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Estimating the conjectural variation and market power in selected industries

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Abstract: In recent studies, many economists have focused on the industry and market. In order to provide a comprehensive framework for target market, Policymakers need to have information about the structure of the market and the factors affecting it. The model which is presented in this research shows the behavior of selected industries. This model investigates the structure from competition to monopoly and makes a link between the consumer and the producer behavior. In this paper ten manufacturing industries in Iran at 4-degree ISIC are chosen and market power and conjectural elasticity (CV) is examined using panel data from 1996 to 2007.The results show that the estimated CV differs significantly from -1 for most of the industries surveyed but two cases, cement and beverage industries with -0.27 and 0.5 respectively. On a scale of -1(no collusion) to $((1/H)-1)$ (full collusion), these industries seem to have competitive behavior. Further, the effects of concentration on both market power and cost efficiency on price is estimated.

Keywords: Conjectural Variation Elasticity, Market Power, Selected Industries

1. Introduction

Analyzing the structure of the market has a long history in economics. Since ninetieth century, some approaches have come into text books to seek for the organization of a market and policy making.

To do this, one of the most advantageous and beneficial approaches is New Empirical Industrial Organization (NEIO). With NEIO, a researcher may identify and estimate market power, which is inferred by conduct of firms. In the framework of NEIO, one should have the firm-level data of a particular industry, which is mostly hard to find, as in our study. Also Bresnahan [8] suggests that basic NEIO is an appropriate tool just for estimating market power but policy making. NEIO investigates structure but is unable to address it to conduct and performance in highly concentrated industry. As a remedy to this, one should have wider range of industry as well as implementing a structural measure, such as concentration, to be appropriate for policy making (Lopez, Azzam and Lirón-España [15]).

In this research, the subdivided model called conjectural variation model has been used. The key feature of CV model is that each firm in an industry has some expectation about the rival's reaction in association with a change in own output.

Other studies such as Azzam and Schroeter [2] and Azzam [3] have improved the NEIO framework that is used by Appelbaum [1], to recognize the effects of concentration on market power and efficiency. Azzam separates the cost efficiency effects from market power effects in result to concentration and reports the findings in US beef-packing industry during 1970-1992. He suggests that cost efficiency effect is more important than market power effect. Azzam and Schroeter attempt to make a connection between concentration and price and the weight of each. Their research is focused on US Portland cement industry over 1978 to 1982. They find that market power effect is greater than cost efficiency effect. Also Lopez et.al survey 255 US manufacturing industries over the period of 1972-1992 and report the relationship between increasing concentration to the market power and cost efficiency effects as well as to welfare. In addition, Jorge Fernandez-Cornejo and David Spielman [13] attempt to inspect the both effects of market power and cost efficiency on margins as a result of concentration and clarify a tradeoff between these two effects in U.S. corn seed industry.

It is worth mentioning that conduct is identical over the

firms but in real world it may not be true due to three following reasons; simplicity, unavailability of firm-level data, and the more attention policy makers pay to the industry indices than firm indices and statistics; therefore, it is assumed that the estimated CV is an averaged-value of all firms.

1.1. The Theoretical Framework

This section explains the model that is used to estimate market power. This model which is based on Azzam, describes how the price index could be related to conjectural variation and marginal cost. Then we will be keeping on determining how and how much the price in an industry would be influenced by the market power-concentration as well as cost efficiency-concentration effects.

Suppose that there are N firms in a typical industry producing homogeneous products, the profit function of firm i, is

$$\pi = pq_i - C_i(q_i, w) \quad (1)$$

Where π is profit, p is price, q_i is firm's product and C_i is total cost of firm i that is positively related to products and the price of inputs. As it can be seen, profit is a positive function of price and firm's product, and negative function of cost function.

There are wide range of cost functions based on the type of work and availability of data. Here for explaining the production costs, we use generalized Leontief or diewert cost function. Following Lever, Nieuwenhuijsen and van Stel [14], this function is the "Gorman polar"[1] form. It assumes that the total cost functions of all firms are linear and the difference is just in intercept (Lever et.al). By this, it is meant that the marginal cost of all the firms are the same and hence, $MC_i = MC$.

The generalized Leontief cost function is defined as:

$$C_i(q_i, w) = q_i \sum_L \sum_K \alpha_{LK} (w_L w_K)^{\frac{1}{2}} + (q_i)^2 \sum_L \beta_L w_L \quad (2)$$

Where $C_i(q_i, w)$ is total cost of firm i, q_i is supply, w_L stands for the price of labor and w_K stands for the price of capital.

By first differentiating in terms of q_i in the total cost function, we have marginal cost function of the firm i which equals to

$$MC_i = \sum_L \sum_K \alpha_{LK} (w_L w_K)^{\frac{1}{2}} + 2q_i \sum_L \beta_L w_L \quad (3)$$

By maximizing (to take the first difference) the equation 1 and substituting equation 3, we have the supply relation as follow:

$$p = \frac{q_i}{Q\eta^2}(1 + \theta_i) + \sum_L \sum_K \alpha_{LK} (w_L w_K)^{\frac{1}{2}} + 2q_i \sum_L \beta_L w_L \quad (4)$$

Where (q_i/Q) is the market share of firm i, η is semi-elasticity and equals to $\eta = (dQ/dp)(1/Q)$ and θ_i is conjectural variation of the firm i and equals to $\theta_i = \sum_{i \neq j}^{N} \frac{q_j}{q_i}$.

By multiplying through equation 4 by the market share of firm i (q_i/Q), and having summation across all the firms in that industry, yield:

$$p \cdot \frac{\sum q_i}{Q} = \frac{\sum {q_i}^2}{Q^2}(1 + \theta_i) \cdot \frac{p}{\eta} + \frac{\sum q_i}{Q} \cdot \left[\sum_L \sum_K \alpha_{LK} (w_L w_K)^{\frac{1}{2}} + 2HQ \sum_L \beta_L w_L\right] \quad (5)$$

$$p = (1 + \Theta)\frac{H}{\eta} + \sum_L \sum_K \alpha_{LK} (w_L w_K)^{\frac{1}{2}} + 2HQ \sum_L \beta_L w_L$$

One of the issues concern the CV which is derived from model 5. It should be noted that there is no need to assume the unity of conjectural variation over all the firms. Actually CV could differ for each firm but the point is that because we estimate CV in the condition which marginal revenue equals marginal cost or in maximizing condition, hence, the estimated CV is an equilibrium and is average of the firms.

1.2. The First Fact to be Explained

As mentioned before, CV describes how firms in an industry act and interact in terms of supply decision. It explains that in what extent each firm's decision may influence the rival's choice of supply. If $\Theta = -1$, so the firms are price takers and market structure is full competition or no collusion is likely to be seemed. So the choices of the firms about supply cannot influence on the rivals and in aggregate on market supply. At the other extreme, if $\Theta = \frac{1}{H} - 1$, so there is one firm (or more than one) that its (their) supply decision will definitely influence the market supply, which corresponds to monopoly or perfect collusion.

The most important issue concerning CV is that it can just explain the decisions of the firms about supply. But as it is known, firms can focus on other available tools such as colluding on price, advertisement expenditure, and so on. For instance, two firms decide to simultaneously lessen the supply to raise their aggregate profit. Or they may pull together to intensify their advertisement expenditure to absorb other rival's market share. Yet, it can be declared that the issues mentioned above affect the supply of the firms indirectly. For example, the firm's supply would raise through the increase in advertisement expenditure that results in increase in market share. So, still CV is an appropriate measure of collusion.

But the market power is beyond the concept of conjecture. If two or more firms decide to collude, their conjecture about the other firms that have the less market share could be truly low. This agreement will have them a market power. Market power is one of the indices to

[1] It suggests that the equations which are based on firm-level data can be used for those which are based on aggregate-level data.

investigate performance of the market which lets the firm or firms to set the price over cost and increase the profit.

It is essential to note that the agreement and cooperation could be formed in these two ways. Two or more firms could have a formal agreement on their behavior such as simultaneous alteration of price, production, advertisement expenditure and so on. This formal agreement is made as a cartel and called explicit collusion. Or it could be formed as an unsettled agreement. It means that the firms recognize the role of each other and implicitly try to coordinate their movement and not to trespass each other's market share.

1.3. Estimating the Market Power

There are some approaches to estimate oligopoly power; however, the best one is Lerner index. Lerner index can be found for a firm from this equation

$$L_i = \frac{p - MC_i}{p} = -\frac{\theta_i}{\eta}$$

Where p, MC_i, θ_i and η respectively are price, marginal cost of firm i, conjectural elasticity of firm i that equals $\frac{\partial Q}{p} \times \frac{q_i}{Q}$ and eventually η is price elasticity of demand.

As mentioned above, the Lerner index is at industry level and θ is the average of industry.

So the estimation equation of the market power is

$$L_n = \frac{p - MC}{p} = -\frac{\theta_n}{\eta_n}$$

Where n is industry index and n=1, 2, …, 10

Table 1. *Estimates for market power in 1996-2009*

Industry	Market power	Classification
Oil	1.9365	4
Dairy	0.8292	7
Beverage	0.3454	9
Apparel	1.8248	5
Printing	3.1	3
Chemical	5.9058	1
Cement	0.3385	10
Steel	4.0724	2
Appliances	0.9056	6
Transportation	0.5286	8

1.4. The second Fact to be Explained

The second fact is starting with this question: what is the source of market power?

There are some reasons that could end up to market power such as market concentration, efficiency (cost efficiency and technology efficiency), fixed cost [2], differential products, price elasticity of demand and conjectural elasticity. Generally, there are three theories about the relation between market structure and performance. The first one is theory of collusion or SCP which is initially offered by Bain [6]. The second one is structural efficiency (Demsetz, [11]) that explains the positive correlation between concentration and profitability. He suggests that the more efficient firms earn more market share than the rivals which ends up to more concentration market. The third theory which is offered by shepherd [16] and [17], implies that the variance in a firm's performance is defined by efficiency and market share. For instance, a firm with more market share will gain more market power. In this point of view, market share is a proxy of market power.

Berger [7] suggests the possible effects of market structure in cost efficiency in following ways. In a more concentrated industry, a typical firm may set the price beyond the competitive level which is so called ''quiet life''. In this situation the firm is not interested in minimizing the cost for maximizing the profit. Also the firm may turn the aim to something other than profit maximization like expanding the production line without efficiency objective. Or it is possible for that firm to spend opportunities to earn and keep market power, for example, expenditure to negotiate with the other rivals for seducing them to collaborate.

The points that are mentioned above suggest that the more profitability is not the right proof of existing market power or being in a monopoly market. Firms in a competitive market may have more profits than the others which benefit cost efficiency. So the Lerner index or market power is not an appropriate measure for policy making and it just provide us information about overall market.

So it is beneficial to track the trace of market power and cost efficiency on behavior. Following Azzam and Rosenbaum [4], to distinguish the effects of concentration on market power and cost efficiency on price, equation 5 should be differentiated with respect to constant (Θ) yields:

$$\frac{\partial P}{\partial H} = \frac{1+\Theta}{\eta} + 2Q\sum \beta_i w_i \qquad (6)$$

Table 2. *Effects of cost efficiency and market power and total effects in 1996-2009*

Industry	Cost efficiency effect $(2Q\sum \beta_i w_i)$	Market power effect $(1+\Theta)/\eta$	Total effect $(\frac{\partial P}{\partial H})$
Oil	1.9365	-0.013426735	1.911829417
Dairy	0.8292	-0.204263677	1.633237769
Beverage	0.3454	0.321154115	1.156508975
Apparel	1.8248	0.026862309	0.032662239
Printing	3.1	-0.070495304	-0.029605214
Chemical	5.9058	-0.023498046	2.735583494
Cement	0.3385	1.55809103	9.680902871
Steel	4.0724	-0.072419457	103.490258843
Appliances	0.9056	0.092304336	1.220882205
Transportation	0.5286	-0.003158424	78.973277706

[2] For instance, if a firm intends to offset its initial investment, it makes a difference between price and marginal cost.

Equation 6 depicts two effects of the market power and cost efficiency through variation of concentration on price. The first statement in the right side is the effect of market power which is obviously positively related to CV and negatively to the elasticity of demand. Also the next statement is the effect of cost efficiency that is derived from the cost function and shows the positive relevance to supply and the price of input factors. Table 2 separately depicts the effects of each one on price.

Here, some descriptive statistics about the variables of the model are shown in table 3.

Table 3. *descriptive statistics and normality test of the variables*

Variable	Mean	Medium	Maximum	Minimum	Jarque-Bera
P	85.54	46.8	220	87.2	69.12 (0.00)
HEL	2627.61	1275.5	12352	145.64	35.86 (0.00)
P_L	8.07E+11	3.7E+11	7.1E+11	59.95	477.86 (0.00)
P_K	8.36E-05	6.8E-06	0.0007	1.6E-08	188.89 (0.00)
U_L	1.4E+25	1.8E+23	3.8E+26	1.2E+20	2042 (0.00)
U_K	1.6E+09	17597	2.8E+10	221.48	1114.7 (0.00)
PEK	5944.2	2171.2	57854	33.12	545.5 (0.00)

The Jarque-Bera statistics is completely significant at all levels and for all variables, hence all the variables are normally distributed.

1.5. Data

The main model of interest as well as cost efficiency and market power effects are estimated with panel data. The data gathered from the central bank and statistical center of Iran which applied in 10 industries with data at 4-digit ISIC level.

The main model includes one endogenous variable, P which denotes price index of each industry, and six exogenous variables which are listed below:

Table 4. *The variables which are used is estimating model*

Variable	Notation of
P	Price index
HEL	Herfindahl concentration index assign to price elasticity of demand (HHI/elasticity) [3]
P_L	price of labor or wage
P_K	price of capital (Profit/K)
U_L	2HQ(p_L)
U_K	2HQ(p_K)
PEK	(p_l*p_k)^1/2

[3] Data for price elasticity of demand is acquired exogenously from some researches about estimating the demand function.

1.6. Estimation Results

The model which has been implemented to investigate the collusion is based on Azzam [3] that formularized material-input margin and then has been used to formularize the supply relation (Azzam and Rosenbaum, [4]).

The model to be estimated is

$$p = (1+\Theta)\frac{H}{\eta} + \sum_i \sum_j \alpha_{ij}(w_i w_j)^{\frac{1}{2}} + 2HQ\sum_i \beta_i w_i$$

$$i = L\ , j = K$$

Where the model for empirical research with two inputs (labor and capital), would be

$$p = (1+\Theta_n)\frac{H}{\eta} + \alpha_1 P_L + \alpha_2 P_K + \alpha_3 (P_L * P_K)^{\frac{1}{2}}$$
$$+2HQ(\beta_1 P_L) + 2HQ(\beta_2 P_K) \qquad (7)$$
$$n = 1,2,\dots,10$$

1.7. Test For Fixed or Random Effects

The essential point to mention is that because the model suffers from serial correlation and lack of observation, two way and random estimation cannot be used in result of the following reasons. At first, when there is serial correlation in model which is interpreted by R^2 and autoregressive process is implemented for remedy, two way estimation cannot be used. Second, two way estimation needs to have more coefficients than observation which in our study coefficients are less than observation.

So the results of fixed effect estimation is as follow

Table 1. *Fixed effect test*

Effects Test	Statistic	Probability
Cross-section F	8.997642	0.0000

Null hypothesis suggests that fixed effects are redundant. So based on estimation results, it cannot be rejected and hence, we have one-way estimation with cross-section effects only.

With respect to the computational equation 7 and the fixed and random test, the estimation results are summarized in table 4.

The effects of market power (*mp)* and cost efficiency (*ce*) and total effects (*te)* which are associated with concentration on price, are designated in table 2. Here are the descriptions of both effects in each industry which are presented separately.

Table 5. *Results of model 7 for the estimation period (1996-2009)*

Industry	Parameter	Estimate	Standard error	Range of CV ($-1 < \Theta < \frac{1}{H} - 1$)
	α_1	-4.23E-11	1.18E-12	-
	α_2	-15361.50*	7932.105	-
	α_3	0.002129	0.000213	-
	β_1	4.81E-25	1.49E-26	-
	β_2	-2.26E-09	1.78E-10	-
Oil	Θ_1	1.007	0.001471	-1 < 1.007 < 7.931
Dairy	Θ_2	1.326	0.028178	-1 < 1.326 < 20.283
Beverages	Θ_3	0.518	0.020820	-1 < 0.518 < 17.266
Clothing	Θ_4	0.985	0.001694	-1 < 0.985 < 36
Impression & publication	Θ_5	1.023	0.000846	-1 < 1.023 < 14.392
Chemical	Θ_6	1.004	0.000410	-1 < 1.004 < 5.757
Cement	Θ_7	-0.277	0.086877	-1 < -0.277 < 21.253
Steel	Θ_8	1.018	0.002729	-1 < 0.1.018 < 4.85
Appliances	Θ_9	0.907	0.017552	-1 < 0.907 < 18.45
Transportation	Θ_{10}	1.006	0.001758	-1 < 1.006 < 2.164
AR (1)		0.338058	0.094021	
AR (2)		0.514075	0.130036	
AR (3)		-0.174070**	0.072920	
R2	0.910226			
F-value	27.03764	(0.000)		
DW-value	1.897124			

* stands for statistically significance at 10%
** stands for statistically significance at 5%

1- Oil *mp*= -0.013 *ce*= 1.9 *te*= 1.9

ce is positive and much greater than *mp* so by increasing the concentration, the price will increase due to greater cost efficiency. On the other hand, if the firms want to have the greater margins, they should improve their production efficiency rather than trying to gain market power.

2- Dairy *mp*= -0.2 *ce*= 1.8 *te*= 1.6

Like oil industry, positive *ce* effect is much greater than negative *mp* effect, hence if concentration increases, cost efficiency will make the price increased.

3- Beverage *mp* = 0.3 *ce* = 0.8 *te* = 1.15

Both *mp* and *ce* effects are positive and on the whole when concentration increases, the firms may benefit from both market power and cost efficiency.

4- Apparel *mp* = 0.02 *ce* = 0.005 *te* = 0.03

As it is demonstrated, the *mp* effect is four times as great as *ce* effect. Hence, when the concentration rises, the firms will profit from *mp* four times bigger than *ce*.

5- Printing *mp* = -0.07 *ce* = 0.04 *te* = -0.03

In this industry, it is clear the net effect of *mp* is greater than *ce* and the *te* effect is negative. So the firms will not benefit from increasing concentration and in total the price will fall off.

6- Chemical *mp* = -0.02 *ce* = 2.7 *te* = 2.7

Chemical industry shows the significant difference with the ideal production efficiency. It means if concentration increases by 1%, the price will increases by 2.7% through efficiency of costs.

7- Cement *mp* = 1.5 *ce* = 8.1 *te* = 9.6

While the both effects are positive, the *ce* effect is about five times greater than *mp* effect. So, the production efficiency with increasing concentration will rise up the price more than market power.

8- Steel *mp* = -0.07 *ce* = 103 *te* = 103

A huge difference can be seen between *mp* and *ce* effect which means concentration-induced changes in cost efficiency is much more than market power (around 1471 times). So the firms in steel industry should investigate on improving the production efficiency than gaining more market power which decreases the price.

9- Appliance *mp* = 0.09 *ce* = 1.2 *te* = 1.2

Both effects in appliance industry are positive and will increase the price but with different scale. The price will be affected by concentration-induced changes in cost efficiency more than market power.

10- Transportation *mp* =-0.003 *ce* = 79 *te* = 78.9

The results show the big distinction of the effect of cost efficiency than market power on price when the concentration changes. As it can be seen the effect of mp is negative so the firms shall benefit from cost efficiency.

With a quick glance to each and total effects as well, it is clear that the cost efficiency effect is higher than market power effect for all the industries surveyed and total effect is also positive which indicates that when concentration increases, the price will rise up in terms of accumulation of both effects.

Also table 4 shows the estimated coefficients of model 7. A quick glance at the results reveals that all the parameters are statistically significant at 10%. The most important coefficients are Θ which for all the industries are completely significant at all levels. As discussed before, Θ or the conjectural variation is the change in the other firm supply in reaction to the change in firm i supply. Also as mentioned earlier, on a scale of -1 to $\frac{1}{H} - 1$, the behavior of

the market differs from perfect competition to monopoly. If the CV equals to -1, no collusion exists and if CV equals to $\frac{1}{H} - 1$, the perfect collusion can be seen; there is one or more firms that act as a single firm.

The results suggest that except cement and beverage industries with CV about -0.27 and 0.51 which show slightly competitive behavior, other 8 industries to some extent show collusive behavior among the firms.

It is managed to tests for autocorrelation by using the Durbin-Watson statistics (DW). Table 4 shows the model with third autocorrelation. The Durbin-Watson statistics is a test for first-order serial correlation. DW around 2 corresponds to having no serial correlation in the model. DW<2 will occur when there is a positive serial correlation and if DW>2, a negative serial correlation will be seen.

As mentioned above, fit of the model is very tight; however, if the model suffers from serial correlation, the estimated coefficients will be biased and incompatible. DW equals to 1.15, hence it is clear that there is a serious problem with the specification of the model. No variable can be removed or added to this model because it was approved and used in some empirical research. In order to get away from this problem, third order of autoregressive models have been used.

The other interest in this research is market power. Azzam and Pagoulatos [5] call oligopoly power as a price distortion which is designated as Lerner index, $L = \Theta/\eta$. Lerner index is estimated for the selected industries and the results are shown in table 1. It is obvious that the cement and chemical industries have the least and the most market power, respectively. By comparing table 1 and table 4, except dairy, chemical, and transportation industries which has considerably different in market power and conjectural variation, in other industries, a corresponding relation can be interpreted.

R-squared statistics measure the potency of the regression in explaining the dependent variable. Here R^2 is 0.91 which is highly close to 1 that means a well-defined estimation.

Also F statistics show the perfect significance of the complete model.

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