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Testing for Monopsony Power in Multiple Input Markets: A Nonparametric Approach with Application to Cigarette Manufacturing

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Abstract

Monopsony power by cigarette manufacturers in procuring domestic and imported tobacco is investigated using a nonparametric method previously developed by Love and Shumway. Their test is extended to assess monopsony market power in multiple input markets. Results indicate that cigarette manufacturers exert significant monopsony power in the domestic tobacco market and exert little monopsony power in the international tobacco market.

Keywords: market power, tobacco, nonparametric, monopsony.

JEL Classification: L1.

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TESTING FOR MONOPSONY POWER IN MULTIPLE INPUT MARKETS: A NONPARAMETRIC APPROACH WITH APPLICATION TO CIGARETTE MANUFACTURING

The cigarette manufacturing industry has long been touted as an example of an imperfectly competitive industry. Given the high level of concentration that exists in this industry, monopoly power exertion by cigarette manufacturers is certainly plausible. In 1992, the industry contained only eight firms with the four largest firms supplying ninety-three percent of cigarette production (Census of Manufacturers). These concentration measures, coupled with characteristics of tobacco supply, also support the possibility of cigarette manufacturers exerting monopsony power in procuring domestic tobacco. In 1995, U.S. tobacco growers produced 1,268 million pounds of tobacco, 933 million pounds of which was sold domestically for the production of cigarettes (USDA). While there were over 350,000 tobacco quota owners in 1993 (USDA-ASCS), each has access to a very limited number of buyers for the product. Tobacco is also a highly specialized crop, in both production and use. According to Rogers and Sexton (1994), "...the relevant markets for raw agricultural products will typically be narrower with respect to both product class and geography than the markets for the finished products they produce"(p. 1143). The relatively inelastic supply of tobacco, due to the U.S. farm program supply restrictions, and high buyer concentration suggest the potential for monopsony market power exertion by cigarette manufacturers in the domestic market. The U.S. is also a relatively large buyer in the world tobacco market. In 1993, the U.S. purchased 21 percent of tobacco leaves sold on the world market (FAO), suggesting potential for monopsony power exertion in the international market as well. The recent inquiry of the Department of Justice (DOJ) into possible collusion by cigarette manufacturers in procuring imported tobacco makes this an appealing analysis as well.

In this study, we extend Love and Shumway's nonparametric monopsony power test to consider monopsony power in two input markets. The test is implemented using cigarette manufacturing industry data. Previous studies have considered monopoly power exertion by tobacco processors (Ashenfelter and Sullivan; Sullivan 1985; Sumner 1981), but cigarette manufacturers' potential monopsony power in procuring tobacco from domestic and international growers has received little attention[1]. While two-digit SIC level manufacturing data has been used to examine market power in the industry (e.g., Roeger 1995; Hall 1988), we conduct our analysis using more specific four-digit SIC code data. We incorporate costs of labor, advertising, capital, and materials.

This paper is organized as follows. We present a brief discussion of the U.S. tobacco program as a potential vehicle for monopsony market power exertion. Next, we follow Love and Shumway in developing the nonparametric test for monopsony market power exertion in a single input market. We extend their test to assess monopsony market power exertion in multiple input markets. We implement both tests to analyze cigarette manufacturers' potential monopsony power exertion in the domestic and international tobacco markets. Empirical results are followed by concluding remarks.

The U.S. Tobacco Program

It is generally assumed among economists that the U.S. tobacco program is designed to transfer income from tobacco buyers to domestic tobacco producers by allowing producers to reduce production to less than free market quantities, thus increasing the market price (Brown and Martin 1996; Brown 1995; Babcock and Foster 1992; Sumner and Wohlgenant 1985; Johnson and Norton 1983). However, this belief is predicated on the untested assumption that buyers of unprocessed tobacco behave competitively. Given the asymmetric numbers of buyers versus sellers, this assumption may not be valid.

Tobacco program production restrictions are administered primarily through price supports and marketing quotas. Such policy tools are distinct, but similar, for the major types of tobacco produced in the United States. Price support levels for both flue-cured and burley tobacco are calculated by adjusting the preceding year's support level by a weighted average of changes in production costs and changes in the 5-year moving average of market prices.[2] National marketing quota levels for both tobacco varieties are determined annually as the sum of intended purchases announced by domestic cigarette manufacturers, the average of tobacco exports for the three preceding years, and an adjustment to maintain loan stocks at the specified reserve-stock level of 15 percent of basic quota, but no less than a specified minimum stock level.[3] Farmers, typically organized through cooperatives, serve as facilitators of the marketing quota and as suppliers of storage capacity for reserved stocks. Cooperatives purchase tobacco when the bid price is less than one cent above the support.

Brown and Martin contend that “the inclusion of domestic purchase intentions and the adjustment for cooperative inventories in the quota formula makes the national marketing quota very responsive to downward shifts in demand for U.S. tobacco” (p.446). Though it is not the program’s intent, inclusion of cigarette manufacturer’s domestic purchase intentions and the adjustment for reserve inventories in the quota formula may actually allow cigarette manufacturers to shift a portion of quota rent from producers to themselves. In effect, the quota adjustment formula gives manufacturers a large degree of control over tobacco producers’ annual production. Indeed, at times, cigarette manufacturers have acted to “maintain” quota by purchasing excess stocks accumulated by cooperatives which threatened to significantly decrease the marketing quota in subsequent years. For example, the 1994 burley tobacco stock levels would have resulted in a forty percent quota reduction for 1995. However, cigarette manufacturers agreed to purchase enough of the excess stocks to avoid a quota reduction (Brown 1996a). A similar situation occurred in the flue-cured market in 1995. In this view, the tobacco marketing quota becomes a quantity controlling device used by cigarette manufacturers to extract monopsony rent from growers. Furthermore, with support price tied to growers’ production cost and lagged price, the support price offers tobacco producers no real protection from this possibility. Cigarette manufacturers apparently have both the motive (profit maximization) and means (high concentration, marketing quota and pricing formulas) to extract quota rents from tobacco growers through monopsony market power exertion.

Nonparametric Market Power Tests

Existence of market power is measured as a deviation from marginal cost pricing. In the case of monopsony power, this translates to an input price less than the value of marginal product (VMP). Several recent studies have developed nonparametric tests to assess market power exertion. Ashenfelter and Sullivan (1987) employ data search methods to measure monopoly power while Love and Shumway (1994), and Lambert (1994), develop nonparametric monopsony market power tests using a linear programming framework. The latter two studies assess monopsony market power in only one input market. Nonparametric market power tests employ a revealed preference approach founded on the Weak Axiom of Profit Maximization (WAPM). For consistency with competitive behavior, WAPM states that the observed input and output quantity choices at output price p and input prices **r** must yield profit at least as great as any other quantity set that could have been chosen (Varian, 1992). Nonparametric market power tests exploit the idea that firms with market power maximize profits by restricting quantities in order to exploit the slope of output demand curves or input supply curves and that, at observed prices, there is no other quantity choice that will yield a higher profit. Market power exertion will be evident from the quantity choices made in each period. Nonparametric tests offer alternatives to parametric tests of market power in that they circumvent the issue of functional form choice for behavioral equations (Varian 1984, 1985, 1990).

Additionally, data requirements are less for nonparametric market power tests than for parametric tests because supply or demand relationships on the opposite side of the market need not be specified.

Consider firm *i*'s profit maximization problem

(1) $$\max_{\mathbf{x}} \ \pi_i = p y_i - \sum_{m=1}^{n} r_m x_{mi} \ \text{subject to} \ F_i(\mathbf{x}) \geq y_i$$

where p is output price, y_i is firm *i*'s output, x_{mi} is quantity of variable input m demanded by firm *i*, r_m is the price of input m, **x** is the vector of variable inputs, and $F_i(\mathbf{x})$ is firm *i*'s production function. The perfectly competitive firm's discrete first-order profit-maximizing condition is

(2) $$\Delta\pi_i = p\Delta y_i - \sum_{m=1}^{n} r_m \Delta x_{mi} \leq 0 \ .$$

Here we assume that prices are exogenous since the firm cannot influence prices through input or output quantity choice. However, a firm with monopsony power in the nth input market can influence input price r_n by its choice of input level x_{ni}. The monopsonistic firm's first-order profit-maximizing condition in discrete terms is

(3) $$\Delta\pi_i = p\Delta y_i - \sum_{m=1}^{n-1} r_m \Delta x_{mi} - r_n \Delta x_{ni} - x_{ni}\Delta r_n \leq 0$$

where x_{mi} is the quantity of variable input x_m purchased by the *i*th firm and x_{ni} is the amount of x_n purchased by the *i*th firm. The monopsony markdown term is the fourth left-hand-side term. By reducing input purchases of x_{ni}, the firm can reduce the price it must pay for every unit purchased. Tests for market power exertion are based on determining the empirical importance of the monopsony markdown term.

Market Power in a Single Input

Recent nonparametric market power tests have incorporated measures of other variables which, if not accounted for, could distort market power measurements (Lambert; Love and Shumway). Love and Shumway's inclusion of technical change measures is based on previous tests for profit maximization under perfect competition by Chavas and Cox (1988, 1990, 1992) and Cox and Chavas (1990). To incorporate technical change measures, consider the primal profit maximization problem presented in equation (1). Redefine $F_i(\mathbf{x}) \geq y_i$ as $F_i(\mathbf{x}) \geq Y_i(y_i, \mathbf{A})$ where Y_i denotes "effective output" and $\mathbf{A}$>0 is a vector of technology indices (Cox and Chavas). $F_i(\mathbf{x})$ is assumed to be strictly increasing and concave in $\mathbf{x}$ and Y_i is assumed to be strictly increasing in y_i. The firm's profit maximization problem when technical change measures are included becomes

$$(4) \qquad \max_{\mathbf{x}} \ \pi_i = p\, y_i(Y_i, \mathbf{A}) - \sum_{m=1}^{n} r_m x_{mi} \ \text{ subject to } \ F_i(\mathbf{x}) \geq Y_i(y_i, \mathbf{A})$$

where $y_i(Y_i, \mathbf{A})$ is the inverse function of $Y_i(y_i, \mathbf{A})$. Assuming the firm chooses quantities $(\mathbf{x}, y_i)$ over T time periods where each time period is characterized by input prices r^t, output price p^t, and technology $\mathbf{A}^t$, it is possible to check the consistency of the decision set, $\Omega_i = \{\mathbf{x}^1, y_i^1; \mathbf{x}^2, y_i^2; \ldots \mathbf{x}^T, y_i^T\}$ with the profit maximization hypothesis while considering the degree of market power exertion.

Since a firm with monopsony power in an input market, x_n, can influence input price r_n by its choice of input level x_{ni}, the resulting first-order profit-maximizing condition in discrete terms is

$$p^t[(y_i(Y_i^t, A^t) - (y_i(Y_i^s, A^s))] - \sum_{m=1}^{n} r_m^t(x_{mi}^t - x_{mi}^s) - r_n^s \eta_i^{ts}(x_{ni}^t - x_{ni}^s) \geq 0 \tag{5}$$

where Δx is approximated as x^t - x^s, Δy is approximated as y^t - y^s, and $\eta_i^{ts} = [(r_n^t - r_n^s)/(x_{ni}^t - x_{ni}^s)](x_{ni}^s/r_n^s)$. This equation simply restates WAPM in terms of the quantity choice at time t, i.e., at observed prices in time t, the observed quantity at time t yields at least as much profit as any other quantity choice and, after appropriate substitutions and cancellations, is identical to equation (3). The price flexibility of the *i*th firm's perceived residual supply curve, η_i^{ts}, can also be written as $\eta_i^{ts} = (VMP_{ni}^{ts} - r_n^t)/r_n^t$, where VMP_{ni}^{ts} is the marginal value product of the nth input for the *i*th firm for the time interval ts (Love and Shumway). Thus, η_i^{ts} gives a direct measure of the monopsony Lerner index. If $\eta_i^{ts} = 0$, then firm *i* cannot impact input price by adjusting quantity purchased in period t, i.e. the firm has no market power. Equation (5) gives the necessary and sufficient conditions for the firm's decision set Ω_i to be consistent with profit maximization (See proposition 1 in Chavas and Cox, 1990).

Empirical implementation of the market power test requires an assumption about the form of technical change. Chavas and Cox (1990) provide a thorough discussion of technical change hypotheses which make the problem empirically tractable without imposing a parametric model of technology. We assume the output translating case which presumes Hicks-neutral technical change. Output translating technical change leaves the marginal rate of substitution between inputs unchanged. It is operationalized by defining $Y_i(y_i, \mathbf{A}) = f_i(y_i, a^+, a^-)$ where a^+ denotes positive technical change and a^- denotes negative technical change. Assuming output translating technical change gives $\Delta y = y_i^t - a^{t+} + a^{t-} - y_i^s + a^{s+} - a^{s-}$.

The inequality in (5) involves variables which are not directly observable. Therefore, the market power test consists of finding whether values exist for a^+, a^-, and m_i^{ts} which satisfy the inequality. Since (5) is linear in the unobserved variables, we can define **z** as the vector of unobserved variables, i.e. a^+, a^-, and m_i^{ts}, and rewrite (5) as $\mathbf{d}'\mathbf{z} \geq \mathbf{c}$ using appropriate definitions of the matrix **d** and vector **c** (Cox and Chavas, 1990). The market power test can now be implemented as the linear programming problem

$$(6) \qquad \min_{z} \{\mathbf{b}\ \mathbf{z}:\ \mathbf{d}\ \mathbf{z} \geq \mathbf{c},\ \mathbf{z} \geq 0\}\ .$$

Since shifts in input supply unmatched by shifts in input demand will cause input price and quantity to move in opposite directions between observations, deleting comparisons where Δr_n does not have the same sign as Δx_{ni} can reduce the possibility of biased market power estimates (Love and Shumway). Such movements are clearly not attributable to market power exertion. In practice, comparisons between time periods are deleted when $\Delta r_n \overset{s}{\neq} \Delta x_{ni}$, where $\overset{s}{\neq}$ means "not the same sign as", to omit supply shifts without corresponding demand shifts. The constraints in (6) are implemented over the time periods where $s \neq t$.

Market Power in Multiple Input Markets

The nonparametric approach to estimating market power exertion is easily extended to measure monopsony market power in multiple input markets. Following (5), the first-order profit maximizing condition for firm *i* with potential monopsony market power in multiple input markets, n-f+1 through n, can be written generally as

$$
\begin{aligned}
(7)\qquad & p^{t}\,[(y_i(Y_i^{t}, A^{t}) - (y_i(Y_i^{s}, A^{s}))] - \sum_{m=1}^{n} r_m^{t}(x_{mi}^{t} - x_{mi}^{s}) \\
& - \sum_{v=n-f+1}^{n} r_{vi}^{s}\eta_{vi}^{ts}(x_{vi}^{t} - x_{vi}^{s}) \;\geq\; 0
\end{aligned}
$$

where f is the number of input markets where the firm potentially exerts monopsony power and η_{vi}^{ts} is the respective price flexibility of firm *i*'s residual supply curve for input v. More specifically, the first-order profit maximizing condition for firm *i* with market power in two inputs, x_n and x_{n-1}, is

$$
\begin{aligned}
(8)\qquad & p^{t}\,[(y_i(Y_i^{t}, A^{t}) - (y_i(Y_i^{s}, A^{s}))] - \sum_{m=1}^{n} r_m^{t}(x_{mi}^{t} - x_{mi}^{s}) \\
& - r_{n-1}^{s}\,\eta_{n-1,i}^{ts}(x_{n-1,i}^{t} - x_{n-1,i}^{s}) - r_n^{s}\,\eta_{ni}^{ts}(x_{ni}^{t} - x_{ni}^{s}) \;\geq\; 0
\end{aligned}
$$

where r_{n-1} is the price of input x_{n-1}. The price flexibilities of the *i*th firm's perceived residual supply curves for x_{n-1} and x_n are represented by $\eta^{ts}_{n-1,i}$ and η_{ni}^{ts}, respectively. As in the single input case, $\eta^{ts}_{n-1,i}$ and η_{ni}^{ts} are direct measures of the monopsony Lerner index for the respective inputs. Equation (8) replaces (5) as the necessary and sufficient condition for the firm's decision set Ω_i to be consistent with profit maximization as represented by

WAPM where monopsony power is presumed in two input markets. Again, using appropriate definitions of the matrix **d** and vector **c** and now rewriting (8) as $\mathbf{d'z} \geq \mathbf{c}$, we implement the test as the linear programming problem represented in (6). We delete comparisons between time periods when $\Delta r_{n-1} \overset{s}{\neq} \Delta x_{n-1,i}$ and $\Delta r_{n} \overset{s}{\neq} \Delta x_{ni}$, and search over $s \neq t$.

Data

The test must be implemented using time series data for output price and quantity and for input prices and quantities. We implement the test using annual 1977 to 1993 price and quantity data for outputs and inputs from the U.S. cigarette manufacturing industry. Aggregate domestic cigarette production and price are used as measures of output quantity and price. Input prices and quantities are included for domestic tobacco purchases, imported tobacco, labor, materials other than tobacco, capital, and advertising. A complete listing of variable names and definitions is included in Table 1. All indices are constructed using 1982 as the base year. Variable names used in application are listed in parentheses.

Four types of cigarettes and their prices are used in calculating a Divisia price index for domestic cigarette price: standard cigarettes (70 mm nonfilter), filter tip cigarettes (80 mm), king (85 mm nonfiltered and filtered) and extra long (100 mm filter tip). Price and quantity data, along with excise tax data, for these cigarette types are taken from *USDA Tobacco Situation and Outlook* (TSO). The annual prices for each type are calculated by weighting corresponding wholesale cigarette price revisions by the fraction of the year that the price was in effect and then subtracting the effective excise tax to reflect the final price received by cigarette manufacturers. The resulting price index for domestic cigarette price

(p_y) is then constructed net of excise tax. Domestic cigarette production (y) is calculated as the total value of cigarettes (net of excise tax) divided by the price index p_y.

Domestic tobacco price and quantity data are taken from various issues of TSO and consist of estimated leaf tobacco used in domestic cigarette production and annual average prices received by growers for unstemmed flue-cured, unstemmed burley, and unstemmed Maryland tobacco. These varieties are chosen because they represent the principal types of leaf tobacco used in domestic cigarette production. A Divisia price index for domestic tobacco (r_{us}) is constructed. Domestic tobacco quantity (x_{us}) is constructed as the total value of these three tobacco varieties used in domestic cigarette production divided by r_{us}.

The source for imported tobacco data is the Department of Commerce's *U.S. Imports for Consumption and General Imports: FT246 and FT247*. The category of tobacco used in cigarette production is called cigarette leaf tobacco and includes five types of tobacco: unstemmed Oriental, unstemmed flue-cured, unstemmed burley, stemmed tobacco except cigar leaf and scrap tobacco except cigar leaf. Price and quantity information for these categories is used to create a Divisia price index for imported tobacco (r_i). Quantity of imported tobacco (x_i) is calculated as total value of imports for these five categories divided by r_i.

Residual materials cost is calculated by subtracting the cost of domestic and imported tobacco from cost of materials as reported in the *Annual Survey of Manufacturers*, various issues. The price index of other materials is proxied by the producer price index for materials as reported in the *Economic Report of the President*. A quantity index for other materials (x_m) is constructed by dividing the residual materials cost by the producer price index for materials (r_m).

Data on advertising expenditures for cigarette manufacturers are taken from TSO. A quantity index for advertising (x_a) is obtained by dividing the cigarette industry's reported annual expenditures on advertising by the cost per thousand advertising price index for magazines. The price index for magazines is chosen as a proxy for cost per unit of advertising (r_a) since magazine advertisements represent a major portion of advertising expenditures for cigarette manufacturers. This index is constructed from indices reported in USDA's *Food Marketing Review*, 1992-1993 and various issues of *Advertising Age*.

Data regarding the cost of labor and the number of employees in cigarette manufacturing are taken from the *Annual Survey of Manufacturers*. Total compensation is divided by the number of employees to calculate average annual compensation per employee. This measure is then normalized to the base year of 1982. The resulting price index for labor (r_L) is used to obtain the quantity of labor (x_L) via total compensation divided by r_L.

Capital price is calculated as the annual cost per unit of capacity where total capacity is the proxy for quantity of capital. Total capacity is recovered by dividing actual cigarette production by the capacity utilization rate as reported in *Annual Survey of Manufacturers*. Annual total cost of capital is calculated assuming a 10 year depreciation rate of new capital expenditures (also from *Annual Survey of Manufacturers*) with no salvage value. A 5 year moving-average of Moody's Aaa corporate bond rate from the

Economic Report of the President is used to estimate annual interest costs. Total annual capital service cost is the sum of depreciation charges and interest charges. Dividing total capital services cost by total capacity gives capital price per unit of capacity. Capital price per unit of capacity is normalized to the base year of 1982 and the resulting index is used to represent annual cost per unit of capacity (r_c). Quantity of capacity (x_c) is constructed as total capital service cost divided by r_c.

Results

Specific programming problems as defined in equations (5) and (7) for the cigarette manufacturing industry are reported in Table 2. Test results for cases where monopsony power is allowed in the domestic tobacco market (single input case) and where monopsony power is allowed in both the domestic tobacco market and international tobacco market (two input case) are presented in Table 3. In general, the results indicate that cigarette manufacturers exert economically significant monopsony market power in the domestic tobacco market. Average estimated monopsony Lerner indices for domestic tobacco in both the single input case and the two input case indicate substantial departures from competitive pricing by cigarette manufacturers. For the single input case with equal weights of one on market power and technical change in the linear programming problem, η_{us}=2.02.[4] Such a measure indicates that cigarette manufacturers internally value domestic tobacco at 202 percent of the price paid to growers. Market power estimates are obtained under various weighting schemes for b^{t+}, b^{t-}, c_{us}^{ts}, and c_i^{ts} within the linear programming problem for the two input case. The highest estimate of the monopsony Lerner index for domestic tobacco is η_{us} =2.33. This Lerner index value occurs under several weighting schemes, including when technical change is weighted 25 times more heavily than market power and when market power is weighted five times more heavily than technical change. A Lerner index value of 2.33 suggests that manufacturers internally value tobacco 233 percent higher than the price they actually pay growers.[4] Even when market power weights are assigned values 100 times greater than technical change weights, the Lerner index of monopsony power is estimated as η_{us} =0.35.

Market power test results from the two input case suggest that U.S. cigarette manufacturers' monopsony market power in the tobacco import market is inconsequential. The average monopsony Lerner index for the international tobacco market, η_i, is estimated at 0.08 under almost all weighting schemes. The lone exception is η_i=0.04 when market power is weighted 100 times greater than technical change within the linear programming problem. Analogous to the domestic Lerner index measure, η_i=0.08 suggests that cigarette manufacturers internally value imported tobacco at 8 percent above the price they pay on the international market.

Monopsony Lerner index estimates for domestic tobacco and imported tobacco by period (assuming equal weights of one) are reported in Table 4. Blank cells indicate no detected market power exertion during that period. Period by period results are consistent in supporting economically significant monopsony market power in the domestic tobacco market and negligible monopsony market power by U.S. cigarette manufacturers in the international tobacco market. In the case of domestic tobacco purchases, results indicate that cigarette manufacturers exerted economically significant monopsony market power in almost all periods prior to 1987. However, in 1987 and following years, no monopsony market power is detected by the test. The lack of market power exertion for the later period in the sample may be partially attributed to the Tobacco Improvement Act of 1985 which reduced price supports and quota formulas in an effort to generate more market-oriented price and production levels. The Act also required domestic manufacturers to purchase existing loan stocks. It is possible that these revisions lessened the capability of domestic manufacturers to exert monopsony market power in procuring domestically grown tobacco. Period by period measures for purchases of imported tobacco indicate that in most years, no market power exertion is detected. However, monopsony market power is detected in two of the most recent three years of the sample, perhaps lending support to the DOJ's recent inquiry into the presence of price fixing by cigarette manufacturers in the purchase of imported tobacco.

The implications of monopsony market power exertion in the domestic market may be illustrated using information regarding cigarette manufacturers' cost per pack of cigarettes (Table 5). Over the period sample, the average cost of domestic tobacco in a pack of cigarettes is \$0.04 while η_{us}=2.33. Recall that η=(VMP-r)/r where r is input price. Using r_{us}=\$0.04 to represent domestic tobacco price on a cost per pack basis, the previous equation can be solved for VMP, i.e. the internal value of that tobacco to the cigarette manufacturer. In this case VMP=\$0.13, indicating that cigarette manufacturers value the domestically produced tobacco in a pack of cigarettes at \$0.09 higher than the price they actually pay to producers for that tobacco. A similar measure can be calculated on a per pound basis using the average price per pound of domestic tobacco for the time period ($\bar{r}_{us}$). Since $\bar{r}_{us}$=\$0.876 and η_{us}=2.33, this implies that VMP per pound for cigarette manufacturers is \$2.92, i.e. \$2.04 higher than the price per pound paid to producers.

Overall, the results are not surprising, given that the U.S. cigarette manufacturing industry is characterized domestically as a few manufacturers purchasing tobacco from a large number of growers and internationally as facing more competition among cigarette manufacturers. Domestically, these results indicate that tobacco program rents resulting from reduced output are being captured, at least in part, by U.S. cigarette manufacturers rather than by tobacco producers who are typically assumed to receive program benefits.

Conclusions

Traditional market power analyses of the cigarette manufacturing industry have considered monopoly power exertion by manufacturers in selling cigarettes to consumers. The characteristics of the market relationship between U.S. cigarette manufacturers and U.S. tobacco producers make it quite plausible that manufacturers exert monopsony market power in procuring domestic tobacco. We investigate the possibility of monopsony market power exertion by U.S. cigarette manufacturers in both the domestic and international tobacco markets by extending Love and Shumway’s test to include potential monopsony market power in multiple input markets. Tests for the single input and two input cases are implemented using annual data from the cigarette manufacturing industry. Results in the single input case indicate a substantial departure from competitive pricing by cigarette manufacturers in the input market for domestic unprocessed tobacco. This result is supported by the outcome in the two input case. The estimate of monopsony market power exertion by cigarette manufacturers is relatively large and of similar magnitude as in the single input case. Results suggest that U.S. cigarette manufacturers exert little, if any, monopsony market power in the world tobacco market. However, the most recent years in the study reveal that perhaps market power in the import market is increasing. Additionally, the results suggest that the benefits of the U.S. tobacco program accrue largely to cigarette manufacturers. Our analysis suggests that policy analyses that *a priori* assume tobacco program benefits accrue to quota owners should be reconsidered.

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NOTES

1. Hamilton analyzes cigarette manufacturing data for the period 1924-1939 for joint oligopoly-oligopsony power. His results suggest that cigarette manufacturers practiced oligopolistic cigarette pricing during this period, but not oligopsony price coordination.

2. Production cost changes are weighted by one third and price changes are weighted by two thirds. See Tobacco Situation and Outlook, December 1996, for a description of costs included in the production cost index.

3. The minimum reserve-stock levels for flue-cured and burley tobacco are 100 million pounds and 50 million pounds, respectively.

4. η_{us} represents the average η_{us}^{ts} over all comparisons within the sample period and where no shifts occurred.

Table 1. Variable Definitions for Empirical Equations.

Variable	Definition
p_y	Domestic wholesale price of cigarettes, net of excise tax (Divisia index)
y	Domestic quantity of cigarettes produced (1000's)
r_{us}	Domestic price per lb. pd to producers (Divisia index)
x_{us}	Domestic tobacco purchased by cigarette manufacturers (lbs)
r_i	Price of tobacco imports (Divisia index)
x_i	Imported tobacco for cigarettes (lbs)
r_L	Average annual compensation of workers in cigarette manufacturers ($'s)
x_L	Annual # of workers employed by cigarette manufacturers
r_m	Price of materials other than tobacco (PPI for containers)
x_m	Materials other than tobacco
r_c	Price per Unit of Capacity
x_c	Total annual capacity
r_a	Price per unit of advertising (PPI for magazine advertising)
x_a	Quantity of Advertising per year

Table 2. Empirical Equation for Single Input Monopsony Market Power Test and Two Input Monopsony Market Power Test.

TEST	Equation	Decision Variables
Single Input	$\min_{a^{t},\, a^{t-},\, \eta^{ts}_{us}} \; (b^{t}\, a^{t} \quad b^{t-} a^{t-} \quad \sum_{t=1}^{T} \sum_{s \neq t}^{T} c^{ts} \eta^{ts}_{us})$ subject to: $p_y^{t}[(y^{t} - a^{t} \quad a^{t-}) - (y^{s} - a^{s} \quad a^{s-})] - r^{t}_{us}(x^{t}_{us} - x^{s}_{us}) - r_i^{t}(x_i^{t} - x_i^{s}) - r_L^{t}(x_L^{t} - x_L^{s})$ $-r_m^{t}(x_m^{t} - x_m^{s}) - r_a^{t}(x_a^{t} - x_a^{s}) - r_c^{t}(x_c^{t} - x_c^{s}) - r^{s}_{us}\eta^{ts}_{us}(x^{t}_{us} - x^{s}_{us}) \geq 0,$ $\forall\; s \neq t$ except when $r^{t}_{us} - r^{s}_{us} \overset{S}{\neq} x^{t}_{us} - x^{s}_{us}$ $\eta_i^{ts} \geq 0, \; \forall\; s \neq t$ $a_i^{t}, \; a_i^{t-} \geq 0, \; \forall\; t$	η^{ts} a^{t+} a^{t-}
Two Input	$\min_{a^{t},\, a^{t-},\, \eta^{ts}_{i},\, \eta^{ts}_{us}} \; (b^{t}\, a^{t} \quad b^{t-} a^{t-} \quad \sum_{t=1}^{T} \sum_{s \neq t}^{T} c^{ts}_{us} \eta^{ts}_{us} \quad \sum_{t=1}^{T} \sum_{s \neq t}^{T} c^{ts}_{i} \eta^{ts}_{i})$ subject to: $p_y^{t}[(y^{t} - a^{t} \quad a^{t-}) - (y^{s} - a^{s} \quad a^{s-})] - r^{t}_{us}(x^{t}_{us} - x^{s}_{us}) - r_i^{t}(x_i^{t} - x_i^{s}) - r_L^{t}(x_L^{t} - x_L^{s})$ $-r_m^{t}(x_m^{t} - x_m^{s}) - r_a^{t}(x_a^{t} - x_a^{s}) - r_c^{t}(x_c^{t} - x_c^{s}) - r^{s}_{us}\eta^{ts}_{us}(x^{t}_{us} - x^{s}_{us}) - r_i^{s}\eta_i^{ts}(x_i^{t} - x_i^{s}) \geq 0,$ $\forall\; s \neq t$ except when $r^{t}_{us} - r^{s}_{us} \overset{S}{\neq} x^{t}_{us} - x^{s}_{us} \wedge r_i^{t} - r_i^{s} \overset{S}{\neq} x_i^{t} - x_i^{s}$ $\eta^{ts}_{us}, \eta^{ts}_{i} \geq 0, \; \forall\; s \neq t$ $a_i^{t}, \; a_i^{t-} \geq 0, \; \forall\; t$	η^{ts}_{us} η_i^{ts} a^{t+} a^{t-}

Table 3. Nonparametric Test Results under Various Weighting Schemes.

Technical Change Weights (b^{t+}, b^{t-})	Market Power Weight--Domestic (c_{us}^{ts})	Market Power Weight--Imported (c_i^{ts})	Domestic Tobacco	Imported Tobacco	Positive Technical Change	Negative Technical Change
			η_{us}	η_i	a^{t+}	a^{t-}
1	1	na	2.02	na	67.21	40.42
1	1	1	2.33	0.08	18.18	0
1	5	5	2.33	0.08	18.18	0
1	25	25	1.40	0.08	44.63	21.76
1	100	100	0.35	0.04	145.99	80.31
5	1	1	2.33	0.08	18.18	0
5	25	25	2.33	0.08	18.18	0
5	100	100	1.76	0.08	18.18	21.76
25	1	1	2.33	0.08	18.18	0

Table 4. Monopsony Market Power Estimates (η) by Time Period for Domestic and Imported Tobacco Purchases.[a]

Year	Domestic Tobacco (η_{us})	Imported Tobacco (η_i)
1977	1.50	
1978	2.32	
1979	7.17	
1980	3.74	
1981	6.22	
1982	2.19	
1983		
1984	2.62	
1985	1.46	
1986	5.50	
1987		
1988		
1989		
1990		
1991		0.66
1992		0.37
1993		

[a] $b^{t=}$, b^{t-}, c_{us}^{ts}, and c_i^{ts} are equal to one for this analysis.

Table 5. Average Cost per Cigarette Pack for U.S. Cigarette Manufacturers using Four-digit SIC data

Year	Labor	Advertising	Materials	Domestic Tobacco	Imported Tobacco	Capital	Total Cost	Revenue	Before Tax Profit
1977	0.02	0.02	0.03	0.03	0.01	0.00	0.13	0.20	0.07
1978	0.02	0.03	0.04	0.04	0.01	0.00	0.14	0.22	0.08
1979	0.03	0.03	0.04	0.04	0.01	0.01	0.15	0.24	0.10
1980	0.03	0.03	0.05	0.04	0.01	0.01	0.18	0.27	0.10
1981	0.04	0.04	0.06	0.04	0.01	0.01	0.20	0.31	0.12
1982	0.04	0.05	0.07	0.04	0.01	0.01	0.22	0.37	0.15
1983	0.04	0.06	0.07	0.04	0.01	0.02	0.24	0.41	0.18
1984	0.05	0.06	0.08	0.04	0.02	0.02	0.26	0.45	0.20
1985	0.05	0.07	0.08	0.04	0.01	0.02	0.27	0.50	0.22
1986	0.04	0.07	0.08	0.03	0.02	0.02	0.27	0.55	0.28
1987	0.05	0.07	0.08	0.03	0.02	0.02	0.27	0.60	0.33
1988	0.05	0.09	0.08	0.04	0.02	0.02	0.29	0.68	0.39
1989	0.05	0.11	0.08	0.04	0.02	0.02	0.31	0.78	0.47
1990	0.05	0.11	0.08	0.04	0.02	0.02	0.32	0.88	0.56
1991	0.05	0.13	0.08	0.04	0.02	0.02	0.34	0.99	0.64
1992	0.05	0.15	0.06	0.04	0.04	0.02	0.35	1.11	0.76
1993	0.05	0.18	0.06	0.03	0.04	0.02	0.38	1.07	0.69
AVG	0.04	0.08	0.07	0.04	0.02	0.02	0.25	0.57	0.31