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Contractual arrangements and transaction costs: The case of smallholder mechanization in Southern Brazil

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Abstract

The mechanization of agricultural production plays an important and in course of time increasing role in the course of agricultural and rural development. Mechanization offers several potential improvements to farming systems such as increased land and labor productivity, reduction of risks, and increase of quality and food safety of animal and plant products. However, investments in own machinery, in particular for small holders, may not be the least-cost option in comparison with outsourcing the required machinery services through different contractual relationships. To choose the optimal contract for obtaining machinery services, it is necessary to evaluate conventional machinery costs as well as transaction costs. The main objective of this research was to assess the role of transaction costs in the choice among alternative contractual arrangements for provision of machinery services. Our hypothesis was that transaction costs can be higher than machinery costs, and therefore, they can play a leading role in the choice of contractual arrangements for provision of machinery services. The empirical data on conventional machinery and transaction costs were collected from farms in Southern Brazil that procure services for corn harvest through various informal and formal contractual forms. We found that transaction costs can be higher than conventional machinery costs, and therefore, influence the choice of contractual arrangement.

Keywords: contractual arrangements, outsourcing machinery, transaction costs, mechanization

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 these small farms are in a process of integration into the market economy, with increasing competition by the formation of MERCOSUR in 1991. The mechanization 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. Farmers with small areas of arable land tend to decide to contract services for machinery instead of buying all machines and implements. Their decision is based on a comparison of marginal costs and marginal return. The smaller the area of arable land to mechanize, the higher the marginal costs and the lower the marginal returns. This leads many farmers in Southern Brazil to look for providers of services for certain machinery types (KLINGENSTEINER, 1982).

Transaction cost theory (WILLIAMSON, 1985) suggests that assets with relatively high initial investment costs, and high specificity, 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[1], which are very specific as they only can be used for the corn harvest) (WANDER, 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 value. In the empirical part, we present data on conventional machinery costs as well as transaction costs for one farm.

2. Conceptual framework

During economic development, the opportunity costs of work of on-farm labor will increase (TSCHAJANOW [CHAYANOV] [1923], 1987). Increasing opportunity costs of work lead to the search for activities, where work is better remunerated. The mechanization of on-farm activities enables such higher remuneration.

Several authors have reviewed some reasons for mechanization (FAO, 1985; HOLTKAMP et al., 1978; STEINMANN, 1988; and WIENECKE and FRIEDRICH, 1982). These are: a) the possibility to introduce new production patterns, which could not have been introduced trough traditional methods; b) the expansion of cultivated area; c) the improvement of quality; d) the reduction of losses; e) the acceleration of work, if there is a time limit to carry out certain activities, increasing potential yields or reducing potential losses; f) breaking work points; g) economizing area of fodder production; h) facilitate the work to farmers; i) the efficient use of other yield improving inputs (seeds, fertilizers and pesticides); j) price gains through improved quality and increased quantity).

The main approach for deciding on own machinery versus outsourcing, at smallholder level, includes calculating the fixed and variable machinery costs and the assessment of the transaction costs when machinery services are hired.

The conventional machinery costs 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 (in the case of family labor, the opportunity costs of this labor).

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 or not and 2) farmers want do decide about buying or hiring machinery services. We focus in this paper on the second case as this is more relevant. For farmers who need to 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 while "a transaction occurs when a good or service is transferred across a technologically separable interface" (WILLIAMSON, 1985). Therefore the resulting transaction costs (TCs) also should be considered. The TCs can be all kind of efforts that have to be done to enable machinery services on a farm. The TCs can also be divided into fixed and variable TCs. Fixed TCs are the setup costs of an institution that enable an alternative contractual choice to be offered. Fixed TCs do not include the price of the machine. The variable TCs represent all expenditures occurring while using an existent short or long-term contractual choice

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

for hiring machinery services. Our study considers only variable TCs, because fixed TCs are beyond the scope of the paper and would have been hard to measure empirically unless data is collected during the formation of machinery services institutions. Our conceptualization of resulting TCs 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). These authors consider the following attributes influencing transaction costs:

- *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;
- *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 in order to have access to services;
- *Length of contractual relationship or amortization period influencing strategic flexibility*: For how long are farm activities limited through the decision choosing a certain contractual arrangement to have access to mechanization (ZELLER, 1990).

Focusing on silage harvester we attempt to assess qualitatively the above characteristics determining TCs. 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 of information asymmetries. Farmers prefer to continuously hire machinery from the same provider with whom they establish a relationship of trust. Farmer contractors represent the most market-oriented solution among the available contractual arrangements. But even here some social relationships between provider and client can be found, built on trust and interest in long-term customer relationship.

- *Hierarchical arrangements*: If a farmer purchases the machine for his farm, one can interpret this as a "hierarchical arrangement" in WILLIAMSON'S (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[2]).

3. Methodology of data collection

The empirical research on determining machinery and transaction costs was carried out in the central region of the Brazilian State Rio Grande do Sul. This region represents one of five areas, where in the 1970s the first state induced mechanization cooperatives (APSAT[3]) had been set-up. Because of the pioneer role that APSAT cooperatives played in the introduction of mechanization services into small farms in Southern Brazil, we expect that mechanization is widely spread and more developed there, than in regions without such cooperatives. Therefore this region suits particularly well for our research agenda.

The universe of our research is all farms of the research region that have used any kind of outsourcing machinery for their on-farm activities in 1998/99. The sampling frame

[2] 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.
[3] APSAT means Association of Provision of Services and Technical Assistance.

was obtained through expert interviews with representatives from rural extension services, cooperatives, banks, ministry of agriculture and farmer contractors. From the sampling frame, a sample of 121 farms were randomly selected and enumerated. Based on data from IBGE (1996), this sample represents about 23% of all farms that outsourced agricultural machinery.

Through a standardized questionnaire the socio-economic data concerning the household, the farm activities and available resources was collected. This data was collected between September 1999 and March 2000.

After this first research step, we focused our analysis on harvest machines because many different contractual arrangements for provision of harvesting services could be observed in the research region. From the first sample we randomly selected a subsample of seven farms using harvesting services in 1998/99. By stratifying the sample, we ensured that different situations – farms using outsourcing only, farms using own machinery and outsourcing, and farms contracting and offering services as farmer contractors – had been included. The data on transaction costs for harvesting services was collected between April and June 2000.

4. Results and discussion

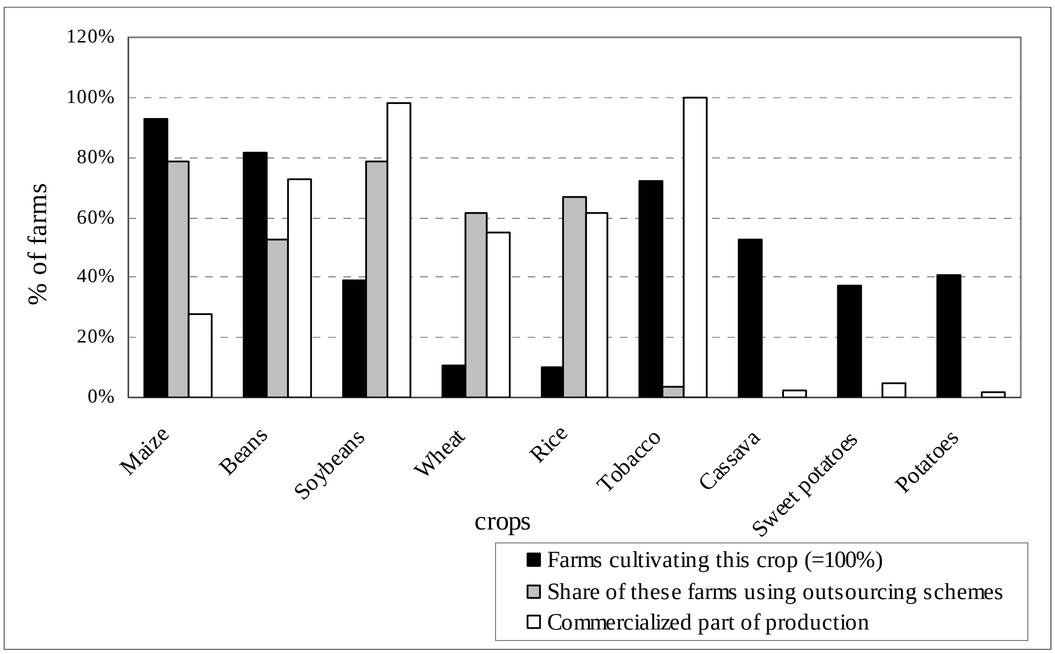
4.1 Farming systems and on-farm activities

The farm-households in our first sample (121) have on average 35.7 hectares (4 to 200, median of 24.0 ha) of total land area. From that total area, on average 27.6 ha (2 to 180 ha, median of 18.5 ha) represent arable land.

In the Centro-Serra region, mechanized activities include soil preparation, planting, crop protection, fertilization and harvesting. Soil preparation takes place above all on smaller plots, where subsistence crops like cassava, potatoes and sweet potatoes and cash crops, like tobacco, are cultivated. Planting, crop protection, fertilization and harvesting activities are mechanized mostly in the cultivation of corn, beans, soybeans, wheat and rice. For tobacco only the soil preparation was mechanized. Other cash crops like soybeans were mechanized by all cultivating farms. Field crops, like corn, beans, wheat and rice, are used as fodder as well as cash crops. They were also frequently mechanized.

Figure 1 shows the major field crops and the share of cultivating farms with use of any scheme outsourcing of machinery for its cultivation. Corn, beans, tobacco and cassava were encountered on more than 50% of farms. Outsourcing of machinery plays an important role in cultivation of corn, soybeans, rice, wheat and beans. Tobacco was also cultivated by many farmers, but almost without any outsourcing of machinery. The commercialized part of tobacco production is 100%. But also for soybeans, beans, rice and wheat the commercialized part of production is high. For corn, cassava, potatoes and sweet potatoes the commercialized part is low, especially because the last three crops are cultivated almost for subsistence only. Corn is cultivated in large scale by many farms, but mainly as fodder (grains, silage).

Figure 1. Cultivated crops, use of outsourcing schemes for its cultivation and commercialized fraction of production



Source: own research

We observe that market oriented crop production is more subject to mechanization. Tobacco represents an exception, because although it is a cash crop, its cultivation is being carried out by manual labor (except for soil preparation) as the harvest cannot be mechanized. Recently, soil preparation is being substituted for no-tillage systems in the study region.

4.2 Contractual arrangements for provision of machinery services

Having shown for which crops mechanization occurs more frequently, we analyze next the machinery ownership and contractual forms for outsourcing different types of machinery. From the 121 sample farms, 63 (52%) own at least one own tractor. Table 1 shows the needed machines and/or implements for each type of work that was mechanized in the farms considered, as well as the proportion of farmers using their own machine/implement or using outsourcing schemes.

It is possible to observe in Table 1 that soil preparation and drilling after tillage become mechanized by those farmers, who own the needed machines. A completely different situation occurs with activities such as no-tillage seed drilling, crop protection, organic fertilization and lime application, and harvest, where more than 50% of the farms with mechanization use outsourcing forms. We concentrate on machines, which first, are contracted by more than 20% of farmers, and secondly, those with more than one outsourcing form. Bulk lime spreader and slurry tank spreader are also not further considered, because of the small number of using farmers, besides the fact that only state institutions offer this service.

Table 1. Mechanized activities and respective machine/implement, and proportion of farms, which in 1998/99 mechanized it with their own equipment and contracted services for it

Activity and respective machine/implement	Farms (N=121)					
	With mechanization (n)		With own machinery*		With outsourcing	
	#	% of N	#	% of n	#	% of n
Soil preparation						
Ploughing / disc plough	50	*41*	50	*100*	-	-
Harrowing / disc harrow	51	*42*	51	*100*	-	-
Cultivating / heavy tine cultivator	40	*33*	40	*100*	-	-
Rotary tilling / rotary tiller	10	*8*	10	*100*	-	-
Drilling/planting						
Drilling after tillage / tillage seed drill	13	*11*	13	*100*	-	-
Direct seeding / no-tillage seed drill	89	*74*	32	*36.0*	57	*64.0*
Crop protection						
Dessication / field sprayer	88	*73*	38	*43.2*	50	*56.8*
Crop protection strictly speaking / field sprayer	54	*45*	23	*42.6*	31	*57.4*
Fertilization						
Lime spreading / bulk lime spreader	6	*5*	-	-	6	*100*
Slurry spreading / slurry tank spreader	17	*14*	5	*29.4*	12	*70.6*
Fertilizer broadcasting / fertilizer broadcaster	10	*8*	10	*100*	-	-
Harvesting						
Threshing / stationary thresher	94	*78*	45	*47.9*	49	*52.1*
Ripping and threshing / combine harvester	74	*61*	4	*5.4*	70	*94.6*
Silage harvesting / forage corn harvester	29	*24*	2	*6.9*	27	*93.1*

* A proportion of the machinery owners offer services to other farmers (informal sharing or farmer contractors).

Source: Own data

Based on these criteria no-tillage drilling, crop protection and harvest technologies will be further analyzed. Table 2 shows the most frequently mentioned service provider for these technologies. Additionally the capital outlays, which are connected with the purchase of machine, are presented.

The field sprayer is almost an universal implement because it can be used for applying herbicides as well as for spraying fungicides, insecticides and leaf fertilization. In addition, the sprayer also implies the lowest investment among the most important machines and implements. Nevertheless, only 38 of 88 (43%) farmers who use sprayers have their own sprayer (Table 1). How can this be explained? One reason is to be found in the fact that the field sprayer in combination with the no-tillage seed drill represents a technology package. They are usually found together since first weeds are desiccated and about three weeks later the no-tillage drilling takes place. And as is also evident in Table 2, the investment for the purchase of a no-tillage seed drill becomes substantially higher than for a field sprayer. The larger investment, together with the higher asset specificity, explain, at least in part, why only 32 of 89 (36%) of the farms using them have purchased their own no-tillage seed drill (Table 1).

Although the forage corn harvester with R$ 4,000 represents a lower investment than the no-tillage seed drill, it is characterized by a high asset specificity, i.e., it can be only used for harvesting silage corn, while the no-tillage seed drill can be used for most field crops (corn, black beans, soy beans and wheat). This may explain the low proportion of farms which have their own forage harvester (2 of 29 farms using them = 7%). As expected, almost half of the farms use a forage corn harvester shared within a group of farmers. A large proportion of the farms receive this service from state institutions. As will be shown in the next section, the rates demanded for the service by the state institutions are far under what other providers (e.g., cooperatives) ask for because of government subsidies. The strongly subsidized services of the state in the preceding years affected the already existent self-help arrangements (farmer groups and cooperatives). Sometimes, the much lower rates made the subsidized services preferable, causing a few self-help organizations to collapse. The fixed TCs – TCs to set-up such arrangements – were surely not taken into account by the local government.

The stationary thresher represents at R$ 3,000 a small investment. It is a relatively specific machine which is used in the region principally to thresh the black beans. Nevertheless 45 of 94 (48%) of the farms own their thresher. That is primarily because many of these farms become active as contractors. These farmer contractors represent the most important provider of services with stationary threshers in the study area (Table 2).

Table 2. Main contracted machinery by type of provider in the Centro-Serra Region (RS, Brazil) 1998/99

Machine/implement		Providers of machinery services*)				
Type	Value (R$)**)	Informal sharing	Farmer contractors	Cooperatives	Farmer groups	Prefeitura***)
Field sprayer (n=50)	2,000	2.9 (*1*)	55.9 (*28*)	5.9 (*3*)	35.3 (*18*)	-
No-tillage seed drill (n=57)	5,000	1.8 (*1*)	45.6 (*26*)	5.3 (*3*)	24.6 (*14*)	22.8 (*13*)
Stationary thresher (n=49)	3,000	8.0 (*4*)	88.0 (*43*)	4.0 (*2*)	-	-
Combine harvester (n=70)	30,000	-	75.7 (*53*)	20.0 (*14*)	4.3 (*3*)	-
Silage corn harvester (n=27)	4,000	7.4 (*2*)	-	11.1 (*3*)	48.1 (*13*)	33.3 (*9*)

n = Number of farms asking for services with the respective machine/implement. (N=121 farms).
*) Values in % (numbers in bracket represent quantity) of n.
**) Value of a new machine/implement except the combines, which normally are bought as second-hand machines from large farms of neighbours regions (exchange rate according to http://www.oanda.com January 30, 2000: 1.0 R$ = US$ 0.55).
***) Local government of the municipalities.
Source: Own research.

Respecting the combine harvester, it is to be said that it represents the most expensive machine with high asset specificity. Moreover, the high investment ensures that only four farms out of 74 (5%) employing them have their own combine. Therefore farmer contractors and machinery cooperatives are particularly suitable, as is also demonstrated in Table 2.

Farms which individually own the machines and devices as specified above can offer their surplus-capacities to other farms as a service. This occurs mostly as informal sharing or farmer contractors. This means that sometimes it concerns the same farms (farmers who own machines can be, at the same time, the providers mentioned by other farmers using machinery services from farmer contractors or as informal sharing).

4.3 The role of transaction costs in comparison to conventional machinery costs in the choice of outsourcing form in the case of forage corn harvester

With respect to contracting services with silage harvesters, mainly asset specificity, the need for group activities and special hold-up effects can result in high amounts of TCs when contracting services with silage harvester (Table 3).

Because the expected TCs for hiring services with a silage harvester can vary considerably, depending on the selected contractual arrangement (HAYAMI and OTSUKA, 1993, and LYONS, 1994) for the provision of services (Table 3). Of the attributes listed in table 1, asset specificity, group activities and special hold-ups are of special interest when analyzing buying versus outsourcing of services for silage harvesters.

According to Table 3, the *informal sharing* of machinery (without monetary payment) is characterized by low transaction costs resulting from the classical attributes. It is even more recommendable when considering the need for group activities and the risk of special hold-ups[4] as can happen for silage harvesting. Only the length of the contractual relationship or amortization period seems to be weaknesses of this agreement because of the inter-dependence (the farmer receiving services depend on them as well as the farmer providing services can also be dependent on receiving labor or whatever else he may receive as return for services provided).

Viewed from transaction costs, *farmer groups* seem to be an interesting solution when providing services with silage harvester, considering uncertainty, frequency, complexity, measurability and especially to cover the need for group activities and avoid hold-ups. However, asset specificity and longer periods of time necessary for planning as well as higher investment levels, if compared to other outsourcing forms, are important weaknesses of this form.

Co-operatives, understood as self-help organizations set up by farmers, but with many more members than a group, still maintain on the one hand to some extent the main strength of groups (cover group activities requirements and avoid hold-ups) while the weaknesses of the groups (asset specificity, needed length of contractual relationship to amortize investments and investment level) are less intensive. On the other hand, they

[4] Special hold-ups occur when an interruption of services may cause the client to lose all received services up to the interruption.

reduce the negative effects of weaknesses of farmer contractors (uncertainty, covering the needs for group activities and the risk of hold-ups).

Asset specificity, shorter terms of contractual relationship to amortize investments and lower investment levels are strengths of *farmer contractors*. While, the weaknesses of farmer contractors are to be found in aspects such as uncertainty, required 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 4 shows the average costs for both (tractor and harvester); including labor costs of R$ 2.00[5] per hour for operating the tractor when the farmers' own machinery is used. To calculate conventional machinery costs, the most frequent tractor and silage harvester types in the research region were considered[6].

Table 3. Importance of attributes of transaction costs by type of contractual arrangement for provision of services with silage harvester in Southern Brazil 1999/00

TCs-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 4. Conventional costs of own machinery for silage harvest in Southern Brazil stratified by the intensity of use of harvester, 1999/2000

Costs for own silage harvester*	Hours of service during one year					
Fixed costs	**25**	**50**	**75**	**100**	**150**	**200**

[5] This is the going wage rate (opportunity costs of farmers); at time of field research (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.

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 the field research (January 30. 2000), R$ 1.00 was equivalent to US$ 0.55.

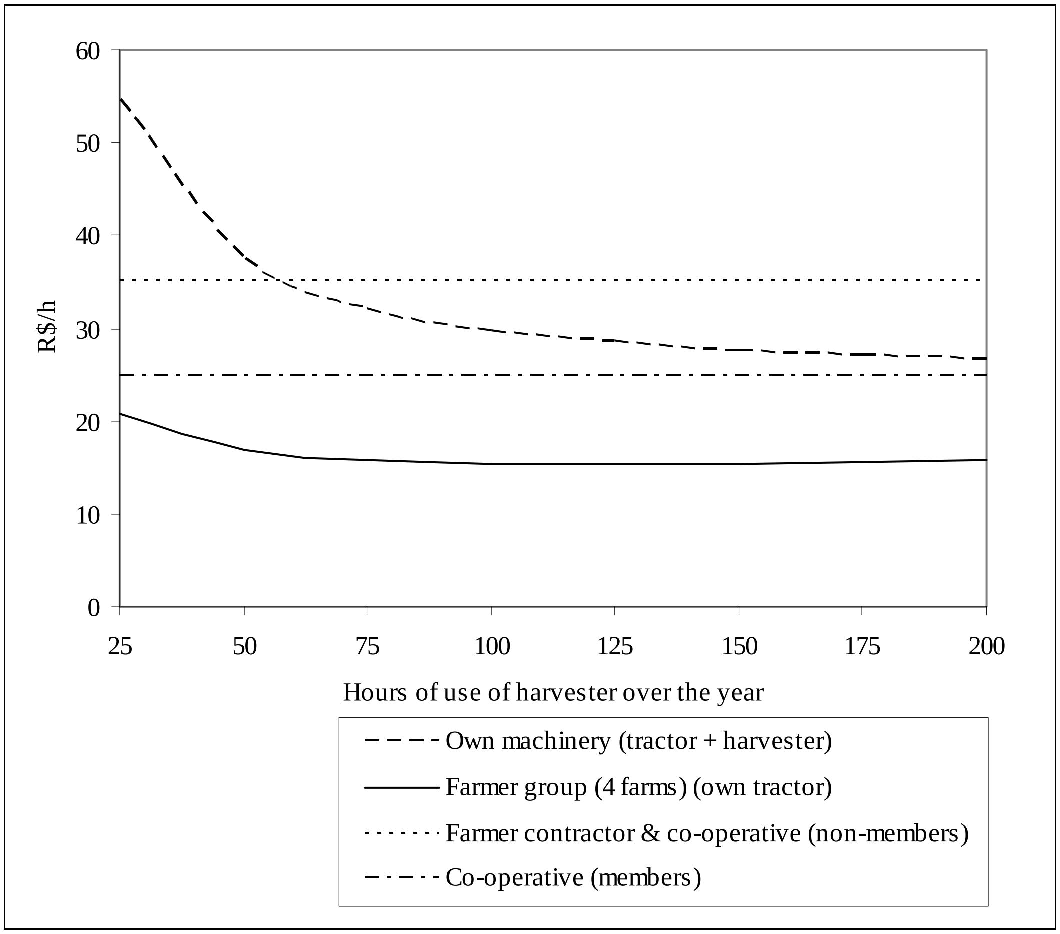
**) The fixed costs per year where estimated to be R$ 865.00 (R$ 40.00 for shed which is 1% of acquisition value, R$ 40.00 for insurances, R$ 462.50 for depreciation, and R$ 322.50 for interest calculated at 15% per year).

Source: Own research.

Figure 2 shows the evolution of the machinery cost curves when using one's own silage harvester, when using it with a farmer group as well as when contracting services from farmer contractors and co-operatives (both as a member and as a non-member) depending on the usage intensity per year. The system tractor-harvester needs six hours to harvest one hectare of silage corn. According to Table 4 and Figure 2, the main degressive effects on cost of owning a silage harvester (or even in farmer groups) is reached by usage of 50 hours per year, i.e., up to eight hectares of harvested silage corn.

With respect to conventional machinery costs, individually owning a harvester would only be cheaper than contracting services from a farmer contractor, or from a co-operative (non-member) if at least nine 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 independent 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 despite smaller areas of silage corn production.

Figure 2. Machinery costs per hour (R$/h) for harvesting silage corn (tractor + harvester) in Southern Brazil, 1999/2000



Source: own research

As shown in Figure 2, 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 the farmers prefer this agreement to mechanize their silage harvest? To answer this question, we must look at transaction costs resulting through outsourcing the silage harvesting technology.

First, we have to consider the costs of contacting the potential providers and, therefore, need to consider the time spent (opportunity costs of labor), traveling expenses and phone calls. Second, we need to consider losses due to delays when starting the harvest. Therefore we base our calculation on the contribution made by HANF (1985), who estimates losses of 1-2% per day for different 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 delays in beginning the harvest. Third, we consider the costs of bringing the machine from the provider to the client, if the client has to pay them. Fourth, losses due to not optimally adjusted implements have to be included.

Fifth, costs of an additional tractor when using one's own tractor for harvesting because another tractor has to be contracted for transportation and compression and vice-versa.

In Table 5, we attempt to present an exemplary calculation of the amount of TCs 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 5, the TCs for contacting providers are comparatively low if compared to losses due to delays in beginning to harvest and costs for additional tractors if needed. As the example shows, the TCs are not only as important as, but even much higher than the conventional machinery costs. We see that in such arrangements which seem to be cheap, such as for the state where no fees are asked for a harvester, the total costs per hectare for harvesting silage corn can be much higher than when employing a farmer contractor.

Table 5. Main TCs of contracting silage harvesting technologies and their amount in comparison to the conventional machinery costs by the chosen contractual arrangement; the case of farm 24, 1999/00

TCs for outsourcing silage harvester	Available providers & resulting TCs (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 TCs	3,607.58	1,019.28
Conventional machinery costs[4)]	460.20	540.00
Total costs	4,067.78	1,559.28
Relation: TCs/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 in our sub-sample that also hired services with silage corn harvesters, the situation is similar: when using the state offer, more than 75% of the total costs are TCs. Both farms also had co-operatives as alternative contractual arrangements and even in that case, the total costs per hectare where high. The contractual arrangement with the lowest total costs (conventional costs and TCs) for harvesting silage corn found in our study was the farmer group (R$ 216/ha on farm 103). But even here, 73% of the total costs where TCs.

Of course, these three farms of the last sub-sample are case studies only, and therefore, they should not be considered as reference when analyzing transaction costs. It is not possible to generalize it. Each case has to be analyzed separately to see if transaction costs are really of crucial importance.

5. Conclusions

TCs are difficult to measure, but they can and should be estimated. TCs can be higher than conventional machinery costs, and therefore, they are important cost elements in the decision-making process concerning the choice of contract for outsourcing harvesting technology for silage corn or own investment. Especially the losses due to delays in beginning the harvest as well as the risk of hold-up effects and the need of group activities (machines and labor) lead farmers to prefer self-help arrangements such as farmer groups and, sometimes, co-operatives to provide the needed services with silage harvesters.

The estimates of TCs done cannot be generalized. Each farm has different conditions and, therefore, has to be analyzed separately.

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