Information asymmetry among dairy producers in Paraná, Brazil

Assimetria de informação entre produtores de leite no Estado do Paraná

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Highlights:
Farmers' organizations improve access to market information on milk quality.
Farmers' organizations improve access to technical information.
Buyer–seller relationships are strengthened by farmers' organizations.
Farmers' organizations improve access to information on milk quality regulations.

Abstract

Milk production has great social and economic importance in Paraná, Brazil. However, dairy farmers have abandoned the activity over the past few years because of difficulties in meeting institutional and market demands for increased milk production and quality. Information asymmetry between dairy farmers and market agents may be contributing to this scenario. It occurs when one agent in a transaction has more or better information than another. Information asymmetry can encourage opportunistic behavior and negatively affect the relationship between parties. These problems can be minimized or resolved by horizontal collaboration, such as participation in farmers' organizations, cooperatives, or associations. The aim of this study was to assess the extent of information asymmetry among dairy farmers and investigate whether participation in farmers' organizations strengthens buyer–seller relationships and stimulates compliance with milk quality standards. A total of 204 semi-structured questionnaires were applied to head farmers of dairy production systems in Paraná. Two sets of variables were analyzed: variables related to socio-economic and production characteristics and variables related to transactions between farmers and the dairy industry and the head farmer's knowledge about milk quality regulations. The second set of variables was subjected to common factor analysis, which generated four factors: F1, knowledge about institutional requirements; F2, technical support from the buyer; F3, technical knowledge; and F4, level of trust in the buyer. Dairy farmers who did not participate in farmers' organizations operated under greater information asymmetry and were disadvantaged with regard to F2, F3, and F4 ($P < 0.05$). Participation in horizontal collaborations can help farmers survive and thrive in the dairy activity.
Key words: Dairy systems. Family agriculture. New institutional economics.

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Resumo

A produção de leite no Estado do Paraná apresenta importância social e econômica. Entretanto, ao longo dos últimos anos, parte dos produtores de leite tem deixado a atividade por não conseguir atender demandas institucionais e de mercado voltadas a escala de produção e qualidade do leite. Nestas relações, entre produtores de leite, mercado e ambiente institucional, problemas de assimetria de informação podem estar presentes. A assimetria de informação pode ser caracterizada quando um agente possui maior grau de informação do que outro em uma dada transação–relação de compra e venda, ou quando as informações transferidas por um dos agentes são imperfeitas – apresentam falhas. Havendo assimetria de informação, ações oportunistas ou falhas na relação podem surgir. A assimetria de informação pode ser minimizada para produtores de leite que participam de arranjos horizontais na produção - cooperativas e associações. Diante deste contexto, buscou-se comparar a assimetria de informação entre produtores de leite que participam de arranjos horizontais e aqueles que não participam, em suas relações com a indústria de laticínios e no atendimento das normas legais para qualidade do leite. Foram aplicados 204 formulários semiestruturados em sistemas produtivos leiteiros SPL paranaenses. Nestes foram coletadas variáveis estruturais e produtivas dos sistemas leiteiros bem como variáveis sociais dos produtores rurais. Além dessas, foram coletadas variáveis sobre as relações entre produtores de leite e a indústria, bem como sobre o conhecimento do produtor rural diante de normativas que regulamentam a produção de leite. Essas últimas variáveis foram submetidas à técnica de Análise Fatorial Comum (AFC). Quatro fatores foram gerados, F1: requisitos institucionais, F2: assistência técnica do comprador, F3: capacitação técnica e F4: confiança no comprador. Pôde-se concluir que produtores de leite que não participam de arranjos horizontais possuíam maior assimetria de informação para os fatores F2, F3 e F4 ($p < 0,05$). Portanto, a estratégia de participação em associações e cooperativas de produção mostrou-se adequada para auxiliar a manutenção destes produtores na atividade leiteira.

Palavras-chave: Sistemas produtivos leiteiros. Agricultura familiar. Nova economia institucional.

Introduction

Agribusiness is one of the most important sectors in the Brazilian economy. It has accounted for about 20% of the national gross domestic product over the past 20 years (Centro de Estudos Avançados em Economia Aplicada [CEPEA], 2019). Brazilian agricultural systems are dynamic and produce food for domestic consumption and export. Estimates show that one out of four agricultural products sold in international markets originate from Brazil (Ministério da Agricultura, Pecuária e Abastecimento [MAPA], 2015). The country is among the world's largest dairy producers (Food and Agriculture Organization of the United Nations [FAO], 2018), with a total production of 30.1 billion liters of milk in 2017 (Instituto Brasileiro de Geografia e Estatística [IBGE], 2018).

The dairy sector is active in all Brazilian states. In Paraná, the third-largest producer, the activity has grown substantially, reaching 3.43 billion liters of milk in 2017 (IBGE, 2018). Milk production has an important social function in the state, as it is typically carried out in family farms and contributes greatly to rural workforce retention. The activity is the main source of income for 36.2% of Paraná dairy farmers. Of these, 71.7% participate in farmers' organizations, such as cooperatives and associations (Instituto Paranaense de Desenvolvimento Econômico e Social [IPARDES], 2008).

Despite the economic and social importance of milk production in Brazil, many obstacles hinder its progress. For instance, poor coordination between agents of the dairy sector generates conflicting relationships, risks, and uncertainties (Brito et al., 2015a). Difficulty in complying with institutional requirements such as those set by Normative Instructions (NI) nos. 51, 62, 76, and 77 is another factor that negatively affects the performance of dairy producers (Defante, Damasceno, Bánkuti, & Ramos, 2019). NI 76 and 77 repealed previous NI 51 and 62, defining new rules for the production, storage, transport, and quality of milk in Brazil (Instrução Normativa n. 62, 2011; Instrução Normativa n. 31, 2018; Instrução Normativa n.

76, 2018; Instrução Normativa n. 77, 2018). Low coordination between agents of the dairy sector is due to, among other factors, intrinsic characteristics of the market. Processing industries dominate the sector, and less power is held by dairy farms. Moreover, misalignment between production characteristics of dairy farms and institutional and market demands contributes to this scenario (Brito et al., 2015b; Defante et al., 2019; Fernandez-Stark, Bamber, & Gereffi, 2012).

Institutional and economic changes that have occurred since the 1990s in Brazil, such as trade opening, economic stabilization, and deregulation of the dairy sector, have shaped the current market (Bánkuti & Caldas, 2018). Economic stabilization increased the demand for milk and dairy products, enhancing the importance of high milk volume and quality (Bánkuti & Caldas, 2018). The sale and purchase of milk were previously regulated by the government, who established minimum and maximum prices for the sale of raw milk to the industry and processed milk to the final consumer, respectively. Now, prices are based on criteria defined by the industry, mainly milk quality and volume (Oliveira & Silva, 2012). In 2002, 2011, and 2018 the Brazilian government set new standards for raw milk quality through NI 51, 62, 76, and 77 (Instrução Normativa n. 51, 2002; Instrução Normativa n. 62, 2011; Instrução Normativa n. 76, 2018: Instrução Normativa n. 77, 2018). These market and institutional changes led some dairy farmers, especially small-scale producers with insufficient resources for investment, to abandon the activity (Bánkuti & Caldas, 2018; Souza & Buainain, 2013).

The new form of transaction with the industry can generate information asymmetry and opportunism (Brito et al., 2015a; Magalhães, 2007), thereby reducing the competitiveness[4] of dairy farmers. Participation in farmers' organizations, which stimulate horizontal agreements and arrangements, can help counteract these problems (Brito et al.,

2015a; Magalhães, 2007). Farmers' organizations include production associations, cooperatives, and horizontal collaborations. Such linkages can help resolve problems of information asymmetry with the industry and help farmers comply with legal norms. Information asymmetry occurs when one agent has more or better information on the characteristics of the transaction or the traded product than the other agent. In this situation, the advantaged party may act in their own benefit in detriment to the other party, characterizing an opportunistic behavior (North, 1990; Williamson, 1985). For instance, in milk trade, the industry analyzes the quality of the milk sold by farmers without necessarily informing them about the results. This information asymmetry can result in unfair selling prices.

We aimed to analyze the extent of information asymmetry among dairy farmers and investigate whether participation in farmers' organizations strengthens the relationship between farmer and the dairy industry and stimulates compliance with milk quality regulations.

Material and Methods

This research has a quantitative focus. We analyzed 204 semi-structured questionnaires administered to head farmers of dairy production systems located in four mesoregions of Paraná (Central-North, Central-East, West, and Southwest) from September to November 2016 (Figure 1). The regions were chosen because of their contribution to milk production in Paraná (IBGE, 2017) and because of the heterogeneity of dairy production systems in these regions (Brito, et al., 2015b; Gazola et al., 2018; Kuwahara et al., 2018; Zimpel, Bánkuti, Zambom, Kuwahara, & Bánkuti, 2017). Dairy production systems were chosen at random from lists provided by government technical assistance and rural extension agencies. Questionnaires were approved by the Human Research Ethics Committee (COPEP; process no. 2.396.173).

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[4] Competitiveness is defined as the ability of an agent to survive or grow in the market in which it operates and/or in new markets (Silva & Batalha, 1999).

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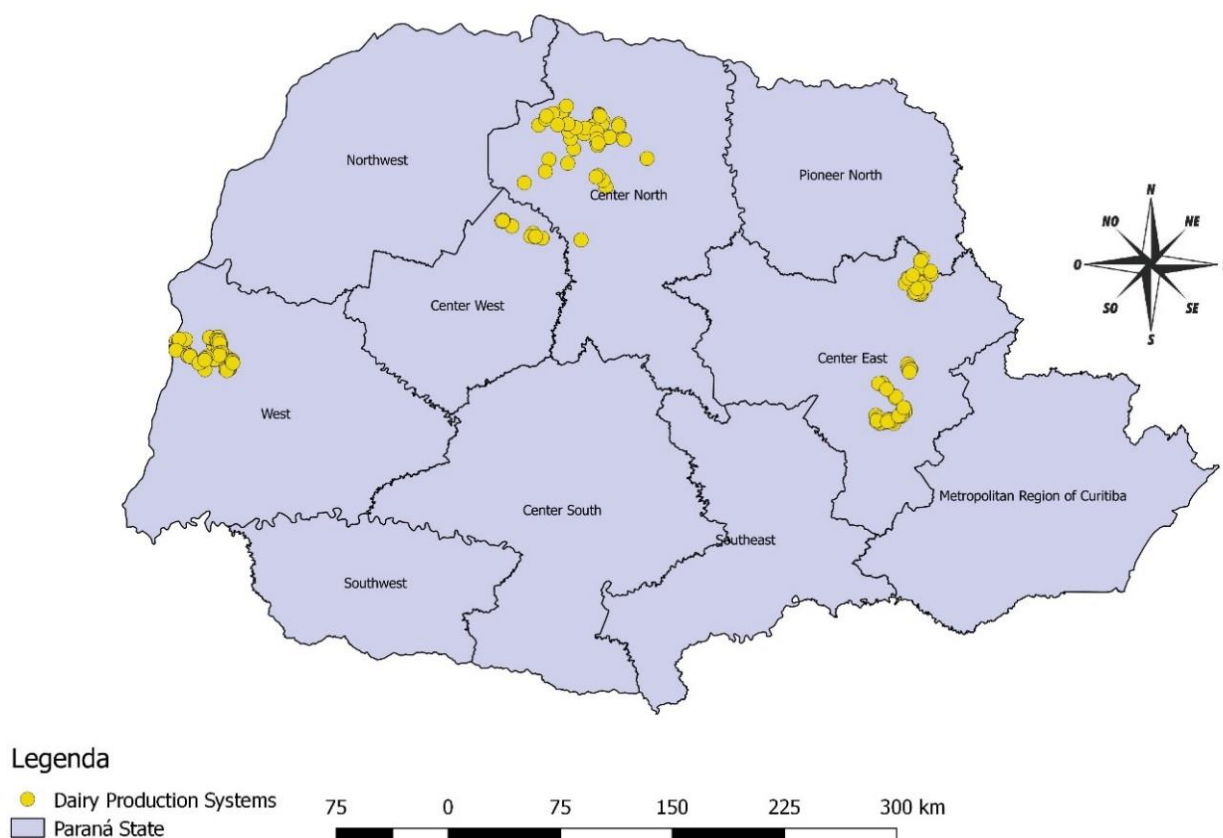
Figure 1. Location of dairy production systems in the state of Paraná, Brazil.

Two sets of variables were collected. The first included socio-economic characteristics of dairy farmers and structural and production characteristics of dairy production systems (V1–V11, Table 1). These data were presented as descriptive statistics (mean, frequency, standard deviation, and minimum and maximum values). Variable V24, "Participation in farmers' organizations" (Table 1), was used to classify dairy farmers into two groups: G1, those who participate in farmers' organizations, and G2, those who do not (Brito et al., 2015b .

The second set of variables was related to transactions carried out between farmers and the dairy industry and knowledge on milk quality standards set by NI 51 and 62 (Instrução Normativa n. 51, 2002; Instrução Normativa n. 62, 2011) (Table 1). Answers were given on different rating scales (Field, 2009). Variables and their levels of measurements are described in Table 1. Common factor analysis was used to define factors representing information asymmetry among dairy producers and farmers' knowledge of institutional demands (Brito et al., 2015a).

Table 1
Variables, their levels of measurement, and methods of statistical analysis

Variable	Level of measurement	Method of analysis
V1. Age of the head farmer (years)	Quantitative (numerical)	Descriptive statistics
V2. Years of formal education of the head farmer	Quantitative (numerical)	Descriptive statistics
V3. Time in the dairy business (years)	Quantitative (numerical)	Descriptive statistics
V4. Total farm area (ha)	Quantitative (numerical)	Descriptive statistics
V5. Area used for milk production (ha)	Quantitative (numerical)	Descriptive statistics
V6. Number of economic activities performed on the farm	Quantitative (numerical)	Descriptive statistics
V7. Percentage of family labor	Quantitative (numerical)	Descriptive statistics
V8. Number of lactating cows	Quantitative (numerical)	Descriptive statistics
V9. Annual milk yield (L day^{-1})	Quantitative (numerical)	Descriptive statistics
V10. Milk yield per cow (L cow^{-1} day^{-1})	Quantitative (numerical)	Descriptive statistics
V11. Milk yield per area (L ha^{-1} day^{-1})	Quantitative (numerical)	Descriptive statistics
V12. Information about the somatic cell count limit set by Normative Instruction no. 62	Nominal categorical (1, I know nothing about it; 2, One million cells/mL; 3, 750,000 cells/mL; 4, 600,000 cells/mL; 5, 500,000 cells/mL)	Common factor analysis
V13. Information about the total bacterial count limit set by Normative Instruction no. 62	Nominal categorical (1, I know nothing about it; 2, One million colony-forming units (CFU)/mL; 3, 750,000 CFU/mL; 4, 600,000 CFU/mL; 5, 500,000 CFU/mL)	Common factor analysis
V14. Level of knowledge about somatic cells in milk	Ordinal categorical (1, I know nothing; 2, I know a little about it; 3, I know a lot about it)	Common factor analysis
V15. Level of knowledge about bacterial counts in milk	Ordinal categorical (1, I know nothing; 2, I know a little about it; 3, I know a lot about it)	Common factor analysis
V16. Buyer provides technical support	Nominal categorical (1, No; 2, Yes)	Common factor analysis
V17. Buyer offers a premium for high-quality milk	Nominal categorical (1, No; 2, Yes)	Common factor analysis
V18. Buyer provides training and education about milk production	Nominal categorical (1, No; 2, Yes)	Common factor analysis
V19. Self-reported score for technical skills in milk production	Ordinal categorical (0 to 10)	Common factor analysis
V20. Number of meetings and events related to milk production attended in the last five years	Quantitative (numerical)	Common factor analysis
V21. Level of trust in the milk transport system	Ordinal categorical (0 to 10)	Common factor analysis
V22. Self-reported score for knowledge about the somatic cell count requirements of Normative Instruction no. 62	Ordinal categorical (0 to 10)	Common factor analysis

continuation

V23. Level of trust in the buyer	Ordinal categorical (0 to 10)	Common factor analysis
V24. Participation in farmers' organizations	Nominal categorical (1, No; 2, Yes)	Simple classification of dairy production systems into two groups

Common factor analysis is an interdependence technique used to reduce a large set of variables to indicators or factors. Each indicator is defined by variables that have high correlation with each other but low correlation with variables of other indicators (Fávero, Belfiore, Silva, & Chan, 2009). Principal component analysis, varimax rotation, Kaiser–Meyer–Olkin normalization (KMO), and Bartlett's test of sphericity were carried out (Fávero et al., 2009). Variables with a low factor loading were excluded. The Kaiser criterion (eigenvalues greater than 1.0) was used to determine the number of extracted factors (Fávero et al., 2009). Factor scores were saved as regression variables and used to compare G1 and G2 farmers (Yabe, Bánkuti, Damasceno, & Brito, 2015; Zimpel et al., 2017). Each dairy production system received a score related to its contribution to the factor. With this procedure, factor loadings are adjusted to take into account the initial correlation between variables, eliminating possible differences between units of measurement and stabilizing the variances. Factor scores can then be analyzed in several ways, including by tests of means (Field, 2009). G1 and G2 were compared using the Mann–Whitney U-test.

Results and Discussion

The mean total farm area of the 204 farms analyzed was 41.05 ± 75.67 ha, 21.89 ± 31.30 ha of which were used for milk production (Table 2). The mean number of lactating cows was 45.71 ± 71.78, the mean milk production was 18.13 ± 7.16 L cow^{-1} day^{-1}, and the mean annual milk production was $1,126.70 \pm 2,577.38$ L cow^{-1}. Milk yield per area averaged 44.46 ± 33.89 L ha^{-1}.

Table 2
Description of the dairy production systems analyzed in this study

Variable	n	Minimum	Maximum	Mean	Standard deviation
V1. Age of the head farmer (years)	204	18.00	84.00	45.75	11.87
V2. Years of formal education of the head farmer	204	0.00	16.00	9.70	3.74
V3. Time in the dairy business (years)	204	1.00	55.00	19.60	11.94
V4. Total farm area (ha)	204	1.00	700.00	41.05	75.67
V5. Area used for milk production (ha)	204	1.00	250.00	21.89	31.30
V6. Number of economic activities performed on the farm	204	0.00	3.00	0.76	0.73
V7. Number of lactating cows	204	3.00	600.00	45.71	71.78
V8. Annual milk yield (L day^{-1})	204	40.00	24.000.00	1.126.70	2.577.38
V9. Milk yield per cow (L cow^{-1} day^{-1})	204	5.26	40.00	18.13	7.16
V10. Milk yield per area (L ha^{-1} day^{-1})	204	4.65	225.00	44.46	33.89

Head farmers had on average 45.75 ± 11.87 years of age, 9.70 ± 3.74 years of formal education, and 19.60 ± 11.94 years in the dairy business (Table 2); that is, most farmers finished only the first year of high school but had ample experience in milk production. Family members accounted for 79.78% ± 34.57 of the labor force.

A KMO value of 0.70 and a significant Bartlett's test of sphericity ($P < 0.01$) confirmed the suitability of data for factor analysis (Fávero et al., 2009). Factor analysis resulted in the identification of four factors with eigenvalues greater than 1.0, which together explained 68.02% of the total variance (Table 3). All other factors had eigenvalues below 1.0 and were therefore excluded from further analysis (Fávero et al., 2009).

Table 3
Total variance explained in factor analysis

Factor	Eigenvalue	Variance explained (%)	Cumulative variance (%)
1	**3.43**	**31.24**	**31.24**
2	**1.73**	**15.79**	**47.04**
3	**1.29**	**11.75**	**58.80**
4	**1.01**	**9.21**	**68.02**
5	0.88	8.06	76.09
6	0.67	6.08	82.17
7	0.58	5.32	87.50
8	0.53	4.87	92.38
9	0.42	3.88	96.26
10	0.29	2.69	98.95
11	0.11	1.04	100

Significant factors are highlighted in bold.

The first factor (F1), accounting for the largest percentage variance (31.24%), was defined by variables (V1, V2, V3, and V4) reflecting the knowledge of farmers about milk quality requirements imposed by NI 51 and 62 (Table 4). Thus, F1 was labeled "Knowledge about institutional requirements." NI 51 and 62 had a tremendous positive impact on milk quality in Brazil. Institutional changes were accompanied by increased demand for higher-quality, differentiated products, which consequently increased competitiveness in the dairy sector. Faced with this new institutional and market environment, dairy farmers who cannot meet quality standards have little chance of remaining in business in the medium and long term.

Table 4.
Rotated factor matrix

Variable	Factor			
	F1	F2	F3	F4
V1. Information about the total bacterial count limit set by Normative Instruction no. 62	**0.814**	0.035	0.055	0.028
V2. Information about the somatic cell count limit set by Normative Instruction no. 62	**0.808**	0.010	0.109	0.013
V3. Level of knowledge about somatic cells in milk	**0.777**	0.275	0.162	0.095
V4. Level of knowledge about bacterial counts in milk	**0.758**	0.305	0.149	0.086
V5. Buyer provides technical support	0.054	**0.814**	0.132	0.010
V6. Buyer offers a premium for high-quality milk	0.181	**0.778**	0.066	0.036
V7. Buyer provides training and education about milk production	0.083	**0.733**	0.133	0.140
V8. Self-reported score for technical skills in milk production	0.094	0.180	**0.828**	0.005
V9. Number of meetings and events related to milk production attended in the last five years	0.218	0.101	**0.797**	0.078
V10. Level of trust in the milk transport system	0.051	0.138	0.001	**0.843**
V11. Level of trust in the buyer	0.134	0.262	0.078	**0.760**

Significant loadings are highlighted in bold.

The second factor (F2) explained 15.79% of the variance among dairy farms (Table 3) and was composed of V5, V6, and V7 (Table 4). It was labeled "Technical support from the buyer." F2 reflects the importance of providing technical support to farmers. It is clear that the technical knowledge of farmers has a large impact on management and milking hygiene practices, aspects directly linked to milk yield and quality.

The third factor (F3) represents the technical knowledge of farmers about milk production and agricultural production in general; the factor was named "Technical knowledge." It explained 11.75% of the total variance (Table 3) and was defined by V8 and V9 (Table 4). The level of knowledge of farmers about general agricultural practices and skills specific to the dairy activity can provide relevant information on farm management and performance. In Brazil, farming knowledge is commonly passed on from parents to their children. This mode of knowledge transmission can help preserve bad practices among farmers, and new

sources of information are essential to bringing technical and scientific advances to dairy production systems. The farmer's interest in learning depends on personal characteristics, but it can be stimulated through technical visits, horizontal cooperation, and participation in farmers' organizations (Carvalho & Barcellos, 2013).

The correct use of mechanized equipment, especially in small-scale farms, helps farmers to improve product yield, quality, and profits, allowing their maintenance and reducing poverty in rural areas. However, the number of small-scale farms using mechanized machinery appears to be small. A study suggested that lack of information about agricultural production techniques and their benefits may be one of the causes of low use of technologies (Wossen et al., 2017), but this issue needs to be further investigated.

The fourth factor (F4) was defined by variables measuring the trust of farmers in the industry (V10 and V11, Table 4). It was thus labeled "Trust in the buyer." F4 accounted for 9.21% of the variance

observed (Table 3). One aim of dairy cooperatives is to increase the access of farmers to relevant information; however, even within cooperatives, information is not symmetrically distributed (Carvalho & Barcellos, 2013). It has been shown that farmers carefully analyze potential buyers and base their choice on the level of trust they have in the company (Hunt, Shiki, Ribeiro, Biasi, & Faria, 2009). Relationships of trust arise from conviviality and frequent transactions (Williamson, 1985). Farmers engaged in horizontal relationships of trust can share important information.

Dairy farmers were classified into two groups according to their participation in farmers' organizations: G1 included farmers who were part of organizations ($n = 150$) and G2 included those who were not ($n = 53$). G1 and G2 were analyzed against F1, F2, F3, and F4 (Table 5).

Table 5
Information asymmetry of dairy farmers who participate in farmers' organizations (G1) and those who do not (G2)

Factor	Group	Mean factor score	Standard deviation	P-value
F1: Knowledge about institutional requirements	G2	−0.219	1.261	0.826
	G1	0.073	0.884	
F2: Technical support from the buyer	G2	−0.606[b]	0.746	0.000
	G1	0.208[a]	0.994	
F3: Technical knowledge	G2	−0.264[b]	0.714	0.038
	G1	0.088[a]	1.071	
F4: Level of trust in the buyer	G2	−0.116[b]	0.824	0.050
	G1	0.040[a]	1.057	

Means followed by different letters differ significantly ($P \leq 0.05$) according to the Mann–Whitney U-test.

No differences ($P > 0.05$) were found between the groups in F1 (Table 5), indicating that G1 and G2 farmers had a similar level of knowledge about milk quality standards set by NI 51 and 62. G1 farmers were expected to have a greater knowledge about institutional requirements, as observed in previous studies (Brito et al., 2015a; Mutura, Nyairo, Mwangi, & Stephen, 2014). G1 and G2 farmers differed ($P < 0.05$) in F2, F3, and F4 (Table 5).

G1 farmers received technical support for milk production more frequently. Compared with G2, G1 farmers received higher premium for high-quality milk from the dairy industry (Table 5). Participation in farmers' organizations strengthens milk production (Mutura et al., 2014). Contact with other market agents minimizes the exchange of incomplete or distorted information, thereby increasing the transparency of transactions with the industry (Carvalho & Barcellos, 2013).

G1 farmers had higher technical knowledge and skills than G2 farmers (Table 5). These results indicate that farmers received technical training from farmers' organizations, cooperatives, or associations (Table 5). Participation of small-scale producers in cooperatives helps increase productivity in developing countries and is considered an important tool for farmers to remain in the business. Information sharing within organizations is beneficial to the farmer and can improve access to policies that encourage the adoption of more effective production technologies and management systems (Wossen et al., 2017).

G1 farmers showed greater confidence in the dairy industry with regard to milk transport and financial transactions (Table 5). It is important to point out that milk transport is a critical part of the transaction, as milk is a perishable product. Furthermore, milk tankers transport milk from several producers, which can be seen as a potential situation for opportunistic behavior by the industry (Brito et al., 2015a). Thus, trust between farmers and the industry is essential to build lasting relationships.

Dairy farmers are more likely to remain in business if they participate in horizontal collaborations, such as cooperatives for milk production and processing. Access to information on milk quality standards is increased, thus reducing possible errors in management practices that may affect transactions with the industry. Furthermore, technical training and information exchange are other benefits promoted by meetings, training, and lectures from state and company technicians in farmers' organizations. Participation facilitates access to credit from financial institutions and increases the economies of scale resulting from collective purchases of inputs. These factors are especially important for small-scale farmers (Wossen et al., 2017).

Conclusions

Dairy farmers engaged in farmers' organizations operated under lower information asymmetry than those who were not engaged. Participation in horizontal collaborations was associated with increased technical knowledge and stronger relationships between dairy farmers and the industry. No differences in knowledge about legal milk quality standards were observed between farmers who participated in organizations and those who did not.

Acknowledgments

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