Research Statement
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Primary Fields: Energy, Environment, Public Finance, Industrial Organization

Regulation is the primary means by which government can influence the business environment. My research studies two broad areas related to regulatory policy. The main line of my research studies the effects of regulation and taxation of energy markets. In this area, my papers estimate the impacts of fuel taxes, consumer decisions about what vehicles to purchase or how much to drive, and the counterproductive effects of regulation. Outside of energy, my work examines how regulations and information influence consumer decisions.

My research has several important policy implications. First, my work directly informs regulatory design. By better understanding how consumers respond to incentives and the counterproductive effects of policy, I hope to help policy makers and regulators design more effective approaches to energy, environmental and fiscal policy challenges. In addition, my research helps to refine empirical strategies used to study regulation. Although many regulations create counterproductive incentives, effects are difficult to quantify, since illegal activity and regulatory avoidance are often clandestine. Much of my research in this area develops empirical strategies with which it is possible to detect or measure counterproductive incentives.

Over the next several years, my primary goal is to continue my work in these two areas of research. The primary motivation of my research agenda is to better understand regulatory design to solve problems in energy and environmental policy. In doing so, I hope my research will inform the development of productive, rather than counterproductive regulation.

1. Research In Energy Economics

My work on energy markets focuses on three areas: (1) the effects of fuel taxes on prices and economic activity, (2) the effect of fuel taxes and other incentives on driver behavior and vehicle purchase decisions, and (3) the effect of economic and environmental regulation.

1.1. The Effect and Consequences of Fuel Taxes

Measuring Illegal Activity and the Effects of Regulatory Innovation ***(Journal of Political Economy, 2008)***

One of the best examples of my approach to empirical work is **"Measuring Illegal Activity and the Effects of Regulatory Innovation: Tax Evasion and the Dyeing of Untaxed Diesel,"** published in the *Journal of Political Economy*. Detecting tax evasion and estimating how it responds to tax and enforcement policy has traditionally been difficult since those engaging in evasion wish to keep this behavior concealed. In this paper, Justin Marion and I develop three tests for tax evasion and use them to examine the short and long-run effects of the introduction of diesel fuel dye, a regulatory innovation designed to prevent diesel fuel tax evasion. Prior to the use of fuel dye, taxed diesel used for on-road purposes, and untaxed diesel, used for agricultural, marine or residential use were identical. On-road fuel taxes created a strong incentive for evasion – firms could purchase untaxed diesel fuel and resell it for on-road use easily. In October 1993, the Federal Highway Administration began requiring that red dye be added to untaxed diesel fuel. The dye allows inspectors to visually check for untaxed diesel, increasing the ease with which regulators can monitor firms.

In this article, we consider the short-run and long-run impacts of the introduction of fuel dye on tax evasion. We estimate the effects of fuel dye using three identification strategies. Our first identification strategy examines the magnitude of the discontinuity in sales of diesel fuel and untaxed fuel oil, a perfect substitute, upon the introduction of fuel dye. We estimate a 25–30 percent discontinuous increase in sales of taxed diesel fuel at the start of the fuel dye program and an equivalent decrease in sales of untaxed diesel fuel. Consistent with a model of tax evasion, the magnitude of the discontinuity is greater in states with high tax rates and states likely to have high initial monitoring costs.

Our second identification strategy compares the seasonality of untaxed diesel sales before and after the introduction of the fuel dye. Residential demand for diesel (used as heating oil) is highly seasonal, while on-highway demand for diesel is not seasonal. Again, we find strong evidence of a reduction in evasion post-dye – Untaxed diesel sales exhibit much greater seasonality after the introduction of fuel dye.

Our final identification strategy formalizes a test for evasion that compares diesel's elasticity with respect to taxation with its elasticity with respect to prices. Importantly, the test is based on sales of the taxed good only and, thus, applicable to contexts in which we do not see illicit sales of untaxed alternatives. Thus, this approach could be more broadly applied as a text for tax evasion in other contexts. Moreover, this approach does not rely on an observable regulatory discontinuity, like our first identification strategy, and thus is more broadly applicable to other contexts. We find a significant gap between diesel's response to prices and taxes in the pre-dye period, rejecting the null hypothesis of no evasion. This gap disappears for 4 years following the introduction of fuel dye as previous methods of evasion were made less effective. Beginning in 1998, the gap reappears, consistent with criminal innovation in response to the dyeing program.

Estimating the Incidence of Fuel Taxes ***(Journal of Public Economics, 2011)***

Building on this research, Justin Marion and I examine the tax policy consequences of fuel tax evasion and other environmental fuel regulations in **"Fuel Tax Incidence and Supply Conditions."** The incidence of fuel taxes play a central role in several recent energy policy debates, from the tax moratorium proposed by Sens. Clinton and McCain in spring 2008 to discussions about whether a carbon-based tax on fuels would be passed on to the consumer. In addition, although the theory of tax incidence is central in the public finance literature, the main predictions of the tax incidence model are largely untested, and there is only sparse evidence regarding the extent to which taxes are incorporated into retail prices. Fuel markets provide an ideal context in which to examine tax incidence – we use twenty years of monthly, state-level data on tax rates and tax-inclusive prices and estimate incidence by regressing the first difference of the tax-inclusive price on the first difference of tax rates. Moreover, capacity and inventory constraints which plausibly affect the supply elasticity of fuel markets are easily observed.

We first estimate gasoline and diesel fuel tax pass-through and test whether fuel tax incidence responds as the theory of tax incidence would predict – namely, we test whether pass-through falls during periods of time in which the supply of refined products is constrained, either by inventories or by refinery production constraints. Our findings indicate that diesel taxes are fully passed on to consumers. We find that state gasoline taxes are born fully by consumers while 65 percent of federal taxes are passed on to consumers. Moreover, in a confirmation of the theory of tax incidence, we find evidence that pass-through falls in situations in which we believe supply to be more inelastic. While taxes are fully passed through in months where refinery capacity utilization is below 95 percent, pass-through falls to 56 percent in months in which refinery utilization is above 95 percent. For both diesel and gasoline, increases in lagged inventories are associated with lower tax-inclusive fuel prices. For gasoline, larger inventories are also associated with greater tax pass-through to consumers - a one standard deviation increase in gasoline inventories is associated with 8 percent greater tax pass-through.

Finally, we examine how gasoline content regulations, which require urban areas with severe pollution problems to use special blends of gasoline, affect incidence. Similar to capacity or inventory constraints, diverse content requirements complicate the supply chain and potentially reduce the elasticity of supply. We use within-state variation in the mix of special gasoline blends required by changes in environmental regulation and estimate how heterogeneous content requirements affect the incidence of taxes. Our empirical approach exploits variation in both the introduction and seasonality of content requirements. Again, we find evidence consistent with the theory of tax incidence, namely that pass-through is lower in states and months in which content requirements are the most diverse. We estimate that tax pass-through in a state like California (which has one uniform, although stringent, blend of gasoline) is approximately 23 percentage points higher than tax pass-through in a state like Illinois (which uses two distinct blends of gasoline in roughly equal proportion).

Do the Laws of Tax Incidence Hold? Point of Collection and the Pass-through of State Diesel Taxes ***(resubmitted to AEJ: Policy)***

The canonical theory of taxation holds that the party responsible for remitting the tax is independent of incidence. However, this theory has been untested empirically. With Wojciech Kopczuk, Justin Marion and Joel Slemrod, we empirically test the canonical theory by exploiting panel variation in the point of remittance for state diesel taxes. Theoretically and empirically, the canonical result breaks down if tax evasion is present in a market. When evasion is possible, tax pass-through declines, since firms engaging in tax evasion respond less to tax changes than a compliant firm. In our empirical setting, the possibilities for evasion differ over time and at different points in the supply chain. We find evidence that collecting taxes from retail stations is associated with lower rates of pass-through. The effect is largely driven by the pre-dye period, when evasion at the retail level was particularly easy to accomplish.

1.2. Driving, Vehicle Purchase and Government Incentives

In addition to studying the pass-through of fuel taxes, my research also examines how state taxes and incentives affect the vehicle purchase decisions.

Gasoline Taxes and Consumer Behavior ***(AEJ: Policy, 2014)***

The gasoline tax is an important policy tool to control externalities associated with automobile use, to reduce dependency on oil imports, and to raise government revenue. In this paper, Shanjun Li, Joshua Linn and I directly examine how gasoline taxes affect consumer behavior as distinct from tax-exclusive gasoline prices. Across a variety of specifications and estimation methods, we find that consumers respond more strongly to gasoline tax changes. Our main specification shows that a 5-cent tax increase would reduce gasoline consumption by 0.87 percent, significantly larger than the effect from an equivalent change in tax-exclusive prices. This difference suggests that traditional analysis could dramatically underestimate policy impacts of tax changes. We further investigate the differential effect from gasoline taxes and tax-exclusive gasoline prices on both the intensive and extensive margins of gasoline consumption. We discuss implications of our findings for the estimation of the implicit discount rate for vehicle purchases and for the fiscal benefits of raising taxes.

Separately estimating the effect of prices and taxes also offers a strategy to address an identification problem common in environmental and energy economics. Energy efficiency- related policies such as CAFE are often advocated because consumers are widely believed to use a high implicit discount rate to value future energy savings. Beginning with Hausman (1979) and Dubin and McFadden (1984), a long literature estimates the implicit discount rates consumers use to evaluate durable goods purchases. The identification problem arises because the econometrician does not observe a consumer's expectation of future energy costs. Consequently, it is impossible to estimate implicit discount rates without making assumptions on consumers' expectations of future energy prices.

Consumer Incentives and Hybrid Vehicle Adoption ***(JEEM, 2010)***

Hybrid vehicles combine a gasoline engine with an electric motor and battery system, consuming less gasoline and emitting less pollution per mile than traditional internal combustion engines with similar performance. Consequently, accelerated domestic adoption of hybrid-vehicle technology plays an important role in both energy and environmental policy debates. Beginning in 2000, federal, state and local governments implemented a broad set of consumer incentives to stimulate hybrid vehicle adoption, including income tax credits and deductions, sales tax waivers, single-passenger access to carpool lanes, and waivers of emissions testing, registration and parking fees. In "**Giving Green to Get Green? Incentives and Consumer Adoption of Hybrid Vehicle Technology,"** Kelly Gallagher and I ask three questions: (1) Is consumer behavior affected by government incentives? (2) Do consumers respond to rising gasoline prices? and (3) Does the form of the government tax incentive matter? By examining quarterly, state-level sales data for the eleven hybrid models offered from 2000 to 2006, we exploit within-state*model variation in incentives and gasoline prices.

We find strong evidence that consumers respond to government incentives. While we do not find broad evidence that access to carpool lanes is correlated with vehicle adoption, we find evidence that state tax incentives are positively correlated with increased hybrid vehicle adoption. More interestingly is that we find strong evidence that the form of the tax incentive matters almost as much as the generosity of the incentive. When we separately examine different types of tax incentives, we find that a sales tax waiver of mean value ($1,037) is associated with triple the demand effect of a tax credit of mean value ($2,011). Conditional on the incentive value, we estimate that sales tax waivers have a ten-fold greater impact on hybrid vehicle sales. This result contributes to the growing literature examining the structure of tax incentives. Separately estimating the coefficients on income tax credits quarterly, we find that point estimate for the credits is greatest in the second quarter. The point estimates then decline monotonically. This pattern of point estimates is consistent with poorly informed consumers who learn about the incentives during tax season and inconsistent with consumers discounting the future benefits of income tax credits. Consequently, we believe our work complements recent results in Chetty, Kroft and Looney (2007) and Finkelstein (2007) who find consumer response to taxation varies with the salience of the tax.

We also find that gasoline prices affect hybrid vehicle adoption decisions, although the effect operates almost entirely through adoption of hybrids with the highest fuel economy ratings. For high fuel-economy hybrids, we estimate that the cross-price elasticity of demand with respect to retail gasoline price is 0.86. We estimate that a $100 increase in annual fuel savings relative to the fleet average is associated with a 24 percent increase in sales. Comparing consumer response to an upfront payment, in the form of a sales tax waiver, to the consumer response to a flow of payments, in the form of future fuel savings, we calculate an implicit discount rate. In contrast to the previous literature (e.g. Hausman and Joskow (1982)) which tends to find that consumers highly discount future energy costs, we estimate that early hybrid vehicle adopters use a discount rate of 15 percent for future energy cost savings.

Consumer Learning and Hybrid Vehicle Adoption ***(EARE, forthcoming)***

Building on the previous work, **Consumer Learning and Hybrid Vehicle Adoption**, currently under resubmission with Garth Heutel examines consumer adoption of hybrid vehicles. The paper focuses on how consumers learn about the quality of hybrid vehicles. In this paper, we examine cross-state variation in initial adoption patterns of the Toyota Prius, which tended to receive positive reviews, and the Honda Insight, which tended to receive negative reviews. Interestingly, initial relative market shares of the Prius and Insight vary substantially across states.

In this paper, we construct a model of consumer learning in which consumer receive noisy signals of both hybrid vehicle quality and the implementation of hybrid vehicle technology by each manufacturer. We then examine state patterns of hybrid vehicle adoption to test the predictions of our theoretical model. To control for the possibility that Priuses were endogenously targeted at states with

a larger proportion of potential hybrid vehicle owners, we instrument for initial relative market shares using the historical non-hybrid market shares of Toyota and Honda and in-state presence of Honda or Toyota production facilities. Non-hybrid market share is likely to be a function of dealer networks or state-by-state brand preferences, unlikely to be correlated with preferences for hybrid vehicle technology, and consequently a valid instrument.

Both before and after instrumenting, we find that states with relatively high initial Prius penetration experienced greater subsequent rates of hybrid vehicle adoption for all vehicles, but especially subsequent Toyota hybrids. States with relative high Insight penetration experienced slower rates of hybrid vehicle adoption, and especially slow rates for subsequent Honda models.

1.3. Regulation and Competition in Energy Markets

Finally, I also have several papers that examine competition and regulation of energy markets.

Regulated Prices and Efficiency in Retail Natural Gas Markets ***(RAND, 2010)***

Perhaps the most important and widely accepted rationale for public intervention in energy markets is natural monopoly. A standard result in regulation is that efficiency requires that marginal prices be set equal to marginal costs. This eliminates the deadweight loss associated with the monopoly and brings the level of production to the socially optimal level. The regulator then recoups the monopolist's fixed costs through public subsidies or through fixed fees. In **"Do Americans Consume Too Little Natural Gas? An Empirical Test of Marginal Cost Pricing,"** Lucas Davis and I apply the standard natural monopoly framework to the United States natural gas distribution market. In this paper, we examine the following questions: (1) How do actual price schedules prices compare to marginal costs? (2) How much welfare is lost from the observed deviations from marginal cost pricing? (3) What explains the observed pattern of prices schedules? (4) Do municipally-owned distribution companies recoup the fixed costs of operation differently than regulated investor-owned distribution companies? (5) What do the observed prices imply for the likely effectiveness of a carbon tax or other policy aimed at addressing the external costs of energy consumption?

Examining data from 1989-2008, we find that price schedules differ substantially from the theoretical ideal. Individually and jointly, for all 50 states we reject the null hypothesis of marginal cost pricing. In practice, most distribution companies charge prices approximately equal to average cost, including the amortization of capital expenditures. Based on conservative estimates of the price elasticity of demand, our results imply that the current pricing system yields annual welfare losses of $2.6 billion compared to marginal cost pricing and almost $0.9 billion compared to Ramsey-Boiteux pricing. Our results are relevant for evaluating the likely effectiveness of proposed legislation which would place a tax on natural gas and other sources of carbon emissions. Our results indicate that, on average, customers already face average markups of 36% above the marginal cost. The average customer markup ($2.57 per McF) is equivalent to a carbon tax of $173 per metric ton, higher than the level of a carbon tax envisioned by most economists. As a point of comparison, Nordhaus (2008) adopts a carbon tax of $35 per metric ton of carbon. Based on $35 per ton, therefore, customers are already facing a marginal price that is above the social marginal cost of natural gas and any policy which further increases the marginal price will further reduce consumption below the efficient level. The broader policy lesson from our analysis is that pre-existing distortions from imperfect regulation are important to consider when evaluating carbon taxes and other policies that would increase the marginal price of energy products.

Regional Gasoline Content Regulations and Market Segmentation

In addition to affecting tax incidence, gasoline content regulations substantially affected fuel markets in a second way - supplementary state regulations substantially increased cross-state product differentiation. Beginning in 1996, a number of states required gasoline to meet more stringent

requirements than those required by the Clean Air Act Amendment. These state regulations made gasoline blends sold in nearby areas non-substitutable. Although I specifically study gasoline fuel markets, many regulations have a similar effect – by setting unique requirements that products or services must meet, states differentiate products. To the extent that two jurisdictions are geographically heterogeneous, inconsistent regulation across the two will have little incremental effect. If transportation or travel costs between the two jurisdictions are low, though, regulatory differentiation may have a substantial effect.

In **"Gasoline Price Spikes and Regional Gasoline Content Regulations: A Structural Approach,"** I study the degree to which gasoline price volatility in three of the states with the most stringent content regulations from 1996 to 2001, California, Illinois and Wisconsin, can be explained by regulatory differentiation rather than geographic differentiation, changes in refinery ownership or refinery production constraints. To examine this question, I specify a structural model based on refiners' production optimization problem and estimate wholesale prices for jet fuel, diesel and four blends of gasoline in each geographic market. This approach controls for transportation costs, refinery capacity constraints, and changes in refinery ownership.

I then simulate a counterfactual in which gasoline regulations are consistent with, rather than exceed, federal requirements. By comparing the simulated prices from the counterfactual to the actual observed fuel prices, I distinguish the degree to which prices spikes in these markets are the result of regulatory differentiation, rather than geographic heterogeneity. I estimate that 72, 92 and 91 percent of price spikes created by refinery fires in California, Illinois and Wisconsin could be mitigated by compatibility with federal RFG standards. This suggests that state content regulations substantially differentiated gasoline in Illinois and Wisconsin, from other blends sold in the upper Midwest. Even in the case of California, for which transportation costs from the Gulf Coast are considerable, the state content regulations further differentiate gasoline sold in California from gasoline sold in other parts of the country.

Edgeworth Cycles Revisited ***(Energy Economics, 2010)***

Tremendous variation exists in the pricing strategies chosen by different businesses and in different industries. Although a long literature in industrial organization identifies different equilibrium pricing strategies, in many cases the models do not make clear predictions as to why firms might choose one set of strategies in one competitive environment and choose a different set of strategies in another competitive environment.

In **"Edgeworth Cycles Revisited,"** Joe Doyle, Kris Samphantharak and I examine why Edgeworth cycles arise in some local gasoline markets, but not in others. In markets exhibiting Edgeworth cycles, the market clearing price slowly falls to marginal cost until one firm stochastically relents, which results in a price spike. The firms then slowly undercut each other's prices until one firm again relents. In the resulting equilibrium, prices exhibit a striking jigsaw pattern. To examine this question, we adapt the model in Maskin and Tirole (1988) to account for two sources of heterogeneity amongst retail stations. First, we allow for loyal consumers who, due to geographic differentiation, brand loyalty or unobservable preference, do not switch to competitors offering marginally lower prices. Second, we allow firms to earn profits from goods complementary to the primary good upon which firms compete, such as convenience store operations. By comparing how profits of cycling and non-cycling strategies vary with the two sources of heterogeneity, we generate testable predictions of where we would expect to see cycling behavior.

We test our predictions using daily, station-level prices for 115 US metropolitan areas, a larger dataset than in previous studies. We document that Edgeworth cycles are only found in a subset of US cities, and a subset of neighborhoods within these cities. Consistent with the theory, we find that greater market penetration by independent gasoline stations offering convenience store services is associated

with cycling behavior. In addition, evidence suggests a non-monotonic relationship between cycling and market concentration: the least and most concentrated markets are less likely to cycle.

2. Predicting Consumer Response to Information and Regulatory Design

In addition to work examining regulation of energy markets, I have several papers and on-going research projects that examine how consumers change behavior in response to regulatory design and information in other contexts.

2.1. Consumer Response to Regulatory Boundaries

Examining Consumer Tax Avoidance ***(BEJEAP, 2008)***

Like the incentives created by differentially taxing diesel fuel used on-road and off-road, differences in cigarette taxes create incentives similar incentives for consumers to cross borders, either physically or online, and purchase in lower-tax jurisdictions. In **"Crossing the Line: Direct Estimation of Cross-Border Cigarette Sales and the Effect on Tax Revenue,"** Lesley Chiou and I revisit the estimation of consumer response to differential state taxation. Although many studies have documented evidence consistent with border crossing, the few studies that estimate consumer border crossing do so indirectly, by inferring border crossing from smoking behavior of individuals who live close to and far from jurisdictional boundaries.

We overcome this challenge by using a dataset in which we directly observe the location of purchase and price paid by each individual. We directly estimate a consumer's choice of location of purchase as a function of travel costs, demographics, and the incentive created by differential taxation; and exploit variation in consumers' choice sets to identify the effects of price and income on the decision to cross the border.

We estimate that the mean individual is willing to travel 3 miles to save one dollar on a pack of cigarettes, corresponding to a marginal cost of travel for the average consumer of approximately 32 cents per mile. Given that the average difference in state taxes is 64 cents per pack for consumers who live near borders, a consumer would be willing to travel 1.3 miles to a lower tax jurisdiction to purchase a pack of cigarettes or approximately 13 miles to purchase a carton of cigarettes. Using our approach, we estimate that 4 percent of smokers will purchase cigarettes out of state.

Cigarette Excise Tax Changes ***(National Tax Journal, 2014)***

In "Consumer Response to Cigarette Excise Tax Changes," Lesley Chiou and I how examine smokers respond to anticipated tax changes using scanner data from Illinois. In particular, focus on three responses: (1) stockpiling prior the tax change, (2) substitution from brand name to generic brands and (3) border-crossing to lower-tax jurisdictions of Indiana and Wisconsin. The use of scanner data enables us to overcome several challenges faced earlier – the scanner data reports weekly, UPC-level sales for over 100 locations in and around Chicago. Thus, we can exploit variation in the proximity to Indiana and Wisconsin and explicitly examine relative sales of branded and unbranded cigarettes. Moreover, the relatively high frequency of observation allows us to carefully examine stockpiling.

2.2. Consumer Response to Weather and Pollution

Impact of Weather and Pollution on Consumer Activity ***(work in progress)***

A rapidly growing literature in environmental economics examines the health impacts of pollution and temperatures by estimating the relationship between pollution and temperature variation and short-run, local health outcomes. Although a number of these papers exploit exogenous sources of pollution, they are typically unable to account for endogenous consumer avoidance. If consumers limit their exposure on highly polluted or very hot days, existing research may underestimate the true impact of pollution and temperature on health outcomes.

This research project, with Daniel Shoag and Jameson O'Toole, uses fifteen months of high-frequency cell phone data from a major cell phone provider in Portugal. The data contains the date, time and geo-coordinates of 453 million cell calls made by approximately 2 million cell users. We merge this data with daily data from pollution and weather monitoring stations and examine whether individuals' patterns change on highly polluted or very hot days.

Weather and Attitudes about Climate Change ***(JEEM, 2014)***

With Evan Herrnstadt, I examine how consumer interest in Climate Change varies with local atmospheric conditions. We merge detailed weekly data on the frequency of internet searches with detailed data on local temperature and precipitation. Our preliminary results suggest three novel results. First, we find an asymmetric relationship between temperature and consumer search intensity – extreme weather in either direction seems to trigger increased consumer interest in climate change. Second, we find that highly salient weather anomalies (e.g. the lack of winter snow) have a much larger effect on consumer search. Finally, the response is greatest for weather anomalies that affect local economic drivers, such as winter tourism or agriculture.

3. Other Research

In addition to my work evaluating the effects of regulation, I have several other projects more generally examining strategy and firm behavior.

Heuristic Strategies ***(JEBO, 2013)***

Finally, in **"Heuristic Strategies, Firm Behavior and Industry Information,"** Cynthia Lin and I study the impacts of heuristic use on firm behavior. We compare one particular heuristic strategy, in which a firm only uses the expectation of the private information a competitor is likely to receive, to the strategy the firm would adopt if it used the full distribution of competitors' private information in its optimization problem. We define the conditions under which the heuristic strategy chosen when a firm approximates is similar to the full-information strategy that is chosen when a firm maximizes expected profits taken with respect to the distribution of opponent's shocks. We characterize conditions under which firms in a market would prefer that all the firms use the full information, and therefore would have incentives to disclose their private information to each other. We also characterize conditions under which a set of firms may be better off when all firms approximate, and therefore may rationally attempt to coordinate, just as a set of firms has the incentive to collectively operate as a cartel. Under these circumstances, firms in the industry have the incentive to collectively withhold information from each other, and like a cartel, create mechanisms to facilitate cooperation.

While we find that there are many cases in which firms would prefer to share their information with their competitors, as is consistent with the previous literature, we also find that, perhaps surprisingly, under certain conditions, industries have the incentive to coordinate on an equilibrium in which all firms calculate strategies based on heuristics rather than on the full information about the distribution of private information. Consequently, our results enable a better understanding of the incentives firms may have to either facilitate or impede access to industry information. Our results not only have theoretical implications for the behavior of firms, but also speak to econometric applications. When the

econometrician either lacks sufficient information or faces computational costs which prevent the estimation of the Bayesian equilibrium, our results present cases in which using an approximation yields an equivalent solution to that from using the full information. Our results also characterize the approximation error the econometrician faces in cases in which the two solutions differ. While we focus on the implications of our results for the behavior of firms, similar results could identify whether econometric estimation of an approximation-based equilibrium would over- or under-estimate a Bayesian equilibrium.

Endogenous Facility Reliability

In many markets, regulators face the challenge of differentiating strategic withholding of capacity from unreliable production. Analyzing the California Electricity Crisis, the Federal Energy Regulatory Commission noted

> "An increased level of unplanned outages at generating plants is another key factor limiting available generation supply in 2000. . . There are several potential explanations for the increased level of outages. . One possibility is that fewer resources are being devoted to planned maintenance . . . A final possibility is just the opposite: owners could be withholding by taking plants out of service at critical times to drive up prices"[1]

The inability to verify "unplanned" outages present a significant problem for policy makers assessing competitiveness or monitoring for strategic withholding. Although an astute regulator evaluating "unplanned" outages may check to see whether firms which had the most to gain were the most likely to suffer "unplanned" outages, in **"Endogenous Facility Reliability: Evidence From Oil Refinery Fires,"** I suggest that this problem is even more difficult for the regulator. I examine an alternative reason why a correlation may exist between the incentives for withholding and facility reliability, absent strategic withholding. I specify a model in which a firm's choices of production and maintenance affect facility reliability and study how incentives arising from ownership of more than one facility affect facility reliability.

To conduct an empirical test of the theory, I collect information on fires, explosions and other unplanned events at domestic oil refineries from January 1995 through December 2001. Importantly, unlike outages at power plants, fires, explosions and other incidents are verifiable, and thus, it is reasonable to think of them as unrelated to explicit strategic withholding by refiners. I then test whether the pattern of incidents is consistent with the predictions of the theoretical model. I find statistically significant evidence that ownership of other local refining capacity is correlated with the probability of an outage at a given refinery. In addition, the relationship between ownership and incident likelihood is greatest for markets with special gasoline formulations, markets where a refinery outage has the largest effect of gasoline prices. In these markets, expected incident likelihood is 30 percent greater for a refinery affiliated with another refinery that it is for an unaffiliated refinery.

[1] FERC Staff Report on Western Markets and the Causes of the summer 2000 Price Abnormalities – Part I, 11/1/2000.