IDENTIFICATION OF MARKET POWER IN BILATERAL OLIGOPOLY: THE BRAZILIAN WHOLESALE MARKET OF UHT MILK[1]

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Abstract

The aim of this study was to test the hypothesis of market power in the wholesale market for UHT milk. The structure of this market is an oligopoly characterized as bilateral and uses the model proposed by Schroeter et al. (2000), which allows testing the hypothesis of market power without assuming the restrictive hypothesis of price-taking behavior on one side of the market. The system of nonlinear simultaneous equations that determines quantity, wholesale and retail prices of UHT milk was estimated by nonlinear generalized method of moments. Estimation of conduct parameter was 0.638, rejecting the hypothesis of a perfectly competitive market. Evidences suggest that retailers exert oligopsony power on the dairy industry; however, the distortions caused by such market power could not be quantified.
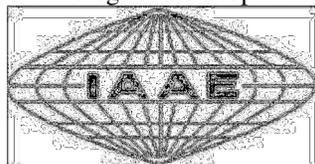
1. Introduction

The dairy sector was significantly affected by the observed macroeconomic changes in the 1990's. The market deregulation, free trade and economic stabilization, increased competition in the Brazilian agro industrial system and, from that time, a wave of mergers and acquisitions (M&A), induced by the idle capacity of the industry and by the rapid and "strong" growth of food consumption was observed after the stabilization (Jank *et al.*, 1999 and Farina *et al.*, 2005).

In this context, the industry of dairy products became more concentrated due to entry of great multinational companies, such as Nestlé, Parmalat, Fleischmann-Royal and Danone, acquiring national dairy companies along the 1990's. Subsequently, a second M&A wave was observed, however, this time involving mainly Brazilian companies such as Perdigao and Laticínios Bom Gosto and also investments funds that made several acquisitions and became great business conglomerates[2] (Jank *et al.*, 1999; Farina *et al.*, 2005; Teixeira *et al.*, 2006; Concha-Amim and Aguiar, 2006 and Azevedo and Politi, 2008).

Likewise, in the distribution and retail system, great distribution networks and hypermarkets were transformed into the main milk distribution channel of dairy products and companies like CBD (Brazilian Distribution Company), Carrefour, Wal-Mart and SONAE adopted M&A strategies to expand their business (Farina *et al.*, 2005; Teixeira *et al.*, 2006; Concha-Amim and Aguiar, 2006 and Azevedo and Politi, 2008).

These transformations brought important impacts to the sector, since in the current market structure; on one side are dairy companies, with relatively concentrated structure, and on the other side, chains of super and hypermarkets, also concentrated. Both milk producers and dairy

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[2] Perdigao was one of the main industries of the food sector in Brazil, acting, mainly, in the manufacturing of poultry and pork. In 2006 it entered the milk sector through the purchase of Batavo and through other acquisitions; in 2007 it became the second largest milk company in Brazil. In 2009 it merged with Sadia, another company of the food sector, which resulted in the creation of Brazil Foods S/A, the largest industry of the food sector in Brazil. The dairy industry Bom Gosto, between 2007 and 2010, made seven acquisitions of dairy companies, distributed within the largest producing states of Brazil and became the second largest dairy industry in terms of milk collection in 2009. In 2010, it merged with Leite Bom, originating the LBR – Milk Brazil S/A and started to process, approximately, 1.8 billion liters of milk per year in 2010.

companies were placed in a situation where they need to negotiate with agents, who have greater bargaining power (Martins and Faria, 2006).

Under this context, the increase in concentration rates causes concern, as high market concentration can be associated with the exercise of market power (Sexton and Zhang, 2001). Final consumers would face higher prices as a result of less competition and producers and/or suppliers, upstream, would face buyers with market power, reducing net prices and imposing specific standardizations in their products (FARINA *et al*., 2005).

Empirical studies seem to suggest that the increase of concentration has not caused damages for consumers. Barros *et al*. (2004) point out that from the consumer standpoint, the sector has shown good performance, as the demand has been attended at declining prices. Likewise, Farina *et al*. (2005) affirm that consumers were benefited by the restructuring that occurred in the food retail sector. Prices have fallen since the economic stabilization in 1994 and, in contrast to what was expected, the number of independent supermarkets and traditional retailers has grown, as well as their participation in food sale. Concha-Amim and Aguiar (2006) also concluded that although the market concentration has increased, his study showed some evidences suggesting beneficial effects in terms of social well-being, in other words, the strengthening of traditional supermarkets and the elevated turnover in several groups of supermarkets. According to the authors "in a scenario where companies have difficulties in maintaining their positions, the search for efficiency profits becomes more probable, as well as transferring high prices to consumers tends to be avoided" (Concha-Amim and Aguiar, 2006, p. 54).

Therefore, from the consumer point of view, evidences do not indicate that the increase of concentration has caused damages in terms of social well-being; however, it is necessari to analyze the wholesale market of dairy products. Concha-Amim and Aguiar (2006) argue that in face of difficulties in transferring more elevated prices to consumers "... bigger supermarkets would be implementing efficiency profit strategies and, simultaneously, practicing monopsony power in relation to suppliers who do not have strong commercial brands" (Concha-Amim and Aguiar, 2006, p. 54).

In this sense, the aim of this study was to contribute with the discussion by investigating the hypothesis of existence of market power in the wholesale market of UHT type milk. In addition,

the study aims at identifying which type of conduct prevails, oligopoly or oligopsony. In the scenario where both market sides (buyers and sellers) are relatively concentrated, market equilibrium, must not necessarily be competitive and both buyers and sellers can exercise market power.

Thus, this study uses the model proposed by Schroeter *et al*. (2000), which solves the problem of market power mensuration without maintaining a hypothesis of competitive behavior on one side of the market. The solution uses a very similar strategy to that used by Bresnahan (1982) to identification in the oligopoly case; however, it transforms the hypothesis of price-taking behavior of the category maintained *a priori,* to a testable hypothesis.

Moreover, the study contributes with the empirical literature when estimating nonlinear equations systems by the nonlinear generalized method of moments (nonlinear GMM). The GMM method is not a traditionally used method in the estimation of models in the Industrial Organization area, however, it is an attractive alternative to traditional methods (2SLS or 3SLS and maximum likelihood), since estimators and the respective standard deviations are consistent, even in the presence of heteroscedasticity and/or autocorrelation. In addition, in contrast to the maximum likelihood method (used by Schroeter *et al*. (2000)), the GMM declines the knowledge of process distribution, as well as the normality hypothesis.

This article is organized in six sections, including the introduction. In the next section the theoretical and empirical bilateral oligopoly model is developed. In section three, the GMM method will be presented for estimation of models and in section four, the variables, source of data and used procedures are described. The results and discussion are presented in section five and final considerations are made in the last section.

2. Theoretical and empirical model of bilateral oligopoly

Economic Theory, more specifically the branch of New Empirical Industrial Organization (NEIO) developed, between the years 1980 and 2000, a wide variety of approaches for market power mensuration; however, all of them assumed that participants in a specific side of the

market were taking prices as given, while agents on the other side could or not, exercise market power.

The wholesale market of UHT milk can be defined as a bilateral oligopoly, which represents a market structure where both buyers and sellers are relatively concentrated and can exercise market power. According to Sexton (2000), models that focus only on the identification of market power from one side take the risk of: (a) not understanding the extension of the market power distortion and/or (b) mistakenly attribute distortions to the wrong form of market power.

Therefore, the model employed for identification of market power in the wholesale segment of UHT milk is the model developed by Schroeter *et al*. (2000). In this model, there are at least three conditions that can prevail: (i) the wholesale market can be perfectly popular, buyers and sellers are price takers; (ii) sellers are price takers, while buyers exercise buying power (oligopsony power) and (iii) buyers are price takers, while sellers exercise market power (oligopoly power). The model focuses primarily on determining prices and wholesale market quantities and is built, from the following logic[3].

According to Schroeter *et al*. (2000) we assume that the demand curve of the retail industry could be described (in reverse form) as:

$$p_r = \alpha_0 + \alpha_1 Q + \alpha_2 Z_2 + \alpha_3 Q Z_3 + \in , \qquad (1)$$

where p_r, is the real price of UHT milk (at the retail level); Q is quantity; Z_2 is an exogenous demand shifter (population, or a time trend variable, for example); Z_3 is an exogenous variable affecting the slope (elasticity) of the demand curve (prices of substitute goods, for example); it is a random error term and αi, $i = 0..., 3$ are the parameters to be estimated. The interaction term is included to ensure identification of the degree of retail market power[4]. Retailers' and manufacturers' marginal costs, MC_r and MC_m, are given by:

$$MC_r = b_0 + b_1 Q + b_2 W_2 + \eta \qquad \text{and} \qquad (2)$$

$$MC_m = c_0 + c_1 Q + c_2 V_2 + c_3 Q V_3 + \mu , \qquad (3)$$

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[3] For further details, see Schroeter et al. (2000).
[4] Solution for identification problem as proposed by Bresnahan (1982).

where W_2 *and* V_2 are exogenous factor prices (prices of other inputs that shift MC_r and MC_m, for example); V_3 is an exogenous variable affecting the slope of MC_m[5], such as for example, price of some factor or substitute product in the manufacturing process; η and μ are random error terms and b_j *and* c_h, $j = 0$, 1 and 2 and $h = 0..., 3$ are parameters to be estimated.

The total revenue for the retail industry is $p_r Q$. Thus, monopoly marginal revenue is $p_r + (dp_r/dQ)Q$ or, using Equation (1), $p_r + (\alpha_1 + \alpha_3 Z_3)Q$. Following the usual way, it is possible to accommodate a range of oligopoly conducts on the part of retailers assuming that their perceived marginal revenue, *PMRr* is given by:

$$PMR_r = p_r + \lambda(\alpha_1 + \alpha_3 Z_3)Q \qquad (4)$$

in which $\lambda = 0$, implicates that the firms behave as prices takers in the retail market and $\lambda = 1$, it corresponds to pure monopoly conduct. The perceived net marginal revenue by retailers (when excluding their marginal cost) is given by: $PNMR_r = PMR_r - MC_r$ or, using (4) and (2):

$$PNMR_r = p_r + \lambda(\alpha_1 + \alpha_3 Z_3)Q - b_0 - b_1 Q - b_2 W_2 - \eta. \qquad (5)$$

In the bilateral price-taking (BPT) solution, the equilibrium quantity is determined by the condition. Thus, equaling equations (3) and (5) and rearranging the terms, the result is as follows:

$$p_r + \left[\lambda(\alpha_1 + \alpha_3 Z_3) - (b_1 + c_1) - c_3 V_3\right]Q - (b_0 + c_0) - b_2 W_2 - c_2 V_2 = (\eta + \mu). \qquad (6)$$

Retail price is the demand price evaluated at the quantity determined by (6) and wholesale price is equal to the common value of $PNMR_r$ and MC_m:

$$p_r - \left[\alpha_1 + \alpha_3 Z_3\right]Q - \alpha_0 - \alpha_2 Z_2 = \epsilon \qquad \text{and} \qquad (7)$$

$$p_w - \left[c_1 + c_3 V_3\right]Q - c_0 - c_2 V_2 = \mu, \qquad (8)$$

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[5] The interaction term $c_3 QV_3$, similar to the strategy proposed by Bresnahan (1982), is included to solve the problem of system identification. The parameter allows that the manufacturers' marginal cost curve rotates – not simply shifts – due to changes in exogenous variables.

where p_w appears from the fact that $p_w = MC_m$. Thus, the system formed by equations (6), (7) and (8) determines three endogenous variables p_r, Q and p_w and represents the solution for the BPT case.

The next step consists in determining the solution where the manufacturing industry is price-taking (MPT). In this scenario, the answer of manufacturing firms is described by the supply curve $P_w = MC_m$ or, by using (3):

$$P_w = c_0 + c_1 Q + c_2 V_2 + c_3 Q V_3 + \mu . \tag{9}$$

Retailers' total expenditure on the wholesale products is $p_w Q$ and monopsony marginal expenditure is $pw + (dp_w/dQ)Q$ or, using Equation (9), $p_w + (c_1 + c_3 V_3)Q$. Again, it is possible to accommodate a range of oligopsony conduct in the wholesale market with the assumption that retailers maximize profit subject to a perceived marginal expenditure PME_r given by: $PME_r = P_w + \delta (c_1 + c_3 V_3)Q$ or, using Equation (9):

$$PME_r = c_0 + (1 + \delta)(c_1 + c_3 V_3)Q + c_2 V_2 + \mu . \tag{10}$$

Similar to λ, the interval of δ is [0, 1]: $\delta = 1$ identifies the pure monopsony case and $\delta = 0$ corresponds to price-taking behavior by retail firms in the wholesale market. Under the MPT case, equilibrium quantity is determined by $PNMRr = PMEr$. Using Equations (5) and (10), an alternative solution to BPT's solution equation (6):

$$\begin{aligned} &p_r + [\lambda(\alpha_1 + \alpha_3 Z_3) - (b_1 + (1 + \delta)c_1) - (1 + \delta)c_3 V_3]Q \\ &- (b_0 + c_0) - b_2 W_2 - c_2 V_2 = (\eta + \mu) \end{aligned} . \tag{6'}$$

Equations (7) and (8) from the BPT solution combined with equation (6') determine the MPT case solution. It is noticed that if $\delta = 0$, the MPT case comes down to the BPT case.

For the third case, where retailers are price takers (RPT), the manufacturing industry faces a retailers' demand curve given by $PNMR_r$. The marginal revenue for the manufacturing industry is $PNMR_r + (dPNMR_r/dQ)Q$ or, using Equations (1) and (5): $PNMR_r + [(1 + \lambda) (\alpha_1 + \alpha_3 Z_3) - b_1]Q$. As previously mentioned, it is possible to allow a range of oligopoly conduct on the part of manufacturers, through their perceived marginal revenue curve:

$$PMR_m = PNMR_r + \gamma[(1 + \lambda)(\alpha_1 + \alpha_3 Z_3) - b_1]Q , \tag{11}$$

where $\gamma \in [0, 1]$ indexes the conduct of manufacturing firms as price takers ($\gamma = 0$) at pure wholesale monopoly ($\gamma = 1$).

The RPT solution is characterized by $PMR_m = MC_m$. Using Equations (11), (3) and (5), this condition implicates that:

$$p_r + [(\gamma + \lambda(1+\gamma))(\alpha_1 + \alpha_3 Z_3) - (b_1(1+\gamma) + c_1) - c_3 V_3]Q$$
$$- (b_0 + c_0) - b_2 W_2 - c_2 V_2 = (\eta + \mu) \qquad (6'')$$

In the RPT model, manufacturers charge a wholesale price equal to the price derived from the demand at the equilibrium quantity: $p_w = PNMR_r$ (monopoly solution). Through equation (5) and substituting p_r of (6'') it results in:

$$p_w + [\gamma(1+\lambda)(\alpha_1 + \alpha_3 Z_3) - (\gamma b_1 + c_1) - c_3 V_3]Q - c_0 - c_2 V_2 = \mu . \qquad (8')$$

Equations (6''), (7) and (8'') describe the solution for the RPT case. It can be noticed that, in this solution, if $\gamma = 0$ the RPT case comes down to the BPT case.

According to Schroeter *et al*. (2000) given the three equilibrium concepts, deciding on the most consistent concept with the observations involves hypotheses tests. As previously demonstrated, it is easy noticing that a simple parametric restriction of $\delta = 0$ converts the MPT solution (6') to the BPT solution (6). Therefore, a bilateral price-taking behavior assumption can be tested *versus* an alternative assumption that only manufacturers are price takers (or some degree different from zero of oligopsony power) testing $\delta = 0$ *versus* $\delta > 0$, using the test-t procedure, based on estimates of MPT equilibrium equations. Similarly, testing $\gamma = 0$ *versus* $\gamma > 0$, in the equations of RPT equilibrium, means comparing BPT solution (6) and (8) with RPT solution (6'') and (8'). Nevertheless, a comparison of the two equilibrium concepts MPT and RPT cannot be obtained by parametric restrictions. This is because neither can be obtained as a parametric restriction of the other.

Thus, Schroeter *et al*. (2000) propose an *ad hoc* approach involving nesting models, where the two equilibrium concepts MPT and RPT are grouped in a larger model. The artificial nesting solution (NST), proposed by the authors can be represented by the following equation:

$$p_r + [(\gamma + \lambda(1+\gamma))(\alpha_1 + \alpha_3 Z_3) - (b_1(1+\gamma) + (1+\delta)c_1) - c_3(1+\delta)V_3]Q$$
$$- (b_0 + c_0) - b_2 W_2 - c_2 V_2 = (\eta + \mu) \qquad (6''')$$

The nesting solution consists of equations (6 '''), (7) and (8'). With $\delta = 0$, (6 ''') reduces to (6") and the NST solution consists the RPT solution. With $\gamma = 0$, (''') (6' is reduced 6 to), (8') is reduced to (8) and the NST solution becomes the MPT solution. With $\delta = \gamma = 0$, (6 ''') and (8') reduce to (6) and (8), respectively, and the result is the BPT solution.

The idea behind the construction of this test involves grouping both concepts in a great (nesting) artificial model and then, test each nonnested model *versus* the nesting model, using marginal significance levels of this test to order the plausibility of both models, originally non-nesting. Given the estimates of the NST model parameters, a test of $\delta = 0$ *versus* $\delta > 0$ is a test of the RPT model *versus* the more general NST model. A test of $\gamma = 0$ *versus* $\gamma > 0$ is a test of the MPT model *versus* the NST model.

According to the authors, a disadvantage of this method, however, is that the NST model, unlike the BPT, MPT and RPT models, has no clear economical interpretation. Consequently, it would be difficult to carry out analysis if in a test result the MPT model is rejected, for example, in favor of the NST model. In this sense, the authors suggest a more direct approach to comparing MPT and RPT models directly[6], the test employed here is the selection test of nonnested models proposed by Rivers and Vuong (2002).

In the proposed formulation, in four solution concepts, the parameters are identified. The fact that δ is identified in the MPT solution means that the bilateral price-taking behavior (BPT) can be empirically distinguished from exercise of retailers monopsony power (MPT) in the wholesale market. Thus, the fact that γ is identified in the RPT solution means that the data may discriminate between the BPT equilibrium and exercise of monopoly power by manufacturers (RPT). The underlying equations to each equilibrium concept are the retailer's demand (eq. 1), retailers' marginal cost (eq. 2) and dairy products marginal cost (eq. 3).

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[6] In the original study, Schroeter *et al.* (2000) use the Full Information Maximum Likelihood (FIML) procedure and then Cox's procedure for tests of nonnested hypotheses.

3. Estimation procedures

The sets of equations for each equilibrium solution appoint four systems of equations, each one representing a proposed equilibrium concept (BPT, MPT, RPT and NST). All systems are formed by three nonlinear equations, which simultaneously, must determine three endogenous variables of the model: p_r, Q and pw and are estimated by the nonlinear generalized method of moments (GMM). The GMM method becomes attractive, since the estimator and the respective standard error are consistent, even in the presence of heteroscedasticity and/or autocorrelation. Moreover, in contrast to the maximum likelihood method, GMM does not make strong assumptions on distribution, or normality.

The basic principle of the GMM method is the theoretical relation that parameters must satisfy orthogonality conditions between some functions in the parameters and a set of instrumental z_t variables. The idea is to choose estimates of parameters, so that the theoretical relation is satisfied as close as possible. The theoretical relation is substituted by its sampling counterpart and estimates are chosen in such a way that they minimize the distance considered between current and theoretical values. Using the notation employed by Gallant (1987), the system referring to any equilibrium can be implicitly written as:

$$q_\alpha\left(y_t, x_t, \theta_\alpha^0\right) = e_{\alpha t} \qquad t = 0, 1, 2..., n \ \alpha = 1, 2 \text{ and } 3 \qquad (12)$$

where t is time, y is a vector of three endogenous variables, x is a vector column of exogenous variables, θ is a vector column of unknown parameters of the model, e is a three dimension vector of error structural terms, $e = \left[e_1, e_2, e_3\right]' = \left[\eta + \mu, \in, \mu\right]'$ and $q(\cdot)$ is a three dimension vector of nonlinear functions of its arguments. Due to the nonlinearity of the model, $et's$ errors are not assumed to be serially independent from the exogenous variables, neither, normally distributed.

As discussed, the GMM method is an estimator that uses instrumental variables to form moment equations. That is, being z_t, a vector K of random variables, the following sampling moments can be formed

$$m_n(\theta) = \frac{1}{n}\sum_{t=1}^{n} m\left(y_t, x_t, \theta\right) \qquad (13)$$

where:

$$m(y_t, x_t, \theta) = q(y_t, x_t, \theta) \otimes z_t = \begin{bmatrix} q_1(y_t, x_t, \theta) z_t \\ q_2(y_t, x_t, \theta) z_t \\ q_3(y_t, x_t, \theta) z_t \end{bmatrix}_{3K} , \qquad (14)$$

equals the theoretical (or population) moment conditions

$$m_n(\theta) = E\big[m_n(\theta^0)\big]$$

and uses the solution $\hat{\theta}$ as estimate of θ^0. The problem is that if the dimension *3K* of $m_n(\theta)$ exceeds the dimension *p* of θ (superdetermined model – as usual), these equations will have no solution. In this case, θ^0 it is estimated by value $\hat{\theta}$ that minimizes the criterion function

$$S(\theta, V) = [nm_n(\theta)]' V^{-1}[nm_n(\theta)], \qquad (15)$$

where

$$V = E\big\{[nm_n(\theta^0)], [nm_n(\theta^0)]\big\}, \qquad (16)$$

is the covariance matrix. Once, $m_n(\theta^0) = \frac{1}{n}\sum_{t=1}^{n} e_t \otimes z_t$ $E[m_n(\theta^0)] = 0$ if z_t is not correlated with e_t and

$$E\big\{[nm_n(\theta^0)], [nm_n(\theta^0)]\big\} = \sum_{t=1}^{n}(\Sigma \otimes z_t z_t') = \Sigma \otimes \sum_{t=1}^{n} z_t z'$$

If $\{z_t\}$ for independence de $\{e_t\}$. This condition is obtained if imposed the hypothesis that $z_t = Z(x_t)$, where Z (x) *is* some function (possibly nonlinear) of independent variables. If it is assumed that Σ is an identity matrix, on weak regularity conditions it is possible to demonstrate that $\hat{\theta}$ is an asymptotically efficient GMM estimator. The problem, however, is that *V* is normally unknown and in dynamic models, x_t can also contain outdated exogenous or endogenous variables, which implicates that $m(y_t, x_t, \theta^0) = e_t \otimes z_t$ it will normally be correlated and Σ cannot be assumed as an identity matrix anymore.

In these cases, the adopted strategy for obtaining asymptotically efficient GMM estimators ($\hat{\theta}$) is to substitute the V matrix for an estimate $\hat{V}$ of sampling covariance matrix, using a consistent estimator with autocorrelation and heteroscedasticity, known as HAC. A HAC estimator of V is a built matrix $\hat{V}$, that estimates V consistently when e_t error terms demonstrate some heteroscedasticity and/or autocorrelation pattern (Davidson and Mackinnom, 1999). The used estimator is one of the most commonly cited in the literature, and was proposed by Newey and West (1987).

The estimate of θ^0, so, now is obtained through the value that minimizes the criterion function,

$$S(\theta,\hat{V}) = [nm_n(\theta)]'\hat{V}^{-1}[nm_n(\theta)], \qquad (17)$$

which is identical to (15), except for the fact that V was substituted by its robust estimate ($\hat{V}$). The variance-covariance matrix is obtained through:

$$\hat{C} = \left[\left(\sum_{t=1}^{n} Q(y_t,x_t,\hat{\theta})\otimes z_t\right)'\hat{V}^{-1}\left(\sum_{t=1}^{n} Q(y_t,x_t,\hat{\theta})\otimes z_t\right)\right]^{-1}, \qquad (18)$$

where $Q(y_t,x_t,\hat{\theta}) = \dfrac{\partial}{\partial\theta'}q(y_t,x_t,\theta)$.

Concerning nonlinear equations systems, the GMM estimator, based on the criterion function (eq. 17), cannot be solved through an equations system (as in the linear case) regarding unknown regression coefficients, where there is a single solution. The problem is that the parameters enter in the equation nonlinearly and an analytical solution usually cannot be found.

In this sense, numerical methods that can find values of parameters θ, optimizing the criterion function, given by equation (17) are necessary. Iterative optimization algorithms, as such methods are called, work taking a set of initial values for the parameters $\theta_{(0)}$, and then calculations based on these values are done to obtain a set better of parameters, for example $\theta_{(1)}$. This process is repeated $\theta_{(2)}$, $\theta_{(3)}$, until the criterion function does not improve (converge to a determined point) between interactions. (EVIEWS, 2010).

According to Gallant, (1987), the widely used method is the modified version of the Gauss-Newton method proposed by Hartley (1961). The Gauss-Newton method, also known as the linearization method, uses a Taylor series expansion to approximate the nonlinear regression model with linear terms and, then, it applies ordinary least squares to estimate the parameters. When the problem consists of nonlinear equations systems, meantime, the software Eviews (used in the analysis), uses an alternative version of the method, denominated Gauss-Seidel, which, first analyses the system to determine if it can be separated in two or more blocks of equations, so that they can be sequentially solved, instead of simultaneously. Once the blocks are determined, each block is individually solved. If the block does not contain simultaneity, each equation in the block is estimated only once. If the block contains simultaneity, equations in the block are solved through the iterative algorithm. (EVIEWS, 2010)

It is highlighted that the choice of initial estimates in the Gauss-Newton method is very important, since a bad choice may result in a very big number of iterations to reach convergence; the procedure may also converge at a local minimum, or, even not converge. According to Gallant (1987), the choices of initial values can be obtained by *a priori* knowing the situation, inspecting data, *grid* survey, or attempt and error.

The way empirical models are presented, however, there is a method that facilitates and also provides a convenient strategy for the determination of initial values. If in final demand equations, retailer's marginal cost and manufacturer's marginal cost are assumed that conduct parameters λ, δ and γ, equal zero, by the logic of the built model, the wholesale market would be considered as bilateral price-taking, in addition, retailers would not exercise market power over consumer, in other words, we would have a perfectly competitive market. This assumption, besides determining the industry conduct, also simplifies the system of equations, as under such assumption, the system becomes linear in parameters and can be solved by the traditional method of analytical equations system and estimates of unknown parameters can be obtained as in traditional linear models. These parameters obtained from the restriction of the market behavior, will serve as initial values for Gauss-Seidel's optimization algorithm.

4. Variables, source of data and used procedures

On account of data availability, it was possible to build a monthly-based database for the states of Rio Grande do Sul, Paraná, Sao Paulo, Minas Gerais and Goiás, encompassing the period of July of 2004 to December of 2009, totalizing 66 observations. These five states produced 19.2 billion liters of milk in 2009 and were responsible for approximately 67% of the national production. In addition, the dairy industry of these five states, jointly, was responsible for attainment and industrialization of approximately 14.5 billion liters of milk, which corresponded to nearly 75% of the total milk industrialized by dairy companies with some type of sanitary inspection in Brazil.

The variables used in the model, basically, are retail and wholesale UHT milk prices and input prices that compose the marginal cost of dairy companies and retailers. The variables, their descriptions and sources are summarized in Table 1. Since exogenous shifter of the retailers' demand the GNP of Brazil was used as proxy of revenue and as exogenous shifter of the demand curve slope, the fruit juice price was used, representing a substitute product in milk consumption. For the components of retailers' marginal cost, the diesel oil price was used, as *proxy* for freight expenses, energy generation and price paid for milk *in natura*, as main input used by dairy companies. Furthermore, a time trend was used as exogenous shifter of marginal cost of dairy companies.

All variables considered exogenous in the model were used as tools in the estimation procedure by the nonlinear GMM method. Besides, two other variables were used as instruments: mean salary of workers of the food retail sector and an international dairy prices rate, released by the *Food and Agriculture Organization of the United Nations* (FAO).

The data source consists, mainly, in monthly publications of the Quarterly Milk Survey (PTL-IBGE) and of the National Consumer Price Index (IPCA), both provided by IBGE. Another data source was the Milk Bulletin, published by the Center for Advanced Studies on Applied Economics (CEPEA). Finally, data obtained in the aggregated dataset of the Institute of Applied Economic Research (IPEA) and Annual Social Information Report (RAIS), prepared by the Mininstry of Labor and Employment (MTE) was also used.

All monetary variables were deflated by the Consumer Price Index (IPCA), so, all series are expressed as real values of Dec/09. Moreover, the existence of seasonal components was investigated in the series that, when identified, the respective series were deseasonalized by the X12 method of the *US Census Bureau*.

5. Results

The first step in the investigation of market power existence is prior delimitation of relevant market, both at the product and geographical dimension. Badly specified markets result in biased estimates regarding market power evidences (Sexton, 2000). However, as the aim of the study was on the wholesale market of UHT milk, the analysis was concentrated on the delimitation of geographical limits of this market.

In the empirical literature, the geographical market of UHT milk is commonly delimited to the national frontiers (Neves and Cônsoli, 2006 and Azevedo and Politi, 2008). In the same sense, reports prepared by Secretariat for Economic Monitoring (SEAE), for concentration acts involving milk sector firms, they define the geographical dimension of market as national, perishability is not a barrier to the market range (as in case of *in natura* milk) and the eventual exercise of market power in a smaller region than in the national territory would be easily impaired by UHT milk suppliers from other regions[7].

Theoretically, the relevant market must be delimited through the Hypothetical Monopolist Test (TMH), however, its application is rarely viable, in this sense, some econometric tests were used in the UHT milk price series to confirm the hypothesis of a national market. According to Haldrup (2003), this analysis supplies indirect evidence for delimitation of relevant markets, in the impossibility of performing TMH. The logic of price behavior tests, also called approach of co-movement of prices is that products and/or different regions should be grouped in one single market when prices moved jointly, at any definite sense.

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[7] See, for example, mergers acts n.: 08012.003824/2010-94 (involving companies Bom Gosto and Parmalat), 08012.003510/2010-91 (involving companies Leite Bom and Gloria), 08012.013697/2007-36 (involving companies Perdigao and Eleva), among others, approved by CADE without restrictions.

The results showed that the price series in five states are stationary in level and the simple correlation coefficients showed, in great majority, superior to 0.8, evidencing thus, a strong relation between the analyzed series. Therefore, the fact that series are integrated of the same order, having an elevated correlation coefficient, become one more index in favor of the existence of a common geographical market.

Finally, Table 2 summarizes a survey carried out for the Brazilian Association of Supermarkets (ABRAS) in 2011, showing five leader selling brands of UHT milk in the supermarkets, in seven Brazilian regions and in Brazil as a whole. It is noticed that among the eight presented strata, the presence of several brands in more than one region occur simultaneously. Elegê brand stands out with 6 registers, Bom Gosto, with 5, and Parmalat, Tirol and Italac brands, each one with 3 registers.

Therefore, based on the empirical literature, especially the definition found in SEAE reports, referring to concentration acts in the milk sector, and also on found empirical evidences we delimited the wholesale market of UHT milk as one single market formed by states of GO, MG, PR, RS and SP and according to this delimitation the equilibrium concepts of bilateral oligopoly (BPT, MPT, RPT and NST models) were estimated for the common geographical market established by five analyzed states.

For obtaining the variables that will be used in the model, the series were built through a weighted average, using as weigh the milk quantity acquired by dairy companies in each state. In this sense, Table 3 summarizes the descriptive statistics of the used variables and Figure 1 represents three main variables of the model (wholesale and retail price and quantity of UHT milk). The models were estimated using monthly data for the period of July of 2004 up to December of 2009, totalizing 66 observations.

The results of nonlinear GMM estimation of BPT, MPT, RPT and NST models are in Table 5, however, as attention focuses firstly on the selection test between competing equilibrium concepts, individual interpretation of estimates is done subsequently. Table 5 summarizes hypothesis tests related to the choice of models. Moreover, super-identification restriction tests are satisfied (bottom of Table 4). All tests did not reject the null hypothesis at up to 10%

significance level that super-identification restrictions are satisfied and, consequently, the estimated models are valid.

The first step of the selection test consists in testing the BPT model as parametric restrictions in MPT ($\delta = 0$) and RPT ($\gamma = 0$) models. Observing the estimate results (Table 5), it is verified that the estimate of parameter δ is 0,638 with statistic t equal to 2.776. In this sense, the null hypothesis is rejected H0: $\delta = 0$ (BPT) in favor of alternative Ha: $\delta > 0$ (MPT) at 1% significance level (one-tailed test)[8]. When parameter γ was observed, its estimate is 8.97×10^{-4} and statistic t equals 0.001, with p-value equal to 0.499[9], which leads not to reject the null hypothesis H0: $\gamma = 0$ (BPT) in favor of alternative Ha: $\gamma > 0$ (RPT). Thus, the first signs are that the MPT model (dairy industry is price taker) is the most adequate model to the structure of data.

While preceding tests suggest that the MPT model is superior to the RPT model, it is possible that different conclusions could be found when MPT and RPT models are compared side by side. Thus, as suggested by Schroeter *et al* (2000), an indirect comparison is carried out between models through the artificial nesting model. The MPT model is the NST model with restriction $\gamma = 0$. The χ^2 likelihood-ratio statistic test is 2.072, with p-value equal to 0.150. The RPT model, however, is the NST model with restriction $\delta = 0$ and the χ^2 likelihood-ratio statistic test is 7.095, with p-value equal to 0.007. These results confirm the conclusions obtained in previous tests, as the null hypothesis H0: $\gamma = 0$ cannot be rejected (MPT) in favor of the alternative Ha: $\gamma \neq 0$ (NST), while the null hypothesis H_0: $\delta = 0$ is rejected (RPT) in favor of alternative Ha: $\gamma \neq 0$ (NST). Thus, there have been indirect evidences in favor of the choice of the MPT model over the RPT model, as the RPT, not MPT, is rejected when tested against the NST nesting model.

Finally, adopting a more defensive approach, as suggested by Schroeter *et al* (2000), the selection test of nonnested models proposed by Rivers and Vuong (2002) was used, in which statistic T, with standardized normal distribution was used to directly compare two equilibrium concepts, MPT and RPT, through the following hypothesis test: H_0: MPT = RPT *versus* H1: MPT, if test is negative and statistically significant; or H_2: RPT, if test is positive and statistically

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[8] Based on MPT model, χ^2 value, from likelihood-ratio test for a test of hypothesis H_0: $\delta = 0$ (ATP) *vs.* H_a: $\delta \neq 0$, is 7.655, with p-value equal to 0.005.

[9] Based on VTP model, χ^2 value, from likelihood-ratio test for a test of the hypothesis H_0: $\gamma = 0$ (BPT) *vs.* H_a: $\gamma \neq 0$, 1.26×10^{-6}, with p-value equal to 0.991.

significant. The result of the proposed test *(T)* was -2.871, with p-value = 0.002, therefore, statistically significant at 1% significance level. Thus, the null hypothesis is rejected, H_0: MPT = RPT in favor of the alternative hypothesis H_1: MPT, reinforcing the previously obtained results, in the choice of the MPT model over the RPT model.

Hence, it is possible to conclude that the structure of data is better represented by the MPT model than by RPT and BPT models. The economical interpretation of this result is that the hypothesis of a perfectly competitive market can be rejected, in favor of a hypothesis of a market with non-competitive price distortions. Furthermore, the results indicate that these distortions are result of the oligopsony exploration power on the retailers' side, while the dairy industry demonstrates a price-taking behavior.

Regarding individual interpretation of estimates, attention is given to the MPT model, which was the equilibrium concept chosen through selection tests. Based of the obtained results (Table 5), it was noticed that the slope of the demand curve faced by the retailer ($\hat{\alpha}_1 + \hat{\alpha}_3 Z_3$) is positive in all sample points, however, statistically non-significant. The estimate of $\alpha 3$ positive and statistically significant meets the hypothesis that fruit juice is a good substitute to UHT milk. Nevertheless, the estimate of parameter α_2, which catches demand dislocations owing to revenue variations, was not statistically significant.

Regarding the marginal cost curve of the dairy industry, its slope, given by, $\hat{c}_1 + \hat{c}_3 V_3$ was negative in all sample points and statistically significant, at 1% significance level. The supply elasticity-price, calculated in the middle point of the sample, was -0.57, also statistically significant, at 5% significance level. Nevertheless, the positive and statistically significant value of c_3 indicates that the marginal cost is growing along the time. In addition, the positive and statistically significant estimate of c_2 indicates that the marginal cost grows with the use of the main input used in the manufacturing process, in other words, *in natura* milk.

The slope of the retailer's marginal cost, given by estimate b_1, was statistically non-significant, demonstrating that the retailer's marginal cost does not alter with increases of sold quantity, whereas the estimate of b_2, positive and statistically significant, implies in marginal cost increases in relation to increases in energy costs and transport.

As for the conduct parameter, estimate of parameter δ, represents the degree of retailers' oligopsony power over the dairy industry and its estimate was 0.638 significant at 1% significance level. Therefore, according to the obtained results, evidences would indicate that the wholesale market of UHT milk considerably distances from a perfectly competitive market. If considering the symmetrical equilibrium solution of Cournot ($n = 1 / \delta$), the degree of oligopsony power would be close to a market structure of symmetrical duopsony ($n = 1.56$) .

From economic theory, it is known that the capacity of exercise of market power is inversely proportional to the supply elasticity and a way of verifying distortions caused by the oligopsony power would be to calculate the *L index*, however, as a negative supply elasticity-price was found, this result causes values that have no useful economical meaning. In this sense, to contribute with the obtained results it is possible appeal to marketing margins[10] to verify the dynamics and identify any specific behavior of total marketing margins of retailers and dairy companies.

It can be noticed in Figure 2, that the total marketing relative margin remained stable along the period, approximately 61%, in Jul/04 it was 59% and in Dec/09 it was 63%. However, the dairy industry's relative marketing margin presented a negative trend, while retailers' relative marketing margin grew along the period. Although it is a synthetic indicator of market performance, evidences meet the results obtained in the bilateral oligopoly model. As retailers exercise oligopsony power over the dairy industry, this fact may be causing constant increase of the relative marketing margin of the first.

6. Final considerations

Regarding the wholesale UHT milk market, the obtained results allowed concluding that retailers exercise oligopsony power over the dairy industry. This result meets the discussion found in the

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[10] The marketing margin is given by the difference between the price for which an intermediate sells one unit of product and the payment that he does to acquire it. In this sense, marketing margins can also be used as an efficiency, or market performance indicator. Total relative marketing margins, of retailer and dairy company, are given, respectively, by: $MT = (p_r - w_1)/p_r$ $MV = (p_r - p_w)/p_r$ e $ML = (p_w - w_1)/p_r$, where p_r, p_w are UHT milk prices at retail level and whole level, respectively and w_1 is the raw milk price, paid to farmer.

economical literature that the restructuring of the milk sector elevated the power of retailers in the marketing of dairy products.

However, although some studies argue that the growth of the number of independent markets has eased the concentration effects and that the *turnover* evidences between sector leaders represent a beneficial competitive energy, the fact that UHT milk is a homogeneous product and of little differentiation, places retailers in a favorable position for exercising market power over the dairy industry.

The estimate value of the conduct parameter was 0.638 demonstrating that the market is considerably far from a perfectly competitive market, nevertheless, the distortions caused by this market power could not be calculated as the supply elasticity-price of the dairy industry was negative. In this sense, the empirical evidences observed by the behavior of relative marketing margins, corroborated the found results, as they showed a growing trend of retailers' relative margin over the dairy industry's relative margin.

This result has important implications, since there is market power in a chain link, this effect extends along the whole productive chain and implies in the reduction of production and sales at a global level. Moreover, there may be great distortions from the point of view of distribution of excesses among agents of the milk chain. Therefore, future studies that quantify these distortions, are of extreme relevance so that the impacts produced by market power can be evaluated from the loss of economic well-being and redistribution of excesses standpoint.

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Table 1 Variables used in estimation of bilateral oligopoly model.

Retailers' demand function

Variable	Description	Source
pr	Monthly mean price of UHT milk liter sold in retail market (in R$)	DIEESE
Q	Monthly acquired quantity of cold *in natura* milk, *in natura* not cold milk and transfer of cooling units/other units of same company.	PTL/IBGE
$Z2$	Monthly GNP, in millions of R$, projected by the Central Bank of Brazil (BACEN)	BACEN
$Z3$	Variation index of added price of fruit juice price, obtained through the IPCA.	IBGE

Marginal cost function of retailers and dairy companies

pw	Monthly mean price of wholesale UHT milk liter, in R$.	CEPEA/ESALQ
$W2$	Mean price charged per liter of diesel in distributors in each state, in R$/liter	ANP
$V2$	Monthly mean price of *in natura* milk liter received by milk producer, in R$/liter	CEPEA/ESALQ
$V3$	Time trend	

Additional instrumental variables

Lr	Mean salary per worker in retail food market, drink and tobacco, in R$.	RAIS/MTE
IPL	International price index of dairy products *(IPL)* – price index calculated based on a weighted price average of butter, whole and skimmed powdered milk, cheese and casein. The weight is done by the world average of exports performed between 1998 and 2000. (Base1998-2000 = 100).	FAO

Source: Prepared by authors.

Table 2 Ranking of five leader selling brands of UHT milk in supermarkets.

Ranking	Brazil	Northeast region	MG, ES and inner RJ	Metrop. region RJ	Metrop. Region SP	Inner SP	PR, SC and RS	MS, GO and DF
1st	Elegê	Bom Gosto	Cemil	Elegê	Italac	Jussara	Tirol	Piracanjuba
2nd	Bom Gosto	Valedou-rado	Elegê	Parmalat	Elegê	Lider	Bom Gosto	Saint Gabriel
3rd	Tirol	Betânia	Cotochês	Da Matta	Parmalat	Sheffa	Elegê	LeiteBom
4th	Italac	Parmalat	Itambé	Bom Gosto	Bom Gosto	Tirol	Lad.	Compeleite
5th	Lider	ALIMBA	LAC	Dutchman	Long	Elegê	Mu-mu	Italac

Source: Magazine Superhiper (2011).

Table 3 Descriptive statistics of used variables.

Variables	Unit.	Mean	Maximum	Minimum	Standard deviation	Obs
p_r	R\$/liter	1.68	2.13	1.48	0.15	66
Q	million liter	1,102,056	1,284,721	916,308	95,498	66
Z_2	millions of R\$	233,708	285,976	188,395	22,598	66
Z_3	index	91.12	101.08	84.10	5.03	66
p_w	R\$/liter	1.45	1.93	1.27	0.14	66
w_2	R\$/liter	1.81	1.93	1.63	0.08	66
V_2	R\$/liter	0.64	0.84	0.51	0.08	66
L_r	R\$	656.57	731.33	525.85	76.81	66
IPL	index	163.61	266.61	117.36	49.15	66

Source: Elaborated by authors from available data.

Table 4 Estimates of BPT, MPT, RPT and NST models for wholesale UHT milk market.

Parameters	BPT	MPT	RPT	NST
α_0	-0.279 (0.552)	-0.594 (0.547)	-0.280 (0.671)	0.304 (0.667)
α_1	-8.72×10^{-7}* (5.00×10^{-7})	-8.00×10^{-7} (4.98×10^{-7})	-8.72×10^{-7}* (5.03×10^{-7})	-8.70×10^{-7}* (5.20×10^{-7})
α_2	-1.05×10^{-6} (1.35×10^{-6})	-8.52×10^{-7} (1.29×10^{-6})	-1.05×10^{-6} (1.37×10^{-6})	-9.51×10^{-7} (1.33×10^{-6})
α_3	1.23×10^{-8} (8.10×10^{-9})	1.58×10^{-8}** (7.89×10^{-9})	1.23×10^{-8} (8.05×10^{-9})	1.24×10^{-8} (9.23×10^{-9})
b_0	-2.102*** (0.385)	-1.670*** (0.351)	-2.100*** (0.386)	-1.660*** (0.336)
b_1	-1.08×10^{-6} (1.69×10^{-6})	-1.20×10^{-6} (1.63×10^{-6})	-1.08×10^{-6} (1.75×10^{-6})	-2.05×10^{-6} (2.80×10^{-6})
b_2	0.168 (0.104)	0.106*** (0.089)	0.169 (0.110)	0.280*** (0.093)
c_0	3.329*** (0.290)	2.995*** (0.313)	3.330*** (0.311)	3.100*** (0.333)
c_1	-2.83×10^{-6}*** (3.30×10^{-7})	-2.56×10^{-6}*** (3.42×10^{-7})	-2.83×10^{-6}*** (3.75×10^{-7})	-2.19×10^{-6}*** (4.52×10^{-7})
c_2	1.379*** (0.096)	1.506*** (0.101)	1.380*** (0.104)	1.470*** (0.114)
c_3	9.53×10^{-9}*** (1.07×10^{-9})	8.35×10^{-9}*** (1.14×10^{-9})	9.53×10^{-9}*** (1.35×10^{-9})	6.83×10^{-9}*** (1.34×10^{-9})
λ	-1.463 (1.117)	-1.731* (1.002)	-1.460 (1.210)	2.560 (1.950)
δ		0.638*** (0.231)		0.926*** (0.347)
γ			8.97×10^{-4} (0.799)	-0.374 (0.260)
	0.1811	0.1577	0.1811	0.1596
Test Over	11.954	10.414	11.954	10.537

Note: standard error in parenthesis.
         *** Significant at 1%, ** significant at 5% and * significant at 10%.
Source: Study results

Table 5 Results of selection hypotheses tests of model in wholesale market of UHT milk.

Tests Bases on Estimates of the MPT Model

H_0: $\delta = 0$ (ATP)	H_0: $\delta = 0$ (ATP)
vs. H_a: $\delta > 0$ (PTP)	vs. H_a: $\delta \neq 0$
$t = 2.776$	$\chi 2 = 7.655$
p-valor $= 0.003$	p-valor $= 0.005$

Tests Bases on Estimates of the RPT Model

H_0: $\gamma = 0$ (ATP)	H_0: $\gamma = 0$ (ATP)
vs. H_a: $\gamma > 0$ (VTP)	vs. H_a: $\gamma \neq 0$
$t = 0.001$	$\chi 2 = 1.26 \times 10^{-6}$
p-valor $= 0.499$	p-valor $= 0.991$

Tests Bases on Estimates of the NST Model

H_0: $\gamma = 0$ (PTP)	H_0: $\delta = 0$ (VTP)
vs. H_a: $\gamma \neq 0$ (NST)	vs. H_a: $\delta \neq 0$ (NST)
$\chi 2 = 2.072$	$\chi 2 = 7.095$
p-valor $= 0.150$	p-valor $= 0.007$

Nonnested Hypothesis Tests

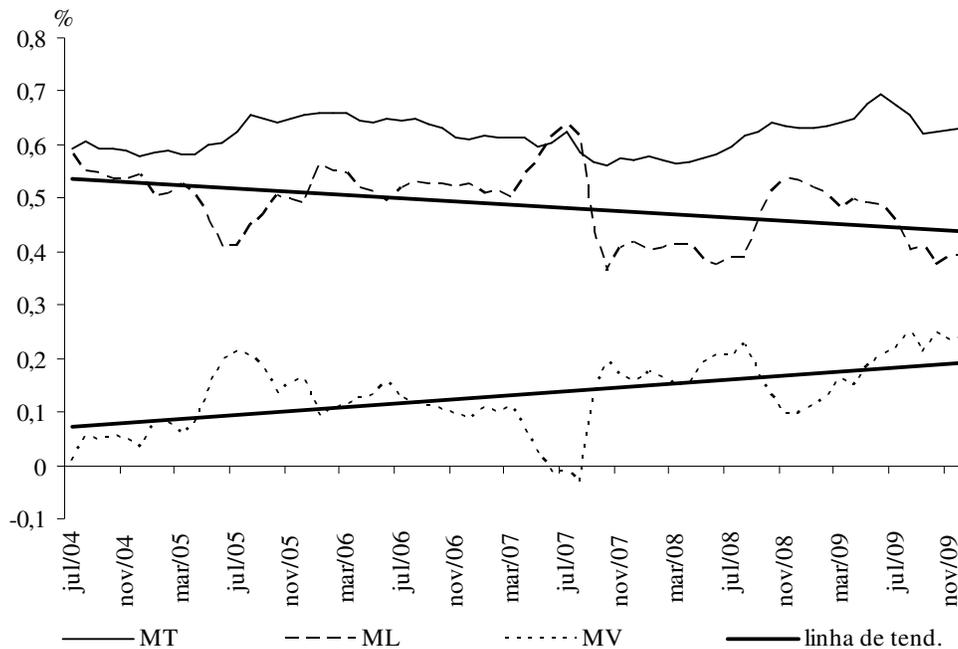| |
|---|
| H_0: PTP |
| vs. H_a: VTP |
| $T = -2.871$ |
| p-valor $= 0.002$ |

Source: Study results

Figure 1 Series of retail and wholesale UHT milk price and quantity of industrialized milk by dairy companies.
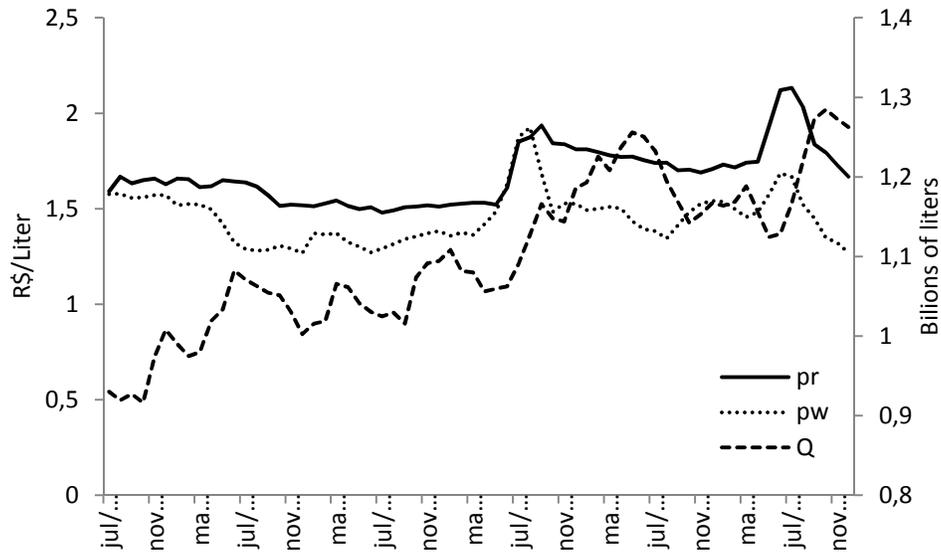
Source: Prepared by authors from available data

Figure 2 Total marketing relative margins of UHT milk retailers and wholesale dairy companies

Source: Study results