

COORDINATION IN AGRIBUSINESS: AN EMPIRICAL ANALYSIS AMONG BRAZILIAN NATURAL RUBBER PRODUCERS AND PROCESSORS

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Abstract

The New Institutional Economics, in particular the Transaction Costs approach, has been applied to Brazilian agribusiness systems analysis. Nevertheless, there are as yet few studies concerning transactions between raw material suppliers and processors. This study tests the alignment of theoretical prediction and empirical findings on the matching of governance modes and transaction dimensions in the natural rubber cluster in the State of Sao Paulo. This cluster has more than 5,000 producers (or rubber tree farmers) and 16 rubber processors, who are an international productivity benchmark in farm rubber production per hectare and produce more than 50% of Brazilian natural rubber output. Our approach features a qualitative research survey and statistical tests using ordered logistic regressions (Ologit). In addition, we test the hypothesis that governance attributes and asset specificity are endogenously determined. The results suggest that the quantity of rubber transacted is positively correlated with highly coordinated modes of governance, and that transaction frequency is associated with relational contracts. The endogeneity hypothesis is rejected.

Key words: Natural Rubber Agribusiness System, New Institutional Economics, Modes of Governance, Transaction Costs Economics, Contracts, Asset Specificity, Informational Asymmetry, Incentives.

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1. Introduction

Despite the success of Brazilian agribusiness, reflected in its international competitiveness, the country is not self-sufficient in some significant agroindustrial products, even where the climate and soil are favorable. Natural rubber is one such case. In 2013, 236,000 tons of the product were imported, amounting to R\$ 1.4 billion (US\$ 649 million)¹. Although local production doubled between 2001 and 2013, Brazil continues to import about 2/3 of its domestic apparent demand. Natural rubber is an indispensable raw material for the manufacture of tires, which accounts for 80% of consumption in Brazil. It is also used elsewhere, such as in the footwear and in mining, steel, electronics, domestic electrical appliance, protective equipment and personal hygiene industries. Rubber is obtained from the processing of latex extracted from the rubber tree (*Hevea brasiliensis*). This tree, of Amazonian origin, has been acclimatized to the Sao Paulo plateau region, which in 2013 accounted for 54% of domestic production. In that year, the total output of the rubber plantations in Sao Paulo reached R\$ 400 million (US\$ 185 million)², and the rubber tree was 18th in the list of the highest grossing agricultural activities in the State (IAC, 2014; IEA, 2014; APABOR, 2014; ABIARB, 2014; ROSSMANN, 2013).

The Agroindustrial System (AGS) of Sao Paulo natural rubber involves around five thousand farms and sixteen processing plants (APABOR, 2014). Producers invest in planting rubber trees, a perennial crop that requires long-term commitment of the occupied land (the tree takes seven years to start producing latex, and has a lifespan of thirty years). In turn, the processing plants invest in equipment and systems dedicated to rubber processing.

Thus, the parties undertake relationship-specific investments, establishing a relationship of co-specialization. In transactions of this nature, with a high level of investment in specific assets, Transaction Cost Economics (TCE) anticipates long-term contracts or vertical integration as the dominant mode of governance (WILLIAMSON, 1979, 1985, 1991, 1996).

Preliminary data indicate that, in the transactions between farmers and processing plants, informal agreements regarding purchase and sale and use of the spot market are prevalent, contrary to the predictions of TCE. Surveys in other markets, such as the North American, show increased use of agricultural contracts in perennial crops (PERRY et al., 2004; MACDONALD et al., 2011). In Brazil, there are few systematic surveys³ on the subject. In the natural rubber agroindustrial system (AGS) of Sao Paulo, there have been reports of disruption in the supply chain, which has reached the point of crippling processing plants due to a lack of raw material (rubber coagulum) and has resulted in decapitalization and the idle capacity thereof. In addition to these coordination failures, it has been claimed that this AGS does not meet the demand of the Brazilian consumer industry.

This paper tests if the modes of governance used by producers of rubber and processors in purchase and sale transactions involving natural rubber are in line with the predictions of TCE when the dimensions of these transactions (asset specificity, frequency and uncertainty) are considered. Different reviews of the empirical studies of TCE confirm the predictive power of the theory, but reveal significant gaps to be explored. In general, the literature does not include explanations for the misalignment between the theoretical predictions and the empirical findings, lack qualitative analyses with appropriate methodology and there are

¹⁻² The average exchange rate R\$ / US\$ was 2.157 in 2013.

³ Recent studies investigate coordination through contracts in other Brazilian agroindustrial systems (Beef: CALEMAN and ZYLBERSZTAJN, 2012; Citrus fruits: MELLO and PAULLILO, 2010).

difficulties inherent to the quantitative methods applied (AUGUSTO et al., 2013; MÜLLER and AUST, 2011; MACHER and RICHMAN, 2008; WANG, 2007; DAVID and HAN, 2004; SHELANSKY and KLEIN, 1995).

This paper presents a qualitative description of the natural rubber AGS of Sao Paulo. Preparatory Semi-structured interviews with natural rubber producers and processors that were collected and enable more accurate construction of variables. These data are also used to refine the hypotheses of the subsequent quantitative test. Proxy variables are used in the dimensions of the transactions according to the traditional TCE model and also an additional variable to capture an aspect of the relationship between the parties. The various modes of governance are addressed by means of a discrete ordered variable. The qualitative stage also allows control variables to be constructed based on the socioeconomic profile of the farmers and aspects surrounding the transactions.

In the quantitative analysis, a questionnaire with closed-ended questions is used, distributed in two ways: (a) a printed questionnaire, distributed through the Sao Paulo Association of Rubber Producers and Processors (APABOR) to 1,800 rubber tree farmers of the State of Sao Paulo; (b) an online questionnaire, sent by email to a national subscription database of Lateks⁴, with 7,400 subscribers, players in the natural rubber production chain. The answers are cross-referenced and checked to avoid redundancy and the data are subjected to ordered logistic regression and econometric modeling with simultaneous equations. The results of the qualitative and quantitative stages are analyzed together.

The potential contributions are of a methodological and managerial nature. The econometric modeling seeks to isolate the effects of possible endogenization of the mode of governance and asset specificity. This precautionary test is as yet little used in TCE studies, where the use of multiple regressions or qualitative studies predominates (SYKUTA, 2005, 2010; AUGUSTO et al., 2013).

The research may provide a basis for farmers and processing plants managers to make better business and investment decisions, as well as indicate possible institutional failures that undermine efficiency and offer guidance for any sectorial policies.

Beyond this introduction, this paper contains the following sections: (2) Theory, (3) Methodology, (4) Results and Discussion, (5) Concluding remarks and (6) References.

2. Theory

2.1 Transaction dimensions and relationship-specific assets

“Transaction Cost Economics adopts a contractual approach to the study of economic organization [...] supports and develops the view that economizing is the central problem of economic organization” (WILLIAMSON, 1996, p. 54-55).

The definition of transaction is taken to be the transfer of goods or services through a technologically separable interface. If the transaction costs were negligible, the organization of the economic activity would also be irrelevant, there being no advantage to one form of organization over another. According to TCE, transaction costs are associated with the main dimensions in relation to which the transactions differ. Williamson (1979) defines these dimensions as: (a) degree of specificity of assets; (b) degree and type of uncertainty to which they are subject; (c) the frequency with which they recur.

Once the dimensions of a given transaction have been considered, which mode of governance is more economical, i.e. which one has lower transaction costs?

⁴ Lateks was a trade publication fully dedicated to natural rubber industry in Brazil.

Modes of governance vary, from market regulation, through the use of informal or formal contracts with different degrees of complexity (hybrid mode), to vertical integration, called hierarchy.

According to Williamson (1996, p. 377), asset specificity “refers to the degree to which an asset may be redirected to alternative uses and by alternative users without losing its productive value”. It is related to the sunk cost, but gains full meaning only in the context of an incomplete contract. The author outlines – albeit not exhaustively – six possible types of asset specificity in a transaction: (a) Site specificity; (b) Physical asset specificity; (c) Human-asset specificity; (d) Brand name capital; (e) Dedicated assets; (f) Temporal specificity.

For each different potential type of transaction, which would be the most efficient governance structure? Market and hierarchy are the modes of governance located at opposite ends of a continuum of multiple potential hybrid modes.

The market is defined as the space where the autonomous parties conduct the transactions (WILLIAMSON, 1996, p. 378). Governance through use of the market is accepted as the most effective way to coordinate recurring or occasional transactions of standardized goods in the absence of relationship-specific investments. These features relieve the parties of the need to provide safeguards against opportunism. Under the market mode, the supply and demand mechanism and prices govern transactions (MÉNARD, 2004, p. 159).

The mode of governance by hierarchy occurs where transactions are conducted within the same company, i.e. where the buyer and the vendor belong to a single organization. In this case, the transaction is subject to administrative controls internal to the organization (WILLIAMSON, 1996, p. 378).

Williamson (1996, p. 378) defines the hybrid mode of governance as that in which long-term contractual relations preserve the autonomy of the parties, but add specific safeguards to the transaction. Later, in a refinement of the theory, Tadelis and Williamson (2013, p.179), interpret the hybrid model as an intermediate form of organization between the market and hierarchy modes, which uses credible commitments to support transactions with average levels of asset specificity.

According to Ménard (2004), there is a wide range of possible hybrid modes located between the market and hierarchy modes. At the nearest end of market governance lies governance through trust, where reputation plays a decisive role. Next, it comes the governance through relational networks, with stronger ties and greater monitoring than under governance through trust. Something approaching the hierarchy mode is governance by leadership, where control and authority are exercised more strongly by a given focal company, which coordinates the activities of the other participants in the supply chain. This control may also be formalized, constituting formal governance, the last stage before the hierarchy mode.

In this paper, the theoretical framework used is based on Williamson (1979, 1985, 1991, 1996, 2000), Ménard (2004) and Zylbersztajn (1996, 2005, 2009). The following empirical studies are used: Saussier (2000a, 2000b), Allen and Lueck (2002), Mondelli and Zylbersztajn (2008), Mello and Paulillo (2010) and Caleman and Zylbersztajn (2012). Finally, Sykuta (2005) is taken as basis for the quantitative modelling.

3. Methodology

The aim here is to assess if there is any statistical significance among the dimensions of the transactions and modes of governance adopted, and whether this relationship is in accordance with the predictions of TCE. The level of analysis is the transaction from the standpoint of the producer. It is approached through two stages. The first step consists of qualitative research (description of the AGS and semi-structured interviews, available from

the authors in Portuguese) and the second step is an econometric test based on primary data from a survey among producers. The sampling method, the definition of hypotheses and the construction of variables are presented hereafter.

Figure 3.1 represents the main elements and transactions of the natural rubber AGS and locates the transaction relevant to this paper. The relevant transaction is T2.

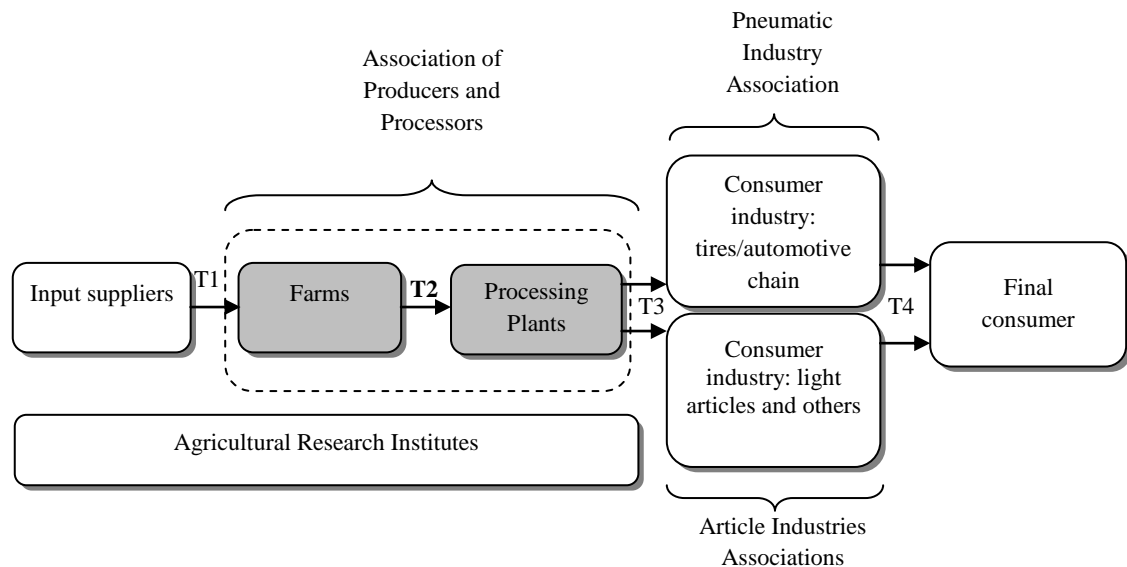


Figure 3.1 – Natural Rubber Agroindustrial System (AGS)
Source: ZYLBERSZTAJN (1996), adapted for the natural rubber AGS.

3.1 Sampling

The sampling criterion (see section 1, p. 3) is convenient for delivering the questionnaires, but this convenience has to be traded off against the fact that this result is a non-random sample.

The printed questionnaire was only distributed to producers who are members of, or who attended events organized by, APABOR. Therefore, those Sao Paulo producers who do not have any contact with APABOR did not receive the questionnaire. Although larger, only 10% of Lateks' database (740 entries) are in fact rubber producers. As a result, it probably does not correct the shortcomings of the APABOR database.

The respondent profile may have been unintentionally filtered due to the level of complexity of the questionnaire, despite the pre-testing conducted. In addition, the research may have some sample bias stemming from the voluntary answer.

3.2 Hypotheses

In the interviews with the three processing plants in the initial stage, the reports are similar in terms of their intent to enter into formal (written) agreements with the rubber producers. However, informal contracts, i.e. verbal agreements to purchase rubber, predominate in the field. This may be an evidence of the difficulties experienced by processors in establishing formal governance. There are also reports of spot sales, without any

prior agreement, according to the buyer's best offer on-site, which reflects the producers' reluctance to establish commitments, even verbal ones. Two farms surveyed have formal contracts with buyers, one directly with the processing plant and the other through a trade association. Both farms have areas of over 100 hectares with rubber trees, and are among the properties with greater investments in rubber tree plantations.

The processing plants have average idle capacity of around 50% and rubber is scarce in the field (all that is produced is bought and processed in the harvest, and there is competition between the buyers). In view of the difficulty of obtaining raw materials, the three plants surveyed have their own rubber plantations or lease them from third parties, from which they get up to 25% of the rubber they process. The management of these rubber tree plantations is problematic in terms of labor (scarce and with high turnover) and compliance with government regulations governing rural labor. The plants surveyed adopt a policy of technical assistance to many of the suppliers, and seek to strengthen their relationship with them through regular visits and business and social meetings.

The price tire manufacturers pay the processing plants for processed rubber is based on a uniform and transparent index (the APABOR index) that tracks the international price of rubber. However, there is room for negotiation between the plants and the farmers (T2). The processors pay the producers prices within a range of 65% to 75% of the APABOR index, corrected by the dry rubber content (typically 53%). According to the surveyed producers, as the volume traded, the rubber quality and the supply warranty increase, higher prices are attained. Unlike the prices paid to the plants, the prices that they actually pay to producers are not fully known by the set of agents surveyed. Producers that bargain with each shipment (usually fortnightly), tend to attain top prices, although they have to negotiate more often, therefore at a higher transaction cost.

Considering the results of the qualitative research and the TCE predicted outcomes, the decisions of the parties as to the modes of governance employed may be summarized in the following propositions⁵:

On the farmer's trade-off: a choice between risk and flexibility:

Proposition 1: The more quasi-rent⁶ available in the transaction, the more the parties intend to commit to a long-term, comprehensive contract to provide protection from opportunism, as far as possible avoiding renegotiations.

Proposition 2: The more the uncertainty in the transaction, the more the parties seek to commit to short, incomplete contracts, in order to avoid being hold-up in long-term, unfavorable contracts.

Hypotheses concerning propositions 1 and 2 have been tested relating the dimensions of the transactions to the predominant mode of governance between farmer and plant.

In order to capture the modes of governance employed, we use the discrete ordered variable *MOD_GOV*. The possible values of *MOD_GOV* are: (1) spot sale; (2) verbal agreement; (3) formal contract. A spot sale is a market mode of governance. A verbal agreement is a hybrid mode, based on trust, relational networks or leadership. A contract is a formal hybrid mode of governance (MÉNARD, 2004).

⁵ Source: SAUSSIÉ, 2000a, p. 384, modified to the current purposes.

⁶ The investment in the rubber plantation (sunk cost with a lifespan of about 30 years) and its condition of specific asset may generate a quasi-rent, in terms of the appropriation of the difference between current income and income derived from the best alternative use (KLEIN, CRAWFORD and ALCHIAN, 1978).

Formalization and control rise from mode (1) to mode (3), increasing coordination of the mode of governance. The following hypotheses are grouped according to the dimensions of the transactions.

3.2.1 Hypothesis on asset specificity (H_A)

The literature indicates that the greater the investment in relationship-specific assets, the greater the exposure of the contracting parties to hold-up and the lower transaction costs if the modes of governance are more coordinated, whether by means of verbal agreements or formal contracts (MÉNARD, 2004; WILLIAMSON, 1979, 1985, 1991, 1996). Each type of asset specificity relevant here is detailed below.

Physical specificity. The long-term and co-specialized investment (land plus rubber tree) may result in a hold-up problem between producers and processors. In order to assess the level of investment made by the farmer, the variable *AREA_BOR* is used, measuring the area (ha) with rubber trees in production of a particular farm. The opportunity cost of the land and investment in planting, expressed in monetary terms, would be more direct measures, but obtaining these financial data is problematic. Assuming that the cost of implementation of the rubber plantation and the income from competing crops, such as sugar-cane, have no significant relative variations, this proxy variable may represent the producer's investment in the implementation of the rubber tree plantation and the opportunity cost of the land use. The theory predicts that the influence of *AREA_BOR* will be positive in the sense of inducing more coordinated contracts, although an empirical baseline study did not find significance in cultivated areas used as proxies of specific investments (ALLEN and LUECK, 2002).

Dedicated specificity. A second proxy of the level of specificity of the assets is the yearly amount of rubber supplied by a particular farm to a particular processor. The greater the quantity sold, the greater the engagement between the parties. The variable *QUANT_BOR* is used to capture this (tons of rubber coagulum or latex sold in the previous harvest). Empirical studies have found a positive and statistically significant relationship between

quantities sold to the same processing plant and more coordinated modes of governance. Mello and Paulillo (2010) found that the largest orange producers in Sao Paulo sell their output to the processing industry using formal and exclusive contracts, i.e. a single buyer for the entire crop. Allen and Lueck (2002) found a relationship between investments in perennial tree crops - measured by means of the quantity harvested - and the use of written contracts, as an alternative to informal ones. Consequently, according to the literature and previous empirical studies, it is expected that *QUANT_BOR* will positively influence the adoption of more coordinated modes of governance. Additionally, an attempt is made to capture this dimension directly using the variable *VALOR_INVEST*, which determines the amount, adjusted for inflation, of the producer's investments dedicated to meeting the requirements of its main buyer (excluding plantation and land). Thus, as with *AREA_BOR* and *QUANT_BOR*, *VALOR_INVEST* is expected to positively influence the adoption of more coordinated modes.

Human capital specificity. The shortage of skilled labor in the farming of the rubber tree (rural workers called rubber tappers) and legal uncertainties regarding the labor costs and taxation of rural partnerships lead to some producers choosing to hire rubber tappers under ordinary employment contracts according to Brazilian labor laws. The rubber tapping quality is essential to ensure the productivity and profitability of the plantation, as well as the sustainability of production. A rubber tapper must be trained in very specific work techniques,

which untrained rural workers have not mastered. Thus, this skilled labor constitutes specific human capital essential to the farming of the rubber tree.

Direct measurement of investment in training is difficult and imprecise. An indirect way to measure this is through the active number of rubber tappers registered on the property, using the variable *NUM_CLT*. Previous studies have found positive statistical significance of investment in human capital in the mode of governance, either measuring training and technical assistance expenses (MELLO and PAULILLO, 2010) or through proxies related to a differentiated production (more demanding in terms of specific human capital), as in the case of young and very young steers (MONDELLI and ZYLBERSZTAJN, 2008). Thus, a positive relationship of *NUM_CLT* and the adoption of coordinated modes of governance is to be expected.

In summary, a positive sign is expected for all investment variables in relationship-specific assets (*AREA_BOR*, *QUANT_BOR*, *VALOR_INVEST* and *NUM_CLT*) and from that H_A is stated.

H_A : The greater the investment in relationship-specific assets, the greater the likelihood of using more coordinated modes of governance, and therefore the lesser the likelihood of using spot sales.

3.2.2 Hypothesis on transaction uncertainty (H_U)

Natural rubber is a commodity priced on Asian stock markets. The industry uses a mechanism that transmits international prices to the domestic market. The price risk of rubber is relevant, and affects the decision of how much and when to produce. The individual producer's perception of this risk is expressed in uncertainty regarding maintaining the plantation in operation. The individual level of uncertainty is captured using the variable *INCERT_EXPLO* on a scale of (1) to (5), ranging from very low likelihood of reducing or suspending operation of the rubber plantation to very high likelihood.

The presence of investments in specific assets is crucial to that uncertainty, having impact on transaction costs (WILLIAMSON, 1985, 1996). With the increase in uncertainty and in the presence of such investments, the use of hybrid modes falls into disfavor, as it becomes more difficult to enter into contracts with full adaptation mechanisms (MILGROM and ROBERTS, 1992). Empirical studies have shown difficulty in measuring uncertainty, finding results both that support and contradict the theory (DAVID and HAN, 2003). Here, *INCERT_EXPLO* reflects the producer's expectations regarding the future. According to proposition 2, it is expected that the uncertainty will make a negative contribution to the adoption of hybrid modes (verbal agreements and contracts) and a positive one in the adoption of a market mode of governance (spot sale).

H_U : The greater the producer's uncertainty regarding the continued operation of the rubber plantation, the lesser the likelihood of using more coordinated modes of governance, and therefore, the greater the likelihood of using spot sales.

3.2.3 Hypothesis on frequency of the transaction (H_F)

At harvest, the delivery of rubber to the processing plant is weekly or biweekly, depending on circumstances surrounding production and transportation. It is difficult to determine accurately, through the survey questionnaire, how many transactions per harvest each producer effectively carried out with each buyer. Producers and processors reported that they renegotiate each season both verbal agreements and formal contracts. This considered, transaction recurrence is used between producers and processing plants as a proxy for

transaction frequency. The variable *NUM_SAFRAS* captures the number of elapsed harvests in which the producer transacts with its main buyer. According to the literature, recurring transactions allow the costs necessary to create more specialized modes of governance to be amortized (TADELIS and WILLIAMSON, 2013). There may also be ambiguous implications: recurring transactions enable reputation mechanisms and cooperation between the parties to emerge, which reduce the need for formalization of agreements and reduces transaction costs. Transaction efficiency benefits from cooperation and ease of adaptation, so that an external element is not necessary to ensure implementation of the agreement (MILGROM and ROBERTS, 1992). Empirical studies find a positive relationship between the frequency of the transaction and the adoption of more coordinated modes of governance (MELLO and PAULILLO, 2010; MONDELLI and ZYLBERSZTAJN, 2008). Here, taking into account the theory and empirical studies, *NUM_SAFRAS* is expected to be positive.

H_F: The higher the frequency of transactions between producer and plant, the greater the likelihood of using more coordinated modes of governance, and therefore, the lesser the likelihood of using spot sales.

3.2.4 Hypothesis on relationship (H_R)

Williamson’s model summarizes the three dimensions that characterize transactions (ZYLBERSZTAJN, 2009). Other aspects of the transaction, such as the relationship or trust between the parties, are more difficult to measure (MONTEIRO et al., 2013), but may influence the mode of governance. Processors have sought to strengthen their relationship with producers by providing agricultural technical assistance free of charge. If technical assistance is provided by the main buyer, the dummy variable *ASSIST_TEC* is (1), otherwise is (0). It is expected that technical assistance will be positively related to the adoption of agreements instead of spot sales.

H_R: The closer the relationship between plants and producers, the greater the likelihood of using more coordinated modes of governance, and therefore, the lesser the likelihood of using spot sales.

Figure 3.2 summarizes the hypotheses:

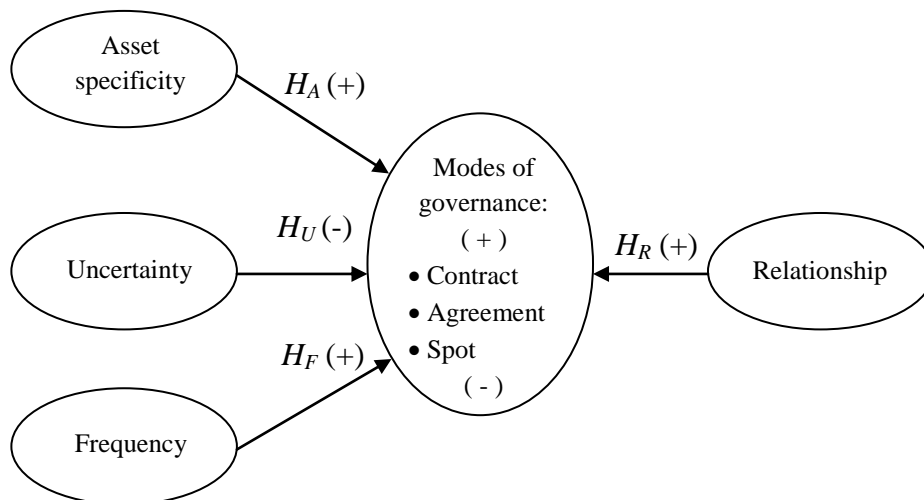


Figure 3.2 – Hypotheses

3.2.5 Control variables

In addition to the independent variables related to the hypotheses, there are others that may affect the choice of the mode of governance. These control variables are also required for the de-endogenization of the simultaneous equations model.

The involvement of the owner in the rubber plantation and his degree of participation in negotiations with the processors are significant aspects of the transaction, and are not covered by the basic dimensions of TCE, but studied in agency theory. When negotiating on behalf of the principal (owner), the agent (employee or partner) will not necessarily act in accordance with the principal's interests. Two dummy variables are used to capture these characteristics. *LOC_RES*, the place of residence of the owner: (0), if he lives elsewhere; (1), if he lives in the farm. *AGENTE*: (0) if the principal is the negotiator; (1) if the agent is the negotiator.

The producer's profile is also captured through time spent working in the activity and his schooling. Time spent working on the activity, expressed in years by the variable *TEMPO_ATIVIDADE*, may reflect different experiences and knowledge of the producer, affecting his decisions regarding investments and the mode of governance to be adopted. The producer's schooling, ranging from elementary school (1), high school (2) to a college degree (3) may have an impact on his understanding of the contracts, and is captured by the variable *ESCOLARIDADE*.

Part of farmers' income may come from other sources (e.g. another activity, whether agricultural or not, financial investments, pension). The percentage that revenue from the rubber trees represents in his total income, as captured by the variable *PERC_REND*, in percentage, assesses relative importance of rubber cultivation. Similarly, revenue from rubber trees as a percentage of total revenue of the farm is also measured, using the variable *PERC_RECE*.

Producers may be members of APABOR or other regional associations. They may also be members of cooperatives or other associations that sell their output, or part thereof, to processors. Belonging to some association may influence the mode of governance adopted. In order to capture this attribute, the discrete variable *ASSOCIACAO* is used: (0) does not participate in any association; (1) is a member of a cooperative, participates in a regional association and/or is a member of APABOR. The parties may adopt the APABOR index as the reference price in the transaction. The variable *PRECO_REF_APABOR* measures this attribute: (0) not used; (1) used.

Level of exclusivity of the business conducted between producer and plant indicates their degree of relationship. Taking into account the shortage of rubber, plants tend to purchase their suppliers' entire output. The variable *NUM_COMPR* measures to how many processors, or different purchasing companies, the producer sold during the last harvest, indicating the degree of exclusivity with which it operates. The producer may engage in a rural partnership to operate the rubber tree plantation. Partners have no employment relationship and receive a percentage of output as payment. The variable *NUM_PARC* captures the number of rural partners of the farm.

3.3 Econometric modeling

Saussier (2000a, 2000b) proposes and empirically tests a quantitative model where relationship-specific investments are treated as endogenous variables (MACHER and RICHMAN, 2008; SYKUTA, 2005, 2010). In order to implement the test, Saussier constructs the following econometric model of simultaneous equations:

$$CONTRACTFORM_i = \sum_j \mu_j SPE_{ij} + \lambda UNC_i + \theta FREQ_i + PREL_i \quad (3.1)$$

$$SPE_{ij} = \sum_k \phi_{jk} X_{ik} + \nu_j CONTRACTFORM_i \quad (3.2)$$

In (3.1), the mode of governance of transaction i ($CONTRACTFORM_i$) is the result of adaptation between the parties to minimize transaction costs, and depends on the transaction dimensions defined by Williamson (1979): SPE_{ij} , investments in specific assets; UNC_i , level of uncertainty and $FREQ_i$, level of frequency of the transaction. Equation (3.1) is consistent with the theoretical framework adopted here⁷.

In (3.2), investments in relationship-specific assets are the result of the role of incentive played by the mode of governance, and also conditioned by a number of exogenous factors (X_{ik}) that would explain the willingness of the parties to make specific investments. This model is derived from the theory of incomplete contracts (GROSSMAN; HART, 1986).

Model (3.1) is estimated using an Ordered Logistic Regression (Ologit)⁸. Two-Stage Least Squares (2SLS) and Three-Stage Least Squares (3SLS) methods, adopting linear regressions⁹ are used to investigate if modes of governance and investments in specific assets are endogenous variables, considering the simultaneous equations model (3.1 and 3.2). In these cases, causality may be bidirectional. For example, the mode of governance (MOD_GOV) may recursively influence the quantity sold ($QUANT_BOR$). The linear regression coefficients are compared with the coefficients estimated by the 2SLS and 3SLS methods using Hausman's specification test. If the null hypothesis of non-systematic variance between the coefficients of the models is rejected, it is considered that the variables are endogenous (GURAJATI, 2011).

⁷ Saussier (2000a) does not reject the equation model (3.1), where the contract has an adaptive function, but rejects the second model (3.2), where the contract would play the role of incentive to the relationship-specific investments. As compared to Saussier (2000a, 2000b), equation (3.1) is modified by the addition of the term REL , the relationship variable $ASSIST_TEC$.

⁸ Ologit is appropriate where the discrete variables are of an ordinal nature, such as is the case of the choice between modes of governance with increasing degrees of coordination (dependent variable MOD_GOV) (SYKUTA, 2005).

⁹ The 2SLS and 3SLS methods use instrumental variables in order to replace the endogenous variables so as not to violate the fundamental assumption of independence between the error term and the independent variables. In the regressions using 2SLS and 3SLS, the discrete variable MOD_GOV is treated as continuous. This treatment is not entirely appropriate (SAUSSIÉ, 2000a).

4. Results and discussion

First, the hypotheses H_A , H_F , H_U e H_R are tested, using model (3.1). Second, the relationship between the producer's profile and the mode of governance is addressed. The results of the Ologit regressions are shown on table 4.1

Table 4.1 – Ologit regressions

Dependent variable		MOD_GOV (Mode of governance)						9
		(1 = spot sale; 2 = verbal agreement; 3 = written contract)						
Models		A	B	C	D	E	F	
	Freq.	50	50	49	49	50	50	46
Independent variables		Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
H_A	QUANT_BOR	0.0085 (0.0035)**	0.0090 (0.0036)**	0.0090 (0.0037)**	0.0088 (0.0038)**			
	NUM_CLT	0.0542 (0.0675)	0.0501 (0.0707)	0.0460 (0.0714)	0.0429 (0.0718)			
H_U	INCERT_		0.1608	0.2536	0.2633			
	EXPLO		(0.2548)	(0.2716)	(0.2729)			
H_F	NUM_SAFRAS			0.0278 (0.0769)	0.0309 (0.0783)			
H_R	ASSIST_TEC				-0.2800 (0.8178)			
Producer profile	LOC_RES					-1.0719 (0.9704)	-1.2935 (1.0258)	-2.1977 (1.1395)*
	ESCOLARIDA DE					-0.0300 (0.7823)	0.3034 (0.8293)	-0.4045 (0.9776)
	TEMPO_ ATIVIDADE					0.0427 (0.0346)	0.0353 (0.0358)	0.0559 (0.0434)
	ASSOCIACAO					1.8112 (0.8370)**	1.6789 (0.8511)**	1.6112 (0.9136)*
	PERC_REND						0.0133 (0.0139)	0.0187 (0.0166)
	PERC_RECE						0.0041 (0.0106)	0.0203 (0.0140)
	AGENT							0.8404 (1.0370)
	NUM_COMPR							-0.0181 (0.8445)
	PRECO_REF_ APABOR							2.4540 (0.9751)**
	Model tests	Log Likelihood	-28.0231	-27.8204	-26.3845	-26.3249	-33.5937	-32.8961
LR chi2		20.00	20.41	19.98	20.09	8.86	10.25	19.52
Prob > chi2		0.0000	0.0001	0.0005	0.0012	0.0647	0.1143	0.0211
Pseudo R2		0.2630	0.2683	0.2746	0.2762	0.1165	0.1348	0.2756
AIC		64.0463	65.6407	64.7690	66.6498	79.1874	81.7923	73.3076

(Standard error between parentheses), *significance at 10%; ** significance at 5%; ***significance at 1%.

4.1 Hypothesis testing

Taking into account the relatively small number of observations ($f = 50$), certain precautions must be taken in the use of the statistical methods. According to Long (1997, p. 54), there are risks in using samples with fewer than 100 observations when maximum

likelihood estimation methods are employed, such as the Ologit. Long recommends using the rule of thumb of at least 10 observations for each parameter, with special attention being paid to variables with high collinearity and little variation in the dependent variable. Thus, in the hypothesis testing, the number of explanatory variables used simultaneously is limited to 5.

The Ologit models (A, B, C and D) on table 4.1 are obtained by introducing incrementally the explanatory variables of mode of governance. Of the four, Model A is the most fitting ($p_value = 0.0000$ and LR Chi2 = 20.00), but we will use as a basis for analysis Model D which is only slightly less fitting but which covers all the hypotheses. The independent variables are treated as exogenous in all models. Table 4.2 summarizes the results.

Table 4.2 - Mode of governance and explanatory variables

Mode of governance	Freq.	<i>QUANT_BOR</i> (ton. / harvest)		<i>INCERT_EXPLO</i> (1 – 5)		<i>NUM_SAFRAS</i> (number of harvests)		<i>ASSIST_TEC</i> (Yes = 1)	
		<i>Ave.</i>	<i>S.D.</i>	<i>Ave.</i>	<i>S.D.</i>	<i>Ave.</i>	<i>S.D.</i>	<i>Ave.</i>	<i>S.D.</i>
Spot sale	10	53	42	2.5	1.5	3.4	4.2	0.70	0.48
Verbal agreement	36	151	158	2.0	1.4	5.5	4.7	0.64	0.49
Written contract	4	600	295	2.5	1.0	1.5	1.7	-	-

H_A – Asset specificity

The variables available for testing H_A are *AREA_BOR*, *QUANT_BOR*, *NUM_CLT*. However, given the constraints imposed by the small number of observations and the high correlation (93%) between *AREA_BOR* and *QUANT_BOR*, only *QUANT_BOR* is kept in the model¹⁰. This variable possibly better captures investment in relationship-specific assets.

Thus, H_A is tested using two variables: *QUANT_BOR* and *NUM_CLT*. The variable *QUANT_BOR* shows statistical significance of 5%. This result does not rule out the hypothesis that the greater the investment in relationship-specific assets, the more coordinated the mode of governance.

Overall, the indication is that the small producer tends to use spot sales, and producers of medium and large quantities tend towards verbal agreements or formal contracts. Indeed, the average batch among producers using spot sales is 53 tons/harvest, among producers relying on verbal agreements, 151 tons/harvest and producers selling to processors under a formal contract, 600 tons/harvest (Table 4.2). As investment in specific assets measured by the proxy *QUANT_BOR* increases, producers adopt more coordinated modes of governance, saving transaction costs. The result supports one of the most prevalent predictions of TCE¹¹. The proxy *NUM_CLT*, although positive as predicted, has no statistical significance, despite specific skilled labor being mentioned by producers as increasingly scarce.

H_U – Uncertainty

Variable *INCERT_EXPLO* has no statistical significance in model D. However, as shown in table 4.2, the average level of uncertainty of producers that use spot sales or formal

¹⁰ The amount of rubber sold reflects the investment in the implementation of the rubber plantation and the productivity level. It is not related only to the sunk cost, as *AREA_BOR*. Alternatively, where *AREA_BOR* is used as a proxy for specific investment, the variable also has significance of 5% and fit of model D declines slightly ($p_value = 0.0042$ and LR Chi2 = 17.17).

¹¹ In a review of 307 empirical studies conducted by David and Han (2004), 60% of cases where investment in specific assets is considered an independent variable support the prediction of TCE.

contracts is greater than those who have verbal agreements. According to the literature, hybrid modes of governance are neglected as uncertainty increases. At higher levels of uncertainty, if investment in specific assets is smaller, the market mode of governance saves transaction costs. On the other hand, if investment is higher, hierarchy becomes more economical.

Thus, the difference presented in the perception of uncertainty of the producers is an indication favorable to hypothesis H_U , when comparing transactions with spot sales and verbal agreements. The result suggests, albeit weakly, that producers who adopt verbal agreements may be less uncertain about the continuity of feasible farm operation. It could be suggested that the verbal agreement is a solution to the producer's trade-off between protecting himself from opportunism and becoming entrapped in a disadvantageous contract (propositions 1 and 2). The adaptability of the verbal agreement and the inherent trust placed therein would be favorable conditions for its suitability.

H_F – Frequency

The variable *NUM_SAFRAS*¹² has no statistical significance. However, it is observed that, on average, producers using spot sales have been trading for 3.4 harvests with the main buyer, while those maintaining verbal agreements have been trading for an average of 5.5 harvests (table 4.2). The longer average recurrence in the verbal agreements than in the spot sales is an indication that supports the prediction of TCE expressed in H_F . The reputation and trust mechanisms associated with the verbal agreement may characterize it as a relational contract. For an intermediate level of asset specificity, bilateral governance through a relational contract is the mode of governance that would involve lower costs when the transaction is a recurring one. As for producers using formal contracts, the average harvests traded with same buyer is much lower, only 1.5 harvests (table 4.2). In the qualitative survey, the processors referred to earlier (failed) attempts to formalize transactions with producers. Thus, one possible interpretation is that formal contracts are more recent, and therefore less time has elapsed. Another interpretation is that, in these transactions, the higher level of asset specificity, associated with irregular recurrence, makes the trilateral mode of governance, as represented by the neoclassical (formal) contract, the most efficient. Under this interpretation, the results, although not statistically significant in the logistic regression, would also be consistent with the prediction of the TCE, since the dimension frequency of transactions may have an ambiguous effect.

H_R - Relationship

The variable *ASSIST_TEC* has no significance under model D. Seventy percent (70%) of the producers who trade via spot sales and 64% of those who maintain verbal agreements received technical assistance from the main buyer. Technical assistance may be understood as the transfer of revenue from the processor to the producer, being a necessary condition for securing the transaction, but is not a sufficient condition to increase the degree of coordination of the mode of governance. Another possibility is that the frequent presence of an agricultural technician from the processor in the farm may increase monitoring and reduce producer opportunism, here understood as bypassing main buyer in the quest for higher prices. None of the four producers with formal contracts received technical assistance. These producers are larger, some are incorporated and possibly have their own agricultural technician in charge, removing the need for the buyer's technical assistance. From the buyer's side, since the formal contract exerts more control over the producer, the monitoring role of technical assistance is less impactful.

¹²The measurement of this variable could be improved if the questionnaire clearly detailed recurrence for each of the possible modes of governance. However, the answers obtained and the prevalence of verbal agreements do not completely invalidate the association between verbal agreements and higher recurrence.

In summary, the test rejects the null hypothesis and accepts H_A . As for H_U , H_F e H_R , there is no evidence allowing the corresponding null hypothesis to be rejected. Thus, taking into account the specificity of assets, which is the main dimension of the transactions according to the literature, and taking into account the comparative study of the increasingly coordinated modes of governance (spot sales, verbal agreements and formal contracts), it may be inferred that there is alignment between governance practice in this agroindustrial system and the prediction of TCE: producers and processors organize the purchase and sale of natural rubber in order to save on transaction costs.

4.2 Modes of governance and producer characteristics

In models E, F and G, the control variables are used as regressors of the mode of governance and also added incrementally (table 4.1). Table 4.3 assists in the analysis.

Table 4.3 – Modes of governance and control variables

Governance mode	Freq.	<i>TEMPO_ ATIVIDADE</i> (years)		<i>PERC_REND</i> (%)		<i>PERC_RECE</i> (%)		<i>AGENT</i> (Yes = 1)		<i>PRECO_REF_ APABOR</i> (Yes = 1)	
		Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.
Spot sale	10	18.9	10.1	31.1	31.7	62.1	30.6	0.20	0.42	0.44	0.53
Verbal agreement	36	20.1	10.6	29.9	26.1	67.2	30.2	0.19	0.40	0.52	0.51
Written contract	4	26.0	6.4	60.0	43.2	90.8	9.4	0.50	0.58	1.00	0.00

In model E, we tested the influence of demographic characteristics and the producer's membership of associations on governance modes. The variable ASSOCIACAO presents 5% statistical significance. The fact of belonging to producer associations is related to a higher likelihood of using verbal agreements and formal contracts. Albeit not statistically significant, time spent working on the activity positively signals the adoption of more coordinated modes of governance (table 4.3).

Under model F, a set of variables (*PERC_REND* and *PERC_RECE*) is added that deal with the relative importance of the rubber tree in the producer's income and revenue of the farm. Neither are significant. It is noted that there is evidence that affiliation to associations varies positively with the importance of the rubber tree in the revenue of the farm ($p_value = 0.12$).

Under model G, variables are added that cover additional aspects of the transactions: whether the transaction is negotiated by an agent of the producer, how many different buyers there are and whether the APABOR reference price is used in the transaction. This is the most fitting model if compared to models E and F. There are three variables with statistical significance under G: *ASSOCIACAO*, which had already been noted under models E and F; *LOC_RES* and *PRECO_REF_ APABOR*.

The place of residence of the producer has a negative coefficient, indicating that if the producer lives in the farm, the mode of governance tends to move towards the less coordinated (spot sale), which requires the presence of the owner of the farm and may become more feasible and frequent when his presence is more constant.

The positive correlation of the use of the APABOR reference price with the most coordinated modes of governance is associated with the need for predictability and adaptability in the verbal agreement and the formal contract. Where the price traded is linked to the index and also to the determination of the dry rubber content, the parties are left to

negotiate the division of the quasi-rent. This is typically expressed by the percentage the APABOR price that processor pays to the producer. Survey data indicate that this percentage has been rising over time.

The differences between the profiles of producers using formal contracts and those using verbal agreements or spot sales are striking. In spite of the reduced number of observations - only 4 cases of producers with formal contracts - it is observed that these producers have been operating longer, the revenue from their property and their income are more concentrated in the rubber tree and all use the APABOR reference price. The owners' agents negotiate the sale of rubber in two observations. This may be interpreted in such a way that the formal contract, as well as reducing the cost of the transactions where there are higher levels of asset specificity, is also used to reduce the agency cost.

4.3 The endogeneity of relationship-specific assets

As proposed under section 3.3, we here test the hypothesis that investments in relationship-specific assets are decision variables, and therefore endogenous to the mode of governance. Due to the constraints on the degree of freedom imposed by the small number of observations, simultaneous equations with the following variables were used:

$$MOD_GOV_i = \mu_1 QUANT_BOR_i + \mu_2 NUM_CLT_i + \lambda INCERT_EXPLO_i + \Theta NUM_SAFRAS_i + (4.1) \\ + P_ASSIST_TEC + u_1$$

$$QUANT_BOR_i = \Phi_1 PERC_RECE_i + \Phi_2 ASSOCIACAO_i + \Phi_3 NUM_PARC_i + \nu_1 MOD_GOV_i + (4.2) \\ + u_2$$

If the specific investment, represented by *QUANT_BOR*, is endogenous, there will be recursion between *MOD_GOV* and *QUANT_BOR*. One way to test this hypothesis is to apply the Hausman's specification test (GUJARATI, 2011, p. 335; MADDALA, 2001, p. 496). First, linear regression is performed on *MOD_GOV* using the same exogenous explanatory variables as under model D. The linear regression model is taken as the efficient model. Second, *QUANT_BOR* is estimated through the instrumental variables¹³ of (4.2) and regression is performed on *MOD_GOV* in 2 stages (2SLS¹⁴) with *QUANT_BOR* endogenous.

By applying the Hausman test with the coefficients of the efficient (linear) model and the consistent (2SLS) model, we obtain *p_value* = 0.9836. Then, the null hypothesis cannot be rejected and the hypothesis that *QUANT_BOR* is endogenous is dismissed. Therefore, as *QUANT_BOR* is an exogenous variable, it may be assumed that the adoption of spot sales, verbal agreements or formal contracts is a result of the level of investment in relationship-specific assets, and not the opposite. This result indicates that the mode of governance has an adaptive function in relation to this aspect of the transaction, in accordance to TCE.

In addition, the endogeneity of the variables is tested by applying discriminant analysis using Probit. In Probit, the dependent variable is necessarily binary. Thus, the hybrid modes are grouped (verbal agreements and formal contracts, *MOD_GOV* = 0) as opposed to spot sales (*MOD_GOV* = 1). When estimating *MOD_GOV* with *QUANT_BOR* instrumentalized by ASSOCIACAO, *p_value* model = 0.0000 and Chi2 = 29.96 are obtained, not rejecting the null hypothesis, which reinforces our point (Wald's exogeneity test of Stata IC13, *P_value* = 0.2938).

¹³ Three instrumental variables of *QUANT_BOR* are used, with the model being superidentified.

¹⁴ The test using 3SLS presents results similar to 2SLS in terms of significance and coefficients.

5. Concluding remarks

One of the criticisms of empirical studies using TCE is insufficient understanding of the context in which the transactions occur. In this paper, the natural rubber AGS was surveyed and described with the depth and breadth necessary for the foundation of testable hypotheses. As to the quantitative methods used, most similar studies use linear or logistic regressions for estimation taking as exogenous all explanatory variables, but without explicitly testing this assumption. In our case, in addition to ordered logistic regression, we tested for endogenization of the investment in specific assets. This paper adds to studies of Brazilian agroindustrial systems that use TCE as a framework by studying a relevant, but as yet unexplored, crop (natural rubber) and using quantitative methods in conjunction with qualitative methods.

By studying transactions and modes of governance between farmers and processors in the Natural Rubber Agroindustrial System of Sao Paulo, using the theoretical framework of Transaction Cost Economics (TCE), the aim is to identify whether the governance adopted by the parties is efficiently aligned with the characteristics of the transactions.

The non-random sample consisted of 50 observations, representing around 1% of the population of Sao Paulo rubber tree growers. In the sample, transactions between producers and processors mediated by verbal agreement were prevalent, totaling 36 observations. These producers have maintained the agreement with their main buyer over 5.5 harvests. In 4 observations there was predominant use of formal contracts. Both verbal agreements and formal contracts are considered hybrid modes of governance. The remaining 10 observations adopt spot sales as the predominant mode of governance and have maintained transactions with the main buyer for 3.4 harvests, on average. Data were subjected to statistical models of ordered logistic regression and a test of variable endogeneity.

The results indicate that investment in relationship-specific assets is the aspect of the transaction with a statistically significant influence on the mode of governance. The higher the quantity of rubber traded, the greater the coordination of the modes of governance adopted, and the greater the likelihood of using verbal agreements and formal contracts rather than the market (spot sales).

The greater stability of verbal agreements, morphing into a relational contract, is possibly due to the adaptability of these relational contracts and to the trust developed over the years between producers and processors. Technical assistance provided by the latter to the former likewise does not influence the mode of governance, however, it may play a dual role: monitoring producer opportunism and transferring an additional portion of the quasi-rent to him.

The mode of governance varies according to three features of producers' profile. Producers residing on the property are more likely to engage in spot sales. Producers organized into associations are more likely to use more coordinated modes of governance, and the use of the APABOR reference price in hybrid modes of governance is also prevalent.

The endogenization test between mode of governance and asset specificity was negative. According to the Hausman specification test, presumably consistent estimators of equations with instrumental variables are no more efficient than simple regression models, indicating that the mode of governance plays an adaptive role *ex post* investment decisions, with the level of investment in specific assets being the cause of the mode of governance and not a consequence thereof. This result is consistent with the adaptive role of the mode of governance predicted in TCE.

Quantitative data on the transactions were collected only from the producer side. Although responses were checked for consistency, the work did not provide for a systematic checking of the information with the counterparty, the processor. The wording and

comprehension of the questionnaire may have affected the accuracy of the data collected. The small sample size, its bias and non-random nature all prevent generalization of the findings. The low degree of freedom prevented the simultaneous testing of hypotheses from the reduced model of TCE and variables relating to the producers' profile. As in most studies of this kind, the transaction cost is not directly measured, but the indirect effects of the transaction dimensions. Additionally, there is the problem of measuring the dimensions through proxies. The assumption that a perennial crop *per se* is a relationship-specific asset is corroborated by other authors, but is still unusual.

There are managerial implications to consider. On the rubber demand side, i.e. the processing plant, the results and discussion may contribute towards managers questioning their practices in terms of the contracts used and their suitability through a more rigorous analysis of the producer's specificities and the level of specific investments involved. The promotion of microenterprise (small holders) in rubber tree cultivation may be inefficient, as it increases the transaction costs. Encouraging pooling and adopting contracts with a pool of suppliers may be more efficient arrangements.

On the supply side, producers may better assess the alternatives concerning transaction costs. Resistance to the use of formal contracts should fall, especially for major producers. More comprehensive contracts may provide protection to the parties against the opportunism.

Other issues are waiting for systematic research. According to Williamson's simple contractual schema, spot transactions, carried out without safeguards and with investment in specific assets presents the latent risk of leaving the investment without protection. In this case, the seller will ask a higher price than under hybrid modes of governance. However, given the shortage of rubber, there are reports that processing plants pay bonuses by volume and loyalty of producers. The study of prices in transactions would bring new subsidies for analyzing relationships in this AGS. It is known that producers' margins have been rising in real terms over the historical time series, available since 2002. However, in order to progress, it is necessary to have price data for each individual transaction. This may be problematic due to the mistrust of the players, but it is important to address some empirical questions: after all, is there is a difference between prices in spot sales, verbal agreements or formal contracts?

The real price of rubber has fallen from 2011 to 2015, reducing the profitability of farms and plants. The industry is seeking to adapt, introducing new modes of governance. One is the lease of the processing capacity of the plant by the producer. In this still incipient arrangement, it is the producer who transacts directly with the (tire) manufacturing company and pays the processing plant per quantity of rubber processed. Whether or not this is a trend, and how the industry will evolve, are open questions.

From the standpoint of the processors, the rubber supply strategy, whether through vertical integration or the leasing of rubber plantations, constitutes an arrangement of plural forms, where "doing" and "buying" coexist. From the standpoint of the producer, the formation of associations and sales pools are strategies already identified for increasing bargaining power. Would there be a preference for certain types of arrangements? Would these arrangements benefit if they were governed by formal contracts? What kind of contracts?

This analysis is aligned with TCE predictions on specific assets as a determinant of governance mode in the natural rubber industry in Sao Paulo, Brazil. Using more direct data on both the division of the quasi-rent generated by the specific assets and the transaction costs are natural pathways for future research.

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