The Role of Collaborative Knowledge Networks in the Brazilian Sugar-Energy Sector

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Abstract

This paper analyzes the role of collaborative knowledge networks in the Brazilian sugar and ethanol industry, in terms of strategic advantage, economic gain and global competitiveness, notwithstanding the risks inherent to the common use of knowledge produced by partners, companies, and other institutions related to the network. In this sense, this paper analyzed the role of the Interuniversity Network for the Development of the Sugar-Energy Sector (RIDESA) in the development, launching, registration and commercialization of new sugarcane cultivars, in Brazil, highlighting two innovation statistical indicators: Varietal Update Index (IAV); and, Varietal Concentration Index (ICV). In this study, we performed statistical analyzes of production data, planted area and sugarcane productivity in Brazil, between 2005 and 2018, conducting tests in historical series of the National Supply Company (CONAB). As a result of the preliminary theoretical analyzes, it can be understood that the collaborative knowledge networks, as a model of network innovation, is a trend that is established in the present, notwithstanding the risks of knowledge shared by the organizations, appearing as an important area of research in the field of intellectual property.

Keywords: Collaborative Knowledge Networks; Brazilian Sugarcane Industry; Varietal Update Index (VAI); Varietal Concentration Index (VCI).

1. Introduction

The theme of Collaborative Knowledge Networks has gained more and more space nowadays, especially in the context of the search for new strategies of organizational innovation, and directly refers to the need to create social capital within organizations. For this reason, collaborative knowledge networks, in the context of organizations, are essentially formed by "self-motivated groups of individuals, and driven

by the idea of something new and exciting, a way to greatly improve a practice or a new product or service for which they see a real need" (GLOOR et al., 2003).

Collaboration is a principle that favors innovation, In this way, organizations must be aware of the new mechanisms of collaborative management of innovation, also with regard to the relationship with customers and suppliers. Innovation is increasingly recognized as being the result of the combination of different knowledge and experiences that exist within different organizations, that is, relationships can have interactive and complementary effects on technological innovation. (JOHNSEN, FORD, 2000).

In this regard, this paper analyzes the collaborative knowledge networks defining collaborative innovation networks, advancing on the role of the Inter-University Network for the Development of the Sugar-Energy Sector (RIDESA) in the development, launching, registration and commercialization of new sugarcane cultivars, in Brazil. In this context of emergence and consolidation of RIDESA in the broader scenario, a study of the crisis in the sugarcane industry was also carried out. For that, it was used data from CONAB, referring to the northeastern region of Brazil, as a way of understanding the role of RIDESA and their varieties, designated by the prefix Republic of Brazil (RB).

The indicators of innovation used in the sugar-energy sector presented a broader picture of the analysis and discussions about the results obtained in the case study, especially the presence and importance of the planted and cultivated cultivars, that can be visualized from statistical historical series. The Varietal Update Index (IAV) and the Varietal Concentration Index (ICV) are presented as important indicators of the presence of sui generis innovation in the agricultural sector.

RIDESA's performance reflect the importance of its contributions in terms of research and development, in the central case that supports the arguments of this article, the original bet in the formation of the network itself, assumed as a collaborative innovation network, would raise questions that would go beyond the limits of RIDESA itself. Thus, when presenting a type of network organization with great potential for economic gain and global competitiveness. It has been shown to be the Inter-University Network for the Development of the Sugar-Energy Sector capable of serving as a model for study and research groups spread throughout the country in other areas of knowledge.

2. Literature Review

2.1 Collaborative Knowledge Networks

The emergence of collaborative knowledge networks is a trend related to innovation in the organizational context. The new information and communication technologies motivate the emergence of these collaborative networks oriented to the sharing of knowledge and experiences. In order to perform an analysis of the collaboration networks, it is necessary to take into account the type and size of the network, the context, objectives, among others, seeking to highlight the key elements for the success or effectiveness of these collaboration networks (PERRY; CANDLOT; CORNE, 2010).

According to the authors, the growth of the economic network is suffering the influence of a new resource: the knowledge commodity. In the area of product development, knowledge networks and team transformations there are opportunities to improve working methodologies and knowledge exchange

among stakeholders. Designers no longer work on a single team, but are involved in multiple projects with different organizations and partners.

Once formed, these knowledge networks are guided by the characteristics of the individuals that compose them, in terms of attitudes and values, which indicate, on the one hand, they do not follow a traditional organizational paradigm and on the other hand it becomes an indication of the formation of social capital. In this sense, according to Gloor (2005), it is generally a voluntary environment, where self-motivation is the prerogative of effective collaboration and learning, that presupposes a lack of hierarchy. In this sense, to support innovation and creative thinking, the organization must be flat, that is, a network structure is the best configuration for an active and open contribution.

Heterogeneity is also a feature that relates to diversity and novelty as two sources of new knowledge and information, and which ensure the adoption of different perspectives for continuous adaptation to fit the external environment and the growth of community value. For the author, cohesion represents the interaction rate among community members. One of the most important features of collaborative knowledge networks is that they are highly interactive networks and connections between members are constantly facilitated. Thus, people interacting in the network come to consider collaborative knowledge networks as a real organization, which internalizes more easily the values of organizations and their strategic objectives.

According to Bush; Amrit (2005) it does not all knowledge and experience of organizations are fully utilized or exploited. This occurs because organizations do not have databases or any type of repository. Collaborative knowledge networks are an attempt by organizations to avoid that much of the organization's knowledge and experience is only in the minds of employees, in the form of tacit knowledge or experience. These networks of knowledge to be self-sustaining must be adherent despite all the implicit difficulty. According to the authors, a collaborative knowledge network is a digital environment through which dispersed users share and apply distributed knowledge. The difference between a cafe and a library is a good analogy to illustrate the differences between knowledge networks and knowledge repositories.

Qiu; Wang; Nian (2014), perform an analysis of the organizational knowledge structure of companies, with the objective of understanding the gaps in the knowledge of companies and the mechanisms capable of filling these gaps. The authors' approach is essential in guiding strategic decision-making, especially in the development of new products. The method presented by the authors has direct repercussions on the issue of organizational innovation, showing itself capable of recognizing and promoting an accelerated fulfillment of the knowledge gaps of companies. According to the authors, when comparing two trees of knowledge structure and calculating their similarity, the most adequate knowledge resources can be found to fill knowledge gaps. Thus, this method can help a company in the search for potential cooperation partners, which can be useful for managers and politicians to make decisions or to build strategic cooperation.

For Gloor (2015) collaborative knowledge networks can be classified into three types of networks, described as follows: A. collaborative innovation networks: they are self-organized, united by a common vision, common goals, and a shared value system; members communicate with each other in a “small-world” network structure, where each team member can be reached quickly. B. collaborative interest

networks: composed of people who have the same interests but do not perform a common job in a virtual team; this type of community is very frequent on the web, it has many silent members who maintain information from websites, portals, forums, and some active members who are inclined to share their knowledge and experiences within the community. C. collaborative learning networks are networks composed of people inclined to share knowledge and practice to benefit both in the personal domain and through the accumulation of collective knowledge among a group of similar people in attitudes.

2.2 The mechanisms and constituent elements of collaborative knowledge networks

Collaborative knowledge networks are effective configurations for the development of new products, services, practices and methodologies. According to Gloor (2005) two different mechanisms operate in the collaborative knowledge networks arrangements: The Dissemination of Innovation and the Innovation Incubation. The Dissemination of Innovation is considered by the author as the container of three levels of concentric collaborative networks, the collaborative knowledge networks basically disseminates new ideas that arise in the collaborative innovation networks, following a "cascade effect", through which each dimension is given to know a innovation from its internal level to the more external levels.

According to the author, for each collaborative knowledge network it is expected to find a central group that generates ideas and proposes new goals. A mid-level community of people who absorb innovation, debate, integrate and transmit to the peripheral group. As a final result of this process, all members of the group become aware of a common goal and how to achieve it. The results, in terms of strategy, methodology and results usually jump from the virtual dimension to the actual organization.

Innovation Incubation is the mechanism around which the spiral of divulgation that is activated by the collaborative knowledge network becomes potentially endless. Also according to the author, while collaborative innovation networks are born to create innovative ideas, collaborative knowledge networks is aggregated to discuss the new idea, to learn through the exchange of information and experiences about the purpose or application of the new idea, and work collaboratively in its development.

A collaborative innovation network is the diaphragm that separates and links innovation to the external environment and the real world. An innovation brought from a collaborative innovation network into a collaborative learning network will once again spread to the collaborative innovation network. What can leverage a new innovative idea. As a consequence of this process, new collaborative innovation networks are formed potentially leading to a “perpetual source of new innovations”.

According to Ahrweiler; Keane (2013, p.75), network innovation is not easy to characterize since its processes are in constant motion and its interactions have strong cognitive and social aspects. In innovation networks, participants from different areas / disciplines / organizations will participate from the beginning of a project and will define new criteria for quality control of the final product.

The constitutive elements of collaborative knowledge networks, according to Gloor (2005), result from a strategic combination between vision and mission, both of the potential of available collaboration technologies and of the process of creating new products and services. Thus, according to the author, the vision corresponds to the evolution of the service offered by the consultancy, the definition of the company

beyond the competitive advantage, benefiting once again from the application of collaboration technologies; while the Mission refers to the creation of new integrated products and services. The creation process consists of a meeting between the members of the different institutions / organizations involved mainly in research activities, with which the idea, its strategic objectives, its value proposition and the basic concepts of culture of collaborative knowledge networks can be shared.

2.3 Collaborative innovation

According to Trkman; Desouza (2012) the growing need for organizations to share knowledge and experience in view of the goals and objectives outlined, contrasts with the problem of misuse of these content. In other words, collaborative innovation, while increasing organizational effectiveness and efficiency, interposes what the authors call "knowledge risks", as a situation that needs to be circumvented. Although the literature has become more and more unanimous regarding the need to share knowledge among organizations, little has been said about the risks inherent in this openness, which is typical of the network environment.

According to the authors, the presence of strategies to address the knowledge risks will not only protect the organization, but will also send a clear signal that the organization is adopting a deliberate approach to its strategy of knowledge transfer and mechanisms. This, in turn, will help build trust and establish clear expectations of how the organization transacts with its business partners.

According to Gloor (2005), collaborative innovation networks can be defined through three fundamental characteristics: 1. Innovate through a solid collaborative creativity; 2. Collaborate within the framework of a strict and tacit code of ethics; and, 3. Communicate in direct contact networks. Thus, the benefits to organizations that adopt the collaborative innovation networks concept are substantial. According to the author, there are at least eight major benefits for organizations: innovation; agility; external knowledge; business opportunities; synergies; reduction of market time; identification of employees; safety.

Still according to the author, collaboration among innovators is the succeed key for the ideas of a collaborative innovation networks take off. However, the author warns that there must be creativity, collaboration and communication in the environment of the collaborative innovation networks. In this sense, for the author, five lessons can be extracted from the experiences with the collaborative innovation networks, characterized from several points of view: I. They are networks of learning; II. They Need a (tacit) code of ethics; III. They are based on trust and self-organization; IV. They make knowledge accessible to all; and, V. They operate in honesty and internal transparency.

For Ahrweiler; Keane (2013, p.78) innovation networks can be seen as social vehicles and organizational forms somehow optimized to negotiate the opening and closing of gaps in a given problem domain, both within the organization or individuals. Organizations and individuals tend to gain by being directly involved in the process and in the mechanisms of constructing these collaborative arrangements. However, collaboration is a value that presupposes a good deal of social capital in organizations, without which the necessary connections to the networks will not be established properly.

2.4 Social capital and collaborative knowledge networks

According to Gloor (2005), self-organization is one of the foundations of Collaborative Innovation Networks. That is, the process of forming the network depends on a willingness of the members of the collaborative innovation network, mutual respect between the parties and a strong set of shared beliefs. These common values, according to the author, act as a substitute for conventional hierarchies of management, directing what each member of the collaborative innovation network "has to do". The concept of social capital applies well to networks of collaborative knowledge, especially on account of collaboration, taken as value in individuals and organizations.

In this sense, for Bush; Amrit (2005), social capital can be understood as the level of trust, respect and proximity of the working relationships that a user has with the other pairs of the users group. According to the authors, such relations characterize the networks of knowledge. On the other hand, for Durmusoglu et al (2014, p.20), although it may seem obvious that a culture of knowledge sharing will significantly improve the level and quality of shared knowledge, this influence has not been tested for acquired knowledge.

The Sociologist Robert Putnam includes several aspects of social organizations to understand the meaning of social capital in individuals and organizations. Values such as trust, but also standards and networks can improve the efficiency of the organization by facilitating coordination. On the other hand, according to Gloor (2005), the World Bank presents a broad view on social capital, in which "social capital" refers to institutions, relationships and norms that shape the quality and quantity of social interactions.

According to the author, an organization whose members have accumulated high levels of social capital offers a fertile ground for collaborative innovation networks, because these organizations have three characteristics strongly related to the accumulation of social capital: Meritocracy, a situation in which organizations reward and promote people solely on the basis of merit; Consistency, a situation in which organizations that behave in a predictable way, governed by a tacit code of ethics; and Internal Transparency, a situation in which organizations that share all the knowledge necessary to make decisions by individuals.

According to Gloor (2005), these three characteristics define an environment for today's organizations and companies to become a greenhouse for collaborative innovation networks. Together, they form a powerful foundation for a collaborative culture where collaborative innovation network will flourish. According to the author, the organizational properties of collaborative innovation networks can be represented as a three-step process: "discover-develop-disseminate" or "create-collaborate-communicate" (steps that correspond to collaborative innovation network members' roles), which is developed on two pillars: the culture (with similar elements in all collaborative innovation networks) and the intensive use of the Internet.

The process of innovation based on culture and technology, on the one hand inform that the collaborative innovation networks are successful because they are able to promote an organizational culture based on transparency, consistency and meritocracy; and on the other hand, they map out a profile in which the Internet is the main technological facilitator of collaborative innovation networks, providing instantaneous and asynchronous access on a global scale. In this context, according to the author, the

innovation process in collaborative innovation networks occurs in three phases: 1. Invention; 2. Creation, collaboration and communication; and, 3. Sale.

According to Johnsen; Ford (2000, p. 4), a more general observation on the issue of collaboration for upstream innovation, at first glance, although some research results are contradictory, a variety of management models have been suggested to potentially reduce increase the quality and value of products and reduce market time, involving supplies in product development and technology.

Finally, in discussing the moderating role of organizational culture in relation to rewards, knowledge sharing and earnings, Durmusoglu et al. (2014) emphasize the need to create mechanisms that can stimulate the sharing of knowledge among organizations. According to the authors, their research has demonstrated that the transfer of knowledge produces a double influence in the organizational culture, acting both on shared knowledge and knowledge acquired, which reveals the overall benefits of this process on the management of organizational knowledge. As a result of their research, the authors argue that the impact of rewards and culture of organizational knowledge sharing were considered positively and significantly correlated with shared knowledge and knowledge gained.

3. Results and Discussions

3.1 The Sugarcane Genetic Improvement Program (PMGCA) and the Inter-University Network for the Development of the Sugar-Energy Sector (RIDESA)

Among the institutional strategies related to the organization of research on genetic improvement of sugarcane, the National Sugarcane Improvement Program, in the 1970s, was an irrefutable historical landmark. However, since the 1920s, with the onset of diseases in sugarcane plantations that directly affected crop productivity, the first institutional efforts were made to organize stations and research groups for breeding. Among these first milestones, the creation of the Piracicaba Experimental Station, focused on the research and combat of the mosaic epidemic, which had a significant impact on sugarcane production in the 1920s, was highlighted. Landell; Bressiani (2010), highlight other milestones of this institutional effort: The creation of the Agronomic Institute of the Northeast in 1946, focused on the study of coal disease; The creation of the National Cane Improvement Program - Planalsucar, in 1970.

With the extinction of Planalsucar in the 1990s, the Inter-University Network for the Development of the Sugar-Energy Sector (RIDESA) was created, composed of 10 federal institutions: Federal University of Alagoas (UFAL), Federal Rural University of Pernambuco (UFRPE), Federal University (UFG), Federal University of Viçosa (UFV), Federal University of Sergipe (UFMT), Federal University of Mato Grosso (UFMT), Federal University of Goiás , Federal University of Paraná (UFPR) and Federal University of Piauí (UFPI) (SILVA et al., 2013b). According to the authors, among these institutions, two stand out: UFSCAR and UFAL, mainly due to the number of RB varieties launched.

One of the direct consequences of the creation and consolidation of RIDESA was the increase in the production of sugarcane byproducts, strengthening the sugarcane industry and alcohol chemistry (SILVA, 2013, p.58). RIDESA cultivars are prefixed with RB (Republic of Brazil) and now account for 65% of the planted area with sugarcane in Brazil. Serra do Ouro, in the municipality of Murici, state of

Alagoas, maintains the germplasm bank of the cultivars RB, being considered the locus of research in genetic crosses necessary to obtain the new botanical seeds.

3.2 Indicators of innovation in sugarcane cultivars

Alongside the conceptual and legal frameworks that permeate the discussion on intellectual property rights in the agricultural sector, there are numerous practical situations that directly implicate the economy and society, one of which refers directly to the crisis in the sugar-energy sector. It is known that, in the last decade, the sector presented negative results in productivity terms in practically the whole national territory, with emphasis in the North-Northeast region. Despite the slight recovery observed since 2011, the statistics are still unfavorable with regard to the trend of recovery of productivity, as shown in Figure 01.

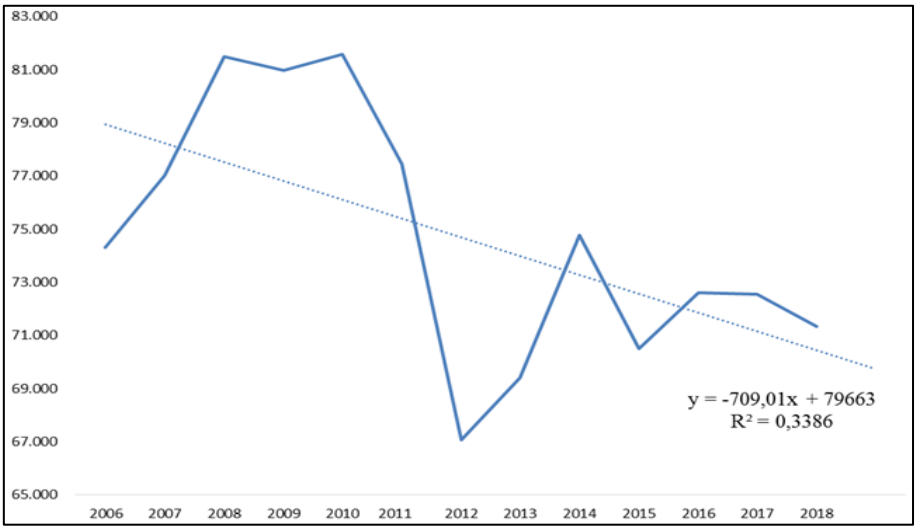

Figure 01. Sugarcane Productivity in Brazil in kg/ha (2006/18)

Source: Prepared by the author (2019)

It is known that productivity represents the relationship between production and planted area in a given period. Figure 01 shows changes in sugarcane productivity in the last decade, as well as the third-order polynomial trend curve with a fall forecast for the next two periods: 2016 and 2017. In the plot area, it is possible to observe the equation obtained from the observed statistical trend: $y = -709{,}01x + 79663$, as well as $R^2 = 0{,}3386$.

Based on statistical analysis, this research sought to determine the extent to which the changes in sugarcane productivity were related to the variations of the planted area, and how important the introduction of new varieties in the Brazilian market in these productivity variations. The results showed that the changes in sugarcane productivity in the analyzed period were more related to the fluctuations of the planted area than in terms of planting of new cultivars. We also analyzed important statistical indices related to innovation in the sector, such as the Varietal Update Index (IAV) and the Varietal Concentration Index (ICV). Table 1 shows the historical series of sugarcane production and planted area in Brazil, between 2005 and 2018.

Table 1. Historical series of sugarcane planted area and production, in Brazil (2005/18)

YEAR	PRODUCTION (in 1000 tons)	PLANTED AREA (in 1000 ha)
2005	431413,40	5840,31
2006	474800,40	6163,30
2007	571370,70	7010,20
2008	571434,30	7057,90
2009	604513,70	7409,50
2010	623905,30	8056,10
2011	560955,20	8362,60
2012	588915,70	8485,00
2013	658822,30	8811,43
2014	634767,00	9004,48
2015	665586,20	8654,24
2016	657184,00	9049,20
2017	633261,90	8729,50
2018	625963,00	8613,60

Source: Prepared by the author (2019)

The data obtained with the statistical analysis of the historical series were later compared with the observations of the Varietal Concentration Index (ICV) and the Varietal Update Index (IAV), in order to evaluate if the sugarcane productivity was more correlated to the variations of the planted area than related to the introduction of new cultivars in the field.

In Figure 2, the historical series of production and planted area were indexed from the data of the matrices X, Y, showing only the variations, since year 2005, instead of absolute values, which allowed to visualize the parallelism between the two curves resulting from matrices. The correlation between the indexed data of the historical production series and planted area of sugarcane was calculated as 0.89. This result confirms the positive correlation between the two datasets, that is, the variation in sugarcane production in the last decade was largely related to the variation of the planted area.

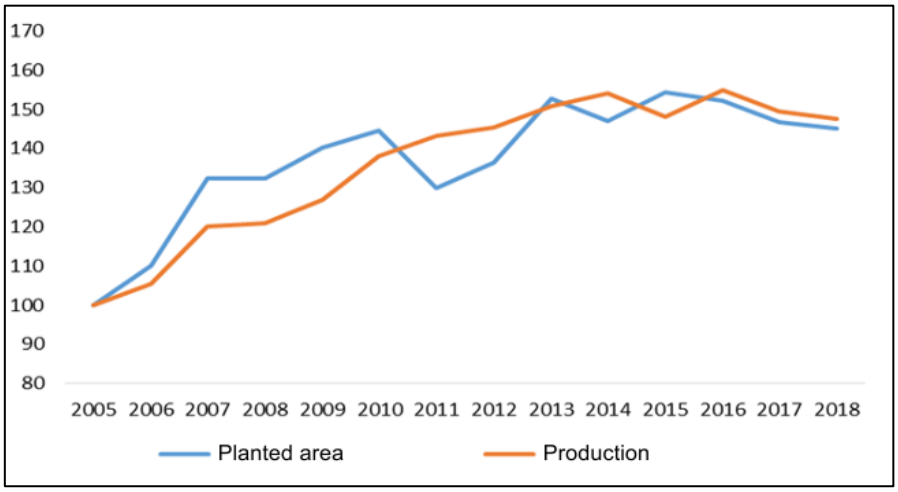

Figure 02. Planted Area and Sugarcane Production in Brazil (2006/18)

Source: Prepared by the author (2019)

From the data available, it was observed that the average productivity of sugarcane in the country, in the last decade, turned around 73 tons/ha. Between 2006 and 2010 alone, this figure was above average, with a slight recovery in the years 2013 and 2015. The trend outlined in this analysis confirms the historical decrease in the growth rate in the decade as a whole, attention to the expected results obtained with technological innovation in the agricultural sector, especially in the case of sugarcane cultivars released and marketed. There is a trend of absolute losses of approximately 8 tons/ha, in terms of average productivity, in the decade.

The Varietal Update Index (IAV) and the Varietal Concentration Index (ICV) were two important indicators for the analysis of the performance of technological innovations in the sugar-energy sector. From the conceptual point of view, the ICV is obtained based on the percentage participation of the three main varieties in the studied region. ICV values above 50% are considered high and not recommended. Values between 40% and 50% are considered intermediate and values less than 40% are considered low and ideal. (CTC, 2016, p.3)

Related to the Varietal Concentration Index, the Varietal Update Index is the indicator that measures technological diffusion, and is therefore of great importance, evaluating the rate at which new varieties of cultivars are launched and marketed. According to the Cane Technology Center (CTC), the Varietal Update Index is obtained by the difference between the current year and the year of crossing of the variety, weighted by the percentage of use of each variety in the region studied. From the value obtained are subtracted 20 years, which corresponds to the average number of years that a variety takes to reach its apex. For this index, values above 7 years are considered high and not recommendable; values between 5 and 7 years are considered intermediate; values below 5 years are considered adequate.

Figure 03 shows the behavior of both indices. The use of 2nd-order polynomial trend lines reveals an alarming situation, when the progressive distance between the IAV and the ICV is observed, projecting up to the year 2020. Also noteworthy is the projection of values above 50% in the ICV index, projected from the year 2016.

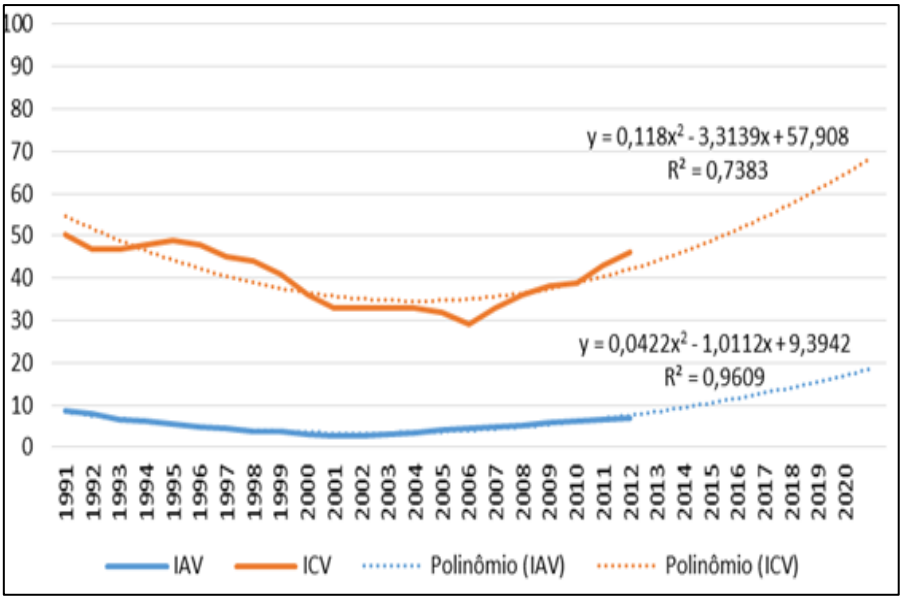

Figure 03. Trend of Varietal Update Index (IAV) and Varietal Concentration Index (ICV) (1991-2011)

Source: Prepared by the author (2019)

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The reversal of this scenario depends both on a reaction of the sugarcane industry to the current scenario of the economy on a global scale and a more detailed analysis of the real impacts of the genetic improvement of the new sugarcane varieties in terms of results and productivity gains and the limits of innovation in the sector.

Figure 04 reinforces the arguments supported, presenting the ten varieties of sugarcane most planted and cultivated in Brazil, in percentage values. It can be observed that cultivar RB867515, launched in 2001 by the Federal University of Viçosa, within the scope of the Inter-University Network for the Development of the Sugar-Energy Sector (RIDESA), stands out both in the condition of variety more planted and more cultivated, in the year of 2012, occupying 40% of the total area encompassed by 10 varieties.

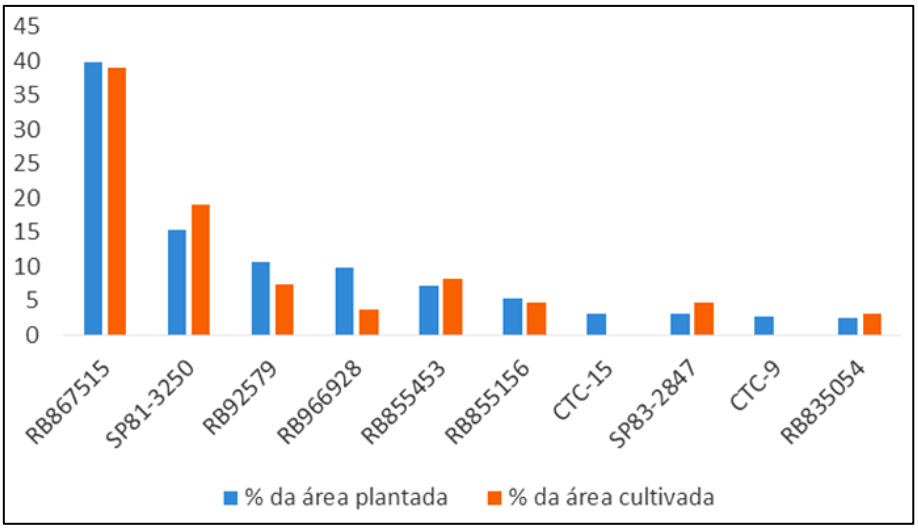

Figure 04. Ten most sugarcane varieties planted / cultivated in Brazil (2012)

Source: Prepared by the author (2019)

The cultivars SP81-3250, RB855453, SP83-2847 and RB835054, presented a percentage of planted area relatively lower than the cultivated area, indicating, on the one hand, the substitution of the currently cultivated variety, on the other, an absolute decrease of the planted area. Regarding the cultivars RB867515 RB92579, RB966928, RB855156, the inverse occurred, in that it can be observed that the percentage of cultivated area is lower than the planted area, indicating that these varieties are still present in the field.

4. Conclusion

The data obtained during the research allowed, finally, to characterize the methodology of operation of the studied network, in a general model that presents a tendency to orient itself as the network arrangements of collaborative innovation. The possibility of carrying out work on a common methodology enabled all of the 10 federal universities that make up RIDESA to stand out in functional terms and qualitative and quantitative performance with regard to Intellectual Property.

It can be concluded, preliminarily, that in spite of the lag between the development of new technologies in the agricultural sector and their commercialization or implementation, by observing the historical series of crude data on planted area and production available, that productivity rates, especially in the case of sugarcane, has been established below that expected and has a high correlation index with the planted area, which can also be observed through the trends revealed by the Varietal Concentration Index (ICV).

The results suggest the need to deepen the studies on the theme and on the role of collaborative networks, such as RIDESA, as a network of public institutions, which holds the intellectual property rights of more than 65% of all varieties of sugarcane currently planted in the country. In this case, a critical perspective is opened that leads to more in-depth analyzes of the real impacts of innovation in the industry on sugarcane productivity, especially related to the launching and planting of new cultivars, as well as variations in planted area.

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