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Social Innovation and Local Development: An Analysis in an Agroenergy Condominium for the Family Agriculture

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Abstract

This article aims to verify how the process of social innovation, resulting from the constitution of an agroenergy condominium in Brazil, was responsible for the promotion of local development. We consider that social innovation promotes development in its multiparadigmatic concept and is an economic means of governance creation. The results show that there were positive implications for the families, the environment and for the technological development. The use of biofuels is an option to the Brazilian energy scenario, since it has reduced transaction costs. But one challenge is the better use of biodigestion residues, used as biofertilizers. This is a developing and costly process compared to traditional fertilizers. There are also challenges regarding the standardization of the distribution of generated energy and technology for the generation of this energy resource. Finally, a model of local development generation based on greater promotion of social innovation is proposed. The findings from this Brazilian research are not limited for use in Brazil only and can be adopted/adapted for application in other countries provided local cultural differences are considered.

Keywords: agribusiness, development, sustainability, biogas, renewable energy

1. Introduction

Increasingly, organizational and sustainability-related studies approach innovation as a means of generating competition and economic development of groups and nations (Lyytimäki, 2018; Martin de Holan, Willi, & Fernández, 2019; Mwirigi, Makenzi, & Ochola, 2009; Tigabu, Berkhout, & van Beukering, 2015). Although the massive concentration of research in Brazil still emphasizes technological, process and product innovation, the concept of social innovation has also aroused the interest of researchers in the face of increasing debates about new solutions that can also bring governance to social groups, communities and to society in general (Agostini, Vieira, Tondolo, & Tondolo, 2017).

In researches that address the relationship between civil society and social innovation, a managerial and economistic approach to the phenomenon prevails (Andion, Ronconi, Moraes, Gonsalves, & Serafim, 2017). For these authors, social innovation is considered a way to promote greater effectiveness and efficiency in public policies and a more economic means of constitution of governance composed by different social actors, a presupposition also adopted in this research and that can be used for all kinds of social organization.

Brazil, for its vast territorial extension and difficulties in solving complex public policy problems, becomes a relevant scenario for the study of how social innovation generates local development. Several studies (Martin de Holan et al., 2019; Mwirigi et al., 2009; Tigabu et al., 2015) indicate that it is possible to make reflections to contribute theoretically and methodologically in the analysis of the generation of development in countries with characteristics of income concentration and other indicators that reflect bottlenecks in the implementation of public policies and income generation. It is also perceived that there is no consensus among authors about how social innovation occurs and what its consequences are.

It is intended to show this process by a more sociological worldview, which also takes into account economic aspects and aims to observe the impact that social and sustainable innovation promote in transaction costs in a sector of extreme importance in Brazil, which is agribusiness. According to the Brazilian Confederation of Agriculture and Livestock (CNA, 2016), it has a strong presence in the Brazilian economy, accounting for 21.5% of the total Gross Domestic Product (GDP) in 2015, 23% in 2016 and 28% in 2017. Specifically, the agricultural sector, including the vast majority of beef, poultry and pork, accounted for 48% of Brazil's exports in 2016 and 61% in 2017, which, according to CNA (2016), guaranteed to the country a positive trade balance revealing the importance of the activity in the Brazilian economy.

According to the Center for Advanced Studies in Applied Research (CEPEA, 2016), agribusiness can be defined as the sum of four segments: (i) inputs used for agriculture, (ii) agricultural activity *per se* (primary activity or inside the gate), (iii) agroindustry and (iv) service sector. These segments are classified by agricultural and livestock activity and their sum offers the agribusiness analysis.

Worldwide, about 40% of all meat consumed is pork and Brazil is the fourth largest producer according to the Brazilian Association of Animal Protein (ABPA, 2015), with a production in 2014 of 3,344 thousand tons of meat. Within the country, the largest pig producer is the state of Paraná, representing 17.7% of the total in 2015, exceeding the state of Santa Catarina with 16.8% and Rio Grande do Sul with 14.7% according to the Department of Rural Economy (SEAB/DERAL, 2016). Much of this production is carried out in a model known as the Agroindustrial Productive Chain (CPA).

CPA can be defined as an evolution of the old way of production with large autonomous farms, which carried out the whole process of creation until slaughter and began to segregate the activities, currently characterized by the specialization of the various economic agents involved. In the case of Southern Brazil, this model is characterized by a strong presence of family arrangements. The main reason for these agglomerations, which can be understood from the point of view of the New Institutional Economics (NIE), is the savings generated in the transaction costs, which allow gains arising from the arrangement for the exploitation of a given activity for all the actors involved (Farina, 2000; Williamson, 1985).

According to the institutional sociological perspective, this process must be viewed under an expanded lens of analysis (Fonseca & Machado-da-Silva, 2010; Jacometti, De Castro, Gonçalves, & Costa, 2016), in which besides the possible gains in the transaction costs, other savings may arise due to technological innovation and concern for the environment, since these activities can somehow have a harmful environmental impact, and thus, the analysis of the sustainability aspects undertaken in this research.

In this way, the question of research is presented: what are the implications of the process of social innovation resulting from the constitution of the agroenergy condominium for family agriculture of Sanga Ajuricaba? Then, the objective is to understand the process of social innovation through the (i) social and economic, (ii) environmental and (iii) technological implications resulting from the constitution of the agroenergy condominium for family agriculture of Sanga Ajuricaba. In the end, this research will help to keep improving the region, because it explains deeper the different impacts of the condominium.

Such topics will be studied from the perspective of institutionalism, without disregarding the economic side of the inhabitants involved, not only with the creation of animals, but also with their use as a conciliator between the scale of production and consumption. This research seeks to understand the association between rural development, preservation and respect for the environment, aspects considered inherent in the process of social and technological innovation.

The research is justified not only by the importance of the state of Paraná in relation to the production of pigs in Brazil, but also by the emphasis it has presented in the production and use of biogas and its by-products. SENAI/PR (2016) emphasizes that the implantation of CIBiogás - ER, the International Renewable Energies Center, located at Itaipu Technological Park, had a national impact on the dissemination of the potential of technology in rural areas allied to the issue of technical knowledge such as the formalization of partnerships and the evolution of public and private policies to encourage biogas.

According to Zanella (2012), Brazil has been gaining prominence in the area of renewable energies due to increased production of biodiesel and ethanol. Finally, regarding the theoretical question, the research is justified because it contributes to the studies that address the question of social innovation under the institutionalist strands in explaining local development. Besides, it provides an alternative for fossil fuels, increasing its importance not only form the academic, but the industrial and the environmental areas.

1.1 Social Innovation and the Institutional Context

In recent years there has been an increasing interest in understanding the phenomenon of social innovation based on the need to find alternative ways to solve collective problems that contemplate regional differences and meet private and public expectations of the problems of modern society. In this context, researches that address the relationship between civil society and social innovation were considered mostly derived from the managerial and economistic approach of the phenomenon (Agostini, Vieira, & Bossle, 2016; Andion et al., 2017).

Although through a systematic review of literature, previous researches have shown that the social innovation process have presented issues related to social change and have evolved to understand the relationships between the different actors, institutions and the social context in which these initiatives are inserted (Agostini et al, 2017). In addition, according to the authors, trends link social innovation to areas such as Institutional Theory, Social Movements Theory, power and perspective of multiple actors and their interactions. In this research, we emphasize the dimensions of social innovation from the point of view of interested actors and effective results, segregated into (i) social and economic, (ii) environmental and (iii) technological implications.

In a survey of farmers in Kenya, Mwirigi, Makenzi, & Ochola (2009) pointed out that biogas technology can be used to solve a macroeconomic and income issue, incorporating investments and would also be linked to the issue of general incentive policies to the development of the economy. Tigabu, Berkhout, & van Beukering (2015) also claim that innovations such as biogas can be understood as issues that facilitate the market and the development of business practices, improve activities and processes, provide resources for companies, users and other stakeholders to a new technology. For the authors, the use of these innovations influences the diffusion and adoption of other technologies in new social processes, being able to affect economic sectors as a whole.

Agribusiness stands out in the Brazilian economy, accounting for 21.5% of the GDP in 2015, going from 23% in 2016 and 28% in 2016, according to CNA (2016). Specifically, the agricultural sector, including the vast majority of beef, poultry and pig, accounted for 48% of Brazil's exports in 2016 and 61% in 2017, which, according to CNA (2016), guaranteed the country a positive trade balance, revealing the importance of the activity in the Brazilian economy.

For Bley Junior (2015), the Western part of Paraná stands out as a national reference in both agricultural and agroindustrial productivity. The author also highlights the potential of the region to become a model for agroenergy development with the use of biogas from the large volume of residual biomass, which demonstrates social innovation as one of the responses to the society.

However, the region that had its economy based on extensive grain production underwent a major shift, focusing on animal protein, which generated a massive amount of organic waste and effluent. Thus, biogas presented itself as a possibility of a renewable energy source, responding to this social demand, no need of a large-scale conventional generation and still boosting the producers' lives through micro-generators (Bley Junior, 2015). This is a viable, cheaper and sustainable way of energy.

Fourth largest producer of pig in the world, Brazil is only behind China (ABPA, 2015) which is also the largest consumer, the European Union and the United States. In the last ten years, Brazil has increased its pig production by about three million tons per year (more than 3.75 million tons in 2017). According to ABPA (2018), by 2015 around 400-500 thousand tons of fresh and frozen pork were exported annually. In 2016, exports increased to 629 thousand tons, and to 593 thousand tons in 2017.

Pig breeding in Brazil is divided into industrial (or technified) and subsistence farming with a strong presence of family producing. However, due to production costs, the majority of the system has migrated to the industrial model (ABPA, 2015). The association also highlights some fundamental changes in relation to pig production in Brazil, which have modified this culture over the years:

• Increasing production scale and reducing the number of producers in all Brazilian regions;

• Changes in the production system, moving to the industrial system;

• Evolution of the agricultural frontier for the Central-west region, with greater access to corn and soybeans, used in animal feed.

The Southern Region, in particular, despite the characterization of its production, increased its national participation from 44.9% to 48.6% (ABPA, 2015). According to SEAB/DERAL (2016), Paraná has 7,134,055 heads, 17.7% of the national total of 40,332,553, thus being the largest herd in Brazil, passing Santa Catarina and Rio Grande do Sul, with 16, 8% and 14.7%, respectively. Then, in

Table 1, it is possible to understand the evolution of the Southern Region, driven by Paraná in the national view of pig farming, since the state accounts for one in four pigs slaughtered in that area.

Table 1. Evolution of the stock by Brazilian region (in millions of heads) - 1980 to 2011

REGION	1980	1985	1990	1995	2000	2006	2010	2011
South	15.412	11.892	10.636	12.495	13.452	17.366	18.930	19.094
North	1.910	2.560	3.750	2.207	2.619	1.594	1.598	1.569
Northeast	7.993	7.872	9.691	6.357	7.140	3.945	6.184	6.079
Southeast	6.141	5.606	6.084	4.496	5.548	5.482	6.857	7.023
Central-west	2.874	2.548	3.459	2.253	2.801	3.559	5.381	5.539
Total	34.330	30.478	33.620	27.808	31.560	31.946	38.950	39.304

Source: ABCS (2016)

Contrary to what is observed at the national level, in the three states that make up the Southern Region, there was a reduction in the number of technified breeders, with the predominance of the participation of family farmers, generally integrated with agroindustrial cooperatives (ABCS, 2016). Also according to ABCS, production is segregated in multiple sites, with little grain production, the main source of animal feed. According to information from SEAB/DERAL (2016), pig farming represents 5.7% of the value of Paraná's production, corresponding to R$4,4 billion (US$ 1.1 billion) per year.

It appears that some factors have an unfavorable performance in this sector, such as the low production of grains in these family arrangements. In 2016, for example, there were losses in the productive poles of the south due to the prices increasing of 55% of corn, according to CNA (2016). This resulted in costs 30% higher than 2015 in the production of pigs. Of the total inputs involved in this type of crop, food accounts for 80% of production costs (CNA, 2016), which reflects the constant search for alternatives that help in reducing opportunity costs for farmers.

Although it occupies a prominent place not only in the economy of Paraná, but in Brazil, there is a negative point related to the environmental impact and the possible reflections that this production can bring to the areas used. According to Barichello (2015), Rocha Jr., Shikida, Souza, & Zanella (2013) and Zanella (2012), pig farming is an extremely polluting economic activity with reflections on soil and water resources. In addition, it has an impact on the consumption of water used in processing the entire production chain and several pollutants to both human and animal health.

The water footprint, which is the measurement of water consumption used in the process of Brazilian pig farms, is 4,818 cubic meters of water per ton of pig, which demonstrates the potential of consumption of scarce resources of this type of crop. The waste generated in pig farming is used to a large extent in the crops as fertilizers, which causes them to reach rivers and springs. This generation of waste is also known as biomass (Barichello, 2015). Biomass can be defined as all energy generated by photosynthesis and its derivatives, such as forest and agricultural products, organic and animal waste, industrial and urban, among others (Zanella, 2012).

Biomass can additionally be classified as clean energy, since it has a comparatively lower environmental impact both in its production process and its use when compared to fossil fuels, such as petroleum, for example (Rathunde, 2009). Biogas, according to Bley Junior (2015), results from the degradation of microorganisms on biomass, which occurs with organic waste. Biogas is part of the Earth's natural metabolism, as it forms part of the biogeochemical cycle of carbon, one of the largest in the world, making it renewable, since it is linked to the degradation of any organic waste.

Brazil has been gaining prominence in the area of renewable energy and this has been occurring due to the increase in biodiesel and ethanol production, which has an intense relationship with the issue of GDP (Zanella, 2012). According to the author, biogas has similar energy content to natural gas, regardless of whether it will be used as electric, thermal or mechanical energy. Biofuel, one of the derivatives of biomass, for example, is highlighted by its potential to reduce the emission of greenhouse gases in a sustainable way, which does not necessarily occur with the use of other alternative sources of fuel. Biogas, in turn, promotes the mitigation of water consumption and atmospheric pollution generated by the disposal of waste in the open.

In addition, biogas provides local development, does not conflict with other energy sources and does not allow other positive externalities linked to the activities that lead to it (Bley Junior, 2015). Within this context is sought to understand how social innovation occurs and what their implications are.

1.2 Energy Efficiency Policies, Legal Environment and Development

According to Schubert (2012), the context of the agroenergy condominium promoted by the energy efficiency policies offers benefits to all involved in the process, providing partnerships between utilities and energy companies, cooperatives, as well as equipment manufacturers and consumers.

It is observed that there is a demand for adaptation to the local culture and respect to the needs of each region. Another highlight is the supply of energy at market prices, as well as the strengthening of institutions for the implementation of these projects and the constant monitoring and verification of energy generated and saved. It also generates savings in the transactional costs of the whole condominium implementation process and its structure, as well as possible scenario changes (Schubert, 2012).

According to article 18 of Normative Resolution 390 (ANEEL, 2009) of the National Agency of Electric Energy (ANEEL), there was the possibility of trade of surplus electricity in the self-production regime. Thus, in the case of biogas producers who converted such an alternative source of biofuel into electricity, it was possible to resell it to other stakeholders by reducing their transaction costs and distributing the excess energy generated. However, it was observed that the legal environment of the biogas was affected by Normative Resolution 482 (ANEEL, 2012), which no longer allowed the sale, only the compensation of the energy surplus at the same property.

It is also worth highlighting the set of legal institutions that must act in the monitoring of activities related to the generation, distribution and compensation of electric energy. Another highlight was the creation of the Brazilian Biogas and Biomethane Association (ABIOGÁS), at the end of 2013, to work on a national policy proposal for the sector (SENAI/PR, 2016).

Regarding the specificity of the assets, Zanella (2012) reveals that the equipment used within the condominium of Sanga Ajuricaba only burn biogas, being the main source for consumption in the food cooking and heating. In this way, these assets are classified as highly specialized, which according to Farina (2000), is related to the possible loss of value that can be generated by the redirection of the asset to another use, being explored in a positive way by the agglomeration, since such assets can bring added value to the condominium.

SENAI/PR (2016) also states that the partnership between rural microentrepreneurs in that region, which had animals generating organic residues and interests in common, set up an alternative for the acquisition and maintenance of certain assets used in the process, reducing the primary costs of the operation and enabling the necessary scale for the operation of biogas technology.

Farina (2000) observes that new technologies tend to raise the uncertainty environment and the specificity of an asset. However, once they are deployed, tested and disseminated, both the uncertainty and the specificity are reduced, causing transaction costs to decrease and allowing them to be minimized in relation to the activities as a whole. The author also notes that transaction costs are sensitive to the institutional environment. This means that, for the same technology adopted, different patterns of integration can be practiced, as it happens in the condominium of Sanga Ajuricaba and that can be equally efficient in its different configurations.

Tigabu, Berkhout, & van Beukering (2015) have observed different integrations in the institutional environment in a comparison of Kenya with Rwanda and understood that innovation involves both collective and individual efforts. For the authors, a process of change implies not only in technical and economic factors, but also in the whole institutional context involved. Thus, capacity, incentives and influences of public policies and their interactions with the actors should be analyzed from different perspectives.

2. Method

The research is classified as a descriptive and exploratory case study (Cooper & Schindler, 2003; Yin, 2001). As Yin (2001) points out, there is more freedom for the authors and they can “report it as it really is”. In this case, interpretation is the cognitive mechanism that promotes the reciprocity between action and institution and, consequently, its simultaneity in the environmental context (Fonseca & Machado-da-Silva, 2010; Jacometti et al., 2016). In this sense, two analytical categories were proposed, according to Board 1:

Board 1. Proposed analytical categories

Analytical Categories	Definition
Social innovation	Dual process seen as a way to promote greater effectiveness and efficiency in the general context and as a more economic means of constitution of governance composed by different social actors.
Institutional Context	Technical environment and relational context.

Source: the authors (2020)

In order to better understand the institutional context in which the agroenergy condominium is inserted, three implications of the social innovation process and their indirect impacts were segregated based on the previous literature: (i) social and economic, (ii) environmental and (iii) technological, which we are considering in this research that, when occurring simultaneously in a positive way, are responsible for the development of the region.

According to this nature, secondary sources were analyzed, such as reports from the Center for Advanced Studies in Applied Research (CEPEA), Department of Rural Economy (SEAB/DERAL), Confederation of Agriculture and Livestock (CNA), Brazilian Animal Protein Association (ABPA), the Brazilian Association of Pig Breeders (ABCS), among other agencies and institutions related to agribusiness, pig production and biogas production and distribution.

In addition, news and specialized reports related to the issue of the implementation of the agroenergy condominium for the family agriculture of Sanga Ajuricaba were used. Such materials bring the development of the project, as well as show its main aspects and implications. Legislation related to the energy issue in Brazil and some of its characteristics were also inserted. Journals and specialized literature were used to elaborate the theoretical framework.

A technical visit to the Ajuricaba Line was also held in April 2019, since the project also serves as a model and replicator for other countries and students who want to analyze their main aspects. A semi-structured interview was developed based on the theoretical framework.

The questions were made to the technician in charge for the Ajuricaba condominium project, whose educational background involves Business Administration and Energy Engineering. Such background was essential in the development of topics related to the research, especially transaction costs and implications from different perspectives analyzed. This interview was not recorded to make the interviewee more comfortable and to allow the research to occur in a more informal tone, which could allow better access to the data.

Another aspect, as reported by Godoy (1995), was face-to-face observation, defined as essential in the case study and non-participant character, seeking to record the maximum details and information. During the visit it was possible to know the Ajuricaba Line and mainly the biogas facilities, as well as other characteristics of the process. Another point observed was the cooperative, which now takes advantage from the biogas generated in the condominium and is on the highway that gives access to the properties of the Ajuricaba Line. In this particular plant poultry is the main product.

3. Results

From now on, the results will be presented depending on their theoretical implications and will be linked to the research objectives.

3.1 Social and Economic Implications

According to the semi-structured interview conducted in loco with the technician in charge, at the beginning of the project meetings were held with the local community. The Ajuricaba Line, as it is called the region, is formed by about 45 housing units. There are farms with potential for biogas generation and all were invited to implement the agroenergy condominium. The project had as one of its objectives the feasibility of different constituent aspects related to the creation of the agroenergy condominium, starting the activities with 33 agricultural properties (Bley Junior, 2015).

> "The decision on which technologies to use was based on manuals, models and experiments already carried out in countries mainly in Europe. Germany has one of the most successful models in terms of biogas and we have had several of its experiences adapted to our region" (interview).

According to SENAI/PR (2016), it was observed that the biogas generation potential for the treatment of milk cattle and pig waste in the region was mostly carried out by total or partial confinement of these animals. According to information from this board, it facilitated the logistics of excrement collection, which is different from that which occurs in beef cattle, which are largely raised loose in the pasture. During the interview, it was also commented on the procedure of waste collection.

> "(...) it occurs within the properties of the condominium participants, being the waste then channeled and following a path called biodigestion. This process is very important because it degrades biomass and transforms it into biogas, which is the cheapest renewable energy source" (interview).

Zanella (2012) states that any biodigester constructed and installed properly can produce biogas and biofertilizer.

Figure **1** shows the model used for the biodigestion of the biomass of pig manure.

Figure 1. Anaerobic biodigester of pig manure

The biodigester is known as “Canadian model” and has low cost and good technology, but ends up being vulnerable to the weather changes, which is crucial for biogas generation (Bley Junior, 2015). However, in the case of properties with higher numbers of cattle, another model named “Pedro” was chosen in honor of Pedro Koeller, who successfully developed fiberglass biodigesters in his dairy cattle using two water containers and that can also be observed in the condominium of agroenergy, as can be seen in Figure 2.

Figure 2. Bovine biodigester

The producer received the visit of technicians who were part of the project and requested their know-how, founded a company and he participated in the Program of Itaipu Ecological Park and was part of the biogas project. The project was coordinated by CIBiogás - ER, a non-profit organization that focuses on the development of biogas as a renewable energy source (Bley Junior, 2015). According to the author, it was first verified that the majority of these producers, whose annual income was less than R$ 100.000 (US$ 25,000) and, consequently, did not reach scale for the implementation and use for energy production with individual biogas, could collectively constitute a condominium for the implementation of the Micro Thermoelectric Plant (MCT). The following part of the facilities visited during the interview can be seen in Figure 3.

Figure 3. Central of operations of the condominium next to MCT

According to the reported, the families that are part of the condominium are connected by a rural gas pipeline of 25.5 km (16 miles) in length and the generated biogas is sent to the MCT, illustrated in

Figure 4. MCT. This model happens differently by the size of the properties and processing power capability. The Itaipu Renewable Energies coordinator promoted the installation of a biodigester in each property and elaborated the construction of a gas pipeline that would transport this biogas to a thermoelectric plant.

Figure 4. MCT

According to EMBRAPA (2015), biogas is still used for the generation of thermal energy in a grain dryer for the farmers. The capacity of the dryer is 470 bags of 60 kilos or 28.2 tons of grains, also allowing savings, since it is for common use. It can be seen in

.

Figure 5. Common use oven

Gains were observed not only on the issue of social innovation arising from the biogas chain and other points that will later be explored, but also indirectly generated by it. According to what was reported by the Presente Rural (2016), the cleanliness of the milking parlor became more practical and efficient, since there is currently the waste channeling. In addition, the biogas generated from the waste produced by the animals is used to heat the water used for cooking in the condominium, bringing well-being to all, as well as cost savings per se, as it enables the reduction of electricity and natural gas consumption, which would not be possible without the creation of such agglomeration.

Another benefit pointed by the Presente Rural (2016) was the use of mechanical milking machines fueled by the generation of biogas, thus increasing local productivity and also the welfare of all involved. In the interview it was described that:

> “Some milk producers have increased the quality of their product and, consequently, their sales and profits because of the cleanliness of the place, since they used sterilized instruments and also avoided contamination of the environment, which could be cleaned more often due to the use of sources of heat generated by the use of biogas” (interview).

The strategy used by the producers in the condominium and by the cooperatives of the region was based, besides structural questions that brought financial advantages, in the guarantee of material supply in desired quantity and quality and in the use of logistic efficiency by all the families. Also, this model, built up for a bigger integration between producers and the agroindustry, allows expressive gains related to the primary production, mainly in food for the animals, generating, among others, important saving in costs of transaction for the producers (ABCS, 2016). These gains are linked to the know-how, this is, the use of modern techniques for collecting manure and saving for the producers, sell of good and by-products generated by the biogas and other alternatives possible after the condominium.

The association highlights that meat consumption in Brazil is fairly regular, but its production is associated with a seasonality, especially in the issues related to pig feed, which are the highest cost of the crop. Thus, the challenge is to conciliate efficiency in the production that assure compatible transaction costs comparing to the market reality (ABCS, 2016).

Looking at the question of minimizing transaction costs in relation to pig production, since it is a production chain with uncertainties (Farina, 2000; Williamson, 1985), during the interview it was asked about the raising and slaughtering of the animals, while they should seek lower costs, trying to minimize the uncertainties inherent to the crop.

> “Our entire process is carried out through the formalization of contracts. We have contracts for the supply of raw materials, which are rations, antibiotics and other medicines, for the purchase of slaughtered animals and we also have signed contracts for making the logistic costs reduced, since most of the slaughter plants are in the region” (interview).

According to Farina (2000), based on Williamson (1985), the creation of agroindustrial systems ends up reducing uncertainties because the creation of contracts minimizes them in the local culture. Biogas is used to obtain energy, either thermal or electric (vehicular in some cases). This provides a reduction of production costs immediately and brings additional gains to all involved. The generation of distributed energy confers greater autonomy to the enterprises, can reduce their dependence on the energy provided by normal distribution networks and also brings indirect gains, with emphasis on social, environmental and technological ones (SENAI/PR, 2016).

Bley Junior (2015) highlights biogas as a complementary energy system, without conflict with other conventional sources and their types of management. By identifying it in this way, it is possible to understand its entire supply chain, as well as its positive externalities such as local development inducers, industry and service activators, and the sustainability of the activities that produce it.

3.2 Environmental Implications

For Bley Junior (2015), the Western region of Paraná stands out as a national reference in both agricultural and agroindustrial productivity in Brazil. The author also highlights the potential of the region to become a model for agroenergy development with the use of biogas from the gigantic volume of residual biomass.

The challenge comes from a rural economy that was based on grain production, mostly corn and soybeans, being focused on the generation of animal protein, classified as an irreversible process in the development of the region. In this way, another dilemma is related to the treatment and final destination of organic wastes and effluents generated by agroindustry (Barichello, 2015; Bley Junior, 2015; Rocha Jr. et al., 2013).

Biomass and its derivatives arise in this scenario with the challenge of ensuring and proving its environmental sustainability. As already commented, Brazil shows a change in its economic development and also of energy production, seeking alternative energy resources (Zanella, 2012). According to the author, biofuels aim to fill this gap by reducing the emission of greenhouse gases and also help to reduce dependence on oil, decreasing pollution.

The development of the rural environment, when dealing with institutional sociological terms, should not dispense a structure that disciplines the most varied issues, such as environmental ones. Thus, organizations should signal a set of rules for those agents that work in the agribusiness, trying to avoid conflicts and encouraging the good performance of the activities of each agent, thus legitimizing good practices (Fonseca & Machado-da-Silva, 2010; Jacometti et al, 2016). This is necessary for stability and security in the use of resources, ensuring the rights and obligations of each party, mitigating uncertainties and opportunistic actions, as well as other possible sources that can increase transaction costs (Zanella, 2012).

Zanella (2012) reports that the potentialities in the use of existing technologies are based on simplicity, self-sufficiency, reduction of energy costs, improvement in internal cleaning of the farm, reduction of odors and flies, micro pathogenic organisms, as well as the benefits of using biofertilizer in agriculture. The rivers surrounding the region, Ajuricaba and Arroio Fundo, according to the interview, started to receive less waste and, after the agreement with the local cooperative, the emission of gases in the atmosphere was also reduced due to the lower burning of firewood.

> "The use of biofertilizer also brings gains for everyone. The average volume produced is 42.75 m^3 per day, which is used in soil preparation for local soy production and forestry. We have a vast corn plantation throughout the region, which is used as an additional source of food for the animals of the condominium. This plantation is fertilized with the by-product of biogas" (interview).

The biofertilizer is a by-product of the biogas that ends up being originated in the biodigestion process, which provides the maximum use of pig waste, optimizing the whole process and adding value to the rural property (Barichello, 2015).

It is observed that the use of biofertilizer in agriculture, although advantageous, in some cases is more expensive than the application of artificial fertilizers (Rathunde, 2009). This happens because most of the pig manure is composed of water and has a very high specific weight, which makes transport expensive. Herein lies the dimension of human capital specificity, quoted by Williamson (1985), which arises through learning. In this case there are several techniques that can be used to reduce the amount of water in the effluent of the biodigester, increasing its density. One of these techniques consists of a natural process of dewatering, since its cost is much smaller, but it needs a considerable area of dispersion of the wastes, which is not a problem in these researched places, since the biodigesters stay inside them and the transport does not have to be done taking the waste from one place to another, which would imply in a cost increasing.

3.3 Technological Implications

Although not widespread in Brazil, the technology used to generate biogas has evolved over the last few years and has some success stories, among them that of Sanga Ajuricaba (SENAI/PR, 2016). It should be noted that there is a plurality of residues that can be used in the biodigestion process both in volume and in kind, which allows the creation of different scales and arrangements of renewable energies. In this way, they are considered inexhaustible, unlike oil and other sources currently used (Cirino, Viana, & Faria, 2013).

In this context, biogas acts as a renewable source and can be exploited associatively to other forms of energy

(Barichello, 2015). The author also shows that the biogas production can happen through specific equipment that is installed for this purpose in the properties and that are interconnected by rural pipelines.

Such structures would form a set of networks allowing the waste to be treated in a centralized process, thus offering biogas production scale. According to information from EMBRAPA (2014), the MCT of the Ajuricaba agroenergy condominium is considered innovative, since it is the smallest generating unit connected to the National Interconnected System (SIN).

Unfortunately, after the approval of Normative Resolution 482 (ANEEL, 2012), related to the general conditions for access to microgeneration and minigeration electricity distribution and compensation systems, the condominium has a generating capacity of 200 to 300 kWh and storage of 600 kWh per day had an increase in its transaction costs, precisely because it could no longer freely negotiate the electricity generated from the biogas.

However, from 2014, through a cooperative created by the producers, Cooperbiogas, an agreement was signed with the local poultry slaughtering cooperative (Copagril) to sell the biogas surplus in its pure form, no longer converted into electricity. During the interview, it was also commented on this legal amendment and its consequences for the producers.

> "The cooperative sells the cubic meter of biofuel for R$ 0,51 (US$ 0.13) with semiannual payments, offering gains in scale with the biogas generated. This would not be possible if the producers were acting alone. With the sale, Copagril no longer burns 10% of the firewood that was used prior to this trade, besides collaborating financially with the local community" (interview).

The issue of financing, maintenance and technological development of the biodigester is also evident in this dimension, since it is still an evolving process. According to the interviewee, the average investment of more than R$ 2.500.000 (US$ 625,000) was funded by Itaipu Binational and had operational counterparts of the Municipal Government of Marechal Cândido Rondon, as well as labor of the farmers who are part of the arrangement. Among the items funded are the financing of the improvement in the stables, the implantation of more than 25 biodigesters, as well as more than 25 kilometers of gas pipeline, construction of a central biogas purification unit and electric and thermal power generation. Here an implicit contract (Coase, 1937) is created between the producers and the sponsoring institutions, both of which do not incur high transaction costs by sharing the assets.

These investments allow the development of scientific research, technical assistance and advice to the families involved and it is observed that the producers qualify their knowledge, they learn with the construction and the management of the biodigesters and the MCT and gradually reduce the difficulties for this system to function correctly (Zanella, 2012).

4. Discussion

This research sought to objectively investigate the (i) social and economic (ii) environmental and (iii) technological implications resulting from the establishment of the agroenergy condominium for familiar agriculture of Sanga Ajuricaba, located in the municipality of Marechal Cândido Rondon in Paraná, Southern Brazil.

Pig breeding in southern Brazil has stood out in recent years, mainly due to the increase in the population of Paraná, based on a differentiated model formed by small families integrated to agroindustrial cooperatives. However, in spite of the prosperity and income brought by the crop, pig breeding is extremely polluting, with water and soil effects, as well as the issue of the polluting gases emission.

Based on this problem arising from the generation of waste from these pigs, it was possible to use such residues for the generation of biomass and its derivatives, with a main focus on biogas, considered a clean, renewable energy that would solve many of the negative impacts on the environment.

The NIE can also be exploited in this context, supported by the Economics of Transaction Costs, technology and market failures. These costs are not necessarily linked to the production themselves, but would be due to the relationships between the agents and related to the coordination between them. Allied to these questions are the different possibilities existing between inter, intra and extra firm relationships and that could also bring benefits to pig producers. Thus, the creation of firms or arrangements would have the main objective of minimizing these costs and obtaining different products and services through a hierarchical structure of processes, generating different forms of savings and advantages for those involved.

With regard to the question of legitimacy and changes in practices, it is observed that the organizations acted for a constant evolution of the legal environment of biogas in Brazil, which was at first affected mainly by Normative Resolution 482 (ANEEL, 2012). However, there was a set of legal organizations that acted to reduce the transaction costs of this still developing activity and allowed its expansion as a sustainable model of renewable energy source, seeking alternatives so that social innovation could continue to occur.

The activities started in the condominium in 2009, coordinated by CIBiogás - ER, brought financial gains, since those producers that had an annual income of less than R$ 100.000 (US$ 25,000) were selected and, consequently, had no scale for isolated power production. Thus, with the help of the Itaipu Renewable Energies coordinator, these families were agglomerated and an MCT was implemented there.

The biogas generation allowed, for example, that these farmers used a communal grain dryer, which guarantees savings for all. There was efficiency in the cleaning of the milking room, since the water was heated with the energy generated and the reduction of the costs with electricity and gas was observed, once they were replaced by the biofuel.

There were advantages in terms of integrating producers and, consequently, gains in terms of human capital, faster and more hygienic collection of milk through the use of mechanical milk collectors run with biogas and improvement of human and animal welfare, which was considered one of the onerous factors of the process and that could compromise the entire productive chain, among others that may occur indirectly.

From the environmental point of view, we can highlight the simplicity of the process, which occurs after its proper implementation, self-sufficiency, energy costs reduction, effluent emission, as well as the improvement of farm cleanliness, odors and flys reduction, among other pathogenic elements.

In spite of the positive implications brought by the specific model, it is also observed, according to SENAI/PR (2016), that there are deficiencies that can be optimized in the use of biogas. These include the few cases in the energy use of biogas generated from both liquid and solid waste and the lack of specific regulation concerning the exploitation, treatment and use of waste for energy generation.

According to SENAI/PR (2016), there is a great opportunity related to the production of energy residues, which allows several alternatives in relation to the diversification of the national energy matrix, due to the large Brazilian pig herd, and especially in the Southern region of the country.

Such opportunities could lead not only to a decrease in dependence on non-renewable fuels, but also to operational costs in agribusiness and the emission of gases in the environment. With this, it is expected an increase of investments in the sector and more possibilities of renewable energy and agriculture (SENAI/PR, 2016).

A limitation for this research is its local application and analysis, giving a less wide perspective in terms of outcomes achieved. This provides an opportunity for future researches that want to broader the outcomes, comparing these results with others from different parts not only in Brazil, but from other countries.

In general, the challenge is the fact that many of the equipment is still adapted from other types of technologies or are from foreign countries, which can be seen as a future opportunity for growth in the industry of alternative energy. Thus, it is concluded that the agroenergy condominium has had different positive implications for the families involved, for the environment and for the development of biogas technology, proving that this type of arrangement is viable and the use of biofuels may be an alternative to the Brazilian energy reality.

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