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Production and milk marketing strategies of small-scale dairy farmers in the South of Rio Grande do Sul, Brazil

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Abstract

Milk production is a socio-economically relevant activity for many small-scale family farms in southern Brazil. The objective of this study was to analyse their production and marketing strategies. A questionnaire was administered to 199 farm households in Rio Grande do Sul State to collect information on farm assets and activities, and particularly on the contribution of milk sale to farm income. Through categorical principal component analysis and two-step clustering, farmers were classified into three types: farmers selling only milk (M); farmers selling cash crops and milk (CM); farmers selling cash crops and surplus milk (Cm). Cattle herd (heads) and size of pasture land were larger on M farms (114 ±71.9; 51 ±49.4 ha) than on CM (31 ±13.4; 9 ±8.9 ha) and Cm (12 ±7.5; 5 ±8.1 ha) farms. Livestock husbandry contributed 71, 59 and 16 % to family income on M, CM and Cm farms, respectively. Daily milk production of the individual cow depended on the area cultivated with fodder maize (ha per cow; $p \leq 0.001$), on sale of milk to cooperatives or to private companies ($p \leq 0.01$), on summer pasture area (ha per cow; $p = 0.001$) and on daily amount of concentrates offered (kg per cow; $p \leq 0.01$). These results indicate that the area available for fodder cultivation is a key factor for milk production on small-scale dairy farms in southern Brazil, while concentrate feeding plays a less important role even for highly market-oriented farms. This must be accounted for when exploring options for strengthening the regional small-scale milk production, in which dairy cooperatives do play an important role.

Keywords: dairy cattle, dairy companies, dairy cooperatives, family farms, farm income, pasture area, resilience

1 Introduction

Currently, almost 50 % of the global cow milk production is concentrated in the USA, India, China, Brazil, Germany, Russia, France and New Zealand (Gerosa & Skoet, 2012). In 2012, Brazil ranked fourth and produced 32.3 million tons of milk from around 22.8 million cows in lactation, with an average annual production of 1417 litres per cow and year (FAOSTAT, 2015). Milk is the sixth most important agricultural commodity in Brazil, and the dairy value chain plays an important role for food supply, job creation and income generation. The sector employs about 4 million people (Fundação Banco do Brasil, 2011) and for each 1 Brazilian real (R$) increase in the value of the milk supply chain an increase of 5 R$ can be expected in the Brazilian Gross Domestic Product (Vilela *et al.*, 2001). Nevertheless, Brazil's dairy sector is of surprisingly low profitability for producers (Fundação Banco do Brasil, 2011). This is in part due to the heterogeneity of production systems, since only 2.3 % of the farms that are specialised in milk production operate modern produc-

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tion systems, whereas 90 % of the milk producers are small-scale farmers with low production volumes, low productivity per cow and limited use of modern technology (*ibid.*).

Until the late 1980s, most milk processing plants were run by farmer cooperatives, producing cheese, powdered milk and UHT milk. The dairy sector in Brazil massively changed in the 1990s when governmental intervention ended, the national currency stabilised, the MERCOSUL/MERCOSUR (Southern Common Market) was created (1991) and the country joined the World Trade Organization (1995). The competition of the private sector with national and multinational companies resulted in an increase in milk production, partly also as a reaction to increasing milk demand. Data for the country's twelve major dairy companies indicate that the number of suppliers reduced by 28 % whereas the milk supply per farm increased by 37 % between 1996 and 1998 (Costales *et al.*, 2008). However, after market liberalisation, many of the local cooperatives could not compete with multinational dairy companies and were thus sold to the latter (Farina, 2002). By the second half of the 1990s, the market share of cooperatives had dropped to 60 %. Despite these developments, by 2008 the cooperatives still collected around 40 % of all milk processed in the country (Costales *et al.*, 2008) and involved more than 1.3 million of mostly small-scale farmers (OCB, 2013).

To increase milk quality, a new national policy was implemented in the early 1990s, which obliged producers to invest in on-farm milk cooling and storage in order to meet international standards. This policy, the general market liberalisation and the increasing competition on the milk market were important causes for the decrease in the number of small-scale dairy farms from 1.8 million in 1996 to 1.4 million in 2003 (Matthey *et al.*, 2004; Costales *et al.*, 2008). Even despite these developments, 80 % of the dairy farmers manage 50 % of the national dairy herd until today, all keeping a maximum of ten cows. Only about 10 % of the dairy farmers keep more than 30 cows – they manage 30 to 35 % of the national dairy herd and produce 30 to 40 % of the national milk yield (Costales *et al.*, 2008).

Milk production within the country is geographically concentrated in six of the 27 federal states: Minas Gerais, Rio Grande do Sul, Goias, Sao Paulo, Parana and Santa Catarina. Accounting for about 12 % of the national milk production, Rio Grande do Sul ranks second among the milk producing states (Zilli & Candaten, 2016). Of the milk produced in Rio Grande do Sul, 57 % comes from small-scale farms, where land property is less than 100 ha, family labour prevails over hired labour and work is supervised by the farmer (Wagner *et al.*, 2004; MDA, 2009; MDA, 2013). Between 1996 and 2000, 26.8 % of these small-scale farmers abandoned milk production (Wagner *et al.*, 2004). However, this dropout was considered relatively moderate, partly explained by the fact that most small-scale farmers in Rio Grande do Sul are organised in cooperatives which secure market access and milk commercialisation (DESER, 2009). Cooperatives guarantee that farmers can sell any amount of milk without a minimum quantity required, because they are able to deal with private companies and larger markets more effectively than a single farmer.

Since dairy production still contributes significantly to household income of small-scale farmers in Rio Grande do Sul, this study aimed at analysing their current situation, thereby focusing on how milk production strategies of more specialised or more integrated farms and milk marketing via cooperatives or private dairy companies, are related to the size of the dairy herd, the area of land devoted to pastures, fodder or cash crops, and to inputs into the dairy unit. This analysis should provide insights into the future development of milk production as part of the income generating portfolio of the state's small-scale farms.

2 Materials and methods

2.1 Study location

The state of Rio Grande do Sul is located in the South of Brazil, comprising an area of 281,748 km^2. According to the 2010 census, the state's population amounted to 10.7 million with an average population density of 38 people per km^2 and its Human Development Index evolved from 0.49 in 1991 to 0.73 in 2010 (IBGE, 2010). The region's Gross Domestic Product (GDP) was 277.658 billion R$ (135.5 million US$) and the annual per capita income averaged 25,779 R$ (12,584 US$) in 2012 (IBGE, 2014). Agriculture plays an important economic role and in 2009 accounted for 10.1 % of the state's GDP (FEE, 2015). The main cities in the South of Rio Grande do Sul are Cangucu (31°23′ S, 52°40′ W), Pelotas (31°46′ S, 52°21′ W) and Sao Lourenco do Sul (31°22′ S, 51°59′ W). The low-lying region (7–500 m a.s.l.) is characterised by a humid subtropical climate with warm summers (December–February). A regular dry season is not observed and annual precipitation ranges from 1250–1600 mm with rainfall concen-

trated in the winter months (June–August, 350–500 mm per month; Defesa Civil do Rio Grande do Sul, 2011).

Dairy farming is the main livestock activity in the region, and little mechanised small farms operate alongside modernised and mechanised larger scale farms, all cultivating to different degrees tobacco, rice, soybeans, black beans and wheat, vegetables and fruits (Alonso & Bandeira, 1994; Sacco dos Anjos, 1995).

2.2 Baseline survey

A baseline survey addressing a total of 199 family farms was conducted from February to April 2010 in the rural surroundings of Pelotas ($n = 76$), Sao Lourenco do Sul ($n = 63$) and Cangucu ($n = 60$). The interviewees were chosen through snowball sampling whereby an initially interviewed farmer supplied names of three colleagues at the end of the interview; amongst these one person was then randomly selected for the next interview. Qualitative and quantitative information regarding family and farm size, household composition, education, crop cultivation, livestock activities, labour endowment, milk marketing strategies, off-farm employment, and membership in cooperatives were collected during the interviews with a pre-tested structured questionnaire.

2.3 Data analysis

The dataset originating from the survey contained ordinal, nominal and scale variables. Data was first subjected to categorical principal component analysis (CATPCA), in which categorical variables were simultaneously quantified while the dimensionality of the data was reduced. Thus, the original set of 204 variables was reduced to a set of 92 uncorrelated components that represented most of the information of the original variables.

After the CATPCA, a two-step cluster analysis was applied, which selected cattle herd size (n), amount of milk (L day^{-1}) produced per lactating cow at interview time, total pasture area (ha) and contribution of livestock income to overall family income (%) as determinant variables to classify dairy farms in the study region. The emerging three farm types were then compared for relevant variables using t-test for normally and Wilcoxon test for non-normal distributed variables. Results depict means and standard deviations (±), significance was declared at $p \leq 0.05$. All statistical analyses were computed in SPSS 19.0 (IBM Corporation, 2010).

Backwards stepwise multiple linear regression analysis was applied to test the impact of different independent variables on milk production, and the binary logistic regression model was used to predict the variables that affect farmers' decision to sell their milk to cooperatives or to private companies. The models were tested for linearity by inspecting the scatter graph, for normality of residues by the Kolmogorov-Smirnov test on unstandardized residuals, for residual auto-correlation by the Durbin-Watson test, and for homoscedasticity by the Pesaran-Pesaran test. Multi-collinearity of independent variables was also verified (Garcia, 2005). Outliers were excluded and missing values were replaced by the mean of that variable across the specific farm type. Variables in the model showed a non-normal distribution, presenting in all cases asymmetric distribution with positive skewedness. To correct asymmetric distribution, variables were ln transformed (*ibid.*). The fit of the final model was assessed by the model Chi-square (Model χ^2) and the goodness-of-fit test of Hosmer and Lemeshow (Archer *et al.*, 2006). Well-fitting models showed significance ($p \leq 0.05$) on the Model χ^2 and non-significance ($p > 0.05$) on the goodness-of-fit test.

3 Results

3.1 Farm types and characteristics of the dairy unit

From the cluster analysis three different types of farmers were identified, namely farmers selling milk only (M, $n = 7$), farmers selling cash crops and milk (CM, $n = 74$) and farmers selling cash crops and surplus milk (Cm, $n = 118$). Milk producers were mainly located near Pelotas (57 %), followed by Sao Lourenco do Sul (29 %) and Cangucu (14 %). CM farms were especially present in Sao Lourenco do Sul (43 %), followed by Pelotas (39 %) and Cangucu (18 %), while Cm farms dominated in Cangucu (43 %), followed by Pelotas (31 %) and Sao Lourenco do Sul (26 %).

Cattle herd size on M, CM and Cm farms averaged 114, 31 and 12 animals. Milk producers (M) owned more female cows aged > 24 months compared to CM ($p = 0.01$) and Cm farmers ($p = 0.007$). Significant differences between groups M, CM and Cm were also observed for the number of young females (≤ 24 months, $p = 0.029$), young males (≤ 12 months, $p = 0.002$) and adult males (> 12 months, $p = 0.04$). Average milk production of lactating cows at the time of interview varied from 5 to 11 litres per day, with insignificant differences between farm types (Table 1).

Cattle herd sizes on M, CM and Cm farms had increased by 2, 3 and 8 % during the 12 months preceding the interview, mainly because female calves were kept in the herd. Animals sold during the preceding 12 months

Table 1: *Size and composition of the cattle herd and milk production on three types of small-scale dairy farms in southern Rio Grande do Sul State.*

Variable	*Farm type*					
	M ($n = 7$)		*CM* ($n = 74$)		*Cm* ($n = 118$)	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Herd size (n)	114	71.9	31	13.5	12	7.5
Females > 24 months (n)	70	40.5	24	11.6	8	5.1
Females ≤ 24 months (n)	25	41.3	5	4.3	2	2.8
Males > 12 months (n)	14	11.1	1	2.3	1	1.8
Males ≤ 12 months (n)	5	11.2	1	2.3	1	1.8
Milk production (L cow^{-1} day^{-1})	11	10.3	7	4.1	5	4.3
Total milk per farm (L day^{-1})	705	641.3	172	125.4	34	32.8

Farm types: M = only selling milk; CM = selling cash crops and milk; Cm = selling cash crops and surplus milk.

Table 2: *Pasture area (ha per head of cattle) across three types of small-scale dairy farms in southern Rio Grande do Sul State.*

Farm type	*Total pasture land*		*Winter pasture area*		*Summer pasture area*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
M ($n = 7$)	0.45	0.212	0.30	0.124	0.10	0.004
CM ($n = 74$)	0.20	0.087	0.20	0.105	0.10	0.005
Cm ($n = 118$)	0.42	0.225	0.35	0.259	0.08	0.003

Farm types: M = only selling milk; CM = selling cash crops and milk; Cm = selling cash crops and surplus milk.

accounted for 15, 13 and 8 % of the cattle on M, CM and Cm farms.

Of the farmers (household heads, 83 % male and 17 % female) belonging to type M, CM and Cm, respectively, 29, 40 and 44 % had completed primary school, and 14, 4 and 3 % had completed secondary school. Twenty two and five percent of M and Cm farmers held a bachelors' degree, whereby education level was generally higher in women than in men. The family size was equal (4 ±1.7) on CM and Cm farms and slightly lower on M farms (3 ±1.4).

Milk producers managed larger areas (ha) of land (70 ±88.6) than CM (27 ±22.5) and Cm farmers (19 ±14.5; $p = 0.006$). Hectares of pasture land (Table 2) differed ($p = 0.008$) between farm types and averaged 51 ±49.4 (M), 9 ±8.9 (CM) and 5 ±8.1 (Cm), whereby a significant correlation was observed between cattle herd size and pasture area ($r = 0.88$ for M; $r = 0.51$ for CM; $r = 0.58$ for Cm). Pasture land was divided in winter and summer areas; the former was sown with ryegrass (*Lolium multifolium* Lam.) and black oat (*Avena strigosa* Schreb.), and the latter with pearl millet (*Pennisetum glaucum* (L.) R.Br.). With areas (ha) of 34 ±39.8 (M), 6 ±6.4 (CM) and 4 ±4.6 (Cm), the winter pastures were larger ($p = 0.006$) than the summer pastures of 11 ±19.1 (M), 3 ±3.1 (CM), and 1 ±3.9 (Cm).

Fodder was cultivated by 57, 80 and 62 % of M, CM and Cm farmers. The area (ha) used to crop fodder – mainly maize (*Zea mays* L.) for silage making or feeding fresh – was larger ($p = 0.004$) on M (21 ±22.1) than on CM (6 ±5.3) and Cm (4 ±4.8) farms. Cattle feed was mainly derived from the fodder maize area and the cultivated winter and summer pastures, but on 114 farms also at least partly from native pastures. Across farm types, the animals' daily grazing time averaged 8 hours (range 3 to 12 hours). In addition to grazing, cattle were supplemented with concentrate feed and cereal grains on 86, 96 and 75 % of M, CM and Cm farms. The total amount of concentrate (kg/month) bought by M farmers (4590 ±4515.7) was higher ($p = 0.001$) than the amounts purchased by CM (1650 ±3402.8) and Cm farmers (270 ±330.3). The daily amount of concentrate and grains (kg/head) offered across young and adult cattle was 1.6 (±2.18) on M farms, 1.6 (±3.11) on CM and 1.5 (±1.98) on Cm farms ($p > 0.05$).

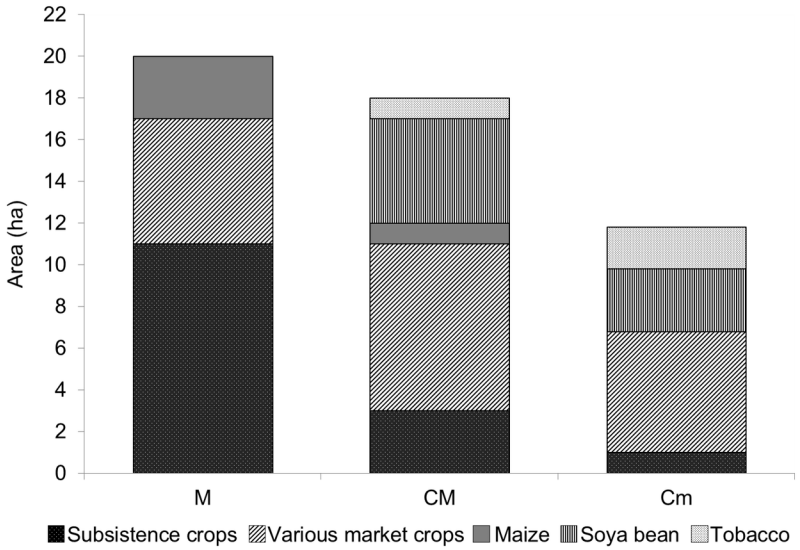

Fig. 1: *Average area per farm dedicated to different cash and subsistence crops for human use across three types of small-scale dairy farms in southern Rio Grande do Sul State (Farm types: M = only selling milk; CM = selling cash crops and milk; Cm = selling cash crops and surplus milk).*

3.2 Crop cultivation and labour allocation

In terms of area cropped, soybeans and tobacco were the most important cash crops on CM and Cm farms (Fig. 1), but a number of other crops that were partly self-consumed and partly marketed were also grown, such as lettuce, cabbage, black beans, tomatoes and strawberries. Selling of tobacco was an important source of cash for 20 % of CM and 43 % of Cm farmers, whereas selling of soybean was important for 15 and 5 % of CM and Cm farmers. Cash crops were mostly sold to traders (CM: 21 %; Cm: 30 %) and private companies (CM: 28 %; Cm: 53 %). Irrespective of farm type, maize was mainly grown for feeding animals (63.6 % of farms).

When asked about the most time consuming activity, all farmers mentioned the dairy unit, whereby milking ranked first for 86, 75 and 67 % of M, CM and Cm farmers. Milking was carried out by both partners on CM farms, only by the woman on Cm farms and only by the man on M farms. Feeding the animals was mainly a task of the male farmer on M farms (42 %), of the female farmer on Cm farms (35 %) and of both partners on CM farms (32 %). Hired labour was employed on 43, 35 and 25 % of M, CM and Cm farms, and was mainly performing general work on M and CM farms (100 and 46 %, respectively), or working in the tobacco plantations (Cm, 70 %). Only 29 % of M farms also charged hired labour with tasks of feeding, milking and pasturing the animals.

3.3 Milk marketing

Ninety-eight farmers (out of 199) were selling their milk to a cooperative; thereof 4 % belonged to cluster M, 36 % to CM and 60 % to Cm. The most important factors determining the choice of a milk cooperative were the area cultivated with subsistence crops, the pasture area per animal and investments in livestock-supporting structures during the last 10 years. Such investments have been undertaken by 14, 21 and 18 % of farmers in clusters M, CM and Cm. Among the influential variables, pasture area per animal was more important (odds ratio = 2.75) than the other predictors (Table 3).

The decision to sell milk to a private company was positively influenced by the area devoted to subsistence crops (odds ratio = 2.20) and years of education of household members, which was calculated as the average of schooling years of all household members aged > 16 years. Of the 65 farmers selling their milk to private companies, 5 % belonged to cluster M, 65 % to CM and 30 % to Cm.

3.4 Factors influencing milk production

To determine the influence of different variables on the daily milk output per farm, multiple linear regression models were run separately for farms selling their milk to cooperatives and private companies, respectively, without accounting for farm type (Table 4).

Table 3: *Parameters of the binary logistic regression analysis for variables predicting the choice of the milk marketing channel (cooperative or private company) across 199 small-scale dairy farmers in southern Rio Grande do Sul State.*

Variable	*B*	*SE B*	*Wald's* χ^2	*df*	*p*	*Odds ratio*
Dairy cooperative						
Constant	1.217	0.642	3.591	1	0.048	n.a.
Tobacco area (ha)	0.142	0.081	3.040	1	0.081	1.152
Fodder maize area (ha)	0.060	0.037	2.612	1	0.106	1.062
Subsistence crop area (ha)	−0.557	0.133	17.473	1	0.000	0.573
Pasture area per animal† (ha)	1.010	0.479	4.452	1	0.035	2.746
Average duration of education of household members (years)	−0.120	0.074	2.642	1	0.104	0.887
Investment in livestock activities in the last 10 years (yes/no)	−1.134	0.451	6.315	1	0.012	0.322
Overall model evaluation (Model χ^2)			69.219	6	0.001	
Goodness-of-fit‡			7.249	8	0.510	
Dairy company						
Constant	−3.550	0.738	23.160	1	0.001	n.a.
Subsistence crop area (ha)	0.787	0.153	26.380	1	0.000	2.197
Average duration of education of household members (years)	0.148	0.068	4.756	1	0.029	1.160
Investment in livestock activities in the last 10 years (yes/no)	1.180	0.614	3.687	1	0.055	3.253
Overall model evaluation (Model χ^2)			87.332	3	0.001	
Goodness-of-fit‡			20.509	7	0.457	

n.a. = not applicable; † animal = cattle, irrespective of age and physiological status; ‡ Goodness-of-fit test.

On all farms, total daily milk output of course depended on herd size ($p < 0.001$). In addition, on farms selling their milk to cooperatives, total daily milk output depended on area cropped with fodder maize ($p \leq 0.01$), and on farms selling their milk to private companies, the amount of concentrates fed per animal and day ($p < 0.001$) and the cultivated summer pasture area ($p \leq 0.05$) played a decisive role. In contrast, group Cm classification negatively affected the choice of private companies for milk sale ($p \leq 0.01$; Table 5).

As far as daily milk production per lactating cow is concerned, on farms selling the milk to cooperatives this variable was only and positively influenced by the fodder maize area ($p \leq 0.01$; Table 6). On farms selling their milk to private companies, variables positively influencing the production of an individual cow were the total amount of concentrate feeds offered per animal and day ($p \leq 0.01$) and the cultivated summer pasture area per animal ($p \leq 0.01$). Again, being part of group Cm had a negative impact on the milk production of an individual cow ($p \leq 0.05$).

3.5 Contribution of dairy farming to family income

Off-farm income contributed 20, 24, and 41 % to household income of groups M, CM and Cm, while crop sales contributed 9 % to total income on M farms, 17 % on CM farms and 43 % on Cm farms. The contribution of livestock husbandry to family income was highest ($p \leq 0.05$) on M farms (0.71 ±0.338), followed by CM (0.59 ±0.251) and Cm farms (0.16 ±0.141). Livestock-based income originated exclusively from milk production for 85 % of the farms (M: 100 %; CM: 78 %, Cm: 86 %), followed by milk production combined with egg sales in 13 % of farms (CM: 18 %, Cm: 12 %), and by milk production, egg and chicken sales in 2 % of farms (CM: 4 %, Cm: 2 %), whereby revenues from milk sales were responsible for at least 95 % of the overall livestock-based income in all cases. The price per litre of milk sold varied between R$ 0.51 and 0.62 (1 R$ = 0.56 US$ at the time of study; World Bank, 2011) depending on the total volume of produced milk. The amount of milk marketed (L day^{-1}) was higher ($p \leq 0.05$) on M farms (702 ±639.4) compared to CM (165 ±124.4) and Cm farms (24 ±31.7). Milk producers and CM farmers sold their milk mainly to cooperatives (M: 57 %; CM: 45 %) and private companies (M: 43 %; CM: 54 %). Cm farmers also sold their milk mainly to cooperatives (50 %) or on a personal basis to neighbours (33 %), but only rarely to private companies (17 %).

Table 4: *Characteristics of small-scale dairy farms selling their milk to cooperatives and to private companies, respectively, in southern Rio Grande do Sul State.*

Variable	*Unit*	*Cooperative*		*Private company*	
Presence of hired labour	(% affirmative)	27		34	
Belonging to group Cm	(% affirmative)	60		30	
		Mean	SD	Mean	SD
Cultivated winter pasture	(ha animal^{-1})†	0.3	3.12	0.2	1.25
Cultivated summer pasture	(ha animal^{-1})	0.1	1.15	0.2	2.41
Total pasture area	(ha animal^{-1})	0.4	1.56	0.4	4.25
Fodder maize area	(ha animal^{-1})	0.2	1.27	0.2	2.59
Herd size	(animals)	22	23.2	32	30.2
Concentrate feed offered	(kg animal^{-1} day^{-1})	1.2	3.56	1.4	1.33

†animal = cattle, irrespective of age and physiological status.

The contribution of dairy production to the overall income of farmers selling milk to cooperatives (Table 4) was negatively affected by the use of hired labour ($p < 0.01$) and membership in group Cm ($p < 0.001$), while the area (per cattle head) of cultivated winter pasture had a positive impact ($p < 0.01$). Considering the same dependent variable for farmers selling milk to private companies, their membership in group Cm ($p < 0.001$) and area of cultivated summer pasture per cattle head ($p \leq 0.05$) were influential in a negative and a positive way, respectively (Table 7).

4 Discussion

4.1 Characteristics of small-scale dairy farms

Keeping dairy cattle is still a viable strategy to enhance income in rural areas of developing countries (Sraïri, 2005; Somda *et al.*, 2005; Radeny *et al.*, 2012). Even in Brazil this activity is essential to numerous small-scale farmers, providing 58 % of the country's milk and contributing to household income and self-consumption (Guilhoto *et al.*, 2006). The establishment of a farm typology has often been used as a tool to verify how different socio-economic and production circumstances affect farmers' management decisions and income (Daskaloupolou & Petrou, 2002; Tavernier & Tolomeu, 2004; Emtage & Harrison, 2006; Toleubayev *et al.*, 2010; Huynh *et al.*, 2014; Cortez-Arriola *et al.*, 2015).

Using labour, management and milk production as classification criteria, Wagner *et al.* (2004) also distinguished three types of small-scale dairy farmers in Rio Grande do Sul State: modern conventional producers, transition producers and traditional producers. For the modern producers, who keep more than 10 dairy animals and have a cumulative milk production of > 68 L day^{-1}, milk production is the main source of farm income and requires the bulk of the labour force; the production is market-oriented and animal management is very good. Transition producers combine milk and cash crop production; they keep 5–10 cows and produce a total of 50–68 L day^{-1} of milk which is sold (*ibid.*). According to these authors, he or she may develop into a modern producer, or discontinue dairy activities, depending on the economic performance of the dairy unit and alternative income opportunities. Traditional producers manage < 5 cows and produce < 50 L day^{-1} of milk, which is not significantly contributing to farm income. Hence, labour input is restricted to the minimum time needed to maintain the dairy system. New investment in milk production is rare; machinery and equipment, if present, are in a poor state, animal management is not specialised and feeding is not sophisticated in most cases (*ibid.*). Carried out about 10 years later, our study shows new elements with respect to the previous classification. As far as milk production priority, importance of income from milk sales, herd size, cow productivity, animal management and feeding strategies are concerned, farmers of type M resemble the "modern conventional producer". However, farmers of type CM (cash crop and milk producers) and Cm (cash crop producers with surplus milk marketing) manage larger herds than the "transition" and "traditional" farmers. This finding shows that in the first decade of the 21st century, the transition farmers, in contrast to what was predicted by Wagner *et al.* (2004), had not yet dropped out of milk production nor, on the other hand, transformed into specialised dairy farmers. Whereas these authors found that 36 % of the small-scale farmers were

Table 5: *Parameters of the multiple linear regression on milk output per farm (L day^{-1}; dependent variable) of farms selling their milk to cooperatives or private companies, respectively.*

Variable	β_0	*SE* β_0	β_i	t	$p \leq$
Selling to cooperatives (Model 1)					
(Constant)	0.686	0.163		4.213	0.001
ln(HS)	1.055	0.127	0.898	8.323	0.001
ln(MA)	0.296	0.097	0.331	3.067	0.004
$r = 0.82$; $r^2 = 0.684$, Adj. $r^2 = 0.664$					
Selling to private companies (Model 2)					
(Constant)	1.339	0.29		4.619	0.001
ln(HS)	0.764	0.156	0.518	4.902	0.001
ln(CG)	0.476	0.124	0.325	3.847	0.001
Cm	−0.364	0.105	−0.365	−3.475	0.002
ln(SP)	0.329	0.121	0.232	2.722	0.012
$r = 0.91$; $r^2 = 0.837$; Adj. $r^2 = 0.811$					

Model 1: $\ln(y) = \beta_0 + \beta_1 \ln(\text{HS}) + \beta_2 \ln(\text{MA}) + \mu$
Model 2: $\ln(y) = \beta_0 + \beta_1 \ln(\text{HS}) + \beta_2 \ln(\text{CG}) + \beta_3 \text{Cm} + \beta_4 \ln(\text{SP}) + \mu$
ln = natural logarithm; y = milk output of the farm (L day^{-1}); HS = herd size (animals†); MA = fodder maize area (ha animal^{-1}); CG = amount of concentrate and grains offered (kg animal^{-1} day^{-1}); Cm = membership in group Cm (yes/no, i.e. 1/0); SP = cultivated summer pasture area (ha animal^{-1}).
† animal = cattle, irrespective of age and physiological status.

Table 6: *Parameters of the multiple linear regression on milk offtake per cow (L day^{-1}; dependent variable) of farms selling their milk to cooperatives or private companies, respectively.*

Variable	β_0	*SE* β_0	β_i	t	$p \leq$
Selling to cooperatives (Model 3)					
(Constant)	0.939	0.071		13.256	0.001
ln(MA)	0.313	0.088	0.528	3.575	0.001
$r = 0.58$; $r^2 = 0.524$; Adj. $r^2 = 0.484$					
Selling to private companies (Model 4)					
(Constant)	1.169	0.119		9.844	0.001
ln(CG)	0.477	0.127	0.526	3.766	0.001
ln(SP)	0.424	0.125	0.480	3.402	0.002
Cm	−0.212	0.086	−0.344	−2.458	0.021
$r = 0.71$; $r^2 = 0.553$; Adj. $r^2 = 0.457$					

Model 3: $\ln(y) = \beta_0 + \beta_1 \ln(\text{MA}) + \mu$
Model 4: $\ln(y) = \beta_0 + \beta_1 \ln(\text{CG}) + \beta_2 \ln(\text{SP}) + \beta_3 \text{Cm} + \mu$
ln = natural logarithm; y = milk output of the farm (L day^{-1}); MA = fodder maize area (ha animal^{-1}); CG = concentrate and grains offered (kg animal^{-1} day^{-1}); SP = cultivated summer pasture area (ha animal^{-1}); Cm = membership in group Cm (yes/no, i.e. 1/0).
animal = cattle, irrespective of age and physiological status.

exclusively relying on dairy production, in our study M type farmers accounted for only 4 % of the sample. Apparently the combination of cash crop and milk production is still the most secure livelihood strategy for many small-scale farmers in the region, even though this is highly labour demanding. Yet, the shift from subsistence to market-oriented dairy production requires more skilled labour, and men are more likely than women to engage in professionalised dairy production (Vasconcelos Dantas *et al.*, 2016). This might explain the observed domination of men in large M farms compared to the two other farm types. This finding is consistent

Table 7: *Parameters of the multiple linear regression on the contribution of the dairy unit to overall income (%; dependent variable) of farms selling their milk to cooperatives or private companies, respectively.*

Variable	β_0	$SE\,\beta_0$	β_i	t	$p \leq$
Selling to cooperatives (Model 5)					
(Constant)	2.059	0.098		21.015	0.001
Cm	−0.532	0.073	−0.768	−7.316	0.001
ln(WP)	0.332	0.118	0.292	2.812	0.008
HL	−0.166	0.077	−0.219	−2.142	0.040
$r = 0.81$; $r^2 = 0.665$; Adj. $r^2 = 0.634$					
Selling to private companies (Model 6)					
(Constant)	1.948	0.076		25.687	0.001
Cm	−0.312	0.055	−0.737	−5.639	0.001
ln(SP)	0.195	0.079	0.322	2.465	0.020
$r = 0.74$; $r^2 = 0.556$; Adj. $r^2 = 0.523$					

Model 5: $\ln(y) = \beta_0 + \beta_1 \mathrm{CM} + \beta_2 \ln(\mathrm{WP}) + \beta_3 \mathrm{HL} + \mu$
Model 6: $\ln(y) = \beta_0 + \beta_1 \mathrm{Cm} + \beta_2 \ln(\mathrm{SP}) + \mu$
ln = natural logarithm; y = contribution (%) of the dairy unit to overall farm income; Cm = membership in group Cm (yes/no, i.e. 1/0); WP = cultivated winter pasture area (ha animal^{-1}); HL = presence of hired labour (yes/no, i.e. 1/0); SP = cultivated summer pasture area (ha animal^{-1}). animal = cattle, irrespective of age and physiological status.

with previous observations by Magalhaes (2009) who reported a decrease of women's participation in dairy production with an increasing economic importance of this activity associated with the strengthening and modernisation of dairy cooperatives and markets.

4.2 Factors determining milk production

The fodder maize area was most influential for individual cow productivity and total daily milk output. The three dairy cooperatives in the study region (see below) are working towards improved feeding strategies; they sell quality maize seeds to their members at an affordable price and provide training courses and individual farm support for making maize silage. The latter is more profitable than the still widely practiced feeding of bulk maize, given the higher nutritive value of silage and the resulting higher milk production (O'Mara *et al.*, 1998; Wander, 2001).

Considering the good quality of natural pastures in the region during summer (Overbeck *et al.*, 2007), the use of cultivated winter pastures is more strongly advised by the cooperatives than the use of cultivated summer pastures. This advice aims at reducing the feeding costs and guaranteeing a good milk production during winter when biomass production on natural pastures is reduced due to climatic conditions. The positive effect of cultivated winter pasture manifested in its (statistical) importance for the contribution of the dairy unit to overall family income.

On farms selling milk to a private company, factors influencing individual cow productivity and contribution of milk sales to farm income were cultivated summer pasture area per cattle head and amount of concentrate feeds used. In the whole study region, cultivated summer pasture is mainly used by specialised dairy farmers (Weber, 2004), while less specialised producers rely on summer grazing of natural pastures (Nero, 2004), which was also the case in the present study. The importance of concentrate feeding and summer pasture cultivation on farms selling milk to a private company points to an intensified animal nutrition on farms that produce higher amounts of milk.

4.3 Milk marketing to cooperatives and private companies

In our analysis, the factors explaining farmers' decision to choose dairy cooperatives as their milk marketing channel were related to their investments into the dairy unit during the past ten years and their feeding strategies, mainly the area of pasture per cattle head, but also depended on the area cultivated with subsistence crops. Among others, these factors point to the attractiveness of the cooperatives' extension programs towards improving dairy units. These results are in accordance with Bourdieu (2005) and Magalhaes (2007) who claimed that dairy cooperatives are essential for the sustainable development of the associated local farmers.

Dairy cooperatives provide extension and on-farm advice, milk production equipment and feed, offer incentives for formal education, foster knowledge exchange, marketing courses and introduce new feed crops or feed conservation methods (Rajendran & Mohanty, 2004). The collective action of cooperatives on commodity markets is an important factor for the economic viability of their (small-scale) members, not only because these organisations are able to buy inputs and sell outputs at better price than the individual, but they also help their members to adapt to new production and marketing patters and standards, and to face regional or (inter)national market competition (Farina, 2002).

In the study region, COSULATI (Cooperativa Sul-Rio-Grandense de Laticinios Ltda.) is the most important cooperative. Located in Pelota and founded in 1932, it has around 20,000 members, employees and collaborators. Of the interviewed farmers, 34 were COSULATI members. In Sao Lourenco do Sul, COOPAR (Cooperativa Mista de Pequenos Agricultores da Regiao Sul) was founded in 1992 and at the time of study had 2050 members, of whom 32 were participating in our study. Thirty-two interviewed farmers in Cangucu were members of COOPAL (Cooperativa de Pequenos Agricultores Produtores de Leite da Regiao Sul). Founded in 1999 with initially 200 members, this cooperative had 650 members in 2010. The 63 interviewees who sold their milk to a private company were all dealing with Brazil Foods (BRF). Existing since 2009, a branch of this company is located in Sao Lourenco do Sul.

The dominance of dairy cooperatives in the South of Rio Grande do Sul State contradicts the predictions of Farina (2002), according to whom the milk market in southern Rio Grande do Sul should by now be in the hands of private companies, because only these were thought to be able to respond to the changes on the milk market since the beginning of the 1990s (Magalhaes, 2007). Whereas the private company BRF encouraged its suppliers through financial incentives to produce $> 100\,\mathrm{L\,day^{-1}}$ of milk, by granting discounts on farm inputs, the three cooperatives motivated their members to deliver $> 50\,\mathrm{L\,day^{-1}}$ but still enabled farmers with variable milk quantities to stay in business. By selling their raw milk directly to consumers in their neighbourhoods, Cm farmers reduce the involvement of marketing intermediaries. This gives them the opportunity to tailor their production to the consumer demand for raw milk and to sustain doorstep milk delivery systems.

4.4 Future development of dairy farming in southern Rio Grande do Sul

Since most of the interviewed farmers were classified as Cm and half of them sold their milk to cooperatives, they face a high risk of being expelled from the milk market when private companies are expanding and the stake of cooperatives dwindles (Costales *et al.*, 2008; dos Santos *et al.*, 2008; Novo *et al.*, 2010). Government policies such as special credit schemes for private companies in order to increase nation-wide productivity of the dairy sector are indirectly supporting the move towards specialised dairy farms with modern technology (Fundação Banco do Brasil, 2011). Our multiple regression analyses indicate that M and CM farmers will be able to deal with both private companies and milk cooperatives, since they can adapt their milk production system to either milk market. Given their more professional herd and feeding management and higher milk production, M farmers are superior to CM farmers and thus the optimal choice for private companies. Due to modest milk production and less professional production system, most Cm farmers will be bound to sell their milk to cooperatives. As long as cooperatives continue to collect milk of all farmers in order to increase total milk volume, these farmers will still have a place in the market. Yet, for both dairy cooperatives and small-scale producers it is high time to comply with the ongoing processes of mechanisation and modernisation in milk production and marketing, in order to stay in business. Since crop and livestock integration is an important characteristic of Brazilian small-scale agriculture (IBGE, 2012) and was in fact practiced on most of the farms surveyed in this study, the current situation of many dairy units is worrisome: Cm farmers who just market surplus milk reap a low income from their dairy unit and do thus not invest in its modernisation. This diverges from the overall development of the Brazilian milk market that requires very professional management and marketing (Farina, 2002). Therefore, even though the doomsday scenario of abandonment of small-scale milk production (Farina, 2002) has so far not materialised in the South of Rio Grande do Sul, cooperatives should be aware that *laissez faire* of their members with respect to extensive and somewhat incidental management of the dairy unit may soon threaten these members' milk production and with this probably also the cooperatives' further existence.

5 Conclusions

In contrast to predictions from the early years 2000, market exclusion of small-scale dairy producers and reduced activities of dairy cooperatives were not the most critical points in southern Rio Grande do Sul State. Instead, fewer specialised larger scale milk producers and an increasing number of small-scale mixed producers, along with an adaptation of dairy cooperatives to a professionalising and globalizing dairy sector were observed. Even though specialised dairy farms offer higher and more efficient milk production than mixed farms with regular or even only occasional milk marketing, the latter two types represented the majority of milk producers in the study region. Considering the importance of mixed small-scale farms, milk cooperatives are important for supporting their milk production and marketing, and thus for the regional development. The current modernisation, diversification and enlargement of the cooperatives' milk processing plants must therefore be paralleled by considerable improvements in the fields of animal nutrition, herd management and milk marketing on the mixed farms in order to sustain their longer-term productivity and economic survival. Given the technical assistance programs already in place, dairy cooperatives are key players in this process. For the sake of sustainable regional development and employment, government initiatives that support the cooperatives' endeavours would be most welcome.

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