indústrias de manufatura. Ademais, algumas pesquisas ignoram que o desenvolvimento de atividades inovadoras podem acontecer na agroindústria. Além disso, agroindústria é geralmente encapsulada como uma commodity e low-tech, caracterizada por uma limitada oportunidade para interação de fluxos de conhecimento, criação de atividades inovadoras e externalidades positivas para o desenvolvimento econômico. Todavia, os avanços da agroindústria tem sido cada vez mais um resultado dos esforços baseados em ciência (Science-based). Portanto, este trabalho lança uma base teórica e analítica para examinar inovação e internacionalização na agroindústria no contexto brasileiro.


**Palavras-chave**: Domínio Tecnológico. Diversificação Industrial. Inovação. Agroindústria.

## INTRODUCTION

This article focuses on technological, innovative, organizational development and environmental sustainability in a natural resource intensive industry in the Brazilian context. The paper seeks to develop and analytical framework that explores the relationship between knowledge flows, technological mastery, innovative results, organizational growth, internationalization patterns and maturity´s segmentation for Brazilian agroindustry. A systematic analysis of these issues in the Brazilian agroindustry context is relevant for the following reasons:

First, a relevant part of the studies examining the implications of technological knowledge flows in the process of technological capabilities building (or technological mastery) interprets the industrialization process primarily based on previously mapped technological route and specifically in the Asian context (e.g. AMSDEN, 1989; HOBDAY, 1995; KIM, 1997a and 1997b; LEE; LIM, 2001; CHOUNG; HWANG; SONG, 2014). Most of these studies understand that this process of industrialization involves a definitive route in the development of so-called high-tech and manufacturing industries (electronics, semiconductors, cell phones, computers, automobiles, etc.). The aptitude of Asian countries for this particular type of industry, for its abundance of skilled labor and with competitive costs, justifies this specialization.

Part of these studies ignores that the development of industrial activities could occur in other industries (e.g., resource intensive). In particular, this type of industrial development is important in contexts of countries abundant in natural resources. From this, would it not be possible for countries rich in natural resources to be able to develop innovative activities in natural resources to obtain technological and economic development?

Second, in the case of resource-intensive industries, between academic researchers and policy makers, these industries are generally encapsulated as simple commodities. Besides that, other research, especially in Latin America, emphasizes that resource-intensive industries are characterized by a limited opportunity for technological learning and accumulation of technological mastery (KATZ, 2007; CASTALDI et al., 2009).

However, the growing demand for natural resources in recent years has created new conditions for resource-abundant emerging countries to create technologies and engage in innovative activities (ANDERSEN, 2011, 2015; MARIN; GONZALEZ; CUNHA, 2012, 2013; NAVAS-ALEMÁN; PÉREZ, 2015; KATZ, 2015; GONZALEZ 2016; PIANA, 2016). In addition, the OECD (2012) argues that innovation in agriculture and agroindustry is particularly relevant to address socio-economic challenges and foster growth at the same time.

Therefore, there is a scarcity of studies at the level of industry and firms that explore the innovation and internationalization process and organizational growth in agroindustry in Brazil. This type of research would allow an expansion of the understanding of the role of natural resource-intensive industries (and, more specifically, agroindustry) in industrial, technological and economic development in Brazil.

Third, agroindustry plays an important role in the Brazilian economy. This industry participated with 45.4% of Brazilian exports in the period between February 2016 and January 2017 - Value corresponding to US$ 85 billion (MAPA, 2017). Agroindustry generated a GDP of R$ 1.425 billion in 2016 (which represents 23% of the Brazilian GDP) (CNA, 2017) and generated more than 19 million jobs in the country (CEPEA, 2017).

Furthermore, major players technical and technological knowledge generation and the implementation of innovative activities in Brazil are national institutions devoted to agroindustry as firms (both in agricultural area - Monsoy, Brasmax, Coodetec etc. - as industrial – Odebrecht Agroindustrial, BRFoods, Agricultural cooperatives, etc.), suppliers (implements, raw materials, machinery and etc – e.g. Dedini and etc.), universities (e.g. IAC/UNICAMP, ESALQ/USP, UFPR, UFL, UFV, UFRRJ, UEL and etc.) and research institutes (e.g. Embrapa, CTC, IAPAR, Phytus, Ibrafe, IBA, IMAmt, APTA and etc.).

Thus, this work was designed to propose an analytical taxonomy to examine the relations between: (a) the flows/channels of technological knowledge; (b) technological mastery/dominance; (c) results from innovative activities; (d) organizational growth; (e) if there were, the patterns of internationalization and, finally, (f) a proposition of a segmentation of innovative and internationalization´s maturity. It is worth mentioning that this analytical structure, although it has a generalist character, is focused on the examination of agroindustry.

## Relevancy of the study

## Perspectives on the role of natural resource industries for economic and technological development in Brazil

Some approaches that examine the role of natural resources in economic development: for example, the Dutch Disease, Resources curse, and Resource Blessing approach. On the one hand, there are two approaches with a negative view on natural resources. The Dutch Disease approach suggests that increasing profits in the primary sector induce a flow of resources for this sector and services, which negatively affects the development of the manufacturing sector, and exports can lead to increases in production costs (MATSUYAMA, 1992; GYLFASON, 2001; LARSEN, 2005, 2006).

The Natural Resources curse approach refers to the findings of different empirical studies (e.g. MATSUYAMA, 1992; SACHS; WARNER, 1995, 2001) that sought to understand the phenomenon of the rate of economic growth in countries abundant in natural resources compared to countries without the same characteristic (Larsen 2006).

On the other hand, there is a group of researchers with a more positive view of the opportunities that natural resources can generate for development. Authors such as Maddison (1994) and Stijns (2005) argue that the conclusions of Sachs & Warner are distorted and that the proposition is not supported.

Contrasting the idea of Natural Resources curse, Stevens (2003), Walker & Jourdan (2003) and Smith (2007) presented evidence that some countries have received a "blessing" and have been able to leverage their economic and technological progress through natural resources. However, for this development to take place, efforts of different natures are needed, for example: human capital, institutions, infrastructure, education, automation, learning and technological dominance (DE FERRANTI, PERRY, LEDERMAN; MALONEY, 2002; LEDERMAN; MALONEY, 2007; SMITH, 2007; TORRES-FUCHSLOCHER, 2010).

In general, neither natural resource-based activities nor the related industries undertake intensive R & D efforts. Instead, they rely on knowledge flows from other capital goods and intermediary institutions and industries (SMITH, 2007). Perez (2010) argues that there are windows of opportunity for countries well provided with natural resources and experience.

A combination of harnessing the benefits of hypersegmentation, application of ICT technologies in the processing industries, enhancement of commodity prices, investment in technological upgrading and diversification of the export mix can improve the technological dominance of a country (or region) to prepare for the next technological revolution and for the creation of social welfare. However, none of these approaches is examined in depth. These studies carry out examinations at a macroeconomic level that do not correspond to the focus of analysis of this study.

In a more recent perspective (last 20 years), with a focus on the Latin American context, a group of economists associated with ECLAC (Economic Commission for Latin America and the Caribbean), concerned about the poor performance of the economy of Latin American countries after the reforms of the 1990s, takes a negative stance on the specialization in natural resources of these countries. This current of thought rescues Prebisch's arguments and postulates of the 1950s. Prebisch (1959) argues that natural resource-based activities face different kinds of supply and demand constraints, with trends of continuous decline in terms of trade. Hirschman's (1958) argument argues that the resource-based industry offers very limited connections to the development of activities in the economy as a whole.

Katz (2000) argues that after the institutional changes of the 1990s (market opening and abandonment of import substitution policy), Latin America has changed its pattern of productive specialization towards natural comparative advantages and capital-intensive firms (e.g. natural resource processing industries). The productive specialization of Latin America was consolidated in a productive pattern of maquila (in the case of Mexico and some Central American countries) and processing of natural resources (in the case of Brazil, Argentina, Chile and other countries in South America) (KATZ; STAMPO, 2001). It is advocated that these industries are specialized in standardized commodities and have low domestic value added (CASTALDI; CIMOLI; CORREA; DOSI, 2009).

Some authors argue that these reforms have led countries like Argentina, Chile and Brazil to a "low-development trap" with negative consequences for technological development (KATZ, 2000; OCAMPO, 2001). This same thinking is replicated by ECLAC: "(...) reinforced the pattern of specialization in sector with static comparative advantages. The outcome has been production structure lock-in and technology lag "(ECLAC, 2012, p.44). Authors like Cavalieri, Torres & Hasenclever (2013, p.18) comment that the expressive growth of Brazilian specialization in industries related to natural resources can generate a "structural change limited to enclaves, with low aggregate demand growth and strong productivity increase in few sectors ". Ferraz, Souza & Kupfer (2010) emphasize that the performance of the natural resource intensive industry is a phenomenon of prices, subject to the ups and downs of commodity prices in the markets.

Katz (2007) and Castaldi et al (2009) argue that Latin American companies have so far not shown significant interest in engaging in technology-generation efforts, R&D activities, interactions with universities, laboratories, research centers or knowledge-intensive companies. It is argued that the trajectory of specialization in resource and capital intensive activities is particularly disappointing, since such activities are typically characterized by low technological content and few learning opportunities:

"In terms of specialization patterns, following the trade reforms, many Latin American economies increased their share of production in (i) natural resources and natural resource processing industries (such as pulp and paper, iron and steel, vegetable oil, etc)... [...] The last couple of decades have been disappointing. [...] The end result is a widening dualism whereby an increasing share of the whole economy is composed of activities typically characterized by a low knowledge content and low opportunities for technological and organizational learning" (CASTALDI et al, 2009, pp. 64-65).

There is a widespread view that highly complex technology sectors are the "answer" to development problems in Latin America. Ocampo (2004, p.38) concludes: "(...) if the region is seeking to achieve the rapid rates of structural change (including penetration into dynamic technology-intensive sectors) that are essential to gradually bridge the gap separating it from the industrialized world". In the taxonomy of Ferraz, Kupfer and Iootty (2004) only the sector of "innovation carrier industry" is considered as real creator of technological development opportunities. Cimoli, Dosi and Stiglitz (2009, p.556) argue that "(...) manufacturing and other increasing return activities such as knowledge-intensive services are at the core of technological learning with reduced demand for skilled labor."

In short, the negative view on natural resources advocated by these approaches has limitations and some considerations can be raised: (i) the definition of what constitutes "Natural Resources" is not clearly defined. That is, this sector is generally treated without due attention to understand the heterogeneities among the different sub-sectors, and these generalizations can lead to the wrong conclusions; (ii) Studies tend to generalize sectors, countries and even Latin America as a whole, focusing on macro and/or sectorial analyzes, without entering the level of firms and their temporal evolution, neglecting activities and phenomena that escape this type of analysis methodology; (iii) This current of thinking ignores the technological advances necessary for natural resource-processing industries to be competitive in the international market, reducing their success factor only in price; (iv) The authors argue that the potential for technological advancement, industrial diversification, and economic growth is mainly (or only) achieved through the high-tech product-based firms; (v) the existence of a set of studies that consider natural resource-processing industries as having very limited opportunities to generate: (a) product and process innovations, (b) technological and organizational learning, (c) spillovers, and (d) industry diversification (GONZALEZ, 2016).

The contributions and insights of the literature dedicated to examining the importance of low- and medium-tech industries (LMTs) can serve as inspiration to understand the role of agroindustry in creating technological development opportunities, once that this type of firm and/or sector possesses some (if not most) of the characteristics of the said LMT's industries.

These scholars criticize the negative generalizations about the innovative performance of LMT firms and industries and present evidence that there is considerable innovation capabilities in this particular type of organization and/or industry. That is, significant differences of intrasectoral heterogeneity are found in terms of R&D intensity.

LMT's industries systematically use distributed organizational knowledge elements, where innovation is largely the result of processes of search, transformation and configuration of internal & external knowledge, components and technologies widely known and developed in others places (VON TUNZELMANN; ACHA, 2004; SMITH, 2004; HIRSCH-KREINSEN, JACOBSON; ROBERTSON, 2006; HIRSCH-KREINSEN, 2008; HIRSCH-KREINSEN, HAHN; JACOBSON, 2008; ROBERTSON; SMITH, 2008; ROBERTSON; VON TUNZELMANN, 2009).

In summary, the literature devoted to the examination of LMT's industries not debate directly with the school of thought of the economists who advocate the idea that specialization in natural resource processing industries limited opportunities for technological advancement, but other characteristics of this body of knowledge are important: (i) Emphasize the importance of sector-level and firm-level studies to understand how innovative activities are being carried out in environments where conventional indicators of innovation measurement - e.g. number of patents and R&D expenditures - are not the most indicated; (ii) They point out the technological opportunities of LMT's industries - where agroindustry can be represented - and their possible impacts on the economy. However, this literature still lacks studies in contexts other than advanced economies (GONZALEZ, 2016).

Thus, in order to provide an alternative interpretation and to add new evidence to the debate about the limited opportunities of technological and economic development in the agroindustry, an empirical examination is justified that seeks to increase the knowledge related to the flows of knowledge, technological mastery, innovative performance, organizational growth and internationalization.

## The relevance of reflection of an analytical structure for maturity analysis of innovation and internationalization process in Brazilian agroindustry

Studies about technological mastery and technological knowledge flows originate in the 1960s. In the late 1960s, Latin America showed considerable growth in its industrial productivity. However, after almost three decades of a policy of industrialization by import substitution in the region, the perspective of Dependency Theory argued that this productivity growth had not developed industrial innovation in the same way (BELL, 2006).

The combination of the continuous import of foreign technology and the perception that Latin American firms and industries failed to internalize the innovation process was described as the process of self-perpetuation of technological dependence. However, the Katz Program challenged this perspective end-of-history (BELL, 2006)

Subsequently, studies about technological mastery and technological knowledge flows were influenced by two phenomena: in Asia, by the emergence of the "Asian tigers"; and in Latin America, by replacing the policy of industrialization by imports due to the liberalization of the economy. From the 1990s and 2000s, there was a profusion of studies that sought to focus on the organizational and managerial dimensions of technological mastery and how this mastery was built from knowledge flows. These studies were influenced by the contributions of the literature on strategic management, innovation and competitiveness in firms from advanced economies (GONZALEZ, 2016) (e.g. BELL et. al., 1982; HOBDAY, 1995; KIM, 1997a, 1997b, 1998; ARIFFIN, 2000; DUTRENIT, 2000; LEE; LIM, 2001; LEE, LIM; SONG; 2005; MARCELLE, 2005; LIU, QIAN; CHEN, 2006; DANTAS, 2006; TSEKOURAS, 2006; FAN; 2006; YORUK, 2009).

From 2010´s, studies about knowledge flow and technological domain advanced the understanding on the dynamics of technological accumulation patterns and the form that firms used the knowledge flows for this development (CUSMANO; MORRISON; RABELLOTTI, 2010; GUO; GUO, 2011; WHANG; HOBDAY, 2011; GUENNIF; RAMANI, 2012; XIAO, TYLECOTE; LIU, 2013; CHONG, HWANG; SONG, 2014; HANSEN; OCKWELL, 2014).

However, literature is limited in understanding how firms explore new directions of innovation (technological trajectory) (BELL, 2010), especially in industries related to natural resources (MARIN; STUBRIN; VAN ZWANENBERG, 2014).

In addition, there have been significant advances in the understanding of the organization of the technological domain. The literature shows that the process of innovation in firms has been substantially disintegrated - or decomposed as advocated by Schmitz and Stramback (2009). The domain of technological capabilities is a process in which the organizations do not act in isolation and are interdependent of other institutions (GONZALEZ, 2016).

Several studies demonstrate the importance of local suppliers and the diffusion of knowledge flows with companies for the innovation process (ARIFFIN, 2000; TSEKOURAS, 2006). Some studies have sought to understand how technological mastery could be distributed in knowledge networks with suppliers, universities and research institutes (DANTAS, 2006; GIULIANI; ARZA, 2009; ZENG, CHIE; TAM, 2010; DANTAS; BELL, 2011; YORUK, 2009; URZUA, 2011; BESSANT, ALEXANDER, TSEKOURAS, RUSH; LAMMING 2012;

GUO; CHEN, 2013; CHOUNG, HWANG; SONG, 2014; ANDERSEN, 2015).

Finally, Mazzoleni and Nelson (2007) argue that technological development in agriculture, for example, "could not simply copy technologies and practice in countries at frontier, but needed to develop technologies suited to their own conditions." (p. 1516). In other words, as this area of knowledge is subject to specific conditions (e.g. soil, climate, water, diseases, pests, etc.), it is necessary (if not mandatory) for countries and/or industries to create their own technological trajectory; while the technological development in the manufacturing industry can be adapted with modest modifications and with not so expressive costs (MAZZOLENI; NELSON, 2007).

In summary, the relevant literature on these themes concluded that: (i) there was a significant advance in the understanding of how traditional (manufacturing) industries in emerging economies (especially in the Asian context) carried out the process of technological domination in technological trajectories already mapped and traveled by world leaders (KIM, 1997a, 1997b; GUENNIF; RAMANI, 2012; XIAO; TYLECOTE; LIU, 2013); (ii) However, to what extent is it possible to apply this approach in resource-intensive industries, since the edaphoclimatic conditions of this particular type of industry preclude a mere technological replication? (BELL, 2010), especially in natural resource-related industries (MARIN; STUBRIN; VAN ZWANENBERG, 2014; GONZALEZ, 2016); (iii) Much of the literature about technological mastery examines individual firms and does not investigate the role of related organizations (universities, research institutes, suppliers, competitors, etc.); (iv) The understanding of the relative importance of knowledge flows in terms of which partners (universities, research institutes, suppliers, competing companies, customers, etc.) were accessed for technological mastery building (GONZALEZ, 2016), and; (v) there is little evidence about how the relative importance of different types of collaboration and how different types of partners change over time while the company builds technological dominance (GONZALEZ, 2016).

## In search of a conceptual framework

### Technological knowledge flows: the various ways that Brazilian agroindustry prospect and internalize knowledge for technological mastery

In this research, learning is understood along the lines of Bell et al. (1982) and Bell (1984), who point out that learning consists of conscious, intentional, costly, non-automatic, active and deliberate processes in which skills and technical knowledge are acquired by individuals and by the organization. Malerba (1992) argues that learning is cumulative and increases the stock of knowledge or technological capabilities of the company. Technological learning can happen internally, by creating knowledge by the company itself, or externally, by searching for sources located outside the organization, which can be in and/or outside of its market and country.

This external relationship (technological knowledge flows) can happen with several actors such as Universities, Research Institutes, Suppliers, Competitors, Users, Partner Companies and etc. In this way, the importance of integrating external and internal learning is imperative (Kim 1997a). Bell & Pavitt (1993, p. 163) comment that: "Technological accumulation (or technological learning) refers to any process by which the resources for generating and managing technical change are increased or strengthened" - therefore, if an organization aims to deepen its technological domain rapidly and overcome technological discontinuities effectively, it is necessary that learning efforts (or knowledge flows) are carried out in an intense way.

The technological knowledge flows will be examined in this research by the different ways of acquiring and assimilating knowledge. Bell (1984) developed a typology of learning activities divided into: Learning-by-doing, operating, changing, searching, hiring, training and system performance feedback. This typology makes an important distinction between active and passive modes of learning.

However, the literature of the subject advances in the proposition of other mechanisms of learning (For a review of the main learning mechanisms, consult Queiroz (2006). Malerba (1992) and other authors argue about five other types of activity: Learning by searching, using, interacting, from inter-industry spillovers e from advances in science and technology. However, other authors examine other learning mechanisms, for example: (i) linkages (LUNDVALL, 1988); (ii) from users (VON HIPPEL, 1988); (iii by competitors (WHIPP, ROSENFELD; PETTIGREW, 1989). (iv) R&D (COHEN; LEVINTHAL, 1989); (v) joint ventures & strategic alliances (DODGSON, 1993); (vi) before doing (PISANO, 1996); (vii) sharing (NELSON; WINTER, 1982; MARCELLE, 2004); (viii) field experimentation (MARCELLE, 2004) e; (ix) large-scale project management (MARCELLE, 2004). These internal and external knowledge flows are useful for understanding the possible sources that organizations, especially those within emerging market contexts, can use to carry out innovative activities.

Nevertheless, the literature on technological knowledge flows in emerging economies is not enough to elucidate some questions about innovation in Brazilian agroindustry. In this way, the literature on learning organizations, organizational learning (OL) and strategic management presents a series of merits that can help innovation scholars of firms in emerging economies understand how knowledge flows occur in this particular type of organization. This literature becomes useful when organizations of emerging economies already master innovative technologies and activities of high complexity.

The focus of this literature is to understand how organizations exploit, increase and renew their innovative technological capabilities and advance the international technological frontier.

Table 1. Types of technological knowledge flows.

| Type of knowledge flow | Knowledge flow description | Some related works |
|---|---|---|
| *Hiring expertise* | Processes to gain access to new knowledge through the hiring of professionals or specialists for production, R&D, organizational and managerial processes, and/or to develop projects | Marcelle (2005); Mazzoleni and Nelson (2006); Guo and Guo (2011), Urzua (2011); Yoruk (2009); Gonzalez (2016) |
| *Training* | The design and/or participation in training, seminars, technical visits, courses and classes for the operation of technologies, use of new processes, incorporation of new techniques or for the accomplishment of innovative activities. This process can be carried out individually or in partnership with universities, research institutes, suppliers, etc. | Marcelle (2005); Mazzoleni and Nelson (2006); Santamaría, Nieto and Barge-Gil (2009); Guo and Guo (2011); Fu, Diez and Schiller (2013); Guo and Chen (2013); Urzua (2011); Yoruk (2009); Gonzalez (2016) |
| *Technical assistance and consulting* | The provision and/or receipt of technical assistance, consulting or auditing in raw materials, products, processes, software, systems, equipment, machines, laboratories and technologies. | Powell, Koput and Smith-Doerr (1996); Inzelt (2004); Mazzoleni and Nelson (2006); Santamaría, Nieto and Barge-Gil (2009); Yoruk (2009); Guo and Guo (2011); Guo and Chen (2013); Gonzalez (2016) |
| *Operational and laboratorial experimentation* | Performing activities on the factory floor or in the agricultural field, based on trial and error, for incremental improvements in raw materials, products, processes, software, systems, equipment, machinery and technologies. This process can be carried out individually or in partnership with universities, research institutes, suppliers, etc. | Powell, Koput and Smith-Doerr (1996); Ariffin (2000); Inzelt (2004); Mazzoleni and Nelson (2006); Santamaría, Nieto and Barge-Gil (2009); Yoruk (2009); Tödtling, Lehner and Kaufmann (2009); Zeng, Xie and Tam (2010); Guo and Guo (2011); Urzua (2011); Hansen e Ockwell (2014); Gonzalez (2016) |
| *Engineering, reverse engineering and design* | Performing of engineering activities, reverse engineering and projects for the design and development of raw materials, products, processes, software, systems, equipment, machinery and technologies. This process can be carried out individually or in partnership with | Powell, Koput and Smith-Doerr (1996); Ariffin (2000); Dantas (2006); Santamaría, Nieto and BargeGil (2009); Tödtling, Lehner and Kaufmann (2009); Yoruk (2009); Zeng, Xie and Tam (2010); Guo and |

| | | |
|---|---|---|
| | universities, research institutes, suppliers, etc. | Guo (2011); Urzua (2011); Hansen and Ockwell (2014); Gonzalez (2016) |
| *Basic and applied RandD* | Conduct R&D activities to explore new scientific fields, and create scientific and technological knowledge capable of generating radically new technologies. It may also be through R&D activities to create new raw materials, products, processes, software, systems, equipment, machinery and technologies. This process can be carried out individually or in partnership with universities, research institutes, suppliers etc. | Powell, Koput and Smith-Doerr (1996); Kim (1998); Ariffin (2000); Inzelt (2004); Dantas (2006); Santamaría, Nieto and Barge-Gil (2009); Tödtling, Lehner and Kaufmann (2009); Yoruk (2009); Zeng, Xie and Tam (2010); Guo and Guo (2011); Urzua (2011); Hansen and Ockwell (2014); Gonzalez (2016) |

Based on Bell et al (1982); Malerba (1992); Kim (1997a, 1998); Guo and Guo (2011); Gonzalez (2016).

Finally, this work starts from the premise that the technological knowledge flows play the role of a variable with greater proximity and with a greater degree of influence in the technological mastery (LALL, 1992; BELL; PAVITT, 1993; BESSANT; ALEXANDER; TSEKOURAS; RUSH; LAMMING 2012).

Malerba (1992) comments that, since there are many mechanisms (flows) of knowledge, different types of learning will affect the stock of knowledge (and therefore the technological mastery) of firms differently. Therefore, Table 1 presents an operational framework to investigate technological knowledge flows.

## Technological mastery: a proposal of hierarchical structuring of technological capability dominance in the Brazilian agroindustry

The definitions of technological mastery (capacity) in the literature are found from the 1970s. Katz (1976) inaugurates the idea of "inventive activity" and Dahlman and Westphal (1982) formulated the concept of "technological dominance/mastery". The concepts of Bell et al. (1982), Westphal, Kim and Dahlman (1984) and Scott-Kemmis (1988) consider that the technological mastery includes the skills and knowledge embodied within the organization, workers, facilities and organizational systems, using the technological knowledge to produce changes both in production and in the techniques used.

Lall (1992) advances this idea and considers that the technological mastery of a firm is intrinsic in nature, that is, it requires a deliberate effort within the organization to dominate new technologies and adapt them to local conditions - and it differs from one to the other, and therefore the technological knowledge is not completely shared, transferred or imitated between the companies. Kim (1993) advances in all the previous propositions and considers that the technological mastery is the ability or capacity to apply technological knowledge in different activities to adapt the organization to the context in which it is inserted and respond to the changes of the environment.

In this article, technological mastery will be based on several conceptual contributions, starting with the idea of Bell and Pavitt (1993 and 1995), which considers the technological domain as the necessary resources to generate and manage technological change, including skills, knowledge and experiences, institutional structures and networks.

Additionally, Dantas and Bell (2009, 2011) argue that the technological domain of companies is not completely concentrated within firms. This technological mastery is distributed outside the organization and a considerable part are housed in suppliers, consultancies, research institutes, universities and so on.

The typology (hierarchical structuring) (Table 2) of technological mastery used in this work is based on the works of Lall (1992), Bell and Pavitt (1995) and more recently in the work of Arnold and Thuriaux (1997), distinguishing four hierarchical levels: Black box, Gray box, White box and Unboxed. For each level, firms (or industry) dominate technologies in different technological functions (Lall, 1992): Genetic improvement, agricultural processes and industrial processes.

Table 2.Tipology of technological domain for Brazilian agroindustry.

| Technological mastery levels | Technological areas (examples of technological activities) | | |
|---|---|---|---|
| | Genetic improvement | Agricultural processes | Industrial processes |
| *Unboxed*<br>*Ability to implement new variants and create new technological segments. Implementation of innovative activities new for the world* | Ability to create cutting-edge innovation in genetic improvement based on world-class R&D, for example: R&D in new biotechnological tools (e.g. QTLs, ESTs and molecular markers).<br>**Transgenics technological route**: R&D for discovery of genes and development of new genetic events. Improvement of new varieties obtained by conventional breeding with the use of genetic engineering (DNA recombination) and use of transgenics, etc.<br>**Conventional improvement technological Route**: Development of new varieties/breeds with the use of conventional breeding techniques with the use of genetic engineering, biotechnological and bioinformatics tools, etc. | Ability to create cutting-edge innovation in agricultural processes based on world-class R & D, for example: R&D in new equipment, machinery and agricultural implements; R&D in new processes, technologies and logistic systems for creation, planting, cultivation, harvesting, slaughter and harvesting of low impact and high yield etc. | Ability to create cutting-edge innovation in industrial processes based on world-class R&D, for example: R&D of new processes for the production of new products; R&D in bioplastics, biochemicals, biopharmaceuticals, biofuels and food, etc. |
| *White Box*<br>*Ability to implement incremental improvements in technology and its application. Realization of innovative activities new for industry / economy* | Ability to implement incremental modifications in technologies for genetic improvement based on exploratory development activities, experimentation, non-original engineering & design, and architectural changes, for example: development of new varieties using conventional breeding techniques based on quantitative genetics; development and expansion of germplasm banks; identification of species and genetic variation.; development of new varieties/breeds with the use of conventional breeding techniques based on phenotypic selection (biometric measurement), etc. | Ability to implement complex modifications of technologies in agricultural processes based on exploratory development activities, experimentation, non-original engineering & design, and architectural changes, for example: Development of automated agricultural processes; mathematical techniques and software for planting, treat, cultivating and harvesting; new methods of land management; new | Ability to implement complex modifications of technologies in industrial processes based on exploratory development activities, experimentation, non-original engineering & design, and architectural changes, for example: Development of new methods of evaporation, separation, fermentation and distillation; new methods for the use of new biomass; new uses of co-products; redesign and reverse |

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|---|---|---|---|
| | | equipment, machines and implements etc. | engineering mechanisms; changes in input specifications; development of evaluation systems, control and production automation etc. |
| *Grey Box* *Ability to implement innovative activities based on minor adaptations. Carrying out innovative activities new for the company* | Ability to implement small adaptations in genetic improvement, for example: conducting trials and adaptability tests of existing varieties for different environmental conditions (characterization tests), conducting trials and adaptability tests of existing animal breeds, etc. | Ability to implement small adaptations in agricultural processes, for example: small adaptations and improvements in agricultural equipment; management of soil preparation processes; management of animal tract, etc. | Ability to implement small adaptations in industrial processes and products, for example: implementation of non-systematic controls of quality processes according to environmental recommendations (e.g., PCP and QC) and productive processes; small improvements in processes, equipment, systems and products etc. |
| *Black Box* *Ability to operate existing technologies. Acquisition of technology in turnkey form. Inability to innovate or "firefighting"* | Ability to perform operational activities based on the use of existing technologies and production systems in genetic improvement, for example: implementation of nurseries with quality control of seedlings and control of diseases etc. | Ability to perform operational activities based on the use of existing production technologies and systems in agricultural processes, for example: use of computerized agricultural production management systems; advanced disease and pest control processes; processes of direct cultivation and optimized planting etc. | Ability to perform operational activities based on the use of technologies and production systems existing in industrial processes, for example: debugging and debottlenecking autonomously; introduction of automated systems; use of quality analysis and testing procedures; quality assurance of products, etc. |

Based on Bell et al (1982 e 1995), Lall (1992), OECD (1992), Arnold & Thuriaux (1997), Bell (2006), Gonzalez (2016).

Innovative performance and organizational growth: the impacts of technological mastery on technological and economic development in the Brazilian agroindustry

For the analysis of the impacts of the technological mastery (Table 3), will be examined the innovative performance (E ENOS, 1962; HOLLANDER, 1965) and organizational growth patterns (PENROSE, 1959; CHANDLER; 1962; TORRES-VARGAS, 2006).

Innovative performance refers to the implementation of creative activities that have created concrete benefits for the organization, such as: (i) Implementation of inventive activities: to be measured by the quantity and quality of the patents deposited by firms (producers, suppliers and/or related), institutes research and universities; (ii) Implementation of innovative activities: systematic analysis of innovative activities carried out by firms (producers, suppliers and/or related), research institutes and universities. The firm's growth pattern refers to the types (Penrose, 1959) and/or growth trajectories (Chandler, 1962) that an organization can perform.

The firm's growth patterns will be examined based on Hendrikse and Van Oijen (2002) and Torres-Vargas (2006) in the following dimensions: (i) Horizontal integration: occurs when the organization expands its existing production units, implements a new unit (organic growth), occurrence of mergers with other groups, or acquires a new company to increase the volume of production and perform economies of scale of existing products; (ii) Vertical integration: there are two forms of vertical integration.

The first refers to upstream vertical integration that occurs when the organization initiates activities of producing machines, raw materials, inputs and other components that were previously provided by other organizations.

The second refers to the downstream vertical integration that occurs when the organization initiates activities of deepening the production to the side of the clients, that is, it performs productive activities of beneficiation of the input, manufacture and/or distribution; (iii) Diversification: Diversification involves the company's entry into the production of "new products", usually in "new markets". This diversification may have a more direct or indirect nature (spin-offs and spillovers).

Table 3. Impacts of the technological mastery: Innovative performance and organizational growth.

| Impacts of Technological mastery | Type | Detail |
|---|---|---|
| *Innovative performance* | Patents | Analysis of the quantity and quality of patents deposited in Brazil and in the world during the period studied. Patents are searched for using keywords such as soybean, corn, wheat, sugarcane, beef, pork, poultry, etc.) and by the organizations studied in the research. Some examples of classes (based on IPC - International Patent Classification): A01 (Agriculture, Forestry, Livestock, Hunting, Trapping, Fishing); A22 (slaughtering of animals, processing of meat, poultry processing or fish processing); A23 (Food or Food Products); B01 (Processes or Physical or Chemical Apparatus in General); B02 (Crushing, Spraying or Disintegration; Preliminary Processing of the Grain before Grinding); B09 (Elimination of Solid Waste, Recovery of Contaminated Soil), etc. |
| | Innovative activities | Analysis of the innovative activities carried out by firms (producers, suppliers and/or related), research institutes and universities in terms of |

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|---|---|---|---|---|
| | | | | processes, products, raw materials, equipment, and environmental focus. |
| *Organizational growth* | Horizontal integration (concentric) | Organic growth | | Considering horizontal growth when the organization realizes the expansion of its capacity in the same activity previously performed according to its ISIC class. |
| | | Fusions and acquisitions | | |
| | Vertical integration (conglomerate) | *Upstream* | | Considering vertical upstream growth when the organization expands its activities, in the production chain, which precede the original activities (upstream). |
| | | *Downstream* | | Considering vertical downstream growth when the organization expands its activities, in the production chain, which are subsequent to the original activities (downstream). |
| | Diversification | Direct | | Analysis of the organization's engagement in new activities or production of other products, that is, diversification occurs when the organization starts to produce products belonging to another ISIC and/or CNAE class from its initial origin. |
| | | Indirect | *Spin-offs* | Creation of new companies/clusters by spin-offs/spillovers that engage in new activities or production of new products belonging to classes ISIC and / or CNAE different from their initial origin. |
| | | | *Spillovers* | |

Based on Penrose (1959); Chandler (1962), Enos (1962), Hollander (1965), Freeman (1982), Schumpeter (1984), Dosi (1998), Tachizawa & Rezende, (2000), Hendrikse and Van Oijen (2002), Torres-Vargas (2006); Phelps, Adams and Bessant (2007); Arundel and Kemp (2009), Rashid, Jabor, Yahya and Shami (2015).

## Internationalization: a taxonomy of international commitment levels of the Brazilian agroindustry

The analysis model created for the Brazilian agroindustry is aligned with the behavioral approach tradition (DIB; CARNEIRO, 2006). In this way, internationalization will be understood as the process of involvement in international operations and involves activities of foreign trade, capital flows, technology transfer, information and data flow, alliances, mergers, acquisitions, (FDI) Foreign Direct Investment and others (WELCH; LUOSTARINEN, 1988).

That is, it is considered as a gradual process of acquisition, integration and use of knowledge about international operations and markets, which incrementally increases commitment and involvement with international markets (JOHANSON; VAHLNE, 1977). These definitions of internationalization are close to the concept given by Lall (1980) where the author argues that the level of internationalization depends on the combination of monopoly advantages with the forms of implications (in foreign markets). Internationalization can take place in several different dimensions, a process that takes place over time, in which an organization gradually commits itself to operations beyond the borders of its country of origin, where its commitment may involve inputs, or products, or stages of the production process and creation of value (OVIATT; MCDOUGALL, 1999).

Internationalization is a topic of great importance to firms as this can result in vital growth, learning outcomes and enhancement in financial performance according to Prashantham (2005). Gonzalez (2010) and Gonzalez and Cunha (2012, 2013) demonstrate that technological development and the process of internationalization are closely linked and exert a relationship of mutual influence.

More specifically, this model (Table 4) is based on the theory constructed by Johanson and Wiedersheim-Paul (1975) and Johanson and Vahlne (1977), who seeks to study the phenomenon of internationalization under the behavioral perspective of the firm of Cyert and March 1963) and Aharoni (1966) together with Simon's (1965) limited perspective of rationality. The internationalization process is interpreted as a process of development, gradual training, integration, learning and use of knowledge in external markets and in international operations, increasing the company's commitment to markets beyond national borders through a phased path (JOHANSON, VAHLNE, 1977); with different strategies and forms of action (LEERSNYDER, 1996). The model distinguishes four levels of international commitment.

Table 4. Levels of international commitment of agroindustry

| Internationalization processes stages | Description |
|---|---|
| *Internationalization* | Stage in which the organization further extends their knowledge of multiple international markets. Focuses efforts to implement commercial and industrial subsidiaries to serve several international markets. It involves strategies with high Foreign Direct Investment (FDI) with high involvement and control over operations, brands, channels and etc. |
| *Direct export via subsidiary* | Stage in which the organization already has significant knowledge of international markets and seeks to adapt to (technological) demands of more demanding markets. It involves strategies that require greater investment expenditures and take control of performance in the international market for its subsidiaries. |
| *Indirect export via agents and representatives* | Stage in which the organization performs its first export activities. It involves strategies that do not require large expenditures on significant investments and delegate the international market to agents, representatives and partners without direct control over activities. |
| *Domestic focus* | Stage in which the organization focuses its marketing, financial, productive and innovative efforts to meet the demands of your local market. |

Based on Johanson and Wiedershim-Paul (1975), Johanson and Vahlne (1977), Andersen (1993), Leersnyder (1996), Johanson and Vahlne (2009), Gonzalez (2010).

Segmentation: suggestions for the creation of a structure of degrees of technological and internationalization maturity for Brazilian agroindustry

Table 5 presents a simple hypothesis about a useful way to segment organizations according to their technological (ability to engage in innovative and research activities, use of more complex knowledge flows, participation in technological networks of knowledge and management awareness about the importance of the technological mastery) and internationalization (knowledge about and commitment with international operations) maturity. Since this is a hypothesis, this structure is still far from perfect and with little empirical basis.

However, this typology is based on the theoretical-empirical findings of different researches with worldwide relevance (PAVITT, 1984; HANNA, GUY; ARNOLD, 1995; ARNOLD; THURIAUX, 1997). This segmentation suggests that organizations can be graded at four distinct levels of maturity.

According with some studies (DANTAS; BELL, 2006; GONZALEZ; CUNHA 2012, 2013; GONZALEZ 2016), a considerable part of the Brazilian organizations are located at the initial levels. However, it is possible to identify organizations that already belong to the most advanced levels. For companies that are already close to the international technological frontier, a reasonable part of their technological efforts is based on joint or distributed efforts (DANTAS & BELL, 2006).

Engagement in more complex activities facilitates the company's entry into international markets (LALL, 1980; GONZALEZ; CUNHA 2012, 2013). Some incipient research that sought to identify the relationship and complexity of technological and internationalization knowledge of agroindustry firms in Brazil has already presented results that corroborate the structure of maturity presented here (e.g. GONZALEZ; CUNHA 2012, 2013; GONZALEZ, 2016).

Table 5. Segmentation of innovative and internationalization maturity for Brazilian agroindustry.

| Maturity level | Description |
|---|---|
| *International research performers* | The organization has a technological mastery near or at the international technological frontier. The management implements specific departments to carry out innovation and research activities. The organization is able to orchestrate technological networks. The organization uses regularly high-complex technological flows to deepen and expand technological mastery. The insertion in the international market has strategic importance for the organization. |
| *Tech competents* | The organization has a reasonable technological mastery. The management implements budget allocation for technological activities and stimulates engineering and development efforts. The technological development is done in partnership with other organizations. The organization has a stock of technological knowledge enough to participate in technological networks in an active way. The organization uses regularly mid-complex technological flows and eventually complex technological flows to enhance its technological mastery. Management is highly aware of the importance of international markets for economic expansion and technological development through interaction with more complex markets. |
| *Adventurers bootstrappers* | The organization has an initial technological mastery. Management understands the importance of technological improvement and ventures into adoption, adaptation and improvement initiatives. Technological development is still massively dependent on foreign/external help. The organization uses regularly low-complex technological flows. Internationalization efforts are growing, but still depend on strategic partners |
| *Peasants* | The organization has a limited technological mastery. Its management is not aware of the need or importance of engaging in innovative activities (and even, not even really needed). The organization uses very basic technological flows (when it uses). Its commercial scope may even be international, but still without active engagement of management. |

Based on Johanson and Vahlne (1977), Pavitt (1984), Hanna, Guy and Arnold (1995), Arnold and Thuriaux (1997).

## Proposition of an analytical model

As presented at introduction, this article seeks to develop an analytical framework that explores the relationship between knowledge flows, technological mastery, innovative performance, organizational growth, internationalization patterns and segmentation of innovative and internationalization maturity for Brazilian agroindustry.

Table 6 aims to synthesize the main constructs used in the analytical model, as well as its simplified definition and the main works on which it is based to explain the origins of taxonomies and their relationship. Figure 1 depicts the relationship between constructs, from the influential factors of the technological mastery (knowledge flows) and their direct implications (innovative performance and organizational growth), indirect implications (internationalization patterns) and a classifying form of technological and internationalization maturity (segmentation).

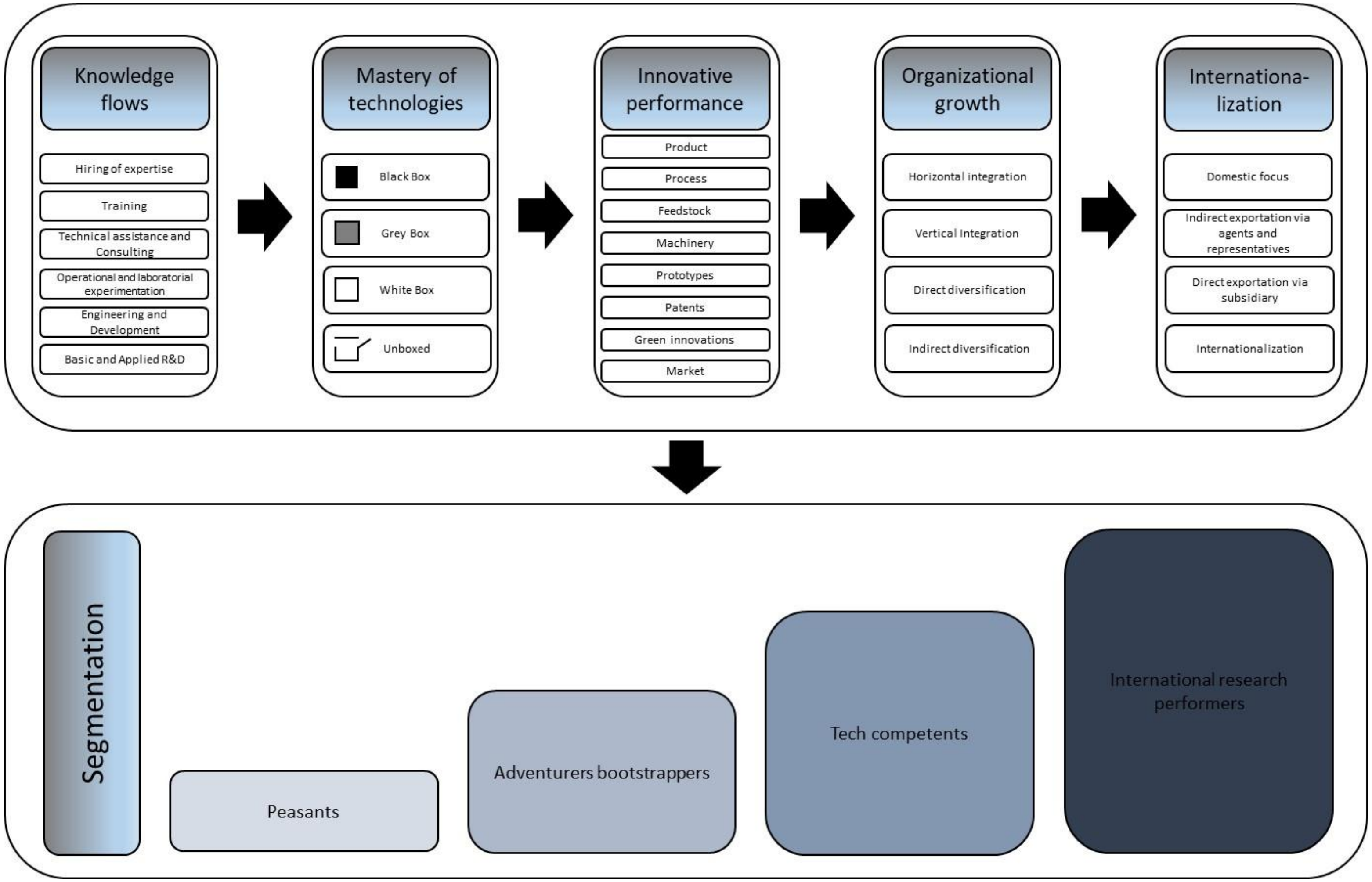
Table 6. Synthetic framework of the main constructs used for the construction of the analytical model for the process of innovation and internationalization for Brazilian agroindustry. Constructed by the author.

Table 6. Synthetic framework of the main constructs used for the construction of the analytical model for the process of innovation and internationalization for Brazilian agroindustry.

| Concept/construct | Synthetic definition | Some related authors |
|---|---|---|
| *Knowledge flows* | Different types of channels to exchange knowledge on which organizations capture external knowledge and seize internal knowledge to master technologies. | Bell et al (1982); Malerba (1992); Kim (1997a, 1998); Guo and Guo (2011); Gonzalez (2016) |
| *Technological mastery* | Set of knowledge-related resources that enable the organization to use and manipulate technological and innovation activities | Bell et al (1982, 1995), Lall (1992), OECD (1992), Arnold and Thuriaux (1997), Bell (2006), Gonzalez (2016) |
| *Innovative performance* | The results of the technological and innovation activities implemented by the organization. | Enos (1962), Hollander (1965), Freeman (1982), Schumpeter (1984), Dosi (1998), Arundel and Kemp (2009), Rashid, Jabor, Yahya and Shami (2015) |
| *Organizational growth* | The different ways in which the organization can expand its operations | Penrose (1959), Chandler (1962), Hendrikse e Van Oijen (2002), Torres-Vargas (2006) |
| *Internationalization* | The organization's process of involvement, engagement and commitment in international and industrial operations | Johanson and Wiedershim-Paul (1975), Johanson and Vahlne (1977), Andersen (1993), Leersnyder (1996), Johanson and Vahlne (2009), Gonzalez (2010) |
| *Segmentation* | The hierarchy or level of innovative and internationalization maturity of an organization | Johanson and Vahlne (1977), Pavitt (1984), Hanna, Guy and Arnold (1995), Arnold and Thuriaux (1997) |

Constructed by the author.

Figure 1. Analytical model of the relationship between constructs.




Constructed by the author.

## Conclusions and Recommendations

This section aims to present the contributions in terms of substantive and methodological contributions and some possible inputs and recommendations that can support the development of new academic research, corporate strategies and public policies to strengthen the competitiveness of agroindustry in Brazil.

With regard to substantive contributions, it is expected that with the theoretical review presented and the analytical model constructed in this paper, the following results will be generated: (a) Generate new evidences, analysis and explanations for the innovation literature, more specifically about technological knowledge flows and technological mastery, and their implications in Brazilian agroindustry, and; (ii) Generate evidence that presents an alternative perspective regarding the conclusions of the approaches that consider agroindustry as an industry that does not generate opportunities for technological, industrial and economic development.

With regard to methodological contributions, it is expected that this work has added on: (i) the development of a specific analytical model and, that respects the intrinsic characteristics of the Brazilian agroindustry; (ii) development of an analytical model that allows generating detailed evidences and explanations of technological and internationalization maturity for Brazilian agroindustry; more specifically, the sources and implications of the technological mastery, and; (iii) The model has the potential to provide support and be the basis for future research that seeks to examine related topics.

Finally, with regard to inputs for future academic research, corporate management and public policy, this analytical model may contribute to generate: (i) opening academic research groups and specific future research to examine the role of the technological mastery in Brazilian agroindustry; (ii) generate potential insights for the conception, modification and implementation of corporate strategies; so that Brazilian agroindustry can increase their technological mastery and create competitive advantages, both nationally and internationally, and; (iii) potential insights for the design, redesign and improvement of public policies, sectorial policies and incentive plans so that the competitiveness of agroindustry can be maintained and expanded, as well as for stimulating the creation and/or expansion of innovative activities in this type of industry.

However, it is worth mentioning that the present study has several limitations that restrict its analysis, such as: (i) As presented in the paper, the literature on knowledge flows, technological mastery and internationalization is extremely broad.

The work was limited to analyze a restricted number of contributions, compromising a richer interpretation of the theme; (ii) Once the work covers only a portion of the relevant literature of the subject, the interpretations made in the paper are limited and several aspects and explanatory factors are left aside (ex: governmental policy, industry´s intrinsic aspects, firms characteristics, leadership, and so on), and; (iii) A segmentation model of technological and internationalization maturity has been elaborated that still lacks empirical validation. This model is, at this moment, mainly speculative, needs improvements and a more in-depth analysis.

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