



Do Environmental Regulations Cause Firms to Exit the Market? Evidence from Underground Storage Tank (UST) Regulations*

Haitao Yin
Erb Institute
University of Michigan

Howard Kunreuther
The Wharton School
University of Pennsylvania

Matthew White
The Wharton School
University of Pennsylvania

Corresponding author: Haitao Yin, Erb Institute for Global Sustainable Enterprise, University of Michigan, 3544 DANA Building, 440 Church Street, Ann Arbor, MI 48109, Tel: (734) 647-5958, Fax: (734) 647-8551, Email: haitaoy@bus.umich.edu

October 2007
Working Paper # 2007-10-17

**Acknowledgements.* We thank Jeff Tanner and Kevin Wieber (Michigan Department of Environmental Quality), Mark Barolo, William Foskett, Paul Miller and Sammy Ng (U.S. Environmental Protection Agency), and Carol Amend (EPA Region 3) for extensive assistance with this project and many insightful comments. This project received financial support from the Wharton Risk Management and Decision Processes Center at the University of Pennsylvania and the Erb Institute for Global Sustainable Enterprise at the University of Michigan.

Risk Management and Decision Processes Center
The Wharton School, University of Pennsylvania
3730 Walnut Street, Jon Huntsman Hall, Suite 500
Philadelphia, PA, 19104
USA
Phone: 215-898-4589
Fax: 215-573-2130
<http://opim.wharton.upenn.edu/risk/>

CITATION AND REPRODUCTION

This document appears as Working Paper of the Wharton Risk Management and Decision Processes Center, The Wharton School of the University of Pennsylvania. Comments are welcome and may be directed to the authors.

This paper may be cited as: Howard Kunreuther, Haitao Yin and Matthew White, **“Do Environmental Regulations Cause Firms to Exit the Market? Evidence from Underground Storage Tank (UST) Regulations,”** Risk Management and Decision Processes Center, The Wharton School of the University of Pennsylvania, October 2007.

The views expressed in this paper are those of the author and publication does not imply their endorsement by the Wharton Risk Center and the University of Pennsylvania. This paper may be reproduced for personal and classroom use. Any other reproduction is not permitted without written permission of the authors.

THE WHARTON RISK MANAGEMENT AND DECISION PROCESSES CENTER

Since its creation 25 years ago, the mission of the Wharton Risk Management and Decision Processes Center has been to carry out a program of basic and applied research to promote effective corporate and public policies for low-probability events with potentially catastrophic consequences. The Risk Center has focused on natural and technological hazards through the integration of risk assessment, risk perception and risk financing with risk management strategies. After 9/11, research activities extended also to national and international security issues (e.g., terrorism risk insurance markets, protection of critical infrastructure, global security).

Building on the disciplines of economics, decision sciences, finance, insurance, marketing and psychology, the Center's research program has been oriented around descriptive and prescriptive analyses. Descriptive research focuses on how individuals and organizations interact and make decisions regarding the management of risk under existing institutional arrangements. Prescriptive analyses propose ways that individuals and organizations, both private and governmental, can make better decisions regarding risk. The Center supports and undertakes field and experimental studies of risk and uncertainty to better understand the linkage between descriptive and prescriptive approaches under various regulatory and market conditions. Risk Center research investigates the effectiveness of strategies such as risk communication, information sharing, incentive systems, insurance and regulation.

The Center is also concerned with training decision makers and actively engaging multiple viewpoints, including the expertise of top-level representatives in the world from industry, government, international organizations, interest groups and academics through its research and policy publications and through sponsored seminars, roundtables and forums.

More information is available at <http://opim.wharton.upenn.edu/risk>

Do Environmental Regulations Cause Firms to Exit the Market? Evidence from Underground Storage Tank (UST) Regulations

Abstract:

This paper examines whether Underground Storage Tank (UST) regulations had uneven impacts on petroleum retail outlets, and explores the reasons why some outlets are more likely to exit the market than others under UST regulations. The analyses suggest that both the *economies of scale* and the *liquidity constraints* arguments can explain the uneven impact UST regulations had on different petroleum retail outlets. *Economies of scale* give large outlets a greater competitive advantage because it is more difficult for small outlets to pass on compliance costs to customers. *Liquidity constraints* make outlets owned by small firms more vulnerable to UST regulations because small firms do not have the financial capability to replace or upgrade equipment as required by UST technical standards. This suggests that small businesses have more difficulties competing with large businesses under environmental regulations.

Key Words:

Environmental Regulations, Economies of Scale, Liquidity Constraints, Underground Storage Tank

1. Introduction

Some facilities/firms exit the market rather than complying with costly environmental regulations. The purpose of this paper is to delineate the types of facilities/firms that are more likely to exit the market and more importantly, the major economic reasons for their exit. These questions deserve answers for several reasons. If many facilities/firms choose to exit the market in response to environmental regulations, the survivors would gain significant market power, and a healthy market competition would be threatened. If certain types of facilities/firms are more vulnerable to environmental regulations than others, public sector agencies may want to couple environmental regulations with appropriate economic assistance to vulnerable businesses if they are considered essential for providing services or spurring competition.

Much literature has been devoted to the uneven impacts of environmental and safety regulations among different types of facilities/firms, especially with respect to firm and/or facility size [2, 3, 8, 19, 20]. Pashigian [19] found that the market share of small plants experienced a larger decrease in the “high pollution abatement cost” group of industries than the “low pollution abatement cost” group of industries from 1972 to 1977, when U.S. environmental regulations became more stringent. Pashigian [19] concluded that “environmental laws ha[ve] ... placed a greater burden on small than on large plants.” Bartel and Thomas [2] found that industries with a high proportion of their workers in large establishments have actually profited from the enforcement of OSHA and EPA regulations, while those with a high proportion of workers in small establishments have been the losers. More recently, Dean, Brown and Stango [8] examined new business formations across 170 manufacturing industries over a ten year span and suggested that a greater intensity of environmental regulation is associated with fewer small business formations.

Our study makes a contribution to this literature not only because it directly addresses firm/facility exit, which is largely left unexplored in the literature¹, but also because of two features which make it different from previous studies. First, the economic mechanisms underlying the uneven impacts of environmental regulations were seldom discussed in the existing literature, and when they were, *economies of scale* occupied almost all the attention. Typically, the papers contend that there are substantial economies of scale involved in compliance, and therefore small facilities/firms are heavily affected [2, 19, 22]. In this paper, we will show that both the *liquidity constraints* and the *economies of scale* arguments can explain why small businesses are more likely to exit the market under environmental regulations. Although both lead to disadvantages for small businesses, for analytical purposes and ultimately, for policy purposes,² these two mechanisms are distinct.

Second, most of the literature [2, 8, 19] relied on inter-industry comparisons. Although these papers provided insights across a broad range of industries, they could not explicate the role of environmental regulations in specific industries [8]. Nor could they provide a deeper understanding of the economic mechanisms underlying the uneven impacts. Environmental regulations may have very different impacts on the dynamics between large and small firms in different industries. Contrary to the dominant view that small firms/facilities may be disadvantaged because of economies of scale, Ringleb and Wiggins [21] argued that small establishments in hazardous industries may benefit from stricter environmental laws because larger firms in these industries tend to transfer hazardous operations to small ones to protect

¹ The literature has investigated whether environmental regulations have a larger impact on small firms' profits, wages and innovation than large firms [2, 23]. Pashigian [19] examined the impact of environmental regulation on the overall market structure but did not separate entry and exit. The impact on firm entry was addressed by Dean and Brown [7] and Dean, Brown and Stango [8].

² If *liquidity constraints* are the major reason, a low interest loan program may be desirable. However, if the *economies of scale* are significant, a tax credit or small-business exemption may be more appropriate. Of course, this will raise a set of interesting policy questions we will discuss briefly in the section 7 but requires future research.

themselves from liabilities associated with environmental regulation. Having not focused on specific industries, the previous literature has not provided a satisfactory discussion of the economic mechanisms driving firms' asymmetrical responses to environmental regulation.

In this paper, we focus on one specific environmental regulation – Underground Storage Tank (UST) regulation, and its impacts on one specific sector – the petroleum retail market. In doing so, we are able to track the regulatory changes over time and study how firms respond to them. We are also able to perform analyses at the facility level – a much finer level than inter-industry comparisons. We focus on Michigan's UST program. During the past twenty years, Michigan's UST regulations have undergone several significant changes, which, as discussed in section 4, provide the researchers with an appropriate setting to test and disentangle the importance of the *economies of scale* and *liquidity constraints* in determining what types of petroleum outlets are most likely to exit the market under UST regulations.

The paper is organized as follows. Section 2 provides a brief background of Underground Storage Tank (UST) regulations and the petroleum retail market. Section 3 discusses the relevance of the *economies of scale* and *liquidity constraints* in explaining petroleum outlets' decisions to exit the market. Section 4 discusses the strategies to test and disentangle the empirical relevance of these two mechanisms. The results and alternative explanations for them are discussed in Section 5 and 6 respectively. Section 7 summarizes the major findings and suggests directions for future research.

2. UST Regulations and Petroleum Retail Market

2.1 Federal and Michigan UST Regulations

UST regulations address the environmental risks posed by UST leaks, one of the most common and serious environmental problems in the United States in the early 1980s. The petroleum products leaking from USTs (e.g., gasoline, diesel, waste oil and kerosene) can contaminate groundwater and pollute drinking water supplies. Most USTs are installed at petroleum retail outlets and were unregulated until 1984. In 1983, the CBS program *60 Minutes* aired a story called “Check the Water,” which brought national attention to families suffering from the effects of gasoline leaking from USTs at gasoline stations and other places. In response to soaring public concerns, Congress expanded the Resource Conservation and Recovery Act of 1976 by enacting the Hazardous Solid Waste Amendments (HSWA) in 1984 that had a provision regulating USTs.

The Environmental Protection Agency (EPA) proposed rules governing USTs in 1987. First, the agency set forth technical standards for the prevention, detection and correction of leaks from new and existing UST systems. Second, the EPA devised Financial Responsibility Requirements (FRRs) that require UST owners and operators to demonstrate financial capability to pay clean up costs and third-party claims. UST owners and operators can comply with FRRs by purchasing private insurance or participating in a qualified state fund program if their state has one.³

³ Other instruments include self-insurance, obtaining a guarantee, a surety bond, or a letter of credit. They are seldom used because they are more expensive than insurance or do not transfer risk in the same way as insurance. Some of these instruments may require assets to be pledged as collateral that are beyond the resources of the average tank owner [11].

Figure 1: UST Regulatory History of Michigan

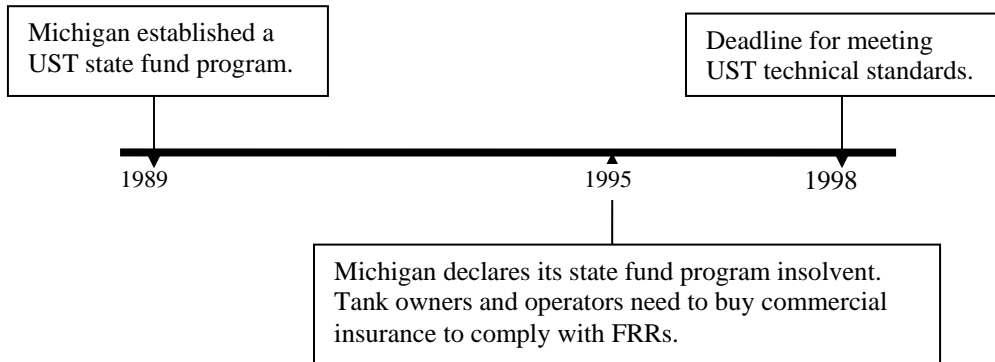


Figure 1 depicts the major events in Michigan’s UST regulatory history. Michigan started its UST programs in the late 1980s; however, prior to 1995, these regulations did not have significant cost impacts on UST owners and operators. First, technical standards were not enforced on existing UST systems.⁴ Second, after Michigan established a UST state fund in 1989, UST owners and operators could comply with FRRs by participating in the state fund program. The UST state fund program is financed with taxes and tank owners and operators can essentially participate for free.⁵

In 1994 and 1995, the Michigan UST state fund program experienced significant financial difficulties, leading the state to discontinue its state fund program in 1995. UST owners and operators now need to buy commercial insurance to comply with FRRs. The insurance premium is normally closely tied to the risk of the insured tank [17]. Table 1 shows the insurance premiums for different types of tanks in 1995 (for \$1 million coverage). For example, the premium is \$1,500 for a single-walled tank of 11-15 years old, and \$400-\$725 for a double-walled tank at a similar age. In response to this regulatory change, petroleum retailers

⁴ The deadline for the owners of existing USTs to meet the technical requirements concerning spill, overfill, and corrosion protection was December 1998.

⁵ Although tank owners and operators have to pay a tank fee, they pay this fee as part of their tank registration requirements whether or not they claim benefits from the state fund program.

had three options. First, they could upgrade⁶ or replace their old USTs and in return pay a lower insurance premium. Second, they could choose not to undertake major upgrading work and then pay a higher insurance premium. Finally, they could choose to exit the market.

Table 1: Tank Quality and Insurance Premium in 1995 (per Tank)

Type of Tank		Insurance Premium
Single-walled		
Tank Age	6-10 years	\$700 - \$1450
	11-15 years	\$1500
	16-30 years	\$2500- \$4000
Double-walled		
Tank Age	6-10 years	\$350-\$725
	11-15 years	\$400-\$725

Source: Public Sector Consultants, Inc. (1995) Premiums are for \$1 million coverage.

Another regulatory change occurred in 1998, when UST owners and operators had to replace their pre-1989 installed tanks with new tanks, or upgrade them to meet UST technical standards concerning spill, overflow, and corrosion protection (40 CFR §280.21). Both options are very costly. The EPA estimated that it would cost between \$80,000 and \$100,000 to replace an existing three-tank facility with three new USTs and piping, assuming no cleanup is needed. The EPA also estimated that it would cost around \$13,000 to upgrade a three-tank system with cathodic protection and spill and overflow protection. EPA recognized, these estimates are *low* [24]. In response to this regulatory change, the petroleum retailers were forced to upgrade or replace their old USTs or leave the business.

⁶ For example, tanks can be retrofitted with interior linings, coated with corrosion resistant materials, or protected by cathodic devices that divert the low-level corrosion-causing electrical charge generated in the ground to another piece of metal [13] (also see 40 CFR §280.21).

2.2 Petroleum Retail Market

Petroleum retailing is a mixed distribution system where there is a variety of contractual forms for the vertical relationship between the retailers and the refiners, including company operated outlets, lessee dealer operated outlets, open dealer operated outlets, and independent retail outlets [12]. For *company operated outlets*, the branded refiner owns the station and an employee of the refiner manages the station. In the case of *lessee dealer operated outlets*, the refiner owns the station and leases it to a residual claimant. For *open dealer operated outlets*, the retailer owns the station property and signs a contract with a branded refiner to sell its brand of petroleum products. All these outlets sell branded petroleum products. If an outlet sells unbranded petroleum products, it is an *independent retail outlet*. Independent retail outlets can sell any type of petroleum products and can purchase them from any refiner.

With respect to the relationship between the petroleum retailers and refiners, a critical question in this research is who is responsible for the costs of regulatory compliance – upgrading or replacing the USTs, and purchasing commercial insurance if required. The short answer is the property owner.⁷ In the case of *company operated outlets* and *lessee dealer operated outlets*, the branded refiner is responsible for financing the UST replacement or upgrading work, and purchasing insurance for FRRs. In the case of *open dealer operated outlets* and *independent retail outlets*, the retailers own the outlet properties, and are responsible for any costs arising from the compliance with UST regulations. In this paper, petroleum outlet refers to a retail station, and petroleum firm refers to the entity that owns retail stations.

⁷ Phone interview with Jeff Tanner at Michigan Department of Environmental Quality (February 7, 2006); interviews with employee at Broad Street Citgo, Philadelphia (February 6, 2006); and interviews with Cathy Mchaney at Sun Oil Company (February 9, 2006).

3. Economies of Scale and Liquidity Constraints

This section discusses the role of the *economies of scale* and *liquidity constraints* in explaining petroleum outlets' exit in relation to the major UST regulatory events in Michigan.

3.1 Economies of Scale

As discussed in section 2, UST regulation includes two elements: technical standards and financial responsibility requirement. In complying with these regulations, UST owners and operators need to replace or upgrade their tanks, and purchase private insurance if a state fund is not available. Both lead to increased costs.

By adapting a model from Kunreuther and Freeman [16] we illustrate the conditions under which the costs arising from UST regulations have a disproportionately large impact on small petroleum outlets. Suppose the gasoline price is P^* without any consideration of the cost of complying with UST regulations. If petroleum outlets choose to stay in business, they must either replace/upgrade their old USTs, or pay higher premiums. In either case, they must determine a breakeven price as a function of the quantity of gasoline (Q_i) they expect to sell in a reasonable period of time, say, a year. Assume that the average cost increase due to the policy transition every year is $C(Q_i)$, which is an increasing function of Q_i because the cost impacts are presumably larger for large petroleum outlets. The breakeven price will then be defined as $P_i^* = P^* + C(Q_i)/Q_i$. In other words, the price margin that needs to cover the cost should be $P_i^* - P^* = C(Q_i)/Q_i$. The question is how the required price margin varies with Q_i . To answer this question, we take the first derivative of the price margin ($P_i^* - P^*$) with respect to Q_i .

$$\frac{d(P_i^* - P^*)}{dQ_i} = \frac{\frac{dC(Q_i)}{dQ_i} * Q_i - C(Q_i)}{Q_i^2} \quad (1)$$

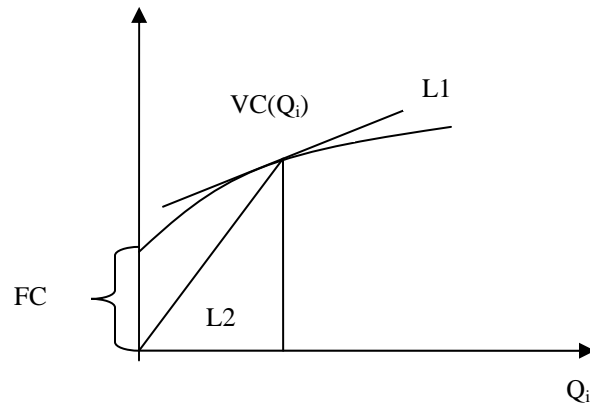
A negative first derivative suggests that the required price margin decreases with Q_i . That is, large facilities need a smaller price increase to cover the increased cost. Equation (1) is negative as long as $\frac{dC(Q_i)}{dQ_i} < \frac{C(Q_i)}{Q_i}$, that is, the marginal cost is smaller than the average cost.

This condition should hold in the case of UST regulations for two reasons. One is the high fixed costs, FC as shown in Figure 2, which include information collection (for both insurance quota and tank technology) and excavation cost (for upgrading or replacing tanks).⁸ The fixed costs also include automated monitor and inventory system, data processing system, and expenses related to monthly monitoring and testing as required in UST regulations.

Another reason is that the variable part of the costs, $VC(Q_i)$ as shown in Figure 2, is a concave function of Q_i because the cost of upgrading or replacing one more tank is normally less than the average variable cost of upgrading or replacing the previous tanks, or the premiums of insuring one more tank is less than the average variable cost of insuring the previous tanks. As such, Figure 2 depicts the tank owners and operators' cost function of complying with UST regulations. It is easy to verify that the marginal cost associated with one more unit of Q_i (the slope of $L1$) is always smaller than the average cost (the slope of $L2$) at Q_i . Therefore, condition (1) holds for any Q_i in Figure 2. This suggests that small petroleum outlets are more vulnerable to the cost impacts arising from UST regulations than large ones because they need a larger price margin to recover the increased costs.

⁸ Email communication with Paul Miller at the EPA Office of Underground Storage Tank (OUST), January 17, 2006.

Figure 2: Concave Cost Function with Fixed Cost



Siebert studied the uneven impacts of UST regulations on petroleum outlets of different size [10]. He showed that the ability to recover the compliance cost largely depends on the volume of gasoline sold. A station selling 25,000 gallons a month would need 6.6 cents per gallon to recover the added costs, while one selling 300,000 gallons a month would need only 0.6 cents per gallon. He points out that the pressure is likely to drive many more small operators out of business, especially in areas where competition takes place among a great number of stations. Stations selling large amounts of gasoline would gain competitive advantage as they are more easily able to pass long cost increases to consumers [10].

We thus argue that small petroleum outlets have more difficulties in passing on the compliance costs to customers. Therefore, they are more likely to exit the market instead of replacing or upgrading their old USTs.

3.2 Environmental Liability and Liquidity Constraints

One of the most serious financial problems facing petroleum retailers in trying to meet UST regulations is their inability to obtain loans for UST replacement, upgrading or other purposes. Emond [10] wrote, “Oil marketers throughout the country have reported how banks

and other lenders have rejected loan applications for fear that they could become liable for leaks, environmental damage and third party damage claims.” Superfund legislation meant to exclude lenders from such liabilities, by holding only the parties actually operating the facilities responsible for environmental damage. However, the famous case of the May 1990 *United States v. Fleet Factors* changed the lenders’ interpretation (perception) of the legislation. In this case, the U.S. Eleventh Circuit Court of Appeals ruled that a secured lender can be held liable if it has the “capability to influence” a business’s handling of hazardous materials. “Because this and other cases expose lenders to possible cleanup and other liabilities, droves of financial institutions have stopped lending to gasoline marketers and many others.” [10].

In a survey of its members, the Independent Bankers Association of America found that seven out of ten banks indicated that there are some classes of loans their institution will not write due to environmental liability concerns [6]. Hayward [13] also noted that:

The uncertain liability situation in this area has hampered owners’ efforts to upgrade tanks. The regulations specify that the Federal Water Pollution Act third party defense applies to USTs, rather than the narrow Superfund third party defense. RCRA forbids owners from using indemnification or hold harmless agreements to transfer from the tank’s owners or operators, or third parties, liability for UST leakage. Even so, banks have refused to lend funds to UST owners to pay for tank upgrading based on the fear that third party liability for environmental damage under RCRA could be construed as broadly as Superfund liability, under which banks have been held liable for cleanup cost [13, p.647].

With limited access to external capital, the ability of petroleum retailers to upgrade or replace their USTs largely depends on whether they have the required funds from within the firm. As discussed in section 2, the refiners normally have no financial responsibility for the petroleum retailers if they do not own the property. For example, an independent owner who holds a Shell Oil Company franchise usually cannot get financial help from Shell. The independent owner is responsible for upgrading or replacing their USTs. The franchisor (refiner) only supplies the fuel

and has no other responsibility for the site.⁹ In other words, the ability of petroleum retailers to finance UST replacement or upgrading depends on the owners' internal capital that is closely related to their business revenue.

In this paper, we will provide an empirical investigation of whether petroleum outlets whose owners have smaller business revenues are less likely to have funds for UST replacement or upgrading. Replacing or upgrading old USTs is less likely to be a feasible option for outlets owned by small firms. Before 1998, these outlets were less likely to upgrade or replace their old USTs and instead pay higher insurance premiums. In 1998 when strict UST technical standards were enforced, those outlets that had not replaced or upgraded their old USTs because of the lack of internal funds would be forced out of the market.

3.3 Anecdotal Evidence

The uneven impacts of UST regulations on small vs. large petroleum retailers have been a constant concern in the formulation and enforcement of UST regulations. Over the years, there has been anecdotal evidence that small petroleum retailers are heavily hit by UST regulations. Right after EPA published the UST regulations in 1988, the *New York Times* ran a front page story with the headline "Fuel-Leak Rules May Hasten End of Mom and Pop Service Station," which estimated that the rules would force the closure of 25% of the nation's service stations [5]. One representative in Congress made the following comment: "It is the small- and medium-sized businesses which will be unable to meet the requirements and, in some cases, will be forced completely out of businesses." [5].

⁹ Phone interview with Jeff Tanner at Michigan Department of Environmental Quality (February 7, 2006); Interviews with employee at Broad St Citgo, Philadelphia (February 6, 2006); and Interviews with Cathy McHaney at Sun Oil Company (February 9, 2006).

National Petroleum News ran a survey every year on the number of gasoline stations. It found that “the decline in station population has been continuous since the beginning of this decade, a situation attributable to tough environmental regulations which have wiped out thousands of marginal, low-volume units. An example of this was the December 22, 1998 UST deadline that caused many sites to shut their doors.” [18].

The pain is most felt by small petroleum retail station owners. “The day of the independent businessman is about gone,” lamented Bob Mercier, owner of a Shell-branded service station in Williamsville, Illinois, a rural community just north of Springfield. Mercier, who spent \$75,000 to upgrade three tanks, says that “there’s no way to pass something that large on.” He has yet to upgrade another station in Elkhart, an even smaller town about 8 miles further north. A survey taken in May 1997 by the Illinois State Fire Marshal indicated that 25% of Illinois gas stations – roughly 4,000 – would be shutting their doors instead of upgrading their tanks. Most of these are the independent owners – the ‘mom & pops.’” [4].

Kelly (1990) particularly emphasized the impacts of the 1998 deadline. He wrote, “The Environmental Protection Agency deadline to upgrade underground storage tanks has come and gone, but not without leaving some lasting effects. Many smaller, rural station owners chose to close their tanks instead of pay the thousands of dollars in service fees required to bring them up to date. Because the EPA set a fine of \$11,000 per day for tank owners who don’t upgrade, closing the tanks was the least expensive way to comply with the law for many marketers.” [15]. All these anecdotes suggest that small petroleum retailers had more difficulties with UST regulations than larger ones.

4. Identification Strategies

4.1 Measurement

To test the *economies of scale*, we ideally need data on the amount of petroleum products sold at each petroleum retail outlet, information that is difficult to obtain. In this study, we use the number of USTs at each petroleum retail outlet as a proxy for the amount of petroleum products sold. The assumption is that the retailers that sell a large amount of petroleum products are more likely to put more USTs under ground. This assumption is plausible as long as the retailers generally make rational decisions based on the expected market demand when they established a retail outlet.

To test the *liquidity constraints*, we need firm-level instead of outlet-level data because it is the petroleum retail firms (outlet owners) rather than retail outlets that are responsible for upgrading or replacing USTs. As discussed in the previous section, the ideal data to test the *liquidity constraints* are the firms' business revenues. As we have not been able to obtain data on the business revenue of individual petroleum retail firms, the number of the outlets that petroleum retail firms own will be used as a proxy. Table 2 shows that the sales per gasoline retail firm increases with the employment size of the firm. It is fair to assume that petroleum retail firms that own more outlets employ more people and have higher business revenue. Therefore, we expect that firms with more outlets are more likely to have internal fund for UST replacement or upgrading.

Table 2: Sales per Gasoline Retail Firm

Size of Gasoline Retail Firm	Sales Per Gasoline Retail Firm (in 1997 US thousand dollars)
less than 5 employees	686
5 to 9 employees	1436
10 to 19 employees	2345
20 to 49 employees	5003
50 to 99 employees	12455
100 to 249 employees	30588
250 to 499 employees	75214
500 to 999 employees	158609
1,000 employees or more	884610

Source: Economic Census 1997.

We notice that the fund availability for a multiple-outlet firm whose outlets are all small may not be much greater than a small outlet operating as a single-outlet firm. The business volume of small outlets is generally very small (see Table 3). Small outlets in multiple-outlet firms are more likely to have internal fund than small outlets operating as single-outlet firms because they can internally borrow money from large outlets in the same firm. Therefore, we focus on the multiple-outlet firms that own at least one large outlet.

Table 3: Sales per Gasoline Retail Outlet

Size of Gasoline Retail Outlets	Sales Per Gasoline Retail Outlet (in 1997 US thousand dollars)
1 employee	392
2 employees	603
3 or 4 employees	994
5 or 6 employees	1393
7 to 9 employees	1787
10 to 14 employees	2283
15 to 19 employees	2968
20 to 49 employees	4627
50 to 99 employees	9691
100 employees or more	17693

Source: Economic Census 1997.

4.2 Three Variations

To identify and disentangle the empirical relevance of the *economies of scale* and *liquidity constraints* in explaining the exit of petroleum outlets in response to UST regulations, we explore three variations on the exit rate of petroleum retail outlets. The first variation is among outlets of different size, *small outlets vs. large outlets*. The second one is the variation among outlets owned by different size of firms, *single-outlet firms vs. multiple-outlet firms with at least one large outlet*. The third one is the variation over time (1992–2000).

A *small outlet* is defined as a *petroleum retail outlet* that operates one or two USTs. A *large outlet* is a *petroleum retail outlet* that operates three or more USTs. A *small outlet* usually has two USTs for regular and premium gasoline.¹⁰ As a robustness check, we also define *large outlets* as *petroleum retail outlets* that operate *five or more USTs*, and compare them with *small outlets* that operate one or two USTs. The major findings do not change at all. Therefore, we only report the results based on the definition of *two or more USTs*.

A *single-outlet petroleum retail firm* is a firm that owns only one outlet. A *multiple-outlet petroleum retail firm with at least one large outlet* is a firm that owns two or more petroleum retail outlets, among which at least one is large. For the sake of conciseness, we refer to them as *multiple-outlet firms*. Given these definitions, we have four types of petroleum retail outlets: small outlets operating as single-outlet firms (SSF), large outlets operating as single-outlet firms (LSF), small outlets in multiple-outlet firms (SMF), and large outlets in multiple-outlet firms (LMF).

We also investigate how the exit rate of petroleum retail outlets evolves over time. Three periods are studied: *State Fund period* (1992-1994), *Private Insurance period* (1995-1997), and

¹⁰ Small outlets also sell the midgrade although they only have two USTs. The midgrade - 89 octane - is a blend of regular and premium (Email communication with Sammy Ng at the EPA OUST, May 11, 2005).

Private Insurance and Technical Standards period (1998-2000). As discussed earlier, neither UST technical standards nor FRRs had actual and immediate cost impacts on petroleum retailers during the *State Fund period* (1992-1994). Technical standards were not enforced on existing UST systems. Petroleum retailers can achieve compliance with FRRs by participating in the state fund program, which is essentially free. In the *Private Insurance period* (1995-1997), petroleum retailers need to purchase commercial insurance to comply with FRRs because the state fund was discontinued. The years from 1998 to 2000 are defined as the *Private Insurance and Technical Standards period* because the EPA and the Michigan Department of Environmental Quality (MDEQ) started enforcing technical standards since 1998.

4.3 Testing the Economies of Scale

We investigate how the exit rate – conditional exit probability – changed across different types of petroleum retail outlets over time. The conditional exit probability is defined as the probability that an outlet exited the market in year t , given that this outlet made it to the start of year t . It is estimated by:

$$\widehat{P(Exit^t)} = \frac{\text{the number of outlets that exit in year } t}{\text{the number of outlets that are in service at the beginning of year } t} \quad (2)$$

To test the *economies of scale*, we investigate $P(Exit_{SMF}^t) - P(Exit_{LMF}^t)$, that is, the difference in the conditional exit probability between small and large outlets in multiple-outlet firms. For these outlets, the *liquidity constraints* should not be a factor because they are all owned by multiple-outlet firms and the decision as to whether to exit the market is driven by whether it is profitable to upgrade or replace old USTs, or buy private insurance. If the

economies of scale is a significant factor in deciding firms' exit decision, one would observe that multiple-outlet firms are more likely to retire small outlets rather than large outlets during the *Private Insurance period*. One may argue, however, that the observed difference between $P(\text{Exit}_{SMF}^t)$ and $P(\text{Exit}_{LMF}^t)$ during the *Private Insurance period* is a continuation of the *State Fund period*. To address this concern, we use the *State Fund period* as a control period to reflect what would happen if there were no policy transition from the UST state fund program to the private insurance market. We expect to observe:

Research Hypothesis 1: $P(\text{Exit}_{SMF}^t) - P(\text{Exit}_{LMF}^t)$ is greater than zero during the Private Insurance period, and is larger than the State Fund period.

4.4 Testing the Liquidity Constraints

To test the *liquidity constraints*, we investigate $P(\text{Exit}_{SSF}^t) - P(\text{Exit}_{SMF}^t)$, that is, the difference in the conditional exit probability between small outlets operating as single-outlet firms and small outlets owned by multiple-outlet firms. *Economies of scale* does not play a role in determining the difference between $P(\text{Exit}_{SSF}^t)$ and $P(\text{Exit}_{SMF}^t)$ because the outlets in these two groups are both small. The difference is that internal fund may be available to small outlets operated by multiple-outlet firms, but not to small outlets operating as single-outlet firms. Because meeting technical standards requires a large lump sum investment, it is more likely to pose a significant financial challenge to small outlets than requiring the purchase of insurance. Therefore, we focus on the *private insurance and technical standards periods* when studying the impact of the *liquidity constraints*.

If the *liquidity constraints* is a significant factor in deciding the outlets' exit decision, one would observe that small outlets operating as single-outlet firms are more likely to exit the market than small outlets owned by multiple-outlet firms in the *Private Insurance and Technical*

Standards period because of the enforcement of UST technical standards. We use the *Private Insurance period* as a control period,¹¹ which reflects what would happen if there were no enforcement of the UST technical standards. We expect to observe:

Research hypothesis 2: $P(\text{Exit}_{SSF}^t) - P(\text{Exit}_{SMF}^t)$ is greater than zero in the Private Insurance and Technical Standards period, and larger than the Private Insurance period.

5. Empirical Investigations

5.1 Data

The Michigan UST database, provided by the MDEQ, is used to test the empirical relevance of the *economies of scale* and *liquidity constraints* in explaining the exit of petroleum outlets in response to UST regulations. We focus on petroleum outlets that already existed in 1992, and follow them all the way to the year 2000.^{12 13} Our final database includes 7,705 petroleum retail outlets that were in service in 1992, and their distribution across various types of outlets is shown in Table 4. The largest firm is Speedway Superamerica LLC that owned 393 petroleum retail outlets in 1992. The largest petroleum retail outlet, which operated 14 USTs in 1992, was owned by Meijer Retail and Grocery.

¹¹ Alternatively, we use both the *Private Insurance period* and the *State Fund period* as control periods. The findings do not depend on which control is used. Conceptually, using the *Private Insurance period* only as the control period is more sensible as we want to disentangle the impacts of the enforcement of technical standards from the impacts of imposing private insurance coverage requirements. We want the only difference between the two studied periods to be the enforcement of technical standards. Because of these, we only report the results using the *private insurance period* as the control period in the regression analyses.

¹² The UST database covers tanks at both commercial and public sites. We omit public entities, e.g. school districts, from the analyses because their decisions are less likely to be explained by the economic mechanisms of interest – *economies of scale* and *liquidity constraints*. These entities are not profit- oriented and do not face severe budget constraints.

¹³ We restrict the sample to the outlets that already existed in 1992 because including new entries may confound the analyses. For example, if new entries are more likely to be large outlets, when we find that large outlets are less likely to exit the market, we are not sure this is because large outlets have fewer difficulties in complying with UST regulations, or large outlets are relatively new.

Table 4: Composition of Petroleum Retail Outlets in 1992

Outlet Size \ Firm size	Single-Outlet Firms	Multiple-Outlet Firms with at Least One large Outlet
Small Outlets (With One or Two USTs)	2206	384
Large Outlets (With Two or More USTs)	2660	2455

5.2 Observations at Aggregate Level

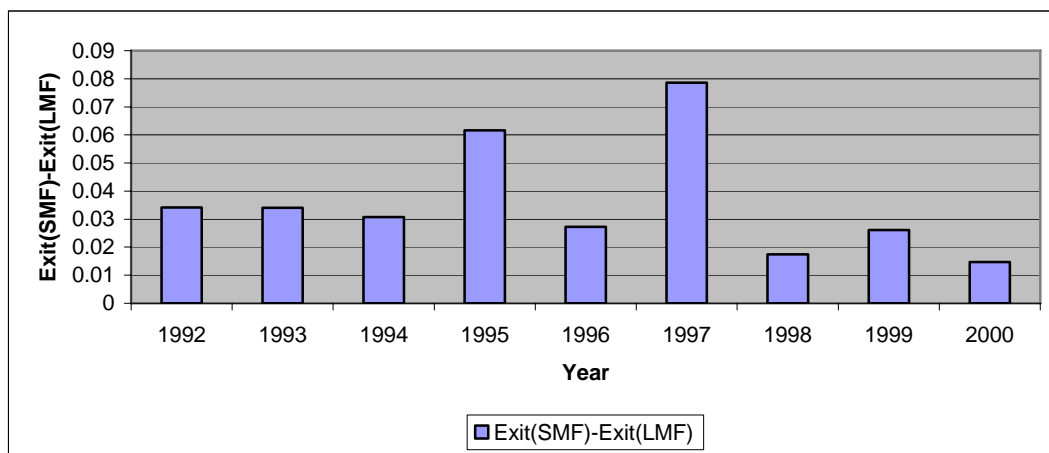
We first look at the empirical relevance of the *economies of scale* in explaining petroleum retailers' exit decision. To do this we examine $P(Exit_{SMF}^t) - P(Exit_{LMF}^t)$, that is, the difference in the conditional exit probability between small and large outlets in multiple-outlet firms. Figure 3 shows that $P(Exit_{SMF}^t) - P(Exit_{LMF}^t)$ during the *Private Insurance period* is positive and is larger than during the *State Fund period*. That is, multiple-outlet firms are more likely to retire their small outlets than large outlets in response to the cost impacts arising from the policy transition from a UST state fund program to the private insurance market. This supports research hypothesis 1 and suggests that the *economies of scale* is a significant factor in determining petroleum retail outlets' decision as to whether to exit the market.

Figure 3 also shows that in the *Private Insurance and Technical Standards period*, the difference in the rate that multiple-outlet firms retire their small outlets and large outlets [$P(Exit_{SMF}^t) - P(Exit_{LMF}^t)$] is smaller, compared to the *Private Insurance period* and the *State Fund period*. This may suggest that multiple-outlet firms already replace or upgrade their tanks before 1998, and therefore the 1998 deadline did not have an actual impact on them.

As discussed earlier, in response to the policy transition from a state fund program to the private insurance market, one of the petroleum retailers' options is to upgrade or replace their old USTs and pay lower insurance premiums. Multiple-outlet firms have financial capability, and

most importantly, have financial incentives to undertake this option. First, by upgrading or replacing their old USTs, they can significantly reduce their insurance premiums. There is empirical evidence that premium discounts and other features of the private insurance market have encouraged petroleum retailers to exert more efforts to take care of their tanks, including replacing or upgrading their old tanks, than a state fund program [25]. Second, if firms waited until the 1998 deadline to upgrade or replace their USTs, they ran the risk of being fined for regulatory violations (up to \$11,000 per tank per day).¹⁴ Therefore, multiple-outlet firms have financial incentives to upgrade or replace their old USTs before the 1998 deadline. If most firms chose to do so, the 1998 deadline for technical standards would not have an actual impact on them. In fact, we should expect that the difference in conditional exit probability between small outlets and large outlets in multiple-outlet firms becomes smaller because they both had already met the technical standards and hence were less likely to exit the market. This is exactly what we observe in Figure 3.

Figure 3: The Difference in the Conditional Exit Probability between Small and Large Outlets in Multiple-Outlet Firms



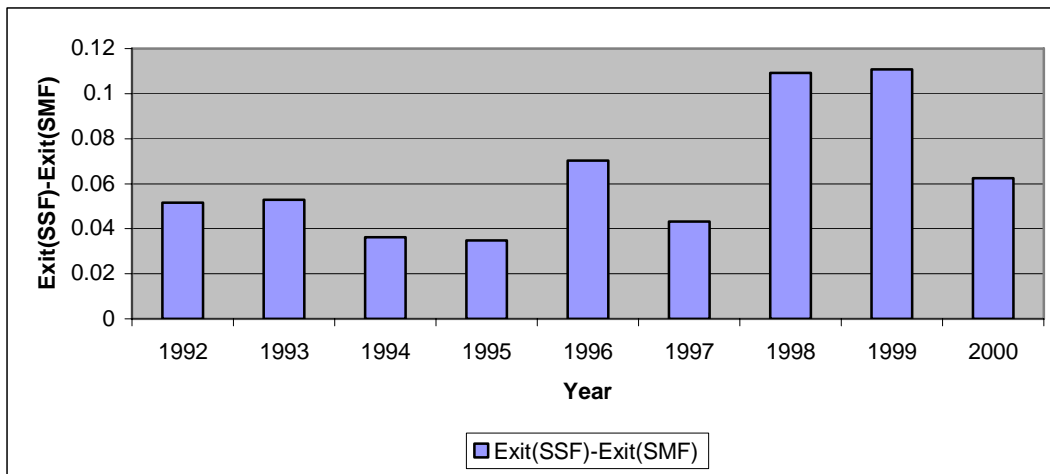
¹⁴ A recent example is Samad Corporation, which operates a Citgo Station in Washington, DC, paid a penalty of \$27,000 for violations, including failure to provide overfill protection (40 CFR 280.23(c)(1)(ii)) and failure to provide cathodic protection (40 CFR 280.20(a)) (Email communication with Carol Amend at the EPA Region 3, October 22, 2007).

We investigate the *liquidity constraints* by studying $P(\text{Exit}_{SSF}^t) - P(\text{Exit}_{SMF}^t)$, that is, the difference in the conditional exit probability between small outlets operating as single-outlet firms and small outlets owned by multiple-outlet firms. Figure 4 shows that $P(\text{Exit}_{SSF}^t) - P(\text{Exit}_{SMF}^t)$ is not very different between the *Private Insurance period* and the *State Fund period*. This suggests that purchasing private insurance does not pose a significant financial challenge to the small outlets operating as single-outlet firms after 1995. Figure 4 also shows that $P(\text{Exit}_{SSF}^t) - P(\text{Exit}_{SMF}^t)$ is positive during the *Private Insurance and Technical Standards period* and is larger than during the *Private Insurance period* (1995-1997). This implies that, in response to the enforcement of UST technical standards, small outlets operating as single-outlet firms are more likely to exit the market than those owned by multiple-outlet firms. This supports research hypothesis 2.

In sum, Figure 4 suggests that the requirement of purchasing private insurance does not change the relative likelihood that small outlets operating as single-outlet firms and small outlets in multiple-outlet firms exit the market. But they may have survived the private insurance period through different approaches. Small outlets in multiple-outlet firms were more likely to upgrade or replace their old tanks and pay a lower insurance premium because they have both the financial capability and incentives to do so as discussed earlier. But because of the lack of internal funds, small outlets operating as single-outlet firms were less likely to undertake major upgrading work and instead opted to pay a higher insurance premium. As the technical standards were enforced in 1998, they had no choice but to exit the market. This explains why the difference in the conditional exit probability between small outlets operating as single-outlet firms and small outlets in multiple-outlet firms became larger in the *Private Insurance and Technical Standards period*, compared to previous periods and implies that the *liquidity*

constraints is a significant factor in determining petroleum retail outlets' decision as to whether to exit the market.

Figure 4: The Difference in the Conditional Exit Probability between Small Outlets Operating as Single-Outlet firms and Small Outlets Owned by Multiple-Outlet Firms



5.3 Regression Analyses

In this section, we perform regression analyses to test the empirical relevance of the *economies of scale* and *liquidity constraints* in explaining the exit of petroleum retail outlets in response to UST regulations. Regression analyses enable one to examine exit behavior at the outlet level and therefore provide a more precise estimate than aggregate analyses. Second, they are able to control potential confounding factors. For instance, we want to control tank ages because outlets with older tanks are more likely to exit and one type of outlet may have more old tanks than others. Omitting tank ages may bias the coefficients of interest. To test research hypothesis 1 and 2, the following logit regression model is performed.¹⁵

¹⁵ Does the dependence among the observations is a concern here? In general, when there are multiple observations for a single facility, it is reasonable to suppose that those observations are not independent, thereby, violating a basic assumption used to construct the likelihood function. However, this concern is not applicable here. In this case, the creation of multiple observations is not an ad-hoc process; rather, it follows directly from factoring the likelihood function for the data. The basic idea is this: For a facility that exits the market in year t , its likelihood function can

$$\begin{aligned}
P(Exit_{jt}) = & F(\alpha + \beta_1 BS_j + \beta_2 * FS_j + \beta_3 * RC1_t + \beta_4 * RC2_t + \beta_5 * FS_j * RC1_t \\
& + \beta_6 * FS_j * RC2_t + \beta_7 * BS_j * RC1_t + \beta_8 * BS_j * RC2_t + \beta_9 * BS_j * FS_j \quad (3) \\
& + \beta_{10} * BS_j * FS_j * RS1_t + \beta_{11} * BS_j * FS_j * RS2_t)
\end{aligned}$$

Where F is the cumulative distribution function of a logistically distributed variable

In (3), $Exit_{jt}$ is a dichotomous variable with 1 indicating petroleum retail outlet j exited the market in year t and 0 that it did not exit, given that it was in business in year t . To test the research hypotheses, we need variables indicating the size of petroleum outlets, the size of petroleum retail firms that own those outlets, and regulatory periods. Let BS_j refer to the size of the petroleum retail firm that owned outlet j . It is a dummy variable, which equals 1 if outlet j was operated as a single-outlet firm in 1992 and 0 if outlet j belonged to a multiple-outlet firm with at least one large outlet. FS_j refers to the size of outlet j . It is a dummy variable, which equals 1 if outlet j was a small outlet in 1992 and 0 otherwise. $RC1_t$ is a dummy variable indicating the *private insurance period*. It equals 1 for the years between 1995 and 1997, and 0 for other periods. $RC2_t$ is a dummy variable indicating the *Private Insurance and Technical Standards period*. It equals 1 for the years between 1998 and 2000, and 0 for other periods.

In (3), we use moderated terms to identify how various types of petroleum retail outlets respond differently to the policy changes. A moderated regression model like this demands careful interpretation [14]. To test research hypothesis 1 (*economies of scale*), we investigate $P(Exit_{SMF}^t)$ and $P(Exit_{LMF}^t)$ in the *State Fund period* and *Private Insurance period*. To test

be written as $P(Exit_{jt} = 1) * \sum_{T=1}^{t-1} P(Exit_{jt} = 0) = P(Exit_{jt} = 1) * \sum_{T=1}^{t-1} [1 - P(Exit_{jt} = 1)]$ where $P(Exit_{jt} = 1)$ is the probability that facility j exit in year t , given it made its way to year t . This factorization follows immediately from the definition of conditional probability. Each of the terms in the equation above may be treated as though it came from a distinct, independent observation. Therefore, this regression model is good as long as the observations are independent across facilities. The dependence among the different observations on the same facility is not a concern here [see 1, pp.223-224].

research hypothesis 2 (*liquidity constraints*), we need to investigate $P(Exit_{SSF}^t)$ and $P(Exit_{SMF}^t)$ in the *Private Insurance period* and *Private Insurance and Technical Standards period*. Based on the regression model given by (3), the estimated conditional exit probability of different types of petroleum retail outlets in different periods are summarized in Table 5.

Table 5: Estimated Conditional Exit Probability

	State Fund Period	Private Insurance Period	Private Insurance and Technical Standards Period
Small Outlets Operating as Single-Outlet Firms(SSF)	$F(\widehat{\beta}_0 + \widehat{\beta}_1 + \widehat{\beta}_2 + \widehat{\beta}_9)$	$F(\widehat{\beta}_0 + \widehat{\beta}_1 + \widehat{\beta}_2 + \widehat{\beta}_3 + \widehat{\beta}_5 + \widehat{\beta}_7 + \widehat{\beta}_9 + \widehat{\beta}_{10})$	$F(\widehat{\beta}_0 + \widehat{\beta}_1 + \widehat{\beta}_2 + \widehat{\beta}_4 + \widehat{\beta}_6 + \widehat{\beta}_8 + \widehat{\beta}_9 + \widehat{\beta}_{11})$
Small Outlets in Multiple-Outlet Firms (SMF)	$F(\widehat{\beta}_0 + \widehat{\beta}_2)$	$F(\widehat{\beta}_0 + \widehat{\beta}_2 + \widehat{\beta}_3 + \widehat{\beta}_5)$	$F(\widehat{\beta}_0 + \widehat{\beta}_2 + \widehat{\beta}_4 + \widehat{\beta}_6)$
Large Outlets in Multiple-Outlet Firms (LMF)	$F(\widehat{\beta}_0)$	$F(\widehat{\beta}_0 + \widehat{\beta}_3)$	$F(\widehat{\beta}_0 + \widehat{\beta}_4)$

Concerning research hypothesis 1, we need to investigate $P(Exit_{SMF}^t) - P(Exit_{LMF}^t)$ in the *State Fund period* and *Private Insurance period*. From Table 5, $\widehat{\beta}_2 + \widehat{\beta}_5$ captures the difference between $P(Exit_{SMF}^t)$ and $P(Exit_{LMF}^t)$ in the *Private Insurance period* and $\widehat{\beta}_2$ captures this difference in the *State Fund period*. Therefore, $\widehat{\beta}_5$ captures whether multiple-outlet firms are more likely to retire small outlets than large outlets in the *Private Insurance period* compared to the *State Fund period*, which provides a test for research hypothesis 1. Similarly, $\widehat{\beta}_8 + \widehat{\beta}_{11} - \widehat{\beta}_7 - \widehat{\beta}_{10}$ captures whether small outlets operating as single-outlet firms are more likely to exit the market than those in multiple-outlet firms in the *Private Insurance and Technical Standards period* compared to the *Private Insurance period*, and therefore provides a test for research hypothesis 2. Column 1 of Table 6 presents the results.

Table 6 confirms the data depicted in Figure 3 and Figure 4. It shows that $\hat{\beta}_5$ is positive and significant, which suggests that multiple-outlet firms are more likely to retire small outlets than large outlets in response to the policy transition from the state fund program to the private insurance market. More specifically, in the *state fund period*, the odds of small outlets in multiple-outlet firms exiting the market is 2.5 ($=\exp(\hat{\beta}_2)$) times the odds of large outlets in multiple-outlet firms exiting the market. This odds ratio increase to 5.5 ($=\exp(\hat{\beta}_2 + \hat{\beta}_5)$) in the *private insurance period*. Again this provides support for research hypothesis 1 and suggests that the *economies of scale* is a significant factor in determining petroleum retail outlets' decision as to whether to exit the market.

Table 6: Logit Estimates of Conditional Exit Probability

	1 Exit	2 Exit	3 Exit	4 Exit
Small_Business ($\hat{\beta}_1$)	1.13 (12.35)**	0.76 (7.36)**	0.79 (7.60)**	0.79 (7.15)**
Small_Facility ($\hat{\beta}_2$)	0.93 (6.05)**	0.73 (4.18)**	0.74 (4.25)**	0.74 (4.36)**
RegChange1995 ($\hat{\beta}_3$)	-0.56 (4.23)**	-0.68 (1.19)	-0.67 (1.16)	-0.67 (1.11)
RegChange1998 ($\hat{\beta}_4$)	0.17 (1.55)	-0.46 (0.79)	-0.48 (0.82)	-0.48 (0.76)
SmallFacility*RegChange1995 ($\hat{\beta}_5$)	0.78 (3.43)**	0.66 (2.56)*	0.66 (2.55)*	0.66 (2.68)**
SmallFacility*RegChange1998 ($\hat{\beta}_6$)	-0.37 (1.50)	-0.41 (1.51)	-0.43 (1.55)	-0.43 (1.46)
SmallBusiness*RegChange1995 ($\hat{\beta}_7$)	0.16 (1.04)	0.08 (0.50)	0.09 (0.51)	0.09 (0.48)
SmallBusiness*RegChange1998 ($\hat{\beta}_8$)	-0.12 (0.88)	-0.12 (0.83)	-0.11 (0.75)	-0.11 (0.70)
SmallBusiness* SmallFacility ($\hat{\beta}_9$)	-0.46 (2.78)**	-0.56 (2.95)**	-0.58 (3.04)**	-0.58 (2.95)**
SmallBusiness* SmallFacility* RegChange1995 ($\hat{\beta}_{10}$)	-0.24 (0.95)	-0.18 (0.63)	-0.18 (0.64)	-0.18 (0.63)

SmallBusiness* SmallFacility* RegChange1998	0.68	0.68	0.67	0.67
($\hat{\beta}_{11}$)	(2.59)**	(2.25)*	(2.24)*	(2.17)*
$\hat{\beta}_8 + \hat{\beta}_{11} - \hat{\beta}_7 - \hat{\beta}_{10}$	0.65	0.65	0.66	0.66
	(2.83)**	(2.36)*	(2.40)*	(2.09)*
Average_Tank_Age A_{jt}		0.04	0.04	0.04
		(13.98)**	(14.07)**	(15.60)**
Ln (Average_Tank_Capacity) $\ln C_{jt}$		-0.34	-0.32	-0.32
		(8.77)**	(8.01)**	(7.83)**
Average_Tank_Age * RegChange1995		0.00	0.00	0.00
		(0.49)	(0.49)	(0.51)
Average_Tank_Age * RegChange1998		0.02	0.01	0.01
		(0.25)	(0.23)	(0.21)
Ln (Average_Tank_Capacity)* RegChange1995		0.02	0.02	0.02
		(3.68)**	(3.70)**	(3.56)**
Ln (Average_Tank_Capacity)* RegChange1998		0.04	0.05	0.05
		(0.71)	(0.73)	(0.69)
Vehicle Miles Traveled (In Billion Miles)			-0.01	-0.01
			(3.32)**	(2.66)**
Constant	-3.75	-1.34	-1.51	-1.51
	(47.64)**	(3.62)**	(4.04)**	(3.91)**
Observations	55052	49222	49222	49222
Clustered on County-Year	NO	NO	NO	YES
Absolute value of z statistics in parentheses				
* significant at 5%; ** significant at 1%				

Table 6 also shows that the estimated $\hat{\beta}_8 + \hat{\beta}_{11} - \hat{\beta}_7 - \hat{\beta}_{10}$ is positive and significant. This tells us that in response to the enforcement of UST technical standards, the small outlets operating as single-outlet firms are more likely to exit the market than those owned by multiple-outlet firms. More specifically, in the *Private Insurance period*, the odds of small outlets operating as single-outlet firms exiting the market is 1.8 ($=\exp(\hat{\beta}_1 + \hat{\beta}_7 + \hat{\beta}_9 + \hat{\beta}_{10})$) times the odds of small outlets in multiple-outlet firms exiting the market. In comparison, this odds ratio increase to 3.4 ($=\exp(\hat{\beta}_1 + \hat{\beta}_8 + \hat{\beta}_9 + \hat{\beta}_{11})$) in the *Private Insurance and Technical Standards period*. Again this provides support for research hypothesis 2 and suggests that the *liquidity constraints* is a

significant factor in determining petroleum retail outlets' decision as to whether to exit the market.

6. Alternative Explanations

The above analyses suggest that small outlets and single-outlet firms are more likely to exit the market under UST regulations because they have more difficulties coping with UST regulations. Small outlets have difficulties in passing the compliance costs to customers (*economies of scale*), and single-outlet firms do not have the financial capability to meet the UST technical standards (*liquidity constraints*). This section serves as a robustness check on the major findings by investigating several alternative arguments that factors other than the *economies of scale* and *liquidity constraints* may explain the observed phenomena. We focus on the estimated coefficients $\hat{\beta}_5$ and $\hat{\beta}_8 + \hat{\beta}_{11} - \hat{\beta}_7 - \hat{\beta}_{10}$ as they provide the empirical evidence on how UST regulations affected petroleum retailers' exit decision because of the *economies of scale* or *liquidity constraints*.

6.1 Original Difference among Different Types of Petroleum Outlets

The four types of petroleum retail outlets may be very different from each other in characteristics such as tank capacity and tank age. These characteristics may interact with some market or regulatory conditions in the studied periods and cause the observed phenomena. To see if this argument is valid, we compare the average tank age and tank capacity for the four types of petroleum retail outlets. Table 7 suggests that the USTs in single-outlet firms are generally older and of smaller capacity, compared to multiple-outlet firms, especially for the

small outlets operating as single-outlet firms. An ANOVA analysis suggests that the difference is statistically significant.

Can this difference explain the observed phenomenon that single-outlet firms and small outlets are more likely to exit the market under UST regulations? To take into account the impacts of tank age and tank capacity on the outlets' exit decision, we include the average tank age at facility j in year t (A_{jt}), the natural log of the average tank capacity at facility j in year t ($\ln C_{jt}$), and their interactions with the regulatory changes, RC_1 and RC_2 , in the regression. Column (2) of Table 6 presents the result. The coefficients we are interested in, $\hat{\beta}_5$ and $\hat{\beta}_8 + \hat{\beta}_{11} - \hat{\beta}_7 - \hat{\beta}_{10}$ are still positive and significant. This suggests that both the *economies of scale* and the *liquidity constraints* arguments have significant explanatory power for petroleum outlets' exit decision after accounting for the impacts of the outlet characteristics such as tank age and tank capacity.

The coefficient of $\ln C_{jt}$ is negative and significant, which provides further support for the *economies of scale* argument in that a low volume outlet would have difficulties in passing on the compliance cost to consumers, and therefore would be more likely to exit the market. The coefficient of A_{jt} is positive and significant, suggesting that outlets with older tanks were more likely to exit the market under UST regulations.

Table 7: USTs Operated in 1992 by Different Types of Petroleum Retail Outlets

	Large Outlets in Multiple-Outlet Firms			Small Outlets in Multiple-Outlet Firms			Large Outlets Operating as Single-Outlet Firms			Small Outlets Operating as Single-Outlet Firm		
	No. Tanks	% of Tanks	Average Capacity	No. Tanks	% of Tanks	Average Capacity	No. Tanks	% of Tanks	Average Capacity	No. Tanks	% of Tanks	Average Capacity
Installed Before 1959	455	0.03	5982.51	51	0.06	4004.29	683	0.06	3995.71	300	0.07	2578.67
Installed 1960-1969	2,394	0.18	7094.57	188	0.21	9159.41	1,827	0.15	5036.71	558	0.14	3472.87
Installed 1970-1979	3,679	0.28	7876.43	269	0.29	6904.02	3,402	0.29	6163.64	1,121	0.28	3333.77
Installed 1980-1986	5,948	0.46	8574.92	316	0.35	8597.32	3,884	0.33	7046.71	1,086	0.27	4664.40
Installation year Unknown	565	0.04	4754.19	90	0.10	4375.92	2,071	0.17	3507.00	951	0.24	2201.18
Average Age		12.43			12.69			15.54			16.68	

6.2 *Changed Market Demand for Gasoline*

One could contend that changes other than environmental regulations may have occurred during the studied period, and caused the phenomena we observed. For example, the changes of the market demand for gasoline may have increased the optimal size of petroleum retail outlets. Large outlets and multiple-outlet firms therefore had a greater competitive advantage, and small businesses were driven out of the market. To investigate whether the observed phenomena could be explained by the changes in the market demand for gasoline, we obtained data from the Michigan Department of Transportation on vehicle miles traveled at county level from 1992 to 2000, a reasonable proxy for the market demand for gasoline. We include this variable in the regression analyses, and the results are reported in column (3) of Table 6. The coefficients of interest, $\hat{\beta}_5$ and $\hat{\beta}_8 + \hat{\beta}_{11} - \hat{\beta}_7 - \hat{\beta}_{10}$ hardly change from column (2). This suggests that the observed patterns are not driven by the changed market demand for gasoline during the studied period. The coefficient for *Vehicle Miles Traveled* is negative and statistically significant, suggesting that the increased market demand for gasoline lowers the likelihood of petroleum retail outlets exiting the market.

6.3 *Local Regulatory Enforcement*

Another concern is that the observed phenomena may be driven by special local conditions. For example, before 2000, some local units of government had the authority to enforce UST rules, and some may have done this more aggressively than others. In fact, because they interpreted things differently, Michigan removed this authority from the local units of

government.¹⁶ One may argue, for example, that in the *Private Insurance period*, some local governments enforced UST rules more aggressively and there happened to be many small outlets in their areas, and this caused the phenomenon that small outlets are observed to be more likely to exit the market.

To address this concern, we clustered the observations by county and year, and perform the regression analysis with those clusters. This accounts for the changes of local conditions (not only regulatory enforcement) across counties and over years, and adjusts the estimates accordingly. Column 4 in Table 6 reports the regression result. The inclusion of the clusters hardly changes the estimates of the coefficients we are interested in, $\hat{\beta}_5$ and $\hat{\beta}_8 + \hat{\beta}_{11} - \hat{\beta}_7 - \hat{\beta}_{10}$. This suggests that the local condition variations across counties and over years are not likely to be a plausible explanation for the observed phenomena.

6.4 Natural Turnover

The higher exit rate of single-outlet firms and small outlets may be explained by the fact that the turnover rate by nature is higher for single-outlet firms and small outlets, that is, more exits and more entries. However, this is not likely to be a plausible explanation for the observed phenomena. When we investigated the exit rate of small outlets and large outlets in multiple-outlet firms in the *Private Insurance period*, we used their exit rate in the *State Fund period* as a control. If *natural turnover* is the explanation, the difference in the exit rate between small outlets and large outlets in multiple-outlet firms should not be different between the *Private Insurance period* and the *State Fund period*. What we observed, however, is the opposite. Likewise, when we investigated the impact of the technical standards enforcement on the exit

¹⁶ Now the UST rules are mainly enforced by the state Hazardous Materials Storage Inspectors (HMSI's). They are located at the district offices, and still have some discretion at some extent (Email communication with Jeff Tanner at the Michigan Department of Environmental Quality, June 22, 2006).

decision of small outlets operating as single-outlet firms and small outlets in multiple-outlet firms in the *Private Insurance and Technical Standards period*, we used the *Private Insurance period* as a control for what would happen if there were no technical standards enforcement. If *natural turnover* is a valid explanation, the difference in the exit rate between small outlets operating as single-outlet firms and small outlets in multiple-outlet firms should not be different between the *Private Insurance and Technical Standards period* and the *Private Insurance period*. What we observed, again, is the opposite. This suggests that natural turnover is not likely to be a valid explanation for higher exit rate of small outlets in the *Private Insurance period* and of single-outlet firms in the *Private Insurance and Technical Standards period*.

As a further investigation on the validity of “natural turnover” argument, we look at the exits, entries, expansions and contractions of different types of petroleum retail outlets between 1992 and 2000. If the *natural turnover* argument is valid, the ratio of the entries to the exits should be similar across different types of petroleum retail outlets between 1992 and 2000. Table 8 shows that 1,438 small outlets operating as single-outlet firms exited the market between 1992 and 2000, but only 154 of them entered the market during the same period. In contrast, multiple-facility firms took 148 small outlets out of the market, but opened 165 new ones. This again suggests that the *natural turnover* argument is not valid.

Table 8: The Dynamics of Different Types of Petroleum Retail Outlets: 1992-2000

		Type of 2000				
		Not Exist	LMF	SMF	LSF	SSF
Type of 1992	Not Exist		146	165	83	154
	LMF	367	1,871	171	24	8
	SMF	148	19	181	1	8
	LSF	1,043	23	1	1,326	266
	SSF	1,438	1	0	24	741

7. Concluding Remarks

Our major conclusion is that environmental regulations have very uneven impacts on different types of facilities/firms. Small firms (single-outlet firms in the context of petroleum retail market) and small facilities (small outlets in the context of petroleum retail market) have greater difficulties in dealing with environmental regulations if compliance cost is significant.

This study suggests that both the *economies of scale* and the *liquidity constraints* arguments play a significant role in explaining the uneven impacts of environmental regulations on different types of facilities/firms. *Economies of scale* provide large facilities with a competitive advantage because it is more difficult for small facilities to pass on compliance costs to their customers. *Liquidity constraints* make small firms more vulnerable to environmental regulations because they do not have the financial capability to meet regulatory requirements. This suggests that small businesses will have more difficulties competing with large businesses under environmental regulations. This highlights a set of policy issues that need to be further pursued. Because small businesses have difficulties in complying with environmental regulations and therefore pose greater environmental risks, it may be socially desirable not to give them special treatment in the future. On the other hand, if the existence of small businesses is essential for providing convenient services in rural or remote area or keeping effective competition, environmental regulations should be implemented with appropriate financial assistance to small businesses (independent petroleum marketers, or “mom & pop” stations in the context of petroleum retail market) so that they can continue to operate. This opens up a rich set of interesting research questions that are beyond the scope of this paper.

Several other interesting questions have been left unexplored in this paper and should be investigated in future research. First, the uneven impacts of UST regulations discussed in this

paper suggest that the structure of the petroleum retail market must have been significantly changed in the 1990s with the implementation of UST regulations. It has been shown that the local market power has a significant impact on gasoline retail price [9]. One could investigate how UST regulations have changed the profit margin in the gasoline retail market. Second, the theories discussed in this paper directly relate to firms' ability to comply with environmental regulations and thus reduce their environmental risk. For example, small firms may pose higher environmental risks because of the lack of resources to achieve compliance with environmental regulations. It would be interesting to investigate whether some observable facility characteristics – large facilities versus small facilities, owned by large firms versus small firms – can predict facilities' environmental risk. This study could be undertaken in the context of UST regulations because a UST leak database is available. The answer to this question can help us structure risk-based management strategies in which limited regulatory resources should be disproportionately allocated to high-risk firms. This is important as the EPA and its state counterparts often find that they do not have the capabilities to enforce environmental regulations with limited person power and a restricted budget [17].

REFERENCES

1. P. D. Allison, *Survival Analysis Using SAS: A Practical Guide*, Cary, NC: SAS Institute Inc., 1995.
2. P. Bartel, L.G. Thomas, Predation through regulation: The wage and profit effects of the Occupational Safety and Health Administration and the Environmental Protection Agency, *Journal of Law and Economics* 30 (1987) 239-264.
3. R.A. Becker, Air pollution abatement costs under the Clean Air Act: evidence from the PACE survey, *Journal of Environmental Economics and Management* 50 (2005) 144–169.
4. N. Boehme, Costly Switch/Changeover of Tanks Forces Some Stations to Close Down, *The State Journal Register*, (1998) September 6, Springfield, IL.
5. J. Boyd, *Liability and Potential Insolvency*, Unpublished Ph.D. Dissertation, University of Pennsylvania, (1993).
6. J. Boyd, W. Harrington, M. Macauley, The Effects of Environmental Liability on Industrial Real Estate Development, *Journal of Real Estate Finance and Economics* 12 (1996) 37-58.
7. T.J. Dean, R.L. Brown, Pollution Regulation as a Barrier to New Firm Entry: Initial Evidence and Implications for Future Research, *The Academy of Management Journal* 38 (1) (1995) 288-303.
8. T.J. Dean, R.L. Brown, V. Stango, Environmental Regulation as a Barrier to the Formation of Small Manufacturing Establishments: A Longitudinal Examination, *Journal of Environmental Economics and Management* 40 (2000) 56-75
9. G. Deltas, Retail Gasoline Price Dynamics and Local Market Power, Working Paper (2004).
10. M. Emond, UST Bell Tolls for Smaller Petroleum Marketers, *National Petroleum News*, 83 (5) (1991) 45-49.
11. Government Accountability Office, *Superfund: Insuring Underground Petroleum Tanks*, (1988).
12. J. Hastings, Vertical Relationships and Competition in Retail Gasoline Markets: Empirical Evidence from Contract Changes in Southern California, Working Paper (2001).
13. A.R. Hayward, Common Law Remedies and the UST Regulations, *Boston College Environmental Affairs Law Review*, 21 (1994) 619-666.
14. J.R. Irwin, G.H. McClelland, Misleading Heuristics and Moderated Multiple Regression Models, *Journal of Marketing Research*, Vol. XXXVIII (2001) 100-109.
15. B. Kelly, The deadline aftermath: How has fleet fueling been affected? *National Petroleum News*, 91 (2) (1999) pp.26-30.
16. H.C. Kunreuther, P.K. Freeman, Insurability and Environmental Risks, in Anthony Heyes (ed). *The Law and Economics of the Environment*, Edward Elgar (2003).

17. H.C. Kunreuther, A. Pfaff, H. Yin, Can Environmental Insurance Succeed Where Others Fail? Conceptual Framework & the Case of Underground Storage Tanks. Wharton Risk Management and Decision Processes Center, University of Pennsylvania, Working Paper #2007-10-16, (2007).
18. National Petroleum News, Annual Station Count Shows No Surprises, 92 (8) (2000) 120.
19. B.P. Pashigian, The Effect of Environmental Regulations on Optimal Plant Size and Factor Shares, *Journal of Law and Economics*, Vol. XXVII (1984) pp.1-28.
20. B.P. Pashigian, Environmental Regulation: Whose Self-Interests are Being Protected? *Economic Inquiry*, Vol. XXIII (1985) 551-584.
21. A.H. Ringleb, S.N. Wiggins, Liability and Large-Scale, Long-Term Hazards, *The Journal of Political Economy*, 98(3) (1990) 574-595.
22. L.C. Schaller, P.J. McNulty, K.R. Chinander, Impact of Hazardous Substances Regulations on Small Firms in Delaware and New Jersey, *Risk Analysis*, 18(2) (1998) 181-189.
23. L.G. Thomas, Regulation and Firm Size: FDA Impacts on Innovation, *The RAND Journal of Economics*, 21(4) (1990) 497-517.
24. U.S. Environmental Protection Agency, Financing Underground Storage Tank Work: Federal and State Assistance Programs, EPA-510-B-99-002 (1999).
25. H Yin, The Environmental and Economic Impacts of Environmental Regulations: The Case of Underground Storage Tank, Unpublished Ph.D. Dissertation, University of Pennsylvania (2006).