THE IMPACT ON PRODUCT PRICES OF MERGERS IN THE PETROLEUM INDUSTRY

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ABSTRACT

Recent oil mergers could have led to oil product price increases by moving the industry closer to an oligopolistic structure which would allow for increased prices. To explore this possibility, we estimate the effects on oil product prices of two large oil mergers in 1984, Texaco-Getty and Socal-Gulf. Reduced-form price equations are used to estimate the impact of the two mergers on petroleum product prices for three U. S. regions. The results indicate that the mergers had no apparent effect on the prices of most products in the sample.

INTRODUCTION

In the current political and economic atmosphere the pricing of petroleum products such as gasoline and home heating oil is a major issue. Often, high petroleum product prices lead to difficulties for some firms and hardships for many consumers. In the past energy concerns have led to recessions and economic down turns. The concerns at present are the fluctuations in home heating oil and gasoline prices. It is feared by many, including the public at large, that rising petroleum product prices could exacerbate our current economic difficulties.

Blame has been levied against many including OPEC and the large oil companies. One can see the effect of OPEC limiting supply on the crude oil prices, an important input into petroleum-based products. This paper focuses on the role of the large oil companies in raising the price of oil-based products. These price raises could happen in conjunction with or independently of OPEC. The oil industry seems to have both monopolistically competitive and oligopolistic characteristics. It may be argued that recent oil mergers could lead to price increases by moving the industry closer to an oligopolistic structure. In 1999, Federal Trade Commission Chairman Robert Pitofsky noted,

> **"There is a significant trend toward concentration in the petroleum industry.....It is certainly fair to say that, if the merger trend continues in the oil industry, we would take that consolidation into account each time we review a deal."**[1]

Pitofsky feels that left unattended these horizontal mergers could raise oil product prices. This paper illuminates the issue by exploring two earlier oil mergers for which there are enough data to assess their impact on product prices.

In the 1980's, the Justice Department and the Federal Trade Commission became much more passive toward horizontal mergers. It was argued that many of the mergers allowed by this policy could lessen competition and, therefore, lead to higher prices.[2] Empirical studies examining the effects of horizontal mergers have obtained mixed results; apparently some mergers increased prices, while others had little or no effect.[3] Among the mergers singled out by the critics were those in the oil industry. In 1984, FTC Commissioner Michael Pertschuk asserted

> **"there are far more losers in our country from these [oil company] mergers than winners. Far more Americans will have to pay higher gasoline and home heating oil prices from reduced competition and exploration than will receive a stock windfall or handsome brokerage fees."[4]**

Before 1980, antitrust fears made oil companies very cautious about horizontal mergers, but the policy changes of the Reagan administration allowed many of these firms to engage in horizontal mergers. The critics maintained that even though national (and sometimes regional and local) concentration ratios in the oil industry appear low to moderate, several circumstances necessitate greater than normal antitrust vigilance of oil mergers. Among these are the history of oil industry collusion, the numerous instances of company cooperation (such as joint ventures), and oil company connections with OPEC. These critics have asserted that the loss of a competitor as a result of a merger will have a greater impact on the petroleum market than on other markets. Noted industrial organization economist, Walter Adams, maintains that oil "seems to be the kind of industry in which a Texaco/Getty or a Socal/Gulf, or Mobil/Superior merger would inevitably lessen competition. . . ."[5]

In contrast to these sentiments, other experts do not find the oil industry very different from other industries. A good reflection of this viewpoint is found in the opinions of the Federal Trade Commission and its staff in their analyses of oil company mergers.[6] They believe that the criteria used to evaluate mergers in other industries are also applicable to the oil industry. Their analysis can be summed up as follows. Because the national and global concentration ratios in crude oil and many petroleum products are medium to low, oil company mergers should not be totally proscribed. Nevertheless, geographic regions may exist where concentration in some products is sufficiently high for some mergers to significantly increase prices. Therefore, at least some petroleum company mergers should be examined, if not enjoined.

Given these differing characterizations of oil industry competitive performance, it seems appropriate to examine directly how oil mergers have affected the price of petroleum products. Therefore, this article estimates petroleum price effects of two large oil mergers, Texaco-Getty and Socal-Gulf. Since the mergers occurred at almost the same time (within one month of one another), only a test of their joint effect can be made. First we examine the institutional setting in which the particular mergers took place. A model to test the effect of these mergers on certain oil product prices is then developed. Finally, empirical results are described and conclusions drawn.

THE S OCAL-GULF AND TEXACO-GETTY MERGERS

This paper focuses on two oil company mergers: (1) the combination of Texaco and Getty Oil and (2) the union of Socal (Standard Oil Company of

California) and Gulf Oil Company, both taking place in the summer of 1984. Here we first describe the mergers, and then we examine how and where they might have affected oil product prices.

In 1984, Texaco, a fully integrated oil company with $48 billion in sales, bought Getty Oil Company, another fully integrated company with $12.3 billion in sales.[7] Both firms were major producers of light refined products such as gasoline, heating oil, and kerosene. They directly competed against one another in the Northeastern and Southwestern United States as well as in other areas. The FTC allowed the merger under the following major conditions: (1) that the new Texaco-Getty to divest itself of certain refineries, pipelines, and terminals, (2) that Texaco as an owner of the Colonial Pipeline (running from the Gulf of Mexico's to New York Harbor) not vote against any expansion of its capacity for a period of ten years, and (3) that the company continue to supply certain independent California refiners with crude oil.

The 1984 combination of Socal ($34 billion in sales) and Gulf ($28 billion in sales) was the largest merger of private companies in history up to that time.[8] Being fully integrated oil companies, both firms faced one another in a number of product markets and geographic areas including the U. S. Atlantic Coast and Gulf Coast areas (called PADDs I and III).[9] In addition, Socal owned a 21.13 percent share of the Plantation Pipeline running from the Gulf of Mexico to the Washington, D.C. area, while Gulf owned a 16.78 percent share in the Colonial Pipeline which runs from the Gulf of Mexico to New York harbor. In order to consummate the merger and avoid an FTC antitrust suit, Chevron, the new company, consented to divest (1) its share in the Colonial Pipeline, (2) the Gulf marketing assets in certain southern states, and (3) one or the other of two Kerojet (jet airplane fuel) refineries in the Southwest along with some connecting pipelines.[10]

The Controversy Surrounding the Mergers

The controversy over these mergers can be divided into two parts; the first is their impact on the industry as a whole, and the second is their effect on particular geographic markets. Walter Adams contended that these mergers could lead to higher petroleum product prices throughout the industry -- not just in areas where the merging parties have major overlaps -- arguing that the normal criteria used by the Justice Department and the FTC in analyzing mergers is inadequate for the oil industry. He gave seven reasons why the low to moderate concentration ratios in production or sales even at the regional level are poor indicators of the competitive situation in the oil industry.[11] Reasons given are: (1) high concentration in "gross reserves" of crude oil, (2) joint ventures between the companies, (3) indirect interlocks in the boards of directors through commercial banks, (4) exchange agreements between companies, (5) the interest of the oil companies in other energy industries, (6) vertical relationships between companies, and (7) the political power of the industry. Adams asserted that due to these conditions mergers between large oil companies can raise prices not only in the sectors where the parties compete but also in the whole industry. Thus, mergers between large oil companies should, in effect, be enjoined.

The second reason for opposition to oil company mergers was that they could raise prices in particular geographic markets. This thesis was developed in the dissenting opinions on the Texaco-Getty and the Socal-Gulf mergers of Federal Trade Commissioner Michael Pertschuk.[12] While Pertschuk agreed with Adams that the mergers could increase industry-wide prices, he believed that many of the remedies worked out by the companies and the FTC did not adequately address the competitive problems at the regional level. He questioned whether the divestiture provisions of both the Socal-Gulf and Texaco-Getty cases would stop prices from rising.

Thus, the concern was first with the impact of the mergers on the industry as a whole and second with efficacy in the regional markets of certain remedies worked out by the FTC and the merging parties. To address these issues, we develop an empirical analysis of the impact of these mergers on certain oil product prices.

The Markets to Be Modeled

In this paper, we use reduced-form price equations to assess the impact of these mergers on petroleum product prices for two areas where merging companies had overlaps and one area where they did not.[13] In PADDs I and III, the first two areas that are examined, the merging parties each had a large presence. In PADD I, two major competitive problems existed.[14] First, all the merged firms competed against each other in this market. Second, the mergers involved the ownership of pipelines that serve this geographic market. In addition, a quite influential econometric study on market definition estimated the residual demand curves for gasoline in this geographic area (Scheffman and Spiller 1987). This study shows that PADDs can be reasonably considered separate markets. Even though the FTC consent orders addressed these problems, some experts thought that the divestitures and restrictions on company behavior toward the pipelines were not enough to prevent increases in product prices.

The second area where the firms faced each other was PADD III. The Socal-Gulf merger involved an overlap in the production of light petroleum products in PADD III. Texaco and Getty had refineries and oil fields in that area. Therefore, we also estimate our price equations for the products in this geographic area.

To examine the issue of whether these mergers had an impact on the entire industry, we also estimate the effect of the Texaco-Getty and Socal-Gulf mergers on the price of light refined products in PADD II where none of the merging parties were important. If the acquired firms (Getty and Gulf) were so large and influential in the oil industry that their disappearance would affect the general price level of petroleum products, then these mergers could have had an effect even in markets where the companies did not have a large presence. An argument for this viewpoint is that as independent entities Gulf and Getty were potential entrants into the markets where they were not important. After the mergers, then, there would be fewer potential interlopers with the capacity to enter the market.

THEORETICAL MODEL

In the petroleum sector, each firm uses oil refining technology to transform crude oil into a large number of final oil-based products among which are gasoline, heating oil, and kerosene. To reflect this situation, we assume each firm uses a multi-product production function to produce various mixes of the products. Hence, there

exists a cost function for firm j that can be summarized as

$$TC_{ji} = TC(q_1, q_2, \ldots, q_n, PI, c^*_{ji}, \varpi_i), \tag{1}$$

where TC_j equals total cost for firm j; q_{ij} equals the output of firm j of product i; PI equals the vector of factor prices faced by the firms in the regional petroleum producing sector; c^*_{ji} is the set of total cost parameters, and the $\square_{ji}$ s are error terms.

To depict the demand side of the model, we assume that petroleum firms sells n products with the following inverse demand functions:

$$
\begin{aligned}
P_1 &= d_1 (Q_1, \ldots, Q_n, Y_1, d^*_1, \varepsilon_1), \\
P_2 &= d_2 (Q_1, \ldots, Q_n, Y_2, d^*_2, \varepsilon_2), \\
&\ldots\ldots\ldots\ldots \\
P_n &= d_n (Q_1, \ldots, Q_n, Y_n, d^*_n, \varepsilon_n)
\end{aligned}
\qquad (2)
$$

where P_i is the price of product i; Q_i equals the industry quantity demanded of product i; Y_i is the vector of demand side exogenous variables for product i; d^*_i is the set of product i demand equation parameters (some of which are zero), and the $\square_i$ s are error terms.

Given the profit-maximizing behavior, firm j equates its marginal revenue with the marginal cost for product i. Since these firms often operate in markets characterized by imperfect competition, the model takes into account the likelihood that the firms face down-sloping demand curves and oligopolistic market situations. Using equations (1) and (2), we obtain this first order condition:

$$P_i + P_{ii}(Q_1, \ldots, Q_n, Y_2, \ldots, e) q_{ij} m_{ij} = MC_{ij}(q_1, \ldots, q_n, PI, \imath, v_i) \qquad (3)$$

where P_{ii} is the derivative of P_i with respect to Q_i; m_{ij} is firm j's conjecture concerning the change in industry output that arises from a change in its own output; MC_{ij} is the marginal cost of product i, the derivative of TC_j with respect to Q_i, while. and ı are parameters and e and v_i are residual terms.

Each firm solves the first-order condition as expressed (3). Solving these conditions simultaneously for all firms results in a reduced-form specification for the market price of each oil product,

$$P_i = P_i(Y_i, PI, p^*_i, u_i) \qquad (4)$$

where p^*_i is the parameters of the total cost equation, and u_i is an error term.

Since the mergers were just one month apart, only a test of their joint effect can be made. To test whether this joint effect entailed higher oil product prices, the reduced-form model (equation 4) is estimated for the post-merger period. The value from this equation (P_{Back}) is, then, computed for each observation in the pre-merger period, and the difference between this predicted "Backcast" price and the actual price is calculated,

$$\Delta P_{Back} = P_{Back} - P_{Actual}. \qquad (5)$$

(See Froeb, Koyak, and Werden (1993) and Sproul (1993) for applications of a similar methodology, the forecast technique, to other markets.) Using the variances for the predicted Backcast price, P_{Back}, for each observation, statistical tests are made to see if the difference between the actual and predicted prices is significantly different from zero.[15] The price "Backcast" from the post-merger regression being significantly greater than the actual price supports the hypothesis that the mergers raised prices, and the price predicted by the Backcast being significantly less than or not significantly different from the actual price suggests that the mergers did not increase prices.

EMPIRICAL MODEL

This section develops and explains the empirical model. This task has three components: determining the sample, choosing the dependent and independent variables, and ascertaining the appropriate estimation technique. The sample consists of a set of monthly observations for the period between October 1981 and December 1990. This is the period immediately following the abolition of the pricing and allocation regime enacted by Energy Policy and Conservation Act of 1975 (EPCA). Including earlier observations creates difficulties with data availability and model specification, and including later observations would lead to problems with long run structural change in markets. A problem with the small sample is that degrees of freedom prevent the use of sub-samples for sensitivity tests.

Since empirical work has demonstrated that oil products markets are usually regional, regional prices will be used. (See Scheffman and Spiller (1989), Spiller and Huang (1986), and Currie (1994).) As stated above, this paper uses three PADDs, I, II, and III. PADD I consists of the North Atlantic and Southeastern parts of the United States; PADD II consists of the bulk of the Midwestern area, and PADD III consists of the Southwestern and Gulf areas of the United States where most domestic crude oil is produced. These regions produce and consume the bulk of the oil products used in this country.

The Model Variables

Table I displays the dependent variables for the various price equations. For this sample petroleum products, the prices are from **Platt's Oilgram**. No. 2 Fuel Oil is used for heating, while No. 6 Fuel Oil and Residual Oil are used for utility fuel. The Gasoline referenced in this paper is the most widely sold unleaded product. Two types of prices are used: spot prices, which are the average actual transactions price for given products in given areas for a given month; and posted prices, which are the prices that are listed by the major sellers of given products.[16] Since the latter are usually only the starting points for negotiation, spot prices are thought to be the best indicators of the actual prices. Nevertheless, they are not always available on a monthly basis. Thus, spot prices are used when available, and the posted prices are used otherwise.

To use the Backcast methodology, an econometric model should be employed that most accurately and efficiently estimate the expected price at a time in the past. The goal, then, is to find the specification that has the smallest predicted variance with the lowest possibility of bias. On the average over a large number of estimation models, this goal can be best fulfilled by including in the reduced-form model the variables suggested by economic theory.

Table 1
Dependent Variables for Reduced Form Price Equations
(Source: Platt's Oilgram)

Regional Market or PADD	Product and Type of Average Monthly Price)
PADD I	No. 6 Fuel Oil, Spot Price for New York
	No. 2 Fuel Oil, Spot Price for New York
	Kerosene, Posted price for Northern Jersey
	Gasoline, Unleaded, Spot Price for New York
PADD II	No. 2 Fuel Oil, Posted Price for Illinois
	Gasoline, Unleaded, Posted Price for Illinois
PADD III	No. 2 Fuel Oil, Spot Price for the Gulf Coast
	Residual Fuel Oil, Spot Price for the Gulf Coast
	Gasoline, Unleaded, Spot Price for the Gulf Coast

With this in mind, the independent variables are now discussed. First, a way is needed to reflect the many small changes in the technological and regulatory environment of the oil industry not accounted for by the below-discussed demand, supply, and regulatory variables. An efficient way to accomplish this goal is to include a time counter variable (T) valued at 1 in the first period in the sample and rising to n for the nth period in the sample period (1981-1990). Throughout this time period, there were numerous small changes in the technology and the oil firm regulation which could affect both supply and demand conditions. New environmental regulations caused refineries to change their operations and alter their product mix. For instance, these laws changed how the refineries disposed of their wastes. On the demand side, they mandated the greatly increased production of no-lead gasoline. Technology also improved in incremental ways during this period. Thus, the time counter is a good way to account for these changes.

Besides the time variable, the right-hand side of the reduced-form equations should include both the relevant demand and supply variables for each product. Probably, the most important of the demand side variables are industrial production and regional income. To portray the first influence, a national index for industrial production (PROD) is used because much of the oil used in given regions is absorbed by industries that export their product to other regions. In contrast, a regional variable, total personal income for the PADD (Y_s for $PADD_s$), is used for household purchasing power because the oil products used by consumers within regions (for driving cars) remains local.

Since the Y_s and PROD portray approximately the same influence, only one of these demand shifter variables is included in each price equation. For Gasoline, Y_s is used, and for Fuel Oil, PROD is used because they seem to be the variables that impact most directly on the particular product prices.

Another factor affecting the demand for petroleum products is weather. Temperature affects not only heating oil and electricity use but also the amount of driving; thus, weather may affect the demand for both heating oil and transportation fuels. So included in the models are two weather variables for a city centrally located in each PADD: the Average Monthly Temperature (AT_{city}) and Heating Degree Days (HD_{city}). The latter variable is a measure of the deviation of the temperature from 65^o; it is often used in models of energy consumption.[17] Again for any given products, only one of the weather indicators is used, since they are very highly correlated, temperature being used for Gasoline and Heating Days for the Fuel Oils.[18]

Since the supplying sector jointly produces all the products, the supply side variables would be identical for all the product reduced-form equations. These variables consist of the prices of the major inputs into the oil refinery process: crude oil price (PCRUD), the rate of interest faced by oil refiners (BOND), oil refinery wages for the major refining state in each PADD (WAG_s), and the Price of Industrial Power for each geographic area (PIP_s).[19] With these input prices, one accounts for the major variations in the supply of petroleum products.[20]

Table II lists the independent variables used in the Backcast equationsIn order to account for possible non-linearities, the Backcast models are estimated in a log-log form. As stated above, the estimating equations for different products include different independent variables, but all of these models have one or the other of the above-mentioned demand side and supply side variables. For instance, the equation for No. 6 Fuel Oil for $PADD_S$ would be the following:

Table II
Independent Variables for Reduced Form Price Equations

Variable	Definition	Source
Regulatory and Technological Variables		
T	A Counter equaling t for period t	
Demand Side Variables		
PROD	Index of Industrial Production (Used in All Markets)	Survey of Current Business
Y_s	Personal Income for $PADD_S$	Bureau of Economic Analysis
AT_{state}*	Average Temperature for certain cities in $PADD_S$	National Oceanographic & Atmospheric Administration
HD_{state}*	Heating Days for certain cities in $PADD_s$	National Oceanographic & Atmospheric Administration
Supply Side Variables		
PCRUD	Crude Oil Price Dubai Fateh light 32 Spot (Used in All Markets)	Platt's Oilgram
BOND	Monthly Triple A Grade Bond Rate: Rate of Interest Variable (Used in All Markets)	Moody's
WAG_s**	Hourly Wage Rate for certain states in $PADD_s$ for SIC 291	Bureau of Labor Statistics
PIP_s	Price of Industrial Power for $PADD_s$	Bureau of Labor Statistics

* For PADD I, these variables are included for Philadelphia (AT_{Ph} and HD_{Ph}); for PADD II, Chicago is used (AT_{Ch} and HD_{Ch}), and for PADD III, Houston is used (AT_{Ho} and HD_{Ho}).

** For PADD I, the state wage rate used is for Pennsylvania; for PADD II, it is for Illinois, and for PADD III, it is for Louisiana.

$$\ln P_{\text{No. 6, s}} = B_0 + B_1 \ln PROD + B_2 \ln HD_s + B_3 \ln PCRUD + B_4 \ln BOND$$
$$+ B_5 \ln WAG_s + B_6 \ln PIP_s + B_7 T + u_{\text{No. 2, s}}.$$

Estimation Problems and Techniques

The estimation of the above model could be problematical if some variables are non-stationary. Regressions with such variables may not be efficient and/or unbiased for small samples, and test statistics such as the R^2, the t values, and the predicted out-of-sample values (Backcast) do not have the characteristics necessary for making rigorous statistical tests.[21] The hypothesis of non-stationarity cannot be rejected for all of the oil product prices. In addition, the hypothesis of non-stationarity cannot be rejected for the following independent variables: PROD, PCRUD, $Y_{s,}$ WAG_s, and PIP_s in all three PADDs. For the remaining independent variables, the hypothesis of stationarity cannot be rejected.[22]

Several methods of estimating regressions with non-stationary variables have been developed. All the methods use the concept of cointegration (Davidson and Mackinnon (1993), p. 715-723). A regression model is cointegrated if its residuals do not have unit roots. When models are cointegrated, certain methods can be used to estimate unbiased and efficient models. These methods usually employ a system of lagged variables and/or first differences to reflect the intertemporal correlations that may exist between realizations of the non-stationary variables. Wickens and Breusch (1988) propose a method based on the Error Correction Model (ECM) which has some very attractive features. [23]

The feature most relevant to this paper is that the estimates for the relevant variables coefficients are not sensitive to the structure of the lag and first difference system. Given that the model's complicated lag structure reduces degrees of freedom, this property is important. For the oil product reduced-form models, this ECM equation consists of a combination of the levels and changes for the non-stationarity (both independent and dependent variables) plus the levels of the stationary independent variables. Nevertheless, the validity of the model is not sensitive to the exact nature of the resulting lag structure. This gives us some freedom in determining the specification of this structure.

Using this latitude to find the best model for the prediction, one starts with the most inclusive model allowed by the degrees of freedom constraint. Then, one eliminates the change variables that do not contribute to the predictive power of the equation until a model is reached that makes the best predictions within the sample period. For instance, the most inclusive possible model for No. 6 Fuel Oil in $PADD_S$ might be:

$$\ln P_{\text{No. 6, s}} = B_0 + B_1 \ln PROD + B_2 \ln HD_s + B_3 \ln PCRUD + B_4 \ln BOND$$
$$+ B_5 \ln WAG_s + B_6 \ln PIP_s + B_7 T +$$
$$\tilde{+}_{00}.\ln P_{\text{No. 2,s, t}} \tilde{+}_{01}.\ln P_{\text{No. 2,s, t-1}} \tilde{+}_{02}.\ln P_{\text{No. 2, t-2}}$$
$$\tilde{+}_{03}.\ln P_{\text{No. 2,s, t-3}} \tilde{+}_{04}.\ln P_{\text{No. 2,s, t-4}} \tilde{+}_{05}.\ln P_{\text{No. 2, t-5}}$$

$$\tilde{+}_{1.}\text{lnPROD} \tilde{+}_{2.}\text{ln PCRUD} \tilde{+}_{3.}\text{lnWAG}_s$$

$$\tilde{+}_{4.}\text{lnPIP}_s + e_{\text{No. 2 s}}. \quad (7)$$

Notice that there are more than one lagged change variables for price. Theory does not specify how many lags can be used; it is only limited by the degrees of freedom and the efficiency requirements of the model. One can then eliminate the lagged dependent change variables and independent change variables which do not contribute to its predictive power during the sample period.

For the cointegrated models, the above-mentioned specification search procedures are applied to the Backcast equations. The resulting models are then used to test the effects of the mergers on the products and markets listed in Table I. Since the Backcast method is used, the model is estimated for the post-merger period, and projections are made back into the pre-merger period to see the prices would have been significantly different.

Since the change in the dependent variable, $.\text{lnP}_{js}$, and its lagged values are likely to be correlated with the residual, an instrumental variable technique (IV) is used. In this situation, we assume that the change, $.\text{lnP}_{js}$, is correlated with the residual. For the lagged values, however, we employ Hauseman tests of the hypothesis of simultaneity. For an unlagged change and where needed for the lagged change, an instrument is used. This instrument is the predicted value of a regression of the relevant variable, either the unlagged or lagged change in price, $.\text{P}_{js}$, on the other independent variables plus one other variable that is not correlated with the residual, e_{js}. For this instrument, the change in the price of the product or a related product in another PADD is used; for PADD's I and II, the instrument is the product price change in PADD III, and for PADD III, the instrument is the product price change in PADD I or PADD II. Since these markets are separated from each other, the change in one price would not be correlated with the residual for the other.

A further complication is that for cointergrated models the characteristics that allow for rigorous tests of hypotheses concerning combinations of regression coefficients may be absent. The out-of-sample Backcast prediction values are essentially weighted combinations of the regression coefficients. At present, the literature is skeptical about the conclusions drawn from tests involving such combinations from cointegrated models. (See Davidson and MacKinnon (1993), p. 725.) A way to rectify this weakness is to use Bootstrap re-sampling models for the prediction equations. (See Johnston and DiNardo (1997), p 362-370.) These models are estimated for the best fitting specifications of the reduced from equations. From these Bootstrap models, distribution free tests of the hypotheses can be performed on the Backcast models (Efron 1987). The results can then be compared to those for the conventional parametric cointegrated models called below the Parametric Instrumental Variable or PIV model.

One other problem is autocorrelation. For none of the reduced form cointegrated product models can the hypothesis of autocorrelation be rejected. Thus, the equations are estimated by a Generalized Least Squares method, and the error of the Forecast or Backcast is calculated taking into account that adjustment. However, we have found no way of computing an error variance that takes into account the variance of the autocorrelation coefficient (commonly called Rho) and its covariance with the other regression coefficients. Consequently, following Pinkyck and Rubinfeld (1991), p. 190-192, the Backcast errors are estimated under the assumption that the Rho coefficient is non-stochastic. This may lead to a possible bias in the error estimate that cannot be avoided.

THE RESULTS

This section describes results. Both the parametric Instrumental Variable (PIV) and Bootstrap Backcast models are estimated for each product for the post-merger period. Then, these models are used to predict the prices for the pre-merger period, and tests are made to see whether the predicted prices differ from the actual prices. For the PIV technique, the Backcast error is computed for each observation in the pre-merger period; and from these error estimates, t values for the difference between the actual and predicted prices are calculated. Then, the predicted and actual prices for the pre-merger period are averaged, and a t value for the average deviation of the two prices is used to see if this average is significantly different from zero. The actual pre-merger price being significantly less than the predicted Backcast price implies that the mergers raised prices, while the actual price being not different from or significantly more than the predicted price suggests that merger did not raise prices.

From the Bootstrap re-sampling models, distribution free tests of the hypotheses can be performed on the Backcast model. Using the Bias Correction method, 95 per cent and 97.5 per cent confidence intervals are calculated for the Backcasts from the Bootstrap estimates of the regression models. The 95 per cent intervals are used for one-tail tests, and 97.5 per cent intervals are used for two-tail tests. (See Efron (1987) and Davison and Hinkley (1997), p. 203-211.) This procedure determines whether the actual prices are inside or outside of the intervals.

If the actual price is less than the lower limit of the confidence interval, then the hypothesis that the mergers raised prices cannot be rejected. If the actual price is within the interval or greater than its upper limit, then the hypothesis that the mergers did not raise prices cannot be rejected. These tests can be compared to the regular parametric ones to see if consistency exists and perhaps buttress our conclusions about the effect of mergers.

Before applying these procedures to each of the products, an examination of one of the econometric reduced form equations can lend context to the discussion. Table III displays the results for PADD I No. 6 Fuel Oil. [Table III about here] For the parametric Instrumental Variables (PIV) procedure, two coefficients (for Crude Oil Price, and the Change in Price Unlagged) are significantly different from zero. While three other coefficients have the wrong sign, they are not significantly different from zero. Nevertheless, the model as a whole is highly significant: the R^2 being 0.944 and the F Value being 63.21. Thus, the model does have a high degree of explanatory power. The averages of the coefficients for the 1000 bootstrap estimates are displayed to the right of the PIV estimates. There is a remarkable consistency between the PIV and bootstrap coefficients.

Table III

Regression for Post-Merger Period Reduced Form Forecast Price Equation for No. 6 Fuel Oil PADD I (Sample: From July 1984 to December 1990)

Variable	Estimated Coefficient for+ Instrumental Variables (PIV)	Bootstrap
Intercept	17.282	13.632
Industrial Production (lnPROD)	-2.499 (-0.89)	-2.023
Heating Degree Days (lnHD $_s$)	0.010 (0.58)	0.018
Crude Oil Price (lnPCRUD)	0.611 (3.08)	0.627
Interest Rate (lnBOND)	0.044 (0.15)	0.011
Oil Refinery Wages (lnWAG $_s$)	-0.218 (-0.14)	-1.231
Industrial Power Price (lnPIP $_s$)	-1.071 (-0.53)	-0.369
Time Counter (T)	0.006 (0.41)	0.006
Variable Changes		
)lnP$_{No.\ 2\ s}$ (same period)	0.909 (3.78)	0.579
)lnP$_{No.\ 2\ s}$ (lagged one period)	0.251 (1.55)	0.154
)lnP$_{No.\ 2\ s}$ (lagged two periods)	0.118 (0.54)	0.005
)lnP$_{No.\ 2\ s}$ (lagged three periods)	0.066 (0.36)	0.034
)lnP$_{No.\ 2\ s}$ (lagged four periods)	0.014 (0.09)	-0.021
)lnP$_{No.\ 2\ s}$ (lagged five periods)	0.010 (0.11)	0.031
)lnY $_s$	0.826 (0.28)	-1.009
)ln PCRUD	-0.615 (-3.53)	-0.372
)lnWAG $_s$	-0.300 (-0.26)	-0.092
)lnPIP $_s$	1.271 (0.71)	0.435
Rho (Autocorrelation Coefficient)	0.924 (2.10)	-0.1601
Number of observations:	77	69++
Adjusted R-squared	0.944	

* Statistically Significant at the 5 per cent level.

\+ The parameter standard errors for the PIV estimators are in parentheses after the coefficients. The standard errors of the Bootstrap coefficients are not given. Because of the nature of the parameter distribution, statistical tests cannot be directly made from these standard errors. Since this paper is not focused on the coefficients, further analysis will not be performed.

++ Because the bootstrap values of price and change in price are calculated from the original regression estimate, there are no bootstrap estimates of change in price before July 1984, and thus there are fewer observations for the bootstrap model.

PADD I (The East Coast from New England to Alabama)

Our description starts with the PADD I products. Table IV displays these results.

Table IV

The Number of Observations for Which the Difference between the Log of the Actual Out-of-Sample Price and the Log of the Price Predicted by the Estimated Backcast Model is Not Significantly Different from, Significantly Less than, and Significantly Greater than Zero for the Sample Refined Petroleum Products

Backcast	Observations Where ($\text{Ln } P_{Actual}$ - $\text{Ln } P_{Backcast}$) is Significantly (at the 5 Per Cent Level)					
	Not Different From Zero*(i. e. the mergers did not change did not change Prices)		Less Than Zero*(i. e. the mergers raised Prices)		Greater Than Zero*(i. e. the mergers lowered Prices)	
PADD/Product	PIV	Bootstrap	PIV	Bootstrap	PIV	Bootstrap
PADD I						
No. 6 Fuel Oil	33	32	0	1	0	1
No. 2 Fuel Oil	24	32	0	0	13	1
Kerosene, New Jersey	31	30	0	0	2	5
Gasoline	32	8	3	25	0	0
PADD II						
No. 2 Fuel Oil	19	30	16	9	0	0
Gasoline	28	12	6	19	0	4
PADD III						
No. 2 Fuel Oil	33	33	0	0	0	0
Residual Oil	32	33	0	0	1	2
Gasoline	32	27	1	0	0	9

* The numbers in the rows do not necessarily sum up to the number of Out-of-Sample Period observations (33) because the category, "Not Different From", is determined by a two-tail test, while the categories "less than" and "greater than" categories are determined by one-tail tests.

Here, four oil product prices are suitable for the model: No. 6 Fuel Oil, No. 2 Fuel Oil, Kerosene, and Gasoline. All these prices are cointegrated for the sample period for both the estimation and the Backcast periods. For the three of the products, No 6 Fuel Oil, No. 2 Fuel Oil, and Gasoline, spot prices are used, while for kerosene we use the posted price. Thus, it is possible to test the hypotheses with these price series.

For No. 6 Fuel Oil, the results are consistent with the merger having no effect on price. For only one period out of the 33 periods between October 1981 and the date of the mergers, July 1984, could the hypothesis that the mergers did not change prices be rejected. This is true for both the PIV and bootstrap models. Additionally, the average actual price for the pre-merger period did not differ significantly from the average price predicted by PIV Backcast model. See Table V. [The t value for the average difference estimated from the PIV model is 0.01 indicating that on the average prices did not change due to the mergers.

For No. 2 Fuel Oil, similar results are found, but the PIV and the Bootstrap results are somewhat inconsistent. The PIV model indicates that the hypothesis of the mergers not having any effect cannot be rejected for 24 of the 33 periods, while the Bootstrap model shows the hypothesis of no change cannot be rejected for 32 periods. Thus, for the more robust Bootstrap model, the results are even stronger. Again, the PIV model t value (1.62) for the average difference between the actual and predicted price indicates no significant difference. However, one-tail tests indicate that the mergers may have lowered prices in some periods: 13 periods of the PIV model and one for the bootstrap.

For kerosene, both models suggest that the mergers did not raise prices. This hypothesis of the mergers not changing price cannot be rejected for 31 periods according to the PIV model and for 32 periods according to the Bootstrap model. As with the first two oil prices, the t value (0.36) for the average price difference also indicates that the hypothesis of no change cannot be rejected.

For Gasoline, the results provide limited support for the theory that the mergers raised prices. The PIV model, however, rejects the hypothesis of increasing prices for most of the sample (30 out of 33 on a one-tailed test). Furthermore, the t value (-0.93) for the average change in price due to the mergers is not significant. In contrast, the more robust Bootstrap model, indicates a statistically significant increase in prices for 25 of the 33 periods. Thus, there is some evidence that the mergers had an impact on the price of this Gasoline. Overall, however, the results for this product are still mixed.

Table V

The Parametric Instrumental Variables (PIV) t-Values for the Average Differences between the Ln of the Actual Pre-Merger Price and the Ln of the Price Predicted by the Post-Merger Period Backcast Model

PADD/Product	**t-Value for Forecast Model*** **(The Probability Values are in Parentheses.)**
PADD I	
No. 6 Fuel Oil	0.01 (0.995)
No. 2 Fuel Oil	1.62 (0.109)
Kerosene (NJ)	0.36 (0.717)
Gasoline	-0.93 (0.359)
PADD II	
No. 2 Fuel Oil	-1.67 (0.101)
Gasoline	-0.91 (0.366)
PADD III	
No. 2 Fuel Oil	-0.34 (0.732)
Residual Oil	1.24 (0.219)
Gasoline	-0.29 (0.776)

* A significant negative t value implies that the mergers increased product price, while a positive t value implies that they lowered price. The figure in parentheses is the probability value.

PADD II (The Midwest)

Interestingly, in the Midwest (PADD II) where the merging companies did not overlap, the results are mixed. For No. 2 Fuel Oil, the PIV model shows that for 16 of the 33 periods, the hypothesis that the mergers increased price cannot be rejected. The PIV t value (-1.67) for the difference in price due to the mergers is marginally significant on a one-tail test: at the 5.1 per cent level. In contrast, the Bootstrap results imply that the mergers did not change the product price for most of the period. For 30 of the 33 periods, the hypothesis of no price change cannot be rejected. The Bootstrap model is the more robust in that it would hold up under the widest range of statistical conditions; thus, greater reliance should put its results that indicate no price change due to the mergers.

For Gasoline, the models are also inconsistent. The PIV model indicates that for only 6 of the 33 periods, the hypothesis that the mergers increased price cannot be rejected, and the t value (-0.91) for the difference in price is not significant on a one-tail test. In contrast, the Bootstrap model indicates that for 19 of the 33 periods, the hypothesis of the mergers increasing price cannot be rejected. These results are remarkably similar to those for Gasoline in PADD I implying the mergers raised prices.

It is strange that there is evidence for a price increase in the one PADD where the merging firms were not important actors. The result for No. 2 Fuel Oil may be consistent with no change in price in that the Bootstrap, the most robust procedure, indicates that the mergers raised prices in only few periods. For Gasoline, however, it is the Bootstrap model that indicates a price change; this is true for both PADDs. Possibly, factors independent of the mergers may be present in the Gasoline market that would lead to an other-things-equal increase in price during the 1980's.

PADD III (The Gulf Coast)

PADD III has two important characteristics; first the merging firms in this area are very large in both absolute size and market shares, and second, the PADD is a net exporter of all oil products. It would stand to reason that the mergers would have a substantial impact in this PADD. Nonetheless, our analysis indicates the mergers had little impact on the price of the sample products. These results are consistent between the two models, Parametric Instrumental Variables (PIV) and Bootstrap.

For No. 2 Fuel Oil, the models find identical results. Both the PIV model and the Bootstrap model indicate that in all 33 periods, the hypothesis that the mergers did not change price cannot be rejected, and the PIV t-value (-0.34) for the differences in price is not significant on a one-tail test. Thus, the hypothesis that the mergers did not change the price for this product in PADD III is consistent with model.

Residual Oil results are as conclusive as those of No. 2 Fuel Oil. The PIV model indicates that for 32 of 33 periods the hypothesis that the mergers did not change price cannot be rejected. Furthermore, The Bootstrap shows that for 33 of 33 periods, the other-things-equal price did not change. The PIV model t-value (1.24) for the average difference in price is not significant on a one-tail test. For one period in the PIV model and two periods in the Bootstrap model, the analysis indicates a decrease in price, but these results show there was no significant change in prices.

For Gasoline the PIV model indicates 32 of 33 periods the hypothesis that the mergers increased prices cannot be supported. For Bootstrap, this is true for 27 of 33 periods. The PIV model t-value (-0.29) for the difference in price is not significant on a one-tail test. One period in the PIV model shows an increase in prices, but nine periods in the Bootstrap model showed prices decreased after the mergers. An argument that the mergers decreased prices may not be valid, but an argument that the mergers increased Gasoline prices in PADD III is also not consistent with the evidence.

CONCLUSION

For most products, the mergers had no apparent effect on price. For all the products in PADD III and three of the four in PADD I, both analytical techniques (PIV and Bootstrap) suggest that the mergers neither increased nor decreased product prices.

For No. 2 Heating Oil in PADD II, however, the PIV technique indicates that mergers may have raised prices in some periods, but the Bootstrap method implies that no change in this price. Since the Bootstrap is the more robust method and, thus, the more creditable, the PIV results may arise out of weaknesses in the technique rather than real world phenomena.

The analysis also suggests that the mergers could have raised the price of one sample product in PADDs I and II -- gasoline. In PADD III, however, both methods suggest that the mergers had no impact on gasoline prices. Other than limitations in the approach, two circumstances could explain the gasoline results. First, possibly the mergers could have had an impact in the gasoline markets of these two PADDs but not on the other products. Second, factors other than the mergers such as new regulations or technological change could have led to an other-things-equal increase in the price of gasoline. To determine which of the hypotheses fits best, a study focused more closely on gasoline can be done.

With these exceptions, the overall results imply that the mergers had little impact on petroleum product prices. Again two possibilities exist. First, the market structure was such that these mergers would have little impact. Oil products even at the PADD level are not highly concentrated, and the existence of refineries in other areas and even overseas precluded firms from substantially raising price merely because when there are fewer immediate players. Second, even if the mergers in themselves might have allowed firms to raise prices, divestitures and other remedial actions mandated by the Federal Trade Commission possibly prevented such price increases.

For policy, the message is rather contradictory; on one hand, little antitrust action may be needed to counter the price effects of horizontal mergers in the oil industry. On the other hand, the measures forced on the merging firms by the Federal Trade Commission may well have been effective at preventing price increases.

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ENDNOTES

1. See Oil & Gas Journal (1999).

2. See Testimony of Jack A. Blum, Michael Pertschuk (Federal Trade Commissioner), and Edwin Rothchild in U. S. Congress (1984). Michael Pertschuk stated "There is little doubt that the current merger wave has been triggered in large part by the administration's lax antitrust policies (p. 35)."

3. See Barton and Sherman (1984) and Schumann, Rogers, and Reitzes (1991 and 1997). These, however, were "case studies" and were not meant to be systematic studies of the general effectiveness of horizontal merger policy.

4. U. S. Congress (1984), p. 34.

5. U. S. Congress (1984), p. 96.

6. See the Texaco-Getty and the Socal-Gulf cases in Federal Trade Commission, (1984), p. 241-263 and p. 597-617.

7. For our purposes, a fully integrated oil company is one that has operations in all the major sectors of the industry including the exploration of and drilling for crude oil, the refining of the crude into products, and the marketing and/or retailing of these products.

8. In 1983, Socal was the seventh largest company on the **Fortune 500** in sales, and Gulf was the ninth largest. Texaco was the fourth largest American company, while Getty was the 24th largest.

9. The letters, PADD, stand for Petroleum Administration Defense District, a designation coined by the Department of Defense. Aside from PADDs I and III, this paper will examine the Midwestern part of the United States (PADD II).

10. These two refineries also made products other than Kerojet, but it was only the overlap with Kerojet that concerned the FTC.

11. U. S. Congress, 1984, p. 91.

12. See Federal Trade Commission (1984), p. 241-244 for the Texaco-Getty case and p. 612-614 for the Socal-Gulf case.

13. An alternative way to analyze these impacts would be to develop structural models of the oil product markets, and use the parameters from the structural equations to estimate the impacts of the mergers. The accuracy of this method, however, is very sensitive to the proper specification of the model. If this specification is wrong, the impact estimators can be very inaccurate. (See Kennedy 1998, p. 173.)

14. An alternative way to analyze these impacts would be to develop structural models of the oil product markets, and use the parameters from the structural equations to estimate the impacts of the mergers. The accuracy of this method, however, is very sensitive to the proper specification of the model. If this specification is wrong, the impact estimators can be very inaccurate. (See Kennedy 1998, p. 173.)

15. Another approach to the analysis is to estimate a model for the whole sample period and use dummy variables to see if the mergers changed prices. The mergers could have changed the industry so much that a complex system of intercept and slope dummies would have to be used. Using this system would accomplish the same end as estimating separate models for each period. We use this latter approach because it is simpler and theoretically just as accurate.

16. See Borenstein, Cameron, and Gilbert (1997) and Balke, Brown, and Yucei (1996) for studies using similar data.

17. For PADD I, the weather variables used are for Philadelphia (AT_{Ph} and HD_{Ph}); for PADD II, Chicago is used (AT_{Ch} and HD_{Ch}), and for PADD III, Houston is used (AT_{Ho} and HD_{Ho}).

18. It has been suggested that seasonality should be directly taken into account by dummy variables. The weather variables probably account for this factor, but experiments were still performed to see if seasonality dummies would improve the performance of the model. Due to the Instrumental Variable estimation technique used, the tests were non-nested J tests which are sometimes inconclusive. Nevertheless, for six of the products (PADD I, No. 6 oil, PADD I, No. 2 oil , PADD I, Gasoline, PADD II, No. 2 oil, PADD III, No. 2 oil, and PADD III, Gasoline), statistical tests indicate either that including the seasonality variables do not improve the model or that no difference exists between the models. For three products (PADD I, Kerosene, PADD II Gasoline, and PADD III, Residual Oil), the tests indicate that including the seasonality variables could possibly improve the models, but when they were included in the models the results were not materially different from those of the

models without seasonality.

19. State-wide wage data for SIC Group 29, Petroleum Refining and Related Industries are used. For PADD I, the state used is Pennsylvania; for PADD II, it is Illinois, and for PADD III, it is Louisiana. In addition to the location of the region's refineries, these choices were dictated by data availability.

20. While conditions in one PADD can influence the product prices in another, variables from one PADD are not included in the product price equations for another PADD. First, across PADDs, the demand and supply shifter variables tend to be very highly correlated. Second, lack of degrees of freedom limit the number of variables that can be included in any one equation.

21. For discussions of the non-stationarity problem and the techniques for overcoming it, see Kennedy (1992), Chapter 16, and Davidson and Mackinnon (1993), p. 669-673 and p. 700-731.

22. The results of these tests are available on request from the author in an Appendix.

23. For discussions of this model, see Maddala (1992), p. 262-264; and Davidson and Mackinnon (1993), p. 723-725.