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INFERENCE OF OLIGOPOLY
POWER WITH LIMITED DATA:
MANUFACTURING IN MOROCCO

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Abstract

Researchers' enthusiasm for estimating industry oligopoly power in developing countries is often not matched with availability of data. Even when available, datasets are often incomplete, inconsistent, too aggregated, and almost always collected by government agencies for purposes different from those of the researcher. This paper demonstrates how some of the theoretical restrictions implied by firm optimizing behavior can be used to specify and make inference about market power in a conjectural elasticity model when data availability is a problem. For illustration, we specify and make inference of market power in an empirical model of 7 manufacturing industries in Morocco. The model requires observations on only two variables likely to be found in most industry statistics collected for tax purposes by governments in developing countries: Sales revenue and payroll.

ملخص

1. Introduction

Researchers' enthusiasm for estimating industry oligopoly power in developing countries is often not matched with availability of data. Even when available, the data is often incomplete, inconsistent, too aggregated and almost always collected by government agencies for purposes different from those of the researcher. As a consequence, a researcher addressing the issue of oligopoly power has five options: 1) ignore the issue, 2) conduct a descriptive industry study, 3) develop an elaborate structural econometric oligopoly model and strip it to suit available data, 4) estimate *ad hoc* regressions using available data, or 5) address the issue by generating theoretical predictions from a stylized theoretical model of oligopoly. None of the options delivers estimates based on explicit theoretical restrictions implied by optimizing behavior of imperfectly-competitive firms.

An alternative option, which this paper suggests, is to use the theoretical restrictions implied by firm optimizing behavior to specify and make inference about market power in a conjectural elasticity (CE) model when data availability is a problem. The novel feature of the model is that it is empirically implemented with observations on only two variables likely to be found in most industry statistics collected for tax purposes by governments in developing countries: Sales revenue and payroll (the wage bill). Inference with only two variables is possible through structural econometric modeling – the hallmark of what is known as the New Empirical Industrial Organization (NEIO) (Bresnahan, 1989). A structural model is any theory-driven model that “provides a behavioral interpretation for some or all the parameters,” (Reiss and Wolak, 2003). The two sources of “structure” in structural econometric modeling are economic theory, which delivers deterministic mathematical relationships between economic variables, and statistics, which defines the stochastic assumptions between the economic variables (Reiss and Wolak, 2002).

For illustration, we use data from the manufacturing sector in Morocco. There, as in numerous developing countries, the problem of data availability usually disables empirical analysis of industries.¹ The source of the Moroccan data is a 2000 manufacturing survey (MIC, 2001). The dataset contains information on revenue from domestic sales and export sales, and the wage bill for each firm with more than 10 employees in 7 Moroccan industries (Food and Beverages, Textiles, Wearing Apparels, Chemicals, Wood and Wood Products, Fabricated Metal and Machinery (except Electrical)) by region. Food and Beverages and Wearing Apparels are by far the most important industries in the country. Together they represent more than 50% of the manufacturing sector's employment and exports (Table 1).

The rest of the paper is organized as follows. The next section sketches out a mainstream structural econometric CE model that can be estimated when data availability is not an issue. The idea behind the section is to show the analytical steps necessary to construct a structural model and, thereby, determine the required data for estimating the model. Section 3 shows how similar analytical steps can be used to specify and make inference in a structural model when only data on sales revenue and the wage bill are available. Section 4 presents and discusses the empirical findings. Summary and conclusions are in the final section.

2. Structure of a Mainstream NEIO CE Model

In general, a typical NEIO CE model has four theoretical building blocks: Market demand, firm marginal cost, conditional demand for factor inputs, and strategic interdependence between the firm and its rivals (Appelbaum, 1982). Appelbaum's model is a perfect illustration of how the three theoretical building blocks are put together to deliver mathematical relationships between economic variables, and how the stochastic assumptions about the relationships between the economic variables permit inference of oligopoly power.

¹ In 2000, Morocco adopted a competition law that formally entered into force in 2001 (IFLR). Assessment of competitive behavior of industries is now in high demand but little data exists to meet that demand.

The theoretical setting is a homogeneous single-product oligopoly consisting of s firms indexed $j=1, 2, \dots, s$, each producing output y^j . Firms face market demand

$$y = J(p, z) \quad (1)$$

where $y = \sum_{j=1}^s y^j$ is industry output, p is output price, and z is a vector of prices of substitutes and income. Each firm has a cost function $C^j(y^j, w)$, where $w = (w_1, w_2, \dots, w_n)$ is a vector of input prices.

Denoting the j^{th} firm's employment of the i^{th} input by x_i^j , conditional inputs demand from Shepherd's lemma are given by

$$x_i^j = \frac{\partial C^j(y^j, w)}{\partial w_i} \quad \text{for } i=1, 2, \dots, n; \quad j=1, 2, \dots, s \quad (2)$$

Assuming profit-maximizing behavior, the supply relation (or optimality condition) of each firm is

$$p(1 - (\theta^j / \eta)) = \frac{\partial C^j}{\partial y^j}(y^j, w) \quad j=1, 2, \dots, s \quad (3)$$

where $\eta = -\frac{\partial J}{\partial p} \frac{p}{y}$ is the price elasticity of market demand (Equation 1), and $\theta^j = \frac{\partial y}{\partial y^j} \frac{y^j}{y}$ is the conjectural elasticity. The left-hand side of Equation 3 is marginal revenue, and the right-hand side is marginal cost.

Equations 1, 2, and 3 constitute a structural model that is in general form and deterministic. To transform the model into explicit form, functional forms for market demand $y = J(p, z)$ and the cost function $C^j(y^j, w)$ are needed. In Appelbaum (1982), demand is specified in double-log, and the cost function is specified as a Generalized Leontief.

To transform the model into an econometric model, it must be embedded with stochastic assumptions about how the data was generated. The most common approach is to append errors to each of the deterministic equations in the system and assume the error data generation process is multivariate normal. As for the source of errors, they are either random deviations from the firm's optimal choice of inputs, failure of firms to optimize, or unaccounted for output demand shifts (Hazilla, 1991). The least common in structural modeling is to introduce stochastic errors from the starting point and allow, for example, for unobserved differences in the firms' cost functions. Ultimately, where a stochastic error belongs depends on whether the researcher assumes firms do or do not observe what he/she cannot observe (Reiss and Wolak, p.9).

Assuming the simple case where error arise from optimizing behavior and random shifts in the output demand, and each variable having t time series observations, the structural econometric model, consisting of the stochastic versions of Equation 1, 2, and 3, can be written more compactly as

$$F_k(y_t, x_t, \beta_k) = \varepsilon_{kt} \quad \text{for } k=1, 2, \dots, M \text{ and } t=1, 2, \dots, T \quad (4)$$

and estimated jointly. Expression 4 represents a real valued function where M vectors of multivariate responses y_t (endogenous variables in the system), determined by k -dimensional exogenous variables, β_k is k -dimensional vector of unknown parameters, and ε_{kt} are the stochastic errors (Gallant, 1987).

Once Equations 1, 2, and 3 are jointly estimated, inference about market power is made by testing for the statistical significance of the CE, θ^j , if firm-level data are available through time, or an industry weighted CE if only aggregate industry data are available. If the CE

estimate turns out to be not statistically different from zero, then price is equal to marginal cost implying price-taking behavior.

In most cases, Equations 1, 2, and 3 are estimated at the aggregate industry level because of unavailability of data at the firm level. Even then, the data requirements are not trivial. Assuming firms use only two factor inputs, and output demand is a function of own price, the price of one substitute, and income, one needs time series observations on 8 variables: 2 factor inputs, 2 factor prices, output, output price, price of substitute, and income.

Now suppose, as in our particular case, one only has information only on sales and payroll across firms by industry. Can one specify and make inference about oligopoly power subject to the restrictions implied by optimizing behavior? We address the question in the next section.

3. Inference of Oligopoly Power from Sales and Payroll Data

The starting point of the empirical model is as follows. Each firm within each of the 7 sectors has the choice of selling in the domestic and the export market. Allocation of output between the two markets is made to maximize profits:²

$$\max_{w.r.t. y, x} (P_y - c)y + (P_x - c)x - f \quad (5)$$

where

y = firm output for domestic consumption

x = firm output for exports

P_y = domestic market price

P_x = export market price

c = average cost of producing a unit of y and x

f = fixed costs.

In general, if a firm exerts market power in the domestic as well as the export market, that firm's first-order conditions can be written as

$$(P_y - c)y = -\frac{\theta_y P_y y}{\eta_y}, \quad (6)$$

and

$$(P_x - c)x = -\frac{\theta_x P_x x}{\eta_x}, \quad (7)$$

where, as in Appelbaum (1982), $\theta_y = \frac{\partial y}{\partial Y} \frac{Y}{y}$ and $\theta_x = \frac{\partial x}{\partial X} \frac{X}{x}$ are the firm's respective conjectural elasticities in the domestic and export market; $\eta_y = \frac{\partial Y}{\partial P_y} \frac{P_y}{Y} < 0$ and

² Although there is no superscript j to refer to the firm, as in Appelbaum (1982), it is understood that the unit of observation is the firm.

$\eta_x = \frac{\partial X}{\partial P_x} \frac{P_x}{X} < 0$ are the respective price elasticities of demand in the domestic and export markets, and Y and X are the respective industry-wide domestic and export sales. The theoretical benchmark for the conjectural elasticities ranges from zero to one, with zero for a price-taking firm and 1 for monopoly (collusive) pricing. The negative of the ratio θ and η is the Lerner index of oligopoly power.

Assuming Moroccan firms are price-takers in the export market,³ we set the conjectural elasticity in the export market to zero. Substitution from the first-order conditions into Equation 5 allows us to re-write profits as:

$$\pi + f = (P_y - c)y + (P_x - c)x = -\frac{\theta_y P_y y}{\eta_y} \quad (8)$$

In words, a firm's surplus (profits plus fixed cost) is equal to the oligopoly distortion. If the firm has no market power, i.e., $\theta_y / \eta_y = 0$, then its surplus is zero.

Denote the labor wage by w , labor by l , and the price of capital by r , the quantity of non-labor inputs by z , and rewrite total variable cost as follows

$$c(y + x) = (wl + rz) \quad (9)$$

Next, let

$$v = P_y y + P_x x$$

denote total revenue from domestic and export sales, and re-write Equation 8 as

$$\left(\frac{v - wl - rz}{v} \right) = -\frac{\theta_y}{\eta_y} \frac{P_y y}{v} \quad (10)$$

or

$$1 - \frac{wl}{v} = \frac{rz}{v} - \frac{\theta_y}{\eta_y} \frac{P_y y}{v} \quad (11)$$

As stated at the outset, the Moroccan manufacturing data base has v (revenue from domestic sales and export sales) and wl (the wage bill) for individual firms for 7 industries. So, the empirical task is to make inference about the non-labor cost variable (rz) in addition to making inference about the price elasticity of industry demand (η_y) and the conjectural elasticity (θ_y) parameters.

To proceed, we first re-write Equation 11 as

$$Y = \alpha V + \beta R_d, \quad (12)$$

where

$$Y = 1 - \frac{wl}{v}$$

$$\alpha = rz,$$

³This assumption is valid for a small country like Morocco and is corroborated by findings in Achy and Sekkat (2003).

$$V = \frac{1}{v},$$

$$\beta = -\frac{\theta_y}{\eta_y}, \text{ and}$$

$$R_d = \frac{P_y y}{v}.$$

So, the unknowns for each firm are α , which stands for non-labor costs, and β , which represents the index of market power. The observables are Y , V , and R_d . If time-series data on the three observables are available for each firm across industries, the unknowns could be estimated for each firm. Since they are not available in our case, Equation 12 must be estimated using observations on a cross section of firms within each industry.

Cross section estimation, however, implies that both the index of market power and non-labor cost are the same across firms. While an identical index of market power is defensible and has often been invoked in the literature (Bresnahan, 1989), the assumption of identical non-labor cost is unrealistic: unequally-sized firms are not expected to have the same level of non-labor cost. To account for different non-labor cost we embed the model with an intercept μ to capture the average share of non-labor cost in the industry. This yields the estimating model

$$Y = \mu + \alpha V + \beta R_d + \varepsilon \quad (13)$$

where ε is a stochastic error, attributed to errors in optimization. The means and standard deviations of Y , V , and R_d for each industry are in Table 2.

4. Empirical Results

Equation 13 is estimated using firm-level data from the Moroccan 2000 manufacturing survey which provides data on the three variables for each firm with more than 10 employees or sales revenue of more than 10,000 Dirhams. Given the low threshold for employment and sales revenue, the survey covers almost all firms in a given industry. Because of the endogeneity of the revenue share R_d , the equation is estimated using two-stage least squares (2SLS) with the familiar White's correction for heteroskedasticity. The exogenous variables used in the first stage are firm's age, sector dummies, and region dummies.

The 2SLS parameter estimates are reported in Table 3. The estimate of the constant μ is less than 1, as to be expected, and is statistically significant for all seven industries. The estimate of α is negative and statistically significant at the 5 percent level or less in the four most important industries, namely Food and Beverages, Textiles, Wearing, and Chemicals. Since α is the coefficient of the inverse of V , an increase in V can be taken as a decrease in the size of the firm, assuming sales and size are positively related; it follows that the share of non-labor inputs increases with firm size. This is not surprising since small firms in Morocco have less access to finance and tend to be more labor-intensive compared to large firms.

The estimate of β , the index of market power is of the correct sign and statistically significant at least at the 5 percent level for Food and Beverages, Textiles, Wood, and Fabricated Metal Products. For these industries, we fail to accept the null hypothesis of price-taking behavior. In other words those industries seem to exert some market power when selling domestically. The question is how much market power?

To answer that question, note that, in theory, β measures the Lerner index of market power, or the gap between price and marginal cost as a percent of price, meaning $\beta = (P_y - c) / P_y$ as can be deduced from Equation 6. The Lerner index implies that the ratio of price to marginal cost can be written as $P_y / c = 1 / (1 - \beta)$. For the latter ratio to make economic sense β must be greater or equal to zero and strictly less than 1. Obviously, all the point estimates of β that are statistically significant (Table 3) are larger than one and, therefore, not consistent with the restriction implied by the Lerner index. However, the 95% percent confidence interval of β for Food and Beverages, Textiles, and Wood Products, and Fabricated Metals Products industries does contain a subset of values that meet the restriction (Table 3).

To bias the results in favor of price-taking behavior by the three industries, we use the theoretically acceptable lower limit of the confidence intervals for the industries' respective β 's and calculate the ratio of price to marginal cost. What we find is that the ratios for the four industries are respectively, 1.0, 3.6, 1.2, and 10. This means that Fabricated Metals exerts the highest market power, followed by Textiles, and Woods Products. The Food and Beverage industry, on the other hand, does not exert market power. It also means that the three noncompetitive industries' respective oligopoly rents as a proportion of total sales, as represented by Equation 4, are approximately 88%, 55%, and 17%. Interestingly, with the exception of the Food and Beverage Industries, the findings of market power in the three industries are in concordance with those of Achy and Sekkat (2007) who used data at the sector level and applied "a nominal Solow residuals" approach a la Roeger (1995). The approach, however, necessitates the construction of capital stock for each sector and is error prone.

5. Summary and Conclusion

Recognizing that structural analysis of competitive behavior of firms and industries is often hampered by unavailability of data in developing countries, this paper demonstrates how to use the theoretical restrictions implied by firm optimizing behavior to specify and make inference about market power in an empirical model when data availability is a problem. The novel feature of the model is that it is empirically implemented with observations on only two variables likely to be found in most industry statistics collected for tax purposes by governments in developing countries: Sales revenue and payroll.

For an application, data from the manufacturing sector in Morocco are used. There, as in numerous developing countries, the problem of data availability usually disables empirical analysis of competitive behavior. Such analysis becomes crucial as Morocco and other developing countries are increasingly adopting competition policies and need to develop a research infrastructure in empirical industrial organization to support those policies.

Competitive behavior is tested in 7 industries: Food and Beverages, Textiles, Wearing Apparels, Chemicals, Wood and Wood Products, Fabricated Metal and Machinery (except Electrical). We find evidence of market power in Fabricated Metals, Textiles, and Wood.

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Table 1: Shares in Total Manufacturing

Variable	Food& Beverages	Textiles	Wearing Apparel	Wood	Chemicals	Metal Products	Machinery except Electrical
Employment	19.44	8.06	34.60	1.94	6.29	4.56	0.98
Value added	23.0	5.10	11.66	1.14	13.97	3.51	0.81
Exports	17.41	2.10	40.47	0.72	14.50	0.76	0.96

Table 2: Means and Standard Deviations

Variable	Food& Beverages	Textiles	Clothin g	Wood	Chemicals	Metal Products	Machinery except electrical
Y							
Mean	0.810	0.726	0.600	0.772	0.831	0.691	0.663
Std.Dev	0.316	0.328	0.283	0.221	0.189	0.373	0.986
V							
Mean	0.0018	0.0013	0.0011	0.0032	0.0007	0.0031	0.0026
Std.Dev	0.0053	0.0045	0.0032	0.0081	0.0029	0.0191	0.0078
R_d							
Mean	0.873	0.762	0.347	0.949	0.922	0.980	0.956
Std.Dev	0.315	0.394	0.453	0.198	0.28	0.107	0.177

Table 3: Estimation Results

Co-efficient	Food & Beverages	Textiles	Clothing	Wood	Chemicals	Metal Products	Machiner y except Electrical
Constant	0.88	0.79	0.62	0.80	0.85	0.71	0.88
<i>t</i> -statistics	78.46	53.70	70.34	40.65	60.35	29.36	9.59
α	-36.31	-54.20	-21.68	-8.23	-25.20	-9.26	-83.24
<i>t</i> -statistics	-6.33	-5.48	-5.49	-1.36	-2.37	1.09	-1.53
β	2.59*	4.15*	13.53	0.90*	0.74	4.38*	-0.38
<i>t</i> -statistics	1.93	2.37	1.80	2.45	1.61	2.47	-0.23
Con-fidence Interval:							
upper limit	1.522	7.58	na	0.18	na	7.86	na
lower limit	-0.04	0.72	na	0.18	na	0.90	na
N	1690	616	1077	363	191	749	153
Adj. R ²	0.39	0.57	0.07	0.09	0.15	0.23	0.43

*Statistically significant at the 5 percent level or less.

na =Not applicable.