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Economic feasibility of harvesting in the sector sugar-energy: a case study

Viabilidade econômica da terceirização de colhedora no setor sucroenergético: um estudo de caso

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Abstract

Maintaining a positive investment flow over time to ensure business competitiveness is a challenge in the Brazilian sugar-energy sector, structured on a competitive price and cost basis that limits corporate margins. Notwithstanding, credit market asymmetries and low capital market liquidity constrain financing sources for long-term investments. Thus, new financial strategies are required to enable long-term investments that guarantee the longevity of companies. This study analyzes the economic viability of the outsourcing of harvesters in light of the decision to purchase the equipment, as this is a strategic management decision that involves the agricultural activity in sugarcane crop, with intensive use of machinery. For that purpose, a case study was performed in a mill located in São Paulo State, with data obtained between 2014 and 2016. Data related to equipment expenses were extracted from the mill itself, and market information was used to determine the discount rate. The method of analysis was Discounted Cash Flow, which allowed to analyze results through the Internal Rate of Return (IRR) and the Net Present Value (NPV). The strategy of outsourcing harvesters proved to be the decision that provides greater value to the company, since it does not impact the need for investments, besides allowing the tax deductibility of expenses with the outsourced service. The incremental NPV of the outsourcing decision was R$ 396,000/machine and the incremental IRR was negative, signaling that for any discount rate, the decision to outsource is economically superior to the acquisition of harvesters.

Additional Keywords: mechanization; *Saccharum officinarum;* sugar-alcohol mills; value generation.

Resumo

Manter um fluxo positivo de investimento no curso do tempo para garantir a competitividade empresarial é um desafio no setor sucroenergético brasileiro, estruturado sob bases competitivas de preço e custos que limitam as margens empresariais. Não obstante, as assimetrias do mercado de crédito e a baixa liquidez do mercado de capitais restringem as fontes de financiamento para investimentos de longo prazo. Assim, novas estratégias financeiras são demandadas para viabilizar os investimentos de longo prazo que garantem a longevidade das empresas. Este estudo analisa a viabilidade econômica da estratégia de terceirização de colhedoras diante da decisão de aquisição destes equipamentos, pois esta é uma decisão empresarial estratégica que envolve a atividade agrícola da cultura da cana mais intensiva em máquinas. Para tanto, foi utilizado um estudo de caso em uma usina localizada no Estado de São Paulo, com dados entre os anos de 2014 e 2016. Os dados relativos aos gastos com os equipamentos foram extraídos da própria usina, e as informações de mercado foram utilizadas para determinar a taxa de desconto. O método de análise foi o Fluxo de Caixa Descontado, que permitiu analisar os resultados por meio da Taxa Interna de Retorno (TIR) e do Valor Presente Líquido (VPL). A estratégia de terceirização das colhedoras mostrou ser a decisão que proporciona maior valor à empresa, pois além de não impactar a necessidade de investimentos, permite a dedutibilidade fiscal das despesas com o serviço terceirizado. O VPL incremental da decisão de terceirizar foi de R$ 396000/máquina, e a TIR incremental foi negativa, sinalizando que, para qualquer taxa de desconto, a decisão de terceirizar é economicamente superior à aquisição das colhedoras.

Palavras-chave adicionais: geração de valor; mecanização; *Saccharum officinarum;* usinas sucroalcooleiras.

Introduction

The Brazilian sugar-energy sector has been considered strategic to the country's energy matrix because of its technological development that allows not only the production of sugar, but of ethanol (biofuel) and electricity (bioenergy) in a clean and renewable way. This meets one of the goals (Clean and Affordable Energy) of the Sustainable Development of the United Nations (UN), in addition to contributing to the reduction of greenhouse gas emissions, food security, sustainable consumption and production (Sehnem et al., 2013; Santos et al., 2015; Moreira et al., 2016; Pinsky & Kruglianskas, 2017).

Brazil is the world's leading producer and exporter of sugar and alcohol, with 39 million tons of sugar produced in 2017 (increase of 18%), along with 27 billion liters of alcohol (CONAB, 2017). The high competitiveness of the country is due to the lower production cost among the main competitors in the international market, besides leading the knowledge of sugarcane biotechnology and technologies applied to machines and implements used in agriculture (Mashoko et al., 2013; Moreira et al., 2016).

São Paulo State stands out as the largest Brazilian producer and, together with the states of Minas Gerais and Paraná, presents a certain balance in the destination of sugarcane: around 40% for ethanol and 60% for sugar (CONAB, 2017). Moreover, São Paulo State concentrates 41.8% of the total sugar and alcohol production units in Brazil. In 2015, the sugarcane, ethanol and sugar production in this state accounted for 55.2%, 48.5% and 63.3% of the total produced in the country, respectively (MAPA, 2016).

Given this scenario, to meet the high volume of raw material from the farm to the mill, it is necessary to allocate lots of people, equipment and services. This requires an efficient management of resources to make each stage of the process competitive, both regarding the cost and the optimization of the flow of raw material to the mills.

Among the different agricultural activities, the operation comprising cutting, loading and transportation (CLT) is the most intensive in machinery and equipment, especially by environmental regulations that require a cleaner and more dignified production process for workers (Santos et al., 2015; Pinsky & Kruglianskas, 2017). For that purpose, different machines are used: harvesters, tractors and diverse trucks, with specific designations such as transshipment, road trains, water trucks, workshop trucks and others, in addition to support vehicles (Françoso et al., 2017).

This set of machinery further extends the complexity of the synchronization of all necessary processes in the activities during harvest, which is why the mechanization of the CLT is indicated as an innovative process of the sugarcane activity. It provides the intensification of agroindustrial production, while reducing production costs and the dependence on nonspecialized labor (Scheidl & Simon, 2012; Aroni, 2013; Ramos et al., 2015). It is also worth noting that CLT-related costs can reach 40% of the agricultural costs per hectare per year (Françoso et al., 2017).

On the other hand, the need for intensive use of these machines and equipment requires from the companies involved large investments in the short term; therefore, the capital recovery term is extended (Farinelli & Santos, 2017). This situation, when combined with the asymmetric reality of the credit market in Brazil, the difficulties in operating in the capital market and the limited margins of the sector, restricts the investment capacity or increases the sector's indebtedness in a way that compromises its sustainability (Manoel et al. al., 2016; Farinelli & Santos, 2017).

Thus, new financial strategies are necessary for mills and distilleries in the sector to keep feasible the addition of technological resources necessary to the competitiveness of their operations, without compromising their financial longevity.

Outsourcing is an already consolidated business strategy that allows the company to focus its management and resources on core activities and, in effect, reduces the need for investments and the risk exposure (Brasil, 1993; Kroes & Ghosh, 2010; Scheidl & Simon, 2012; Pongpat et al., 2017). However, outsourcing results are controversial, especially for the Brazilian reality, which implies the need for studies with greater depth and breadth to assess its viability. Each context becomes a unique and specific case, whose extrapolation is limited and should be made at the limit of the differences between the scenarios analyzed (Paulillo, 1999; Moura Jr, 2017).

There are several terminologies used to denominate third party contracting: outsourcing, subcontracting, recentralization, unbundling, externalization of employment, targeting, partnership, labor placement, labor intermediation, contracting of a service or hiring of a worker through an interposed person (Scheidl & Simon, 2012; Pongpat et al., 2017).

Although the outsourcing strategy is relevant and consolidated in many sectors and countries, its use became more legally based in Brazil only in 2017. Studies in the literature on this agribusiness area discuss it mainly under two axes: governance and transaction cost theory (Bezerra et al., 2017) and cost analysis (Novais & Romero, 2009). No studies were identified that evaluate the economic potential of the outsourcing strategy in light of the decision to make investments by agribusiness companies.

Present in almost all segments of the mills, outsourcing is already a reality for several service activities, but its use in fixed assets is a paradigm for the sugar-energy sector. Therefore, the objective of this study is to analyze the economic viability of the strategy of outsourcing sugarcane harvesters in light of the decision to purchase the equipment.

Capital expenditure on harvesters, coupled with the need for maintenance, impose new demands on the capital budgeting of sugar-alcohol mills; in this sense, the strategy of outsourcing harvesters does not impact the need for investments in these assets and there is still the tax deductibility of the service. Nonetheless, the evaluation of the viability of this strategy involves its effective capacity to create value, that is, to enable the generation of added value superior to the decision to invest in harvesters (Manoel et al., 2016; Pereira & Silveira, 2016).

The sizing of the mechanization structure through technical parameters contributes to rationalization in the selection of agricultural machines and implements, avoiding oversizing and increased fixed costs of production. However, planning must take place under the support of adequate financial strategies that, in addition to making feasible the operation, also help in evaluating the value creation potential of the strategy to be used for the investment (Artuzo et al., 2015).

The results of this study can contribute to the decision-making process of more than 420 sugar mills and distilleries in Brazil's sugarcane sector and provide insights for other agribusiness chains that show intensive mechanization of agricultural activities.

In view of this context, this study analyzes the economic feasibility of the strategy of outsourcing sugarcane harvesters considering the decision to purchase the equipment, from a case study performed in a mill established in São Paulo State.

Material and methods

The present study was based on the qualitative approach, which presents as a major proposition not to previously consider hypotheses, but to be concerned with obtaining data and/or evidence that confirm or deny preliminary assumptions. This is done while maintaining the commitment to present these data in a clear way and with a methodological approach, in a continuous validation process (Silva et al., 2005; Câmara, 2013).

Field data were collected through in-depth and semistructured interviews with the employees responsible for the mechanized sugarcane harvesting area in the company surveyed. Moreover, there was an extensive consultation of secondary data that were made available by the company, such as Management Reports, Operational Data Bank, Cost Sheets, Tables of Prices paid for outsourced harvesting, always in accordance with the theoretical reference for the case study (Silva et al., 2005).

Throughout the methodological process for data collection, visits were made to the company under study: a sugar and alcohol mill that has two production units in the western region of São Paulo State, in the municipalities of Brejo Alegre and Promissão.

The data collected in the qualitative research strictly followed the theoretical reference for content analysis, according to theoretical precepts recommended by the researched authors, within the following stages: Pre-analysis, through a categorization of the data obtained; Material Exploitation, for data coding; and Treatment of Results, for the inference and interpretation of the collected data (Bardin, 2011; Câmara, 2013).

For this stage of the work, the research was developed next to the already specified mill, which crushes approximately 30,000 tons of sugarcane daily, with a target of 6,000,000 tons of milling material per harvest in its two units. The mill surveyed has approximately 93,000 hectares of sugarcane, which is owned by first and third parties. Furthermore, it has 700 equipment items, including tractors, trucks, harvesters and other implements, in addition to approximately 1,300 people involved in the harvesting sectors of the two units.

It should be noted that, despite all the exposed infrastructure, the research is focused only on harvesters of one of the units, being the motto of the present study hereafter.

After obtaining the basic data needed to start the analysis, the following variables were taken:

i. The averages of harvest months are used to define the total annual value;
ii. The case study is based on 03 (three) equipment items (average per harvest front);
iii. The initial investment for each harvester is R$ 1,100,000.00;
iv. Annual revenues are considered according to the production capacity of the equipment in the topography and conditions based on the historical averages of the analyzed company;
v. Maintenance costs have annual increases also based on the average of the analyzed equipment of the same company;
vi. The sales residual considered is proportional to 20% of the total value of the initial investment;
vii. An attractiveness rate of 10% per year is considered, once the company would have available resources, with the option to apply in the financial market;
viii. The average lease value is R$ 20,049.00 per equipment, for 9 months, according to the data survey provided by the company.

The relevance of the economic-financial analysis of investment is justified as to the verification of whether the benefits generated by the investment compensate the expenses incurred. The feasibility analysis needs to be close to the reality, being indispensable to know the indicators, which are elements that integrate the cash flow, and how to interpret them, defining decision criteria aligned with the business strategy (Assaf Neto, 2012). Among these indicators, we can highlight the Net Present Value, the Internal Rate of Return and the cost-benefit ratio (Curran et al., 2017; Farinelli & Santos, 2017).

Investment analysis techniques are used by companies to select projects that can maximize the wealth of their owners and, consequently, generate aggregate economic value. Thus, for any of the investment analysis techniques, a basic cash flow should be prepared, in which basic components such as initial investment, cash inflows and residual cash flow are highlighted (Gitman, 2010; Assaf Neto, 2012; Costa et al., 2013).

Assaf Neto (2012) defines the period for capital recovery, also called payback period, as a generalized method in which the time necessary for the initial investment to be recovered in cash inflows is determined, defining the return on investment with a rapid measurement of the project risk.

In the conception of Gitman (2010) and Assaf Neto (2012), the decision to accept or reject the project is based on the capital recovery period, which should be less than a maximum acceptable period. If the period is longer, the project is rejected, because the greater the proximity of investment recovery, the lower the risks. This technique represents a measure of risk used by many companies as a basic decision criterion or as a complement to more sophisticated analysis techniques.

According to the authors, in contrast, the main deficiency of this technique lies in the inability to specify the remuneration of capital throughout the project, since it only measures the time in which the project reaches its break-even point, thus not considering cash flows that occur after the capital recovery. Given that gains above investments are basic assumptions for project approval, as a measure of risk, companies predefine the acceptable time to recover the invested capital (Gitman, 2010; Assaf Neto, 2012; Costa et al., 2013).

Gitman (2010) and Braga (2011) discuss the Net Present Value (NPV) by highlighting it as a rather sophisticated technique, since it considers money over time in a way that conditions future cash flows to a discount rate. This rate is also called opportunity cost, capital cost, opportunity rate, and represents the minimum rate that must be obtained by a project to maintain its market value unchanged.

Braga (2011) states that NPV is obtained by the difference between the present value of net cash benefits, forecasted for each period of the project, and the present value of the investment, using a financial discount rate. Thus, the decision criterion in the analysis of investments by the NPV technique has the simple verification of NPV as a process of acceptance or rejection. If it is greater than zero, that is, if future cash balances, discounted in the opportunity rate, are greater than the investment at zero date (present value), the project will be accepted. On the other hand, if the NPV is less than zero, or the discounted future cash balances are less than the monetary value of the investment, the project will be rejected. The formulation for the NPV calculation, according to Gitman (2010), can be expressed according to Equation 1:

$$\text{NPV} = \sum_{t=1}^{t} \frac{\text{FCF}_j}{(1+i)^n} - I_0 \qquad (1)$$

Wherein: NPV = Net Present Value; FCF = Free Cash Flow (difference between inflows and outflows); n = number of flows; i = discount rate; t = period of analysis (j= 1, 2, 3...); I = Investment.

Gitman (2010) notes that the Internal Rate of Return (IRR) is one of the most sophisticated ways of evaluating capital investment proposals, representing the discount rate that equals future cash inflows and outflows, that is, the rate that produces an NPV equal to zero. The decision-making criterion of the IRR is similar to that of the NPV, where a project is accepted or rejected if the IRR is greater than the cost of capital. If it is smaller, it is rejected. This rate synthesizes information from a project into a single rate and gives people a simple way to discuss and decide on projects. It is added to the context that, since the IRR is calculated by obtaining the rate for which the NPV is null and as no reference is made to the discount rate, in decision making, the discount rate or attractiveness rate should be known to be compared with the IRR that was calculated. The formulation for the calculation of IRR, according to the author, can be represented in Equation 2:

$$0 = \sum_{t=0}^{n} \frac{\text{FCF}_j}{(1+IRR)^n} \qquad (2)$$

Results and discussion

Table 1 shows the number of people involved in the harvesting process, considering a "Work Front". Work front is a common terminology in the industry to designate a work team that performs a task with all the necessary resources.

In CLT activities, the profile of the work fronts varies according to factors associated with sugarcane variety, soil and land characteristics, carriers, spacing between planting rows, and the availability of resources for the activity itself.

From the previous table, the cost with approximate salary is projected according to average monthly payment functions and values (Table 2), monthly maintenance costs based on historical averages during harvest, for harvesters (Table 3), and a monthly comparison of the average cost of diesel oil per equipment during harvest, discarding the industry's downtime (Table 4).

From the variables shown, a spreadsheet was used with tabulated data from the information collected at the mill investigated, referring to the harvests of 2015/2014 and 2016/2015. The average results are shown in Table 5. Table 6 shows the results of the cash flow of the mill, considering the costs and investment for a proper structure for harvesting.

Considering the strategy of outsourcing the CLT, the company would not invest in equipment and, in this sense, the entire structure dedicated to the equipment destined to CLT would not be necessary. On the other hand, it would incur the cost of the third service regarding CLT. Based on data collected from the mill and suppliers of the CLT service, it was found that the price of the service for the period studied was R$ 10.00/t. Considering the sugarcane cycle of the mill as 05 (five) years, the flow of payments to the outsourced company was projected in Table 7.

The flow of expenses related to outsourcing is higher than the impact on the cash flow of an own fleet. However, the outsourcing strategy does not require the company to invest R$ 3.3 million in machinery and equipment. Nevertheless, it is important to highlight the effect of tax deductibility on both cash flows. As outsourced payment flow is higher at the beginning, there is greater tax deductibility, which decreases the absolute difference to the expenses pointed out with an own fleet.

Table 1 – List of professionals involved in harvesting activities

Unit	Work Front	Harvester Operator	Transshipment Driver	Front Leaders	Fireman-driver	Mechanics	Couplers	Senior Leader	Supervisors	Field Driver	Logistics Operator	Slave Driver	Traffic Control	Flatbed truck driver	Manager	Fireman-driver	Fireman	Doblo Driver	Oil Tanker	Shovel Operator	Driver	Fleet Inspector	Total
Own	F11	12	18	3	3	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
	F12	12	18	3	3	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
	F13	12	18	3	3	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
	F14	12	18	3	3	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
	Transport	-	-	3	-	-	15	1	-	75	-	12	-	-	-	-	-	15	-	-	-	1	122
	Logistics	-	-	-	-	-	-	1	-	-	-	-	-	15	-	-	-	3	-	-	-	-	19
	Burning	-	-	3	-	-	-		-	-	-	-	-	-	-	15	15	-	-	-	-	-	33
	Support	-	-	-	-	-	-	6	3	-	1	-	-	-	1	-	-	-	-	-	-	1	12
	Road	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	4	6	-	20
	Farm Fence	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	5
	Traffic	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	6
	Mech. Eng.	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12
	Road Driver	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Total		48	72	22	12	15	51	8	3	75	1	12	6	15	1	15	19	18	7	4	6	2	412

Table 2 – Total direct labor and social costs with the CLT operation.

Function	Total People	Value per Hour (R$)	Monthly Value (R$)	Prize (R$)	Total (R$)	Average Charges	Cost for the Mill (R$)	Total (R$)
Harvester Op.	48	7.57	1,665.40	908.40	2,573.80	34%	3,448.89	165,546.82
Mechan. Eng.	12	12.73	2,800.6	700.15	3,500.75	34%	4,691.01	56,292.06
Road Driver	3	8.67	1,907.4	476.85	2,384.25	34%	3,194.90	9,584.69
								231,423.56
Monthly average per work front (04 fronts)								57,855.89

Table 3 – Total monthly maintenance costs of harvesters.

Description	Total cost (R$)
Average cost of maintenance	36,494.21
Minimum	1.00
Maximum	160,156.00
Standard deviation	33,011.20

Table 4 – Average cost of diesel oil per harvester.

Fuel Consumption	
Hours	13
Liters per hour	40
Liters per day	520
Value per day (R$)	1,216.80
Value per 25 days (R$)	30,420.00
Value per 3 harvesters (R$)	91,260.00
Value per 9 months (R$)	821,340.00

Table 5 – Data for Investment Analysis - Mill

Data	Qt.	Value (R$)	Total (R$)	Notes
Initial investment	3	1,100,000.00	3,300,000.00	-
Employess	3	57,855.89	520,703.01	Harvest
Maintenance/Lubricants	3	10,494.21	283,343.67	Harvest
Increased maintenance	3	9,000.00	27,000.00	Incr. / Harvest
Fuel	3	20,857.01	821,340.00	Harvest
Rent	3	20,049.00	541,323.00	Harvest
Residual value of equipment	3	220,000.00	435,600.00	20% Initial investment and net taxes
Machine life	-	-	-	05 harvests

Table 6 – Cash flow of the Mill for a CLT structure

Cost Item	Harvest 00	Harvest 01	Harvest 02	Harvest 03	Harvest 04	Harvest 05
Residual value of equipment	-	-	-	-	-	435,600.00
Rent	-	541,323.00	541,323.00	541,323.00	541,323.00	541,323.00
Employees	-	(520,703.01)	(520,703.01)	(520,703.01)	(520,703.01)	(520,703.01)
Maintenance / Lubricants	-	(283,343.67)	(526,343.67)	(769,343.67)	(1,012,343.7)	(1,255,343.6)
Fuel	-	(821,340.00)	(821,340.00)	(821,340.00)	(821,340.00)	(821,340.00)
Tax benefit	-	480,781.65	563,401.65	646,021.65	728,641.65	811,261.65
Initial investment	(3,300,000.0)	-	-	-	-	-
Cash flow balance	(3,300,000.0)	(603,282.03)	(763,662.03)	(924,042.03)	(1,084,422.0)	(809,202.03)

Table 7: Cash flow of the Mill with CLT's third party contracting (values in R$)

Item	Harvest 0	Harvest 01	Harvest 02	Harvest 03	Harvest 04	Harvest 05
Outsourced service payment	0	(2,700,000.00)	(2,362,500.00)	(2,025,000.00)	(1,687,500.00)	(1,350,000.00)
Tax benefits of outsourcing	0	918,000.00	803,250.00	688,500.00	573,750.00	459,000.00
Net disbursement of outsourcing	0	(1,782,000.00)	(1,559,250.00)	(1,336,500.00)	(1,113,750.00)	(891,000.00)

The comparison of Tables 6 and 7 requires an economic analysis that goes beyond the direct evaluation between the values resulting from the zero date to the fifth harvest, since one must consider the value of money over time. In this sense, Table 8 shows the incremental cash flow, with the respective values of the strategy of using outsourcing compared to an own fleet.

Table 8: Incremental cash flow (CF) between expenses, in "reais" (R$), with outsourced and own CLT (cutting, loading and transportation)

CF Outsourced CLT	-	(1,782,000)	(1,559,250)	(1,336,500)	(1,113,750)	(891,000)
(-) CF Own CLT	(3,300,000)	(603,282)	(763,662)	(924,042)	(1,084,422)	(809,202)
Incremental CF	3,300,000	(1,178,718)	(795,588)	(412,458)	(29,328)	(81,798)
Discounted cash flow	3,300,000	(1,071,562)	(657,511)	(309,886)	(20,031)	(50,790)
NPV (10% p.a.)	1,190,220	IRR	(13.71%)			

NPV - Net Present Value; IRR - Internal Rate of Return.

The results of this study demonstrate that the outsourcing strategy is the most competitive for the researched case, since it can create additional value in light of the decision of own investment in the equipment. The proposed valuation was based on discounted cash flow rather than a simplified analysis of costs and expenses.

Notwithstanding, from the results obtained in the investment analysis of the harvesters, it is pointed out that it is not feasible for the company to purchase the equipment. According to Table 8 (Incremental Cash Flow), the Net Present Value for an attractiveness rate which the company considers to be 10% per annum was R$ 1,190,220. In other words, the difference, in present value, of the additional expenses with outsourcing compared to an own structure is R$ 2,109,779, which is less than the R$ 3.3 million required for the investment.

It should be noted that the IRR of the project is negative in 13.71%, that is, for the structure of expenses presented between the two flows in any positive discount rate scenario, the strategy for outsourcing will be the best decision. Hence, this study demonstrates the importance of outsourcing capital-intensive activities in the sugar-energy sector, further revealing opportunities for new businesses in this productive chain.

However, there are many hindrances that directly affect the results presented. In this way, it should be pointed out that these results can consider constant production values during subsequent years, whose reality can vary drastically according to the maintenance performed, the quality of the operation, the availability of repair parts, the topography of most areas of action, and the climatic adversities of recent years.

Study limitations include being a single case study and the impossibility of replicating such results in other contexts without considering the differences in specificities that result in heterogeneous case flows and discount rates. Moreover, it was not possible in this study to analyze possible additional costs of managing outsourced contracts.

Conclusions

The verified data show a reality not yet fully explored by the sugar-energy market, especially with regard to mills and distilleries, as to the possibility of outsourcing the sugarcane harvesting activity. New regulations and environmental demands required investments in harvesters and implements that automated the cutting, harvesting and loading process; despite the productivity of this activity, the sector needed to direct high capital resources to these equipment items. Nonetheless, credit and capital constraints in the country, coupled with restricted profit margins, have motivated mills and distilleries to find alternatives to enable their operations with lower capital expenditures.

Despite the study limitations, it is understood that the outsourcing strategy for machinery and equipment in this sector may constitute a new business in this chain, as well as in other capital intensive industries (mining, petrochemical, air transport and road transport). The development of this business can also be beneficial to the industry by reducing outsourced CLT costs, increasing service levels, creating resale market, and reducing chain risk.

Thus, new research on other economic groups and even on other large agricultural activities such as soybean and maize cropping can be used to analyze new business alternatives with the creation of independent services in the management of agricultural machinery and equipment.

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