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Technological cooperation of universities on market impact and economic development: multiple case studies with milk producers

Impacto no mercado e no desenvolvimento econômico de cooperação tecnológica leiteira de universidades: estudo de casos múltiplos com produtores

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Abstract
Cooperation between universities and organizations is important for the development of technologies in agribusiness. In the milk production sector of Mato Grosso do Sul, Brazil, the Rio de Leite Program (PRL) stands out for Technology Transfer (TT) from universities to properties. This research uses multiple case studies to identify the effects of joining the Rio de Leite Program (PRL) on the market impact and the economic development of rural properties in the Pantanal region of Mato Grosso do Sul, Brazil. The results showed positive effects on both the market and the economic development, based on a TT model recognized worldwide from the perspective of the milk producers interviewed. Here, we present convergences and divergences to the model and other studies, considering TT evidence to properties, in addition to a new finding related to economic development. Thus, this study contributes to the literature on the topic proposed and highlights positive effects of the PRL.
Keywords: contingent effectiveness model of technology transfer, milk production chain, properties.

Resumo
A cooperação entre universidades e organizações revela-se importante para o desenvolvimento de tecnologias no agronegócio. Na produção de leite de Mato Grosso do Sul, destaca-se o Programa Rio de Leite (PRL), em que se trabalha a Transferência de Tecnologia (TT) de universidades para propriedades rurais. A pesquisa, que se utilizado método de estudo de casos múltiplos, objetivou identificar os efeitos da adesão ao Programa Rio de Leite (PRL), quanto aos seus impactos no mercado e desenvolvimento econômico, em propriedades rurais da região do pantanal sul-mato-grossense. Com base em modelo de TT reconhecido mundialmente, foram verificados e são descritos, na perspectiva dos produtores entrevistados, evidências de impacto no mercado e desenvolvimento econômico. Apresentam-se convergências e divergências ao modelo e a outros estudos, considerando as evidências das TTs às propriedades, além de um novo achado relativo ao desenvolvimento econômico. Assim, a pesquisa contribui para a literatura sobre o tema e para ressaltar efeitos positivos do PRL.
Palavras-chave: modelo de eficácia contingente de transferência de tecnologia, cadeia produtiva do leite, propriedades.

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1 Introduction

Milk production in Brazil has room for improvements in terms of health, herd genetic improvement, pasture management, food supplementation strategies during droughts, milk quality, and administrative and financial management (Simões, De Oliveira, & Lima-Filho, 2015, p. 164).

Data from the Agricultural Census of the Brazilian Institute of Geography and Statistics (IBGE, 2017) indicate that cattle milk production in Brazil (in 1,000 liters) jumped from 20,567,868 in 2006 to 30,100,791 in 2017. The share of Mato Grosso do Sul State, Brazil, in milk production rose from 383,880 in 2006 to 408,557 in 2017, a smaller increase considering the entire country's production.

In terms of productivity (liter per cow), the Brazilian Agricultural Research Corporation (EMBRAPA, 2017), based on the organization of IBGE data, showed a negligible increase of 0.1% in Mato Grosso do Sul State, from 2014 to 2015, with a record of 1,022 liters/cow in 2014 and 1,023 liters/cow in 2015. This means that milk production increase was 5.5% from 2014 to 2016 in comparison to the Brazilian scenario.

The use of animal breeds that are inefficient for milk production and inadequate management practices for dairy cattle are some factors that hinder the development of the milk production chain in Mato Grosso do Sul State, Brazil (Simões, De Oliveira, & Lima -Filho, 2015, p. 164). The authors highlight the importance of the role of governments in joining efforts and resources to shift milk farming from a subsistence to a profitable activity for milk producers, expanding their commercialization possibilities, in compliance with hygienic and sanitary standards established by control bodies.

Therefore, milk production in Mato Grosso do Sul State should encompass the creation of partnerships with institutions for scientific and technological development. In this sense, *open innovation*, a strategy for organizations in search of external sources of innovation (CHESBROUGH, 2003), is achieved by technology transfer (TT) from the university to organizations, which can contribute to improvements of the current situation.

TT has been increasingly recognized as a source of local and regional development (Armstrong, 2009; Teng, 2010; Fini *et al*., 2011; Pogue *et al*., 2014) with competitive advantage and market impact (Savory, 2006, Closs & Ferreira, 2012; Matulova *et al*., 2018).

The Contingent Efficacy Model by Bozeman (2000) is one of the TT models accepted worldwide. This model allows a better understanding the TT effects in various fields from universities (agents) or research institutes to organizations that receive the knowledge (recipients), determining its effectiveness (Benito-Bilbao, Sánchez-Fuente, & Otegi-Olaso, 2015; Bozeman, 2000; Bozeman, Rimes, & Youtie, 2015; Philippi, 2015).

The Rio de Leite Program (PRL) is carried out in the Pantanal region of Mato Grosso do Sul State (Brazil), aiming to train higher-level labor, specialized in milk production, to transfer modern technologies to milk production systems in the state of Mato Grosso do Sul, providing producers with technical and administrative assistance to become rural entrepreneurs (SIMÕES, 2008).

The PRL relies on cooperation between the Animal Science Course of the State University of Mato Grosso do Sul (UEMS) and the Biology Course of the Federal University of Mato Grosso do Sul (UFMS) and milk producers in the region. There is also a partnership with other entities, such as funding bodies, UEMS, UFMS, the Ministry of Education (MEC), the National Council for Scientific and Technological Development (CNPq), and the Financier of Studies and Projects (FINEP) (Rio de Leite, 2017). In 2013, the PRL won the prize as the 3rd best program at the IX Sul-Mato-Grossense Public Management Award (O Pantaneiro, 2014).

Technological Cooperation and Technology Transfer processes have presented great benefits and the PRL has a significant role for the milk production sector in Mato Grosso do Sul State (Brazil); therefore, this study investigated the perception of milk producers (recipients) on the effects of adherence to the Rio de Leite Program (PRL) in relation to the market where they operate and the economic development of their farms. The objective was to identify the effects of joining the Rio de Leite Program (PRL) in terms of its impacts on the market and economic development for dairy farms in the Pantanal region of Mato Grosso do Sul State. The investigation regards milk producers of the municipalities of Aquidauana and Anastácio, in terms of TT based on Bozeman's Contingent Effectiveness Model (2000). In the model, revisited by Bozeman, Rimes, and Youtie (2015), the market impact and economic development are presented as criteria for TT effectiveness and understood as effects of this process.

Market impact refers to TT influence on product materialization and increases of the market share, sales, and profitability of the recipient (Bozeman, 2000; Ogunyemi, 2013; Borge & Bröring, 2017; Bozeman, Rimes, & Youtie, 2015; Philippi, Maccari, & Da Costa, 2018). Economic development refers to TT contributions at the regional or national levels, such as income increases and the creation of new jobs or new businesses as a result of TT (Harmon *et al*., 1997; Bozeman, 2000; Borge & Bröring, 2017; Bozeman, Rimes, & Youtie, 2015; Philippi, 2015; Philippi & Maccari, 2017; Philippi, Maccari, & Da Costa, 2018).

Public authorities, universities, and enterprises need to be made aware of the benefits of TT to favor its expansion (Closs & Ferreira, 2012; Philippi, 2015); therefore, it is expected that the research results contribute to both reinforcing previous studies on the subject and mainly improving and propagating the PRL and other technological cooperation projects involving universities in the region.

2 Theoretical Reference

2.1 Technological cooperation and Technology Transfer (TT)

Interaction between universities and organizations generates mutual benefits (Etzkowitz & Leydesdorff, 2000) while stimulating economic development and competitiveness (Bozeman, 2000; Siegel, Waldman, & Link, 2012; Philippi, 2015).

Studies indicate that the most significant benefits for universities encompass the possibility to attract additional resources for basic and applied research and to provide technological advances to teaching, with less investment, less time, and lower risks (Puffal, Trez, & Schaeffer, 2012).

Rothaermel, Agung, and Jiang (2007) mention complementing academic research by funding graduate students, laboratory equipment, and providing insights into their own research as a relevant benefit for faculty members, in addition to possible business opportunities to arise from the interaction between universities and organizations.

Moreover, organizations (recipients) benefits from access to human or material resources, enabling technological and personal development, administrative support in innovation processes (Benedetti, 2011) and access to research and academic discoveries (Rothaermel, Agung, & Jiang, 2007), in addition to the capacity to develop technology with less investment, less time, and lower risks (Puffal *et al*., 2012).

The society also benefits from TT, as it stimulates economic development (Siegel, Waldman, & Link, 2003), improving competition among enterprises in the national market (Closs & Ferreira, 2012), while leveraging the country's technological growth and promoting

scientific development in the academic environment, benefiting Brazil (Segatto-Mendes & Sbragia, 2002).

2.2 Effects of TT on market impact and economic development

As for TT from universities or research institutes (agents), Bozeman (2000) lists effectiveness criteria, understood as effects and/or benefits of the TT process, such as market impact and economic development, with possible benefits for TT agents and recipients (milk producers).

Philippi (2015) conducted a study applying the Bozeman's Contingent Technology Transfer Effectiveness Model (2000) on the characterization and verification of the TT effects from agriculture schools in the United States and in Brazil and found that the model was adequate to verify the TT effects, considering the macro context, highlighting the impact on the market and economic development.

Market impact refers to TT influence on product materialization as well as increased market share and profitability of the recipient (Bozeman, 2000; Ogunyemi, 2013; Borge & Bröring, 2017; Bozeman, Rimes, & Youtie, 2015; Philippi, Maccari, & Da Costa, 2018; Park & Chang, 2020).

Although Bozeman (2000) reports on a consensus that TT has little potential for economic development, studies show evidence of TT effects, namely the creation of new TT companies (Bozeman, 2000; Bozeman, Rimes, &Youtie, 2015) upstream and downstream, including suppliers, *start-ups*[1], and *spinoffs*[2] (Harmon *et al*., 1997; Bozeman, 2000; Borge & Bröring, 2017; Bozeman, Rimes, & Youtie, 2015; Philippi, 2015; Philippi, Maccari, & Da Costa, 2018) with further creation of new jobs (Bozeman, 2000; Borge & Bröring, 2017; Bozeman, Rimes, & Youtie, 2015; Philippi, 2015; Philippi & Maccari, 2017) and of job positions that did not exist before (Philippi & Maccari, 2017).

Harmon *et al*. (1997) are careful to not create expectations about the immediate economic impact of TT. Furthermore, studies show that TT has mechanisms that influence economic development. Bravo and Resende (2014) highlight the importance to align the needs of innovation systems, including all stakeholders, such as research and development institutions, business organizations, and intermediaries.

Thus, criteria for market impact and economic development assess the effects of TT on the market (organizational level or regional or national scales), according to the commercial success of the technology (Borge & Bröring, 2017).

3 Methodology

The research was characterized as eminently qualitative, encompassing a more in-depth and integrated study of relationships, processes, and phenomena than quantitative research (Eisenhardt, 1989; Godoy, 1995; Flick, 2004).

Regarding objectives, the research is classified as exploratory, as it involves familiarization with a phenomenon that has been little explored and allows new perceptions of the phenomenon and discoveries (Babbie, 1998). The phenomenon studied "effects of technological cooperation between universities in Mato Grosso do Sul State through the PRL"

[1] Small start-up companies with innovative business models and high scalability potential, but highly susceptible to risks (FONSECA, 2019).

[2] Enterprises that commercialize research results and scientific knowledge from universities (TORRES; INVERNIZZI, 2022)

has not yet been studied with the proposed approach, considering the dairy farms assisted by the program.

The strategy adopted was the study of multiple cases (Godoy, 1995; Yin, 2001), suitable for research to answers questions about "how" and that requires in-depth investigation of the phenomena. Five cases of technological cooperation were then defined, represented by five dairy farms assisted by the PRL, indicated and understood by the PRL leaders as cases that deserved to be studied, adopting the intentional non-probabilistic sample (Schiffman & Kanuk, 2000).

The multiple case study protocol is essential and guides the researcher to collect data, with relevance for research reliability (YIN, 2001). Thus, the protocol developed presented the following main elements: (a) activity plan, with a research overview, unfavorable scenarios, and possible changes in conduct; (b) cover letter with the research objective and guiding questions; (c) instructions for the ethical conduct of research, including a consent form with the protection of privacy and confidentiality; (d) interview script and recording form; (e) script for a research report, considering its central objective.

Codes were assigned to the cases studied represented by the interviewees to facilitate data organization and the understanding of the results (Table 1).

Table 1 – Coding of cases

Interviewees	Code
Producer 1	P1
Producer 2	P2
Producer 3	P3
Producer 4	P4
Producer 5	P5

Source: elaborated by the authors

The data collection techniques essentially covered in-depth interviews over the telephone after a previous contact via WhatsApp with an explanation of the research objectives. We also requested a formal consent of research participation and, afterward, we scheduled the interviews. The interviews lasted 30-40 min and were conducted individually with a semi-structured script sent via WhatsApp in advance to the interviewee, prepared with the support of Google Forms. Each interview was recorded on Google Forms. The interviews were carried out in October 2020 with the consent of the participants, established in a specific term.

The categories of the analysis were pre-established in line with Yin (2001), who prescribes analyses of literature review on the subject to develop more assertive research questions in case studies. In addition to the categories established in advance, new categories were created based on data collection (Godoy, 1995; Yin, 2001). Thus, a mixed grid was adopted in which the categories referring to the research objectives were preliminarily defined, but with the possibility of including new categories (Vergara, 2005).

In the semi-structured script, the questions focused on the effects of adherence to the PRL from the perspective of milk producers. To this end, the theoretical construct was divided into two central criteria: market impact and economic development (Table 2).

Table 2 – Theoretical construct

Effects/efficacy criterion	Categories	Authors
Market impact	Materialization of the product(s) (including improvements to existing ones); market share expansion, and increases in sales and profitability	Bozeman (2000); Ogunyemi (2013); Borge and Bröring (2017); Bozeman, Rimes and Youtie (2015); Philippi, Maccari and Da Costa (2018); Park and Chang (2020)
Economic development	Regional or national economic development, including increases in income, creation of work opportunities (more jobs and/or new jobs) or new businesses (downstream and upstream)	Harmon *et al*. (1997); Bozeman (2000); Borge and Bröring (2017); Bozeman, Rimes and Youtie (2015); Philippi (2015); Philippi, Maccari and Da Costa (2018)

Source: elaborated by the authors based on the theoretical reference

For Miles and Huberman (1994) and Eisenhardt (1989), the analysis of results in case studies requires establishing the categories of the analysis. The data were analyzed qualitatively, using the content analysis technique by categories in which the presence or absence of content characteristics was verified, identified in fragments of messages. The characteristics are initially represented by the effectiveness criteria regarding market impact and economic development by Bozeman (2000) and by the categories associated to them (Table 2). The phases recommended by Bardin (2011): (1st) pre-analysis, (2nd) analytical description, and (3rd) interpretation were followed to organize the analysis. The phases were used for each case.

In the pre-analysis phase, the data collected was organized. Data collected from each source was divided according to the general characteristics of the interviewees and of the dairy farms. Next, the data were divided into market impact and economic development as well as in unrelated contents.

In the analytical description phase, the relationships between the contents were identified, divided, and related to the assumptions of the literature consulted, seeking convergences and divergences.

In the referential interpretation phase, connections between ideas were deepened, relating content between sources, in a complementary manner, seeking to identify latent content, such as other market impacts and economic development effects, not present in the literature consulted.

After the phases described, a cross-analysis was carried out (Creswel, 2014) to verify convergences or divergences between cases, highlighting the results inherent to each case.

4 Results and Discussion

This chapter presents the research results. Initially, the interviewees, the dairy farms (recipients), and activities were characterized and then market impact and economic development on the recipients were addressed.

4.1 Characteristics of interviewees, recipients, activities, and history in the PRL

Table 3 presents characteristics of interviewees, recipients (dairy farms), activities developed, and history of cooperation with universities in the PRL.

Table 3 - Characterization of the interviewees

Producers	Schooling	Sex	Age

P1	Middle School – complete	Female	47
P2	College Education – incomplete	Male	50
P3	Middle School – incomplete	Male	63
P4	Middle School – complete	Male	73
P5	High School – incomplete	Male	73

Source: primary data (interviews)

Dos cinco produtores entrevistados, dois informaram que possuem ensino médio completo, enquanto os demais possuem ensino fundamental completo. Two of the interviewees reported that they had completed middle school (P1 and P4); one had college education incomplete (P2); one had incomplete middle school (P3), and another had incomplete high school education (P5) All interviewees were male, except for one (P1). Most interviewees (three) are over 50 years of age. Table 4 shows the characteristics of the dairy farms of the recipients.

Table 4 - Characteristics of the dairy farms (recipients)

Producers	Ownership time	Hectares (ha)	Hectares (ha) of milk production	Number of dairy cows	Cattle breeds
P1	2003	30	20	15	Jersey and Girolando
P2	2012	19.6	05	15	Girolando and Gir
P3	1986	37	30	50	Girolando and Tucura
P4	2003	22	22	36	Girolando and crossbred
P5	1995	51	51	30	Girolando

Source: primary data (interviews)

Two producers have owned the farm since 2003, one since 1986, another since 1995 and the other (P2), since 2012. P1 farm has 30 ha in total, with 20 ha for milk production, and with 15 cows of Jersey and Girolando breeds. P2 farm has 19.6 ha in total, being 5 ha for milk production with five cows of Girolando and Gir breeds. P3 farm covers 37 ha in total and 30 ha of which are allocated for milk production with 50 cows of Girolando and Tucura breeds. P4 farm covers 22 ha and all area is dedicated to milk production with 36 Girolando and crossbred cows. P5 farm covers 51 ha and all area is allocated to milk production with 30 Girolando cows. Table 5 summarizes the history of the farms in the PRL Program.

Table 5 – History of participation of dairy farms in the PRL Program

Producers	Start	Finish	Main reasons to join PRL
P1	2008	2013	Qualification through courses
P2	2016	Not certain	Knowledge
P3	2004	Not certain	Veterinary and technical assistance
P4	2008	2013	Knowledge and skill learning
P5	2004	Not certain	Knowledge and qualification

Source: primary data (interviews)

Table 5 shows that two farms joined the PRL in 2004, when the program was started, two joined in 2008 and one in 2016. Regarding the end of activities in the program, two farms terminated the activities in 2013, while the other interviewees did not inform exactly the year of termination. The reasons to join the PRL Program were the learning, knowledge, and qualification, in addition to technical assistance, as mentioned by P3.

4.2 Technical implications of the PRL program

Table 6 presents changes of work processes in terms of genetics, machinery and equipment acquisition, and new procedures for the activities as a function of participation of farms in the PRL.

Table 6 – Main technical implications of the PRL on dairy farms

Producers	Genetics	Machinery/ equipment (milk)	New procedures for the activities
P1	Insemination	Mechanical milking	Milking hygiene, mastitis testing and cattle management
P2	Insemination and herd standardization	Mechanical milking, forage harvester and silage machine (press)	Management in general, pastures, reproduction and feeding, etc.
P3	Mechanical milking	Sugarcane crusher, covered shed	Mechanization, land and cattle management
P4	Insemination and herd standardization	Not specified	Insemination, pasture management, calf rearing
P5	Herd standardization	Tractor, truck, crusher etc.	Milking, genetics, crossing, pasture management, etc.

Source: primary data (interviews)

Technical implications of adherence to the PRL program in terms of genetics showed that three producers started to adopt artificial insemination after joining the program, one (P3) started using mechanical milking and three adopted herd standardization. As for the acquisition of equipment and machinery, all five producers interviewed purchased machinery: P1 purchased a mechanical milking machine; P2 acquired a mechanical milking machine, a forage harvester and a press machine; P3, purchased a sugarcane crusher and built a covered shed; P4 did not specify the purchases; and P5, purchased a tractor, a truck, a crusher, among others. Considering new ways of carrying out farm activities, P1 acknowledged the adoption of hygienic processes in milking, mastitis testing and cattle management, P2 mentioned changes in management in general, pasture care, reproduction, herd feeding, among others, P3 started using machinery and acquired learning to improve land and cattle management, P4 adopted insemination, pasture management, calf rearing, and P5 implemented changes in the milking process, in genetic and crossing procedures, in pasture management, among others.

4.2 Effects of the PRL Program on dairy farms – efficiency criteria

Next, the effects of cooperation with universities through participation in the PRL are presented, focusing on the farms participating in this research, mainly in terms of market impact and economic development.

4.2.1 Market impact

Initially, it is presented differences in productions of farms and a possible increase in the production volumes of milk and dairy products as a result of the adherence to the PRL. Table 7 presents aspects about products and production volume.

Table 7 – Products and production volume

Producers	What started to produce differently	Increase in milk production: liters/day	Higher volume of dairy products/day
P1	Sugar cane and Napier grass	*From 35 to 50 liters/day	No increase
P2	Cheese production	From 30 to up to 140 liters/day	From 20 to 80 cheese rolls
P3	Agriculture and cheese	*From 80 to 150 liters/day	Cheese (not specified)
P4	Nothing	*From 45 to 50 liters/day	No dairy programs
P5	Nothing	*From 60 to 200 liters/day	No dairy programs

Source: primary data (interviews)
*Annual average considering seasonality between year periods

Table 7 shows that only two producers did not start production of other products, only milk, after joining the PRL Program. Of those who diversified production, one producer started producing sugar cane and Napier grass[3], another started producing cheese and the other invested in cheese production alongside agricultural production.

Significant increases were observed in relation to the volume of production (liters per day) and P5 presented the most significant increase by tripling its production after joining the PRL. On the other hand, P4 showed much smaller production increase than the others, in proportional terms. Similar to the analysis to Table 6, P4 was the same interviewee who did not specify the investments made in machinery and equipment), did not mention changes regarding production processes and did not diversify its production with dairy products.

Regarding the increase in the volume of dairy products, only two producers started producing dairy products (P2 and P3), with P2 increasing cheese production from 20 to 80 rolls and P3 increasing cheese production, but did not specify the quantity.

Table 8 shows the impact of adherence to the PRL Program on market share, considering the increase in sales, profitability, and market share.

Table 8 – Market impact – commercialization and profitability

Producers	Sales increase	Business stimulus (upstream: suppliers)	Business stimulus (sales - downstream: resellers)	Increased profitability
P1	No	Yes. Increased purchase of mineral salt and medicines	Yes – Yes. Due to better milk quality	Yes, due to improvements in processes with changes of cattle breed and increased milk production
P2	Did not answer	Yes. Increased purchase of medicines, feed, semen, etc.	Yes – Yes. Due to better milk quality	Yes, due to value added to milk.
P3	Yes. Milk and cheese	No	Yes.	Yes, due to increased volume of milk production.
P4	Yes. Due to increased volume of milk production.	Yes. Increased purchase of fertilizers, lime, urea, besides a larger number of suppliers.	Yes – Yes. Due to increased volume of milk production.	Yes. Improvements in the process reduced costs and added value to the product.
P5	Yes, mostly because of the increased demand for the milk due to participation in the PRL program.	Yes. Increased purchase of equipment.	Yes – Yes. Due to the increased production volume and more sales, even with the opening of a dairy retail business.	Yes, due to improvements in the processes (mainly pasture management).

Source: primary data (interviews)

Three of the five producers interviewed stated that milk sales increased and one producer (P3) and one of them acknowledged an increase in cheese sales. As for business stimulus for upstream trade (supplies), only one producer (P3) reported no changes, while the

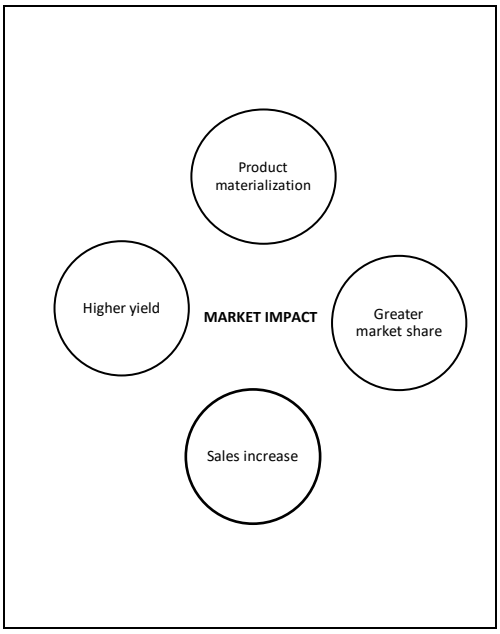
[3] Grass known as elephant grass (*Pennisetum purpureum*). Type of pasture species used on dairy farms with favorable characteristics to animal production (PEREIRA *et al*., 2011)

others reported increased purchase of inputs and P4 highlighted a larger number of suppliers thus diversifying the supplier market. Regarding increased sales and increased sales downstream (resellers), all producers acknowledged a higher volume of sales after joining the PRL Program. P3 reported that their farm does not operate in the resale sector. P1 and P2 recognized that improved milk quality due to adherence to the PRL Program boosted milk sales, while P4 and P5 attributed increased sales to the higher volume produced, with P5 highlighting the direct incentive of the PRL to open a market niche with sales to a dairy factory.

All producers interviewed reported a positive influence of the PRL Program to increase profitability. P1 and P3 linked higher profits to the increased volume of milk produced, while P1 also mentioned process changes. P4 attributed herd improvement favored cost reduction. P5 mentioned that improvements of pastures promoted yield gain. P2 and P4 stated that profit increases were attributed to value added to the product and P4 mentioned that this aggregation of value allowed for increased product prices and thus higher profitability.

Therefore, regarding market impact, the PRL Program allowed for product materialization by improving existing products due to process improvements, in addition to the creation of new products, with an increase in sales for three of the milk producers interviewed. It is observed that one of these three farms entered a new market with sales to a dairy company and all properties reported an increase in the volume produced and greater profitability. Thus, the results converge, for the most part, with the studies by Bozeman (2000) Ogunyemi (2013), Borge and Bröring (2017), Bozeman, Rimes, Youtie (2015), and Philippi, Maccari, da Costa (2018). Figure 1 summarizes the market impact due to adherence to the PRL Program from the perspective of recipients (dairy farms).

Figure 1 – Synthesis of market impact evidences of PRL Program on dairy farms



Source: elaborated by the authors based on research evidences

Figure 1 briefly presents the research results regarding the effects of the PRL Program on market impact from the perspective of recipients (dairy farms).

4.2.2 Economic development

Table 9 presents the effects promoted by adherence to the PRL on dairy farms in terms of local economic development.

Table 9 – Local economic development – jobs and income

Producers	Income generation	New job opportunities
P1	No	No
P2	Yes. Services of equipment and farm maintenance, construction of fences, etc.	Yes. Labor force
P3	Yes. Local labor force	Yes. Labor force
P4	Yes. On the farm to suppliers and even to competitors	Yes. On the farm and to competitors (searching for quality of commercialization)
P5	Yes. Increased income to the personnel involved and to university students that qualified and worked in milk production	Yes. Labor force and commercialization

Source: primary data (interviews)

Table 9 shows that, regarding the income generation due to adherence to the PRL, of the five producers interviewed, only P1 reported that joining the program did not affect income generation. The remaining respondents reported an increase in business income (P4 and P5) and others also reported increases in income from external activities related to the farms: service providers (P2), local labor (P3), and university students (P5) that currently work in milk prodution, after qualifying in the RPL Program. One of the interviewees also reported income increase even from competition (P4).

Except for P1, all other producers reported job creation due to joining the PRL Program, especially considering training. One of the interviewees (P4) also reported that the change in the way of carrying out the activities internally also led to similar changes in the competition.

Therefore, there were increases related to the income generation categories and new job opportunities in most properties. Furthermore, the answers showed that there were no implications of adherence to PRL on opening new businesses or creating new jobs, either upstream or downstream.

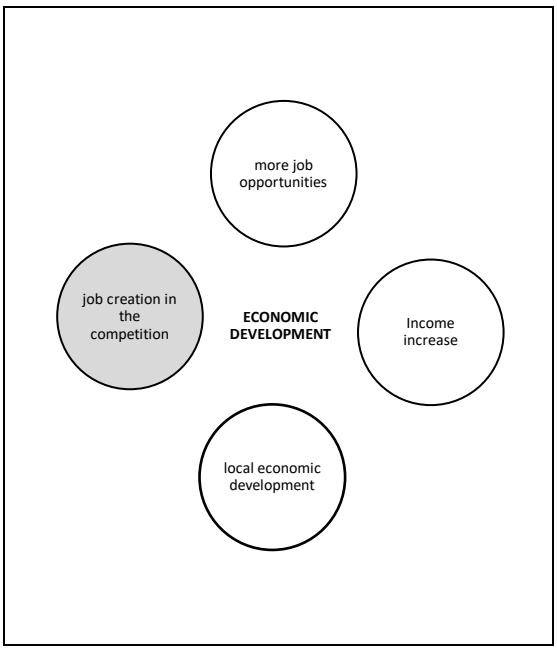
Regarding economic development, the study highlighted only local development, in line with Bozeman (2000) about the timid potential of TT to foster economic development. Except for P1, income generation is evident on the dairy farms, on the own farms and suppliers and even the agent (university students who actively participated in the PRL on the farms). Future studies may indicate this fact on regional development and other regions, depending on the geographic area where they operate.

Regarding job creation upstream and downstream (Bozeman, 2000; Borge & Bröring, 2017; Bozeman, Rimes, & Youtie, 2015; Philippi, 2015; Philippi & Maccari, 2017), only four farms revealed job creation internally; however, a new finding is highlighted with the generation of job opportunities in competition. The cases studied did not show the creation of a new job position (Philippi & Maccari, 2017).

Furthermore, there is no evidence about the opening of new businesses, as Harmon *et al*. (1997), Bozeman (2000) and Bozeman, Rimes, Youtie (2015) point out that the creation of new businesses is possible, differently from Borge and Bröring (2017), Bozeman, Rimes and Youtie (2015), Philippi (2015), Philippi, Maccari and Da Costa (2018). Figure 2 summarizes

the effects of the adherence to the PRL Program on economic development from the perspective of recipients (dairy farms).

Figure 2 – Synthesis of economic development evidences of the PRL Program on dairy farms



Source: elaborated by the authors based on research evidences

The circle highlighted in gray in the figure (job creation in the competition) deals with a new finding of this research, something not evidenced in the studies on economic development presented in subchapter 2.1 and, consequently, in the theoretical construct presented in chapter 3.

5 **Final remarks**

Technology Transfer (TT) from the university to the PRL Program in the five cases studied showed effects on market impact and economic development, although in a less pronounced way than in other studies, due to the scope of TT, as the study is characterized as informal and the small number of the recipients in the PRL Program.

Market impacts occurred with increases in both the production and commercialization of milk and dairy products, as well as in profitability, and in some cases the diversification of the array of products and, particularly in expanding the market share, as a direct consequence of the PRL performance.

In terms of economic development, the effects were at a local level, with greater income generation and job opportunities identified, mostly limited to farms and opportunities for work in competition, differently from what was pointed out in the theoretical framework and in the research construct. Thus, further studies should investigate economic development of TT from universities.

The evidences largely confirm the assumptions highlighted in the literature review, with emphasis on a new finding: the generation of job opportunities in the competition, which can be investigated in further studies.

As for study limitations, it was intended to also use non-participant observation as a data collection instrument to complement data collected in the interviews; however, the COVID-19 pandemic was an obstacle. The pandemic also limited the number of research participants, since one more producer could have been interviewed, but it did not have the technological resources necessary to carry out the interview in the developed modality. The case study research strategy, given the established depth, was ideal for studying the proposed topic; nevertheless, it does not present the possibility of generalization, as it occurs in survey studies.

Similar studies should be carried out in other TT programs, involving milk and dairy production and even in other production chains, such as fruits, vegetables, and green leafy vegetables, also involving universities as "agents" and dairy farms as "recipients". Studies involving other dimensions of the Bozeman Model (2000), such as policies and human, scientific and technical capital, can also be carried out with the same interviewees, as well as in other cases of cooperation, considering TT agents and recipients, as also evidenced in the Bozeman Model (2000).

Furthermore, the importance of the role of other actors is reinforced, such as governments, involving the federal, state, and municipal spheres, as well as class entities in promoting programs that boost technological cooperation and the provision of subsidies to strengthen dairy production. It is understood that, in the context of the dairy farms studied, the role of universities is relevant; however, market impact and economic development can be even more significant when joint, orderly, and continuous actions are implemented.

For the PRL Program, it is recommended to use the results revealed here to join more farms thus strengthening the local and regional milk production chain, as well as technological cooperation processes that highlight contributions of science and technological research developed at universities as partners in solving society's problems.

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