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Own machinery versus outsourcing in Southern Brazil - a transaction cost approach

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Abstract
The mechanization of agricultural production plays an important and over time increasing role in the course of agricultural and rural development. Mechanization offers a number of potential improvements to farming systems such as increased land and labor productivity, reduction of risks, and increase quality and food safety of animal and plant products. Yet, investments in own machinery, in particular for smallholders, may not be the least-cost option in comparison with outsourcing the required machinery services through different contractual relationships. For choosing the optimal contract for the procurement of machinery services, conventional machinery costs as well as transaction costs need to be evaluated. The main objective of the research presented here is to assess the role of transaction costs in the choice among alternative contractual arrangements for provision of machinery services. Our hypothesis is that TC are important cost elements and influence the choice of contractual arrangements for provision of machinery services together with machinery costs. The empirical data on conventional machinery and transaction costs were collected from farms in Southern Brazil that procure services for maize harvest through various informal and formal contractual forms. We show that transaction costs can influence the choice of contractual arrangements.

1. Introduction
With the Green Revolution the use of modern inputs like seeds, mineral fertilizers, pesticides and mechanization increased rapidly around the world, even in smaller farm units. In Southern Brazil however these small farms are in a process of integration into the market economy, which has been accelerated by the formation of MERCOSUR in 1991 since it provided new opportunities as well as led to increased competition. Increased competition induces farmers to reduce the costs of production and improve the quality and quantity of production. The mechanization[1] of different agricultural activities can be seen as strategy used by farmers to improve their competitiveness. Agricultural machinery is a non-divisible technology, and its adoption is strongly related to farm size. For small farms of Southern Brazil, with a much diversified

[1] Mechanization understood as the use of engine powered machines.

agricultural production on areas of less than 100 hectares, they are often too small to own all the needed machinery (Klingensteiner 1982).
Transaction cost theory (Williamson 1985) suggests that assets with relatively high initial investment costs and high specificity in use such as specialized machinery that can be only used for particular crops, will likely be sourced through contract services rather than through asset ownership. For Southern Brazil, these specific and expensive technologies are mainly harvesting machinery (combines, which are very expensive, and silage harvesters[2], which are very specific as they only can be used for the maize harvest) ((Wander 2001), (Wander and Zeller 2001)).
The major objective of this paper is to assess the role that transaction costs play in the optimal choice of the contract. Next we distinguish different elements of transaction costs, and discuss for the case of machinery services their expected importance. In the empirical part, we present data on conventional machinery costs as well as transaction costs that the principal author collected from farms in Southern Brazil.

2. Conceptualizing machinery and transaction costs

The main approach includes calculating the fixed and variable machinery costs and the assessment of the transaction cost when hiring machinery services.
The machinery costs, as shown by Brandes/Woermann, include different elements, which can be divided into fixed and variable costs (Brandes and Woermann 1971). The fixed costs include depreciation, interest and insurance. The variable costs include fuel, lubricants, repairs and salary of operator. Labor is considered as a variable cost element, because the operators not only operate this machine, but doing any kind of work.
For comparing among alternative contract choices, two different situations have to be considered: 1) farmers already own the needed machinery but seek whether hiring is cheaper and 2) farmers want do decide whether to buy or hire machinery services. We concentrate on the second case. For farmers who need decide between to buy the machines or to hire machinery services specially the depreciation and opportunity costs of capital as components of fixed costs become very important. In our case both, fixed and variable costs, are included in the comparison between owning and hiring machinery services.
Hiring machinery services represents a transaction and therefore the resulting costs (TC) also have to be considered. The TC can be all kind of efforts that have to be done to enable machinery services on a farm. The TC can also be divided into fixed and variable TC. As fixed TC the setup costs of an institution that enables an alternative contractual choice to be offered. Fixed TC do not include the price of the machine. Here, we assume that TC for buying the own machinery are negligible and therefore must not be included. Therefore the variable TC represent all expenditures occurring while using an existent short or long-term contractual choice for hiring machinery services. Our study considers only variable TC, because fixed TC are beyond the scope of the paper and had to be measured empirically unless data is collected during the formation of machinery services institutions. Our conceptualization of resulting TC when hiring services is based on the contributions of various authors like (Williamson 1985), (Alchian and Demsetz [1972]1999), (Barzel 1982), (Beckmann 2000) and (Shelanski and Klein 1995) considering the following attributes:

- *Asset specificity*: The extent, to which the investment in a certain type of machinery is limited to certain crops and/or activities;
- *Uncertainty*: The importance of issues such as timeliness;

[2] One-row tractor mounted silage corn harvesters.

- *Frequency*: The frequency with which the machine is used (number of transactions) over a year;
- *Complexity*: The complexity of the contracts between the transaction partners that are appropriate to assure their satisfaction;
- *Measurability*: The possibilities of the farmer receiving the service of the machine to measure the quality of this service;
- *Level of investment*: The amount of capital to be invested in each contract form to have access to services;
- *Length of contractual relationship or amortization period*: For how long are farm activities limited through the decision choosing a certain contractual arrangement to have access to mechanization (Zeller 1990).

Focussing on silage harvester we attempt to assess qualitatively the above characteristics determining TC. The main contractual agreements for provision of services can be divided into three groups:

- *Market arrangements*: A market transaction occurs, if a farmer hires a machine from a provider without establishing any relationship with the provider. In a typical agricultural setting, this pure "spot market" for machinery services does not appear to be very relevant, because the farmers may continuously hire machinery from the same provider, thus establishing a relationship. Between the available contractual arrangements farmer contractors represent the most market-oriented solution. But even here some relationships between provider and client can be found. In some cases the farmers prefer to re-use the same farmer contractor because of the established relationship. This leads to the following type of governance structure.
- *Hierarchical arrangements*: If a farmer purchases the machine for his farm, one can interpret this as a "hierarchical arrangement" in Williamson's (Williamson 1985) sense because the transaction is organized within the farm enterprise (hierarchy) rather than hired in form of a market transaction. If a farmer establishes a long-term relational contract with an enterprise to hire in machinery services, this can also be considered as a hierarchical arrangement.
- *Co-operative arrangements***:** In principle it is useful to consider three different types of co-operative arrangements: (a) informal sharing (= sharing of machinery and work between neighbors without cash payment, which in the region occurs mainly on farms with smaller area), (b) farmer groups (= informal group of farmers, who buy machinery together and use it within the group. Often extended family members and neighbors) and (c) Cooperatives (= formal organized larger group of farms, where farmers are members and pay annual fees and the machinery belongs to the cooperative[3]).

3. Methodology

The empirical research on determining machinery and transaction costs was carried out in the central region of the Brazilian State Rio Grande do Sul. The region was part of the first mechanization program in the early 1970s and is also characterized through small scale mixed farms (less than 100 ha). In total, 121 farms contracting services were randomly selected and enumerated. A sub-sample of seven farms using machinery services for harvest was randomly selected to enumerate TC. Three farms of the sub-

[3] In the Brazilian case, mechanization co-operative covers the area of 500 square kilometers and has approximately 50 to 300 members. The formation of these co-operatives was state-induced.

sample used services with silage harvester. They are the data basis of our paper. The data was collected through standardized interviews.

4. Results and discussion

Table 1 shows that for contracting services with silage harvesters mainly asset specificity, the need for group activities and special hold-up effects can result in high amounts of TC when contracting services with silage harvester.

Based on that the expected TC for hiring services with silage harvester can vary considerably depending on the selected contractual arrangement ((Hayami and Otsuka 1993) and (Lyons 1994)) for provision of services (table 1). From the attributes listed in table 1, asset specificity, group activities and special hold-up are of special interest when analyzing owning versus outsourcing of services with silage harvesters.

After table 1 the *informal sharing* of machinery (without monetary payment) is characterized by low transaction costs resulted through the classical attributes. It is even more recommendable when considering the need for group activities and the risk of special hold-up[4], as it can happen for silage harvesting. Only the length of contractual relationship or amortization period seems to be a weakness of this agreement, because of the inter-dependence (farmer receiving services depend on it as well as farmer providing services could be dependent on the receiving labor or whatever he receives as return for provided services).

From transaction costs point of view, *farmer groups* seem to be an interesting solution for providing services with silage harvester when considering uncertainty, frequency, complexity, measurability and specially cover the needs for group activities and avoid hold-up. However, asset specificity and longer planning time as well as higher investment level, if compared to other outsourcing forms, are important weaknesses of this form.

Co-operatives, understood as self-help organizations setup by farmers, but with much more members than a group, on the one side still maintain to some extent, the main strengths of groups (cover requirements of group activities and avoid hold-up) and the weaknesses of the groups (asset specificity, needed length of contractual relationship to amortize investments and investment level) are less intensive. On the other side, they reduce the negative effects of weaknesses of farmer contractors (uncertainty, covering the needs for group activities and the risk of hold-up).

Asset specificity, shorter length of contractual relationship to amortize investment and lower investment level are strengths of *farmer contractors*. Therefore, the weaknesses of farmer contractors are to be found on aspects like uncertainty, needed complexity of contracts, low measurability of services, insufficient possibilities to cover the required group activities and the risk of special hold-up effects.

As has been mentioned, the silage harvesters are tractor mounted, so tractor costs have to be included. Table 2 shows the average costs for both (tractor and harvester), including labor costs of R$ 2.00[5] per hour for operating the tractor, when using own machinery. For calculation of conventional machinery costs, the most frequent tractor and silage harvester types in the research region were considered[6].

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[4] Special hold-up occurs when an interruption of service may cause the client to loose all received service up to the interruption.

[5] This is the going wage rate (opportunity costs of farmers); at field research time (January 30, 2000) R$ 1.00 = US$ 0.55.

[6] Tractor: acquisition value (P) is R$ 22,000, service life is 20 years or 10,000 hours, residual value is R$ 1,000, yearly usage of 400 hours; Silage harvester: acquisition value is R$ 4,000, service life is 8 years, residual value is R$ 400; Common: interest rate for invested capital is 15% per year.

Table 1 Importance of attributes of transactions as factors explaining the choice for or against this type of contractual arrangement for provision of services with silage harvester in Southern Brazil 1999/00

TC-Attribute	Informal sharing	Farmer groups	Co-operatives	Farmer contractors
Asset specificity	+	---	-	++
Uncertainty	+	++	+	---
Frequency	+	+	-	-
Complexity	+	+	-	--
Measurability	+	++	-	--
Group activities	++	+++	+	---
Special hold-up	++	+++	+	---
Planning time	-	---	-	++
Investment level	+	--	-	++

"+" indicates that attributes favours the choice of this contractual arrangement, while "-" indicates that the attribute discourages the choice of this agreement.
Source: Own work based on (Williamson 1985), (Alchian and Demsetz [1972]1999), (Barzel 1982), (Beckmann 2000) and (Shelanski and Klein 1995).

Table 2 Conventional costs of own machinery for silage harvest in Southern Brazil stratified by the intensity of use of harvester, 1999/00

Costs for own silage harvester*	Hours of service during one year					
Fixed costs	***25***	***50***	***75***	***100***	***150***	***200***
*Fixed costs per hour (R$/h)***	*34.60*	*17.30*	*11.53*	*8.65*	*5.77*	*4.33*
Variable costs						
Lubrificants (R$/h)	0.65	0.65	0.65	0.65	0.65	0.65
Repairs (% of P)	*0.059*	*0.068*	*0.076*	*0.085*	*0.103*	*0.120*
Repairs (R$/h)	2.35	2.70	3.05	3.40	4.10	4.80
Variable costs per hour (R$/h)	*3.00*	*3.35*	*3.70*	*4.05*	*4.75*	*5.45*
Total costs own harvester (R$/h)	**37.60**	**20.65**	**15.23**	**12.70**	**10.52**	**9.78**
Total costs own tractor (R$/h)			**16.90**			
Costs of tractor + harvester (R$/h)	**54.50**	**37.55**	**32.13**	**29.60**	**27.42**	**26.68**

*At the time of field research (January 30. 2000), R$ 1.00 was equivalent to US$ 0.55. The fixed costs per year was estimated to be R$ 865.00 (R$ 40.00 for shed which is 1% of acquisition value, R$ 40.00 for insurances, R$ 462.50 for depreciation, and R$ 322.50 for interest calculated, at 15% per year).
Source: Own research.

Figure 1 shows the evolution of the machinery cost curves when using own silage harvester, when using it among a farmer group as well as when contracting service from farmer contractors and co-operatives (both, as member and as non-member) depending on the usage intensity per year. The system tractor-harvester needs 6 hours to harvest one hectare of silage corn. According to table 2 and figure 1, the main cost degression effect of owning silage harvester (or even in farmer groups) is reached until an usage of 50 hours per year i.e., up to 8 hectares of harvested silage corn.
Considering conventional machinery costs, owning individually the harvester would only be cheaper than contracting services from a farmer contractor or from a co-operative (non-member) if at least 9 hectares (54 hours of usage per year) of corn could be harvested. For farmers who are members of a co-operative, which offers this service, using this service would always be cheaper than owning the harvester independently of

the usage intensity. If a farmer has the possibility to use his overcapacity to offer services to other farmers, it could also be economically interesting to buy the harvester with smaller areas of silage corn production.

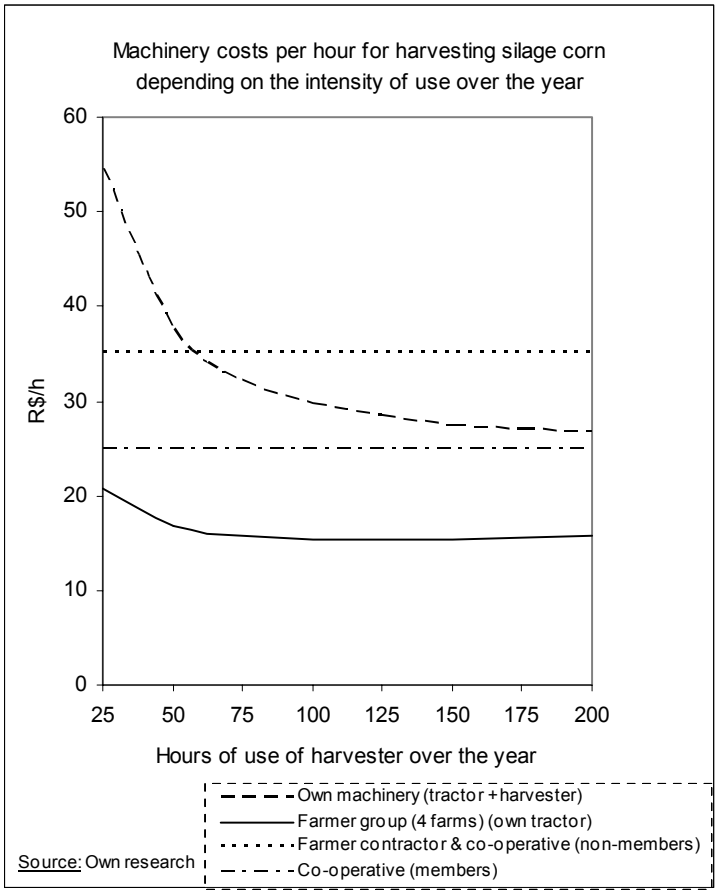

Figure 1 Machinery costs per hour (R$/h) for harvesting silage corn (tractor + harvester) in Southern Brazil, 1999/2000

As shown in figure 1, the farmer group is characterized by the lowest machinery costs for all considered intensities of usage i.e., cultivation areas. But if the costs of machinery are so low, why do not all farmers prefer this agreement to mechanize their silage harvest? To answer this, we must look at transaction costs resulting through outsourcing the silage harvesting technology. First, we consider the costs for contacting the potential providers, and therefore need to consider the time spent (opportunity costs of labor), traveling expenses and phone calls. Secondly, we need to consider losses due to delay in starting harvest. Therefore we base our calculation on the contribution of Hanf (Hanf 1985), who estimates losses of 1 to 2% per day for cereals. For silage corn these losses are even higher, because plants become too dry to enable a good silage quality, and we assume losses of 3% per day due to delay in starting harvest. Third, we consider the costs of dislocating the machine from provider to client, if client has to cover it. Fourth, losses due to not optimally adjusted implements have to be included. Fifth, costs of additional tractor, when using the own tractor for harvesting, then another tractor has to be contracted for transportation and compactation and vice-versa.

In table 3, we attempt to present an exemplary calculation of the amount of TC for silage corn harvesting for farmer 24 of our sample with respect to alternative contracting arrangements (state or farmer contractor).

As can be seen in table 3, the TC for contacting providers are comparatively low, if compared to losses due to delay in starting harvest and costs for additional tractors, if needed. As the example shows, the TC are not only important as, but even much higher than the conventional machinery costs. We see that such arrangements, which seem to be cheap, like the state, where no fees for harvester are asked for, the total costs per

hectare for harvesting silage corn can be much higher than when using a farmer contractor.

Table 3 Main TCs for outsourcing silage corn harvesting technologies and their amount in comparison to the conventional machinery costs by of the chosen contractual arrangement on farm 24, 1999/00

TCs for outsourcing silage harvester	Available providers & resulting TC (R$ per year)	
	State	Farmer contractor
1) Contacting provider:		
- Time consumption	4.00	-
- Phone calls	2.50	-
- Traveling expenses	10.00	-
2) Losses due to delays in time[1)]	2,795.40	559.08
3) Dislocation of machine[2)]	30.68	-
4) Losses during harvest	-	-
5) Costs for additional tractor[3)]	750.00	460.20
Sum of TC	3,607.58	1,019.28
Conventional machinery costs[4)]	460.20	540.00
Total costs	4,067.78	1,559.28
Relation: TC/total costs	88.7%	65.4%
Total cost per hectare	813.56	311.86

(1) 3% x (days of delay) x 150 tons (potential production: 5 ha x 30t/ha) x R$ 62.12 (total production costs of one ton silage including gross margin for soybeans); (2) State: 2h x 14.34 (conventional cost of one hour for own tractor); (3) State: 30h x R$ 25.00/h (hired tractor) and farmer contractor 30h x R$ 15.34/h (own tractor); (4) State: 30h x R$ 15.34/h (own tractor) (no fees to pay for harvester). Farmer contractor: 30h x R$ 18.00/h (including tractor, harvester and operator).

For the other two farms of our sub-sample, who also hired services with silage corn harvester, the situation is similar: when using the state, more than 75% of the total costs are TC. Both other farms also have co-operatives as alternative contractual arrangements. Even there, the total costs per hectare are high. The contractual arrangement with the lowest total costs (conventional costs and TC) for harvesting silage corn found in our study was the farmer group (R$ 216/ha on farm 103). But even there 73% of the total costs where TC.

5. Conclusions

TC are difficult to measure. But they can and should be estimated. TC are important cost elements in decision process concerning the contract choice for outsourcing harvesting technology for silage corn or own investment. Specially the losses due to delay in starting harvest as well as the risk of hold-up effects, and the need for group activities (machines and labor) leads farmers to prefer self-help arrangements like farmer groups, and sometimes co-operatives to provide the needed services with silage harvester.

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