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Oligopsony/Oligopoly Power and Factor Market Performance

Yang-Ming Chang

Kansas State University, Manhattan, KS, USA

and

Victor J. Tremblay

Oregon State University, Corvallis, OR, USA

This paper is concerned with the economic performance of factor markets in an oligopsony/oligopoly setting. Firm and industry indexes are developed to measure factor market price distortions caused by exerted oligopsony/oligopoly power. These measures indicate that the elasticity of output demand, the elasticity of input supply, and the input and output conjectural elasticities determine the degree of non-competitive performance in factor markets. It is also shown that under special conditions the firm index equals the Lerner index and the industry index equals the Herfindahl–Hirschman index.

INTRODUCTION

Compared to output markets, relatively little research has been done on the economic performance of factor markets under imperfect competition.[1] Furthermore, the research that has been done has been primarily empirical. For example, Just and Chern (1980) examined the degree of oligopsony power in the tomato-processing industry and rejected the hypothesis that tomato processors behave competitively in the market for raw tomatoes. Booton and Lane (1985) found empirical support for the hypothesis that the wages of registered nurses are suppressed by the monopsony power of hospitals. Finally, Schroeter's (1988) empirical results reveal significant input price distortions in the oligopsonistic wholesale beef market.

The purpose of this paper is to theoretically analyze the economic performance of factor markets. Since, as Robinson (1934, p. 227) has stated, 'The most important cases of monopsony will occur in connection with monopoly', we consider a general model where firms can possess market power in the input market, the output market, or both markets. First, we use a conjectural variation approach to develop a firm index of oligopsony/oligopoly power that measures the extent to which an input price actually paid by a firm deviates from the value of the factor's marginal product.[2] From this firm measure we derive an index of aggregate oligopsony/oligopoly power for a factor market as a whole. Given familiar sets of assumptions, our firm index reduces to the Lerner index and our industry index reduces to the Herfindahl–Hirschman index.

FACTOR MARKET PERFORMANCE INDEXES UNDER OLIGOPSONY/OLIGOPOLY

A Firm Index

Consider an industry in which there are N firms ($i = 1, 2, 3, \ldots, N$) producing a homogeneous product. The inverse market demand function is given by

$$p = p(Q) \tag{1}$$

where $Q = \Sigma q_i$ is industry output and q_i is the output of the ith firm. Assume N is sufficiently small and entry is blocked so that non-competitive behavior in the output market is possible.

On the production side each firm uses physical capital, k_i, that is purchased from a competitive capital market. In addition, each firm requires the use of a specific factor, x_i. For instance, this input may represent baseball players to professional baseball teams or cattle to beef processors. In the market

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for the specific factor, however, non-competitive buyer behavior is possible.[3] In this case, the inverse market supply of the specific factor is given by

$$w = h(X) \tag{2}$$

where X is the total supply of the specific factor and w is the per unit price of X. Further, dw/dX is assumed to be positive, and N is assumed to be sufficiently small so that each firm can influence the price of this factor. Finally, the ith firm's production function is

$$q_i = f_i(x_i, k_i) \tag{3}$$

and is assumed to be strictly concave and continuously twice differentiable.

The problem of the ith firm then is to choose x_i and k_i in order to maximize the firm's profit function given by

$$\pi_i = p(Q)q_i - h(X)x_i - rk_i \tag{4}$$

where π_i is the ith firm's profits and r is the rental rate of capital. The first-order necessary conditions are:

$$(\mathrm{d}p/\mathrm{d}Q)(\mathrm{d}Q/\mathrm{d}q_i)(\partial q_i/\partial x_i)q_i + p(\partial q_i/\partial x_i) - (\mathrm{d}w/\mathrm{d}X)(\mathrm{d}X/\mathrm{d}x_i)x_i - w = 0 \tag{5a}$$

$$(\mathrm{d}p/\mathrm{d}Q)(\mathrm{d}Q/\mathrm{d}q_i)(\partial q_i/\partial k_i)q_i + p(\partial q_i/\partial k_i) - r = 0 \tag{5b}$$

To measure input price distortions we concentrate on the market for the specific factor. We define the firm index of input price distortions as the difference between the value of the marginal product and the input price divided by the value of the marginal product.[4] The ith firm's index is derived from Eqn (5a) and is given as (see the Appendix for a proof)

$$I_i \equiv [p(MPx_i) - w]/[p(MPx_i)] = (\beta_i/\varepsilon + \alpha_i/\eta)/(1 + \beta_i/\varepsilon) \tag{6}$$

where

$MPx_i \equiv \partial q_i/\partial x_i$, the marginal product of the industry-specific factor of the ith firm,

$\eta \equiv -(\mathrm{d}Q/\mathrm{d}p)(p/Q)$, the price elasticity of demand in the output market,

$\alpha_i \equiv (\mathrm{d}Q/\mathrm{d}q_i)(q_i/Q)$, the ith firm's output conjectural (or perceived) elasticity with respect to total industry output,[5]

$\varepsilon \equiv (\mathrm{d}X/\mathrm{d}w)(w/X)$, the input price elasticity of market supply for the specific factor,

$\beta_i \equiv (\mathrm{d}X/\mathrm{d}x_i)(x_i/X)$, the ith firm's input conjectural elasticity with respect to the industry's total factor demand.

Because this index allows for non-competitive behavior in both the factor and output markets, it will be referred to as an oligopsony/oligopoly index. It directly reflects the allocative inefficiency due to market power by measuring the non-competitive rents acquired by the firm as a proportion of the value of the marginal product. It comes as no surprise that the index has two components: (β_i/ε) reflects the non-competitive performance in the input market and (α_i/η) reflects the non-competitive performance in the output market.

Because $p(MPx_i) \geqslant w \geqslant 0$, the value of I_i can range from 0 to 1. When the specific factor is paid the value of its marginal product, that is, $w = p(MPx_i)$, the factor market is allocatively efficient and $I_i = 0$; as the factor price is reduced and approaches 0, *ceteris paribus*, I_i approaches 1. Thus, greater inefficiency is implied by a higher value of I_i. Given that α_i and β_i are positive, the oligopsony/oligopoly index indicates that there will be greater inefficiency, *ceteris paribus*, (1) the lower the price elasticity of demand for output (η), (2) the lower the input price elasticity of supply of the specific factor (ε), (3) the higher the firm's conjectural elasticity with respect to industry output (α_i), and (4) the higher the firm's conjectural elasticity with respect to industry demand for the specific factor (β_i).

This oligopsony/oligopoly index is quite general since no restrictions are placed on the conjectural elasticities of the firm (i.e. they may range from perfectly competitive to collusive). For example, in the case of Cournot behavior in both the input and output markets, $\mathrm{d}X/\mathrm{d}x_i = 1$ and $\mathrm{d}Q/\mathrm{d}q_i = 1$.[6] As a result, β_i is the input market share and α_i the output market share of the ith firm.

Alternatively, consider the special situation where the output market is competitive and the specific factor market is imperfectly competitive. In this case $\alpha_i = 0$ (because $\mathrm{d}Q/\mathrm{d}q_i = 0$) and $0 < \beta_i \leqslant 1$. The firm index derived from Eqn (6) then reduces to the following oligopsony/competition index ($I_{o/c}$):

$$I_{o/c} = \beta_i/(\varepsilon + \beta_i) \tag{7}$$

In pure monopsony where there is just one input buyer, $x_i = X$ and therefore $\beta_i = 1$. In this case the index equals $1/(\varepsilon + 1)$. When both the output market and the input market are competitive, $\alpha_i = \beta_i = 0$

and the index equals 0 (indicating that the factor market is operating efficiently).

In the case of market power in the output market alone, $0<\alpha_i\leqslant 1$ and $\beta_i=0$. In this competition/oligopoly setting the index ($I_{c/o}$) becomes

$$I_{c/o}=\alpha_i/\eta \tag{8}$$

Finally, there is the classic case of monopsony/monopoly suggested by Robinson where $\beta_i=1$ for a monopsonist (because $x_i=X$) and $\alpha_i=1$ for a monopolist (because $q_i=Q$). In this situation the monopsony/monopoly index ($I_{m/m}$) equals

$$I_{m/m}=(1/\varepsilon+1/\eta)/(1+1/\varepsilon) \tag{9}$$

Although Lerner (1943, pp. 210–11) initially discusses both monopoly and monopsony power, he ultimately attempts 'to find the amount of monopoly revenue . . . so that there was no monopsony'. In Lerner's case of pure monopoly ($\alpha_i=1$) with no monopsony power ($\beta_i=0$) the index in Eqn (9) reduces to the well-known Lerner index, $1/\eta$.

An Industry Index

Next, an index of oligopsony/oligopoly power for the specific factor market as a whole (I^*) is developed. This aggregate index, which is derived from Eqn (6), is defined as

$$I^*=\Sigma\{[p(MPx_i)-w]/[p(MPx_i)]\}Sx_i=\Sigma I_i Sx_i \tag{10}$$

where $Sx_i=x_i/X$ (the input market share of firm i). This industry measure is a weighted average of each firm's index of power with input shares used for weights.

In the case of oligopsony/competition and given the definition of β_i, the industry index becomes

$$I^*_{o/c}=\Sigma u_i(Sx_i)^2 \tag{11}$$

where $u_i=(\mathrm{d}X/\mathrm{d}x_i)/(\varepsilon+\beta_i)$. If the input conjectural variations are constant and the same for all firms, then u_i is identical for all firms and the industry index is proportional to the Herfindahl–Hirschman index of the input market $[\Sigma(Sx_i)^2]$.[7] In the special case where $u_i=1$, the industry index equals the input market Herfindahl–Hirschman index.[8]

Finally, when the focus is on output market power as in a competition/oligopoly setting, it may be convenient to change the weights from input to output market shares and define the industry index as

$$I^*_{c/o}=\Sigma\{[p(MPx_i)-w]/[p(MPx_i)]\}Sq_i$$
$$=\Sigma v_i(Sq_i)^2 \tag{12}$$

where $v_i=(\mathrm{d}Q/\mathrm{d}q_i)/\eta$ and $Sq_i=q_i/Q$ (the output market share of firm i). When all firms have constant and identical conjectural variations, then v_i is the same for all firms and the industry index is proportional to the Herfindahl–Hirschman index of the output market $[\Sigma(Sq_i)^2]$. If $v_i=1$, then the industry index equals the output market Herfindahl–Hirschman index.

Index Implementation

An important use of this index is to assess the degree of oligopsony and oligopoly power in a factor market. This can be accomplished, for example, by collecting the appropriate data and first estimating the following production, output market demand, and input market supply functions:[9]

$$q_i=f_i(x_i,\mathbf{Z}_1) \tag{13}$$

$$p=p(Q,\mathbf{Z}_2) \tag{14}$$

$$w=h(X,\mathbf{Z}_3) \tag{15}$$

where $\mathbf{Z}_1$, $\mathbf{Z}_2$, and $\mathbf{Z}_3$ are vectors of relevant exogenous variables.[10] These empirical results can then be used to produce estimates of the marginal product of input x ($\partial q_i/\partial x_i$), the slope of the demand function in the output market ($\partial p/\partial Q$), and the slope of the supply function in the factor market ($\partial w/\partial X$).

Given the estimated values from above and defining $\theta_2\equiv\alpha_i(Q/q_i)$ and $\theta_3\equiv\beta_i(X/x_i)$, the following rearranged version of Eqn (5a) can then be estimated:

$$w=\theta_1[p(\partial q_i/\partial x_i)]+\theta_2[(\partial p/\partial Q)$$
$$\times(\partial q_i/\partial x_i)q_i]-\theta_3[(\partial w/\partial X)x_i] \tag{16}$$

where θ_1, θ_2, and θ_3 are unknown parameters.[11] Because $\alpha_i=\theta_2(q_i/Q)$ and $\beta_i=\theta_3(x_i/X)$, the degree of oligopsony and oligopoly price distortions can be determined. For example, the hypothesis that input price distortions are present is rejected if $\theta_1=1$ and $\theta_2=\theta_3=0$. This result indicates that the market is operating efficiently because the factor price equals the value of the marginal product. Significant positive values of θ_2 and θ_3 indicate the presence of oligopoly and oligopsony power, respectively. Finally, the degree of input price distortion at the firm level can be calculated by inserting the data into the index in Eqn (6). This information, along with the data on firm market share, can also be used to calculate the degree of average input price distortion at the industry level from Eqn (10).

CONCLUSIONS

This paper draws on the theory of oligopsony and oligopoly to analyze factor market distortions caused by market power in the input market, the output market, or both markets. Indexes capable of measuring exerted oligopsony/oligopoly power at the firm and industry levels are developed, and empirical implementation of the indexes is discussed. These measures indicate that the elasticity of output demand, the elasticity of input supply, and the input and output conjectural elasticities determine the degree of non-competitive performance in factor markets. It is also shown that under special conditions the firm oligopsony/oligopoly index is identical to the Lerner index and the industry oligopsony/oligopoly index is identical to the Herfindahl–Hirschman index.

APPENDIX

A formal derivation of Eqn (6) is as follows. First, Eqn (5a) can be rearranged as

$$\begin{aligned}&[(\mathrm{d}p/\mathrm{d}Q)(Q/p)][(\mathrm{d}Q/\mathrm{d}q_i)(q_i/Q)][p(\partial q_i/\partial x_i)]\\&+[p(\partial q_i/\partial x_i)]=[(\mathrm{d}w/\mathrm{d}X)(X/w)]\\&\times[(\mathrm{d}X/\mathrm{d}x_i)(x_i/X)]w+w \qquad \text{(A1)}\end{aligned}$$

Factoring out $p(\partial q_i/\partial x_i)$ from the left-hand side and w from the right-hand side of the equality in Eqn (A1) gives

$$\begin{aligned}&p(\partial q_i/\partial x_i)\{1+[(\mathrm{d}p/\mathrm{d}Q)(Q/p)][(\mathrm{d}Q/\mathrm{d}q_i)\\&\times(q_i/Q)]\}=w\{1+[(\mathrm{d}w/\mathrm{d}X)(X/w)]\\&\times[(\mathrm{d}X/\mathrm{d}x_i)(x_i/X)]\} \qquad \text{(A2)}\end{aligned}$$

By substituting the definitions from the text, Eqn (A2) can be written as

$$p(MPx_i)(1-\alpha_i/\eta)=w(1+\beta_i/\varepsilon) \qquad \text{(A3)}$$

which implies that

$$w/[p(MPx_i)]=(1-\alpha_i/\eta)/(1+\beta_i/\varepsilon) \qquad \text{(A4)}$$

Multiplying both sides of the equality by -1 and adding $[p(MPx_i)]/[p(MPx_i)]$ to both sides of the equality in Eqn (A4) gives

$$\begin{aligned}&[p(MPx_i)]/[p(MPx_i)]-w/[p(MPx_i)]\\&\quad=1-(1-\alpha_i/\eta)/(1+(\beta_i/\varepsilon)) \qquad \text{(A5)}\end{aligned}$$

Simplification and rearranging terms yields

$$\begin{aligned}&[p(MPx_i)-w]/[p(MPx_i)]\\&\quad=(\beta_i/\varepsilon+\alpha_i/\eta)/(1+\beta_i/\varepsilon) \qquad \text{(A6)}\end{aligned}$$

which is Eqn (6). QED

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NOTES

1. See Scherer and Ross (1990) for a survey and Dansby and Willig (1979), Appelbaum (1982), Kamien and Schwartz (1983), and Daughety (1985) for a discussion of imperfectly competitive output markets.
2. Although Schroeter developed a measure of monopsony power, it applies only to the special case where the production technology is characterized by fixed proportions between the quantity of output (dressed beef carcasses in his study) and the quantity of the monopsonistically demanded input (live beef).
3. Input market sellers are assumed to have no market power. This assumption is certainly realistic for many raw materials suppliers (e.g. tomato farmers and cattle ranchers), but even the monopsony power in labor markets has not always generated effective collective bargaining power for labor. For example, Booton and Lane (1985, p. 185) argue that monopsony power in nursing exists in the absence of widespread unionization. Dworkin's (1981) account of professional baseball in the USA indicates that union power was, until recently, so weak that the reserve clause (making each player the property of one team) existed for almost 90 years before the first collective bargaining contract.
4. This approach is similar to that developed by Lerner (1932), who defined the index of monopoly price distortions as the difference between the (output) price and marginal cost divided by the price.
5. See Dickson (1981) and Appelbaum (1982) for a discussion of conjectural elasticities with respect to output markets.
6. Daughety (1985) has shown that the Cournot equilibrium is also a 'consistent conjectural variation' equilibrium.
7. If, for example, all firms have the same objective function, face the same cost function, and produce a homogeneous product, then in equilibrium their conjectural variations must also be the same.

8. If the input shares are the same for all firms, the input Herfindahl–Hirschman index equals $1/N$, the same property that holds for the output Herfindahl–Hirschman index when output shares are equal.
9. Alternatively, a cost or profit function could be estimated and used to derive the production function (McFadden, 1978).
10. To estimate this system, functional forms must be chosen, the variables in $\mathbf{Z}_1$, $\mathbf{Z}_2$, and $\mathbf{Z}_3$ must be identified, and firm and market data must be obtained.
11. The bracketed terms are regressors, containing exogenous and predicted variables. See Murphy and Topel (1985) for a method of obtaining asymptotically correct standard errors when estimating an equation with predicted variables.

REFERENCES

E. Appelbaum (1982). The estimation of the degree of oligopoly power. *Journal of Econometrics* **19**, August, 287–99.

L. A. Booton and J. I. Lane (1985). Hospital market structure and the return to nursing education. *Journal of Human Resources* **20**, 2, Spring, 184–96.

K. Cowling and M. Waterson (1976). Price-cost margins and market structure. *Economica* **43**, August, 267–74.

R. E. Dansby and R. D. Willig (1979). Industry performance gradient indexes. *American Economic Review* **69**, 3, June, 249–60.

A. F. Daughety (1985). Reconsidering Cournot: the Cournot equilibrium is consistent. *Rand Journal of Economics* **16**, 3, Autumn, 368–79.

V. A. Dickson (1981). Conjectural variation elasticities and concentration. *Economics Letters* **7**, 281–5.

J. B. Dworkin (1981). *Owners versus Players: Baseball and Collective Bargaining*, Boston, MA: Auburn House.

R. E. Just and W. S. Chern (1980). Tomatoes, technology, and oligopsony. *Bell Journal of Economics* **11**, 2, Autumn, 584–602.

M. I. Kamien and N. I. Schwartz (1983). Conjectural variations. *Canadian Journal of Economics* **16**, 2, May, 191–211.

A. P. Lerner (1971). The concept of monopoly and the measurement of monopoly power. In *Readings in Microeconomics*, 2nd edn (edited by W. Breit and H. M. Hochman), New York: Holt, Rinehart, and Winston, pp. 207–23.

D. McFadden (1978). Cost, revenue, and profit functions. In *Production Economics: A Dual Approach to Theory and Applications* (edited by M. Fuss and D. McFadden), Amsterdam: North-Holland.

K. M. Murphy and R. H. Topel (1985). Estimation and inference in two-step econometric models. *Journal of Business and Economic Statistics* **3**, 4, October, 370–79.

J. Robinson (1934). *The Economics of Imperfect Competition*, London: Macmillan.

F. M. Scherer and D. Ross (1990). *Industrial Market Structure and Economic Performance*, 3rd edn, Boston, MA: Houghton Mifflin.

J. R. Schroeter (1988). Estimating the degree of market power in the beef packing industry. *Review of Economics and Statistics* **70**, 1, February, 158–62.