The Market Effects of Going Green: Evidence from California's Wholesale Reformulated Gasoline Market

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This paper analyzes the market changes that occurred in California's refining industry following the 1992 implementation of the California Air Resources Board's Phase II reformulated gasoline regulations. This paper uses monthly panel data to determine the impact that these regulations have had on the disparity between California's finished gasoline rack prices and that in other regions of the country. The findings suggest that large refiner compliance to Phase II increased the rack price of finished gasoline in California as compared with other regions. This relative price increase, which was likely triggered by the increased production costs associated with Phase II, is consistent with similar results found throughout the literature. However, as small refiners were required to comply with these regulations, this analysis finds that the premium paid for finished gasoline in California increased significantly. This additional increase in the rack price differential, along with trends in industry concentration, suggests that Phase II may have disproportionately disadvantaged California's small refiners, causing increased profits and market share for larger competitors.

1. INTRODUCTION

In 1992, the California Air Resources Board (CARB) implemented Phase II of its reformulated gasoline regulations. These regulations were aimed at reducing emissions from gasoline fueled vehicles and were expected to substantially increase costs for both large and small refiners in the state. Because of this cost increase, the Western States Petroleum Association (WSPA) opposed Phase II. Additionally, the California Air Resources Board voiced concern over the ability of small refiners to remain in the market under what appeared to be a

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disproportionate burden resulting from compliance to Phase II.[1] ARCO Products Company, on the other hand, provided strong support for Phase II, as well as the original, more stringent set of regulations proposed.[2] This support for the Phase II CARB gasoline regulations has previously been thought of as a strategic action by ARCO to raise rivals' costs.[3]

This paper aims to empirically analyze the market changes resulting from Phase II by examining the impact that these regulations had on the wholesale price of finished gasoline in California, as compared with several Petroleum Administration for Defense Districts (PADD's) throughout the country, as well as trends in industry concentration and market share.

While a few recent studies have focused on the impact of environmental regulations on wholesale fuel markets,[4] this study focuses specifically on the impact of gasoline content regulation on California's wholesale gasoline market. This focus is important for two reasons.

First, California has historically been much more stringent regarding environmental regulations than other states in the United States and, indeed, the Phase II CARB reformulated gasoline regulations exceeded federal reformulated gasoline regulations amounting to what the WSPA referred to as "the most costly regulation ever considered for the refinery industry."[5]

Second, the possible use of the Phase II reformulated gasoline regulations as a raising rivals' costs measure by ARCO raises some questions as to whether these regulations produced significant changes in California's refining market, as would be consistent with a raising rivals' costs strategy.[6] This is important because, while other studies have examined the price difference between conventional and reformulated wholesale gasoline prices, this study is able to consider the general heightening of wholesale gasoline prices in California that may have occurred, regardless of formulation, as certain segments of the refining market were disproportionately burdened by Phase II.[7]

The analysis finds that large refiner compliance to Phase II increased the rack price of finished gasoline in California, as compared with other regions, in a manner consistent with the literature. This may suggest that increased production costs associated with Phase II placed upward pressure on relative wholesale gasoline prices. However, as small refiners were required to comply with these

1. Final Statement of Reasons, ARB, 1992
2. Final Statement of Reasons, ARB, 1992
3. Bial and Innes (2002) asserted that ARCO's support of Phase II was a cost raising strategy.
4. Brown, et al. (2008) and Muehlegger (2006)
5. Final Statement of Reasons, ARB, 1992
6. While it is difficult to prove the intention behind a raising rivals' costs strategy, the impact of Phase II on California's wholesale fuel market is examined as a piece of the overall story so that, strategy notwithstanding, the consequences of these types of environmental regulations can be better understood.
7. For an overview of the market changes that can result from a raising rivals' costs strategy, see: Salop and Scheffmen (1983), Krattenmaker and Salop (1986), Salop and Scheffman (1987), and Granitz and Klein (1996).

regulations, this paper finds that the wholesale premium paid for finished gasoline in California increased, again, in a statistically significant manner. This combined increase exceeds the estimated increase in the average variable cost associated with Phase II[8] which may suggest increased profitability to surviving firms.[9] Additionally, because the impact of Phase II on wholesale gasoline prices in California exceeds that which has been found in earlier studies, this result suggests that the combination of adjustments in market structure and increased costs of production related to Phase II were more costly to consumers than previously thought. Finally, along with trends in industry concentration, this result suggests that Phase II may have disproportionately disadvantaged California's small refiners in a manner consistent with raising rivals' costs.

2. BACKGROUND

2.1 Literature Review

Pashigian (1984) first offered insight regarding the impact that environmental regulations can have on industry by empirically measuring the significant benefits environmental regulations have bestowed upon a select group of industry members in the past. The author not only provides an empirical examination of the effect that environmental regulations have on plant size and market structure but, in doing so, provides a deeper understanding of the effectiveness of environmental regulations, as compared with Occupational Safety and Health Administration (OSHA) regulations, in causing a shift in market shares to larger firms within an industry, thus providing incentive for larger firms to support these regulations.

Pashigian's analysis reveals that the environmental regulations enacted between 1972 and 1977 resulted in a market structure change which included a shift toward fewer plants in the industry. In addition, those plants able to weather the cost increases associated with such regulations tended to be large (or had the capacity to increase in size for survival's sake) and tended to experience an increase in capital intensity in an already relatively capital intensive environment.[10]

Several recent studies consider the impact that environmental regulations can have on prices in the petroleum industry. Taylor and Fischer (2003), for example, explore the make-up of the differential in finished gasoline retail prices between California and the Gulf Coast. The authors identify several factors

8. Taylor and Fischer (2003)

9. For simplicity, the focus of this paper is solely on the wholesale market of gasoline in California. However, because of the vertical nature of many of the refiners in the state, future research will explore the effect that the Phase II regulations may have also had on California's retail gasoline market.

10. Interestingly, these same types of results did not surface when a similar regression was performed with respect to OSHA regulations which implies that, as compared with occupational health and safety regulations, environmental regulations have the capacity to invoke significant changes on an industry and, depending on the structure of the policy, these industry changes tend to favor larger, more capital intensive firms.

contributing to the price differential including California's reformulated gasoline regulations.

Muehlegger (2006) examines the impact that gasoline content regulation has had on gasoline prices throughout various regions of the United States. Among other results, the author finds that California's gasoline content regulations increased the wholesale price of gasoline by 4.8 cpg as a result of both increased production costs and product heterogeneity across regions.

Brown, et al. (2008) use a city-level analysis to estimate the impact of gasoline content regulation on the wholesale price of gasoline. Through a differences-in-differences approach, the authors find that the implementation of gasoline content regulation increased the wholesale price of gasoline. The authors also find that a reduction in the number of suppliers positively impacts the wholesale price of gasoline.

The purpose of this paper is to build on these previous studies by analyzing not only the production cost driven price increases resulting from the implementation of gasoline content regulations, but also the price impacts that occur when a portion of the industry carries a relatively larger burden of compliance than their competitors.

2.2 Technical Review

The purpose of the Phase II reformulated gasoline regulations, which were a follow up to the 1991 "Phase I Reformulated Gasoline" regulations, was to "establish a comprehensive set of gasoline specifications designed to achieve maximum reductions in emissions of volatile organic compounds ("VOCs"), oxides of nitrogen ("NOx"), carbon monoxide, sulfur dioxide and toxic air pollutants from gasoline-fueled vehicles."[11]

As a result of several disadvantages the Phase II CARB Gasoline Regulations were expected to impose upon the smaller refiners within California's petroleum industry, modifications were made to the original regulation to provide relief to small refiners such that they would eventually be able to come into compliance with the new regulations. Without such relief, the California Air Resources Board believed that, "… the Phase 2 RFG regulations may cause some small refiners to go out of business" and that "Elimination of the small refiner segment of the California refining industry would result in job losses and could have significant anti-competitive effects because small refiners contribute to competition in the petroleum industry."[12] The relief afforded the small refiners came in the form of an extension of the compliance deadline, from March 1996 to March 1998, which would apply to roughly half of the required specifications.

In terms of the costs ultimately imposed upon California's refining industry as a result of Phase II, Lidderdale and Bohn (1999) estimate that, during the period of January 1997 to December 1998, the wholesale price of CARB

11. Final Statement of Reasons, ARB, 1992.
12. Final Statement of Reasons, ARB, 1992.

gasoline in Los Angeles was 4.2 cpg higher than that of conventional gasoline in the same city.[13] Much like Muehlegger (2006), Taylor and Fischer (2003) consider this price difference to be driven by increased production costs and use it as an estimate of the increased average variable cost associated with producing CARB reformulated gasoline. In addition to an increase in the average variable cost of production, Phase II compliance also required many capital improvements which resulted in over three billion dollars of capital expenditures for refiners throughout the state.[14]

3. MARKET OUTCOMES

3.1 Price

In a simple analysis of gasoline rack prices in California, it may not be obvious whether the peaks and valleys in the data represent a significant, sustained increase in price as the result of any one regulation. This is because, due to the driving force that many national shocks have on local markets, it is not possible to isolate the effect that any one local shock may have without controlling for movements in gasoline rack prices in other parts of the country. Because of this, it is the price differential (or the relative rack price of gasoline in California as compared with that in other parts of the country), that holds the key to determining the true effect that the Phase II CARB gasoline regulations have had on the gasoline market.[15] This price differential reveals the average premium paid for wholesale finished gasoline in California stemming from local shocks in the refining industry.

3.1.1 Data Description

To determine the factors that have influenced this price differential, this study uses monthly rack price data[16] from 1994–2003 to form a panel of the gasoline rack price differential between California and each PADD (excluding the western PADD) in the United States. This panel of data represents the dependent variable, denoted "Rack Differential", and is adjusted for inflation using the Producer Price Index (PPI),[17] as provided by the Bureau of Labor Statistics, for gasoline, with a base year of 1982.[18]

13. This price difference is consistent with results found by Brown, et al. (2008) and Muehleggher (2006).

14. Taylor and Fischer, 2003, pg. 236.

15. This is similar to the methodology used by Taylor and Fischer (2003) in their analysis of retail gasoline prices.

16. California Total Gasoline Rack Sales Price by All Sellers (C/gal) and PADD 1, PADD 2, PADD 3, and PADD 4 Averages/Totals Total Gasoline Rack Sales Price by All Sellers (C/gal), US Department of Energy, Energy Information Administration.

17. Bureau of Labor Statistics, Series Id: WPU0571; PPI, Commodities, Fuels and related products and power, Gasoline.

18. Unless otherwise stated, all results are reported in 1982 prices.

Because past rack price differentials are expected to be helpful in explaining the current premium paid for wholesale gasoline in California, several lags of "Rack Differential" are used. These lags are denoted "Rack Differential L(1)" through "Rack Differential L(5)" as there are five lags of this variable included in the model.

With the exception of the pricing data, the most fundamental components of this analysis are the variables that represent the passage of the Phase II reformulated gasoline regulations. For this, two variables are used: "Large Compliance" and "Small Compliance". "Large Compliance" is a dummy variable which represents the March 1996 Phase II compliance deadline for large refiners in California. "Small Compliance" is a dummy variable that represents the March 1998 Phase II compliance deadline for small refiners. Both "Large Compliance" and "Small Compliance" are expected to have impacted the rack price differential in a positive and significant manner.

In order to account for major refining supply disruptions throughout the country, data detailing the monthly production loss in California as well as in each of the control groups is used.[19] Because some months experienced multiple refinery outages, the average loss per day (in thousands of gallons) is calculated for each month in the data set. This calculation is represented in this analysis by two variables. The average daily loss of gasoline production in California as a result of refinery outages each month is denoted "CA Outage Severity" while the average daily loss of gasoline production in each of the control groups each month is denoted "Control Outage Severity". Because this data is continuous and reveals the severity of the refinery outages each month, the coefficient for each variable will provide a clear picture of the way in which increasingly severe refinery outages impact the wholesale price of gasoline. A severe outage in California is expected to have a positive and significant impact on the dependent variable while an outage in one of the control PADDs should reduce the gasoline rack price differential.

In March of 1995, Unocal announced that it intended to collect royalties on patents it had obtained with respect to the process used to produce the summer blend of reformulated gasoline. In order to take into account these patents, a dummy variable is created, "UNOCAL", which denotes the months (March through October) in which the patents would be in force. However, because lengthy litigation[20] delayed the payments of patents to Unocal until the year 2000, "UNOCAL" begins in March of the year 2000, and continues each month thereafter during which the royalties for these patents would be collected. It is expected that

19. This data was collected by Muehlegger (2006) and spans 1995 to 2001.

20. In April of 1995, ARCO, Exxon, Mobil, Chevron, Texaco, and Shell all filed suit against Unocal challenging the validity of their patents. (Union Oil Co of Cal. V. Atlantic Richfield Co., No. CV-95-2379-KMW, slip op. (C.D. Cal. Mar. 10, 1998)) Unocal, in turn, countersued each of these companies for patent infringement. Eventually, in March of 2000, Unocal's patents were upheld with a final decision by the Federal Circuit Court. (Union Oil Co. of California v. Atlantic Richfield Co., 208 F.3d 989, 994 (Fed. Cir. 2000))

"UNOCAL" would have had a positive effect on the price differential. However, the magnitude of this effect is not clear.[21]

Finally, data[22] which details monthly stocks of gasoline available in each PADD is used to determine the differential in available stocks between the west coast (PADD 5) and each of the four control groups (PADDs 1,2,3 and 4). This differential is denoted "Stocks Differential L(1)". This variable has been lagged by one month because it is expected that a region's low stocks in any particular month will have a tightening effect on supply the following month, increasing prices in that region.[23] An increase in "Stocks Differential L(1)" is expected to reduce the finished gasoline rack price differential between California and the control groups.

Given the nature of future pricing expectations in the refining industry, it is likely that "Stocks Differential L(1)" is endogenous to some degree. Because of this, the model is assessed both including and excluding this variable in order to determine the effect, if any, that it may have on the Phase II compliance variables.

3.1.2 Descriptive Statistics

Table 1 provides information regarding the continuous variables being used in the regression analysis.[24]

Table 1. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Rack Differential (cents per gallon)	480	9.1200	11.5064	-20.2985	50.3629
Stocks Differential L(1) (thousands of barrels)	480	-14881.46	22348.30	-40556	29583
Control Outage Severity (thousands, gal/day)	336	10504.35	33051.87	0	284724
CA Outage Severity (thousands, gal/day)	336	26585.92	71557.75	0	378069

As is shown above, between 1994 and 2003, California maintained, on average, fewer stocks of gasoline than other regions of the country. Further, the average refinery outage in California between 1995 and 2001 resulted in more

21. Taylor and Fischer (2003) suggest that both Unocal's negotiation of royalty rates and the relatively small portion of the refining process subject to the Unocal patents imply that the gasoline retail price increase resulting from the Unocal patents may have been significantly less than the official cost of these patents to competing refiners.

22. Source: Energy Information Administration, www.eia.doe.gov, Total Gasoline Ending Stocks (Mbbl).

23. This tightening effect is expected to be subject to the mobility and substitutability of gasoline formulations across each PADD.

24. The complete dataset is available upon request.

than twice the average daily production loss of finished gasoline than the average refinery outage in other regions. Moreover, the average premium paid for wholesale gasoline in California is 9.12 cpg across the dataset.

3.1.3 Regression Analysis: Rack Prices

The model for this analysis is as follows:

$$(RD)_{it} = \alpha_i + \beta(RD)_{it-1} + \psi(RD)_{it-2} + \xi(RD)_{it-3} + \tau(RD)_{it-4} + \pi(RD)_{it-5} + \theta(LC)_{it} + \lambda(SC)_{it} + \omega(UN)_{it} + \rho(SD)_{it-1} + \phi(COS)_{it} + \gamma(CAS)_{it} + \varepsilon_{it} \quad (1)$$

Where:
RD_{it} = *Rack Differential.*
α_i = *PADD-level fixed effects.*
LC_{it} = *Large Compliance.*
SC_{it} = *Small Compliance.*
UN_{it} = *UNOCAL.*
SD_{it-1} = *Lagged Stocks Differential (in thousands of barrels) or Stocks Differential L(1).*
COS_{it} = *Control Outage Severity (thousands, gallons/day).*
CAS_{it} = *California Outage Severity (thousands, gallons/day).*

In this model, PADD-level fixed effects are included to control for unobserved characteristics which might create a unique relationship between California and each of the four control groups. Additionally, the data suffers from heteroskedasticity and panel-specific autocorrelation. To correct for this, generalized least squares is used. The results of this model are shown in Table 2 below:

As is shown in Table 2, "UNOCAL" is positive and statistically significant in the complete model (GLS-3). However, the exclusion of "Stocks Differential L(1)" impacts the significance of this variable. This slightly ambiguous result is consistent with the intuition provided by Taylor and Fischer (2003). "Stocks Differential L(1)" is negative and statistically significant at the 99 percent confidence level suggesting that, as the differential in the stock of finished gasoline between California and each of the control groups widens by an additional one thousand barrels, the premium paid for wholesale gasoline in California will diminish by 0.0008 cpg, ceteris paribus. This, again, is consistent with prior expectations.

The coefficients for "Control Outage Severity" and "CA Outage Severity" suggest that there is not significant evidence that an outage in one of the four control groups has an impact on the rack price differential. However, regardless of the specification of the model, as the severity of a refinery outage in California increases by a monthly average of one thousand gallons per day, the rack price

Table 2. Regression Results

Dependent Variable: Rack Differential (1982 Dollars)				
	OLS 1	**GLS 1**	**GLS 2**	**GLS 3**
Rack Differential L(1)	0.6079*** (0.0550)	0.6358*** (0.0542)	0.6310*** (0.0539)	0.5279*** (0.0529)
Rack Differential L(2)	-0.3858*** (0.0678)	-0.40499*** (0.0658)	-0.4266*** (0.0653)	-0.3206*** (0.0630)
Rack Differential L(3)	0.1306* (0.0717)	0.1441** (0.0703)	0.1235* (0.0705)	0.0833 (0.0662)
Rack Differential L(4)	-0.0788 (0.0647)	-0.0549 (0.0643)	-0.0611 (0.0640)	-0.0561 (0.0602)
Rack Differential L(5)	-0.1407*** (0.0484)	-0.1409*** (0.0489)	-0.1650*** (0.0489)	-0.1539*** (0.0466)
Large Compliance	**5.1714*** (1.1372)**	**3.4331*** (1.2119)**	**3.522*** (1.1790)**	**5.4641*** (1.1856)**
Small Compliance	**3.0941*** (1.0596)**	**3.2644*** (1.1377)**	**4.0310*** (1.1279)**	**3.3011*** (1.1037)**
UNOCAL	2.3086** (1.1147)	1.9286 (1.1916)	1.5109 (1.1674)	2.5031** (1.1409)
Stocks Differential L(1)	-0.0007*** (0.0001)	-0.0002*** (0.00002)	–	-0.0008*** (0.0001)
Control Outage Severity (thousands, gal/day)	-0.00002 (0.00001)	-0.00002** (0.00001)	-0.00003* (0.00001)	-0.00002 (0.00001)
CA Outage Severity (thousands, gal/day)	0.00005*** (0.000007)	0.00006*** (0.000007)	0.00006*** (0.000007)	0.00006*** (0.000007)
Stocks Diff (L1) Included?	YES	YES	NO	YES
Fixed Effects	YES	NO	YES	YES
Observations	336	336	336	336

The asterisks in Table 2 refer to the level of significance of each coefficient. One asterisk indicates 90% significance, two asterisks indicate 95% significance and three asterisks indicate significance at or above the 99% level.

differential is expected to increase by 0.00006 cpg, ceteris paribus. As suggested by Muehlegger (2006), the large impact of California refinery outages on the rack price differential, as compared with other regions, may be due to California's relatively isolated refining market resulting from both its geographic location and its uniquely differentiated gasoline formulation.

"Large Compliance" is found to be significant at a 99 percent level of confidence regardless of the model specification used. This suggests that large refiner compliance to the Phase II reformulated gasoline regulations resulted in an increase in the wholesale price of gasoline in California as compared with other regions in the country. Additionally, the coefficient for this variable ranges from 3.43 cpg without the use of the PADD-level fixed effects to 5.46 cpg in

the complete model. This is consistent with the literature regarding the estimated impact of gasoline content regulations on wholesale gasoline prices[25] and, similar to Muehlegger (2006) and Taylor and Fischer (2003), might be thought of as a representation of the increase in the average variable cost of gasoline production resulting from Phase II.

Finally, "Small Compliance" is also found to be significant at a 99 percent level of confidence regardless of the model specification used. This suggests that small refiner compliance to the Phase II reformulated gasoline regulations resulted in an increase in the wholesale price of gasoline in California as compared with other regions in the country. The coefficient for this variable ranges from 3.09 cpg using the OLS specification to 3.30 cpg in the complete model. Because the implementation of Phase II among small refiners would not impact the cost structure among large refiners, this relative increase in the rack price of finished gasoline in California, which occurred as small refiners were required to comply with Phase II, may represent increased profits among large refiners in the state.

3.2 Industry Concentration

In an effort to examine the impact that the implementation of Phase II had on the industry concentration of California's wholesale fuel market, data detailing the yearly atmospheric crude distillation capacity of each refinery throughout the country is used.[26]

An analysis of this refinery capacity data reveals that, during the time period following the implementation of the Phase II CARB gasoline regulations, a significant number of small refineries chose to either opt out of CARB gasoline production or to shut down altogether. In fact, with the onset of the small refiner compliance date in 1998, only one small refiner decided to produce finished reformulated gasoline in California. All other small refineries remaining in operation opted out of the CARB gasoline market to instead focus on other petroleum based goods and markets.[27] This reduction of finished gasoline production capacity in California is expected to have increased market share for surviving firms within the industry. Such an expectation is readily supported in the data provided in table 3 below.[28]

Table 3 illustrates the Herfindahl Index for California's petroleum industry which is calculated using atmospheric crude distillation capacity data for all refineries in California.[29] In addition, the HHI for atmospheric crude distillation capacity is calculated for the United States as a whole, excluding California, in order to provide a comparison of the trends in industry concentration throughout the rest of the country.

25. See Lidderdale and Bohn (1999), Muehlegger (2006), and Brown et al. (2008).

26. Form EIA-820, "Annual Refinery Report", Petroleum Refinery Capacity Data by Refinery.

27. California Energy Commission http://www.energy.ca.gov/oil/refineries.html

28. For Table 3, data for 1996 and 1998 are not available.

29. Source: Energy Information Administration, Form EIA-820, "Annual Refinery Report", Petroleum Refinery Capacity Data by Refinery.

Table 3. Industry Concentration and Market Share

Year	HHI CA Finished Gasoline Prod	HHI Nationally Excluding CA	Mkt Share Small Refiners: Atmospheric Crude Distillation Capacity – Finished Gasoline
1994	1202.17	356.26	12.43
1995	1193.75	349.10	12.82
1996	.	.	.
1997	**1249.02**	**360.93**	**10.07**
1998	**.**	**.**	**.**
1999	**2035.44**	**398.09**	**1.56**
2000	1913.73	444.34	1.33
2001	1669.51	444.70	1.32
2002	1652.77	491.97	1.31
2003	1575.54	491.94	1.31

Recall, full enforcement of the Phase II reformulated gasoline regulations was to take place in 1996 for large refiners and 1998 for small refiners. As is shown above, during the time period of 1997 to 1999, industry concentration experienced a substantial spike for the finished gasoline market in California. Specifically, California's finished gasoline market was considered moderately concentrated in 1994. However, between 1995 and 1999, the index increased over 800 points bringing the market to a concentrated level. In total, from 1994 to 2003, this HHI for the finished gasoline market rose by approximately 373 pts.[30] When compared with national trends, the spike in industry concentration which was experienced during the time frame of small refiner compliance, 1997 to 1999, does not appear to have been echoed by that which was experienced by the refining industry throughout the rest of the country.

In terms of small refiner market share, using this same atmospheric crude distillation capacity data for California refineries, the finished gasoline market share allotted to small refiners[31] was calculated from 1994 to 2003. This data, also included in table 3 above, shows that the small refiner market share of atmospheric crude distillation capacity (capable of producing finished gasoline) in California dropped from 12.43 percent to 1.31 percent during the time period of 1994 to 2003 and from 10.07 percent to 1.56 percent during the time period of small

30. When evaluating mergers, the Department of Justice considers an HHI between 1000 and 1800 points to denote a market that is moderately concentrated and an HHI of over 1800 to denote a market that is concentrated. In addition, "Transactions that increase the HHI by more than 100 points in concentrated markets presumptively raise antitrust concerns under the Horizontal Merger Guidelines issued by the U.S. Department of Justice and the Federal Trade Commission." (http://www.usdoj.gov/atr/hhi.htm)

31. A small refiner is defined in the ARB Final Statement of Reasons as a refinery which has a production capacity of less than 55,000 barrels per day.

refiner compliance (1997 to 1999). This suggests that both a statistically significant rack price increase, as detailed in the previous section, and a rapid decline in market share among small refiners coincided with small refiner compliance to Phase II. In fact, this result shows that the rack price increase resulting from small refiner compliance detailed above could not have been due to production cost increases but was more likely the result of shifting market shares as nearly all small refiners simply chose to give up their share of California's finished gasoline market in the face of these regulations.

4. CONCLUSION

This paper uses monthly panel data to measure the impact that California's reformulated gasoline regulations had on the premium paid for wholesale finished gasoline in California. The results show that both large refiner compliance to Phase II and small refiner compliance to Phase II resulted in significant increases in the finished gasoline rack price differential between California and other regions of the country. The impact of large refiner compliance is consistent with previous results found in the literature. However, the significant impact found regarding small refiner compliance to Phase II suggests that the total impact of these regulations may be larger than previous thought.

Additionally, trends in industry concentration during the time period of reformulated gasoline regulation compliance appear to have favored large refiners as small refiner market share decreased and industry concentration increased simultaneously from 1997 to 1999.

While these results do not decisively prove that large refiners in the industry engaged in raising rivals' costs behavior, as suggested by Bial and Innes (2002), they do suggest that small refiners were disproportionately disadvantaged by Phase II and that, strategy notwithstanding, large refiners very likely gained from Phase II in terms of both market share and profits.

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