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Market Effects of Regulatory Heterogeneity: A Study of Regional Gasoline Content Regulations

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MARKET EFFECTS OF REGULATORY HETEROGENEITY: A STUDY OF REGIONAL GASOLINE CONTENT REGULATIONS

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Abstract

The Clean Air Act Amendments of 1990 and subsequent state-level environmental regulations specify regional content criteria that gasoline must meet prior to retail sale. Since the early 1990's, the regulations have created fifteen unique blends of gasoline for use in different locations. Allowing gasoline content to vary by jurisdiction allows regulators to more efficiently address local air emission problems. However, increasing the number of blends of gasoline imposes additional refining, transportation and storage costs. This paper surveys the tradeoff between the benefits of allowing heterogeneous regulation of content and the potential market impacts of increasing the number of blends of gasoline.

Keywords: Environmental Regulation, Gasoline, Product Heterogeneity

I. Introduction

Federal gasoline content regulations define both what must be removed from gasoline during the refining process and what must be added to the fuel, prior to retail sale. Local regulations can impose additional requirements to address local air emissions concerns. Currently, federal and state-level regulations of gasoline content define fifteen blends of gasoline to be sold in different markets at different times of the year. Initially introduced as part of the Clean Air Act Amendments of 1990 (CAAA) to reduce air emissions, regional state and federal content regulations have attracted interest from legislators, regulators and consumers, as gasoline prices have risen more than sixty cents per gallon since January 2006, to an average of $2.87 per gallon.[1] On April 25, 2006, in a speech to the Renewable Fuels Association, President Bush directed the Environmental Protection Agency (EPA) to assess current federal and state environmental regulation of gasoline content. In particular, he directed the EPA to analyze the costs and benefits of local regulation of gasoline content and to convene a task force to consolidate state and federal gasoline requirements. Of particular concern to regulators is that "unique fuels may present serious challenges to the fuel distribution system and, especially in time of disruption, my have the potential to result in local supply shortages."[2]

In this paper, I discuss the benefits and costs created by heterogeneous environmental regulation of gasoline content. Allowing regulations to vary by jurisdiction creates several benefits. First, regulators can tailor rules to better address problems specific to the jurisdiction. In addition, local tailoring allows locations where the benefits of regulation would be lower to impose less stringent standards, reducing unnecessary regulatory burden. In the case of gasoline content regulation, the composition of gasoline affects the amount and type of emissions created. By requiring gasoline sold in a specific location to meet more stringent content standards, regulators can selectively reduce air emissions problematic in a particular area without imposing incremental production costs in areas without air emission problems. Second, jurisdictional variation allows regulations to better match local preferences for the provision of public goods. If citizens place a higher value on air quality in one location than another, legislators can require gasoline to meet more stringent requirements, further reducing air emissions.

However, heterogeneous regulation may increase the costs of production, as firms must produce, transport and sell gasoline meeting more stringent regulations. In particular, heterogenous regulation of gasoline content forces refineries to produce blends of gasoline meeting a variety of stringent content specifications. Producers must then transport and store the gasoline blends without intermixing them with other gasoline formulations. In addition to the costs of production specifically related to the stringency of the environmental regulations to which the gasoline conforms, increasing the number of gasoline blends may increase transportation and storage costs, leading to higher prices nationally. Furthermore, to the extent that costs associated with producing gasoline meeting local regulations increases gasoline prices in areas with stringent content regulations, price differences in neighboring regions affects the efficacy of the environmental regulations. Consumers and firms may respond to differences in prices caused by heterogeneous regulations in different jurisdictions, either legally through their choice of purchase or siting location or illegally by evading regulation. As a result, consumers and firms may purchase gasoline in areas with less stringent regulations and lower prices, and then use the gasoline in areas with stricter standards and greater air emission problems. Finally, diverse regulations complicate the response of local gasoline markets to shocks by reducing the fungibility of gasoline. Gasoline meeting compatible requirements may be moved between areas in response to supply or demand shocks. Incompatible gasoline formulations complicate producer response to shocks by limiting suppliers' ability to move gasoline between locations. If, for example, a refinery fire affects the production of a unique blend of gasoline, other producers cannot move incompatible gasoline into markets affected by the refinery fire. Consumers may face higher prices during the time it takes other refineries to produce gasoline conforming to the unique standards.

This paper presents the benefits and costs of allowing local jurisdictions to supplement federal regulations in the context of gasoline content regulations. This paper provides a background on regulation of gasoline content in the United States and, more generally, the effects of heterogeneous regulation. In Section II, I detail federal and state environmental regulations pertaining to gasoline content. Section III discusses the benefits of allowing content regulation to vary by jurisdiction. In Section IV, I present the effects of allowing heterogeneous regulation of gasoline content on gasoline markets. Section V concludes.

II. Environmental Regulation of Gasoline

A. Federal Regulation of Gasoline Content

The EPA regulates the chemical content of motor fuels through Section 211 of the Clean Air Act (CAA). Section 211 grants the EPA the power to "control or prohibit the manufacture, introduction into commerce, offering for sale, or sale of any fuel or fuel additive for use in a motor vehicle, motor vehicle engine or non-road engine or non-road vehicle" based on the emissions and health consequences caused by a particular fuel.[3] Section 211 not only specifies the criteria gasoline must meet, but also defines the set of additives producers are required to add or prohibited from adding to gasoline. Six programs comprise federal content regulation: (1) the prohibition on leaded anti-knock additives, (2) the mandatory addition of detergents, (3) the Tier 2 gasoline sulfur program, (4) low Reid vapor pressure gasoline, (5) oxygenated gasoline, and (6) reformulated gasoline (RFG). The content regulations mandated at the federal level vary in both seasonal and geographic scope. Table 1 presents a three part taxonomy for federal content regulations, encompassing geographic scope, temporal scope and method of implementation. Of the six programs, the former three are national regulations. The latter three are required regionally and differentiate gasoline sold in different local markets. I briefly discuss the national programs and then focus on the regional programs.

i. National Regulations

The first of the three nationwide content regulations is the prohibition on lead-based additives effective January 1, 1986.[4] Prior to 1986, producers used lead-based additives to increase octane. The EPA's new standards placed a nationwide limit of 0.1 gram of lead per gallon of gasoline, in contrast to the previous limit of 1.1 gram per gallon. In 1996, leaded gasoline was formally banned, ending the retail sale of leaded gasoline in the US. The regulation had a dramatic effect on lead emissions - from 1983 to 2002, the average concentration of airborne lead fell by 94 percent. A second national program mandated by the CAAA requires refiners to add detergents to gasoline beginning in January 1, 1995. Detergents reduce the accumulation of deposits in engines, increasing fuel efficiency and decreasing emissions. The CAAA require detergent additives, but states have the flexibility to specify the set of acceptable detergent additives. The final set of nationwide regulations is the Tier 2 Vehicle and Gasoline Sulfur program, designed to lower the sulfur content of gasoline. Phased in gradually over 2004 to 2006, the Gasoline Sulfur program lowered the allowable average sulfur content of gasoline to thirty parts per million (ppm). The reduction in sulfur from the 1990 baseline standard of 338 ppm improves the operation of catalytic converters, reducing emissions.

ii. Regional Regulations

The CAAA regionally differentiate gasoline through three programs: Low Reid Vapor Pressure gasoline, oxygenated gasoline and reformulated gasoline. The objective of the programs is to reduce mobile source emissions of carbon monoxide (CO) and precursors for ground-level ozone pollution: volatile organic compounds (VOC) and Nitrogen Oxide (NOx). The regional design for the programs targets local air emissions problematic in particular areas – the only areas required to participate are those designated in CO or ozone non-attainment, having previously failed to meet EPA guidelines for air quality. Table 2 lists the characteristics and content requirements of current federal content regulations.

Reid vapor pressure (RVP) regulation limits the propensity of gasoline to evaporate during fueling and vehicle operation.[5] RVP regulation is seasonal, in effect during May 1 to September15, the "ozone season," when higher temperatures and additional sunlight increase both fueling emissions and ground-level ozone formation. The EPA introduced low RVP gasoline in two stages. Phase I, effective Summer 1989, mandated regional RVP limits from 10.5 to 9.0 pounds per square inch (psi). Phase II, effective Summer 1992, place a national cap of 9.0 psi on gasoline vapor pressure. To address the regional variation in the severity of ozone pollution, the RVP requirements for Phase II are more strict in ozone non-attainment areas. For non-attainment areas, Phase II requirements vary from 7.8 psi to 7.0 psi during the ozone season – warmer areas, where fueling emissions and ozone formation are greatest, must meet the more stringent 7.0 psi standard.[6]

Oxygenated gasoline, introduced in November 1992, contains additives that supplement the oxygen content of gasoline. Oxygenated gasoline burns more completely in cold weather, reducing CO emissions. To meet EPA criteria, oxygenated gasoline must contain 2.7 percent oxygen by weight. Producers have flexibility in the choice of additives used to meet the requirements, including methyl tertiary butyl ether (MTBE) and ethanol. Like RVP regulation, baseline EPA requirements to oxygenate fuels have a seasonal component, making of gasoline mandatory for areas in CO non-attainment from November through February. The CAAA initially required the use of oxygenated gasoline in the 39 areas in CO non-attainment in 1988 and 1989, home to approximately 87.5 million people. In addition, any region failing to meet EPA standards for CO must begin oxygenation during winter months specified by the

EPA. Of the original CO non-attainment areas, areas containing approximately 46 million people subsequently came into CO attainment and stopped gasoline oxygenation.[7]

RFG requirements are the most comprehensive federal content regulations targeting both CO emissions (like oxygenated gasoline) and NOx and VOC emissions (like low RVP gasoline). RFG reduces air emissions through a combination of explicit content criteria, specifying maximum benzene and minimum oxygen content, and a set of performance standards. The performance standards specify reductions of VOC emissions, NOx emissions and toxic air pollutants (TAP) emissions relative to gasoline sold in 1990, but allow refiners to choice of how to formulate gasoline to reduce emissions.

The EPA phased-in RFG regulation, with the performance standards becoming stricter over time. During phase I, effective January 1, 1995, RFG needed to meet content criteria and reduce VOC and TAP emissions by fifteen percent relative to the baseline 1990 gasoline. Phase II, effective January 1, 2000, required twenty-five percent reductions in VOC and TAP emissions in addition to the content standards. In both phase I and phase II, gasoline qualifying as RFG must also have NOx emissions no greater than baseline 1990 gasoline. The CAAA requires gasoline to meet RFG standards year-round in areas in severe ozone non-attainment. Initially, the CAAA required RFG in nine cities containing a total of 63 million people: Baltimore, Chicago, Hartford, Houston, Los Angeles, Milwaukee, New York City, Philadelphia and San Diego. Regulations also require areas subsequently reclassified as being in severe non-attainment to adopt RFG. For example, Sacramento was reclassified as a severe ozone non-attainment area in the summer of 1995 and was required to use reformulated gasoline beginning January 1, 1996.[8]

B. State-level regulation of gasoline content

The set of federal content regulations define the minimum standards that gasoline in particular areas must meet. State regulations introduce additional heterogeneity in two ways: voluntarily adoption of content regulations consistent with federal regulations or introduction of content regulations more strict than the federal standards. Voluntary adoption of regulations consistent with RVP limits, oxygenated regulations or RFG regulations has little effect on regulatory heterogeneity, aside from expanding the scope of the regional programs. Only the scope of the federal RFG program has expanded substantially as a result of voluntary local adoption. Since 1995, areas containing approximately 35 million people have "opted-in" to the federal RFG program. Approximately one third of RFG usage is in areas not required to use RFG by the CAAA. Fewer areas in CO attainment have opted-in to the oxygenated gasoline program. Portland, OR and Tucson, AZ, for example, require gasoline to be oxygenated during winter months although both are in CO attainment.

In contrast to opt-in, state-level regulations that increase the stringency of content standards beyond federal requirements increase the number of gasoline blends in use. Local regulations supplement federal requirements by increasing the seasonal duration or stringency of the federal regulations, by enacting state programs to supplant federal regulation, and by constraining the set of additives used to supplement the oxygen content of RFG or oxygenated gasoline. For seasonal RVP limits and oxygenated gasoline regulations, some participating states choose to extend seasonal programs beyond the duration required by the EPA. For example, Minnesota requires statewide oxygenation year round, rather than only during the winter. Areas increase the stringency of programs by enacting standards more strict than federal content regulations or by enacting a state-level program which supplants federal content standards. In the case of oxygenated gasoline, a number of states require higher oxygen content than the 2.7 percent required federally. For example, Arizona and Nevada both require 3.5 percent oxygen.

California supplants federal RFG regulations with a year-round state program run by the California Air Resources Board (CARB). Beginning in 1992, California began a three phase state-run program regulating gasoline content. Content regulation in Phase I of the California program, effective January 1, 1992, capped gasoline vapor pressure at 7.8 psi during the summer and required an oxygen content of 1.8 - 2.2 percent during the winter. CARB Phase II regulations, effective statewide in March 1996, lowered the summer vapor pressure limit from 7.8 psi to 7.0 psi and placed year-round limits on benzene content to 1 percent, oxygen content to 1.8 to 2.2 percent, and sulfur content to 40 ppm on all gasoline. Phase III CARB, effective March 31, 2003, tightened limits on sulfur content to 20 ppm and on benzene content to 0.8 percent by volume. Although no performance standards are specified, CARB gasoline exceeds the emissions reductions of federal phase II RFG. The state of Arizona has also adopted CARB regulations for gasoline sold in the Phoenix metropolitan area.

Finally, a number of states constrain the set of additives used to increase oxygen content. In particular, a number of states using either RFG or oxygenated gasoline induce or require refiners to blend ethanol into gasoline.[9] The motivation for this is twofold. In 1996, Illinois enacted tax incentives to encourage producers to supplement gasoline with ethanol in order to support ethanol producers and increase demand for corn-based ethanol.[10] More recently other states, beginning with California, banned MTBE due to concerns over water contamination. As of summer 2005, twenty one states outlawed the use of MTBE as an additive. Requiring the use of ethanol increases the number of blends of gasoline as well – gasoline must be refined differently to be blended with ethanol, an additive with RVP substantially above the national standard, and to continue to meet RFG performance standards.

C. From Gasoline to "Boutique Blends"

In 1991, gasoline across the country met a consistent set of content standards. These standards include national regulations limiting lead and sulfur content and requiring the use of detergents. Subsequent federal regulation mandated three sets of regional content requirements to address local air emissions problems in CO and NOx non-attainment areas: low RVP, oxygenated and reformulated gasoline. The federal regulations themselves are not mutually exclusive. More than one set of regional requirements may apply to a particular area. For example, prior to coming into CO attainment in 2000, reformulated gasoline sold in New York City area was oxygenated during the winter beyond RFG requirements to meet requirements for the oxygenated gasoline as well. In addition, areas required to use RFG also had to meet RVP limits during summer months. Not only does this differentiate summer RFG from winter RFG, but since RVP limits vary by location, RFG used in different locations meet different requirements during the summer. Federal regulations introduce a substantial amount of heterogeneity within the domestic supply of gasoline. During the winter, federally-mandated blends include conventional, oxygenated, RFG and in the case of NYC prior to 2000, oxygenated RFG. During summer months, federally mandated gasoline blends include conventional, northern low RVP (7.8 psi), southern low RVP (7.0 psi), northern RFG and southern RFG. Subsequent state-level regulation imposes more stringent requirements than federal content regulations, further increasing the number of fuels in use. Supplementary oxygenation requirements, CARB gasoline requirements, and state prohibitions on the use on MTBE increase the number of gasoline blends. In a under a decade, the US gasoline market became considerably more differentiated. Currently, heterogeneity introduced by state and federal regulations necessitates fifteen "boutique fuels," each meeting a separate set of content requirements.

Although the regulations do increase production costs and retail prices, the regulations substantially reduce mobile source emissions of CO, NOx, TAP and VOC. Table 2 and 3 list the reduction in emission over conventional gasoline associated with the use of federal and state boutique fuels. For each gasoline blend, I calculate the NOx, TAP and VOC reduction over conventional gasoline using the emission model used by EPA to evaluate gasoline for the RFG performance standards. Since CO emissions are not calculated by the complex emissions model and vary substantially with temperature and vehicle operation, I omit reductions in CO emissions. Lowering vapor pressure primarily reduces VOC emissions, oxygenating gasoline reduces CO emissions and reformulated gasoline requirements reduce a combination of VOC, TAP and CO emissions. Relative to other regulatory strategies for reducing mobile-source air emissions, Harrington, Walls, and McConnell (1995) find that regulation of gasoline content is a relatively low cost way of abating air emissions. Comparing the costs per unit abated of RFG to a number of other existing and potential policy instruments, including fuel-economy regulation, vehicle emissions standards, emission-based registration fees, and premature vehicle retirement, Harrington, Walls and McConnell (1995) find that the federal RFG program is cost-effective method of reducing local emissions VOC emissions.

III. Benefits of Regulatory Heterogeneity

The previous section presents the air emission benefits of the various state and federal content requirements. In this section, I focus specifically on the benefits of allowing content requirements to vary regionally rather than imposing uniform national standards. Intuitively, the benefit of regulatory heterogeneity is that regulators are able to target locations with severe air emission problems without forcing other areas to meet costly environmental standards. For areas not in CO or ozone attainment, gasoline content regulations reduce emissions of NOx, TAP and VOCs. Low RVP gasoline, oxygenated gasoline and RFG gasoline reduce specific air emissions and create substantial air emission benefits. At the same time, heterogeneity allows regions in CO and ozone attainment to use gasoline meeting less stringent standards, entailing lower production costs.

Regulatory heterogeneity enables regulators not only to better address local air emission problems, but also allows local jurisdictions to tailor the stringency of regulations to match local preferences. In areas where citizens place a high relative value on air quality, local jurisdictions can voluntarily adopt federal content regulations or impose regulations which are more stringent than those required by the CAAA. For example, although not required by the CAAA, Connecticut, Delaware, Massachusetts, Rhode Island, and portions of eight other states opted-in to the federal RFG program. Similarly, California implemented stricter content regulations than those required federally, further reducing emissions from gasoline through CARB regulation. States also tailor regulation to match preferences other than those for air quality. Tax incentives, enacted in Illinois in 1995, induce producers to sell ethanol-blended RFG in Chicago and Milwaukee, subsidizing Midwestern ethanol production. More recently, motivated by concerns of MTBE-related water pollution, California and twenty other states chose to ban MTBE as an gasoline additive. Again, allowing state the flexibility to enact regulations supplementary to federal content regulations allows states to better match content regulations to local regulatory priorities.

Whether regulatory heterogeneity is preferable to uniform regulation depends on the degree to which the emission abatement benefits of content regulation vary across jurisdictions as well as on the additional costs imposed by more stringent content requirements. If the costs of regulation are low or if all areas would benefit from regulations of similar stringency, a common set of regulations is beneficial. In the context of gasoline content regulation, an example is the prohibition on leaded additives to gasoline. Eliminating the use of the leaded additives substantially reduced atmospheric lead concentration and created benefits in all locations. Moreover, the costs associated with phasing out lead-based additives were relatively small. Even for areas where airborne lead concentrations are relatively low, the additional costs associated with the regulation are negligible. Thus, the benefits of regulatory heterogeneity, in this case, are small.

On the other hand, if benefits vary substantially across locations and the costs imposed by the regulations are high, heterogeneous regulation may be preferable to uniform standards. In non-attainment jurisdictions in which the emission abatement benefits are high relative to the costs of regulation, regulation creates substantial net benefits. For jurisdictions in CO and ozone attainment, for which the emission abatement benefits are lower, heterogeneous regulation allows gasoline to meet to a less stringent standard, reducing the costs of more stringent regulation to those areas.

For the three regional programs mandated by the EPA, ex-ante estimates suggest that the incremental costs to produce gasoline meeting more stringent standards are non-negligible. Required additives can raise the cost of gasoline or may reduce the energy content of gasoline, lowering the fuel economy of cars.[11] Content regulations also induce refiners to process gasoline more than they otherwise would, increasing production costs. The Environmental Protection Agency (1993) estimated that Phase I reformulated gasoline would increase production costs by three cents per gallon. In addition, the EPA estimated that Phase II RFG regulations and CARB gasoline regulations would increase production costs by an additional one to two cents per gallon and eight to eleven cents per gallon. For oxygenated gasoline, ex-ante estimates by Lidderdale (1992) predict prices of oxygenated gasoline three to five cents per gallon higher than conventional gasoline. More recent, Chakravorty and Nauges (2004) and Brown, Hastings, Mansur and Villas-Boas (2005) compare of gasoline prices in areas subject and areas not subject to regional content regulations. The studies find results of similar magnitude to the ex-ante predicitons – even after controlling for underlying heterogeneity of prices in different regions, wholesale and retail prices are higher in locations with more stringent gasoline regulations. A back-of-the-envelope calculation based on the ex-ante estimates by the EPA suggest that requiring RFG nationally since 1995 would impose additional production costs totaling approximately 40 billion dollars to produce RFG for areas in ozone attainment and using conventional gasoline.[12]

IV. Costs of Regulatory Heterogeneity

Although regulatory heterogeneity may reduce the costs of gasoline produced for areas meeting EPA standards for CO and ozone pollution while still allowing non-attainment areas to improve local air quality, heterogeneity itself creates costs by increasing the number of blends of gasoline used. That is, in addition to the costs discussed previously, which arise directly from the stringency of local regulation, increasing the number of distinct blends of gasoline has additional effects which must be considered when evaluating whether common or heterogeneous regulation is preferable to national standards. Even if the benefits to heterogeneity discussed in the previous section are substantial, significant costs arising from heterogeneity may make uniform regulation preferable.

In this section, I specifically discuss the costs of regulatory heterogeneity of gasoline content. I focus on the three costs arising from the increasing the number of blends of gasoline. First, the use of many different fuels increases the cost of refining, transporting and storing gasoline. Second, since not all gasoline meets the content requirements necessary for sale in all locations, increasing the number of gasoline blends decreases the compatibility of gasoline across different locations. In the event of a market shock to an area with especially stringent content requirements, it may be more difficult for suppliers to react and provide product to the area. Third, consumers and firms may respond to avoid stringent content regulation if nearby jurisdictions with less stringent regulation also have lower prices. Regulatory avoidance, through choice of purchase or siting location, or regulatory evasion, by firms who sell gasoline failing to meet required content regulations, reduce the efficacy of regulation.

A. Effects of Regulatory Heterogeneity on Transportation and Storage

Increasing the number of gasoline blends creates additional costs associated with transportation and storage of all blends of gasoline. Heterogeneity of content regulation complicates the transportation of gasoline from refiners to wholesale terminals. Gasoline is transported to wholesale terminals either through pipelines or by barge, depending on the locations of the refinery and terminal. In order to ensure that fuel meets specifications after transportation, different blends of gasoline must be transported separately. While regulatory heterogeneity does not significantly complicate barge transportation, pipeline transportation becomes more complicated as the number of transported fuels rises, increasing transportation costs. Moreover, state regulations requiring the use of ethanol introduce additional transportation difficulties. While refiners produce and mix other oxygenates, such as MTBE, at the refinery prior to transportation to the wholesale terminal, ethanol is not produced at the refinery, and cannot be mixed with blendstock prior to transportation by pipeline.[13] This requires ethanol to be transported by rail to wholesale terminals, at which point it is blended with gasoline to meet content requirements.

Regulatory heterogeneity also imposes costs on wholesale terminals which must store gasoline meeting different content requirements. Wholesale terminals serving areas requiring different blends of gasoline must have sufficient storage at the terminal to maintain separate inventories of each gasoline formulation. Moreover, terminals must also have the infrastructure to handle and distributed gasoline meeting different content requirements in a way which maintains the content and performance requirements of each blend. The use of ethanol as an oxygenate creates similar costs at wholesale terminals. Not only must wholesale terminals keep inventories of ethanol, but terminals must have the infrastructure to blend ethanol into gasoline. Prior to the prohibition of MTBE in California, Gomez, Brasil and Chan (1998) noted that the inability of wholesale terminals to store and blend large amounts of ethanol constrained the introduction of widespread ethanol usage in California.

B. Market Response to Shocks

In August 2001, the head of the EPA, Christie Whitman, suggested that “limiting the number of ‘boutique blends’ to three or four formulas could increase fuel supplies and help prevent large spikes in the prices drivers see at the pump.”[14] Increasing the number of gasoline blends reduces the ease with which gasoline in one location can be substituted for gasoline in another location in response to market shocks. Meta-analyses of gasoline demand elasticity studies by Dahl and Sterner (1991) and more recently by Espey (2001) find that gasoline demand is relatively inelastic, with median and mean demand elasticities of -0.23 and -0.26 across a large number of studies. This creates the potential for significant volatility in gasoline prices in the event of shocks that cause local shortages of gasoline, such as local refinery outages due to fire or temporary reductions in local pipeline capacity. Two sources can help to mitigate potential price volatility created by a local supply shocks. First, inventory stored at wholesale terminals provides a cushion in the event of a supply shock. In addition, refiners can also choose to reallocate gasoline in response to a local shock, so long as the gasoline meets the relevant content requirements. As the number of gasoline blends increases, each of these sources becomes less effective, and thus, price volatility might increase as a result of increasing the number of blends of gasoline.

As discussed above, wholesale terminals must carry inventories of all formulations of gasoline used in nearby areas. For wholesale terminals serving areas with disparate regulations, terminals must either substantially invest in additional storage capacity or carry lower inventories of each blend of gasoline. Moreover, seasonal variation in content regulations, such as the RVP regulations and attendant summer reformulated gasoline, requires wholesale terminals to drain inventories of gasoline meeting less stringent winter requirements prior to building inventories of summer formulations. In its investigation of the Midwestern gasoline price spike in the spring of 2000, the Federal Trade Commission (2001) found, among other explanations for high gasoline prices, that the reduction in inventories prior to the introduction of Phase II RFG standards limited the ability of refiners and marketers to respond to reductions in pipeline capacity on the Explorer and Wolverine pipelines serving the Midwest and to refinery outages at several Chicago refineries.

In addition to reducing inventories of gasoline at wholesale terminals, increasing the number of blends of gasoline also impacts the ability of refiners to respond to local supply shocks. As discussed above, content regulations often require refinery investment, which not all refiners choose to make. In addition, making large, short-term changes to production is costly for refiners (Borenstein and Shepard 2000). Thus, only refiners producing a particular blend of gasoline at the time of the market shock are immediately available to respond to high local prices. For example, the Federal Trade Commission (2001) found that the requirement to use ethanol as an oxygenate in Chicago and Milwaukee reduced the ability of other refineries to substitute MTBE-blended Phase II RFG for ethanol-blended Phase II RFG during the Midwestern price spikes. A later investigation conducted by the US Senate Subcommittee on Investigations (2003) echoed this, stating "the current gasoline production and distribution system is able provide adequate quantities of boutique fuels," but "in the event of a supply disruption or shortage, it may be more difficult to bring in additional supply to an area that requires a boutique fuel rather than a conventional fuel, because fewer refiners may be readily capable of producing the required gasoline."[15] Empirical evidence also suggests that regulatory heterogeneity increases the magnitude of prices spikes in markets with special regulations. Muehlegger (2006) estimates that if local regulations were compatible with federal RFG, compatibility would mitigate approximately 70 and 90 percent of local price spikes arising from refinery outages in California and Illinois.

Finally, increasing the number of gasoline blends, in theory, has the potential to increase the ability of refiners to coordinate production decisions or exercise market power, if some gasoline blends are produced by a small number of refiners. In fact, market power concerns motivated the FTC Midwest gasoline price spike investigation. In the case of the prices spikes in the spring of 2000, though, the FTC found no evidence of coordinated actions by the industry participants finding that "prices rose both because of factors beyond the industry's immediate control and because of conscious (but independent) choices by industry participants." [16]

C. Consumer Avoidance of Regulation

As discussed in Section III, the production costs of gasoline tend to increase with the stringency of the content regulations. If regulatory heterogeneity causes gasoline prices to differ in neighboring jurisdictions, consumers and firms may make choices that reduce emission abatement in the area with more stringent content regulations. Consumers and firms respond to differences in prices across jurisdictions by choosing where to purchase gasoline based on the potential savings from traveling to a nearby jurisdiction and the costs associated with traveling to the jurisdiction. If the potential savings for consumers are high relative to the travel costs associated with purchasing fuel in a jurisdiction with less stringent content requirements, consumers in areas with more stringent regulations may travel and purchase gasoline meeting lower standards. This has the direct effect of reducing the emission abatement efficacy of local content regulations, as consumers use gasoline failing to meet stringent local standards. Similarly, the incentive for regulatory evasion, through the purchase and sale of gasoline not meeting required content regulations, depends on the relative price of gasoline meeting stringent standards and gasoline meeting less stringent standards and the costs associated with evading content regulations.

In the case of many local content regulations, the incentive for regulatory avoidance or evasion is low. Although gasoline prices rise with regulatory stringency, the incremental effect on prices tends to be small, and thus, the benefits to an individual consumer of purchasing gasoline in a region with less stringent regulation is also low. Moreover, many local content regulations are mandated at the state level, and thus, the costs associated with traveling to a less stringent jurisdiction are often substantial. In cases, though, where local regulations require substantially more costly regulations over a small geographic scope, such as regulations mandated for Phoenix, Chicago, Milwaukee and Atlanta, regulatory avoidance and evasion become more of a concern.

V. Conclusion

Over the past fifteen years, federal and state regulation of gasoline content has substantially differentiated the domestic supply of gasoline. Content regulations tailor the formulation of gasoline to address problematic local air emissions and to better match local preferences for air quality. This paper considers the benefits and costs of existing heterogeneity in the regulation of gasoline content. The benefits from heterogeneity arise from the tradeoff between the emissions abatement benefits of stringent content regulations and the additional production costs incurred in producing gasoline satisfying more stringent requirements. Regional heterogeneity allows areas with air emission problems to substantially abate air emissions through strict requirements while allowing areas without air emission problems to use gasoline meeting less stringent (and less costly) standards. At the same time, heterogeneous regulation of gasoline content imposes systemwide transportation and storage costs, increases the volatility of gasoline prices by reducing gasoline fungibility, and creates incentives for consumer avoidance or evasion of regulation.

Regulatory policy focused on consolidation or expansion of gasoline content regulation should weigh the costs and benefits associated with increasing the amount of heterogeneity. Existing air emission problems suggest that efficient regulatory policy would maintain a menu of content regulations to target locations with specific air emission problems without imposing substantial costs on areas meeting EPA air emission standards. At the same time, regulators should consolidate duplicative formulation requirements that possess similar emissions characteristics, but unnecessarily increase the number of blends of gasoline. In 2005, 138 billion gallons of gasoline were sold in the United States.[17] To the extent that excessive heterogeneity of gasoline content imposes costs on producers and consumers, large potential benefits exist to standardizing the existing set of gasoline content regulations.

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Endnotes

[1] Energy Information Administration (EIA), US Retail Gasoline Price Report, May 29, 2006.
[2] "EPA Administrator, Governors to Review Boutique Fuels", Environmental Protection Agency News Release, 5/4/2006.
[3] Clean Air Act, Section 211 (c)(1)
[4] "EPA Sets New Limits on Lead in Gasoline", EPA press release, March 4, 1986.
[5] Lowering RVP substantially reduces VOC emissions during vehicle fueling. The EPA complex gasoline emissions model estimates that lowering RVP from 8.7 to 7.8 psi reduces fueling VOC emissions 26% and exhaust VOC emissions 3%. Lowering RVP from 8.7 to 7.0 psi reduces fueling VOC emissions 42% and exhaust VOC emissions 6%.
[6] For a list of areas with low-RVP standards, see "Guide on Federal and State Summer RVP Standards", http://www.epa.gov/otaq/regs/fuels/420b05012.pdf.
[7] For a list of areas using oxygenated gasoline, see "State Winter Oxygenated Fuel Program Requirements for Attainment or Maintenance of CO NAAQS", http://www.epa.gov/otaq/regs/fuels/420b05013.pdf.
[8] For a comprehensive list of areas subject to RFG regulation, see http://www.epa.gov/otaq/rfg/whereyoulive.htm.
[9] Some states explicitly require the use of ethanol. A number of other states prohibit the use of MTBE. Limitations on the supply of oxygenates other than ethanol makes the prohibition of MTBE equivalent to requiring ethanol.
[10] The Gasohol Fuel Tax Abatement Act exempts 30 percent of gasohol containing 10 percent ethanol from state sales taxes. Effective July, 2003, 20 percent of gasohol sales are exempt from state sales tax.
[11]Oxygenates and benzene have lower energy content than gasoline. As a result, oxygenated gasoline lowers fuel efficiency 2-3 percent. RFG benzene limits partially counteract fuel efficiency effects of oxygenation – CARB and RFG have approximately 1-2 percent lower fuel efficiency than conventional gasoline.
[12] Based on incremental costs of Phase I RFG and Phase II RFG of four cents per gallon and five and half cents per gallon for all conventional gasoline from 1995 through 2004.
[13] Ethanol is has an affinity for water and will separate from gasoline in water's presence. Presence of sufficient water in product pipelines forced ethanol to be blended at the wholesale terminal rather than prior to pipeline transportation.
[14] "EPA mulls limiting number of special gasoline blends", The Associated Press, 8/6/01
[15] US Senate Subcommittee on Investigations (2003) at pg 74-75.
[16] Final Report of the Federal Trade Commission, Midwest Gasoline Price Investigation, March 29, 2001.
[17] EIA Petroleum Marketing Annual, 2005, Table 48.

Table 1: Federal Gasoline Content Regulations

Regulation	Required Geographic Scope	Seasonality	Method of Compliance	Notes
Lead Anti-knock Agents	National	Full Year	Alternative Additives	
Detergents	National	Full Year	Additives	
Tier 2 Gasoline Sulfur Program	National	Full Year	Refining	Phase in from 2004-2006.
Phase II Reid Vapor Pressure	National	Summer	Refining	National: 9.0 psi limit.
Phase II Reid Vapor Pressure	Ozone Non-Attainment Areas (NAA)	Summer	Refining	Regional: 7.0 - 7.8 psi limit.
Oxygenation	CO NAA	Winter	Additives	Period and Additives vary by location.
Reformulated Gasoline	Severe or Extreme Ozone NAA	Full Year	Additives, Refining	Phase I in 1995, Phase II in 2000.

Table 2: Properties of Current Federal Gasoline Blends

Specification	National RVP Limit	Low RVP Northern Region	Low RVP Southern Region	Oxygenated	RFG Phase II Winter	RFG Phase II Summer North	RFG Phase II Summer South
Scope							
Retail Implementation Date	1-May-92	1-May-92	1-May-92	1-Nov-92	1-Jan-00	1-Jan-00	1-Jan-00
Temporal	May 1 - Sept 15	May 1 - Sept 15	May 1 - Sept 15	Nov 1 - Feb 29	Year-Round	Year-Round	Year-Round
Geographic	National	Regional	Regional	Regional	Regional	Regional	Regional
Content Regulation							
RVP limit	9.0	7.8	7.0	-	-	7.8	7.0
Oxygen Content (% weight)	-	-	-	2.7 % min	2.0 % min	2.0 % min	2.0 % min
Benzene Content (% volume)	-	-	-	-	1.0 % max	1.0 % max	1.0 % max
Sulfur Content (ppm)	-	-	-	-	-	-	-
Performance Standards							
NOx Reduction	-	-	-	-	0.0%	0.0%	0.0%
VOC Reduction	-	-	-	-	25.0%	25.0%	25.0%
TAP Reduction	-	-	-	-	25.0%	25.0%	25.0%
Emission Reduction over Conventional Gasoline^							
NOx Reduction	0.0%	-0.3%	-0.5%	-0.3%	-0.2%	-0.5%	-0.7%
VOC Reduction	0.0%	-11.5%	-18.9%	-0.6%	-0.5%*	-11.9%*	-19.4%*
TAP Reduction	0.0%	-1.4%	-2.4%	-8.6%	-14.9%*	-15.8%*	-16.5%*

^ Based on EPA complex emissions model.

* Emissions reduction based explicit content Standards only. Performance Standards must still be met.

Table 3: Properties of State Gasoline Blends

Specification	CARB Phase I	CARB Phase II	CARB Phase III Using Ethanol	RFG Phase II Using Ethanol	Oxygenated Using Ethanol	Oxygenated Using Ethanol
Scope						
Retail Implementation Date	1-Jan-92	1-Mar-96	31-Mar-03	1-Jan-00	1-Nov-92	1-Nov-92
Temporal	Seasonal	Year-Round	Year-Round	Year-Round	Winter	Winter
Geographic	California	California	California	Various Locations	Various Locations	Pheonix, Las Vegas
Content Regulation						
RVP	7.8	7.0	7.0	-	-	-
Oxygen Content (% weight)	1.8 % - 2.2 %	1.8 % - 2.2 %	1.8 % - 2.2 %	2.0 % min	2.7%	3.5%
Benzene Content (% volume)	-	1.0 % max	0.8 % max	1.0 % max	-	-
Sulfur Content (ppm)	-	40.0	20.0	-	-	-
Performance Standards						
NOx Reduction	-	-	-	0.0%	-	-
VOC Reduction	-	-	-	25.0%	-	-
TAP Reduction	-	-	-	25.0%	-	-
Emission Reduction over Conventional Gasoline^						
NOx Reduction	-0.3%	-11.6%	-12.6%	-0.2%	-0.3%	-0.3%
VOC Reduction	-11.5%	-22.8%	-23.0%	-0.5%	-0.6%	-0.8%
TAP Reduction	-1.4%	-23.9%	-24.3%	-12.0%	-3.9%	-3.9%

^ Based on EPA complex emissions model.

* Emissions reduction based explicit content Standards only. Performance Standards must still be met.

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