TIMBER SUPPLY FOR PULP PRODUCTION: AN APPLICATION OF TRANSACTION COSTS ECONOMICS

Ana Raquel Bueno Moraes Ribeiro [1]
Luiz Carlos Estraviz Rodriguez [2]
Decio Zylbersztajn [3]

ABSTRACT

The Brazilian pulp and paper sector is characterized by an upstream vertical integration, i.e. firms produce the timber they need in order to supply the industrial plants. The elimination of tax incentives to reforestation, at the end of the 80's, raised production costs in forest plantations substantially, favoring the development of a new integration structure more dependable on third party contractors. Based on a quantitative model, the empirical case study demonstrates that three aspects – asset specificity, frequency and transaction uncertainty – supported the company decision to maintain a predominantly hierarchical wood supply strategy, even in the absence of tax incentives to reforestation.

Key words: vertical integration, transaction costs, pulp, wood, tax incentives

1 Introduction

The matter of choosing between alternative organization forms of production (vertical and non-vertical, i.e. hierarchical and contractual) has gained importance over the last decades. The importance is either

[1] Agronomist, MS in Applied Economics ESALQ/USP
[2] Agronomist, PhD in Forest Biometrics and Management UGA, Associate Professor ESALQ/USP
[3] Agronomist, PhD in Economics NCSU, Associate Professor FEA/USP

academical, due to theoretical controversies, or empirical due to private sector demands for a solution. In this context, the New Institutional Economics comes as the main theoretical reference to explain the decision process between organizational forms, and the Transaction Cost Economics (TCE) as its more specialized research branch (Azevedo, 1996).

An interesting example of organizational change was observed in a very important pulp and paper company, which will be the focus of this paper. The recent evolution of the supply composition of the Suzano Pulp and Paper Co. shows that between 1993 and 1996 there was a significant modification in the governance structure used to manage wood supply. During that period, the participation of wood harvested in owned areas dropped from 89% to 72% of the total amount consumed.

In this paper, the governance structure of the wood supply system in the Suzano Co. was analyzed. The study of a Brazilian eucalyptus pulp agribusiness was developed following Harvard University's *agrichain* concepts and *transaction cost economics (TCE)* principles. More specifically, an answer is given to the following question: given the new institutional environment observed after the elimination of the reforestation tax incentives, and the specificity level of the involved assets, is it more advantageous to buy wood or to produce it?

The work results in (i) the study of a fundamental transaction for the Eucalyptus pulp industrial sector, the wood supply chain; and (ii) the development of a quantitative model to correctly estimate the relationship between *proxies* to transaction costs and transaction attributes. Both results are illustrated in a real study case.

2 A Quantitative Model to Choose Among Governance Structures

Riordan and Williamson (1985) presented the reduced form of a model to empirically test the basic propositions of the TCE theory.

Besides continuing advances brought by empirical studies, its main limitation, the lack of more rigorous quantitative analysis, is still to be overcome. Some quantitative studies have searched for numerical evidences to corroborate TCE hypotheses, but they have avoided the estimation of function that relate transaction costs and attributes to each governance structure.

Undoubtedly, the quantification of transaction attributes and costs is very problematic, given the level of subjectivity of some attributes and the difficult to measure total transaction costs.The problem of measuring transaction costs and attributes when the objective is to relate organizational strategies to transaction characteristics can be resolved by using *proxies* to these variables.

Particularly in this paper, where the central discussion refers to institutional changes that can alter the prevailing organizational structure to an empirically non-observable structure, it is impossible to use traditional econometric models. To express the effect of the institutional changes being studied, this paper recurred to the calculation of indirect estimates of the values used in the function to relate transaction costs and attributes.

The quantitative analysis presented in this paper was done based on estimates to transaction cost values and assets specificity. The other two attributes (frequency and uncertainty), cited by Ribeiro (1998), were not incorporated in the quantitative model given that they had not altered significantly during the period of analysis.

Next sections describe the assets specificity and transaction costs estimates that will allow for the use of a numerical analysis model to describe the governance structure based on TCE principles.

2.1 Asset Specificity

The main types of specificity related to wood assets in the pulp mill supply transaction chain are three: physical, locational and asset

appropriateness. Ribeiro (1998) clearly demonstrates the existence of such asset specificity when he compares the value of pulpwood to the value of the same wood when destined to other alternative uses. The analysis was developed individually for each specificity type, meanwhile, in practice, they occur simultaneously at delivery time in the pulp mill.

Each specificity type corresponds to several characteristics of the transactional asset and, therefore, corresponds to the same product. It is possible to characterize three wood products, varying the specificity level discretely:

(i) Eucalyptus wood that complies with the mill volume demand (asset appropriateness specificity), without physical and locational specifications;

(ii) Eucalyptus wood that complies with the mill volume demand and comes from an economically adequate transportation distance (asset appropriateness and locational specificity);

(iii) Eucalyptus wood that complies with volume and transportation demands, but also possesses the most desirable physical and chemical characteristics (asset appropriateness, physical and locational specificity).

Once established the specificity level, it is possible to imagine a continuous graduation, from the wood product that do not reach the mill volume demand (k_0), to a specific wood type that totally satisfies the mill demands, distance and wood quality (k_3). This graduation corresponds to one of the dimensions needed to define the function that relates asset specificity and transaction costs (k_0, k_1, k_2, k_3).

The wood characterization and its corresponding specificity level identify the contribution, in terms of cost reduction, that each product offers to the business. The contribution of higher levels of specificity is detailed in Table 1.

Table 1. Logical structure of the wood specificity calculation

Specificity level	Harvested wood cost	Transportation cost $F_2<F_1$	Conversion factor $T_2<T_1$	Wood participation in pulp cost $Y_3<Y_2<Y_1$	Specificity value (k)
	(US$/st[1])	(US$/st)	(st/ton pulp)	(US$/ton pulp)	(pulp kg/US$)
(1) = Asset appropriateness	C_1	F_1	T_1	$Y_1 = (C_1 + F_1) T_1$	$k_1 = 1000/ Y_1$
(2) = (1) + + Locational	C_1	F_2	T_1	$Y_2 = (C_1 + F_2) T_1$	$k_2 = 1000/ Y_2$
(3) = (2) + + Physical	C_1	F_2	T_2	$Y_3 = (C_1 + F_2) T_2$	$k_3 = 1000/ Y_3$

Obs: 1 estereo(st) = 1 m^3 pilled

The first column in Table 1 presents different levels of wood specificity when it is used as the main raw material to produce pulp. In (1) the wood complies only with the appropriateness requirement. The wood value in this case is compounded of the harvest cost (C_1), including direct and indirect plantation, silvicultural and cutting costs, and maximum and viable distance transportation cost (F_1). The sum of C_1 and F_1 costs is multiplied by a maximum acceptable wood-pulp conversion rate (T_1). The wood-pulp conversion rate reflects the amount of wood necessary to produce one ton of pulp.

In (2), the wood transaction considers raw material that is also a locational specificity. In this case, more specificity allows for a reduction on transportation costs, from F_1 to F_2, corresponding to the difference between the largest and smallest distance, respectively.

In (3), wood incorporates physical specificity. That is, wood quality is such that there are significant gains in the industrial process. Therefore, the consumption of this type of wood results in more pulp with lower levels of volume inputs, reducing the conversion rate from T_1 to T_2.

Values C_1, F_1 and T_1 predefine the minimum acceptable specificity level k_1 to the company. In other words, wood located outside the economical range of distances to the company (transportation costs larger

than F_1), or wood from tree species other than the accepted by the industrial process (conversion rates larger than T_1), present a low specificity level. Levels k_2 and k_3 correspond to wood with higher specificity levels, meaning that the allocation of this type of wood to other uses would certainly reduce its value.

It is important to note that this form of specificity evaluation results in adequate analysis scales. Product specificity tends to zero when wood costs are too high and, otherwise, can reach infinite values when wood costs are tool small.

The suggested method to evaluate specificity can also be used to analyze the impact of reforestation tax incentives. Tax incentive legislation had granted significant reduction costs on wood production during the 70's and 80's, being part of the total costs paid by public funds. Cost reductions are incorporated in the suggested specificity evaluation method by subtracting planting and silvicultural costs from the total wood production cost.

Availability of reforestation tax incentives shifts function curves in the *specificity* x *transaction* cost graph. The analysis of these shifts can be the basis for the impact study of eliminating tax incentives over the governance structure for wood transactions.

The determination of specificity levels defines only one of the needed dimensions. The next section presents criteria for evaluating the second dimension (transaction costs).

1.1 Transaction costs

Cheung (1990)[4], cited by Azevedo (1996), presents transaction costs as (a) contract elaboration and negotiation, (b) property rights quantification and monitoring, (c) performance monitoring, and (d) activities organization. To these costs, Azevedo (1996) adds the costs of inefficient adaptations to the economic system.

[4] Cheung, S. (1990) On the New Institutional Economics. In: Cheung, S. *et alii.* Contract Economics, 48-75 p.

The activities described by Cheung (1990) and Azevedo (1996) are realized internally by the set of management areas responsible for the adequate bureaucratic functioning of the firm. In the case of forestry companies, "adequate functioning of the firm" means the guaranteed supply of wood that attends the characteristics of volume, cost and quality. Therefore, there are different areas in the bureaucratic structure of the firm, which are not directly related to production, that have to guarantee each wood characteristic or specificity.

The cost of some management areas in forest companies is directly related to the supply process, i.e., with the commitment to deliver the specificity demanded by the pulp mill (appropriateness, physical and locational specificity). Therefore, these costs can be used as a *proxy* to transaction costs. This is indicated in Azevedo (1996):

> "... it is enough to observe the internal expenditures on controlling and monitoring workers activities to verify how relevant internal transaction costs are to the company. Supervisor salaries, presence cards and auditing procedures can be cited as examples that show the firm's preoccupation with the adequate execution of its internal contracts, which translate into economic cost."

It is important to realize that internal bureaucratic costs and transaction costs are not exactly equal. Mainly because the cost of inefficient adaptations to changes in the economic system is not captured by internal bureaucratic costs. Another limitation of using these costs as a proxy to transaction costs is the undesirable inclusion of some transformation costs.

In this study the classification of the bureaucratic areas in the company was done based on the Natural Resources Division (NRD) annual budget. This budget lists all costs of each area, including salaries, fees, office supplies, traveling, training, consultants' honorariums and equipment depreciation.

Of all areas in the firm, those responsible for the k_1, k_2 and k_3 specificity levels were identified. The Operational Forest Division and Procurement Division deal with the delivery of wood to the mill (k_1).

The first division is responsible for the production of the company's own wood, and the second one guarantees the total wood volume consumed by the pulp mill buying it from other producers.

Only management costs in the Operational Forest Division (OFD) were considered in the calculation of the value used as a proxy to the transaction costs. Hence, transformation costs in operations like planting, fertilization, weed control and harvest were not included in the calculation. It is necessary to point out that all management functions in the Operational Forest Division exist only because of its function in the hierarchical governance structure adopted by the firm. Otherwise, it was considered that the wood is supplied by a contractual governance structure regulated by contracts, under the responsibility of the Procurement Division.

The strategic location of the forests to be harvested is accomplished jointly by the work of the two already mentioned divisions and the services of the Planning, Inventory and Control (PIC) Division. Stepping from specificity level k_1 to k_2 implies in more than choosing areas close to the pulp mill to plant or harvest. Specificity level k_2 depends on obtaining, managing and controlling information about production areas, forming a detailed data base to subsidize the analysis of each area, the creation of volume prediction models and the planning process. The planning, inventory and control areas are completely independent from production activities, although both benefits from informational and strategic services provided by the database maintained by the PIC division. The maintenance costs of these services were considered in the calculation of the transaction costs.

The third specificity level is obtained considering all previous services plus the work of the Research Division (RD), which generate costs that account for the difference between k_2 and k_3. The RD professionals determine technical directions and monitor wood quality to achieve the best results in the pulp production process. It is in this sense that RD costs add to the total transaction costs. The fact that research

activity is capable of producing physical gains, originated for example by genetically improved trees, was not ignored in this paper. Total RD costs were accounted as transaction costs, even though overestimating the real value, because it is practically impossible to account for the exact amount returning as benefits. This is one point that has to be improved in future developments of this approach.

Total transaction costs estimates are presented in Table 2. For each specificity level it is informed which areas and correspondent costs were considered. It is also demonstrated how costs from supportive areas were distributed among the three specificity levels.

Alternative organizational forms for wood supply to pulp mills are constrained to hierarchies and contracts by the forest legislation, as described by Ribeiro (1998). Estimated functions for some different combinations of these two governance types were adjusted considering the 0% to 100% interval, with 10% increments. Functions were adjusted for both scenarios, with and without tax incentives.

Table 2. Transaction costs (TC) estimations for each *k* level

Divisions	Specificity Level		
	k_1	k_2	k_3
Operational	A	A	A
Plan, Inv.		B	B
& Control			
Research			C
Procurement	D	D	D
Subtotal	$E_1 = A + D$	$E_2 = A + B + D$	$E_3 = A + B + C + D$
Supportive*	$S_1 = S\ (E_1 / E_3)$	$S_2 = S\ (E_2 / E_3)$	$S_3 = S$
Total	$TC_1 = E_1 + S_1$	$TC_2 = E_2 + S_2$	$TC_3 = E_3 + S_3$

* S = Total cost from supportive services of other divisions (generic administrative costs).

Costs used as proxies to transaction costs were extracted from the 1996 budget, where costs are monthly described. Costs appropriation for the present governance (70% hierarchical and 30% contractual) structure followed the directions presented in Table 2. Costs were similarly estimated for the remaining scenarios, and based on the present governance structure. Therefore, for each case, the total cost in each division (Operational, PIC, Research, Procurement and Supportive) were proportionally adjusted according to the hierarchical composition of the governance structure.

Once the values for the two dimensions, transaction costs and asset specificity, were determined, the respective functions were easily adjusted. These estimated functions for each governance structure are presented in the next section.

3 Quantitative Model Application and Results Analysis

High levels of asset specificity tend to reduce transaction costs for the hierarchical structures. This happens because the investment in specific assets enhances the tendency of opportunism, and transactions made in a vertically integrated (hierarchical) structure reduce this phenomenon, compared to transactions made in the market by contracts (Masten, 1994).

The preliminar analysis suggests the test of the following hypothesis: The absence of tax incentives to reforestation elevates production costs[5], and stimulates the reduction of hierarchical integration. However, high transaction costs from contractual structures (because of transaction characteristics) may induce the company to keep the hierarchical integration as the main governance structure.

[5] Rigourously, production costs in this paper are transformation costs. According to Azevedo (1996), production costs are the sum of transaction and transformation costs. Transformation costs include all cost necessary to transform production factors into products, not considering the acquisition cost of these factors and transaction cost to sell the products.

The hypothesis was tested after adjusting an exponential model relating transaction cost and specificity:

$$ln\ TC_G = ln\ a + k\ ln\ b$$

where: TC_G = transaction cost for governance structure G
a e b = function estimated parameters
k = specificity value

The estimated values for the parameters a and b are shown in Tables 3 and 4, for the scenarios with and without tax incentives, respectively. Estimated functions for three hierarchical structures (100%, 30% and 0% external timber acquisition) and two scenarios, with and without tax incentives, are shown in Figures 1 and 2.

Table 3. Function parameters for the scenario without tax incentives

Scenarios	Governance Structure (%)		Parameters		R^2
	Hierarchical	Contractual	a	b	
1	0	100	0.000009	3.062400	0.999
2	10	90	0.000025	2.775822	0.997
3	20	80	0.000065	2.540628	0.995
4	30	70	0.000158	2.344083	0.992
5	40	60	0.000358	2.177344	0.987
6	50	50	0.000767	2.034075	0.981
7	60	40	0.001568	1.909613	0.974
8	70	30	0.003077	1.800445	0.963
9	80	20	0.005828	1.703875	0.950
10	90	10	0.010700	1.617798	0.933
11	100	0	0.019123	1.540545	0.911

In both figures, results confirm the predictions of the TCE theory. Higher levels of asset specificity involve higher transaction costs for all

governance structures, especially for contractual structures. Low levels of asset specificity are associated to lower transaction costs in contractual structures.

Table 4. Function parameters for the scenario with tax incentives

Scenarios	Governance Structure (%)		Parameters		R^2
	Hierarchical	Contractual	*a*	*b*	
12	0	100	0.000018	2.652917	0.999
13	10	90	0.000058	2.374154	0.999
14	20	80	0.000164	2.156297	0.998
15	30	70	0.000416	1.982039	0.996
16	40	60	0.000966	1.839927	0.993
17	50	50	0.002084	1.722104	0.988
18	60	40	0.004225	1.623025	0.982
19	70	30	0.008127	1.538668	0.975
20	80	20	0.014943	1.466057	0.964
21	90	10	0.026430	1.402944	0.950
22	100	0	0.045201	1.347603	0.931

Source: Research data

Considering the production costs in several countries, the aim of the company was to maintain costs close to US$ 215 / ton of pulp (Ribeiro, 1998) to become competitive. Considering also that 40% of this cost corresponds to timber production, the specificity was evaluated at 11.6 kg pulp/US$[6]. This value is used as a reference to choose the governance structure in a situation without tax incentives.

With tax incentives, pulp production costs were lower. It was possible to produce more pulp for each dollar invested, and consequently the specificity value was higher. Without tax incentives Ribeiro (1998) calculated that the costs would increase 16%, and the specificity value would climb to 13.4 kg pulp/US$.

[6]Formulas in Table 4 show that, for Y=(21*0.40), k = 1000/(215*0.40) = 11.627907.

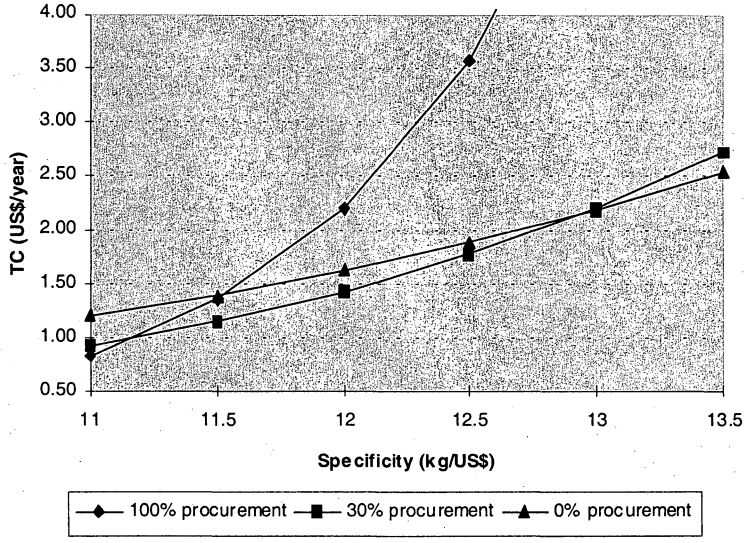

Figure 1 - Governance structures without tax incentives

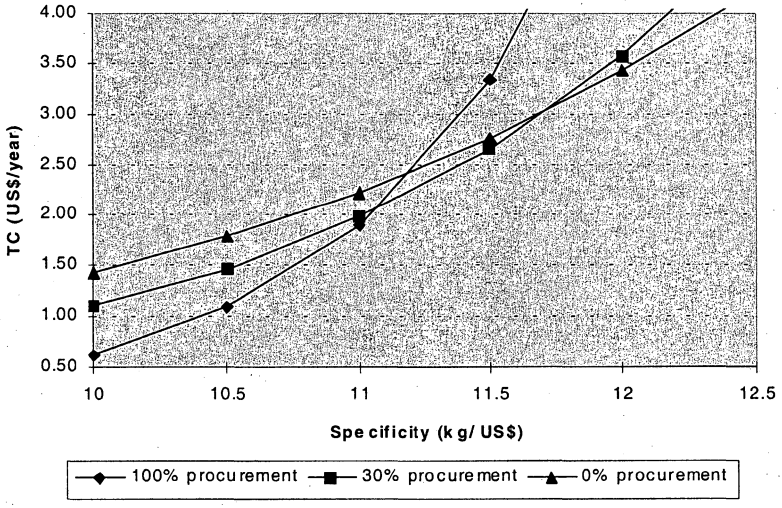

Figure 2 - Governance structures with tax incentives

According to Figure 2, during the period with tax incentives, the lowest cost structure that corresponds to a 13.4 kg pulp/US$ specificity level is the hierarchical integrated structure. During that time, the company made a great effort to produce 100% of the timber needed by the plant, although they have never succeeded in this task. However, seven years after the end of tax incentives, in 1993, the supply composition gradually changed. The volume of external timber increased, pointing to a reorganization of the governance structure. Considering that seven years is the time needed for a forest to be harvested (average rotation length), the changes in the supply structure of 1993 results from changes in the planted areas since 1986, exactly when tax incentives ended.

Therefore, strong evidences suggest that changes in the supply governance structure presented above were originated by institutional changes induced by the end of tax incentives. The impacts of such changes are now discussed. Figure 2, compared to Figure 1, shows that the end of tax incentives determined an elevation of transaction costs for all governance structures. For the 11.6 kg pulp/US$ specificity level, there are governance structures of lower transaction costs than 100% hierarchical integrated. The lowest is a mix of 80% integration and 20% contracts.

Other mixes of hierarchical and contractual integrations, composed mainly by vertical integration, show similar effects, meaning that some variations can still occur. What is not expected is a change to structures with timber supply based totally on contracts. These results corroborate the hypothesis that the less expensive structure would basically be vertically (hierarchically) integrated.

4 Conclusions

This paper used theoretical concepts from the Transaction Costs Economics (TCE) theory to analyze the pulp mill wood supply process in two historical moments. These moments, characterized by different institutional environments, represent the period of time when the pulp

industry was being established in Brazil, and reforestation tax incentives were still prevailing, and the present moment when tax incentives do not exist any more and national markets were opened favoring international competition.

In a very objective way, the elimination of tax incentives has resulted in costs elevation, given that the government is not paying for a significant part of the forest production costs anymore. This raising in forest production costs occurs in a moment when the level of competitiveness (sustainable and for the long term) is also high and affects all participants of the industrial system.

The model presented in this paper fits reasonably the needs to analyze the impacts of reforestation tax incentive elimination over wood supply transactional governance structures. Results obtained with the model were coherent with TCE theory and reality.

Results show that the studied company chose the most adequate governance structures on both periods of analysis. One hundred percent hierarchical governance structures were more efficient when reforestation tax incentives were still available, otherwise, a supply strategy based on a 80%-hierarchical and 20%-contractual structure becomes more adequate.

Other significantly hierarchical structures have similar performances. Small variations in the supply composition can be expected due to changes in legal regulations, although a total shift to one hundred percent contractual structures are very unlikely. This paper confirmed the hypothesis that even after the elimination of the reforestation tax incentive, the lowest cost governance structure would still be predominantly hierarchical.

In theoretical terms, the model proposed in this paper shows a simple form to evaluate transaction costs and attributes, which is also coherent with TCE theory. Therefore, this paper contributes to reduce some of the criticism, providing a quantitative application of TCE principles. It is a specific model, suited for one single application, which can be extended to other study cases or industrial systems analysis.

The calculation of the specificity value, as suggested in this paper, may need a few adjustments when applied to other studies. However, the definition of specificity as the "product quantity / invested monetary value" ratio is a valid approach that preserves the fundamental concept of value loss when the asset is used in other alternatives in which the asset is less specific.

For further studies, the development of more applications based on the principles set by the Transactional Cost Economics theory is suggested. TCE offers a set of realistic and consistent analytical tools, which are coherent with well-succeeded corporate behavior. The development of quantitative empirical work based on TCE concepts will help companies in the decision process and will promote robust theoretical advances.

5 References

AZEVEDO, P.F. Integração Vertical e Barganha. São Paulo, 1996. 219p. Tese (Doutorado) - Faculdade de Economia e Administração, Universidade de São Paulo.

BACHA, C.J.C. A Dinâmica do Desmatamento e Reflorestamento no Brasil. Piracicaba, 1993. 236p. Tese (Livre Docência) - Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo.

CAIXETA FILHO, J.V. Mercado de Fretes e Roteamento de Cargas Florestais. Material de apoio ao curso ministrado no II Programa de Reciclagem em Métodos Quantitativos IPEF Piracicaba, 1996.

LARSON, E.D.; RODRIGUEZ, L.C.E.; AZEVEDO, T.R. Farm Forestry in Brazil. Apresentado ao BioResources '94 Biomass Resources: a means to sustainable development, Bangalore, India, Oct. 3-7, 1994.

MACEDO, A.R.P.; MATTOS, R.L.G. A Trajetória de Crescimento dos Principais Produtores Brasileiros de Papel e Celulose - 1970/94 Revista BNDES Setorial, n.3, 49-72p., Mar 1996.

MASTEN, S.E. Empirical Research in Transaction Cost Economics: Challenges, Progress, Directions. Versão preliminar preparada para Conference on TCE and Beyond Rotterdam, Jun 1994. 27p.

RIBEIRO, A.R.B.M. Abastecimento de Madeira para a Produção de Celulose: Uma Aplicação da Economia dos Custos de Transação. Piracicaba, 1998. 117p. Dissertação (Mestrado) - Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo.

RIORDAN, M.H.; WILLIAMSON, O.E. Asset Specificity and Economic Organization. International Journal of Industrial Organization, n.3, p.365-78, 1985.