Stochastic Frontier Estimation of Buyer Power:
An Application to the Brazilian Milk Market

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1. Introduction

The prevalence of buyer power—the ability of buyers to depress or change the terms of trade in their favor is on the rise due to concentration in retail and other downstream sectors. In spite of its prevalence, the empirical literature has largely side-stepped the issue concentrating on monopoly power with little attention to buyer power. For every paper that examines oligopsony power there are 15 papers on oligopoly power.[1] Although this inattention is in part due to the relative welfare impacts on consumers vs. producers, lack of data on wholesale and intermediate prices for key inputs is another important contributor.

In this paper, we develop a model for oligopsony power analysis which can be applied when there is only limited data. Our model is based on the stochastic frontier analysis proposed by Kumbhakar et al. (2012) and only uses a panel data with marketing margins and prices of other inputs used on transformation process. Because our empirical application we use an assumption of fixed proportions technology, however the model if very flexible and can be extend to accommodate others assumptions. Another important characteristic is that contrary to the traditional NEIO models, the measure of market power is not an average measuring. It can vary over time and among the units used in the panel data.

We use the model to analyze the oligopsony market power of retail food industry on the dairy manufactures in Brazil. Retail food sector in Brazil has undergone considerable restructure caused by change in consumer habits, company mergers and acquisitions and because of lack of data there is no works that address buyer power form Brazilian retailers. The few studies we have found concerned about it use assymetric transmition price method to found evidences about imperfect markets (Aguiar and Santana 2002; Azevedo and Politi 2008; Aguiar and Figueiredo 2011). Data on retailer and wholesale prices of Ultra High Temperature (UHT) Milk[2] in Brazil show an average markup between January 2010 and December 2015 was 20.3% and in some states these margins have been increasing over this period. Moreover, there are significant differences between the states suggesting that there may be different conducts of retailers in each one of them.

[1] For instance, the IDEAS RePEC website (https://ideas.repec.org), lists 6,0000 papers on oligopoly power and only 400 papers on oligopsony power since 1980 at the advent of the New Empirical Industrial Organization.
[2] The UHT milk is the most important fluid milk consumed in Brazil. According with Brazilian Association of UHT Milk Industry around 80% of all fluid milk produced in 2011 was UHT.

2. Conceptual framework

Consider an industry in which N firms distribute a homogeneous good and use additional inputs Z bought at fixed prices. Let q_i denote the quantity of the homogeneous good bought and sold by firm *i* and $Q = \sum_{i=1}^{N} q_i$ the total quantity of bought or sold. Each firm can exercise market power on the input and/or the output market. Profits for the *ith* firm are

$$\pi_i = (p_r(Q) - p_w(Q) - c(W))q_i, + FC_i), \quad (1)$$

where $p_r(Q)$ and $p_w(Q)$ are selling and buying prices of the commodity being distributed, W is a vector of prices for inputs used in distribution, $c(W)$ is the unit costs of distribution, and FC_i is the fixed cost of distribution accruing to firm *i*. The first order condition (FOC) for profit maximization is given by:

$$p_r - p_w = c\ (W) + s_i(1 + \theta_i)\left(\frac{1}{\varepsilon} + \frac{1}{\eta}\right), \quad (2)$$

where $s_i = q_i/Q$ is the market share of firm *i*, $\varepsilon = (\partial Q/\partial p_w)/(1/Q\ )$ is the semi-elasticity of market supply with respect to price, $\eta = -\,(\partial Q/\partial p_r)/(1/Q\ )$ is the absolute value of semi elasticity of market demand with respect to price , and $\theta_i = \sum_{i\neq j}^{N}\left(\partial q_j/\partial q_i\right)$ is the rival's responses to a change in the volume of the product being distributed.

In the same spirit from Azzam (1997) and Lopez et al. (2002), we multiply both sides of (2) by s_i and sum across all distributors to obtain:

$$p_r - p_w = c(W) + H(1 + \theta)\left(\frac{1}{\varepsilon} + \frac{1}{\eta}\right), \quad (3)$$

where $H = \sum_{i=1}^{N} \mathrm{S}_\mathrm{i}^2$ is the Herfindahl-Hirshmann index and θ is the industry conjectural variation ($\theta_i = \theta_j = \theta$). The perfect competitive benchmark can be obtained when $H = 1$ or $\theta = -1$ or both $\in$ and η are infinite which is unlikely at the market level. The non-competitive deviation can be expressed as

$$u = \Phi\left(\frac{i}{\epsilon} + \frac{i}{\eta}\right), \quad (4)$$

where $\Phi = \mathrm{H}(1 + \theta)$. Thus, the allocation of oligopoly and oligopsony pricing behaviors are directly related to their inverse semi-elasticities. Market power can be characterized as having two components: buying power and selling power of the distributors. More specifically, we can define:

$$MPI = BPI + SPI, \quad (5)$$

where $BPI = \Phi\varepsilon^{-1}/p_w$ and $SPI = \Phi\eta^{-1}/p_w$. BPI is the buyer power index, (Blair and Harrison 2010) and SPI is the seller power index. Let the market power index be expressed as MPI = BPI+SPI = u/p_w, Thus, oligopsony power relative to the importance of oligopoly power can be expressed as $BPI/SPI = {}^{n}/_{e}$.

Figure 1 illustrates alternative scenarios as to how the degree buyer power relative to seller power by a given distributor. As ${}^{n}/_{e}$ increases, the degree of buyer power increases as a percentage of the marketing margin. Likewise, the larger ϵ is relative to *n*, the greater the relative degree of oligopoly power in the system.

With adequate information available, Φ, ε, θ and η could be calculated. However, this is rarely the case. Thus, in the same spirit of Kumbhakar, Baardsen, and Lien (2012), we rewrite equation (3) as:

$$p_r - p_w = c(W) + u + v, \quad (6)$$

where *v* is a traditional error term *iid* with mean of zero and variance σ_v^2, $v \sim N(0, \sigma_v^2)$. However, the non-negative term *u* represents the market power deviation from perfect competition. Equation (6) takes form of a stochastic frontier function and the *u* has a truncated (at zero) normal distribution and variance σ_u^2, $u \sim N^+(0, \sigma_u^2)$.

3. An application to the Brazilian milk market

To estimate equation (6) we assume the marginal cost of distribution $c(W)$, takes the form of a Generalized Leontiefff function where three inputs are used into marketing process of UHT milk: labor (L), capital (K) and energy (E) bought at prices w_L, w_K and w_E, respectively. The information available from different sources constitutes a panel data spans the monthly period from January 2010 until December 2015 and five Brazilian states. Table 1 summarizes the descriptive statistics. For simplicity, we do not use a subscript to indicate a Brazilian state. The analogue of (6) is then:

$$p_{rt} - p_{wt} = \alpha_0 + \textstyle\sum_i \alpha_i w_{it} + \sum_i \sum_j \alpha_{ij} \left(w_{it} w_{jt}\right)^{\frac{1}{2}} + u_t + v_t, \quad (7)$$

where *i*, *j* = labor, capital and energy and $\alpha_{ij} = \alpha_{ji} \;\; \forall \; i \neq j$.

Table 2 presents the estimated parameters for equation (7). All signs conform to a priori expectations. Table 3 summarizes the estimate of $\hat{u}$ by states and denotes nominal deviations of market power from perfect competition. The average deviation was R$0.139, which represents around eight percent of the buying (wholesale) price for milk across states. This amount varied considerably across states, ranging between R$0.064 in Rio Grande do Sul and R$0.218 in Goias. As a percentage of the wholesale price, this accounted for between four and 12 percent of the average buying price.

Figure 2 depicts the overall deviations of pricing (seller plus buyer power) as a percentage of the wholesale milk price for each Brazilian state over the sample period. Peak deviations normally occur during the transition from the dry to the rainy seasons. Furthermore, it seems that volatility of the non-competitive gaps is increasing across all state, except for Rio Grande do Sul. The only state to show a long-term decline in the non-competitive gaps is Sao Paulo—the largest consumer market in the country.

Using (4) and (5) and prior elasticity estimates for supply (0.25, from Alves et al. 2003) and demand (−1.129, from Coelho, Aguiar, and Eales, 2010), the semi-elasticities were computed for each period and state. The average estimate BPI = 0.06 and SPI = 0.02, which indicates that 75% of the market power exerted by milk retailers comes from oligopsony power.

4. Conclusion

In this article, we developed a framework to decompose retail market power into buyer and seller power and can be applied in situations where we don't have so much information available. The channel market power allocated to buyer power depends on the relative price semi-elasticities of demand and supply facing the retailer. We illustrate the methodology using a stochastic frontier model Kumbhakar, Baardsen and Lien (2012) applied to data from the Brazilian milk market and estimate that 75% of the milk retailers' power comes from buyer rather than seller power. The methodology can be applied to other markets to provide a rapid assessment of the degree of market power, as well as to separate buyer from seller power.

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Table 1 – Variable definition and descriptive statistics

Variable	Mean	S.D.	Min.	Max.	Definition	Unit	Source
Margins (by states*):							
GO	0.55	0.16	0.25	1.07	UHT milk marketing margin ($p_r - p_w$)	Reals(R$) / Liter	Retailer prices (***p_r***): Inter-Union Department of Statistics and Socio-Economic Studies – DIEESE; and Wholesale Prices (***p_w***): Center of Advanced Studies in Applied Economics – ESALQ/USP.
MG	0.49	0.11	0.24	0.85			
PR	0.40	0.15	0.03	0.76			
RS	0.15	0.08	-0.02	0.40			
SP	0.85	0.22	0.46	1.37			
L	840.86	150.04	574.92	1225.89	Average salary pay to workers in retail business of food drinks and tobacco by state	Reals (R$) / Month	Ministry of Laybor and Employment - CAGED/TEM
K	4627.63	1,574.26	1,834.06	8,606.16	Average price of square meter (m2) of used residential apartments in capital of each state	Reals(R$) / m2	Foundation Institute of Economic Research - FIPE/ZAP.
E	2.01	0.26	1.70	2.72	Average distribution price of Diesel Oil in each state	Reals(R$) / Liter	National Agency of oil, natural gas and biofuels - ANP.

Note: * States Acronym: GO – Goias, MG – Minas Gerais, PR – Parana, RS – Rio Grande do Sul, SP – São Paulo.

Table 2 – Stochastic frontier results

Parameters	Est. coef.	S.E.	p-value
α_0	−0.219	0.075	0.004
α_{LL}	0.051	0.007	0.000
α_{KK}	0.002	0.000	0.000
α_{EE}	12.058	2.032	0.000
α_{LK}	−0.015	0.002	0.000
α_{LE}	−1.358	0.231	0.000
α_{KE}	0.075	0.030	0.012
μ	−1.691	3.985	0.671
σ_u^2	0.522	0.496	0.293
σ_v^2	0.114	0.014	0.000
λ	4.549	0.491	0.000

Table 3 – Non-competitive deviations ($\hat{u}$)

States	Mean	S.D	Min.	Max.	MPI Mean
Goias	0.218	0.149	0.034	0.709	0.12
Minas Gerais	0.115	0.052	0.048	0.386	0.06
Parana	0.129	0.078	0.035	0.445	0.07
Rio Grande do Sul	0.064	0.020	0.033	0.149	0.04
Sao Paulo	0.171	0.104	0.046	0.466	0.10
Average	**0.139**	**0.105**	**0.033**	**0.709**	**0.08**

Figure 1 – Buyer and seller power shares of a retailer's market power.

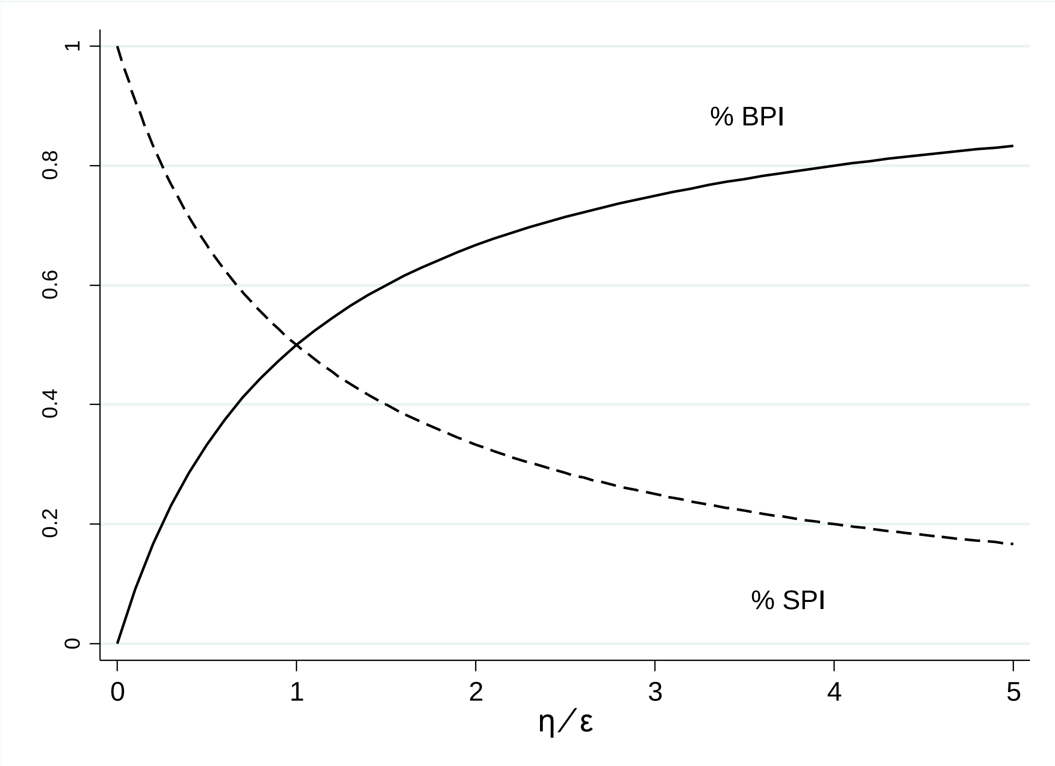

Figure 2 – Non-competitive percent deviations of milk pricing in Brazilian states.