Staff Paper

Monopsony Power in Multiple Input Markets: A Nonparametric Approach

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Staff Paper #99-62 **December, 1999**

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Staff Paper No. 99-62, 31 pages

Abstract

Cigarette manufacturers' monopsony power exertion in procuring domestic and imported tobacco is investigated using nonparametric methods. While it is often assumed that tobacco program rents are captured by growers, results indicate the opposite actually occurs. Cigarette manufacturers appear to exert significant monopsony power in the domestic leaf tobacco market and capture a large portion of program rents. Cigarette manufacturers appear to exert monopsony power of much smaller magnitude in the international leaf tobacco market, but with increasing magnitude in more recent years.

Keywords: market power, tobacco, nonparametric, monopsony, imports.

JEL Classification: L1.

Kellie Curry Raper is assistant professor of agricultural economics at Michigan State University. H. Alan Love is associate professor of agricultural economics at Texas A&M University. The authors wish to thank George Davis for the use of his data set and Diana Burton and Mike Wohlgenant for helpful comments. This manuscript reports research conducted in part by the Texas Agricultural Experiment Station, Texas A&M University System and Michigan Agricultural Experiment Station, Michigan State University. Additional support was provided by a USDA Cooperative State Research, Education, and Extension Service (CSREES) Special Grant to the Food Marketing Policy Center, University of Connecticut, and by subcontract at the University of Massachusetts, Amherst.

MONOPSONY POWER IN MULTIPLE INPUT MARKETS: A NONPARAMETRIC APPROACH

The cigarette manufacturing industry has long been touted as an example of an imperfectly competitive industry. In 1992, the four largest firms supplied ninety-three percent of cigarette production in an industry that consisted of only eight firms (Census of Manufacturers). Given the high concentration that exists in this industry, monopoly power exertion by cigarette manufacturers is certainly plausible and is often examined (Ashenfelter and Sullivan 1987; Sullivan 1985; Sumner 1981; Roeger 1995; Hall 1988). However, there is another possibility that has not received much attention. High concentration in cigarette manufacturing also supports the possibility that cigarette manufacturers exert monopsony power in domestic and international tobacco procurement.

U.S. leaf tobacco producers are organized as a cartel through a marketing quota system administered through the U.S. Department of Agriculture. It is generally assumed the marketing quota system is effective and that growers capture quota rents achieved by reducing production to less than free market quantities and thereby raising 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 tobacco leaf buyers behave competitively. Even if the quota effectively restricts supply, there is no guarantee that growers capture quota rents. Cigarette manufacturers' monopsony market power exertion could shift quota rent from growers to manufactures.

U.S. cigarette manufacturers are also relatively large buyers in the world leaf tobacco market. In 1993, U.S. firms purchased 21 percent of tobacco leaves sold on the world market (FAO), suggesting the possibility that U.S. cigarette manufacturers may also exert monopsony power in the international leaf tobacco market. Recent Department of Justice (DOJ) inquiries into possible collusion by cigarette manufacturers in procuring imported tobacco makes this an appealing analysis as well.

Previous studies have considered monopoly power exertion by tobacco processors (Ashenfelter and Sullivan; Sullivan; Sumner), but cigarette manufacturers' potential monopsony power in procuring tobacco from domestic and international growers has received little attention[1]. In this study, we draw upon Love and Shumway's (1994) nonparametric monopsony power test to consider possible monopsony power exertion by cigarette manufacturers in procuring domestic and imported leaf tobacco. We expand the test to examine monopsony power in two input markets, including domestic and imported tobacco. We also extend the test to include the possibility of both Hicks-neutral and biased technical change in output and all inputs. While two-digit SIC level manufacturing data has been used to examine market power in the industry (e.g., Roeger, Hall), 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 present Love and Shumway's approach to monopsony market power measurement, extending their test to assess monopsony market power exertion in multiple input markets. We also extend the approach to measure biased technical change in addition to Hicks neutral technical change. The tests are then implemented to analyze cigarette manufacturers' potential monopsony power exertion in the domestic and international tobacco markets. Empirical results are followed by concluding remarks.

Institutional Setting

Flue-cured and burley tobacco national marketing quota levels 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.[2] Eligible producers must approve the quota in a referendum held every three years; once approved, all producers are required to maintain marketing quota equivalent to their sales weight. Individual growers are assigned a specific quota in exchange for a price support equal to the preceding year's support price adjusted by changes in the five year moving average of cash prices excluding the highest and lowest years (weighted b) and changes in a cost of production index (weighted a). The cost of production index used in the support price formula is based on variable cost and excludes land and quota rent and other capital costs. As a result, the support price does not offer leaf tobacco producers a guarantee of price above the average variable cost.

Producer-owned cooperative associations have administered the support price program on a "no-net-cost" basis since 1982. Any support payments must be covered by farmer member expenditures.[3] 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. Inventories obtained through price support activities must be liquidated in subsequent periods. In 1993, the USDA-ASCS reported over 350,000 tobacco quota owners.

The common assumption in the literature is that the marketing quota is effective and that the entire quota rent is captured by quota owners (Brown and Martin 1996; Brown 1995; Fulginiti and Perrin 1993; Babcock and Foster 1992; Sumner and Wohlgenant 1985; Johnson and Norton 1983). However, cigarette manufacturers are highly concentrated. According to Philip Morris, the top 4 cigarette manufacturing firms produced 42.3%, 28.8%, 18.7%, and 7.2% of total output in 1996 (97% of production). Since manufacturers have a large part in determining national quota levels, and since the support price can do little to raise cash price above average production cost, it is unclear whether the program actually succeeds in transferring quota rent to leaf growers as is commonly assumed.

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 and ultimately market price. 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 excess stocks to avoid a quota reduction (Brown 1996a). A similar situation occurred in the 1995 flue-cured market. It is possible that quota reductions not anticipated by manufacturers would restrict leaf supply and require cigarette manufacturers' to bid more aggressively in future periods. As a consequence, rents would be shifted to growers and manufacturers would lose control of market supply. In this light, manufacturers' excess stock purchases might be viewed as a strategic decision to maintain control of future quota levels. In this institutional setting it is unclear whether the tobacco program offers producers the protection commonly assumed in policy analyses or whether cigarette manufacturers extract at least a portion of quota rents through monopsony market power exertion in leaf purchases.

Nonparametric Market Power Tests

Market power exertion is typically measured as the 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 utilize data search methods to measure monopoly power while Love and Shumway and Lambert (1994) develop nonparametric monopsony market power tests in a single input market using a linear programming framework. Nonparametric market power tests employ a revealed preference approach founded on the Weak Axiom of Profit Maximization (WAPM). Such 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).

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 test incorporates Hicks neutral technical change measures following techniques from Chavas and Cox's (1988, 1990, 1992) and Cox and Chavas' (1990) work in production economics. However, it may be unreasonable to assume that only Hicks neutral technical change occurred over the time period. Biased technical change measures are also easily incorporated, again following techniques developed in the aforementioned studies.

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 or input supply and that, at observed prices, there is no other quantity choice that will yield a higher profit. Market power exertion will then be evident from the quantity choices made in each period. Consider firm *i*'s profit maximization problem

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

where p is output price, y_i is firm *i*'s output, r_m is the price of input m, x_{mi} is quantity of variable input m demanded by firm *i*, and **x** is the vector of variable inputs. $F_i(\mathbf{x}, \mathbf{B})$ is firm *i*'s production function and $F_i(\mathbf{x}, \mathbf{B}) \geq Y_i(y_i, \mathbf{A})$ where Y_i denotes "effective output" and **A**>0 and **B**>0 are technology indices (Cox and Chavas). Note that this specification of the test allows Hicks-neutral technical change with respect to output and biased technical change in all inputs, including monopsonistically purchased inputs. $F_i(\mathbf{x}, \mathbf{B})$ is assumed to be strictly increasing and concave in **x**. Y_i is assumed to be strictly increasing in y_i 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, technology $\mathbf{A}^t$, and technology $\mathbf{B}^t$, it is possible to check the consistency of the decision set, $S_i = \{\mathbf{x}^1, y_i^1; \mathbf{x}^2, y_i^2; \ldots \mathbf{x}^T, y_i^T\}$ with the profit maximization hypothesis while considering the degree of market power exertion.

A firm with monopsony power in the nth input market can influence input price r_n by its choice of input level x_{ni}, i.e. by reducing input purchases of x_{ni}, the firm can reduce the price it must pay for every unit purchased. The monopsonistic firm's first-order profit-maximizing condition, in discrete terms and including technical change measures, is

$$(2) \qquad p^t[(y_i(Y_i^t, A^t) - (y_i(Y_i^s, A^s))] - \sum_{m=1}^{n} r_m^t [x_{mi}^t(X_{mi}, \mathbf{B}) - x_{mi}^s(X_{mi}, \mathbf{B})] - r_n^s \eta_i^{ts}(x_{ni}^t - x_{ni}^s) \geq 0$$

where t and s represent different time periods, x_{mi} is the quantity of variable input x_m purchased by the *i*th firm, x_{ni} is the amount of x_n purchased by the *i*th firm, and $\eta_i^{ts} = [(r_n^t - r_n^s)/(x_{ni}^t - x_{ni}^s)](x_{ni}^s/r_n^s)$.

Equation (2) 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. Equation (2) also gives the necessary and sufficient conditions for the firm's decision set S_i to be consistent with profit maximization (See proposition 1 in Chavas and Cox, 1990). The term 0_i^{ts} gives the firm's perceived price flexibility of residual supply for the nth input and provides a measure of monopsony power exertion. The price flexibility, 0_i^{ts}, can also be written as $0_i^{ts}\ '\ (VMP_{ni}^{ts} \& r_n^t)/r_n^t$, 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, 0_i^{ts} gives a direct measure of the monopsony Lerner index. If $0_i^{ts} = 0$, then firm *i* cannot impact input price by adjusting quantity purchased in period t, i.e. the firm has no market power.

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. Love and Shumway 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 $)y = y_i^t - a^{t+} + a^{t-} - y_i^s + a^{s+} - a^{s-}$. Biased technical change allows for a change in the marginal rate of substitution and can be operationalized via input translating technical change where $F_i(\mathbf{x}, \mathbf{B}) = f_i(\mathbf{x}, b^+)$ becomes $)x = x^t + b^{t+} - x^{s} - b^{s+}$.

The inequality in (2) involves variables which are not directly observable. Therefore, the market power test consists of finding whether values exist for a^+, a^-, b^+ and 0_i^{ts} which satisfy the inequality. Since (2) is linear in the unobserved variables, we can define **z** as the vector of unobserved variables, i.e.

a^+, a^-, b^+ (where applicable) and η_i^{ts}, and rewrite (2) 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

$$(3) \qquad \min_{z} \ \{\mathbf{b}'\mathbf{z}: \ \mathbf{d}'\mathbf{z} \geq \mathbf{c}, \ \mathbf{z} \geq 0\}$$

where **b** is a vector of weights in the objective function, **d** is a vector of known data points, and **c** is a vector of constraint values.[4] The program in (3) is implemented over the time periods where $s \neq t$.

Chalfant and Zhang (1997) point out that nonparametric tests like in (3) are not invariant to data scaling. We incorporate their suggestion of using price vectors as weight scale adjustments in the objective function to minimize variance. For example, if $\mathbf{b}=\boldsymbol{\alpha}$ in (3), incorporating Chalfant and Zhang's adjustment results in $\mathbf{b}=\boldsymbol{\alpha}\mathbf{p}$ where **p** is the chosen price vector for scale adjustment.

Additionally, monopsony market power cannot be appropriately measured when input supply shifts between time-period comparisons. Such shifts will result in input price movements that are clearly not attributable to market power exertion. However, supply shifts unmatched by shifts in input demand are easily detected since such shifts 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). 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.

Market Power in Multiple Input Markets

Love and Shumway's nonparametric approach to monopsony market power estimation is easily extended to measure monopsony market power in multiple input markets. Following (2), 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

$$(4)\qquad p^t[(y_i(Y_i^t, A^t) - (y_i(Y_i^s, A^s))] - \sum_{m=1}^{n} r_m^t[(x_{mi}^t(X_{mi}^t, B^t) - x_{mi}^s(X_{mi}^s, B^s)] - \sum_{v=n-f+1}^{n} r_{vi}^s \eta_{vi}^{ts}(x_{vi}^t - x_{vi}^s) \geq 0$$

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

$$(5)\qquad p^t[(y_i(Y_i^t, A^t) - (y_i(Y_i^s, A^s))] - \sum_{m=1}^{n} r_m^t[(x_{mi}^t(X_{mi}^t, B^t) - x_{mi}^s(X_{mi}^s, B^s)] - r_{n-1}^s \eta_{n-1,i}^{ts}(x_{n-1,i}^t - x_{n-1,i}^s) - r_n^s \eta_{ni}^{ts}(x_{ni}^t - x_{ni}^s) \geq 0$$

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 (5) replaces (2) as the necessary and sufficient condition for the firm's decision set Σ_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 (5) as **d'z≥c**, we implement the test as the linear programming problem represented in (3). 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≠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 as reported in farm sales weight. 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

Three test results are presented. First, Chavas and Cox's (1990) weak separability test is employed to determine whether the cigarette manufacturing industry has experienced biased technical change. Second, we implement Love and Shumway's test to investigate monopsony power exertion by U.S. cigarette manufacturers in procuring domestic tobacco. Third, we implement our extended approach to measure monopsony power exertion by U.S. cigarette manufacturers in both domestic and import markets.

We implement Chavas and Cox's test to investigate the weak separability of all inputs from the technology indices (Chavas and Cox, p. 453). If weak separability for all inputs holds, we can assume that the marginal rate of substitution between any two inputs is independent of technical change, i.e. Hicks-neutral technical change. Results of the weak separability test indicate that the input vector is weakly separable from the technology indices, suggesting that this data set does not exhibit input biasedness and that representation of technical change through output translation is a viable choice for this data set.

Market power tests are implemented using GAMS. All tests define **p**, the chosen price vector for scale adjustment, as the vector of mean output and input prices for the sample period. We conduct Love and Shumway's single input test and our adaptation to the two input case under two different scenarios regarding technical change. One set assumes the possibility of Hicks-neutral technical change only, while the second set allows the possibility of both Hicks-neutral and biased technical change. The two input case is also conducted under various weighting schemes regarding technical change, as denoted in the tables. Specific programming problems as defined in equations (2) and (5) for the cigarette manufacturing industry are reported in Table 2 and Table 3. Table 2 includes programming problems that allow only Hicks-neutral technical change. Table 3 includes programming problems that allow both Hicks-neutral and biased technical change.

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) allowing only the possibility of Hicks-neutral technical change are presented in Table 4. Test results for the single and two input cases where both Hicks-neutral and biased technical change are allowed are presented in Table 5. 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 and two input cases under both technical change scenarios indicate substantial departures from competitive pricing by cigarette manufacturers. Under both scenarios of technical change, Love and Shumway's test for monopsony power in a single input market indicates that cigarette manufacturers appropriate relatively large monopsony rents in the domestic tobacco market. When only Hicks-neutral technical change is allowed and all "=1 (i.e. market power and technical change weighted equally at one), O_{us} = 3.044.[5] Such a measure indicates that cigarette manufacturers internally value domestic tobacco at 304 percent of the price paid to growers. When the possibility of both Hicks-neutral and biased technical change is included under the same weighting scenario, O_{us} = 3.869.

Market power estimates are obtained under various weighting schemes for " (the vector of weights on market power and technical change) within the linear programming problem for the two input case. The first set of weighting schemes holds all technical change weights at one while choosing market power weights from the range {1, 2.5, 5, 7.5, 10}. The second set of weighting schemes hold all market power weights at one while choosing technical change weights from the range {1, 2.5, 5, 7.5, 10}. Tests in the two input case also indicate economically significant monopsony power exertion in the domestic tobacco market, though the magnitude is slightly smaller than in the single input case. Under the assumption of Hicks-neutral technical change only and all "=1, O_{us} = 2.879. Again, the interpretation of O_{us}=2.879 is that cigarette manufacturers internally value domestic tobacco at 288 percent higher than the price they pay to growers. The measure of O_{us} is also 2.879 under the possibility of both Hicks-neutral and biased technical change. In fact, the monopsony Lerner index measure is identical for both technical change scenarios under all weighting schemes for ", including when technical change is weighted 10 times more heavily than market power and when market power is weighted 10 times more heavily than technical change.

Results from the two input case suggest that U.S. cigarette manufacturers' monopsony market power in the tobacco import market is much less in magnitude than in the domestic market. However, it may be economically significant as well. The average monopsony Lerner index for the international tobacco market, θ_i, is estimated at 0.236 under all weighting schemes, suggesting that cigarette manufacturers internally value imported tobacco at 23.6 percent above the price they pay on the international market.

Solution values for Hicks-neutral technical change parameters are also reported in Tables 4 and 5. Table 5 also reports solution values for biased technical change parameters. Biased technical change parameters are zero in all cases, confirming that Hicks-neutral technical change is a reasonable assumption for this data set. In fact, market power parameters for both θ_{us} and θ_i are identical across technical change assumptions and across weighting schemes.

Monopsony Lerner index estimates for domestic tobacco and imported tobacco by period (assuming equal weights of one) are reported in Table 6. 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 substantially less 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 several periods prior to 1987. However, in 1987 and following years, monopsony market power detected by the test is generally less in magnitude than pre-1987 measures. The decrease in 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 7). Over the period sample, the average cost of domestic tobacco in a pack of cigarettes is \$0.04 while θ_{us}=2.879 (two input case, α=1). Recall that θ=(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=\$0.15, indicating that cigarette manufacturers value the domestically produced tobacco in a pack of cigarettes at \$0.11 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 $\bar{r}_{us}$=\$0.88 and θ_{us}=2.879, this implies that VMP per pound for cigarette manufacturers is \$3.41, i.e. \$2.53 higher than the price per pound paid to producers. For comparison, Fulginiti and Perrin's (1993) supply elasticity estimate for domestic tobacco under the assumption of no tobacco program is 7.14. This would result in θ_{us}=0.14 under full monopsony power exertion since θ is defined as the price flexibility of supply. Using $\bar{r}_{us}$=\$0.88 implies that VMP per pound for cigarette manufacturers assuming no tobacco program and holding all else constant would be $1.00 or only $0.12 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 in large part by U.S. cigarette manufacturers rather than by tobacco producers who are typically assumed to receive program benefits.

Summary and 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. The fact that the U.S. is a relatively large purchaser of tobacco in the world market makes monopsony power exertion plausible in that market as well. 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. The tests are implemented under two sets of assumptions regarding technical change. The first set allows Hicks-neutral technical change only, while the second set allows both Hicks-neutral and biased technical change. Results in the single input case under both technical change assumptions 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 under both technical change assumptions and bolsters the postulate that cigarette manufacturers are able to appropriate monopsony rents through the U.S. tobacco program. 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 monopsony market power of much smaller magnitude in the world tobacco market. However, results from the most recent years in the study reveal that market power in the import market may be increasing, lending credence to the Justice Department's recent inquiry into price fixing by cigarette manufacturers.

Our results differ from those of traditional economic analysis of this industry in two significant ways. First, traditional economic analysis of cigarette manufacturers has assumed the possibility of monopoly power exertion in output while assuming competitive behavior in tobacco procurement. Our analysis does not *a priori* assume competitive procurement behavior by cigarette manufacturers and, in fact, indicates that they exert substantial monopsony power in the domestic tobacco market and at least some monopsony power in the world tobacco market. Second, the standard assumption in studies of the U.S. tobacco production sector is that the tobacco program successfully transfers quota rent to producers. Our results suggest instead that benefits from the U.S. tobacco program accrue largely to cigarette manufacturers, rather than to tobacco growers as commonly assumed. High cigarette manufacturer concentration and the structure of the U.S. tobacco program may combine to give cigarette manufacturers the efficacy to use the program as a vehicle for monopsony power exertion to capture a large portion of quota rents previously assumed to be captured by producers. Overall, this 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. The minimum reserve-stock levels for flue-cured and burley tobacco are 100 million pounds and 50 million pounds, respectively.

3. However, the estimated administrative cost of the program is $16 million per year.

4. See Tables 2 and 3 for specific empirical equations used in the linear programming problem for this data set.

5. 0_{us} represents the average 0_{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. Single Input and Two Input Monopsony Market Power Tests Allowing Hicks Neutral Technical Change.

TEST	EQUATION
Single Input Case	$$\min_{a^{t+},\, a^{t-},\, \phi_{us}^{ts}} \left(\bar{p}_y \beta_y^{t+} a^{t+} + \bar{p}_y \beta_y^{t-} a^{t-} + \sum_{t=1}^{T} \sum_{s \neq t}^{T} \bar{r}_{us} \beta_0^{ts} \phi_{us}^{ts} \right)$$ subject to: $$p_y^t[(y^t - a^{t+} + a^{t-}) - (y^s - a^{s+} + a^{s-})] - r_{us}^t(x_{us}^t - x_{us}^s) - r_i^t(x_i^t - x_i^s) - r_L^t(x_L^t - x_L^s)$$ $$- r_m^t(x_m^t - x_m^s) - r_a^t(x_a^t - x_a^s) - r_c^t(x_c^t - x_c^s) - r_{us}^s \phi_{us}^{ts}(x_{us}^t - x_{us}^s) \geq 0,$$ $$\forall\, s \neq t \text{ except when } r_{us}^t - r_{us}^s \underset{\neq}{S}\, x_{us}^t - x_{us}^s$$ $$\phi_i^{ts} \geq 0,\ \forall\, s \neq t$$ $$a_i^{t+},\ a_i^{t-} \geq 0,\ \forall\, t$$
Two Input Case	$$\min_{a^{t+},\, a^{t-},\, \phi_i^{ts},\, \phi_{us}^{ts}} \left(\bar{p}_y \beta_y^{t+} a^{t+} + \bar{p}_y \beta_y^{t-} a^{t-} + \sum_{t=1}^{T} \sum_{s \neq t}^{T} \bar{r}_{us} \beta_{0us}^{ts} \phi_{us}^{ts} + \sum_{t=1}^{T} \sum_{s \neq t}^{T} \bar{r}_i \beta_{0i}^{ts} \phi_i^{ts} \right)$$ subject to: $$p_y^t[(y^t - a^{t+} + a^{t-}) - (y^s - a^{s+} + a^{s-})] - r_{us}^t(x_{us}^t - x_{us}^s) - r_i^t(x_i^t - x_i^s) - r_L^t(x_L^t - x_L^s)$$ $$- r_m^t(x_m^t - x_m^s) - r_a^t(x_a^t - x_a^s) - r_c^t(x_c^t - x_c^s) - r_{us}^s \phi_{us}^{ts}(x_{us}^t - x_{us}^s) - r_i^s \phi_i^{ts}(x_i^t - x_i^s) \geq 0,$$ $$\forall\, s \neq t \text{ except when } r_{us}^t - r_{us}^s \underset{\neq}{S}\, x_{us}^t - x_{us}^s \ \vee\ r_i^t - r_i^s \underset{\neq}{S}\, x_i^t - x_i^s$$ $$\phi_{us}^{ts}, \phi_i^{ts} \geq 0,\ \forall\, s \neq t$$ $$a_i^{t+},\ a_i^{t-} \geq 0,\ \forall\, t$$

Note: Parameters denoted by overbars (e.g. $\bar{\mathbf{p}}$ and $\bar{\mathbf{r}}$) represent mean price over the data set.

Table 3. Single Input and Two Input Monopsony Market Power Tests Allowing Hicks Neutral Technical Change and Biased Technical Change.

TEST	EQUATION
Single Input Case	$\min_{a^{t+},a^{t-},\theta^{ts}_{us},b^{+}_{us},b^{+}_{i},b^{+}_{L},b^{+}_{m},b^{+}_{c},b^{+}_{a}} (\bar{p}_y \lambda_y^{t+} a^{t+} + \bar{p}_y \lambda_y^{t-} a^{t-} + \bar{r}_{us} \lambda_{us}^{t+} a_{us} + \bar{r}_i \lambda_i^{t+} a_i + \bar{r}_L \lambda_L^{t+} a_L + \bar{r}_m \lambda_m^{t+} a_m + \bar{r}_c \lambda_c^{t+} a_c + \bar{r}_a \lambda_a^{t+} a_a + \sum_{t=1}^{T} \sum_{s \neq t}^{T} \bar{r}_{us} \lambda_0^{ts} \theta_{us}^{ts})$
	subject to:
	$p_y^t[(y^t - a^{t+} + a^{t-}) - (y^s - a^{s+} + a^{s-})] - r_{us}^t(x_{us}^t + b_{us}^{t+} - x_{us}^s - b_{us}^{s+}) - r_i^t(x_i^t + b_i^{t+} - x_i^s - b_i^{s+}) - r_L^t(x_L^t + b_L^{t+} - x_L^s - b_L^{s+}) - r_m^t(x_m^t + b_m^{t+} - x_m^s - b_m^{s+}) - r_a^t(x_a^t + b_a^{t+} - x_a^s - b_a^{s+}) - r_c^t(x_c^t + b_c^{t+} - x_c^s - b_c^{s+}) - r_{us}^s \theta_{us}^{ts}(x_{us}^t - x_{us}^s) \geq 0,$
	$\forall\, s \neq t$ except when $r_{us}^t - r_{us}^s \underset{\neq}{S} x_{us}^t - x_{us}^s$
	$\theta_i^{ts} \geq 0, \; \forall\, s \neq t$
	$a_i^{t+}, \; a_i^{t-}, b_{us}^{+}, b_i^{+}, b_L^{+}, b_m^{+}, b_c^{+}, b_a^{+} \geq 0, \; \forall\, t$
Two Input Case	$\min_{a^{t+},a^{t-},\theta^{ts}_{us},\theta^{ts}_{i},b^{+}_{us},b^{+}_{i},b^{+}_{L},b^{+}_{m},b^{+}_{c},b^{+}_{a}} (\bar{p}_y \lambda_y^{t+} a^{t+} + \bar{p}_y \lambda_y^{t-} a^{t-} + \bar{r}_{us} \lambda_{us}^{t+} b_{us}^{+} + \bar{r}_i \lambda_i^{t+} b_i^{+} + \bar{r}_L \lambda_L^{t+} b_L^{+} + \bar{r}_m \lambda_m^{t+} b_m^{+} + \bar{r}_c \lambda_c^{t+} b_c^{+} + \bar{r}_a \lambda_a^{t+} b_a^{+} + \sum_{t=1}^{T} \sum_{s \neq t}^{T} \bar{r}_{us} \lambda_{0us}^{ts} \theta_{us}^{ts} + \sum_{t=1}^{T} \sum_{s \neq t}^{T} \bar{r}_i \lambda_{0i}^{ts} \theta_i^{ts})$
	subject to:
	$p_y^t[(y^t - a^{t+} + a^{t-}) - (y^s - a^{s+} + a^{s-})] - r_{us}^t(x_{us}^t + b_{us}^{t+} - x_{us}^s - b_{us}^{s+}) - r_i^t(x_i^t + b_i^{t+} - x_i^s - b_i^{s+}) - r_L^t(x_L^t + b_L^{t+} - x_L^s - b_L^{s+}) - r_m^t(x_m^t + b_m^{t+} - x_m^s - b_m^{s+}) - r_a^t(x_a^t + b_a^{t+} - x_a^s - b_a^{s+}) - r_c^t(x_c^t + b_c^{t+} - x_c^s - b_c^{s+}) - r_{us}^s \theta_{us}^{ts}(x_{us}^t - x_{us}^s) - r_i^s \theta_i^{ts}(x_i^t - x_i^s) \geq 0,$
	$\forall\, s \neq t$ except when $r_{us}^t - r_{us}^s \underset{\neq}{S} x_{us}^t - x_{us}^s$ ¸ $r_i^t - r_i^s \underset{\neq}{S} x_i^t - x_i^s$
	$\theta_{us}^{ts}, \theta_i^{ts} \geq 0, \; \forall\, s \neq t$
	$a_i^{t+}, \; a_i^{t-}, b_{us}^{+}, b_i^{+}, b_L^{+}, b_m^{+}, b_c^{+}, b_a^{+} \geq 0, \; \forall\, t$

Note: Parameters denoted by overbars (e.g. $\bar{\mathbf{p}}$ and $\bar{\mathbf{r}}$) represent mean price over the data set.

Table 4. Nonparametric Test Results Allowing Hicks-Neutral Technical Change.[a] (Shifts = 216)

Technical Change Weights ($"_y^{t+}$, $"_y^{t-}$)	Market Power Weights ($"_{0us}^{ts}$, $"_{0i}^{ts}$)	Domestic Tobacco	Imported Tobacco	Positive Hicks-Neutral Technical Change	Negative Hicks-Neutral Technical Change
		0_{us}	0_i	a^{t+}	a^{t-}
1	1	3.044	----	23.598	24.545
1	1	2.879	0.236	0.330	9.821
1	2.5	2.879	0.236	0.330	9.821
1	5	2.879	0.236	0.330	9.821
1	7.5	2.879	0.236	0.330	9.821
1	10	2.879	0.236	0.330	9.821
2.5	1	2.879	0.236	0.330	9.821
5	1	2.879	0.236	0.330	9.821
7.5	1	2.879	0.236	0.330	9.821
10	1	2.879	0.236	0.330	9.821

[a]Values reported for variables represent overall average for data set, given assigned weights.

Table 5. Nonparametric Test Results Allowing Hicks-Neutral and Biased Technical Change.[a] (Shifts = 216)

Technical Change Weights ($"_y^{t+}$, $"_y^{t-}$, $"_L^{t+}$, $"_m^{t+}$, $"_c^{t+}$, $"_a^{t+}$, $"_i^{t+}$, $"_{us}^{t+}$)	Market Power Weights ($"_{0us}^{ts}$, $"_{0i}^{ts}$)	Domestic Tobacco	Imported Tobacco	Positive Hicks-Neutral Technical Change	Negative Hicks-Neutral Technical Change	Biased Technical Change					
		0_{us}	0_i	a^{t+}	a^{t-}	b_i^+	b_m^+	b_l^+	b_c^+	b_a^+	b_{us}^+
1	1	3.869	----	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000
1	1	2.879	0.236	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000
1	2.5	2.879	0.236	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000
1	5	2.879	0.236	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000
1	7.5	2.879	0.236	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000
1	10	2.879	0.236	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000
2.5	1	2.879	0.236	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000
5	1	2.879	0.236	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000
7.5	1	2.879	0.236	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000
10	1	2.879	0.236	0.100	2.981	0.000	0.000	0.000	0.000	0.000	0.000

[a]Values reported for variables represent overall average for data set, given assigned weights.

Table 6. Monopsony Market Power Estimate Average (0^t) by Time Period for Domestic and Imported Tobacco Purchases.[a]

	Hicks Neutral Technical Change Allowed		Hicks Neutral and Biased Technical Change Allowed	
Year	Domestic Tobacco (0_{us})[b]	Imported Tobacco (0_i)[b]	Domestic Tobacco (0_{us})[b]	Imported Tobacco (0_i)[b]
1977				
1978				
1979				
1980	5.687		5.687	
1981	14.813		14.813	
1982	3.519		3.519	
1983	3.034		3.034	
1984	4.648		4.648	
1985				
1986		0.323		0.323
1987				
1988	0.885		0.885	
1989	0.217		0.217	
1990	3.321		3.321	
1991	2.013	1.521	2.013	1.521
1992		0.495		0.495
1993				
Average 0	2.879	0.236	2.879	0.236

[a]All "'s set to one for this analysis.
[b]Values reported for variables represent overall average for time period.

Table 7. 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