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A MULTIPLE-CRITERIA ANALYSIS APPLICATION FOR VERTICAL COORDINATION IN THE TRANSPORTATION OF AGRICULTURAL COMMODITIES IN BRAZIL[1]

JEL classification: L1, R4, C8, Q1

Abstract: *The strategies used to perform the transportation of agricultural commodities by truck in Brazil are a challenge to decision-making. This paper brings together the widely held theories, vertical coordination and decision analysis, to present a discussion of decision-making in organizations. From a model capable of processing main objectives, multiple criteria, and variables found in transport verticalization problems, the results showed worse performance than hybrid or outsourced alternatives. These results support that in environments with high dependence on low costs and asset specificity, they are no more likely to meet hybrid structures or market coordination. As the price difference between the outsourced and vertical model decreases, there is a preference for hierarchical structure, given its better performance related to the benefits offered. Changes in the institutional environment, such as transport regulations, may modify competitive arrangements. This type of preference by decision-makers for vertical structures could allow larger scale in conjunction with strategies by shippers, as operation costs remain close to those charged by carriers.*

Keywords: truck transport, vertical coordination, decision analysis

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1. INTRODUCTION

Vertical coordination can be observed in determined supply-chains, reflecting governance patterns among active agencies. In agrobusiness, companies possess diverse models of vertical integration, and in the case of solid agricultural grain transport, this characteristic is relevant in strategic decision making.

This work proposes a way to facilitate decision making through a fundamental model seen in classical theories, such as vertical coordination (Williamson, 1989; Zylberstajn, 1995). and multiple-criteria decision-making analysis (Belton & Stewart, 2002; Franco & Montibeller, 2010). The principal trade-offs encountered during the decisive process of vertical integration in highway transport will be discussed. At the end of the study, structuring company decisions based on better competitive advantages and performance through a multiple-criteria model will be proposed.

While grain production in Brazil stands out in the world due to high productivity and the occurrence of at least two crops per year, the logistical deficiency in the entire agroindustrial system is the greatest challenge. The logistical impact directly affects production costs, as well as the value of products in agroindustrial units, since the most common pricing determination for agricultural commodities is grain quotation in the international market, discounting freight costs. The objective of vertical coordination is to minimize transaction costs and can be highly efficient if the institutional environment can reduce uncertainties.

According to the soybean transport matrix developed by ANEC (2010), the participation of highway transport in Brazil is considerably elevated (53%), while other countries with continental dimensions such as the United States possess a larger participation of waterway transport (60%). Transport had a share of 10.6% of the Gross Domestic Product (GDP) in 2010 (ILOS, 2013), and was one of the most important segments of the Brazilian economy. On the other hand, the significant dependence on the highway system has been offset by its lack of organization and uneven regulation up to now. The unavailability of information, lack of professionalism, and limited knowledge on the part of agents has yielded a market of highway freight which is highly seasonal and "informal". A group of diverse researchers has done pioneering research in the logistics related to agricultural commodities in Brazil (CAIXETA-FILHO & GAMEIRO, 2001; CORREIA JUNIOR, 2001; GAMEIRO, 2003; MARTINS, 2008).

Due to government initiatives, advanced technology, and strong investment by the private sector, there has been a dramatic change in the last

decade in the profile of the entrepreneur who works with logistics (NTC, 2014). The numbers presented in the bibliographies at the end of the ´90s, by Soares & Caixeta-Filho (1997) for example, do not represent the current market which has been modernized to a point of economic equilibrium, more secure and controlled, with more active transport companies involved, and less autonomous participation (ANTT, 2013). In spite of the seasonality of the freight as one characteristic factor in the agroindustrial sector, described by Caixeta-Filho & Gameiro (2001), the current values practiced cover the costs of the transporter, permitting fleet modernization. In 2013, with an average age of 10.9 years, 73% of the heavy fleet was retired in the next ten years, meaning that approximately 48% of the equipment was less than five years old (ANTT and ANFAVEA, 2013). The agroindustrial sector corresponded to 81% of highway licensing implemented in the last ten years (ANFIR, 2013), clearly showing the importance of agricultural commodities for transport, and vice versa.

Political initiatives were vital for this growth. Long-term investments in infrastructure, low-cost lines of credit, electronic financial transactions, and the increased autonomy of the regulatory agency ANTT (Agência Nacional de Transportes Terrestres: The National Agency of Terrestrial Transport|) have allowed greater security for investors (NTC, 2014).

The combination of factors shown here has allowed the entrepreneur to procure investment opportunities in transport. Vertical coordination permitted large industries to perform investments and reduce costs at the same time. This theory can be observed in the literature of the Transaction Costs Economics, as described by Zylbersztajn & Nogueira (2002), showing that contractual agreements could be copied and used in a symmetrical way by agents in the same system.

Naturally, such investment decisions are not simple, and require adequate tools to predict results. Due to the complexity of defining a model which gives the most adequate solution, multiple-criteria analysis can facilitate turning subjective solutions into more objective ones, based on criteria linked to value curves. The use of Multiple Criteria Decision Analysis (MCDA) has now been studied for 20 years in Brazil in the logistics sector (PRADO, 2011), and was always more focused on the selection of suppliers. Its use was also spread to support linear programming models such as the proper localization of factories and warehouses, optimization models in general, and even public political decisions (MONTIBELLER & YOSHIZAKI, 2011; PADOVANI et al., 2008; FRANCO & MONTIBELLER, 2011; ROY, 2010).

Among the diverse complexities seen in establishing a decision-making process, Keeney (1982) points out that multiple objectives, intangible aspects, various decision-makers, trade-offs, long-term horizons, risks, and uncertainties all create a relatively difficult atmosphere in which to make clear decisions. As a result, the theoretical approach of multiple-criteria selection can allow stakeholders to improve their decisions. In this context, Almeida (2010) defined

value trade-off as the indifference between two consequences, and thus, the stakeholders (the persons affected by the decision) would be equally satisfied with the choice.

Thus far, such research presented has stressed the importance of this theme, principally for shippers of agricultural cargo who could adopt similar strategies depending on the environment to which they are exposed. In such a dynamic market, possessing strategic flexibility is a differential. Consequently, the existence of analytical intelligence which permits an assertive position is extremely important.

As such, the primary objective of this work is to propose a model capable of facilitating decision-making based on the ideal type of governance for road transport of solid agricultural grains from the view of "Trading". For this, the theoretical reference from the "Transaction Costs Economics", allied with the multiple-criteria decision, will be used. Through this approach, it is possible to determine if verticalized transport models are more attractive than outsourced ones.

The alternative proposals for the analysis consider the following governance arrangements:

I. Total vertical integration with active acquisition and operation

II. Partial vertical integration with active acquisition and operation by third parties

III. Partial vertical integration by sub-contracting third parties

IV. Total outsourcing, with the presence of long-term contracts

V. Total outsourcing, without the presence of contracts (spot).

The principal expected results relate to arrangements observed in the market through the proposed model. The following research is also expected to be conducted:

- a review of the complete literature that relates to the history of road transport and its regulation in Brazil;
- introduction to the concept of "Transaction Costs Economics" and its impact on vertical coordination;
- description of the vertical structures related to road transport of agricultural cargoes;
- development and application of a multiple-criteria model to an actual problem faced by a large shipping company;
- evaluation of the performance of each alternative proposed in relation to the application to be implemented;
- facilitation of the decision-making of shipping companies in relation to the governance model most recommended for the proposed scenario.

1.1. Model and Data

The methodological proposal to conduct this work will be done through the process of Multiple-Criteria Analysis (MCDA) found in Franco & Montibeller´s work (2010). This section will allow the reader to understand which concepts will be used in the application of the model, and into which context the problem will be inserted.

An application of the method was done through an actual case study using a large commodities shipper denominated in this work simply as "Trading" (to preserve the confidentiality of the company).

The modelling sequence used in the proposal by Franco & Montibeller (2010) is composed of three phases that will be presented in this section: the Structure of the problem, Structure of the model, and the Modelling of preferences and evaluation of alternatives.

1.1.1. Structure of the problem

The first phase of modelling consists of the definition of a common problem for the group, the identification of the stakeholders, and the scope in which the problem will be developed. In the first stage, interviews with managers of diverse shipping companies of agricultural commodities were conducted. The execution of this descriptive and exploratory phase helped to map existing structures in the market and choose the best context in which to apply the methodology.

The initial sample was composed of 11 managers and logistics directors from large shippers of agricultural commodities, and was distributed as follows:

- ABIOVE (Brazilian Association of Vegetable Oil and Biodiesel Industries) Associates, who transport solid grains and represent approximately 60% of the soy volume processed in Brazil, through 12 associated companies, nine of them shippers and grain exporters;
- ANEC (Brazilian Association of Cereal Exporters) Associates, composed of about 35 associates who contribute nine highway transport companies (including some associates who are not involved in land transport or who are already listed by ABIOVE);
- ANDA (National Association of Fertilizer Diffusion) Associates, composed of the country´s principal fertilizer mixers, with 122 associates.

The interviewees responded to open questions focused on the leveraging of existing coordination structures, characteristics of the segment, and the relevance of transport to their businesses. From these interviews, five vertical coordination models for transport were identified. Among these companies, one showed interest in resolving a problem aligned with the objective of this work:

The choice of a strategic transport arrangement which would be more adequate for its activities. This opportunity thus delimited the group of stakeholders and the scope in which the model was applied.

Those who participated in the model´s application were Logistics, Operations, and Transport Managers. On average, the group had more than 15 years of experience in the agroindustrial sector as well as internal company processes. In addition to specific knowledge, the group interviewed possessed strong influence on the the logistics decisions of their companies.

Given the complexity of routes, seasonality, the difficulty of measuring costs, and the importance of transport to the sommercialization of their products, the scope was limited to a single route and specific volume that was representative to that business. It was defined that the ideal scenario would be a route where there was linear movement throughout the year, where the transport market would have the most regulation possible, and most importantly for the company´s business was that the grain purchase was made from rural producers and exported from these markets.

The intermodal route, with its origin as Highway BR-163 and a major transshipment point in Ferronorte, demonstrated such a representative option that fit the requirements. The average distance of 900 kilometers is close to the national average of 1,000 kilometers, as presented by ANEC (2013), possesses low seasonal movement due to long-term rail contracts, and is inside the state of Mato Grosso which has pioneered fiscal regulation. In the collective opinion of the group, it was the most relevant route to serve as the object of the study. BR-163 in Mato Grosso state is in the principal grain-producing region in Brazil, and is comprised of municipalities such as Sorriso, Simop, Lucas do Rio Verde, and Nova Mutum, among others. It alone accounts for 15% of the national production of soy and corn crops, according to Conab (2013). Ferronorte (a railroad operated by Latin America Logistics - ALL) possesses transshipment centers in the cities of Rondonópolis, Itiquira, Alto Araguiai, and Alto Taquari. These can be operated by the companies´ own operators, as well as third parties or shippers who own warehouses with railway siding.

As a result of seasonality, and the lack of a futures market for freight, 2013 was chosen as the year of reference for the application of the problem. Franco & Montibeller (2011) stressed that the problem needs to be one which the stakeholders are well aware of. This particular year had just seen the incorporation of the obligations of the Motorist Law (Law No. 12.619/12) reflected in the freight price, while the volume executed per month by Trading was already known, and it was possible to examine the levels of transport costs, spot freight, and contracts done. To avoid the effects of seasonality, a fixed monthly volume was considered which in total represented 40% of the volume transported by Trading during the year.

The approach used for the application was "Alternative Focused Thinking" (AFT) since the alternatives to be evaluated were already present in the

environment, and in principle, the decison-makers should elect the strategy that best achieves the objective. To facilitate the support of the application, a modality denominated as "Facilitative Mode" was used where the model´s developer participated as a facilitator active in understanding the problem at hand. According to Prado (2011), the characteristics of the environment and the necessity of interaction with the group decision-maker create a situation better handled by a facilitator than a specialist (the so-called "Expert Mode"). Three face-to-face sessions with all the participants were conducted, each one lasting around two hours. The primary focus was the structure of the problem and its variables; the secondary focus was the measurement of value; and the third, the evaluation of alternatives. Throughout the process, small individual meetings with each of the members were conducted to check understanding and facilitate the model´s development.

1.1.2. Structure of the model

The second stage of modeling proposed by Franco & Montibeller (2010) is the structure of the model which is composed of four phases. The first of them is the identification of fundamental objectives. Together they should result in the final decision, and because of this, they should be obtained through group consensus, preferably a multidisciplinary agreement among the areas involved.

Among the trade-offs observed in agrobusiness logistics, the balance between cost and benefit is the most important. While the cost establishes the competitiveness of a product (the lower the cost, the bigger the purchasing power), the product´s quality during the execution of embarkation determines the result of the negotiation. During the presentation, notes were made on a flip chart where the objectives were also listed, along with the premises and principal trade-offs. From the fundamental objectives came the construction of a tree of values. This structure should clearly represent the problem, and according to Franco and Montibeller (2011), can be built from "the bottom up" conforming to the AFT approach, or "top-down" conforming to VFT. This property grounds the choice of the AFT application, and consequently, the model will be detailed beginning with the sub-criteria to then reach the global objective.

The attributes or criteria can be qualitative or quantitative, and should be capable of differentiating characteristics of a determined choice. Many times they appear to be in conflict, and for this, Franco & Montibeller (2007) used compensation by way of value curves to quantify and differentiate preferences in real problems. Due to the great quantity of criteria and different approaches for classification, the use of technological tools aided in the processing of information. The student version of V.I.S.A. was chosen and its methodology presented because of its easy use and processing capacity, as well as the fact that it was already used in diverse studies of MCDA.

During the description of the problem, diverse attributes which could play a part in the objectives of a decison-maker were raised. Later, these criteria were brought to the application to be incorporated or excluded by the model

adopted by Trading. In the application stage, these attributes were developed, or in other words, were recognized by the decision-maker. As well as the attributes, the variables obtained in the primary survey were also ratified by the group in this session.

In the problem confronted, the variables chosen were the models of verticalization available in the market, excluding alternatives which did not exist or were not operationalized (such as outsourcing labor only). The variables were also evaluated individually, while they were not submitted to an evaluation through a hybrid model between the two strategies of verticalization, specifically to determine which would be the best strategies individually.

1.1.3. Model preferences and evaluation of alternatives

The last stage of modeling consists of balancing weights, constructing value curves, and applying the model to obtain global performance. For each sub-criterion, value curves were created which were capable of explaining the preferences of the group related to the compensations of each choice. Keeney (1982) reasserted that judgments about consequences are not right or wrong, but only serve to determine the attitude and limits of the decision-maker. These curves measure the relative value between possible performances so that priorities can be established in relation to performance.

The amplitude to which a determined attribute must always vary happens between a minimum and maximum level of acceptance. Also, non-linear preferences can be obtained, and it is very common that the non-linearity between the best and worst performance yields intermedialte results which can be almost as good as the best, or almost as bad as the worst performance.

After the construction of the value tree, with the weight of the criteria attributed and value functions constructed, it is already possible to evaluate alternatives. In this process, the performances are assigned to each strategy and each attribute so that performance composition will be capable of classifying the alternative that best achieves the company´s objectives. In this stage of modeling, a second interview with the group was conducted in which a partial evaluation of alternatives was done, together with the construction of the value tree.

The same members who participated in the original interview took part again, and the facilitator was a doctorate student. The points raised in the first meeting were consolidated, and the process was then focused on the construction of value curves and evaluation of alternatives. As an auxiliary tool, an electronic form was used for each of the attributes where the value functions were developed and later the performances of each alternative for each attribute were registered.

After the partial performances were obtained, their consolidation was accounted through the use of the V.I.S.A. software. With this platform, it is possible to make compelling analysis related to decisions with the identification

of trade-offs, and a more specific investigation of sensitivity. Even though consolidation was not done directly in the meeting, principal points that could play an important part in the sensitivity analysis were raised. These were defined as the model´s "turning points", at first altering Cost and Benefit preferences, and later, measuring the existing difference between the totally verticalized option and the lowest cost.

2. MAIN RESULTS

The results obtained from the model can be best interpreted through sensitivity analysis, which can help in the understanding of the tradeoffs between costs and benefits, showing when there are preference changes for the best arrangement. These results showed that subcontracting is preferred whenever the cost of weight is greater than or equal to 30% in the opinion of the decision maker. As the cost becomes less relevant, vertical partial becomes prefereable to the total vertical only when the cost is zero. The best performance of vertical integration occurs when the total cost is lower than 14%; after this, vertical is the second preferred one, weighting 70% of the cost. When cost has a weight greater than 70%, spot arrangement becomes the alternative preferred by the group, and such alternative is the third most suitable for the cost weights varying from 30 to 70%.

Given the preference to the trading cost, performance simulations were performed indicating strategies related to changes in the weight of the cost x benefit ratios. Imagining that the cost will always be an important variable, it was also compared the relative difference between outsourcing and vertical integration strategies (best and worst in the original model, respectively). In the original model, the cost difference between outsourcing and vertical integration was 13%; if it were 2%, that is, if the total vertical option were 2% more expensive than outsourcing, it would be the preferred one due to the observed benefits.

One of the variations considered the assignment of equal weights (50/50). In such type of analysis there is a tie between the vertical part and the alternative spot, with preference for vertical alternative. The contract strategies or full verticalization have the worst performances with these weights, and subcontracting lose points since there is greater preference for benefits. For vertical integration, the subcontract was the preferred one, with the vertical part having a cost of no more than 3.5% higher than the cost of outsourcing.

Another simulation which was conducted involved the reversion of the initial preference, i.e., assigning up to 30% to the weight and 70% to the cost benefit. This model showed a technical tie between the subcontracting strategies and partial vertical integration; it was also observed a tie between full vertical integration and outsourcing through contracts, being the alternative spot the least preferred one. The maximum cost difference allowed between total verticalization

and outsourcing was 5%, and at this point there would have a turning point in the preferences by the Trading respondents.

The use of sensitivity analysis proved to be very important to identify turning points, where decision-makers change their preference. This means that as the performance of each alternative changes, the decision may also change. Based on the criteria of cost and benefit, this model can be applied in situations where the service level is more noticeable and in environments where the cost has different behaviors. Whereas the difference between the total vertical and freight subcontracting was only 13%, if the freight value remains increasing above inflation rates because of the demand for the cargo, the vertical option would become more attractive every year.

3. CONCLUSIONS

The use of "the Transaction Costs Economics" theory, allied with Multiple-Criteria Analysis (MCDA) shown in this work, creates an interesting combination to evaluate competitive arrangements. The study uses value trees to classify verticalization strategies, comparing them in terms of costs and benefits. Beyond this, the study brings an extensive bibliographical review, and a diagnosis of the structures present in shipping companies which deal with solid agricultural grains, forming the basis for the outcome of this dissertation.

Among the models of vertical coordination observed, the following stand out: i. Total vertical integration with active acquisition and operation; ii. Partial vertical integration with active acquisition and operation by third parties; iii. Partial vertical integration without active participation, but subcontracting third-party transport; iv. Total outsourcing with the presence of long-term contracts; v. Total outsourcing without the presence of contracts (spot).

These strategies are used by shipping companies, and the differences among them are characteristics of the market, distinct types of operations, and costs, among others. The regulatory situation that highway transport is currently passing through signals that a dominant model will suffer alterations which, depending on the future scenario, will favor a structure that is more or less vertical.

Aspects contained in the theory of the “Transaction Costs Economic”, suggest that in environments with a higher degree of uncertainty and a larger degree of active specificity, a tendency to find vertical structures exists. This theory could also be applied to highway cargo transport, and is aligned with the results obtained by the model developed in this work.

The model developed and applied through a case study from a large shipper shows that the preferred level is 70% cost in relation to benefit, and the strategy of partial verticalization through the subcontracting of third parties had the best performance (93). Total verticalization presented a cost of 13% higher to

the winner, and because of this, was the least preferred strategy in the proposed scenario with a performance of only 31, in the opinion of the group. Intermediate solutions, such as partial verticalization with active participation by third-party operators, proved to be preferred when the benefit had more weight in the decision, and was also the second alternative classified in the case study.

The method developed shows the capacity to work with objective principles, criteria, and variables encountered in decisions about verticalization. Although the value curves and evaluation of alternatives were developed for a specific situation, the proposed model could be used in similar situations with value curves adjusted to the necessities of each shipper. The analyses presented reinforce that the decisions, albeit subjective, can be quantified. It would be difficult to arrive at whatever result through a mere price chart, and due to this, when using qualitative data drawn from the multiple-criteria approach, the result can be visualized in the clearest manner possible.

Despite the theoretical references of ECT and MCDA being amply diffused, this type of analysis is normally studied through statistical analysis and numerical quantification of attributes, respectively. Still, the model developed essentially considered the opinions of various agroindustrial logistics managers, applied to a specific case study, and capable of bringing a satisfactory result. It would effectively be more adequate if the modeling considered only exact attributes like costs, for example. However, the creation of value curves and evaluation based on value allows the decision-makers to quantify preferences, even though they may be subjective. In addition, the multiple-criteria approach permits a graphic analysis and a better comparison between existing trade-offs.

The descriptive development of highway transport of agricultural grain is currently a point of departure for a more profound study of the changes that will accompany the regulation of the sector. The organizations that are active in this environment will require studies that facilitate the best competitive design so that investments will not be stifled, and that will contribute to the evolution of this segment that remains so very vital to the Brazilian economy.

Regarding the recommendation of future work, it is suggested that a montage of new studies be conducted, considering diverse environments and situations which could explore all alternatives. This research would expand frontiers, compare and contrast highway transport in different countries, or even different regions of Brazil, and then the model could be applied in situations that are seemingly more regulated. The possible variations presented showed that the cost significantly changes the result. Perhaps, in this light, an intriguing opportunity exists to develop fresh alternatives aiming to minimize costs and this complete this line of research.

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