Measuring Market Power Exertion in the U.S. Ethanol Industry

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OBJECTIVE

The objective of this study is to investigate potential market power exertion in the output market of the ethanol-producing sector using the Solow Residual-Based (SRB) test and its different modalities (primal and primal-dual). The markup estimates (Lerner's index) obtained using different instrumental variables for the primal SRB are compared to the primal-dual SRB estimates.

BACKGROUND

Recent market reports show that ethanol production in the U.S. is mostly driven by private corporations rather than individual farmers. As the next table shows, there are two companies that currently control 24% of ethanol production in the U.S.: Archer Daniels Midland (ADM) and POET. If the next ten corporations on the list are included, approximately 42% of the production is controlled by 12 corporations. Out of these 12 companies, 4 account for approximately 44% of the total planned expansion (Renewable Fuels Association, 2009). The overwhelming financial strength of these companies might encourage acquisitions and mergers of small companies.

MAJOR ETHANOL PRODUCERS IN THE U.S.

	Company	Nameplate Capacity (mgy)	Operating Production (mgy)	Expansion Capacity (mgy)
1	Abengoa Bioenergy Corp.	198.0	168.0	176.0
2	Archer Daniels Midland	1,070.0	1,070.0	550.0
3	Aventine Renewable Energy LLC	207.0	207.0	
4	Vera Sun Energy Corp.	915.0		
5	Advanced Bioenergy LLC	182.0	182.0	33.0
6	AltraBiofuels LLC	183.5	31.5	
7	Hawkeye Renewables, LLC	445.0	445.0	
8	Pacific Ethanol	190.0	40.0	70.0
9	POET	1,469.0	1,469.0	
10	The Andersons, LLC	275.0	275.0	
11	Valero Renewable Fuels	670.0	450.0	
12	White Energy	258.0	148.0	
	Total	6,062.5	4,485.5	829.0
	Industry Total	12,619.4	10,558.4	1,887.0
	Percentage	**48%**	**42%**	**44%**

Source: Renewable Fuels Association, 2009

mgy = millions of gallons per year

According to the U.S. Energy Information Administration (2009), ethanol demand has increased greatly in the last couple of decades and has exceeded supply since approximately 2003. The main reasons being: the ban of Methyl Tertiary Butyl Ether (MTBE), the Renewable Fuels Standard (RFS) provision of the 2005 Energy Policy Act, the blenders' tax credit and the import tariff on foreign ethanol. All the factors previously mentioned are evidence of the possible market power exertion from the ethanol-producing sector. In this study, the exercise of market power is identified using the Lerner's index:

$$L \equiv \frac{p - MC}{P}$$

SOLOW RESIDUAL

There are currently several alternatives to measure the Lerner's index in an industry. To mention a few: the New Empirical Industrial Organization (NEIO) approach, the Solow Residual-Based (SRB), and Non-Parametric (NP) tests. Among these alternatives, the SRB test, which builds upon the theory of total factor productivity first introduced by Solow (1957), circumvents the difficulty of functional choice posed by the widely accepted NEIO. The SRB approach is based upon a smaller set of assumptions and requires less data compared to the NEIO approach.

The primal SRB test was first introduced by Hall (1988) as a test for market power exertion. The main premise on which the test is based upon is that the difference between the year-to-year output growth rate and the weighted average of factor inputs, using the cost share of each input on revenues as weights, is not entirely explained by autonomous technical change but by a price-cost margin (or markup factor). Under Constant Returns to Scale (CRS) and price competition, the input shares are equivalent to the elasticity of output with respect to the inputs and must sum to one. Under market power exertion, the input shares do not sum to one due to the existence of a markup (marginal cost falls short of price). Hall's approach suffers from a potential endogeneity problem between output growth and productivity growth. Hence, Hall suggested identifying an instrumental variable (IV) that is related to changes in output but unrelated to productivity growth (i.e. supply shifter). Under some restrictive assumptions, the best candidates for this category of instrumental variables would be pure demand shocks.

Roeger (1995) developed a primal-dual approach, or the difference between the quantity-based and price-based residuals, with the objective of avoiding some estimation difficulties experienced with the primal SRB method, mainly the choice of adequate IVs. Roeger's maintained hypothesis was that the difference between the primal and the dual was not only caused by fixed factors of production (labor hoarding and excess capacity) but also by a positive markup. Roeger's primal-dual approach also circumvented the markup estimation problem caused by classical measurement error.

METHODOLOGY

Primal

The model maintains the assumptions of regularity, monotonicity, concavity, and a differentiable production function of a single-output (ethanol) with n inputs (materials, capital and labor) that exhibits CRS and Hicks-neutral technical change. In this case, the test assumes a competitive behavior in the inputs' market and that factors of production can be adjusted instantaneously. According to Domowitz et al. (1988), the production function can represented as following:

$$y_t = A_t e^{\gamma_t} f(x_t)$$

where the subscript t is years (1997-2008), y is output (gallons of ethanol), A represents a productivity shock, γ is the rate of Hicks-neutral technical progress and x is a vector of inputs (materials, labor and capital). After some mathematical manipulation, we obtain the following Solow Residual (SR) representation:

$$\left(\dot{\tilde{y}}_t / \tilde{y}_t\right) - \sum_{i=2}^{n} \alpha_{it} \left(\dot{\tilde{x}}_{it} / \tilde{x}_{it}\right) = \beta \left(\dot{\tilde{y}}_t / \tilde{y}_t\right) + (1-\beta)\left(\dot{A}_t / A_t + \dot{\gamma}_t\right)$$

where the subscript i represents the inputs used (materials, labor and capital), α is the input cost share of the revenues ($\alpha = x_i r_i / py$), and an instantaneous change in any variable, A, is denoted by $\dot{A}$ and is approximated discretely by $A_t - A_{t-1}$. The superscript ~ represents the variables that have been normalized by x_1 (or labor). Solow and Hall maintain the assumption that output is valued at marginal cost in a competitive market. However, by relaxing that assumption and including a markup estimate β (or the Lerner's Index), Hall concluded that if $\beta = 0$, the market behaves competitively. If $\beta > 0$, there is a positive markup implying market power exertion and that the marginal contribution of output to revenues exceeds its marginal cost by the ratio p/MC (i.e. $p > MC$). By denoting the left hand side of the previous equation by SR, we can estimate the markup using ordinary least squares (OLS) with the following specification:

$$SR_t = b_0 + b_1 \left(\dot{\tilde{y}}_t / \tilde{y}_t\right) + \varepsilon_t$$

where ε is the error term and represents productivity growth. However, due to the possible endogeneity of the output growth rate, we need an IV that is correlated to the output growth rate and not to productivity growth. Hence, in this study the two IVs used were the rate of change of imported quantities of ethanol in liters and the rate of change of the U.S. refinery and blender net input of crude oil. Due to the existing tariffs on imported ethanol, the imported quantity figures reflect the need of blenders to resort to foreign ethanol, in certain years, since domestic production is not enough. Hence, ethanol imports represent a pure demand shock. The Energy Policy Act of 1992 and 2005 established minimum-blend requirements increasing the demand for ethanol. Hence, due to these blend-requirements, the annual quantity of processed crude oil is also a variable that represents a pure demand shock.

Primal-Dual

However, Roeger's specification circumvented the difficulty of choosing an adequate IV. Roeger's approach is based on the cost function. According to Domowitz et al. (1988), the cost function can be represented as following:

$$C_t = \frac{G(r_t) y_t}{A_t e^{\gamma_t}}$$

where r is a vector of input prices (materials, labor and capital). Under perfect competition in the output market $MC = G(r)/Ae^{\gamma}$. Again, by relaxing the assumption of competitive behavior and using the markup estimate β, after some mathematical manipulations we obtain the following dual representation of the SR:

$$\sum_{i=2}^{n} \alpha_{it} \left(\dot{\tilde{r}}_{it} / \tilde{r}_{it}\right) - \left(\dot{\tilde{p}}_t / \tilde{p}_t\right) = (1-\beta)\left(\dot{A}_t / A_t + \dot{\gamma}_t\right) - \beta \left(\dot{\tilde{p}}_t / \tilde{p}_t\right)$$

where p is the price of the output (ethanol). The superscript ~ represents the variables that have been normalized by r_1 (labor price or wage). By denoting the left hand side of the previous equation by SRP (Solow residual price-based), a simpler representation of the residual is obtained:

$$SRP_t = b_0 + b_1 \left(\dot{\tilde{p}}_t / \tilde{p}_t\right) + \upsilon_t .$$

By subtracting the SRP from the SR, Roeger obtained an expression that is independent of the productivity growth and, hence, circumvents the IV estimation procedure. The resulting equation can be estimated using OLS:

$$SR_t - SRP_t = b_1 \left(\dot{\tilde{y}}_t / \tilde{y}_t + \dot{\tilde{p}}_t / \tilde{p}_t\right) + b_2 \left(\dot{\widetilde{GDP}}_t / \widetilde{GDP}_t\right) + \vartheta_t$$

where ϑ should be identically zero for all t under the maintained assumption that factors of production can be adjusted instantaneously. However, Roeger mentions that two important sources of a non-zero ϑ are classical measurement error and the presence of Keynesian demand effects due to labor hoarding and excess capacity. Following Roeger's methodology, the rate of change of gross domestic product (GDP) was added to the previous equation as an explanatory variable to identify if a source of difference between the primal and dual residuals is fixed factors of production.

DATA

Data on output and input quantities and prices were obtained for the period between 1997 and 2008 using the North American Classification System (NAICS) and the Standard Industrial Classification (SIC) for ethyl alcohol manufacturing. Three types of inputs were considered: materials, labor and capital. The total cost of materials, total employee compensations (including payroll and total fringe benefits) and new capital expenditures were obtained from several issues of the Annual Survey of Manufacturers. Quantity and price indexes were estimated from these three totals. Ethanol production and prices were obtained from the U.S. Energy Information Administration in millions of gallons and from Hart's Oxy Fuel News, respectively. Ethanol imports (liters) were obtained from the U.S. International Trade Commission.

Crude oil prices were obtained as the composite refiner acquisition cost, from the U.S. Energy Information Administration. The U.S. refinery and blender net input of crude oil figures (in thousands of barrels) were obtained from the Energy Information Administration. U.S. GDP figures were obtained from the U.S. Census Bureau as billions of current dollars.

RESULTS

The results obtained are summarized in the following table:

SRB Test Results for Market Power

Statistic	Primal	Primal-Dual
Parameter estimate		
b_0	-0.023	
Std Error	0.124	
p-value	0.855	
b_1	1.013	0.919
Std Error	0.564	0.048
p-value	0.073	0.000
b_2		-0.747
Std Error		0.843
p-value		0.399
Centered R^2	0.817	0.958
Durbin-Watson statistic	2.410	2.637
Breusch-Pagan / Cook-Weisberg test		
Chi-square statistic	0.280	4.720
p-value	0.595	0.030
Wu-Hausman test	0.038	1.613
p-value	0.850	0.240

From the previous table it is evident that there is a positive markup estimate in the ethanol industry implying market power exertion in the industry as a whole. Both estimates are significantly different from zero and relatively close to each other. The markup parameter estimated with the primal-dual approach is more significant than the one from the primal SRB test. A potential explanation from this difference in significance could be the IVs used.

From the previous table it is important to note that when estimating the primal SRB test, endogeneity is not an issue implying that output growth and productivity growth are not related. Both equations were estimated by 2SLS and the standard errors are heteroskedasticity and autocorrelation-consistent statistics. Their respective Wu-Hausman post-estimation tests were obtained. As previously stated, the IVs used were ethanol imports (in liters) and processed crude oil (in thousands of barrels). The Wu-Hausman tests if there is any efficiency gain by estimating the equation by 2SLS rather than by OLS (Baum et al., 2003). Both tests are not significant meaning that OLS is more efficient than 2SLS. Hence, endogeneity between output growth and productivity growth is not an issue when estimating the primal test. One possible explanation for such result is that the policies that affect the ethanol industry the most are demand-enhancing rather than technology-enhancing.

Following Roeger's methodology, GDP's growth rate was added to the primal-dual specification to check for Keynesian demand effects. The estimated parameter is not significantly different from zero meaning that the difference between the primal and the dual SR specifications are not caused by fixed factors of production. The high centered R-squared for the dual specification is evidence of the presence of a positive markup in the ethanol industry.

CONCLUSIONS

Based on the primal SRB test:

- There is a positive markup and it is statistically significant at the 10% level. Implying the presence of market power exertion in the industry as a whole.
- By using ethanol imports and processed quantities of crude oil as IVs, OLS is more efficient than 2SLS. The lack of endogeneity could be a consequence of the demand-enhancing policies currently affecting the industry.

Based on the primal-dual SRB test:

- There is a positive and slightly higher markup than the one obtained from the primal SRB test. It is also highly significant (at the 1% level) confirming the presence of market power exertion.
- The explanatory variable included to account for Keynesian demand effects is not statistically significant implying that the difference between the primal and dual residuals can be mainly attributed to the existence of a positive markup estimate.

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