Boutique Fuel Markets and Security-Environment-Economic Trade-offs

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Introduction

Since the emergence of boutique fuel regulations 25 years ago, U.S. gasoline markets have been segmented based on fuel content regulations. With the promulgation in the 1990s of standards on reformulated gasoline, Reid vapor pressure, oxygenated fuels, California cleaner burning gasoline, and state boutique fuels the program, there are more than 45 different gasoline fuel blends sold in America (Chakravorty et al. 2008; Aldy 2015). State policies also imposed limitations on the design and marketing of gasoline (Anderson and Elzinga 2014).

While these air quality regulations are intended to improve air quality – primarily local ground-level ozone concentrations – they also create small Balkanized markets. The regulations impose significant and heterogeneous price impacts, with averages on the order of about 7 cents per gallon, reflecting both geographic isolation and imperfect competition (Sweeney 2015; Brown et al. 2008). These regional markets are potentially less resilient to supply shocks because neighboring markets do not have regulation-compliant fuels to export to those experiencing a shock. For example, in 2000 the Chicago metro area was short gasoline with the implementation of the second phase of reformulated gasoline due to a pipeline outage that spring (Bulow et al. 2003). As a result, Chicago gasoline prices in June 2000 were some 50 cents higher per gallon than fuel sold in areas that were not exposed to the supply shock.

Many U.S. regional fuel markets have been adversely affected by supply shocks resulting from hurricane damage to the Gulf Coast states. As a leading tool to promote U.S. energy security, the Strategic Petroleum Reserve has been used more often – through Presidentially-directed releases and Department of Energy authorized exchanges – to address hurricane-related shocks than to mitigate the impacts of geopolitical events (Bingaman 2009; Department of Energy n.d.). Reflecting the concerns about the economic costs borne by households and businesses as a result of such shocks, some politicians have advocated for regional product reserves as a part of the Strategic Petroleum Reserve (e.g., S. 1362, The Strategic Gasoline and Fuel Reserve Act of 2007). In the aftermath of a severe winter in 2000 and Hurricane Sandy in 2012, the Department of Energy created the Northeast Heating Oil Reserve and the strategic gasoline reserve in New York and New England, respectively.

Creating a product strategic petroleum reserve is costly, especially relative to the potential benefits of addressing low-frequency events. For example, the Northeast Heating Oil Reserve has not been tapped for an emergency in its 15 years of existence. Since some of the economic costs of supply shocks reflect the Balkanization of U.S. fuel markets, it may be possible to modify the fuel content regulations to mitigate the economic impacts of temporary supply shocks. This may serve as a lower-cost, more flexible policy approach to ensure U.S. energy security in product markets. Indeed, this motivated Congress to grant EPA the authority to waive temporarily fuel content regulations in the 2005 Energy Policy Act. In the first year of this authority, EPA granted requests from 16 states for 31 waivers (Aldy 2015). Most of the waiver requests reflected concerns about pipeline outages due to Hurricanes Katrina and Rita affecting downstream markets. To date, EPA has granted about 60 waivers.

The proposed research will assess the welfare consequences of waiving fuel content regulations in order to offset the economic and security impacts of domestic product supply shocks. I will undertake

statistical analysis to estimate the impacts of waivers on air quality, health outcomes, and fuel prices in order to produce benefit and cost measures for this policy. These results will address the question of whether fuel content regulation waivers increase or decrease social welfare. They will also inform the subsequent energy security question about whether they can sufficiently mitigate price impacts from supply shocks to nullify the need for regional product reserves.

Methods

To estimate the impact of waivers on air quality and health outcomes, I plan to employ several empirical strategies. First, I will implement a difference-in-differences estimator. In this framework, a waiver will treat a given geographic market for the period of time covered by the waiver decision. For example, the impact of a waiver on ozone concentrations could be estimated by:

$$[O_3]_{it} = \alpha_i + \delta_t + \beta 1[waiver]_{it} + X'\gamma + \varepsilon_{it} \quad (1)$$

where $[O_3]_{it}$ is the ozone concentration (either daily maximum or highest daily 8-hour average) on day t in county i; the indicator function for the waiver takes the value for 1 for the dates that county i is covered by a waiver; the vector X includes other determinants of ozone concentrations (such as temperature and precipitation), and α_i and δ_t are county and date (e.g, day of week, month, and year) fixed effects. In addition to ozone concentrations, I will also estimate the impact of waivers on particulate matter concentrations, volatile organic compounds, as well as health outcomes, such as cause of death mortality, and fuel prices.

There are two considerations in constructing the sample. First, there is the issue of what counties should be in the control group. Since most fuel content regulations are targeted to areas with poor air quality, I plan to limit the sample to metropolitan areas subject to some form of regulation. This is an assumption that can be tested with a broader sample as well. Second, there is the issue of whether the shock triggering the waiver could have impacts on air quality beyond fuel content regulations. For example, Louisiana received a waiver in the aftermath of Hurricane Katrina. The vast disruption caused by the hurricane could have had a larger impact on air quality than the characteristics of the fuels sold at fill-up stations. I plan to conduct analyses with two samples: one for all waivers and one for waivers that are spatially distant from the shock (e.g., at the other end of a pipeline).

The impact of a waiver on air quality may differ spatially and temporally with respect to the waiver decision. While a waiver may start at a given point in time, it cannot influence the fuel available at fill-up stations until their next round of deliveries at a future date. Moreover, it may be easier for substitute conventional gasoline for the waived fuel in markets that are close by large, conventional gasoline markets. (For some waivers, multiple states are the covered geographic market.) To test for these effects, I will allow for the effects of the waiver indicator to vary over the course of the waiver period and to vary spatially within a covered geographic market.

The second empirical strategy will employ regression discontinuity estimators. In this case I will exploit the temporal and spatial limits to the waiver decisions to assess the impacts of waiving fuel content regulations. One approach to these estimators will be to compare changes in outcomes just before and after the start (and just before and after the end) of a waiver period for a given geographic market. A second approach to these estimators will be to compare changes in outcomes between counties just inside the outer boundary of the geographic market with the waiver and those counties just outside the geographic market.

In implementing the regression discontinuity estimators, I will focus on ways to minimize potential spatial spillovers that would undermine statistical identification. Let me note two such spillovers here (also see Sweeney 2015 and Auffhammer and Kellogg 2011 for discussion of these issues, respectively). First, the reaction of fuel markets to a waiver should result in lower-price fuel that is not subject to fuel content regulation leaving unregulated, neighboring markets and entering the higher-price fuel market that just received the waiver. Thus, simply using the neighboring market in a spatial RD estimator could in a bias for the estimated price impacts of waivers. Second, pollution moves across county and state borders, and thus a waiver in one geographic market could affect air quality downwind in markets that did not receive a waiver. I will undertake an array of robustness checks to the selection of the sample counties and time periods in an effort to minimize the effects of these spillovers.

The final empirical strategy will employ a matching estimator. Since about 90 percent of the waivers over 2005-2014 are made in response to a hurricane disrupting supplies, I will review pre-2005 hurricanes and associated refinery and pipeline outages to identify events that could have triggered a waiver if EPA had the authority to do so before 2005. I will then take each of these events and match them on geographic and seasonal characteristics with waiver decisions. I will then compare the array of outcomes with this sample of waiver observations and "would-have-been-a-waiver" observations.

Based on the estimated impacts of waivers on air quality, health outcomes, and prices, I will generate estimates of social welfare. The cost of the waivers will reflect foregone air quality benefits. The benefits of the waivers will reflect the reduction in fuel prices. The initial welfare estimates will be specific to the geographic market receiving the waivers. Refinements to the benefits measures will account for the transfers that occur, both between producers and consumers and among consumers in markets with a waiver and unregulated markets.

To provide a basis for assessing the incremental benefits of a product reserve, the assessment of social welfare from the waivers will first determine if the waiver policy has positive net social benefits. If it does not, then this suggests that alternative options, such as a product reserve, should be examined. If it does, then the timing and magnitude of the price impacts of the waiver could inform the consideration of the benefits of a product reserve.

Data

Waivers: I have already compiled a dataset describing all EPA waivers of fuel content regulation since 2005. This includes dates, geographic coverage, and rationale for the waiver decision. Thus, I can identify and discern waivers due to a shock local to a market (e.g., Hurricane Katrina and Louisiana) from a shock affecting refining capacity or a pipeline distant from a given market (e.g., Hurricane Rita and Kentucky).

Air Quality: I will use hourly air quality monitoring data from the EPA for ozone, volatile organic compounds, and particulate matter.[1] I already have daily weather data (temperature, precipitation, dew point, wind speed) from the National Weather Service aggregated to the county level from another project that I will match with the air quality data.

[1] I have downloaded these data from: http://aqsdr1.epa.gov/aqsweb/aqstmp/airdata/download_files.html.

Health Outcomes: I am using daily, county-level mortality data by age and cause of death from the National Center for Health Statistics in another project. I will request the use of these data for this project. I will also explore options for acquiring patient discharge data – by location, date, and cause of admission – for a number of states.

Prices: I will use state and city-level gasoline price data from the Energy Information Administration. I will also investigate the purchase of gasoline price data from the Oil Price Information Service.

Preliminary Results

I have undertaken some preliminary analysis of the impacts of the 2005 waivers on ground-level ozone concentrations. In this work, I have used the online data appendix to Auffhammer and Kellogg (2011) for measures of ozone concentrations as well as relevant weather (temperature and precipitation) controls. Auffhammer and Kellogg estimated the impact of reformulated gasoline regulations on local ozone concentrations. I have estimated equation (1) for two measures of ozone concentration – the daily maximum and the highest daily 8-hour average – for two samples – all counties and all waivers in the Auffhammer and Kellogg dataset and all counties and waivers EXCEPT for those in Louisiana, Mississippi, and Texas. I include temperature and precipitation functions, as well as county, day of week, month, and year fixed effects.

The table presents the results from these initial regressions. For the full sample regressions, waiving the fuel content regulations appears to increase ozone concentrations by about 2 to 2.5 percent. In eliminating Louisiana, Mississippi, and Texas observations from the sample, which includes eight of the 2005 waivers issued by the EPA, the estimated impacts of the waiver are statistically precise zeroes. A negligible or zero effect on ozone concentrations would not be surprising in light of Auffhammer and Kellogg's paper, which shows that reformulated gasoline did not reduce ozone concentrations outside of California. Since some of the waivers addressed sulfur regulations, and some controls of volatile organic compounds address fine particulates, subsequent work will investigate the impacts of waivers on particulate matter concentrations and mortality outcomes.

Policy Implications

U.S. clean air policy has produced a highly segmented transportation fuels market – in effect, many distinct local and regional markets. This imposes economic costs that are magnified when domestic product supply is subject to shocks, especially from hurricanes. Given continuing interest in promoting U.S. energy security and resilience in domestic product markets, this proposed project would evaluate the social welfare implications of waiving fuel content regulations in response to such shocks. This analysis would illustrate how markets respond to changes in regulatory implementation and highlight whether alternative instruments for promoting energy security, such as a strategic product reserve, would yield meaningful incremental benefits.

Research Team

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References

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Table. Impact of Waiving Clean Air Act Fuel Content Regulations on Ozone Concentrations, 2000-2005

	ln(max O_3)	ln(8-hour O_3)	ln(max O_3)	ln(8-hour O_3)
Waiver Indicator	0.022***	0.026***	0.000	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
N	1,887,254	1,887,254	1,667,226	1,667,226
R^2	0.46	0.46	0.48	0.47
Fixed Effects				
Day of Week	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Month	Yes	Yes	Yes	Yes
County	Yes	Yes	Yes	Yes
Sample	All States	All States	No LA, MS, TX	No LA, MS, TX

Notes: Heteroskedasticity robust standard errors are presented for all regressions (* p<0.10, ** p<0.05, *** p<0.01). Regressions include cubic polynomials in minimum and maximum daily temperatures and precipitation.

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Call for Proposals: Economics of Energy Markets

Aldy, Joseph <Joseph_Aldy@hks.harvard.edu> Wed, Nov 4, 2015 at 10:49 PM
To: "epepe@nber.org" <epepe@nber.org>

Dear Elisa Pepe,

Please find attached my research proposal for the Economics of Energy Markets call for proposals.

I do not have any financial conflicts of interest related to the proposed work.

Best,

Joe

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