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Soybean cropping by family farmers: a new institutional path for rural development in Brazilian Central-West

Marcos Rodrigues[1], Indio Campos[2]

[1] *Universidade Federal Rural da Amazônia (UFRA)*
[2] *Universidade Federal de Mato Grosso (UFMT)*

Abstract. Soybean cropping in Mato Grosso is historically present in large farms. However, in recent years, small farmers have joined this supply chain. In this study, we aimed to identify how small farmers can surpass the paradigm of large-scale production in soybean production in Mato Grosso. A case study in six municipalities in Mato Grosso was conducted to gather data from 72 family farmers. A pooled panel data regression analysis was performed to verify the impact of small farmers solutions in the economic results of soybean. Results showed that small farmers reduce long-term needs of investment in markets of used machines and third-party harvest service market; trading companies contractually provide the short-term inputs, which family farmers can pay for in soybean equivalent; suppling farmers lack financial resources. Economies of scale is present in small farms. In spite of that, prices, climate risks and other environmental problems make it difficult for soybean to increase family farmers competitiveness and sustainability.

Keywords: mechanization, transaction costs, production costs, institutions, innovation.
JEL codes: Q12, Q13.

1. INTRODUCTION

Brazil is recognized worldwide for the high agriculture productivity. The expansion of its agriculture followed the liberalization trends in developing countries – mostly since the 1990s, with strategic economic liberalization (Serrano, Pinilla, 2014). Nowadays, agribusiness is a national strategic economic sector, accounting for 21.6% of the Gross Domestic Product (GDP) in 2017 (CEPEA/ESALQ 2017). Soybean figures do represent the main national commodity, with a total production of 114 million tons in 2015/2016, according to the National Supply Company (CONAB, 2017), accounting for 25.717 billions of dollars (MDIC 2018). In this scenario, the State of Mato Grosso is national reference in technological and institutional innovations in agribusiness. In 2016/2017, the state was the national leader in soybean production

(26.7%), maize (29.5%), cotton (66%), and cattle (13.88% of total livestock in 2016), (CONAB, 2017; IBGE, 2018).

In contrast to different regions in Brazil, the soybean supply chain in Mato Grosso, is based on a strong relationship between industry, farmers and large trading companies (Wesz Jr., 2016). It is also organized and oriented by technical and economic constraints, which establish the land as a solution for economic efficiency (economy of scale). This productive paradigm is responsible for the leadership of Mato Grosso in soybean production and sets Brazil as a major exporter of the commodity (Wesz, 2016). But, historically, this has excluded small farmers in favor of large farmers, who can replicate technological packages.

Distant from the requirements of commodities markets, small farmers are driven to develop alternative activities (e.g. non-farm rural labor) or join markets with lower coordination and added value, which have reduced capital, technology and land requirements (Haggblade *et al.,* 2010). Consequently, government policies in Brazil are oriented to poverty reduction, income distribution and subsidized credit to economic diversification (Nunes, Mariano, 2015). But, in recent years, small farmers in rural areas have been planting soybean with economic efficiency using the same technological patterns of large farmers, contradicting the existent technological and capital constraints. Has the productive paradigm changed or have small farmers adapted to existing mechanisms to join themselves in this market?

Previous studies have already dealt with some problems faced by small farms and rural areas in Brazil, such as cash transfer programs and support policies in rural areas (Dou *et al.,* 2017), food insecurity and the role of small farmers to reduce poverty (Nolasco *et al.,* 2017), the impacts of emerging biofuels markets to smallholders (Watanabe *et al.,* 2012; Dal Belo Leite *et al.,* 2015; Petrini *et al.,* 2017), and development of small farmers' rural areas in Brazil focusing on cash transfer programs and support policies (Dou *et al.,* 2017). More than income distribution policies, market mechanisms are necessary to small farmers so they can adjust the costs structure and capital needs to their reality and develop new alternatives of rural development.

We aimed to identify how small farmers can surpass the paradigm of large-scale production of soybean production in Mato Grosso. We sustain that small farmers adhere to soybean production supply chain by replicating efficient parameters of production through new institutional mechanisms. In order to break barriers brought about by economies of scale, family farmers resort to governance structures that reduce their long-term investment and supply short-term funding needs.

2. SOYBEAN IN MATO GROSSO: TECHNICAL, HISTORICAL AND INSTITUTIONAL DETERMINANTS

Over the last three decades, Brazil has become an agricultural exporter thanks to the expansion of capital-intensive agriculture in the Brazilian savannah (*Cerrado*), in the Central-West part of the country. Mato Grosso increased its production from 0.45 millions of tons in 1976/1977 (3.71% of the national total) to 31.49 millions of tons in 2016/2017 (26.7% of the national total). This leadership in grain production has been historically driven by technical, cultural and institutional determinants.

The Brazilian Central-West occupation in the 1970's was propelled by large private colonization projects and government support to increase demography in the frontier (Jepson, 2006). The occupation of Central and Northern Mato Grosso was predominantly done by flows of immigrants from the southern states of Brazil (Paraná, Santa Catarina, Rio Grande do Sul), where grain farming was historically predominant (Mier y Terán Giménez Cacho, 2016). This cultural vocation for grain production, added to the investment in research and the subsides for agriculture, paved the way for soybean production in Mato Grosso.

However, the economic crises in the 1990's reduced significantly the participation of government in agriculture (Delgado, 2009). The liberalization of economy was then necessary as a means to rescue the agricultural sector, allowing large companies (trading) to replace the government as funding source (Wesz Jr., 2016). The new institutional environment replaced the historical subsided agriculture with a productive paradigm oriented by intensive mechanization and use of modern inputs (fertilizers, pesticides, quality seeds). Consequently, the agricultural area of *Cerrado* expanded by 87% between 2000 and 2014 (Filho, Costa, 2016). In the same period, soybean in Mato Grosso increased from 9.6 to 26.4 million tons (average growth of 13.41% per year) (Conab, 2017).

The fast expansion of soybean not only lead to economic growth but also raised new problems regarding the environment and human health. The pressure of new arable lands over the Amazon and *Cerrado* increased deforestation (Fearnside, 2001; Barona *et al.,* 2010) and new mechanisms of control – e.g. the Soy Moratorium – had to be developed (Gibbs *et al.,* 2015; Rudorff *et al.,* 2011). Intensive use of agrochemical pesticides in this new model can lead to health problems, contaminating not only the grain but also soil, air and water (Pignati *et al.,* 2014). The importance of agroindustry for local and national economy challenges the social interests for health (Berger, Ortega, 2010). Such issues increase the

debate about how sustainable is the soybean production and if the integration of small farmers can be justified in this environment of medium-to-long term of exposure to agrochemicals.

In contrast to other Brazilian regions – e.g. Southern states with predominance of cooperatives as main agents in soybean (Clasadonte *et al.,* 2013) – Mato Grosso shows a close relationship between farmer and trading companies. In the current scenario, the short-term purchase contracts, signed by tradings companies and large farmer, do prevail providing the funding sources for cropping (Brum *et al.,* 2011; Rodrigues, Marquezin, 2014). Due to techniques (e.g. zero tillage, culture rotation, spacing), high mechanization and production costs, large-scale cropping is so far the only way to achieve economic efficiency (Vander Vennet *et al.,* 2016). Consequently, small farmers should remain outside the soybean production chain (Tab. 1).

In terms of efficiency, large farms have more economic advantages than small farms –with lower cost per unit of production and more production per unit of labor –, suggesting that agricultural production may shift from small to large farms (MacDonald *et al.,* 2013). Small scale farming must develop alternative economic use of land with higher use of labor and less area requirements (avoiding economies of scale). Activities with such characteristics include dairy production (Monteiro *et al.,* 2013), organic agriculture (Qiao *et al.,* 2018) and fish farming (Lima *et al.,* 2018).

Medium and large farms are predominant in soybean production in Mato Grosso, as observed in Table 1, farms with less than 100 hectares are just 8.84% of total properties that cultivated soybean in 2006 (Ibge, 2006). Yet, a growing number of small family farmers have shifted to soybean cropping in Mato Grosso in the last years, opposing to the shift from small to large farms in agricultural commodities production. Considering the constraints of soybean, the phenomena should be the reverse (decrease or disappearance of small farms in this type of production). To support the empirical evidences in this study, the New Institutional Economics (NIE) provides an important theoretical background.

Tab. 1. Comparison between soybean and total rural properties in Mato Grosso by groups of area.

Classes of area	Number of rural properties		Ratio (a/b)
	Soybean [a]	Total [b]	
Very small farmers (Less than 10 ha)	3	16005	*0.02%*
Small Farmers (10-100 ha)	393	61781	*0.64%*
Medium Farmers (100-1000 ha)	1706	26457	*6.45%*
Large Farmers (More than 1000 ha)	2378	8744	*27.20%*
Total	4480	112987	*3.97%*

Source: IBGE (2006).

According to North (1990, p.3) «institutions are the rules of the game in a society or, more formally, are the devised constraints that shape human exchange, whether political, social, or economic». For Greif (2006, p.30) «an institution is a system of rules, beliefs, norms, and organizations that together generate a regularity of (social) behavior». They specify mechanisms of enforcement that monitor and punish deviations. An organization is a group of individuals with a common objective (a small or large farmer or a trading company). All these organizations exist in a competitive environment with limited resources (North, 2008, p.22).

The institutional environment has the basic institutions that arrange the social and economic relations. They are hard to be changed by the influence of one individual organization itself. The institutional arrangements are, in turn, the rules that organizations establish in a given institutional environment. These arrangements create structures to change property rights or change the ways by which organizations cooperate (Davis, North, 1971). The result is the institutional matrix with a set of possible opportunities for organizations, which will invest knowledge and skill to find the most beneficial structure for its purpose (North, 2008). This institutional matrix determines the costs of the organization.

The total cost of a good or service is the sum of the production costs – land, capital and labor – and the transaction costs. As pointed by Williamson (1985, p.1) "a transaction occurs when a good or service is transferred across a technologically separable interface. One stage of activity terminates, and another begins". A transaction is the transference of an asset between agents. The transaction costs are the costs involved in this process. They exist because transaction informations are incomplete, generating uncertainty. In this scenario, agents manage to obtain better information and safety, increasing the transaction costs.

In nations where property rights are uncertain, the transaction costs are higher. Hence, organizations have few incentives for investment. Their main option is high return activities that do not contribute to development (Shirley, 2008). Institutions matter because they affect the economic performance of agents and the economic development. Some studies have demonstrated the relations between trading and development, and how they are affected by the institutional environment (Knack, Keefer, 1995; Lin and Fu, 2016; Mavragani *et al.,* 2016).

The liberalization of economy in Brazil in the 1990's favored the trading companies because the institutional environment changed, creating safe mechanisms for transaction and reducing transaction costs.

The institutional environment impacts heavily the economic performance of agents in the soybean production chain. Institutional constraints, such as phytosanitary norms, product characteristics, trading laws, the soy moratorium (Gibbs *et al.,* 2015) affect the terms of contracts, forcing the agents to rework their strategies. Aimed at reducing transactions costs, the institucional arrangements adapt to these constraints, and in the historical case of Mato Grosso, have resulted in an increase in the scale of production among large farmers (economy of scale). On the other hand, institutional inovations allowing the insertion of small farmers in the soybean production chain indicate the creation of mechanisms to reduce costs and provide funding.

Watanabe, Bijman, and Slingerland (2012) highlighted the importance of transaction costs in agricultural markets in their study on the supply of raw materials by family farmers to biodiesel industries in Minas Gerais. The authors verified that castor beans are the product with the highest specificity because there is only one buyer in the region – i.e. a monopsony. Thus, the contracts are, at the same time, a part and evidence of a hierarchical structure of governance. Uncertainty and risk on the part of the small farmers do not allow an efficient reduction of transaction costs, which is the reason why fewer small farmers still produce castor beans, which compromises public policies in the biodiesel sector.

In China, the solution for land tenure conflicts that threatened small herders began with the support of institutional arrangements, which included their sustainable practices in public policies (Chen, Zhu, 2015). In Brazil, Vilpoux (2011) identified six institutional arrangements ruling the relations between cassava producers and starch industries. He concluded that, even though the traditional governance structures reduced the transaction costs, they did not meet the industrial demand for raw materials. Intermediate safeguard and guarantee mechanisms are more suitable for cassava farmers and the industries.

Wander and Zeller (2002) studied family farmers' behavior in Rio Grande do Sul when switching from using their own machinery to contracting third-party service providers. According to the authors, 94.6% of the properties had no harvester. Instead of acquiring expensive machinery, small farmers contract outsourced services. From this strategy emerged a new, low-cost institutional arrangement, namely the market of harvesting services – and vice versa. The contracts specify payments per ton of harvested crop and include guarantees related to delays that can cause losses during harvesting.

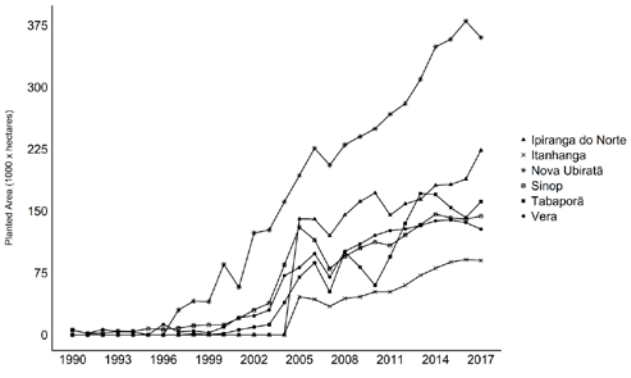
The transaction cost approach contributes to understanding how economic agents behave in a given institutional environment. It applies to several fields of study, both within and outside agriculture, such as production decisions and participation in public programs according to the quality of the land (Hallmann, Amacher, 2014), preservation or use of biodiversity (Badstue *et al.,* 2006) and so forth. In this study, we connect the transaction costs and institutional environment of soybean production by small farmers with the mechanisms developed to increase their competitiveness.

3. METHODOLOGY

This research was conducted in Northern Mato Grosso. The region is characterized as a biome transition zone between the *Cerrado* and the Amazon. Also, in the selected municipalities the soybean production had a great expansion in the 2000's (Figure 1 shows the evolution of soybean planted area in the municipalities of this study). This late boost – when compared with other municipalities from Southern Mato Grosso – was fundamental to economic viability of soybean in small farms; the institutions developed were based in new market solutions.

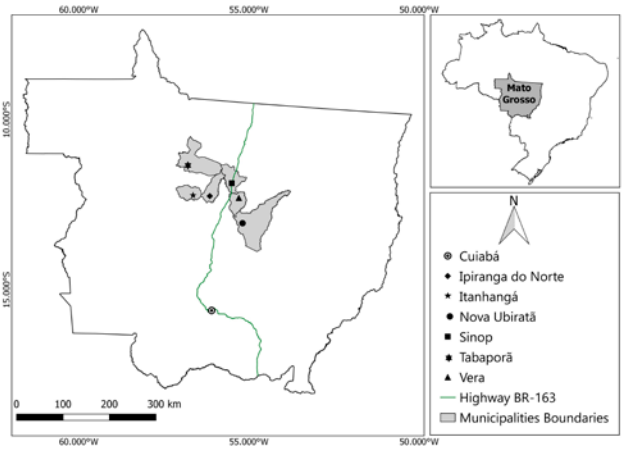
We selected the case study as the best research method (Yin 2009) to understand how small farmers – against all odds – are switching to soybean cropping. These municipalities were select because they have some similarities: they where recently founded by private colonization projects; large settlements established in the 1990's by the federal government; later expasion of soybean; market and logistic infrastructure developed to

Fig. 1. Soybean cropping area in studied municipalities – 1990 to 2017.



Source: Brazilian Statistical Office (Ibge, 2019).

Fig. 2. Map of Mato Grosso and the researched municipalities.



Source: Authors.

attend large soybean farmers – but that also attend small ones – and the presence of Mato Grosso public technical assistance company (EMPAER-MT) in proximities. An official list of small farmers that cultivate soybean does not exist. Hence, to identify the farmers we rely on informations of the EMPAER-MT of each municipality, which indicates some small farmers and spots that cultivate soybean (chain-referral sampling).

From January to December of 2016 we surveyed 72 farmers in six municipalities of Mato Grosso, namely Ipiranga do Norte, Itanhangá, Nova Ubiratã, Sinop, Tabaporã, and Vera (Fig. 2). The exploratory approach provides specific recent data from small farmers in this new wave of soybean expansion in Mato Grosso, while the New Institutional Economics provides the theoretical background to understand the role of governance, institutions and transaction between agents.

The questionnaire had three sections: I. Characteristics of family farmers (age, gender, family origins, total number of family members); II. Characteristics of land use (economic use, non-economic activities, total land area and its economic use, improvements and equipment use); and III. Characteristics of soybean production (production costs and techniques, costs funding source, prices, productivity, machines, commercialization). Family farmers had different forms of land tenure – own area, rural settlement and rented area. But, to respect federal legislation the threshold of farm size[1] for farmers in Sinop, Vera and Nova Ubiratã was 360 hectares and in Ipiranga do Norte, Itanhangá and Tabaporã was 400 hectares.

The total cost for soybean cropping had three elements: I) the inputs, such as seeds, fertilizers, pesticides, fuel, labor and other crop expenses; II) land leasing costs; III) costs with mechanization services for farmers that contracted machinery services. Total revenue was obtained by multiplying the average price of soybean by total production. Small farmers have scarce use of management tools, the crop profit was obtained by subtracting revenue from the total cost.

To identify if the mechanism developed in the institutional arrangement has impact in total profit of family farms we performed a pooled panel data regression with four crop year (2012/2013, 2013/2014, 2014/2015 and 2015/2016) – Equation 1.

$$P_{it} = \beta_1+\beta_2 CPR_{it}+\beta_3 BIO_{it}+\beta_4 LAND_{it}+\beta_5 MC_{it}+\gamma_{it} D+\varepsilon_{it}$$

P_{it} is the total profit of family farm (i) in the year t. The independent variables are the CPR, the Rural Product Contracts, in R$1000; BIO is the revenue from biodiesel market, in R$1000; LAND is the total cultivated area with soybean (in hectares); MC is a dummy variable identifying if the farmer rents machinery (1) or has his own machines (0); β_1 is the respective coefficient of each independent variable and, ε is the random error term. D is a matrix of dummies that represents each crop year (Y1314 = crop year 2013/2014; Y1415 = crop year 2014/2015; Y1516 = crop year 2015) to verify if external events change the profit of soybean cropping (prices, climate) and γ_i is the coefficient associated with each crop year. We used the Brazilian General Index Price (*Índice Geral de Preços* – IGP-DI) to fix the inflation effects.

4. RESULTS AND DISCUSSION

According to data, each family owns on average 131.75 hectares (ha), of which an average 114 ha is arable land. Less than 18 ha remain for native forest preservation, housing, gardening and other needs. Indeed, land shortage does not allow cropping based on gains of scale. The suveyed farmers are predominantly born in Southern Brazilian states (90,3%), which are one of the main drives for the production of this commodity. When questionned about the reasons for chosing soybean production instead other agricultal activity, 56% of farmers appointed that «soybean is the best option in Mato Grosso», followed by «experience/tradition» with 24%, and «other activities were unsuccessful» with 16%. Other reasons just accounted for 2%. Farmers mentioned

[1] Brazilian federal law considers family farmers those who meet all the criteria: i) have up to four *módulos fiscais* in total area size, which varies for each municipality; ii) predominance of income from rural activities; iii) predominance of family labor and; iv) family management of activities in the farm.

that fewer climate changes, market support, infrastructure and technology are also factors for choosing soybean in the state.

Since the 1960's, INCRA – the national authority for colonization and land reform – expropriates inefficient or idle large farms and provides landless rural families with small farms within official settlement projects. In the 1970's and 1980's, INCRA also used public vacant land for the same purpose. After decades, some rural researchers argue that, from the very beginning, most of the new small farms have been inefficient and not able to overcome the limitations of self-subsistence (Alves *et al.,* 2012). Furthermore, inefficiency and rural poverty lead to food insecurity (Portal *et al.,* 2016). 75% of the interviewed farms were located within such settlement projects, while 19.4% were outside them. The remaining 5.6% are lessee farms. At times, some farmers aimed at gains of scale also rent neighboring areas.

Although soybean cropping is the main activity, small farmers also grow other crops, especially maize, which is present in 98.6% of the surveyed farms. Despite the lower gains, large farmers also sow maize after soybean harvests. The consecutive use of the arable land – so-called «safrinha» – allows farmers to take full advantage of the nitrogen and other macro-nutrients left behind in the soil. Rice cropping is also significant and is present in 40.3% of the farms. As reported by small farmers, the low natural fertility of recently deforested savannah areas supports two or three rice crops at most, before switching to soybean and the use of industrial fertilizers became unavoidable. All farmers reported to use zero tillage agriculture.

Highest soybean productivities are then associated with the utilization of a standardized technological package prescribed by the trading companies support agents (e.g. research, technical assistance, input industries). It includes the use of modern inputs (fertilizers, agrochemicals, pesticides, and high-quality seeds), and implies long-term investment in labor-saving machinery, and amortization requires large extensions of arable land. Pressed by downstream and upstream oligopolistic market structure, determining production cost and soybean prices, liquid revenue of soybean farmers depends on the size of their arable land. The necessity of inputs is very stable and practically does not vary with the production scale and long-term costs play a central role by determinating the production scale that maximizes profits. Below this optimum, the smaller the disponibility of land is, the smaller the profit margin becomes until it finally turns negative.

In general, farmers make use of Rural Product Contracts (*Cédula de Produto Rural* – CPRs) to meet their annual capital needs. The trading company involved provides production inputs, and the farmers pay their costs in soybean equivalent. Rodrigues and Marquezin (2014) reported that in 2012 the CPRs funded 65% of the annual costs of soybean and maize cropping in Sinop.

As shown in Table 2, the CPRs are also the main credit source for 57.66% of the surveyed farmers in crop year 2015/2016. Surprisingly, 45.28% of them allocate their own resources, showing the oft-mentioned risk avoidance by small farmers. The Nation Program from Family Agriculture (PRONAF) is an official program offering subsidized credit for small farmers in Brazil. However, its credit limits per family are far below the capital needs even for a small soybean cropper. That is the reason why only 2.41% of them use this credit line.

The CPR is an important institutional breakthrough in Brazilian Central-West agriculture. It establishes a cooperative relationship between croppers and trading companies, reducing both uncertainty and transaction costs. Because of the bankrupt of the Brazilian rural credit system in the 1980's, the following expansion of soybean crops in the region would not has been feasible without alternative credit lines. As seen above, small farmers resort to CPRs as well. To verify the impact of CPR in farms profit we performed a pooled panel data regression (Tab. 3).

The results showed that the variable is significant and negative, the increase in dependence of CPR decreases the farm profit. The inverse dependence of this variable with profit is associated with the bargain

Tab. 2. Market contracts for family farmers' soybean production.

Variable		2012/2013	2013/2014	2014/2015	2015/2016
Funding Sources as % of total funding	CPR	*46.99*	*45.84*	*47.08*	*57.66*
	Pronaf	*1.9*	*1.86*	*1.82*	*2.41*
	Self funding	*42.83*	*43.76*	*45.28*	*31.53*
Harvest services as % of total cost		*8.44*	*7.85*	*8.93*	*9.77*
Average biodiesel bonus price contribution to total revenue (%)		*2.63*	*2.50*	*2.60*	*2.33*

Source: research results.

Tab. 3. Coefficients of pooled panel data regression.

Variable	Coefficient
Intercept	-10.166
CPR	-0.232 *
BIO	0.570
LAND	0.705 *
MC	6.382
Y1314	6.199
Y1415	10.600
Y1516	-44.995 *

Source: research results.
Note: CPR = Rural Product Contracts, in R$1000; BIO = Revenue from biodiesel market selling, in R$1000; LAND = total cultivated area with soybean (in hectares); MC = dummy identifying if the farmer rent machinery (1) or has his own machines (0); Y1314 = dummy for crop year 2013/2014; Y1415 = dummy for crop year 2014/2015; Y1516 = dummy for crop year 2015/2016;
* p-value < 0.05.

force of trading companies. Although this contract has negative impacts on farm's profit, it is essential to small farmers since their lack of resources is complemented with CPR. Besides, CPR does not compromise soybean production in small units as will be discussed.

The long-term capital needs to acquire machinery, such as harvesters, tractors, and sprayer and it demands diversified institutional solutions. The harvester, by far the most expensive equipment[2], can raise a hard obstacle for potential soybean cropper, whose land availability is not sufficient to meet annual capital amortization needs. Hence, the real barrier is not the access to credit lines, bearing in mind that machinery contractors also provide the funds and accept payments in soybean equivalent in installments, but the low production scale due to land shortages. In practice, if there is no enough land it is not worth acquiring harvesters.

Nowadays, there are two market solutions designed to reduce family farmers' long-term investment needs. The first solution is to acquire a second-hand harvester that is already technologically obsolete for a large producer. Low cost and the use of family labor for maintenance compensate the technological lag, and the machinery performance fits the small scale of production. Thus, 52.8% of surveyed farms (average size of 128.76 ha) employ a second-hand harvester, whose price hardly reaches 20% of a new one. In general, the buyer can pay it in installments or in soybean equivalent. Due to the widespread knowledge about harvester characteristics, such as harvest efficiency, depreciation, fuel consumption, maintenance costs, the transaction costs are very low.

The second solution is to engage third-party harvesting services provided by specialized firms through frequent informal contracts. This practice occurred with 36.1% of the surveyed farmers, especially with the smallest farms (average size of 66,19 ha). As payment, the firms received 5% up to 7% of harvested soybean plus fuel costs, which represented 8.93% of total costs in crop year 2014/2015. In the panel data model (Tab. 3), machinery renting did not show significant impact in farm's profit. For small-scale farmers, machinery renting is an important contract, which reduces their dependence of long-term funding to acquire machines.

According to Watanabe, Bijman, and Slingerland (2012), family farmers' soybean production in Minas Gerais would not be possible without sharing the use of machinery. This kind of solution presupposes a different set of institutions based on social capital such as confidence and equity of information. Agricultural cooperatives of small farmers in Rio Grande do Sul also employ non-market services for soybean crops. In turn, in the recently colonized northern Mato Grosso, where the foundations of cooperative practices are still lacking, small farmers have managed to become soybean producer by using new market mechanisms with low transaction cost.

Just 11.1% of surveyed farmers have acquired new machines. On average, each of them owns 314.38 hectares. Even if this area is compatible with some gains of scale, the profit income per ha is relatively low in comparison to larger farms. However, the family income can increase with the provision of third-party harvesting services.

An important public policy that aims to increase income for small farmers is the Brazilian National Program of Biodiesel (*Programa Nacional de Produção e Uso do Biodiesel* (PNPB). Refineries that process soybean produced by small farmers receive tax incentives. In return, they must provide small farmers with price incentives and technical assistance.

In the crop years 2012/2013, small farmers received an additional R$1.20 per sack (60 kilograms). The incentive rose to R$1.35 in 2015/2016, when the local soybean price reached US$ 20.00 per sack at a currency exchange rate of R$3.20 for US Dollar. The program benefited 43.1% of the surveyed farmers. Price bonus reduces risks associated with market events. In 2014/2015 the price bonus contributed with 2.60% to small farmers' income. In 2015/2016 climatic events reduced soybean productivity, and price bonus contributed with 2.33% to that income (Tab. 2). The BIO variable in panel data did not

[2] In regional market, a harvester can cost up to US$ 300,000.00.

show significance in the increase of soybean profits; few farmers (41,6%) joined the program. As the Biodiesel Program develops and the demand for oilseeds also increases, new small farmers can join the program and increase its importance for rural development.

Technical parameters of production depend on the employed technological package. The average productivity by small farmers reached 47.37, 50.37, 53.17 and 44.02 sack/ha in 2012/2013, 2013/2014, 2014/2015 and 2015/2016, respectively. According to data from the Instituto Matogrossense de Economia Agropecuária (IMEA), the average in the state (considering both large and small farms) was 49.8, 51.9, 51.9 and 49.8 sack/ha in the same years (IMEA, 2016; IMEA, 2015). In 2014/2015, the average productivity by small farmers was even higher than the state average. Only in crop years 2015/2016 a significant divergence of productivity per ha occurred due to climate events that particularly affected the harvest. Therefore, given the relatively stable weather conditions of Brazilian Central-West, only the divergence of labor productivity is significant. It has claimed institutional solutions in addition to CPR.

In 2014/2015[3], farmers owning up to 50 ha obtained an average annual profit of US$7,694.15. In the next stratum –50 to 100 ha – the profit rose to US$ 16,893.09, and to R$ 33,113.63 in the stratum from 100 to 200 ha. It reached US$ 63,188.36 in the stratum over 200 hectares (Table 4). The results show a significant difference of profit per stratum of the area, demonstrating that even in small farmers soybean production is correlated to economies of scale. These data are corroborating with panel data results (Tab. 3), where LAND variable showed to be positive and significant. However, even farmers with less than 100 hectares can assure a family income many times greater than the national minimum wage of monthly US$ 300.00/month. Climate variations in 2015/2016 increased soybean price. However, the lower productivity and increased costs of production showed how risky for families' incomes is soybean production. The average net profit in that year reduced by 49.4% (all farmers) comparing with 2014/2015. This result is also verified in Table 3, variable Y1516 showed to be negative and significant.

Tab. 4. Average crop profit for sampled small farmers.

Class of Area (hectares)	Average net profit (US$)[1]			
	2012/2013	2013/2014	2014/2015	2015/2016
0 ⊢ 50	6185,66	7374,77	7694,15	3661,45
50 ⊢ 100	13947,04	14572,37	16893,09	8357,98
100 ⊢ 200	26947,76	27579,61	33113,63	22753,95
200 ⊢⊣ 400	53481,43	52171,58	63188,36	26826,27

Source: research results. [1] Cambial exchange rate of R$3,20 = 1 US$.

[3] A very stable crop in climate phenomena and prices.

Institutional paths of innovation are allowing small farms to switch to soybean production with potential economic results in stable market and climate conditions. The benefits of this mechanism are spread throughout the entire network, reducing investment costs (second-hand machines, markets, and harvest services), funding the production (CPR) and increasing revenue (biodiesel).

Some of these institutional innovations aim to protect the rainforest and, therefore, have impacts on family farms located in rainforest areas. The Soy Moratorium, for example, is an agreement signed by Greenpeace, farmers, and the trading companies that since 2008 establish trading barriers for soybean produced in the deforested Brazilian Amazon rainforest (Gibbs *et al.,* 2015; Rudorff *et al.,* 2012). The Brazilian Forest Code sets limits for deforestation in farms as well. Since the productive paradigm is still conflicting with sustainable agriculture and social interests, new institutional mechanisms are necessary to face this problem and enhance the opportunities for rural development, reducing the risks for small farmers in highly integrated commodity markets.

5. CONCLUSION

This study addressed the mechanisms that contributed to the economic viability of soybean production in family farms in Mato Grosso. The traditional soybean technological package implies gains of scale and intensive use of modern inputs. Despite this, in Northern Mato Grosso, family farmers are shifting to soybean cropping thanks to new institutional market mechanisms created within the soybean production chain. The Rural Product Contracts signed by trading companies and family farmers cover the annual requirements for soybean cropping. Second-hand machinery markets and third-party harvesting services, in turn, contribute to reducing the long-term capital need. Lastly, the official biodiesel program provides family farmers with a stable stream of income through price incentives and contractual trade connections with refineries – biodiesel policies are still restricted to a few farmers and need improvements though.

These market innovations are not changing the technological paradigm, they are creating contitions

for family farmers to engage in the soybean production with satisfactory economic efficiency. However, pressure for increased productivity with intense use of inputs and economies of scale is present even in small farming systems. And soybean cropping is risky for small farmers in short-term because small changes in productivity and prices can lead to insecurity in families' incomes as observed in crop year 2015/2016. Also, future studies can verify the environmental, social and health impacts of soybean production to improve the debate of how sustainable soybean can be in medium and long term.

The NIE promises to analyze how small farmers can join highly verticalized markets, establishing institutional arrangements to surpass some economic barriers. Nonetheless, these institutional arrangements differ in the various regions of Brazil – e.g. the case of cooperatives in Southern states –, so it does not allow such generalization. Current policies and institutional environment must be reviewed to face the consequences of large monocultures and set soybean as a solid path for local rural development.

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