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Measuring the Degree of Oligopsony Power in the Brazilian Raw Milk Market

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Abstract

This study sets out to measure the degree of oligopsony power in the Brazilian raw milk market. The analysis was undertaken in fifteen producing regions between January 1997 and December 2011. The results led to the authors rejecting the monopsony hypothesis. In six regions, the hypothesis of perfect competition was not rejected. In the other nine, the conduct parameter estimates were very close to zero. These results contradict both the empirical literature and the reports produced by Parliamentary Inquiries in the early 2000s, which found suspicions of market power in dairies in several Brazilian states. Although the dairy industry concentrates on the marketing of Brazilian raw milk, the survey results indicate that the behavior of firms is similar to that of a perfect competition market model.

Keywords: oligopsony power, dairy sector, imperfect markets, market concentration, new empirical industrial organization.

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Introduction

In Brazil, the first half of the 1990s saw the beginning of restructuring in the milk production chain. During this period, the retail prices paid for pasteurized and raw milk from farmers were no longer controlled. Furthermore, there was a trend toward the liberalization of trade and economic stabilization which led to a macroeconomic environment which helped to surmount the lack of productive dynamism seen in the sector (Martins and Faria 2006).

The liberalization of trade and differences in raw milk prices impacted the market first by increasing competition and reducing costs and inefficiency; this, in turn, increased competition and promoted quality improvement and product diversification. In the industrial sector, economic openness led to increased competition, initially via imports and, subsequently, through the entry of new multinational firms. In the distribution system, large supermarket chains became the main channel for the sale of dairy products.

Against this background, there was a wave of mergers and acquisitions (M & A), which resulted in increased industrial concentration. This first move was made primarily through the entrance of multinational companies, including Nestlé, Parmalat, Fleischmann-Royal and Danone. National companies with less financial capacity achieved a prominent role only by the mid-2000s with the second wave of mergers. National companies, including Perdigão and the Bom Gosto Dairy[1], led the M & A process. In 2007, two investment funds in the sector, Laep and GP investments gained prominence with their purchase of Parmalat in Brazil and Morrinhos Dairy, respectively.

When the raw milk market itself is analyzed, the increase in market concentration is significant because the geographical scope of the relevant market for agricultural commodities tends to be narrower than that for final products, and consequently, rural producers are restricted to few buyers, in the vicinity of their farms. In addition, the supply of raw milk is usually inelastic and there are also barriers to output. These characteristics are structural conditions conducive to the exercise of market power by the dairies (Sexton and Zhang 2001).

This issue gained prominence in the early 2000s, when Parliamentary Inquiries (PI)[2] were set up in six major milk producing states of Brazil[3] to investigate the suspected misuse of market power, price control, cartel formation (both for dairies and retailers) and the adulteration of products. All the investigations indicated that the farmers were the most vulnerable part of the

[1] Perdigão was one of the main companies in the food sector in Brazil, working primarily in the processing of chicken and pork. In 2006, it entered the dairy sector through the purchase of Batavo. Other acquisitions followed in 2007. Thus, Perdigão became the second largest milk collection company in Brazil. In 2009, it merged with Sadia, another Brazilian company in the food sector. This resulted in the creation of Brazil Foods S/A, the largest company in the food sector in Brazil. Between 2007 and 2010, the Bom Gosto Dairy acquired seven dairies scattered over Brazil's major producing states. In 2009, it became the second largest dairy in terms of quantity of milk collected. In 2010, Bom Gosto merged with the LeiteBom Dairy, giving rise to the LBR – Lácteos Brasil S/A, and in 2010 it was processing approximately 1.8 billion liters of milk per year.

[2] The PIs were committees made up of state legislators, members of the Legislative Assemblies of their respective states, with the aim of investigating the suspected manipulation of milk prices.

[3] The six states investigated were Rio Grande do Sul, Paraná, Santa Catarina, Minas Gerais, Goiás and Mato Grosso do Sul. Together, these six states were responsible for nearly 70% of the total raw milk production in 2002.

production chain and that there were high levels of market concentration, both in the dairy and retail sector. In addition, there was evidence that the dairies and large supermarket chains were able to dictate the prices paid for their inputs (ALRS 2002; ALMG 2002). Reports of these investigations were sent to the Council for Economic Defense (CADE) and whenever there are large price shocks, this same discussion arises.

This problem is also discussed in the empirical literature and concerns about increasing concentration and increasing market power are found in several studies, such as: Jank, Farina and Galan (1999), Barros, et al. (2004), Farina, Nunes and Monteiro (2005), Concha-Amim and Aguiar (2006), Martins and Faria (2006), and Azevedo and Politi (2008).

Against that background, this study hopes to contribute to the discussion on the existence of market power and fill an existing gap, specifically in the raw milk market. Its aim was to measure the degree of oligopsony power of the dairy industry over milk producers and check out if dairies really do distort the price paid for raw milk.

It is worth noting that evidence found in the Parliamentary Inquiries and certain empirical studies (Jank, Farina and Galan 1999 and Martins and Faria 2006, for example), are based on the assumption of the structure-conduct-performance paradigm which associates the increase in market concentration with the increase and, consequently, exercise of market power. This is not necessarily true (Sexton 2000). In addition, the literature does not have any study on measuring the degree of oligopsony power of the dairy industry over milk producers in the Brazilian market.

This measurement will be done from the perspective of the Theory of New Empirical Industrial Organization (NEIO), which supports the investigation of the conduct of market players and identification of the degree of market power in the industry by means of conduct parameter estimation. This parameter is a quantitative indicator which supports the inference of the degree of market distortion caused by the exercise of oligopsony power.

Similar research studies were conducted in Ukraine and Hungary. Perekhozhuk, Grins and Glauben (2009) investigated the existence of oligopsony power in 23 regions of Ukraine but only found evidence in four. However, the estimates of conduct parameters proved small (between 0.007 and 0.022). Hockmann and Võneki (2007) considered that the raw milk market in Hungary was national and rejected the hypothesis of perfect competition. However, the conduct parameter estimate was close to zero (0.001) as in the former study, which indicates that the influence of oligopsony power on the raw milk market segment was very small.

In this study, we defined the relevant geographic market for raw milk as regional and measured the degree of market power in a sample of fifteen producing regions. The monopsony hypothesis was rejected for all markets while that of perfect competition was only rejected for a few, but the conduct parameter estimates were small indicating a slight degree of oligopsony power. These results support the inference that even if the dairy industry is concentrated, it does not exercise market power, at least in relation to distortions in the prices of raw milk paid to milk producers.

The remainder of this article is organized as follows. The next section contains a description of the transformations which occurred in the Brazilian raw milk market and its main characteristics. The theoretical and empirical models of oligopsony are presented in Sections 3 and 4, respectively, while Section 5 describes the variables used in the study. The estimated results are presented in Section 6; and the conclusions in Section 7.

The Brazilian Raw Milk Market

In 1991, after 45 years of control and regulation, the government failed to set prices and allowed free negotiation between raw milk suppliers and the industry. The process of trade openness begun in 1990, and the economic stabilization achieved with the launching of the 1994 *Plano Real*, resulted in establishing the macroeconomic environment necessary for the agents in this sector to surmount the low productive dynamism of the period (Martins and Faria 2006).

This was accompanied by a significant increase in milk production, which soared from 14.4 billion liters in 1990 to 30.7 billion liters in 2010 (113% increase). Productivity also increased by 80%, according to data from the Municipal Livestock Research (PPM), conducted by the Brazilian Institute of Geography and Statistics (IBGE). However, there was a reduction in the number of farmers and an increase in production concentration. The results of the agricultural census showed a drop in the number of establishments from 1.8 million in 1985 to 1.3 million in 2006. In other words, over two decades, approximately 500,000 agricultural establishments (27%) stopped producing milk (IBGE).

The emergence of bulk milk collection and the cooling of milk on the farm required investments in specific assets, including mechanical milking systems and cooling tanks. The difficulties involved in making these investments are cited as one of the causes for the reduced number of farmers (especially small farmers). However, the drop in the prices paid for raw milk is another likely factor. Unlike the growth in production, prices continued to follow a decreasing trend and fell approximately 3% per year, from 1980 to 1994 (when the new economic plan was implemented). From August/1994 to February/1998 alone, there was a cumulative decline of approximately 40%.

The ongoing increase in raw milk production and falling raw milk prices can be explained, at least in part, by increased productivity and economies of scale and/or scope for those farmers who remained on in the sector. According to the results of the agricultural census, average production increased from 2.63 liters/cow/day in 1985 to 4.37 liters/cow/day in 2006 (66% increase) and the average volume of raw milk produced per establishment increased from 18.84 liters/producer/day to 40.93 liters/producer/day - a growth of 117% (IBGE).

In the industrial and marketing sectors, there was a wave of M & A which resulted in increased industrial concentration and increased market power of dairies and supermarkets (Jank, Farina and Galan 1999; Farina, Nunes and Monteiro 2005). Restructuring forced the farmers to negotiate with an increasingly concentrated industry (Martins and Faria 2006).

From 1990 to 2010, over fifty M & A operations were identified in the dairy industry. Between 2003 and 2010 alone the number of dairies decreased from 1,973 to 1,149 (42% reduction) in

Brazil (Conejero, Consoli and Neves 2006; Ministry of Agriculture, Livestock and Supply). At the same time, raw milk collection almost doubled between 1998 and 2010, increasing from 10.7 billion to 20.9 billion liters (Quarterly Milk Survey - IBGE). This represented 68% of all raw milk produced in Brazil in 2010, compared to 57% in 1998. Raw milk collection in the twelve major dairies also doubled over this period, but the concentration indices of these twelve and of the four largest dairies are reasonably low: 26.2% and 18.9%, respectively (Leite Brasil 2011).

It must be stressed, however, that this evidence should be carefully interpreted because the calculated concentration indices only show the concentration rate at national level. Raw milk is a perishable product and, due to transportation limitations, has numerous geographic market areas that are smaller than the nation as a whole[4]. Therefore, there could be significant regional variations. In the state of Rio Grande do Sul, for example, the PI report indicated that two companies alone (Parmalat and Elegê), accounted for approximately 70% of the raw milk market (ALRS 2002).

Finally, as regards the marketing of dairy products, after market deregulation and the promotion of trade openness, there was a significant increase in imports, which almost quadrupled between 1990 and 1995 (Ministry of Development, Industry and Foreign Trade), representing approximately 16% of national production (Barros et al. 2004). But from that period onwards, imports decreased, primarily because of currency devaluation and other protectionist measures (Barros, et al. 2004; Martins and Faria 2006). However, it is important to note that international trade plays a significant role in determining the behavior of the dairy industry through market contestability. The PI investigations indicated that imports were crucial for maintaining domestic prices (ALRS 2002 and ALMG 2002). Furthermore, Barros et al. (2004) found evidence that in the fluid milk market, domestic and foreign markets are integrated and imports are brought in with sufficient frequency to meet the needs of the domestic market, thus guiding the process of price formation. Santos and Barros (2006) also concluded that import prices provide a ceiling for the domestic market and export prices provide a floor.

Theoretical Model of Oligopsony

The model used to measure the degree of oligopsony power in the raw milk market follows the original proposal of Muth and Wohlgenant (1999), which circumvents the existing problem of the need for data, especially of non-specific inputs in the manufacturing process. The works of Hockmann and Võneki (2007) and Perekhozhuk, Grins and Glauben (2009) are other examples of the application of this model to the dairy sector.

Consider an oligopsonistic industry that demands a specific input produced by farmers, represented by a supply function in its reverse form as follows:

$$(1)\quad w_M = g(x_1, z)$$

[4] Some studies in the empirical literature defined the raw milk market as regional. See Perekhozhuk, Grins and Glauben (2009) and Alvarez et al. (2000).

where w_M is the deflated price paid to farmers for raw milk; x_1 is the amount of raw milk offered and z is a vector of exogenous factors which shift the supply. The profit equation for a representative dairy is described as follows:

$$(2)\quad \Pi = p \cdot f(x_1, x) - w_M x_1 - w' x ,$$

where p is the deflated price for the dairy products (at the wholesale level), $f(\cdot)$ is the production function, x is a vector quantity of other inputs used in the production process (e.g., labor, energy and capital) and w is a vector of the deflated prices for the other inputs.

Assuming that dairies maximize profit and determine the price of raw milk, the demand for the specific input will be given by the first-order condition (FOC) of the profit equation (2), where the marginal cost of the input equals the marginal revenue product.

$$(3)\quad w_M\left(1+\frac{\theta}{\varepsilon}\right) = p\frac{\partial f(x_1, x)}{\partial x_1}.$$

$\varepsilon = (\partial x_1 / \partial g(\cdot))(w_M / x_1)$ is the price elasticity of the supply of raw milk, and θ is a parameter which indexes the degree of market power. If $\theta = 0$, the market is perfectly competitive and the marginal revenue from the dairy product is equal to the price of the raw milk; if $\theta = 1$, the market is a monopsony, and marginal revenue from the dairy product equals the marginal input cost (price of raw milk plus a discount factor referring to the reduced monopsony price). The intermediate values of θ represent the degrees lower than full market power (monopsony), such as the condition of the Cournot equilibrium, $\theta = 1/n$. The FOC can be interpreted as the "perceived" marginal input cost for the dairy, which is equal to the marginal revenue from the dairy product.

To estimate the degree of oligopsony power, the FOC (3) must be specified with the quantity data for all non-specific inputs included in the production function $f(\cdot)$, i.e., other inputs besides x_1. As data on these questions are not available for the dairy industry, the profit equation must be redefined in order to circumvent this restriction. Muth and Wohlgenant (1999) suggest replacing the optimum amounts of non-specific inputs with their conditional quantities at the optimum level of the x_1 input. Thus, assuming that there are three non-specific inputs involved in the manufacturing of dairy produce, namely, work (x_2), energy (x_3) and capital (x_4), the profit equation (2) can be rewritten as follows:

$$(4)\quad \begin{aligned}\Pi(p, x_1, z, w_2, w_3, w_4) = p \cdot f(x_1, x_2^*, x_3^*, x_4^*) - g(x_1, z)x_1 \\ - w_2 x_2^* - w_3 x_3^* - w_4 x_4^*\end{aligned},$$

where x_2^*, x_3^* and x_4^* are the optimal quantities of x_2, x_3 and x_4 conditional on the level of specialized input x_1; and w_2, w_3 and w_4 are the prices of the non-specific inputs: labor, energy and capital, respectively. Specifically, the following equations are obtained: $x_2^* = x_2(x_1, w_2, w_3, w_4, p)$, $x_3^* = x_3(x_1, w_2, w_3, w_4, p)$ and $x_4^* = x_4(x_1, w_2, w_3, w_4, p)$.

Assuming that the non-specialized inputs are purchased in a perfectly competitive market, the new FOC in relation to the selection of x_1 is given by the following:

$$(5)\quad \begin{aligned} w_M &= -\theta \frac{\partial g(x_1, z)}{\partial x_1} x_1 + \\ &p \frac{\partial f\left[x_1, x_2(x_1, w_2, w_3, w_4, p), x_3(x_1, w_2, w_3, w_4, p), x_4(x_1, w_2, w_3, w_4, p)\right]}{\partial x_1}. \end{aligned}$$

In other words, the FOC for profit maximization can be derived by simply differentiating the equation (4) with respect to x_1 and maintaining x_2, x_3 and x_4 at the levels optimally determined (an application of the Envelope Theorem). It should be noted that the marginal product is defined by the prices of the non-specialized inputs rather than the corresponding quantities.

Empirical Model

For the empirical application of the structural oligopsony model, it was assumed that the supply function for raw milk, equation (1), can be represented by a second-order approximation of a transcendental logarithmic function (translog), represented by the following:

$$(6)\quad \begin{aligned} \ln x_1 &= \beta_0 + \sum \beta_i \ln W_i + \phi_R \ln R + \delta T + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln W_i \ln W_j \\ &+ \sum_i \delta_{iT} \ln W_i T + \phi_{RT} \ln RT \end{aligned},$$

where W_i (i = M, C, Z, E) are, respectively, the price paid to farmers for raw milk (W_M), the price paid for feed (W_C), the price of live cattle (W_Z) and the exchange rate (W_E). R is the size of the herd and T is a time trend, specified to capture technical changes and other unobserved factors which affect the response of the raw milk supply in the short-term. Based on equation (6), it is possible to derive the price elasticity of the raw milk supply, given by the following:

$$(7)\quad \varepsilon = \frac{\partial \ln x_1}{\partial \ln W_M} = \beta_M + \sum_i \beta_{Mi} \ln W_i + \delta_{MT} T.$$

Considering the definition of the profit function for the dairy, given by equation (4), the marginal product of the dairy $\partial f(\cdot)/\partial x_1$ in (5) is also derived from an approximation of a translog function and is given by the following:

$$(8)\quad \frac{\partial f(\cdot)}{\partial x_1} = \frac{Y}{x_1}\left(\alpha_x + \alpha_{xx} \ln x_1 + \sum_{i=2}^{4} \alpha_{xi} \ln w_i + \alpha_{xp} \ln p\right)$$

where Y is the total output, x_1 is the amount of raw milk purchased and industrialized by the dairy industry, w_2 is the cost of labor in the dairy industry, w_3 is the cost of electricity in the industrial sector, w_4 is the cost of capital, measured by the real interest rate, and p is the price of the dairy product (at wholesale level).

Before proceeding with the definition of the model, however, it is necessary to assume a simplification in equation (8). Raw milk is the basic input in the production of several dairy products (fluid milk, cheese, butter, yoghurt, etc.). These products have different relevant markets and also different prices, so it would be impossible to group them into one single oligopsony model. To circumvent this problem, we assume a similar simplification used by Schroeter et al. (2000) and convert the quantity of dairy products Y into the equivalent liters of raw milk. This transformation means that $Y = x_1$, and the term Y/x_1 in (8) is canceled. Additionally, by applying this transformation, we are also obliged to place dairy product prices at the wholesale level p. Therefore, equation (8) becomes the following:

$$(9)\quad \frac{\partial f(\cdot)}{\partial x_1} = \alpha_x + \alpha_{xx}\ln x_1 + \sum_{i=2}^{4}\alpha_{xi}\ln w_i + \alpha_{xp}\ln p^*$$

where p^* is now the price of dairy products (at wholesale level) converted into equivalent liters of raw milk[5]. Based on (9), all of the components are available to define the FOC, given by equation (3). Using the equations (7) and (9), equation (3) is described by the following:

$$(10)\quad w_M = \frac{p^*\left(\alpha_x + \alpha_{xx}\ln x_1 + \sum_{i=2}^{4}\alpha_{xi}\ln w_i + \alpha_{xp}\ln p^*\right)}{\left(1 + \dfrac{\theta}{\beta_M + \sum_i \beta_{Mi}\ln W_i + \delta_{MT}T}\right)}$$

Equations (6) and (10) form a system of simultaneous equations for determining the degree of oligopsony power for the dairy industry in the purchase of raw milk. The econometric model is a nonlinear simultaneous equation system where the variables x_1, w_1 and p^* are jointly determined, and a term of disturbance is added to the two equations to allow for the existence of random shocks.

The nonlinear Generalized Method of Moments (GMM-NL) was used to estimate the model. The GMM is a robust estimator which, unlike the maximum-likelihood estimator, requires no information about the exact distribution of residuals (Gallant 1987). The heteroscedasticity and autocorrelation consistent (HAC) covariance matrix estimation also results in estimates that are robust to heteroscedasticity and autocorrelation in the residues. Thus, the traditional tests for detecting heteroscedasticity, autocorrelation and the distribution of residues are expendable. The only test required is the assessment of the validity of the restrictions of super-identification[6].

[5] The next section describes price conversion procedures.
[6] Moreover, in nonlinear regression models, the coefficient of determination R^2 loses value as a descriptive statistic for checking the quality of the model adjustment. The residual sum of squares plus the explained sum of squares is not necessarily equal to the total sum of squares. Therefore, the residual sum will not necessarily be equal to zero (Davidson and Mackinnom 2003).

Description of the Variables Used

The database used to estimate the structural model is a set of monthly data for covering the January/1997 to December/2011 period and gives a total 180 observations. Because of the restriction imposed on the geographical breadth of the relevant market, the data were obtained at the level of mesoregions (the most disaggregated level possible) so that tests could be carried out to delimit the relevant market. In total, information from fifteen Brazilian mesoregions was collected. The sample period and the regions analyzed were chosen according to data availability.

Figure 1 shows the distribution of the fifteen mesoregions in the sample. They are distributed over the six major milk producing states of Brazil – Rio Grande do Sul (3), Paraná (3), São Paulo (2), Minas Gerais (3), Goiás (2) and Santa Catarina (2) – which were responsible for 74% of national production in 2011. The twenty largest producers in Brazil are found in nine of these regions. Together, they produced 13.5 billion liters of raw milk in 2011, corresponding to 44% of the total Brazilian production (IBGE). The dairy industry collected 21.7 billion liters of raw milk throughout Brazil in 2011. In the fifteen mesoregions alone, 10.4 billion liters were collected, the equivalent of 47.7% of the total volume (IBGE).

Figure 1. Spatial distribution of the fifteen mesoregions selected.
Source. Drawn up by the authors

The variables used in the production function of raw milk are described below:

- Amount of raw milk (x_1) - monthly raw milk collected by the dairies in each mesoregion. The values are expressed in liters and were obtained from the Quarterly Milk Survey conducted by IBGE.

- Price of raw milk (w_M) - monthly average net price (after shipping rates and taxes) paid to farmers in each mesoregion. The values are expressed in R$/liter and were obtained from the Milk Bulletin, published by the Center for Advanced Studies in Applied Economics (CEPEA) at the *Universidade de São Paulo*[7].
- Price of feed (W_C) - monthly average price per kilogram of concentrated feed (R$/Kg) for dairy cows in the state of São Paulo; obtained from the database of the Institute of Agricultural Economics (IEA).
- Price of live cattle (W_Z) - monthly average price paid per *arroba* (unit of weight equal to 15 kg) of live cattle (R$/arroba) in the state of São Paulo; also obtained from the database of the Institute of Agricultural Economics (IEA).
- Exchange rate (W_E) - monthly average value of the commercial exchange rate, measured in nominal terms (R$/US$); published by the Brazilian Central Bank.
- Herd (R) - number of cows milked annually in each mesoregion analyzed, data provided by the Municipal Livestock Survey, conducted by IBGE. The data was interpolated (using a linear function) for conversion into a monthly series.

In addition to the price and quantity of raw milk, the following variables were used to estimate the demand function for raw milk by the dairy industry:

- Wage (w_2) – monthly average real wage index of Brazilian industry (for January/1997 = 100), obtained from the Institute of Applied Economic Research (IPEADATA).
- Energy (w_3) – monthly average price of electricity, charged per Megawatt/hour (R$/MWh) to the industrial sector, divided into the large Brazilian regions (South, Southeast and Midwest); released by the National Electrical Energy Agency (ANEEL).
- Capital (w_4) – monthly real interest rate, calculated as the difference between the Over/Selic rate provided by the Brazilian Central Bank, and the Consumer Price Index (IPCA) provided by IBGE.
- Prices of dairy products (p^*) – monthly price index calculated by a weighted average of the prices of dairy products at wholesale level, converted into the equivalent in raw milk. First, the following dairy products, milk powder, butter, cheese and other dairy products[8] were defined. They were converted into the equivalent in raw milk using the conversion table provided by the Brazilian Agricultural Research Corporation (EMBRAPA). Then, a weighted average price is calculated using the weight of each product in the international trade of dairy products (similar to the international price index of dairy products - DPI - published by FAO) as weighting factors. Table 1 summarizes the multiplication factors for conversion and the weight of each dairy product in the calculation of the price index.

[7] The series of prices paid for raw milk had to be interpolated because the research conducted by CEPEA started in 2004. Accordingly, between January 1997 and mid-2004 (the series were released as the mesoregions were being incorporated into the research), the price series of each mesoregion corresponds to the average price paid for raw milk in the State, which is provided by the *Fundação Getúlio Vargas*.
[8] Fluid milk in its many varieties is included.

Table 1. Multiplication and weighting factors used to calculate the weighted price index of dairy products, in equivalent raw milk

Dairy Products	Multiplication Factor[2]	Weighting Factor[3]
Milk powder	8.2	8.16%
Butter	1.65	9.16%
Cheese	10.0	12.81%
Other dairy products[1]	1.0	69.81%

Sources.
[1] Other dairy products include fluid milk, yoghurt, cream and condensed milk.
[2] Brazilian Agricultural Research Corporation (EMBRAPA);
[3] UN Food and Agriculture Organization (FAO).

The GMM needs instruments for parameter estimation other than the exogenous variables included in the equations of supply and demand, and so other variables were used as instruments in the estimation process: the international price index of dairy products released by FAO; the fuel price index, provided by *Fundação Getúlio Vargas* and two dummy variables – one covering the rainy season[9] and the other referring to the second half of 2007, which was characterized by increased prices on the international market.

All the variables representing monetary values were converted into real values by an aggregate price index, the Broad Consumer Price Index (IPCA), which is published by IBGE and defined as the official indicator of Brazilian inflation. All the series used were expressed in real values as of December/2011. In addition, the series were deseasonalized by the X12 method.

Estimation and Empirical Results

The definition of the relevant market, for both product and geographical region, is a key step in studies on market power (Sexton 2000) and was, therefore, the first step undertaken in this analysis. The relevant market for raw milk is the commercial relationship between farmers and the dairy industry in the marketing of raw milk. In terms of product, the relevant market is raw milk, which has no substitute. Geographically, two characteristics are essential in defining the market: perishability and transportation costs. These two characteristics significantly restrict the possible distance that raw milk can be transported from a farm to a dairy.

This restriction has been seen in the empirical literature. Perekhozhuk, Grins and Glauben (2009) claim that even if the adoption of cooling systems and bulk collection on the farm allowed raw milk to be transported to more distant regions, the geographical market in Ukraine does not exceed a radius of 150 km from the farm. Alvarez et al. (2000) also adopt the definition of a regional market (without specifying the distance) when they analyze the existence of oligopsony power in Spain. In Brazil, Conejero, Cônsoli and Neves (2006) found evidence for collection centers being situated close to dairies so as to minimize freight costs. In this context, we start with the hypothesis of a narrower geographic market (restricted to regional boundaries).

[9] During the rainy season, there tends to be a greater availability of fodder for livestock, which reduces the need for feed supplementation.

As explained, the database comprises a sample of fifteen producing mesoregions in Brazil. Raw milk production and collection in each of these regions is summarized in Table 2. It is noteworthy that raw milk collection by the dairies is greater than the amount produced only in four (North Central Paraná, East Central Paraná, Porto Alegre Metropolitan Area, and Central Goiás) of the fifteen mesoregions. In the other regions, the amount of raw milk collected is below the local production. This evidence supports the hypothesis of a market which is restricted to regional boundaries. However, additional statistical tests were carried out to corroborate this hypothesis.

Table 2. Raw milk production and collection in the selected mesoregions in 2011.

Region	**Mesoregion**	**Raw milk collection in 2011 (million liters) (A)**	**Prop. (%)**	**Raw milk production in 2011 (million liters) (B)**	**Prop. (%)**	**A/B (%)**
1	Triângulo Mineiro/Alto Paranaíba	1,949	8.94	2,093	6.82	93.12
2	Vale do Rio Doce	545	2.50	589	1.92	92.54
3	Southern/Southwestern Minas	919	4.22	1,361	4.43	67.51
4	São José do Rio Preto	190	0.87	345	1.12	55.10
5	Vale do Paraíba Paulista	197	0.91	212	0.69	93.18
6	North Central Paraná	257	1.18	237	0.77	108.48
7	East Central Paraná	504	2.31	433	1.41	116.44
8	Western Paraná	547	2.51	888	2.89	61.60
9	Western Santa Catarina	1,284	5.89	1,742	5.67	73.69
10	Vale do Itajaí	54	0.25	217	0.71	24.70
11	Northeastern Rio Grande do Sul	1,483	6.80	2,400	7.81	61.81
12	Northeastern Rio Grande do Sul	170	0.78	396	1.29	42.79
13	Porto Alegre Metropolitan Area	164	0.75	148	0.48	110.55
14	Central Goiás	1,267	5.81	809	2.63	156.75
15	Southern Goiás	882	4.05	1,655	5.39	53.30
	Total Sample	10,413	47.70	13,526	44.00	76.98
	Brazil	**21,799**	**100**	**30,715**	**100**	**70.97**

Source. Brazilian Institute of Geography and Statistics (IBGE)

Stationarity tests, serial correlation and co-integration[10] were applied to the series of prices paid for raw milk in the fifteen mesoregions. In all the tests, the hypothesis of markets larger than the borders of the mesoregions was statistically rejected. These results corroborate the existence of separate relevant markets restricted to regional borders (mesoregions). Although the market apparently stretched beyond its boundaries in four regions, there are no data on the neighboring regions to allow us to carry out aggregation tests. Accordingly, we assume that the fifteen mesoregions correspond to fifteen individual relevant markets for the raw milk trade.

[10] For further details of these tests, see Haldrup (2003) and Forni (2004)

Thus, the econometric model of oligopsony was estimated using the GMM-NL for each mesoregion, which resulted in a total of fifteen systems of nonlinear simultaneous equations. The results of the estimates are summarized in Table A (attached). As discussed earlier, the GMM estimator is robust and, unlike the maximum-likelihood estimator, requires no information about the exact distribution of residues (Gallant 1987).

Under the null hypothesis that the restrictions of over-identification are met, the validity test for the restrictions was performed by multiplying the value of the objective function $S(\theta, \hat{V})$ by the number of observations. The test is asymptotically distributed as χ^2, with the degrees of freedom equal to the number of over-identification constraints. The tests are recorded at the bottom of the table. It can be seen that the null hypothesis is not rejected in any of the models. Therefore, one can conclude that the estimated models are valid and the inference can be made.

The own-price elasticities for the supply of raw milk (ε) and the estimates of the conduct parameter (θ) of the oligopsony model are particularly interesting for estimates. These estimates are summarized in Table 3. The own-price elasticities of supply, obtained from equation (7) for each mesoregion, were calculated at the midpoint of the sample. The standard error and the p-value estimates were also informed. Only three of the fifteen estimates were statistically non-significant and some estimates showed a negative sign, contrary to the a priori expectation.

Table 3. Estimated results of the own-price elasticity of supply at the midpoint of the sample and conduct parameters.

Mesoregion	***ε***	**des-pad**	**p-value**	***θ***	**des-pad**	**p-value**
Triângulo Mineiro/Alto Paranaíba	0.273	0.074	0.00	0.000	0.001	0.430
Vale do Rio Doce	-0.219	0.033	0.00	**0.012**	**0.005**	**0.014**
Southern/Southwestern Minas	-0.138	0.023	0.00	**0.003**	**0.001**	**0.019**
São José do Rio Preto	0.059	0.032	0.07	0.018	0.018	0.301
Vale do Paraíba Paulista	-0.530	0.152	0.00	0.007	0.006	0.217
North Central Paraná	-0.724	0.163	0.00	**0.089**	**0.041**	**0.030**
East Central Paraná	0.824	0.535	0.13	-0.020	0.027	0.462
Western Paraná	-0.046	0.043	0.28	**0.004**	**0.002**	**0.057**
Western Santa Catarina	0.128	0.045	0.01	**-0.006**	**0.002**	**0.011**
Vale do Itajaí	0.403	0.074	0.00	**0.017**	**0.007**	**0.016**
Northwestern Rio Grande do Sul	-0.343	0.095	0.00	**0.005**	**0.002**	**0.018**
Northeastern Rio Grande do Sul	-0.172	0.036	0.00	**0.019**	**0.007**	**0.008**
Porto Alegre Metropolitan Area	1.212	0.199	0.00	0.016	0.012	0.173
Central Goiás	-0.412	0.086	0.00	**-0.013**	**0.007**	**0.057**
Southern Goiás	0.017	0.010	0.12	-0.002	0.002	0.215
Average	0.022			0.010		
Maximum	1.212			0.089		
Minimum	-0.724			-0.020		

Source. Research results

The negative sign of the own-price elasticity of supply could be a consequence of the constraints on the variables used (such as the technology shifter), or it could also be a result of the characteristics of the sector. According to Tauer and Kaiser (1988), there may be a downward sloping supply function for profit-maximizing firms facing a cash flow constraint. The necessary condition is that at least one of the factors be a no-cash input. The authors found empirical evidence that milk farmers commonly increase production even at lower prices by increasing, for example, the number of milkings performed per day.

Finally, with the exception of the Metropolitan mesoregion of Porto Alegre, all the estimates are smaller than unity. Therefore, the price elasticity of raw milk supply is inelastic. This characteristic is important because a high concentration of buyers in the relevant market and an inelastic supply of farmers are structural conditions conducive to the exercise of oligopsony power by dairies, as already documented by Sexton and Zhang (2001). Any distortion in the price offered by dairies has little impact in relation to a production adjustment for farmers, which enables the dairies to obtain higher profits.

With respect to the estimates of the degree of oligopsony power, not all estimates were within the interval of theoretical significance ($0 \leq \theta \leq 1$). In the mesoregions of East Central Paraná, Western Santa Catarina, Central Goiás and Southern Goiás, the estimates were negative, although only two were statistically significant. In six regions, the conduct parameters were not significantly different from zero. Thus, the assumption of perfect competition was not rejected. In other regions (in bold), the parameters were significantly different from zero at the 10% level of significance, but the estimated values were very small. The average value obtained was 0.01, while the maximum and minimum values were 0.089 and 0.02, respectively.

These results were close to those found by Hockmann and Võneki (2007) and Perekhozhuk, Grins and Glauben (2009). In the former, the authors indicated the existence of oligopsony power in the raw milk market in Hungary. However, the power of oligopsony was very small and the estimate of the parameter θ was equal to 0.001. Similarly, Perekhozhuk, Grins and Glauben (2009) found evidence of oligopsony power in only four of the twenty-three regions they analyzed in Ukraine. In the regions where the assumption of perfect competition was rejected, the estimates ranged from 0.007 to 0.022.

The results support the inference that oligopsony power is not a problem which significantly affects the Brazilian raw milk market. The estimates support the rejection of the hypothesis of monopsony in all the regions analyzed and the degree of distortion generated by oligopsony power, when identified, was small. This result is significant because it contradicts what is presented in the Parliamentary Inquiry reports on milk prices (ALRS 2002 and ALMG 2002) and also the discussion reported in the empirical literature, relating increasing concentration to increased oligopsony power in the dairy industry (Jank, Farina and Galan 1999; Martins and Faria 2006). Although the raw milk market could be concentrated and the dairies could have market power, the results support the existence of markets with the dynamics of perfect competition or at least close to perfect competition.

Although our results contradict common sense, there is certain evidence to corroborate our findings, which therefore gives greater support to our conclusions. One such is the possibility of competition through imports (market contestability). As previously discussed, Barros et al. (2004) and Santos and Barros (2006), found evidence that imports are brought in with sufficient frequency to supply the domestic market and influence domestic prices. So, because domestic prices tend to follow international prices, this creates a certain rigidity in the capacity of the dairies to fix prices.

Secondly, the informal marketing of raw milk and the idle capacity of the dairy industry are two factors which restrict the possibility of collusive action on the part of the dairies. Bánkuti, Schiavi and Souza Filho (2005) found evidence that there is an informal market not only in small but also in medium-sized farms, and that farmers operate simultaneously in both. In addition, we also found various cases of small farmers getting together to produce dairy products on the farm itself to sell in regional markets and fairs.

In this scenario therefore, there is keen competition between the dairies for milk producers and any price manipulation could lead to a loss of these suppliers. Although there are no data for the industry as a whole, Barros et al. (2004) found evidence that the dairies award bonuses for production volume. This is a clear strategy for holding on to large milk producers and is totally contrary to the hypothesis of the exercise of oligopsony power.

Conclusion

The purpose of this study was to measure the degree of oligopsony power in the Brazilian raw milk market. After defining the relevant market, the econometric model was estimated at the level of mesoregion. The results did not indicate the existence of any large distortions caused by oligopsony power. The estimates led to the rejection of the hypothesis of monopsony in all the regions analyzed and, in general, the conduct parameter estimates were close to zero, which would indicate markets whose dynamics are very close to those of perfectly competitive markets.

This result is significant because it contradicts the suspicions of market power, found in investigations carried out by the milk price Parliamentary Inquiries and it also contradicts the discussion in the literature that increased market concentration led to an increase in the market power of dairies. Even if the raw milk market is concentrated on the part of the dairies, the evidence does not support the hypothesis that they distort the market by imposing prices lower than those that would be paid in a competitive market.

Finally, we wish to emphasize that this study is limited to an analysis of market power in the supply chain link, represented by the relationship between farmer and dairy, in the supply of raw milk, hence the conclusion that the problem of market power is not relevant, and cannot be extended to the supply chain as a whole. If there are distortions in other links, they tend to be transmitted along the entire chain. Thus, an investigation of other links in the milk supply chain is to be recommended.

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Appendix

Table A. Estimated results of the simultaneous equation system of the oligopsony model

Part 1.

	Tr. Mineiro/A. Paranaíba			Vale do Rio Doce			Southern/South-western Minas			São José do Rio Preto			Vale do Paraíba Paulista		
Param	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val
β_0	33.36	17.21	0.05	-33.31	16.94	0.05	-24.41	7.42	0.00	26.13	9.67	0.01	-47.74	17.72	0.01
β_M	-1.04	0.33	0.00	-4.86	0.73	0.00	11.91	2.04	0.00	8.22	3.06	0.01	-15.38	4.36	0.00
β_C	0.49	4.20	0.91	3.64	5.35	0.50	-0.36	2.83	0.90	-12.30	4.12	0.00	0.12	4.34	0.98
β_Z	-4.29	7.18	0.55	21.66	7.43	0.00	8.88	2.85	0.00	4.51	5.33	0.40	41.55	8.47	0.00
β_E	3.17	2.64	0.23	-3.19	3.13	0.31	8.82	1.81	0.00	7.04	2.11	0.00	-9.34	3.45	0.01
β_R	-0.78	0.35	0.03	0.38	0.25	0.13	1.96	0.34	0.00	-1.47	0.38	0.00	-1.86	0.53	0.00
δ	-0.15	0.08	0.08	0.08	0.06	0.21	-0.24	0.06	0.00	-0.13	0.04	0.00	-0.34	0.08	0.00
β_{MM}	-0.14	0.04	0.00	-1.47	0.22	0.00	6.62	1.11	0.00	-7.79	2.09	0.00	12.78	3.67	0.00
β_{MC}	3.82	1.06	0.00	1.73	0.27	0.00	2.30	0.39	0.00	8.82	2.37	0.00	-11.68	3.33	0.00
β_{MZ}	0.19	0.06	0.00	0.79	0.12	0.00	-1.19	0.21	0.00	-2.63	0.87	0.00	4.52	1.29	0.00
β_{ME}	0.98	0.28	0.00	-0.02	0.01	0.28	-2.13	0.36	0.00	-2.59	0.73	0.00	5.98	1.70	0.00
β_{CC}	-2.13	1.41	0.13	-2.75	1.26	0.03	0.74	0.78	0.34	-8.67	2.51	0.00	8.06	3.19	0.01
β_{CZ}	0.69	0.98	0.48	-0.36	1.20	0.77	0.69	0.66	0.30	3.67	1.04	0.00	-1.07	1.19	0.37
β_{CE}	-0.49	0.36	0.18	-0.38	0.47	0.41	-0.20	0.36	0.58	2.72	1.07	0.01	-3.56	1.31	0.01
β_{ZZ}	1.44	1.69	0.39	-5.33	1.64	0.00	-2.01	0.69	0.00	-1.19	1.22	0.33	-9.89	1.96	0.00
β_{ZE}	-0.46	0.61	0.45	0.78	0.74	0.29	-2.57	0.46	0.00	-1.61	0.47	0.00	2.83	0.96	0.00
β_{EE}	-0.92	0.44	0.04	0.87	0.43	0.04	0.19	0.24	0.44	-1.80	0.66	0.01	2.55	0.73	0.00
δ_{MT}	$-2.27x10^{-3}$	0.00	0.00	$1.57x10^{-3}$	0.00	0.00	$-2.52x10^{-2}$	0.00	0.00	$2.20x10^{-2}$	0.01	0.00	$-3.50x10^{-2}$	0.01	0.00
δ_{CT}	$-1.27x10^{-2}$	0.00	0.00	$-3.15x10^{-3}$	0.00	0.39	$-1.36x10^{-2}$	0.00	0.00	$-1.49x10^{-2}$	0.00	0.00	$1.81x10^{-2}$	0.01	0.02
δ_{ZT}	$-1.37x10^{-2}$	0.00	0.00	$1.05x10^{-2}$	0.00	0.00	$9.58x10^{-3}$	0.00	0.00	$-6.45x10^{-5}$	0.00	0.98	$1.67x10^{-2}$	0.00	0.00
δ_{ET}	$3.42x10^{-4}$	0.00	0.86	$-9.16x10^{-3}$	0.00	0.00	$1.51x10^{-2}$	0.00	0.00	$5.79x10^{-3}$	0.00	0.00	$-2.92x10^{-2}$	0.01	0.00
δ_{RT}	$1.54x10^{-2}$	0.01	0.02	$-8.18x10^{-3}$	0.01	0.11	$1.28x10^{-2}$	0.00	0.00	$1.03x10^{-2}$	0.00	0.00	$2.19x10^{-2}$	0.01	0.00
α_x	$-3.91x10^{-2}$	0.01	0.00	$-1.38x10^{-1}$	0.02	0.00	$-5.75x10^{-2}$	0.01	0.00	$-4.72x10^{-2}$	0.02	0.04	$8.28x10^{-2}$	0.02	0.00
α_{xx}	$9.61x10^{-4}$	0.00	0.04	$3.03x10^{-4}$	0.00	0.61	$9.16x10^{-4}$	0.00	0.12	$1.29x10^{-3}$	0.00	0.28	$-5.15x10^{-3}$	0.00	0.00
α_{x2}	$2.73x10^{-3}$	0.00	0.06	$1.66x10^{-2}$	0.00	0.00	$3.81x10^{-3}$	0.00	0.00	$7.50x10^{-3}$	0.00	0.00	$3.78x10^{-3}$	0.00	0.08
α_{x3}	$-5.40x10^{-4}$	0.00	0.22	$-1.01x10^{-3}$	0.00	0.35	$-5.08x10^{-4}$	0.00	0.14	$-2.62x10^{-4}$	0.00	0.82	$-1.51x10^{-3}$	0.00	0.00
α_{x4}	$-6.98x10^{-4}$	0.00	0.00	$1.29x10^{-4}$	0.00	0.62	$-2.77x10^{-4}$	0.00	0.04	$-3.18x10^{-4}$	0.00	0.38	$1.77x10^{-4}$	0.00	0.47
α_{xp^*}	$3.88x10^{-3}$	0.00	0.12	$1.36x10^{-2}$	0.00	0.00	$6.78x10^{-3}$	0.00	0.00	$-3.12x10^{-4}$	0.00	0.85	$-1.78x10^{-4}$	0.00	0.90
θ	0.00	0.00	0.43	0.01	0.00	0.01	0.00	0.00	0.02	0.02	0.02	0.30	0.01	0.01	0.22
$s(\varepsilon,\hat{v})$	0.0937			0.1266			0.1208			0.0997			0.1081		
Over-id	16.87		0.99	22.78		0.99	21.74		0.99	17.94		0.99	19.46		0.99

Source. Research results

Table A. Estimated results of the simultaneous equation system of the oligopsony model-*Cont.*

Part 2.

Param.	North Central Paraná Est.	stand-error	p-val	East Central Paraná Est.	stand-error	p-val	Western Paraná Est.	stand-error	p-val	Western Santa Catarina Est.	stand-error	p-val	Vale do Itajaí Est.	stand-error	p-val
β_0	290.95	59.47	0.00	-368.65	167.98	0.03	57.91	13.18	0.00	84.65	20.40	0.00	-181.22	22.41	0.00
β_M	75.92	13.31	0.00	-26.97	13.11	0.04	13.31	3.63	0.00	20.26	7.02	0.00	-12.27	2.58	0.00
β_C	35.58	15.61	0.02	-42.02	27.81	0.13	7.16	2.41	0.00	8.60	3.89	0.03	0.52	4.72	0.91
β_Z	-120.02	28.27	0.00	176.59	65.25	0.01	-7.64	5.03	0.13	-9.62	5.54	0.08	-11.41	5.79	0.05
β_E	45.29	6.95	0.00	-46.05	14.43	0.00	1.76	1.66	0.29	4.95	3.42	0.15	-0.07	3.05	0.98
β_R	-0.33	2.13	0.88	1.82	4.92	0.71	-1.68	0.29	0.00	-3.17	1.33	0.02	19.15	1.66	0.00
δ	-0.42	0.25	0.10	-0.43	0.36	0.24	-0.18	0.04	0.00	-0.41	0.13	0.00	1.10	0.14	0.00
β_{MM}	3.33	1.10	0.00	18.76	7.02	0.01	-1.05	0.34	0.00	1.39	0.49	0.00	-6.01	0.94	0.00
β_{MC}	13.84	2.51	0.00	-25.60	8.29	0.00	1.52	0.41	0.00	5.03	1.75	0.00	-7.49	1.07	0.00
β_{MZ}	-19.01	3.32	0.00	10.70	3.97	0.01	-3.34	0.91	0.00	-3.79	1.31	0.00	1.16	0.50	0.02
β_{ME}	9.91	1.79	0.00	-2.15	3.21	0.50	1.39	0.38	0.00	-0.67	0.24	0.01	-1.30	0.24	0.00
β_{CC}	8.06	3.93	0.04	5.87	4.91	0.23	2.95	0.97	0.00	1.42	1.62	0.38	5.44	1.65	0.00
β_{CZ}	-4.63	3.06	0.13	5.39	5.41	0.32	-0.85	0.51	0.10	-0.64	1.07	0.55	-0.98	1.09	0.37
β_{CE}	-2.00	1.13	0.08	-2.92	2.28	0.20	-2.13	0.28	0.00	-0.28	0.55	0.61	-1.13	0.59	0.06
β_{ZZ}	26.30	6.31	0.00	-42.07	15.28	0.01	1.22	1.07	0.25	1.78	1.29	0.17	2.52	1.30	0.05
β_{ZE}	-9.66	1.63	0.00	9.98	3.21	0.00	-0.31	0.39	0.43	-1.62	0.85	0.06	-0.43	0.75	0.57
β_{EE}	0.92	0.95	0.33	4.83	2.56	0.06	0.44	0.27	0.10	0.18	0.38	0.64	2.38	0.59	0.00
δ_{MT}	1.81×10^{-2}	0.00	0.00	-1.09×10^{-1}	0.04	0.00	-2.76×10^{-3}	0.00	0.01	-2.37×10^{-2}	0.01	0.00	5.02×10^{-2}	0.01	0.00
δ_{CT}	-6.51×10^{-2}	0.01	0.00	7.41×10^{-2}	0.02	0.00	-1.24×10^{-2}	0.00	0.00	-2.66×10^{-2}	0.01	0.00	-1.15×10^{-3}	0.00	0.79
δ_{ZT}	7.56×10^{-3}	0.01	0.15	6.37×10^{-2}	0.02	0.00	7.28×10^{-3}	0.00	0.01	8.90×10^{-3}	0.01	0.13	1.32×10^{-2}	0.00	0.00
δ_{ET}	1.55×10^{-2}	0.01	0.01	-3.81×10^{-2}	0.01	0.00	1.45×10^{-3}	0.00	0.41	1.76×10^{-2}	0.00	0.00	-8.82×10^{-3}	0.00	0.00
δ_{RT}	3.19×10^{-2}	0.02	0.14	1.20×10^{-2}	0.03	0.73	1.25×10^{-2}	0.00	0.00	2.81×10^{-2}	0.01	0.00	-9.92×10^{-2}	0.01	0.00
α_c	-1.85×10^{-2}	0.01	0.06	-4.69×10^{-2}	0.00	0.00	-6.53×10^{-3}	0.01	0.27	-7.37×10^{-3}	0.01	0.25	-3.29×10^{-2}	0.01	0.00
α_{cc}	-9.12×10^{-4}	0.00	0.01	1.53×10^{-3}	0.00	0.00	2.56×10^{-3}	0.00	0.00	1.94×10^{-3}	0.00	0.00	-1.55×10^{-4}	0.00	0.68
α_{cz}	1.99×10^{-3}	0.00	0.25	4.40×10^{-4}	0.00	0.64	-4.00×10^{-3}	0.00	0.00	-3.52×10^{-4}	0.00	0.77	8.25×10^{-3}	0.00	0.00
α_{cd}	2.21×10^{-3}	0.00	0.02	1.10×10^{-3}	0.00	0.00	-1.83×10^{-3}	0.00	0.00	-1.39×10^{-3}	0.00	0.00	5.09×10^{-4}	0.00	0.42
α_{ed}	5.28×10^{-4}	0.00	0.05	-2.07×10^{-4}	0.00	0.07	1.00×10^{-4}	0.00	0.30	-7.03×10^{-4}	0.00	0.00	-5.02×10^{-4}	0.00	0.01
α_{cq^*}	3.83×10^{-3}	0.00	0.00	4.22×10^{-3}	0.00	0.00	-5.92×10^{-4}	0.00	0.41	-2.45×10^{-3}	0.00	0.00	-2.03×10^{-4}	0.00	0.87
θ	0.09	0.04	0.03	-0.02	0.03	0.46	0.00	0.00	0.06	-0.01	0.00	0.01	0.02	0.01	0.02
$s(\hat{e},\hat{v})$	0.1266			0.1063			0.1356			0.0925			0.1296		
Over-id	22.79		0.99	19.17		0.99	24.41		0.99	16.65		0.99	23.34		0.99

Source. Research results

Table A. Estimated results of the simultaneous equation system of the oligopsony model-*Cont*

Part 3.

	Northwestern Rio Grande do Sul			Northeastern Rio Grande do Sul			Porto Alegre Metropolitan Area			Central Goiás			Southern Goiás		
Param.	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val
β_0	37.66	13.09	0.00	33.09	15.47	0.03	-109.97	32.72	0.00	-64.43	15.05	0.00	-61.95	17.33	0.00
β_M	0.76	0.23	0.00	47.19	8.30	0.00	-20.29	3.49	0.00	-11.14	2.27	0.00	0.70	0.36	0.06
β_C	18.22	2.89	0.00	11.54	2.95	0.00	4.25	5.60	0.45	13.00	3.38	0.00	-8.55	4.55	0.06
β_Z	-18.46	5.28	0.00	-7.37	6.96	0.29	20.52	10.39	0.05	36.07	8.66	0.00	24.54	5.84	0.00
β_E	9.78	2.12	0.00	13.50	2.58	0.00	8.13	4.74	0.09	-3.69	2.91	0.21	-2.37	1.72	0.17
β_R	1.22	0.54	0.02	0.97	0.44	0.03	6.56	1.92	0.00	0.22	0.99	0.83	2.13	0.76	0.01
δ	-0.05	0.04	0.27	0.08	0.10	0.45	0.43	0.19	0.03	-0.26	0.10	0.01	0.20	0.05	0.00
β_{MM}	-0.03	0.04	0.36	-6.33	1.22	0.00	-16.37	2.69	0.00	5.72	1.16	0.00	1.71	0.86	0.05
β_{MC}	-0.71	0.22	0.00	5.38	1.10	0.00	7.16	1.15	0.00	-2.37	0.48	0.00	-2.14	1.07	0.05
β_{MZ}	-0.68	0.19	0.00	-11.91	2.09	0.00	2.93	0.53	0.00	3.65	0.73	0.00	-0.05	0.03	0.09
β_{ME}	1.25	0.35	0.00	0.73	0.24	0.00	-4.78	0.77	0.00	0.05	0.06	0.33	0.60	0.30	0.05
β_{CC}	6.22	0.98	0.00	6.24	1.31	0.00	3.90	1.97	0.05	6.03	1.32	0.00	1.61	1.70	0.34
β_{CZ}	-3.87	0.65	0.00	-1.09	0.60	0.07	0.70	1.19	0.56	-2.59	0.76	0.00	1.94	0.98	0.05
β_{CE}	-0.78	0.32	0.01	-1.87	0.44	0.00	-1.24	0.62	0.05	-2.81	0.33	0.00	-1.72	0.47	0.00
β_{ZZ}	4.50	1.18	0.00	0.23	1.56	0.88	-3.93	2.31	0.09	-8.03	1.98	0.00	-5.91	1.34	0.00
β_{ZE}	-2.03	0.50	0.00	-3.71	0.66	0.00	-3.03	1.21	0.01	0.46	0.70	0.51	0.27	0.43	0.54
β_{EE}	-0.85	0.46	0.06	1.26	0.53	0.02	0.02	0.59	0.97	1.61	0.49	0.00	1.79	0.50	0.00
δ_{MT}	$1.10x10^{-2}$	0.00	0.00	$1.16x10^{-2}$	0.00	0.00	$3.07x10^{-2}$	0.01	0.00	$-3.16x10^{-2}$	0.01	0.00	$-4.59x10^{-4}$	0.00	0.10
δ_{CT}	$-1.13x10^{-2}$	0.00	0.00	$-2.92x10^{-2}$	0.01	0.00	$-2.58x10^{-2}$	0.00	0.00	$-4.57x10^{-3}$	0.00	0.19	$4.21x10^{-3}$	0.00	0.19
δ_{ZT}	$-1.84x10^{-3}$	0.00	0.51	$2.99x10^{-2}$	0.00	0.00	$-1.07x10^{-2}$	0.01	0.13	$8.26x10^{-3}$	0.00	0.03	$5.51x10^{-3}$	0.00	0.06
δ_{ET}	$6.21x10^{-3}$	0.00	0.00	$2.52x10^{-2}$	0.00	0.00	$3.27x10^{-2}$	0.00	0.00	$5.21x10^{-3}$	0.00	0.04	$1.10x10^{-3}$	0.00	0.53
δ_{RT}	$4.40x10^{-3}$	0.00	0.18	$-1.74x10^{-2}$	0.01	0.06	$-3.43x10^{-2}$	0.02	0.02	$1.60x10^{-2}$	0.01	0.05	$-1.61x10^{-2}$	0.00	0.00
α_c	$3.98x10^{-3}$	0.01	0.55	$-2.02x10^{-2}$	0.00	0.00	$-5.56x10^{-2}$	0.01	0.00	$-1.43x10^{-2}$	0.01	0.06	$-3.09x10^{-2}$	0.01	0.00
α_{cc}	$1.85x10^{-3}$	0.00	0.00	$1.22x10^{-4}$	0.00	0.63	$1.28x10^{-4}$	0.00	0.67	$1.34x10^{-3}$	0.00	0.00	$-1.33x10^{-4}$	0.00	0.76
α_{cz}	$-5.39x10^{-3}$	0.00	0.00	$4.08x10^{-3}$	0.00	0.00	$1.08x10^{-3}$	0.00	0.00	$-1.12x10^{-3}$	0.00	0.49	$4.74x10^{-3}$	0.00	0.00
α_{cs}	$-1.30x10^{-3}$	0.00	0.00	$3.80x10^{-4}$	0.00	0.55	$-1.19x10^{-4}$	0.00	0.84	$-1.04x10^{-3}$	0.00	0.09	$-2.83x10^{-5}$	0.00	0.95
α_{cd}	$-1.83x10^{-5}$	0.00	0.90	$-4.59x10^{-4}$	0.00	0.01	$-7.84x10^{-5}$	0.00	0.73	$-2.66x10^{-4}$	0.00	0.11	$-1.40x10^{-3}$	0.00	0.00
α_{cp^*}	$1.41x10^{-4}$	0.00	0.87	$5.74x10^{-4}$	0.00	0.59	$1.85x10^{-3}$	0.00	0.05	$1.57x10^{-3}$	0.00	0.36	$3.85x10^{-3}$	0.00	0.00
θ	0.00	0.00	0.02	0.02	0.01	0.01	0.02	0.01	0.17	-0.01	0.01	0.06	0.00	0.00	0.21
$s(e,\hat{v})$	0.1062			0.1019			0.1211			0.1212			0.0938		
Over-id	19.11		0.99	18.34		0.99	21.80		0.99	21.82		0.99	16.88		0.99

Source. Research results

