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# Determinants of Outsourcing Contracts in Agricultural Mechanization Services: the Brazilian Coffee Agribusiness Case

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## ABSTRACT

The Brazilian Coffee Agribusiness system has been modified over the last years. An evidence is the outsourcing contracts in agricultural mechanization of harvesting services. Brazilian coffee growers have replaced their own machineries for specialized services firms. The Coase (1937)'s make or buy paradigm sheds light the decision of farmers of the coffee chain with the investment lens. The investigation analyzes the determinants of outsourcing contracts in the transaction of harvesting mechanization in the agribusiness system of coffee in Brazil based on a quantitative approach through a probit regression with 105 Brazilian coffee growers' interviews. The results validated the path dependence aspect and the hypothesis of the asset specificity and uncertainty of the efficient alignment argument of the Transaction Cost Economics, pointing out the high level of education of the farmer and the adoption of contracts as a way of coordinating other transactions as determinants of the outsourcing contracts of the transaction of harvesting mechanization. The study brought a change in coffee grower's profile to a modern pattern of decision-making with three different institutional arrangements for the transaction of harvesting mechanization: total vertical integration, tapped vertical integration and outsourcing contracts or only outsourcing contracts.

**Keywords:** *outsourcing contracts; governance; harvesting mechanization; coffee crop; Brazil.*

## 1. Introduction

The Brazilian Coffee Agribusiness system has been modified over the last years. Economic organization and strategies are not the same due to the modernization of production processes in the agriculture. An evidence is the outsourcing contracts of agricultural mechanization of harvesting services (Yang, Huang, Zhang, Reardon, 2013; Houssou, Diao, Cossar, Kolavalli, & Jimah, Aboagy, 2013). The same phenomenon is present in the coffee agribusiness system of Brazil<sup>1</sup>; Brazilian coffee growers have replaced their own machineries for specialized services firms. The Coase (1937)'s make or buy paradigm sheds light the decision of farmers of the coffee chain with the investment lens. The decision behind of the transaction between machinery industry and coffee growers involves direct impacts on the farmer's economic performance such as coffee quality. Therefore the present paper focuses on the following question: what are

<sup>1</sup> Brazil has two different species of coffee, but the present study analyses only the *Coffea arabica* due to economic relevance. This specie was responsible for about 30 million of bags of coffee and 4.7 billions of reais in 2016 while the *Coffea canephora* represented 580 thousands of bags and 67 millions of reais (CECAFE, 2016).

the determinants of outsourcing contracts of harvesting mechanization services in the Brazilian coffee agribusiness system?

The choice of coffee production as a research agenda lies in the economic relevance of the activity in Brazil. The country is the world leader in the production and export of the grain. Brazilian production is responsible for about 50 million bags of coffee per year, representing about the twice of production of the second largest producer, Vietnam. Moreover, the production generated about 4.7 billion reais of exportations in 2016 (Conselho dos Exportadores de Café do Brasil [CECAFE], 2016).

Regarding the decision of the literature, two arguments are presented. First, there is the emergence of a new institutional arrangement that focuses attention on the paradigm of make or buy of the modern agricultural firm, given the limitation of the scale economies as the exclusive factor in the decision of this transaction. The research is based on the theoretical framework of Transaction Cost Economics (TCE) to analyze the outsourcing contracts of harvesting mechanization with the efficient alignment hypothesis proposed by Williamson (1985), contributing to the literature of agricultural contracts, which is limited (Allen & Lueck, 2002).

Secondly, the focus on the transaction of harvesting mechanization is because the activity is directly related with the coffee quality and with the economic performance of the farmer (Silva, Salvador, Padua & Queiroz, 2001). Brazilian farmers are using different institutional arrangements to coordinate the transaction of harvesting mechanization. According to the Instituto Brasileiro de Geografia e Estatística (IBGE, 2006), about 485 thousand rural farms are using outsourcing contracts in harvesting mechanization services, representing 27,1% of all coordination mechanism. On the other hand, the mechanization by own machineries is used by approximately 1.5 million rural farms, representing 52.3% of the total<sup>2</sup>.

The transaction between machinery industry and coffee growers has been coordinated by outsourcing contracts recently (Ministério Público do Trabalho [MPT], 2005), as well as the cases in soybean and sugarcane crops (Mascarin, 2014). This institutional arrangement excludes the need for investments to purchase own machineries and brings other relevant factors to the arena. However, these factors that affect the producers' choice are poorly understood, which raises other contribution of the paper in the aim of analyzing the determinants of the choice of outsourcing contracts in the transaction of harvesting mechanization of the Brazilian coffee agribusiness system.

The paper has four sections, besides this introduction. Section 2 presents the literature of agricultural mechanization in the international and Brazilian scenarios focusing in the transaction of harvesting mechanization in the coffee production with the Transaction Costs Economics approach. Section 3 outlines methodological procedures. Section 4 brings the results. Section 5 shows the final considerations and limitations.

## **2. Agricultural mechanization literature**

### **2.1 Harvesting mechanization around the world**

The relevance of agricultural mechanization might be related with the cost in the production factor of "labor". According to Calvin and Martin (2012), labor cost represents 42% of the cost structure of a farm, as the case of the harvest of fruits and vegetables produced in the United States.

Takeshima, Nin-Pratt & Diao (2013) argues that mechanization is critical when high labor costs have negative effects on agricultural productivity and the welfare of farmer. Although the international literature presents some obstacles to adoption of harvesting mechanization. There are cases that the vertical integration faces constraints such as the size of the farm (Igata, Hendriksen & Heijamn, 2008; Tiepo, 2015) and government subsidy credit (Hossou et al., 2013).

Otherwise the use of the vertical disintegration is emerging to overcome those difficulties. The externalization of the harvesting mechanization is occurring in developed (Navarro, 2002, Igata, Hendriksen & Heijamn, 2008, Fisher & Knutson, 2013, Takeshima, Nin-Pratt & Diao, 2013) or underdeveloped economies (Hossou et al 2013, Yang et al., 2013, Chaddad, 2014 and Tiepo, 2015).

Yang et. al. (2013) argues that the outsourcing of mechanization began due to incapacity of investments in fixed assets and the increasing in the rural worker's salary in 2004 in China. Since then some

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<sup>2</sup> IBGE (2006) does not segregate the level by farmers, it only analyzes the level by farms, which might be carry some bias because a farmer might has more than one farm. Unfortunately this segregated data about Brazil does not exist.

Chinese farmers adopted the outsourcing governance and brought the issue of the site asset specificity, because the machinery transportation in Chinese provinces might result in high costs according to the distance between the agents, and also could damage the equipment.

Hossou et. al. (2013) emphasizes the time and location as influencing factors in mechanization services in Ghana. The temporal aspect relates to the specific month to crop an agricultural product due to the influence of weather and rains. The use of machinery occurs in the months of June and July in northern Ghana, while in the south it appears from April to June and from September to October, in other words, it is possible to argue that delays in harvesting might damage the current or the next crop. The location factor is similar to China. The service providers increase their payments according to the distance.

Takeshima, Nin-Pratt and Diao (2013) argue about the location in Africa, specifically in harvesting mechanization services in Nigeria. In the South there are farmers with a large structure of investments in their own machineries. While in North the outsourcing contracts rise to complement the workforce structure of mechanization as an additional resource.

Fisher and Knutson (2013) argue that the human capital as another piece of the puzzle. Training and experience of the driver interfere in the governance decision. They demonstrate the higher the knowledge requirement the higher is the adoption of mechanization services in the harvest activity in some crops of the US agriculture.

Igata, Hendriksen and Heijamn (2008) point out that the impact variables in the decision of outsource the mechanization in the Netherlands and Japan are: farm size and investments in own machineries. Size demonstrates that small farmers are able to acquire the technology only with external services. While the ownership of own machines indicates low seeking of services through external contracts.

The Spain brings the case of the farmer's family and his traditions influencing the choice in the institutional arrangement to the mechanization transaction (Navarro, 2002). The traditionalism in agriculture production takes the closeness of the farmer's transactions interfering in the use of own machineries. The Spanish farmers have adopted the vertical integration of the transaction of mechanized harvesting over the years when they already use it as their governance mechanism in past decisions.

## **2.2 Harvesting mechanization in Brazil**

The analysis of the governance choice focused on the harvesting mechanization in agricultural literature in Brazil looks mainly on extensive crops such as forestry and soybean crop.

Canto et. al. (2006) shows that the determinants of outsourcing contracts in the forestry harvesting service are: financial incapacity to acquire machineries and equipments, lack of technical knowledge of the farmer and the work time to act exclusively in the forestry activity.

Morais Filho (2006) also analyses the Brazilian forestry sector, where some cases present low specialization as well as some service providers without basic technical knowledge.

Morais (2012) emphasizes the concerning in the delays in the activities of forestry production, especially in the harvest stage, whose allow the losses in value due to the delay of service providers. Novais and Romero (2009) also argue about the possibility of productive inefficiency due to delays in harvesting operation, in addition to pointing out that outsourcing is adopted to reduce investments in fixed assets. The last is reinforced by Zanchet (2009), who pinpoints that farmers do not use external contracts when they have their own machineries.

According to Laurenti (2004), the use of third parties in agricultural services has been increased as a consequence of the creation of the Brazilian labor bill number 4330/2004. The author claims that Brazilian rural producers are adopting external contracts in order to reduce the risks of legal conflicts of labor. Indeed the labor regulation proposed in the bill was modified in 2015 and the farmers began to have liability in cases of legal problems. That is, not only the service provider, but the farmer also became responsible for carrying out those obligations.<sup>3</sup>

It is possible to see the overlapping in the international and Brazilian scenarios. The timing aspects of the provision of the service, the need of specialized workforce, among other factors, are also relevant for the Brazilian farmers however some new points emerged such as the labor law conflicts. Therefore, based on the evidence from the different countries and agricultural crops, it is possible to observe the fit of the Transaction

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<sup>3</sup> The institutional environment regarding the outsourcing of activities is changing. Brazilian labor law has diverging in different court's decisions on this point. There are conflicts between the norms of the current law number 331 of the Superior Labor Court (TST, 2011) and the Bill 4330/2004 (Brazil, 2004). Thus, that uncertainty emerges as a relevant point to be considered in our analysis.

Cost Economics to analyze the transaction of harvesting mechanization in the Brazilian coffee chain. The next section raises the relevant points in that governance decision based on this theoretical framework.

### 2.3 Outsourcing contracts in harvesting mechanization through the TCE's lens

The harvesting mechanization services extended the coordination to the outsourcing contracts as other institutional arrangement. The change allowed the use of external contracts as a new form of coordination and, consequently, raised the conflicts in contractual relations such as hold-up problems (Klein, Crawford & Alchian, 1978, Williamson, 1985). Economic efficiency is associated with coordination issues - asset specificity and other characteristics of the transaction (uncertainty and path dependence), rising the main questioning of firm theory, the vertical integration dilemma (Coase, 1937).

Verticalization emerges to economize the risks of appropriating quasi-rents from specialized assets (Klein, Crawford & Alchian, 1978). Asset specificity is associated with specific investments that might lost value when applied in an alternative use (Williamson, 1981), its levels are idiosyncratic, intermediary level of specialization and with no specific application. The transaction of harvesting mechanization in coffee is surrounded by the specificity of assets of different natures, uncertainty and path dependence. The allocation of resources in that transaction - whether for the purchase or outsourcing contracts - is directly associated with: decisions made in the past (family and farmer's tradition), farmer's profile (location and education level), training investments and experience of the driver of the machinery, structure of the farm (size and investments in specialized assets), and the timing to an efficient harvesting.

The human capital specificity rises as the knowledge to operate the coffee harvester. For instance, driving specialization requires investments in training and accumulation of knowledge through the driver's experience to provide an efficient service. The allocation of resources for driver training or experience over time increases specialized knowledge, that is, the specificity of the transaction (Lyons, 1994; Williamson, 1985, 1996).

The site asset specificity is related to the distance between the farmer and the service provider (Caleman & Zylbersztajn, 2012; Williamson, 1985, 1996; Miele & Zylbersztajn, 2005). The transporting costs are high, so the farther the farmer, the higher are the investments to transport the harvesters. Besides that firms of harvesting mechanization services for coffee crop are concentrated in certain regions, which stresses their distance from the coffee grower as a relevant factor.

The physical asset specificity is associated with the investments in specific equipments for coffee harvesting (Joskow, 1987; Lyons, 1994; Williamson, 1985; 1996). The capital structure in harvesters characterizes the degree of specialization of the farmer.

The time asset specificity is also present in the coffee harvesting activity. The delay in carrying out this operation might cause losses to the farmer due to the quality in agricultural products. Days of delay to harvest coffee may result in a substantial loss in the quality of the grain. Thus, time specificity arises in situations of sensitivity in the delays of harvesting as the coffee crop demonstrates (Masten, 2000; Williamson, 1985, 1996).

Different types of asset specificities influence the transaction of mechanized harvesting in coffee crop. A transaction with high asset specificity, there are higher quasi-rents, which induces strict hierarchical coordination (Klein, Crawford & Alchian, 1978; Williamson, 1985, 1996), in other words, the use of own machineries in the case of coffee production. This association is present in the transaction of harvesting mechanization in the coffee crop and builds the first hypothesis:

*H<sub>1</sub>: The higher the asset specificity, the lower the adoption of outsourcing contracts as the governance form in the transaction of harvesting mechanization in the Brazilian coffee production.*

The uncertainty is exposed by the inability to predict an event, or rather, the lack of knowledge about the probability distribution function of the phenomenon (Williamson, 1985, 1996). This attribute is present in agribusiness systems through the institutional environment (Zylbersztajn, 1996).

Formal institutions are able to decrease or increase the level of uncertainty in transactions (Williamson, 1985; North, 1990), because their agents have limitations due to bounded rationality (Simon, 1955). Then the uncertainty is surrounded by the court's ability to hold, process, and analyze the information. In addition to this assumption also raises the difficulty of measurement of contracts as potential factors in the increasing of uncertainty in a given environment (Hermalin, Katz & Craswell, 2007).

Mascarin (2014) shows divergences in Brazilian labor law in the use of outsourcing contracts of agricultural equipment services. The author points out the uncertainty in that institutional environment,

because there is not a pattern of decisions regarding the prohibition or not of outsourcing contracts in harvesting mechanization services. The instability is a consequence of ongoing changes in the law that deals with the outsourcing of activities. Some court decisions are in favor of outsourcing contracts, while in others the subcontracting of mechanization services by the farmers is considered illegal and punishable.

The complexity behind a contractual analysis and the lack of standardization in decision-making in the courts brings uncertainty to the harvesting mechanization transaction in the Brazilian coffee crop. *Ceteris paribus*, the option with lower transaction costs is the less formal institutional arrangement such as market relationships (Williamson, 1996). Therefore, considering the uncertainty attribute, the vertical integration occurs in environments with high uncertainties, that is, the coffee grower is just limited in the using of outsourcing contracts when he faces a scenario this feature. Based on it, the second hypothesis is the following:

*H<sub>2</sub>: The higher the uncertainty, the lower the adoption of outsourcing contracts as the governance form in the transaction of harvesting mechanization in the Brazilian coffee production.*

The past experiences also interfere in the choice of the institutional arrangement of the transaction of harvesting mechanization in the coffee farmer. Decision-making over time builds a path dependence that limits future negotiation options due to past choices. The concept emphasizes that previous relationships might influence the future on the basis of losses in the act of breaking that path dependence. The equilibrium between the benefits of continuing to adopt the structure already used in the past and the costs of entering a new path highlights the impossibility of change (North, 1990).

Path dependence might limit the rational choices of economic agents. This attribute brings the influence between short and long term decisions. An example may be the exacerbated allocation of resources in a specialized activity, which can not be ignored due to their specific investments. However, even with such a limitation in choices, reality is based on a non-ergodic world (North, 1990), that is, the economic system is not stationary and decisions change drastically depending on the functioning of the market.

This scenario applies to the present study. Specific investments in harvesters made in the past may limit the possibility of outsourcing in the present. This limitation is the result of situations in which producers who borrowed financial resources and allocated them in specific resources, for example. This coffee grower has restrictions in decision making because he might gets debts over the years. Thus, this type of coffee grower will hardly outsource and pay for the hours of service provided, since he already has his own machinery and debts.

The application of path dependence in this transaction is assumed by the coffee grower's experience in the activity. The years in the coffee-growing activity and the knowledge transmitted by the family generations might influence the decision to use outsourcing contracts due to previous investments. The history of Brazilian coffee production shows that the transaction of harvesting mechanization has been vertically integrated since its origin (Silva et. al., 2001). The long-term contact with the activity implies in the tradition of use of own machineries. The successor of a coffee grower who already owns the equipment may be influenced to maintain this practice also. Therefore, this factor brings the verticalization in this transaction, building the third and last hypothesis:

*H<sub>3</sub>: The higher the path dependence of the coffee grower, the lower the adoption of outsourcing contracts as the governance form in the transaction of harvesting mechanization in the Brazilian coffee production.*

### **3. Methodology**

The study has an exploratory, descriptive and quantitative approach. The exploratory aspect is used as a consequence of the emerging of service providers in harvesting mechanization and the use of outsourcing contracts to coordinate that transaction by the coffee growers. The model uses primary data collected through a survey based on the Transaction Cost Economics literature.

The questionnaire was validated by two specialists in the coffee market during July and September in 2015. A pre-test was carried out with a collection of 30 observations during the International Coffee Week in September 2015, a meeting with a diversity of profiles of Brazilian coffee growers. Further 39 observations were collected by telephone to verify the behavior of the coffee growers during the interviews.

Then a final sample of 105 observations of coffee growers with mechanized harvesting (by his own structure or by outsourcing contracts) with non-probabilistic nature was built with personal interviews (55

observations) in two Brazilian conferences (FEMAGRI 2016 and SimCafé 2016) related to the object of study, and also the data collection by telephone (50 observations) used the database of associations and cooperatives of the coffee sector in Brazil. The data collection was carried out only with coffee farmers with mechanized harvest, either subcontracted or with their own machineries. The farmers interviewed are from the states of Minas Gerais and São Paulo because they are the two main regions of coffee production in Brazil and they have the variety of production structure found in other states. Thus, the questionnaires were answered by arabica coffee farmers who bring the different characteristics of high-quality coffee plantations and the mechanized harvesting processes found in the country.

The analysis assumes that economic efficiency is based on Williamson's concept of efficient alignment (Williamson, 1985, 1996) and the literature on the subcontracting of agricultural mechanization.

### 3.1 Metrics on the decision of mechanization outsourcing in coffee production

The metrics are based on the literature of outsourcing of agricultural mechanization, using the theory of Transaction Cost Economics. The structure of this section is focused on the hypotheses: asset specificity, uncertainty, path dependence and control variables. The metrics are presented in Table 1 with their theoretical variables, types, the expected signal and the reference of similar use in the literature.

**Table 1 – Model's variables.**

Variable	Hypothesis	Type	Sign	Reference
<b>Dependent</b>	1 = outsourcing contracts of harvesting mechanization services, 0 = use of own machineries and services (vertical integration)	<i>Dummy</i>	---	---
<b>Human asset specificity (H<sub>1</sub>)</b>	The higher the need for driver's experience, the higher is the using of own machineries and services. (dri_exp)	Discrete (years)	-	Lyons (1994) and Williamson (1985, 1996)
	The higher the relevance of driver's training, the higher is the using of own machineries and services. (dri_train)	Ordinal (Likert scale of 05 points)	-	Lyons (1994) and Williamson (1985, 1996)
<b>Site asset specificity (H<sub>1</sub>)</b>	The presence of services provider in the farm's region minimizes the site asset specificity and enables the outsourcing contracts of harvesting mechanization (pres_serv)	Dummy (1=presence, 0=absence)	+	Caleman and Zylbersztajn (2012), Williamson (1985, 1996) and Miele and Zylbersztajn (2005)
	The longer the distance between farmer and service provider, the higher is the site asset specificity and, consequently, the higher is the using of own machineries and service. (dist_serv)	Continuous (kilometers)	-	Caleman and Zylbersztajn (2012), Williamson (1985, 1996) and Miele and Zylbersztajn (2005)
<b>Physical asset specificity (H<sub>1</sub>)</b>	The higher the investments in specific equipments to coffee harvesting, the higher is the physical asset specificity and, consequently, the higher is the using of own machineries and services. (log_investequip)	Continuous (Natural logarithm in reais)	-	Joskow (1987), Lyons (1994) and Williamson (1985, 1996)
<b>Time asset specificity (H<sub>1</sub>)</b>	The higher the perception of value losses due to delay in harvesting, the higher is the time asset specificity and, consequently, the higher is the using of own machineries and services. (delay_harvest)	Ordinal (Likert scale of 05 points)	-	Masten (2000) and Williamson (1985, 1996)
	The existence of "Termos de Ajustamento de Conduta" in farmer's region denotes barriers and institutional uncertainty, that is, implies in the using of own machineries and service. (pres_tac)	Dummy (1=existence, 0=absence)	-	Hermalin, Katz and Craswell (2007), Mascarin (2014) and North (1990)

<b>Uncertainty (H<sub>2</sub>)</b>	The existence of labor lawsuit in farmer's farm denotes barriers and institutional uncertainty, that is, implies in the using of own machineries and services. (exist_lawsuit)	Dummy (1=existence, 0=absence)	-	Hermalin, Katz and Craswell (2007), Mascarín (2014) and North (1990),
	The contracting to other services denotes greater management ability to solve contractual conflicts, that is, implies in fewer uncertainty and the higher the use of outsourcing contracts in harvesting mechanization (other_contracts)	Dummy (1=other contracts, 0 = otherwise)	+	Hermalin, Katz and Craswell (2007)
<b>Path Dependence (H<sub>3</sub>)</b>	The higher the family tradition in coffee production implies in higher conservatism in farmer's decision, consequently, the higher the the using of own machineries and services due to path dependence (fam_tradition)	Dummy ( $\geq 3^{rd}$ family's generation =1)	-	North (1990) and Silva et. al. (2001)
	The longer the farmer's activity in coffee production implies in higher conservatism in farmer's decision, consequently, the higher the using of own machineries and services due to path dependence (farmer_experience)	Discrete (years)	-	North (1990) and Silva et. al. (2001)
<b>Control variables</b>	The higher the farmer's education level, the greater management ability to solve contractual conflicts, that is, it might change the path dependence and the higher the use of outsourcing contracts (education)	Dummy ( $\geq$ Undergraduate education level)	+	---
	Farm size could generate scale economies and minimize the costs of capital immobilization, that is, implies in the using of own machineries and services (hectares)	Discrete (hectares)	-	---
	The own workforce structure might influence in the amount of investments in fixed assets such as manual or semimechanized workforce implying in outsourcing contracts of harvesting mechanization. (workforce_structure)	Ordinal (Likert scale of 03 points)	+	---
	The farmer's ability to produce high-quality coffee grains presents greater caution in harvesting activity, that is, the higher the use of own machineries and services (perc_gourmet)	Continuous (% of premium coffee production)	-	---

Source: Author.

Human capital asset specificity has two metrics: the need for driver's experience and the relevance of driver's training. The first observes the need in years of experience in driving harvesting machineries for coffee crop. The second is a scale of the relevance of training of the driver. Both metrics lay their reference on Lyons (1994) Williamson (1985, 1996). In harvesting mechanization it is possible to analyze the specialization of the driver to maintain the optimum productive level. If the need of knowledge is higher, even experience over the years or technical training, the higher is the use of vertical integration to guarantee this accumulation of experiences over time, that is, the farmer does not have control to guarantee that the employee do not be fired in a private enterprise, which causes the losses in the accumulated knowledge of the human capital<sup>4</sup>.

<sup>4</sup> It is reasonable to expect and opposite results, but in this case there is a issue based on the efficiency of the service at a whole, for example, the quality of the harvesting process and the knowledge about the crop – which implies in caution in damages in the coffee trees and in the machineries.



Site asset specificity is associated with the location of the harvesting mechanization service provider. The first metric is a dummy variable that measure the existence or not of the service provider in the farmer's region. The second measures the distance in kilometers between the service provider and the farmer. The reference lies on Caleman and Zylbersztajn (2012), Miele and Zylbersztajn (2005 and Williamson (1985, 1996). The first two studies presents the distance between the agents involved in the transaction as an indicator to measure the investments of transportations as well as the site asset specificity involved.

Physical asset specificity is associated with the investments in specific equipments for coffee harvesting. The metric is the natural logarithm of the investment (in reais) in own machineries, using the references on Joskow (1987), Lyons (1994) and Williamson (1985, 1996)'s works. The authors pointed out that the investments in specialized fixed assets denote specificity.

Time asset specificity is analyzed by the possibility of losses due to delays in the harvesting process. The measurement is a five-point Likert-scale with increasing order in the perception of loss of the producer if there is a delay in the harvesting activity. The decision to adopt a scale is interconnected the ability of this type of variable to capture the interviewee's perception, because a more reliable variable, such as the number of days for the loss of value is difficult to be measured by the coffee grower himself. The reference is Masten (2000) and Williamson (1985, 1996). The first author affirms that agricultural products have time asset specificity because they are perishable.

Uncertainty is analyzed as the difficulty of the institutional environment in interpreting complex forms of governance, using the references of Hermalin, Katz and Craswell (2007), Mascarini (2014) and North (1990). The metric observes the uncertainty in labor lawsuits and the coffee grower's competence to manage contractual conflicts. In the region where a coffee grower has faced a judicial process related to labor law, it is expected to observe the vertical integration of the harvesting mechanization transaction, because the agent tries to avoid other lawsuits called "Termos de Ajustamento de Conduta"<sup>5</sup>. The metric of the existence of other contracts indicates the farmer's capability to manage contractual problems with service providers and with the courts. It is expected that: a) the indicators of the existence of Terms of Adjustment of Conduct and the existence of a labor judicial problem imply in the use of the own machineries and serves; and b) the use of contracting for other services implies in the outsourcing of harvesting mechanization services.

Path dependence is measured using the farmer's family tradition and the time of experience in the activity of the farmer. Tradition is measured by a family's 3rd generation dummy metric in coffee production. The experience time is measured by the years of experience. The long period of coffee production limits the decision making possibilities. Past experiences build another path that may become more costly if you make a change in the pattern you have previously adopted. These aspects highlight the orientation towards vertical integration and it shows a limitation of change in the choices made in the past by the agent, that is, conservatism in the agricultural sector implies the closeness between the farmers and their transactions of fixed assets due to investments made in past decisions. The references are North (1990) and Silva et. al. (2001)

The model also adopts control variables that solve possible interferences. The expectation of the educational level is the results favoring the outsourcing. The indicator aims to capture the change of tradition in the farmer's decision based on the path dependence due to the increasing in his technical knowledge in the management of his assets. Even though it is not a specific domain, education in general could increase their specialized capabilities such as the management of coffee grower transactions. Therefore the higher the educational level, the higher the use of outsourcing of harvesting mechanization services. The metric is a dummy variable that verifies the presence of the level of education equal or greater than the undergraduate level.<sup>6</sup>

The number of hectares of coffee crop is used to analyze scale economies. Larger farms have greater capability to invest in fixed assets. Those coffee growers tend to use their own machinery because of the dilution of the fixed costs that the size of their crop provides. Thus the higher the hectares in coffee crop, the higher the use of own machineries and service.

The own workforce structure influences positively the use of outsourcing of harvesting mechanization services. The metric is a three-points Likert scale with decreasing levels of mechanization using,

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<sup>5</sup> Termos de Ajustamento de Contuda is a document ordering changes and fixing penalties after a investigation that found irregular conditions of production in Brazilian farms. The main issue of this kind of lawsuit is related with rural labor.

<sup>6</sup> We chose the dummy variable because the use of the years of formal education was not feasible. Analyzing the answers of the years of study and the level of education, it was noticed that the respondents contradicted the pattern of years of education found in the Brazilian educational system. In this way, the continuous variable could bring spurious results.

that is, it originates from a mechanized structure to semi-mechanized to the manual level. The adoption of manual workforce will make the use of outsourcing of agricultural mechanization services cheaper than a mechanized one, in other words, this metric also captures the structure of investments in fixed assets.

The control variable of the percentage of gourmet coffee production analyzes the influence of an upstream transaction in a downstream transaction. The ability to increase quality in the coffee carries the portrait of a producer with a greater knowledge of coffee production, as well as a competence in the management of the technical attributes of the crop and more caution in the harvesting activity (e.g. to regulate and to use the machinery to catch matures and high-quality fruits). The metric brings the profile of a high-quality coffee grower implying in the use of own machineries and service.

### 3.2 Econometric model

It was used a probit regression which its theoretical presentation is shown in Equation 1 based on Green (2003). Probit regression estimates the likelihood  $P(y = 1 | x) = \Phi(x' \beta)$ , where  $\Phi$  represents the cumulative normal density function.

**Equation 1.** Probit regression

$$y_{it}^* = x_{it}' \beta + \varepsilon_{it}$$

Where,

$$y_{it} = 1, \text{ if } y_{it}^* \geq 0$$

$$y_{it} = 0, \text{ if } y_{it}^* < 0$$

The econometric model (Equation 2) lies in the background of its theoretical model (Equation 1) and also it uses the metrics presented in the last section (Table 1). The quantitative results were obtained from the STATA 12 software.

**Equação 2.** Probit regression with TCE variables

$$P(\text{mechanization}=1|x) = \Phi(\beta_0 + \beta_1 X \text{dri\_exp} + \beta_2 X \text{dri\_train} + \beta_3 X \text{pres\_serv} + \beta_4 X \text{dist\_serv} + \beta_5 X \text{log\_investequip} + \beta_6 X \text{delay\_harvest} + \beta_7 X \text{pres\_tac} + \beta_8 X \text{exist\_lawsuit} + \beta_9 X \text{other\_contracts} + \beta_{10} X \text{fam\_tradition} + \beta_{11} X \text{farmer\_experience} + \beta_{12} X \text{education} + \beta_{13} X \text{hectares} + \beta_{14} X \text{workforce\_structure} + \beta_{15} X \text{perc\_gourmet})$$

Where,

*Mechanization* [1= outsourcing of harvesting mechanization services, 0 = using own machineries and services]

## 4. Results

The results come from a survey with 105 questionnaires with Brazilian coffee growers between December (2015) and April (2016). The paper uses some assumptions: i) the decision of “make or buy” in the transaction of harvesting mechanization in coffee crop has influence of asset specificities, uncertainty and path dependence; ii) using the specific investments lens, there is the correlation between asset specificity and vertical integration; iii) uncertainty deals with contractual problems and labor lawsuits, which implies in vertical integration; iv) path dependence is observed through in farmer’s tradition in his decision-making process, even by himself or by his family’s tradition in continue using the harvesting mechanization with own machineries and services.

Firstly a probit regression model was performed to analyze the make or buy decision in the transaction of mechanized harvesting of the Brazilian coffee farmer. It was verified that there is no evidence of multicollinearity among the independent variables and heteroscedasticity in residuals. However it was opted for the model with correction of robust errors.<sup>7</sup>

<sup>7</sup> The Variation Inflation Factor (VIF) test was performed for the multicollinearity test (FIV <10) and the Breusch-Pagan / Cook-Weiserg test for heteroscedasticity.

Table 2 shows a summary with descriptive statistics of the model's variables.

**Table 2** – Descriptive statistics of model's variable

Variable	Obs	Mean	Standard-Deviation	Min	Max
education	105	0,4285714	0,4972452	0	1
hectares	105	0, 447619	0, 4996336	0	1
workforce_structure	105	87,38095	185,1324	2	1160
perc_gourmet	105	1,790476	0,8400462	1	3
dri_exp	104	0,1480769	0,2445447	0	0,8
dri_train	105	4,742857	0,5888152	2	5
pres_serv	105	2.695238	1.754795	0	10
dist_serv	105	0,7333333	0, 4443376	0	1
log_investequip	104	50,24038	110,1837	0	600
delay_harvest	105	10,06386	5,1721	0	15,89495
pres_tac	105	3,780952	1,263245	1	5
exist_lawsuit	104	0,2211538	0, 4170337	0	1
other_contracts	103	0,1747573	0, 3816164	0	1
fam_tradition	104	0,2692308	0, 4457081	0	1
farmer_experience	105	0,3714286	0, 4855042	0	1
education	105	23,75238	12,77225	2	60

Source: Research data.

Table 2 shows the results incrementally. Model A presents the findings with control variables. In the following models (B to D) there is the aggregation of the theoretical variables of asset specificity, uncertainty and path dependence.

**Table 2** - Models of probit regression with robust errors

Dependent variable out_mec	1 = outsourcing of harvesting mechanization services, 0 = using own machineries and services (vertical integration)			
	<b>Probit models with robust errors</b>			
	A	B	C	D
education	0,860158*** (0,3269167)	0,7697873* (0,4295236)	1, 361012*** (0,4500213)	1,877423 **** (0,5295506)
hectares	-0,0031283*** (0,0011108)	-0,004091*** (0,0012699)	-0,0049898**** (0,001371)	-0,0053918**** (0,0014967)
workforce_structure	-0,9530112**** (0,1822731)	-0,7929665**** (0,284833)	-1,02925*** (0,3405358)	- 1,151986*** (0,4311868)
perc_gourmet	-0,4115334 <sup>NS</sup> (0,6120936)	-0,4259199 <sup>NS</sup> (0,69683)	-0,5971315 <sup>NS</sup> (0,7104125)	- 1,279375* (0,7389933)
dri_exp		0,2817679 <sup>NS</sup> (0,2893532)	0,4567159 <sup>NS</sup> (0,3210895)	0,3787929 <sup>NS</sup> (0,3222173)
dri_train		-0,5674558**** (0,1508671)	-0,6501894**** (0,1761673)	-0,8187704**** (0,2530336)
pres_serv		-0,1422537 <sup>NS</sup> (0,3737092)	-0,3218772 <sup>NS</sup> (0,472818)	-0,3534104 <sup>NS</sup> (0,5463152)
dist_serv		-0,0004335 <sup>NS</sup> (0,0013595)	-0,0003523 <sup>NS</sup> (0,0016648)	-0,001436 <sup>NS</sup> (0,0020574)
log_investequip		0,2105818*** (0,0766268)	0,2589756*** (0,0800915)	0,3351083**** (0,0914593)
delay_harvest		-0,2463278* (0,1434641)	-0,3240412** (0,1611737)	-0,3083747* (0,1867566)
pres_tac			-0,9307705** (0,4168441)	-1,330273*** (0,4977225)

exist_lawsuit			-0,1685882 <sup>NS</sup> (0,6800922)	0,5978889 <sup>NS</sup> (0,82946)
other_contracts			0,7275881 <sup>NS</sup> (0,55626)	1,057064* (0,6202775)
fam_tradition				-1,576367*** (0,4934657)
farmer_experience				-0,0157878 <sup>NS</sup> (0,0184781)
Constant	1,3736**** (0,3936778)	-0,0722283 <sup>NS</sup> (1,578245)	-0,5944175 <sup>NS</sup> (1,651)	0,1785578 <sup>NS</sup> (1,713184)
Nº observations	104	103	101	101
Log-likelihood	-51,525911	- 36,037203	- 32,27187	-27,474126
LR-chi2	33,66	32,13	37,04	34,79
Prob>chi2	0,0000	0,0004	0,0004	0,0026
Pseud-R2	0,2757	0,4894	0,5350	0,6042

NS not significant, \*p<0,1, \*\*p<0,05, \*\*\*p<0,01, \*\*\*\*p<0,001

Source: Research data

Model D was chosen. In this model, the variables tested are related to all hypotheses and to the research problem. The previous models only had the objective to show the interaction of theoretical variables. The model D presented good estimates according to its structure: i) log-likelihood of -27.40; ii) Likelihood ratio (LR) chi-square with 14 degrees of freedom equal to 34.97; (iii) probability of chi-square equal to 0.0025.

Considering the lowest level of significance, all hypotheses (H1, H2 and H3) were validated with a level of 0.1%, 1% and 1%, respectively. Within the group of each hypothesis it was possible to observe the levels of significance of 0.1%, 1% and 10% for H1; 1% and 10% for H2; 1% for H3; and 0.1%, 1% and 10% for the control variables.

It was observed that the variables with 0.1% significance (p <0.001) were: EDUCATION, HECTARES and LOG\_INVESTEQUIP. At 1% significance (p <0.01) emerged: WORKFORCE\_STRUCTURE, DRI\_EXP, PRES\_TAC and FAM\_TRADITION. At 10% significance (p <0.1) the variables PERC\_GOURMET, DELAY\_HARVEST and OTHER\_CONTRACTS were obtained. The variables that did not present significance were: DRI\_TRAIN, PRES\_SERV, DIST\_SERV, EXIST\_LAWSUIT and FARMER\_EXPERIENCE.

About Hypothesis 1 (H1) it is possible to observe that the variables DRI\_EXP (p <0.01) and DELAY\_HARVEST (p <0,1) affect negatively the outsourcing governance and tend to vertical integration as expected, that is, the higher the asset specificity involved in the transaction of mechanized harvesting, the higher is the tendency to adopt own machineries in coffee harvesting mechanization (vertical integration). The variables that represent the asset specificity in that transaction were human capital (years of experience of the driver) and time (losses due to delay in coffee harvesting).

The variable LOG\_VAL\_MAQPPROP showed opposite sign than expected, but significant. Possibly, this result is related to the fact that the interviewees considered the investments in general, not only those specific to the coffee harvester. The argument is based on the variable PERC\_GOURMET, that is, the coffee farmer who outsources may lose quality of production due to the carelessness the service providers in the harvest of good (i.e mature) coffee. Therefore farmer who uses outsourcing contracts seek another means of increasing the quality of still immature fruits, such as investments in post-harvest equipment, which can reach values as high as investments in harvesting machinery.

The result of DRI\_TRAIN was opposite to expected and not significant. It is suggested that incentives of the service provider to keep the human capital is such high as to the coffee growers' incentives. The concern with the losses caused by the inefficient operation of the machineries and the attempt to avoid damage to the crop is intertwined with the experience of the driver. The efficient operation carries better results for both - firm and farmer. The result of the DRI\_EXP variable corroborates this argument. The tacit knowledge of the driver who carries the solution of the coffee grower's desires, because the employee will be able to minimize such losses according to the greater knowledge of the coffee plantation in which he is operating (eg tree height or distance between trees).

The variables PRES\_SERV and DIST\_SERV presented the expected signal, but they were not significant. The finding suggests that both factors might not interfere in the make or buy decision of transaction of mechanized harvesting, because there is a strategy of amplification of service area of the service providers throughout the Brazilian territory. Specialized firms began to move in the coffee producing regions during the

harvest period, as well as in the case of soy and sugar cane. In this way, the transportation investments of the machines are now compensated by the volumes of operation, as the operators move towards regions with a reasonable number of farms that demand the service. Thus the revenue generated by the number of operations performed is higher than the cost of transportation, which means that the availability of the service is not influenced by the location of the coffee crop itself.

About Hypothesis 2 (H2), it is noted that the variable PRES\_TAC ( $p < 0.01$ ) negatively affects outsourcing contracts and favors vertical integration. While the variable OTHER\_CONTRACTS ( $P < 0.1$ ) directs the decision to outsourcing contract. Both results occurred as expected. The first one is that there is higher uncertainty in the regions where the Public Prosecutor's Office already banned, at least once, the outsourcing of mechanization through the TAC, which implies the vertical integration of the transaction. And the second result shows that the lower uncertainty of the competence to deal with contractual management (eg, conflict resolution, negotiability) implies in outsourcing contracts.

The variable EXIST\_LAWSUIT of H2 appeared with an opposite sign to the expected and not significant. The possible justification is given by the fact that the existence of labor problems in the coffee culture has been frequent for many years. Coffee producers are aware of the institutional environment's action on this topic. The conflicts over processes to guarantee workers' rights have started from the beginning of coffee production in Brazil. Therefore, frequent contact with labor rights issues of employees makes this uncertainty less relevant to the transaction.

About Hypothesis 3 (H3), the finding of the FAM\_TRADITION variable ( $p < 0.01$ ) confirms the family tradition as relevant. Involvement in crop production across generations carries the aspect of path dependence in decision making. This factor influences the use of the machines themselves as expected.

However, the FARMER\_EXPERIENCE variable appeared with the expected signal, but not significant. Possibly, this result means that path dependence requires a long period of time to be built, as well as it suggests that the intrinsic conservatism in the tradition in the activity can also only be constructed in the long term, because the time of an individual is not sufficient.

All control variables obtained significance in the model: EDUCATION ( $p < 0.001$ ), HECTARES ( $p < 0.001$ ), WORKFORCE\_STRUCTURE ( $p < 0.01$ ) and PERC\_GOURMET ( $p < 0.1$ ).

The variable EDUCATION showed that the increase in the level of education positively influences the outsourcing of mechanization, because the contractual management will be stronger and the capacity of the producer to deal with the arrangement is potentialized, so the tradition deriving from the path dependence might be minimized.

The variable HECTARES appeared as expected. The expectation on this metric was the negative influence in the outsourcing, because the larger the coffee crop, the higher the possibility of dilution of fixed costs of capital due to the scale of the operation. The larger coffee grower will tend to use his own machinery for the cost-benefit ratio. The need to provide a service in a coffee crop in larger areas raises the costs, as there will be a need to contract more hours of service.

The WORKFORCE\_STRUCTURE variable had its result different than expected. The scale of the variable around labor (WORKFORCE\_STRUCTURE) should positively affect outsourcing, because the structure of labor adopted in a farmer tending to manual would have to make greater investments to adopt mechanization through its own machineries. However, the result of negative correlation with outsourcing suggests that the obstacle is not a high capital investment, but rather the impossibility of mechanization, that is, the coffee grower in hilly and rugged regions is unable to adopt mechanization, because this topography might restrict the entry of large machineries, as in the case of some regions of the South of Minas Gerais that only adopt manual harvesting.

The variable PERC\_GOURMET appeared as expected. The expectation on this metric was the negative influence in the outsourcing. This result led to the fact that the coffee grower is meticulous in the harvesting process aiming to obtain better quality in his fruits, that is, he has to do the activity with caution (e.g. exact regulation in the machinery).

## 5. Final Remarks

The objective of analyzing the mechanization outsourcing of the harvest in coffee crop was reached in conjunction with the exposure of its determinants. Theoretically, it was obtained the empirical proof and validation of the hypotheses of asset specificity and uncertainty of the efficient alignment of the theory of the Transaction Costs Economics, as well as the validation of path dependence.

About business and management applications some strategic points were obtained for the coffee grower and for the firms providing the service. It was observed that the characteristics that counteracted outsourcing contracts were: the need for driver's experience, the investments in specific machineries for coffee harvesting, the producer's perception of loss of value due to delayed harvesting, existence of TAC, farmer's family tradition in coffee production, farmer size (number of hectares of coffee), capability to produce high quality coffee. While the determinants of subcontracting were: high education level and the adoption of contracts as a way of coordinating other transactions.

The findings of this study showed that the producer of this activity is able to use the harvesting mechanization through three scenarios: exclusive use by own machineries, exclusive use of outsourcing contracts or use of both - own machineries and outsourcing contracts. The decision of which scenario to adopt depends on the characteristics of each farm. It is possible to affirm that the transaction of harvesting mechanization of the coffee farmer has changed and probably continues to change constantly. The generalist view of the conservative farmer might be taken as extinct, because several agents are able to use outsourcing contracts and other coordination mechanisms offered by the sector.

The main managerial and public policy contribution is that the outsourcing of agricultural mechanization should be seen as a legal institutional arrangement, not a coordination form that aims to precarious work. Specifically, attention is drawn to political interference in outsourcing decisions, which may limit the choice of the productive agent and affect his economic performance. Thus, the efforts of political decision-makers should be directed to the normalization of monitoring mechanisms and control of the employment of the work as a whole, whether outsourced or not, because the worker will continue to work, but with a different boss.

The results can be extended to other countries and other crops with a careful generalization in order to help the agents of the institutional environment in the creation of regulations for the legislation still in closing, aiming at the reduction of potential conflicts. Indeed, the study highlights similar points able to generalize the results in the transaction of harvesting mechanization, for example, the influence of specialization of human capital in rural decisions as mentioned by Fisher and Knutson (2013) in the U.S. agriculture, the amount of investments in specialized assets in rural farms in China (Yang et. al., 2013) and Netherlands and Japan (Igata, Hendriksen & Heijamn (2008), the concerning with time in agricultural production in Ghana (Hossou et. al., 2013), the interference of the tradition on past decisions in Spain (Navarro, 2002).

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