Gasoline Content Regulation as a Trade Barrier: Do Boutique Fuels Discourage Fuel Imports?

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Abstract

This paper examines the impact of Clean Air Act Amendments of 1990 (CAAA) environmental regulations on U.S. motor gasoline import patterns. Following the damage to U.S. petroleum refining infrastructure from hurricanes Katrina and Rita, the federal government provided temporary relief for several weeks from so-called "boutique fuel" specifications designed to improve air quality in certain regions of the country. These temporary waivers increased marketers' ability to sell gasoline originally destined for specific regional markets into a greater number of markets. We hypothesize that these same waivers also encouraged gasoline imports more than increased prices would have alone. We test our hypothesis using two analyses. The first consists of a simple transfer function analysis designed to separate price effects (and thus effects of refinery closures) from the effects of regulatory relief. The second analysis consists of a natural experiment comparing the primary recipient of regulatory relief — the Gulf Coast gasoline market — to the rest of the United States. Both analyses suggest that the CAAA-related specifications prevent a substantial amount of gasoline imports from entering the United States under normal circumstances.

JEL Classification codes: L71, F14, Q52, Q56, Q48

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1 Introduction

This paper examines the relationship between regulations designed to enforce the Clean Air Act Amendments of 1990 (CAAA) and motor gasoline imports into the United States. Major government studies on the proliferation of so-called "boutique" fuel specifications were conducted in both 2001 and 2006 out of concern for their effect on supply chain management in times of disruption (EPA, 2001, 2006). Boutique fuels are gasoline formulations designed to meet mandated air quality standards. Some of these mandates are federal, from the CAAA, while others are state-imposed, from state opt-in provisions of the CAAA or from independent state legislation. Economists also have examined the effects of boutique fuel proliferation both on long-term prices across segmented, regional markets and on short-term price volatility within regional markets. Neither set of studies devote much attention to the role of imports, however.

Our main hypothesis is that, in some instances, fuel specification regulations on gasoline sold in the United States create an artificial market in which imports are lower than they would be otherwise and thus domestic refiners are sheltered from international competition. We use two different approaches to show that imports played a large role in supplying the United States with gasoline following hurricanes Katrina and Rita in the fall of 2005. We are able to divide this imports surge into two component parts: that accounted for by higher domestic prices versus that accounted for by the environmental waivers issued in the weeks after the hurricanes. The results suggest that under normal conditions, regulations and the diversity of fuel specifications prevent large amounts of gasoline imports from entering the U.S. market.

2 Background

In a system free of trade barriers, foreign suppliers would be expected to fill domestic supply gaps when prices rise. And foreign refiners with comparative advantages, such as proximity to inexpensive crude oil, would compete aggressively with U.S. refiners. We do not observe such, however, as government regulations have inhibited competition between foreign and domestic refiners.

Competition from gasoline imports has varied during the past three decades. The U.S. refining industry changed substantially following President Ronald Reagan's deregulation of the oil production and refining industries in 1981, and the competition from foreign imports even led some in industry to call for protection on grounds of national security (Wollstadt, 1985). Deregulation caused this pain due to the build-up of small-scale, inefficient refining capacity during the 1970s. From 1981 until 1989, domestic refiners' operating ratios trended gradually upward, from a low of 68.6 percent to a peak of 95.5 percent[1], and average refining capacity per operating unit also increased markedly. As the domestic refining industry struggled to find its competitive footing, the refineries that survived deregulation tended to operate at larger scale and to employ more complex technologies (Chen, 2002).

After Congress passed amendments to the Clean Air Act in December 1990, over the next year the EPA conducted analysis and drafted regulations in collaboration with all major constituencies except one: foreign refiners (Anderson and Rykowski, 1997). The increasing number of fuel specifications mandated by the amended CAAA forced refiners to produce more gasoline formulations at lower scale during this period (Yacobucci, 2004). The regulatory heterogeneity across jurisdictions in the United States has resulted in different fuel specifications in at least fifteen states. ExxonMobil cites 18 different gasoline formulations in the United States

[1] *Oil & Gas Journal*, via Haver Analytics.

in 2002, but the tally can vary depending on how fuel specifications are defined. (Yacobucci, 2004) In its 2001 "Study of Unique Fuel Blends," the EPA counted 15 specifications, using a broad definition of boutique fuels that includes all local, state and federal programs. Figures citing a larger numbers of fuels typically include multiple grades of each fuel type.

Several private sector and government studies point to varying — but positive — degrees of hardship imposed on the industry by regulations associated with the 1990 CAAA. For a summary, see U.S. Permanent Subcommittee on Investigations Majority Staff (2002).The high number of non-substitutable fuels creates both financial and logistical impediments for refiners. Evidence from regulatory studies and economists suggests that fuel diversity resulting from the 1990 CAAA results in higher marginal and fixed costs of refining (Meuhlegger, 2006).

While fuel diversity imposes some costs on domestic refiners, the regulations may also benefit domestic refiners by shielding them from foreign competition. Vogel (Vogel, 1997) showed that the EPA's reformulated gasoline requirements placed domestic refiners at an advantage over their foreign competitors. Indeed, in a case brought by Petróleos de Venezuela, S.A. in 1995, a dispute panel at the World Trade Organization found that the United States had violated the principle of equal treatment in Article III of the General Agreement on Tariffs and Trade. The United States revised the disputed policies in 1997, but importers lost ground during this period.

Gasoline imports (finished gasoline plus blending components) generally declined between 1989 and 1996, erasing some of the gains made following the 1981 deregulation. After constituting about 6 percent of domestic consumption during the mid and late 1980s, imports' share fell and remained below 5 percent until 1996. The slide in blending component imports ended in 1996, but importers did not see gains in market share until 1999. Since then, gasoline imports have risen substantially, to 12 percent in 2005.[2]

Even after the WTO ruling removed regulatory bias, the CAAA regulations could still depress imports in two ways. For one, regulations could prevent the sale of imported gasoline that does not meet the minimum standards for any U.S. region. Second, the differential requirements for “boutique fuels” spread the total gasoline demand among many formulations, thereby creating many small markets instead of a single large one. In some cases, gasoline cannot even be traded among adjacent counties, and sometimes nearby major metropolitan areas use different formulations. (Muelegger, 2006) Further, the frequency of changes to regulatory standards present a financial risk, limiting foreign refiners’ capital investment in gasoline production for the U.S. market.

Discussions of gasoline regulations’ impact on trade often focus on the legal aspects of environmental rule-making and the interests of foreign refiners (Duncan, 2001). Separately, the industrial organization literature demonstrates how the existence of many regional gasoline markets can increase barriers to entry and reduce competition, particularly when production is disrupted (Muehlegger, 2006). Kumins (Kumins, 2004) notes the challenges faced by foreign refiners that might be attracted U.S. prices, but we have not found explicit discussion of the idea that fuel diversity could be a trade barrier that restrains competitive forces in the U.S. refining sector.

Brown (Brown, 2006) suggests that regulatory cost-benefit analyses should consider the indirect costs of reduced competition in regional markets in addition to accounting for the incremental capital costs necessary to produce mandated fuels. According to our analysis, federal

[2] Energy Information Administration, U.S. Department of Energy.

fuel mandates may reduce competition by funneling foreign imports into several large metropolitan gasoline markets. The cohort of countries exporting gasoline to the United States following the hurricanes suggests that, in the presence of more uniform fuel standards across the country, gasoline exporters are more willing to direct smaller-than-normal increments of fuel to the U.S. market in response to price signals.

The remainder of this paper is organized as follows. First, we examine the circumstances of hurricane-related refinery outages and of each gasoline supply component in the weeks before, during, and after the emergency. Second, we describe the emergency gasoline waivers issued in response to supply disruptions. Next, we formulate and perform two tests (one a natural experiment) to measure the degree to which regulatory waivers contributed to increased gasoline imports into the U.S. Gulf Coast. The data in this section focus only on the waiver period and the weeks immediately before and after the hurricanes. We conclude with some policy considerations.

3 Hurricane disruptions and policy responses

3.1 Hurricane-Related Supply Disruptions

Two powerful hurricanes, Katrina and Rita, hit the U.S. Gulf Coast in late August and late September of 2005, respectively. In addition to damaging oil and gas production in the Gulf of Mexico, about 70 percent (almost 5 million barrels per day of crude processing capacity) of the Gulf Coast's refining capacity was shut down. In 2004 PADD III[3], the U.S. regulatory region that includes the Gulf Coast, was responsible for 43.7 percent of the nation's finished gasoline production and 47.9 percent of total refinery production, so the fall in gasoline production was

[3] PADD stands for Petroleum Administration for Defense Districts, which are illustrated in Figure 1. The PADDs were developed during World War II for oil allocation purposes.

felt widely in both U.S. and world markets. Our analysis of supply patterns related to the hurricanes centers around a 10-week emergency period (August 25 to October 28, 2005) when the EPA suspended environmental regulations for gasoline. We also analyze the 10 weeks preceding (June 17 to August 19) and the 10 weeks following (November 4 to January 6) the emergency period, comparing production, exports, imports, and inventory adjustments during the three periods. The relationship between these components is illustrated in Equation (1):

$$\textit{Supply} = \textit{Production} - \textit{Exports} + \textit{Imports} - \textit{Change in Stocks} = \textit{Demand} \qquad \textbf{(1)}$$

Table 1 summarizes supply behavior, comparing the changes in each component of Equation (1) from the pre-emergency period to the emergency period, and from the emergency period to the post-emergency period.[4] During the emergency, production dropped an average of 540,200 barrels per day and an average of 9,860 barrels of net inventory were exhausted daily.[5,6] Imports were the biggest factor in offsetting this deficit (142,300 barrels per day), and reduced exports added 66,100 barrels per day. That is, imports and exports cut the Gulf Coast gasoline production deficit by 38.2 percent. Fernandez, Gilmer, and Story (Fernandez et al., 2006) provide a detailed description of gasoline import patterns during this period.

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[4] We made a relatively minor adjustment to the data to include net output of blending components in total production. The Department of Energy reports weekly net input of blending components (net output with the opposite sign) for the entire United States., but these data are not separated by region, or PADD. We allocated the total U.S. figure to PADDs based on the difference between gross refinery inputs and gross output reported for each PADD.

[5] Weekly production and inventory data cited here are from the Energy Information Administration but have been seasonally adjusted by the authors. Data series cited here for imports, exports and net blending components are too small to be seasonally adjusted. Because of seasonal adjustment, totals do not add perfectly in later calculations.

[6] The Energy Information Administration does not report weekly gasoline exports by PADD. It does report monthly exports by PADD and weekly exports of total refined products by PADD. The weekly data on refined products were used to allocate the monthly export data to individual weeks.

In the rest of the United States, a 217,900 barrel per day increase in gasoline production during the emergency was offset by an almost equal increase in inventory accumulation.[7] The net increase in gasoline supplies was only 17,100 barrels per day. After the emergency passed, much of the apparent increase in Gulf Coast production was offset by inventory buildups, increased exports and a big drop in imports. The 344,100 barrel-per-day increase in production became a net gasoline supply increase of only 68,700 barrels per day.

These supply patterns suggest that gasoline imports were the most important feature of the effort to reduce the gasoline shortages along the Gulf Coast after the hurricanes, adding 142,300 barrels per day to total supplies. Forces influencing the level of imports during the emergency included emergency stock releases, environmental waivers, and world price differentials, particularly between the United States and Europe.

Concerned about the impact of the hurricanes on the global prices for gasoline, member countries of the International Energy Agency responded to gasoline production losses on the U.S. Gulf Coast in a variety of ways. The United States released crude from its Strategic Petroleum Reserve. Other countries, particularly in Europe, made more gasoline available by limiting additions to their strategic reserves and by making some reserves available for sale on the open market. The IEA's *Oil Market Report*s from September 9 and October 11, 2005 detail these actions. By allowing market mechanisms to allocate these product stock offerings, IEA members affected gasoline prices around the world without actually shipping gasoline from their emergency reserves directly to the U.S. Gulf Coast. However, since the emergency stocks were auctioned on the open market, the role of emergency stock releases of gasoline abroad was

[7] In regions other than the Gulf Coast, gasoline was pulled out of inventory before and after the storms, but inventories were built at a pace of 43,600 barrels per day during the storms. Building inventories during periods of uncertainty — whether the uncertainty stems from weather, mechanical problems or geopolitics — has become a common reaction in recent years. One curious result of this hoarding behavior in the face of uncertainty is a correlation between high prices and high petroleum inventories, the opposite of what should be expected.

subsumed in the price effects. Consequently, we assume in the rest of this paper that incentives for foreign exporters to supply fuel to the United States stem from only two sources: environmental waivers and price differentials.

3.2 Environmental waivers

On September 13, 2005, 15 days after Hurricane Katrina struck the Gulf Coast, the EPA issued temporary waivers on gasoline requirements, with the explicit objective of increasing both domestic and international gasoline supply to make up for lost domestic production.[8] This easing of restrictions lasted for about two months and was applied differentially across the country. PADD III (the most affected area) was the main target, while other regions were only collaterally affected.

The initial set of waivers eliminated Reid Vapor Pressure requirements for summertime gasoline.[9] Under normal conditions, summertime RVP requirements end on September 1, except in Texas, California, and Arizona. Subsequent waivers removed the RVP requirements even for these three states through the end of 2005. Georgia has more stringent sulfur requirements than other states, and these requirements were lifted from September 1 through October 24.[10] Both of

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[8] Waivers addressed regulations related to volatility requirements, Reid Vapor Pressure (RVP), reformulated gasoline (RFG), and Texas Low Emission Diesel (TXLED) among others.

[9] Only gaseous hydrocarbons burn, so if the air is cold, the fuel has to be very volatile. But in the summer, a volatile fuel can boil, cause vapor lock, and produce high levels of evaporative emissions. As a result, the volatility of fuel is adjusted according to altitude and ambient temperature. This volatility change has been performed automatically for decades by oil companies, despite minimal public knowledge of the process, and it is one reason that storage of gasoline through seasons is not a good idea. Gasoline volatility is being reduced as modern engines, with their fuel injection and management systems, can automatically compensate for some of the changes in ambient conditions, such as altitude and air temperature, resulting in acceptable drivability using fewer fuel volatility requirements. Reid Vapor Pressure (RVP), normally measured in pounds per square inch, is a measure of the front-end volatility of gasoline. This is important for starting a carbureted car in cold weather. Summer RVP=7 psi, and winter RVP=13.5 psi.

[10] Sulfur adversely affects exhaust catalysts and fuel hydrocarbon lead response and also may be emitted as polluting sulfur oxides. Leaded gasoline cannot be more than 0.15 percent sulfur by mass, and unleaded gasoline cannot be more than 0.10 percent sulfur by mass. Typical U.S. gasoline levels are 0.03 percent sulfur by mass.

these waivers helped create a more uniform U.S. gasoline market, with Texas and Georgia of particular importance due to their dependence on Gulf Coast refineries.

Other waivers offered relief to areas not located on the Gulf Coast but served by Gulf Coast refineries through major pipelines. St. Louis on the Explorer Pipeline and Virginia on the Colonial Pipeline were both offered a set of staggered waivers, from September 2 to October 26 in Virginia, and from September 27 to October 27 in Missouri. These waivers allowed conventional gasoline to be sold in areas normally designated for reformulated gasoline sales only.[11] These waivers were not intended to increase gasoline production in these regions as much as they were intended to make gasoline fungible regionally and to simplify production and logistics for the Gulf Coast refineries. They also opened up major Gulf Coast pipelines for additional import and sale of conventional gasoline.

Some waivers were aimed more directly at the Gulf Coast, targeting specific cities and refineries. The Houston and Dallas areas were offered waivers of reformulated gasoline requirements from Sept. 22 to Oct. 30. Also, two Houston-area refineries were targeted to produce defined quantities of relatively high-sulfur gasoline.

With the suspension of specification regulations, the United States imported higher-than-normal quantities of gasoline from traditional trade partners, but many non-traditional partners such as Lithuania, Estonia, India, Latvia, Bulgaria, Peru, Brazil, Chile, and Qatar also sold gasoline into the U.S. market during this period. Table 2 shows the sources of gasoline imports during the four months around the time of the hurricanes. By comparing imports during August

[11] Colonial is the largest-volume pipeline transporter of refined petroleum products in the world, moving an average of 80 million gallons of petroleum products each day, through an underground pipeline that stretches from Port Arthur, Texas, to Linden, N.J. (New York Harbor area). It supplies products to parts of Louisiana, Alabama, Georgia, Tennessee, South Carolina, North Carolina, Maryland, Virginia, and New Jersey.

to the following three months, we see that European suppliers supplied the bulk of the incremental imports.

4 Measuring the impact of environmental waivers on gasoline imports

4.1 Transfer function analysis

Gulf Coast refinery outages and the resulting increase in gasoline spot prices served as a substantial incentive for foreign refiners to import gasoline into the United States. This fact complicates our effort to measure the impact on imports of environmental waivers alone.

During the emergency 10-week period, gasoline imports on the Gulf Coast rose by 152,500 barrels per day, or more than twice the normal level. These additional imports were drawn to the U.S. by the high domestic price of gasoline; the difference between the price of gasoline in the U.S. and Rotterdam, for example, increased by almost 5.8 cents per gallon during the 10-week emergency period. Also, during the 10 week period, environmental waivers opened the doors to more conventional gasoline and blending components than would have entered under more restrictive clean air rules.

To formally separate the effects of price incentives and environmental waivers on import levels, we estimate the following equation:

$$y_t = \alpha + E\theta_t + \Sigma^{l}_{i=1} \beta_t y_{t-1} + \Sigma^{L}_{i=0} \delta_t d_{t-L} + e_t \qquad \textbf{(2)}$$

where:

y_t = Imports of gasoline to the U.S. Gulf Coast

d_t = Gasoline price differential between the U.S. Gulf Coast and Rotterdam

$\theta_t =$ Dummy variable, which is equal to 1 during the 10 weeks the environmental waivers are in effect, zero otherwise.

Thus, we hypothesize that the weighted average of weekly imports to the Gulf Coast is explained by the weighted average of lagged import levels and current plus lagged values of gasoline price differentials between the Gulf Coast and the rest of the world. We chose the price differential between the U.S. and Rotterdam spot markets because the bulk of incremental gasoline product imports were supplied from European firms via market mechanisms. A dummy variable is also included for the 10-week period of waivers, to measure the effect of regulatory relief.

Previous researchers have conducted to determine the appropriate lag length in the equation (Akaike, 1973; Schwarz, 1978; Ng and Perron, 2001). Testing for up to 12 lags, all methods agreed on only one lag for the dependent variable, and all agreed that three or fewer lags were needed for the price differential. Tests for autocorrelation were negative.

We estimated Equation (2) using weekly EIA data from May 2004 to July 2006 for four imports series: total gasoline, finished gasoline, conventional and reformulated finished gasoline, and blending components. Estimation results are summarized in Table 3. Price has a large and highly significant coefficient in the estimated equations for total imports and for blending components. Environmental waivers have a statistically significant effect on imports of total gasoline, conventional gasoline, and blending components.

The significance of these results is best illustrated in Table 4. For example, total gasoline imports in the emergency period rose from 71,200 barrels per day to 223,700. This increase of 152,500 barrels per day can be attributed to: (i) environmental waivers (88,180) and (ii) an increase in the price differential from the 2.27 cents per gallon that prevailed before and after the emergency period, to 8.03 during it. The effect of the U.S.-Rotterdam price differential rising by 5.76 cents should have resulted in 8.56 x 5.76 x 1000 = 49,306 more imported barrels per day, where 8.56 is the estimated coefficient from Table 3. Price and waivers together account for 137,486 barrels per day, almost all of the emergency increase of 152,500 barrels.

In sum, this first analysis suggests that the emergency waivers played an important role in the large increase in Gulf Coast (PADD III) gasoline imports during the emergency period, especially for conventional gasoline. In addition, the results suggest that environmental waivers have a larger influence than price differentials on incremental gasoline imports, by a margin of three to one. With respect to blending components, price and waivers play a more equal role. Over the entire sample period, environmental waivers for total gasoline imports were about twice as influential as price incentives. We find that waivers have an even greater influence on imports in the next section, which examines only the periods immediately preceding and following the emergency.

4.2 Natural Experiment: Difference-in-differences model

The unusual and volatile circumstances in the gasoline market during the period after the hurricanes complicate the effort to measure the distinct effect of environmental waivers on imports. We approach this unusual circumstance by performing a natural experiment. Natural experiments have gained popularity in economics in recent years, and Rosenzweig and Wolpin (2000) provide a survey of a particular kind, referred to as “natural natural experiments.” The former often depend on group assignments made by policymakers, whereas the latter depend on seemingly random events such as the weather to determine the “treatment” group. In either case, the researcher calculates the difference between groups before the treatment from the difference between groups after the treatment (hence, the difference in differences).

Brown (Brown, 2006) and Muehlegger (Muehlegger, 2006) apply the difference-in-differences method to examine the CAAA regulations we study here. For these authors, the treatment is the presence of regulation; however, in our analysis, the treatment is the temporary relief *from* regulation. In our case, the difference-in-differences approach amounts to subtracting the effect of regulatory relief from other phenomena observed in the gasoline market during the study period. In our analysis, PADD III is the treatment group, because most of the waivers focused on the Gulf Coast markets and markets supplied by product pipelines originating on the Gulf Coast. All other PADDs together represent our "control" group. By subtracting the trend common to all PADDs across periods, we isolate the specific effect of the regulatory treatment on PADD III.

Difference-in-differences experiments require a counterfactual, the validity of which is established by demonstrating that the treatment and control groups have similar time trends. An analysis of the weekly data from May 2004 to January 2006 for total gasoline imports and its components (reformulated, conventional, and blending components) for the control and treatment groups reveals that the two follow similar time trends for the period considered. (See Table 5.)

4.2.1 Estimation and interpretation of results of difference-in-differences

We conduct the analyses with weekly data on conventional gasoline imports for PADD III and the rest of the United States. Since the waivers were issued soon after Hurricane Katrina passed and were in place for about ten weeks, we analyze imports in 10 week windows before, during, and after the regulatory relief. We define a dummy for the treatment group, equal to one if in the treatment group and zero otherwise. We also define a dummy variable for time, equal to one if during the regulatory suspension and zero if before or after the waivers. Formally, our difference-in-differences approach is defined as follows:

$$Y_i = \beta_0 + \beta_1 treatment_i + \beta_2 after_i + \beta_3 treatment_i * after_i + \beta_4 pricediff + \varepsilon_i \qquad \textbf{(3)}$$

where:

Y_i = The natural log of imports into i^{th} geographic region (PADD III or rest of U.S.)

$treatment_i$ = Dummy variable, which is 1 if in the treatment group and 0 if in the control group

$after_i$ = Dummy variable, which is 1 if during treatment and 0 if before or after treatment

pricediff = Difference between the natural logs of the spot prices for regular motor gasoline on the Gulf Coast and New York Harbor markets.

The price variable included is a control for possible differences between Gulf Coast and New York gasoline prices and potential incentives to import into one rather than the other. Thus, $pricediff = GulfCoast - NewYork = (GulfCoast - Rotterdam) - (NewYork - Rotterdam)$. The usual difference-in-differences framework assumes that $GulfCoast = NewYork$.

The coefficient of the interaction term β_3 gives us the difference in differences estimate of the treatment effect and can be interpreted as the average increase in imports in PADD III attributed to the waivers. In simple terms, β_3 is the difference between of the control and treatment groups before and after the waivers. The *pricediff* variable controls for price differences between the Gulf Coast and New York Harbor spot markets, and the coefficient β_4

thus represents the incentive of a dollar increase in Gulf Coast regular gasoline relative to the counterfactual market.

Estimates of the parameters for the environmental waivers and price differential in Equation (3) are listed in Table 6, along with their respective *t*-statistics. For four of the five series, our results confirm the distinct, significant role played by environmental waivers in bringing more gasoline imports into PADD III than would have been the case without the waivers. Not surprisingly given the specific federal mandates for reformulated gasoline, we did not see a statistically significant import response to the environmental waivers for this product. Instead, the response came from conventional gasoline and blending components. As for prices, we obtain results significant at a 95 percent confidence interval only for conventional gasoline. So, although prices played a role, waivers were the most important factor in increasing imports during the emergency period.

Transforming these results into actual barrels that entered the U.S market due to the waivers, we take the before-and-after regulatory relief average of total, finished, and conventional gasoline imports, as well as blending components and multiply by the corresponding statistically significant environmental waiver coefficient (β_3). The results are presented in Table 7.[12]

These results suggest that about 130,000 barrels per day of gasoline entered the U.S market due to the hurricane waivers. The environmental relief created a short-term harmonization that opened the market for gasoline imports and showed that boutique fuels represent a barrier to U.S. gasoline trade. It is worth noting that, since the Gulf Coast is a relatively small importer of gasoline, with only 9.1 percent of U.S. gasoline imports in 2005, the

[12] The number of barrels due to price computer in Table 4 cannot be computed in this framework. The price variable here is only a control for New York prices versus Gulf Coast prices.

potential for imports is much larger — perhaps 10 times larger — if comparable regulatory relief were offered on a nationwide basis. CAAA regulations therefore keep more gasoline imports out of the U.S. market than the 130,000 barrels per day estimated in our analysis.

5 Conclusions

The arrival of hurricanes Katrina and Rita on the U.S. Gulf Coast marked a period of significant turmoil in U.S. and global gasoline markets. In PADD III, reduced exports and increased imports were the primary vehicle to offset lost production after the hurricanes, and together they made up for almost 40 percent of production losses. Imports added an additional 152,500 barrels per day to gasoline supplies during the emergency period, and we estimate that at most one-third of these imports are attributable to higher prevailing U.S. gasoline prices. The rest of the increased level of imports resulted from waivers of environmental restrictions.

In the opening paragraph of its 2001 study on unique fuel blends, the EPA states that CAAA-related clean fuels programs have been an integral part of the nation's strategy to reduce air pollution. At the same time, however, we know that there are periods of supply disruption when the lack of fungibility among many blends of gasoline causes delivery problems and price spikes.

Yacobucci (Yacobucci, 2004) provides some discussion of the trade-offs associated with fuel content harmonization — including cost, production capacity, supply stability, and air quality — and on the importance of how harmonization is defined and implemented in to its outcome. The role of imports and their potential to alleviate supply constraints are rarely mentioned (if at all) in conjunction with content harmonization and regional supply issues. The waivers of 2005 were an extreme measure, but they show the potential for a significant supply response to even small changes in restrictions**.** The harmonization of standards, perhaps combined with more certainty about the long-term content requirements for U.S. gasoline, could allow for significant additions to U.S. supplies through imports, especially during short-term, emergency periods of disruption.

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Table 1

Contribution of various factors to the change in gasoline supplies during and after the emergency (Thousand barrels per day)

	Gulf Coast		Rest of U.S.	
	Emergency	Normal	Emergency	Normal
Production	-540.2	344.1	217.9	-135.2
Change in inventory	-9.9	-81.8	-220	72.3
Imports	142.3	-167.2	19.5	-36.2
Exports	66.1	-36.5	-0.4	-2.5
Total gasoline supplies	-334.1	68.7	17.1	-102.6

Note: Parts do not add to total due to seasonal adjustment
Source: Authors' calculations from Energy Information Administration data.

Table 2

Gasoline imports from groups of countries in Fall 2005 (Thousand barrels)								
	Finished motor gasoline				Blending components			
	Aug	Sept.	Oct.	Nov.	Aug	Sept.	Oct.	Nov.
"Core" supplier countries*	9,989	9,157	11,437	7,093	3,013	2,727	2,529	1,069
EU member countries	3,967	8,752	11,853	9,024	8,359	7,370	9,257	7,682
Non-EU European countries	582	271	1,549	325	695	2,183	2,186	1,287
Others	1,315	1,147	2,017	1,066	4,372	4,978	4,872	2,524
TOTAL								
Source: Authors' tallies from Energy Information Administration data.								

*Core countries are Canada, Virgin Islands, and Venezuela

Table 3

Transfer analysis of effects of price and environmental waivers on gasoline imports into PADD III

	Intercept (α)	Lagged dependent (E)	Price (δ_i)	Waivers (β_i)	R^2
Total	28.70	0.173	8.56	88.18	0.392
	(2.44)	(1.85)	(3.30)	(2.98)	
Finished	5.81	0.234	2.42	42.89	0.293
	(.96)	(2.45)	(1.73)	(2.70)	
Conventional	8.10	0.092	2.17	41.35	0.207
	(1.35)	(.093)	(1.55)	(2.66)	
Reformulated	-0.90	0.211	0.58	6.17	0.376
	(-0.67)	(2.52)	(1.85)	(1.69)	
Blending Components	25.60	0.080	6.41	47.84	0.321
	(3.12)	(0.86)	(3.58)	(2.39)	

Note: *t*-statistics are given in parentheses below the coefficient. The price coefficient is the sum of the current and lagged coefficients for the price differentials, and the test statistics are for the sum.

Table 4

Role of price and waivers in incremental gasoline imports into PADD III during the emergency period

(Thousand barrels per day)

	Observed change	Estimated change due to waivers	Estimated change due to price
Total	152,500	88,180	49,306
Finished	69,100	42,890	13,939
Conventional	62,700	41,350	12,499
Reformulated	6,400	6,170	3,341
Blending components	83,400	47,840	36,922

Note: Barrels due to price apply an average price differential of 5.76 cents per gallon in the emergency period less the difference prevailing in the 10 weeks before and after the hurricanes.
Note: Changes do not sum due to seasonal adjustment; other components do not sum because they are estimates from separate equations.

Table 5

Regression results on a time trend with corresponding p-values:

	Treatment	Control
TOTAL	1.335 (0.000)	0.943 (0.107)
Reformulated	0.129 (0.113)	0.103 (0.726)
Conventional	0.369 (0.028)	0.368 (0.322)
Blending Components	0.836 (0.000)	0.471 (0.261)

Table 6

Results of difference-in-differences

	Environmental waiver (β_3)	Price differential (β_4)	R^2
Imports			
Total	1.826**	0.035	0.576
	(2.16)	(0.65)	
Finished	2.018*	0.129*	0.720
	(1.88)	(1.88)	
Conventional	2.242**	0.192**	0.764
	(2.09)	(2.80)	
Reformulated	1.099	-0.072	0.816
	(1.16)	(-1.20)	
Blending components	1.363*	0.024	0.503
	(1.95)	(0.54)	

Note: *t*-statistics are given in parentheses below the coefficient.
*Coefficient is statistically significant at the 90-percent confidence level
**Coefficient is statistically significant at the 95-percent confidence level

Table 7

Role of waivers in gasoline new imports during the emergency period according to difference-in-differences analysis

(Thousand barrels per day)

	Observed change	Due to waivers
Total	152,500	129,947
Finished	69,100	35,500
Conventional	62,700	27,660
Blending components	83,400	73,056

Figure 1 (*Source*: Energy Information Administration, U.S. Department of Energy)